DRAFT Amendment to IEEE Standard for Local and metropolitan area networks

Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems

Advanced Air Interface

Sponsor

LAN/MAN Standards Committee
of the
IEEE Computer Society

and the

IEEE Microwave Theory and Techniques Society

Introduction

This introduction is not part of IEEE Std 802.16m, IEEE Standard for Local and metropolitan area networks—Part 16: Air Interface for Broadband Wireless Access Systems - Amendment: Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Advanced Air Interface

This amendment updates IEEE Std 802.16 to enhance the OFDMA Physical layer and the MAC layer to define an Advanced Air interface suitable to meet IMT-Advanced Requirements while maintaining backward compatibility.

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The following is a list of participants in the ... Working Group.

Roger B. Marks, *Chair*
Jose Puthenkulam, *Vice-Chair*
Herbert M. Ruck, *Secretary*
Scott Migaldi, *Treasurer*

The following members of the [individual/entity] balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Draft Amendment to IEEE Standard for

Local and metropolitan area networks

Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems —

Advanced Air Interface

NOTE-The editing instructions contained in this amendment define how to merge the material contained herein into the existing base standard IEEE Std 802.16-2009 as amended by IEEE Std 802.16j.

The editing instructions are shown ***bold italic***. Four editing instructions are used: ***change***, ***delete***, ***insert***, and ***replace***. ***Change*** is used to make small corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by 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. Editorial notes will not be carried over into future editions because the changes will be incorporated into the base standard.

1. Overview

1.1 Scope

This standard amends the IEEE 802.16 WirelessMAN-OFDMA specification to provide an advanced air interface for operation in licensed bands. It meets the cellular layer requirements of IMT-Advanced next generation mobile networks. This amendment provides continuing support for legacy WirelessMAN-OFDMA equipment.

1.2 Purpose

The purpose of this standard is to provide performance improvements necessary to support future advanced services and applications, such as those described by the ITU in Report ITU-R M.2072.

2. Normative references

[Insert the following references:]

RFC 2132, http://www.ietf.org/rfc/rfc2132.txt

RFC 3315, http://www.ietf.org/rfc/rfc3315.txt

http://www.iana.org/assignments/bootp-dhcp-parameters/

http://www.iana.org/assignments/dhcpv6-parameters/

3. Definitions

[Insert the following definitions:]

3.97 AAI subframe: A structured data sequence of predefined duration used by the Advanced Air Interface specification.

3.98 advanced base station (ABS): A base station that supports the Advanced Air Interface protocol defined in Clause 16.

3.99 advanced mobile station (AMS): A subscriber station capable of performing te 12.5 WirelessMAN-OFDMA TDD Release 1 subset of mobile station (MS) features and functions additionally implementing the Advanced Air Interface protocol defined in Clause 16.

3.100 advanced relay station (ARS): A relay station that supports the Advanced Air Interface protocol defined in Clause 16.

3.101 superframe: A structured data sequence of fixed duration used by the Advanced Air Interface specifications. A superframe is comprised of four frames.

3.102 multi-carrier transmission: More than one carrier is used to exchange data between ABS and AMSs.

3.103 primary carrier: An OFDMA carrier on which ABS and the AMS exchange traffic and full PHY/MAC control information defined in the Advanced Air Interface specification. Further, the primary carrier is used for control functions for proper AMS operation, such as network entry. Each AMS shall have only one carrier it considers to be its primary carrier in a cell.

3.104 secondary carrier: An OFDMA carrier that AMS may use for traffic, only per BS's specific allocation commands and rules, typically received over the primary carrier. The secondary carrier may also include control signaling to support multi-carrier operation.

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

3.106 partially configured carrier: A carrier with only downlink transmission in TDD or a downlink carrier without paired UL carrier in FDD mode and configured with all control channels to support downlink transmission.

3.107 physical resource unit (PRU): The basic resource allocation unit that consists of 18 adjacent subcarriers in consecutive symbols in the same AAI subframe.

3.108 distributed resource unit (DRU): The resource allocation unit of the same size as the PRU that has undergone the subband partitioning and miniband permutation, assigned to distributed allocation and will be submitted to the subcarrier permutation in DL and tile permutation in UL.

3.109 contiguous resource unit (CRU): The resource allocation unit of the same size as the PRU that has undergone the subband partitioning and miniband permutation, assigned to contiguous allocation and will bypass subcarrier permutation in DL and tile permutation in UL. Also known as a localized resource unit.

3.110 logical resource unit (LRU): the generic name of logical units for distributed and localized resource allocations. LRU is of same size as PRU.

3.111 transmission time interval (TTI): The duration of the transmission of the physical layer encoded packet over the radio air interface and is equal to an integer number of AAI subframes. The default TTI is 1 AAI subframe.

3.112 MIMO layer: An information path fed to the MIMO encoder as an input

3.113 MIMO stream: Each information path encoded by the MIMO encoder that is passed to the precoder

3.114 horizontal encoding: Indicates transmitting multiple separately FEC-encoded layers over multiple antennas. The number of encoded layers may be more than 1

3.115 vertical encoding: Indicates transmitting a single FEC-encoded layer over multiple antennas. The number of encoded layers is always 1.

3.116 resource unit: A granular unit in frequency and time, described by the number of OFDMA subcarriers and OFDMA symbols

3.117 single user MIMO (SU-MIMO): A MIMO transmission scheme in which a single MS is scheduled in one RU

3.118 multi-user MIMO (MU-MIMO): A MIMO transmission scheme in which multiple MSs are scheduled in one RU, by virtue of spatial separation of the transmitted signals

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

3.120 16m (DL/UL) Access Zone: An integer multiple of subframes located in the MZone of the ABS frame or ARS frame, where an ABS or ARS transmit to the AMSs or receive from AMSs.

3.121 16m (DL/UL) Relay Zone: An integer multiple of subframes located in the MZone of the ABS frame, where an ABS transmit to the ARSs and/or AMSs or receive from ARSs and AMSs, or ARS frame, where an ARS transmit to the ABS or receive from ABS.

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

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

3.124 relative delay (RD): The delay of neighbor DL signals relative to the serving/attached BS.

3.125 round trip delay (RTD): The time required for a signal or packet to transfer from a MS to a BS and back again.

3.126 Macro hotzone ABS: An ABS with smaller transmission power than macro ABS's (larger than femto ABS's) and possibly overlaid under the coverage of another macro ABS. Macro hotzone ABS may be deployed by service provider. It may be deployed in outdoor environment.

3.127 frame index: The frame order within a Superframe (i.e. the 1st, 2nd, 3rd, or 4th frame of Superframe).

3.128 Femto ABS: an ABS with low transmit power, typically installed by a subscriber in the home, SOHO, or enterprise to provide the access to closed or open group of users as configured by the subscriber and/or the access provider. A Femto ABS is typically connected to the service providers network via a broadband connection.

3.129 OSG Femto ABS: a femto ABS accessible to any AMS.

3.130 closed subscriber group (CSG): a set of subscribers authorized by the Femto ABS owner or the network service provider, for accessing CSG femto ABS.

3.131 CSG Femto ABS: CSG-Closed or CSG-Open Femto ABS.

3.132 CSG-Closed Femto ABS: a femto ABS accessible only to the AMSs, which are in its CSG(s), except for emergency services. AMSs which are not the members of the CSG(s), should not try to access CSG-Closed Femto ABSs.

3.133 CSG-Open Femto ABS: a femto ABS primarily accessible to the AMSs that belong to its CSG(s), while other AMSs, outside CSG(s), may also access such Femto ABS, and will be served at lower priority. CSG-Open Femto ABS will provide service to such AMSs as long as the QoS of AMSs in its CSG(s) is not compromised.

4. Abbreviations and acronyms

[Insert the following abbreviations:]

AAI	advanced air interface
ABS	advanced base station
aGPS	adaptive grant polling service
A-MAP	advanced MAP
AMS	advanced mobile station
AOA	angle of arrival
A-Preamble	advanced preamble
ARS	advanced relay station
CAS	CRU allocation size
CDR	conjugate data repetition
CL	closed-loop
CLRU	contiguous LRU
CMH	compact MAC header
CMI	codebook matrix index
CRU	contiguous resource unit
CRV	CoRe version
CoRe	constellation re-arrangement
CSG	closed subscriber group
CSM	collaborative spatial multiplexing
DL	downlink
DLRU	distributed LRU
DSAC	downlink subband allocation count
DRU	distributed resource unit
EH	extended header
FFR	fractional frequency reuse

FID	flow identifier
FMT UL	feedback mini-tile
FP	frequency partition
FPEH	fragmentation and packing extended header
FPC	frequency partition configuration
FPCT	frequency partition count
FPS	frequency partition size
FPSC	frequency partition subband count
GRA	group resource allocation
GMH	generic MAC header
GPCS	generic packet convergence sublayer
HARQ	hybrid ARQ
HE	horizontal encoding
HMT	UL HARQ mini-tiles
ICV	integrity check value
IE	information element
IR	incremental redundancy
LBS	location based services
LDM	low duty mode
LRU	logical resource unit
MCEH	MAC control extended header
MCS	modulation and coding scheme
MEF	MIMO encoder format
MEH	multiplexing extended header
MEHB	multiplexing extended header block
MLRU	minimum A-MAP logical resource unit
MU	multi-user

NIP normalized interference power

NLRU miniband LRU

OL open-loop

OSG Open Subscriber Group

PA persistent allocation

PA-Preamble primary advanced preamble

PFBCH UL primary fast feedback channel

PGID paging-group identifier

PMI preferred matrix index

PPRU permuted physical resource unit

PRU physical resource unit

P-SFH primary superframe header

PSI pilot stream index

RA-ID ranging code identifier

RCP ranging cyclic prefix

RFMT Reordered UL feedback mini-tile

RFPEH rearrangement fragmentation and packing extended header

RHMT Reordered UL HARQ mini-tile

RMEHB rearrangement multiplexing extended header block

RP ranging preamble

RU resource unit

S-ABS serving ABS

SAC subband allocation count

SA-Preamble secondary advanced preamble

Sc sub-carrier

SFBC space-frequency block code

SFBCH UL secondary fast feedback channel

SFH	superframe header
SLRU	subband LRU
SOHO	Small Office Home Office
SPID	subpacket ID
S-SFH	secondary superframe header
STC	space-time coding
STID	station identifier
SU	single-user
T-ABS	target ABS
TOA	time of arrival
TSTID	temporary STID
UCAS	uplink CRU allocation size
UFPC	uplink frequency partition configuration
UL	uplink
USAC	uplink subband allocation count
VE	vertical encoding

5. Service Specific CS

5.1 ATM CS

Insert the following paragraph at the end of 5.1:

The ATM CS is not supported by the AMS or the ABS.

5.2 Packet CS

[Insert the following paragraph at the end of 5.2 as indicated:]

The packet CS is used for transport for all packet-based protocols as defined in 11.13.18.3.

ABS and AMS shall use either the IP CS of the packet CS or the GPCS for all packet-based protocols.

5.2.1 MAC SDU format

[Change Section 5.2.1 as indicated:]

Once classified and associated with a specific MAC connection, higher layer PDUs shall be encapsulated in the MAC SDU format as illustrated in Figure 8. The 8-bit PHSI (payload header suppression index) field shall be present when a PHS rule has been defined for the associated connection. PHS is described in 5.2.3. The 8-bit Protocol ID field shall be present when a Multiprotocol flow is defined for the associated connection. This is described in section 5.2.6.

[Replace Figure 8 with the following:]

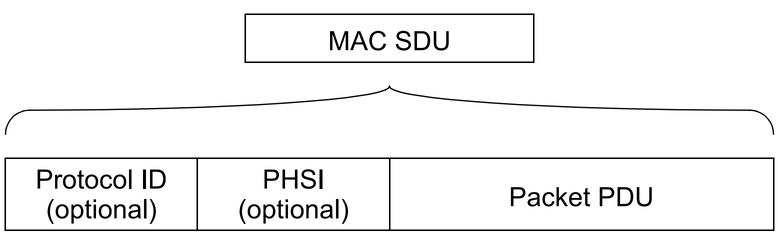

Figure 8—MAC SDU format

5.2.2 Classification

[Change the second paragraph of 5.2.2 as indicated:]

A classification rule is a set of matching criteria applied to each packet entering the IEEE 802.16 network. It consists of some protocol-specific packet matching criteria (destination IP address, for example), a classification rule priority, and a reference to a CID, or for an ABS or AMS reference to a STID+FID combination. If a packet matches the specified packet matching criteria, it is then delivered to the SAP for delivery on the connection defined by the CID or STID+FID. Implementation of each specific classification capability (as, for example, IPv4 based classification) is optional. The service flow characteristics of the connection provide the QoS for that packet.

Replace Figure 9 in 5.2.2 with the following figure:

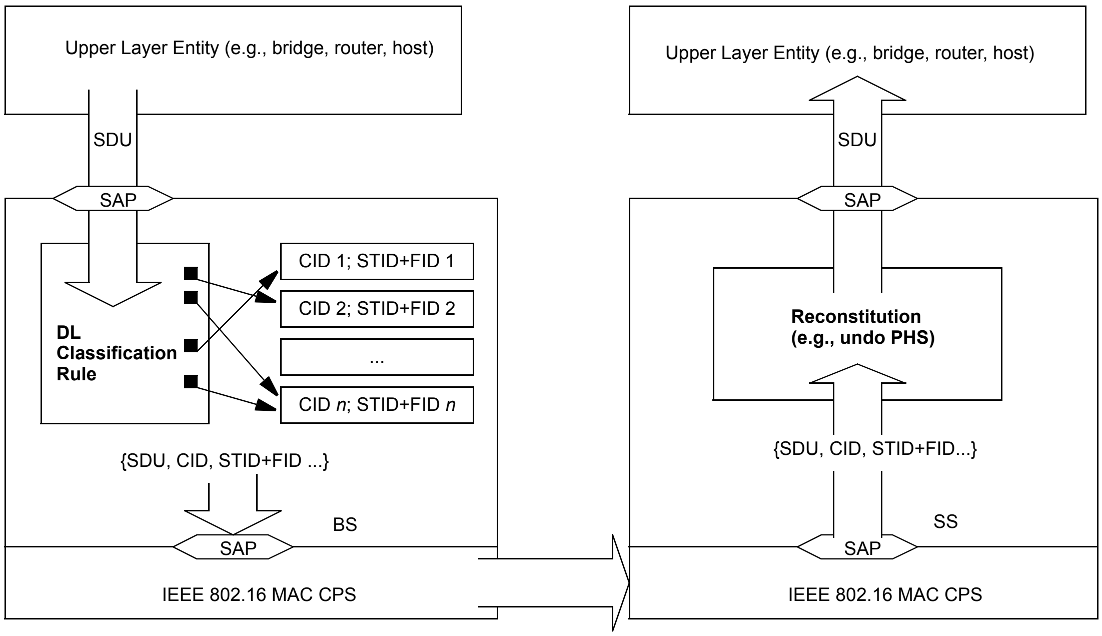

Figure 9—Classification and CID mapping (BS to SS)

Replace Figure 10 in 5.2.2 with the following figure:

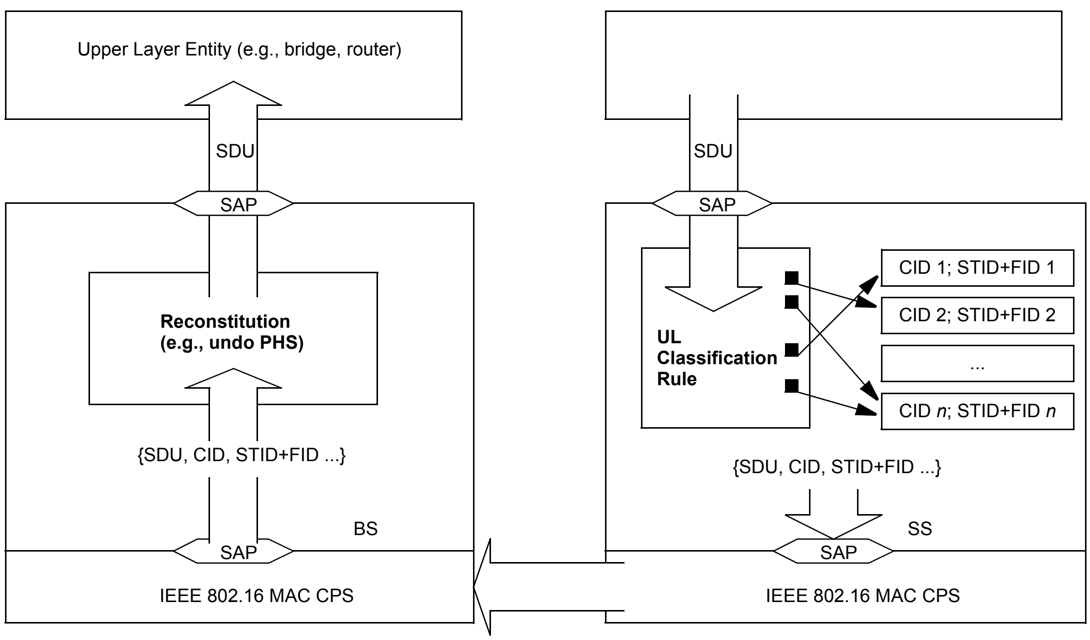

Figure 10—Classification and CID mapping (SS to BS)

5.2.3 Payload header suppression (PHS)

Change the second paragraph of 5.2.3 as indicated:

The sending entity uses classification rules to map packets into a service flow. The classification rule uniquely maps packets to its associated PHS Rule. The receiving entity uses the CID or STID+FID and the PHSI to restore the PHSF. Once a PHSF has been assigned to a PHSI, it shall not be changed. To change the value of a PHSF on a service flow, a new PHS rule shall be defined, the old rule is removed from the service flow, and the new rule is added. When all classification rules associated with the PHS rule are deleted, then the PHS rule shall also be deleted.

Change the fourth paragraph of 5.2.3 as indicated:

The BS shall assign all PHSI values just as it assigns all CID or STID+FID values. Either the sending or the receiving entity shall specify the PHSF and the payload header suppression size (PHSS). This provision allows for preconfigured headers or for higher level signaling protocols outside the scope of this standard to establish cache entries.

Change 5.2.3.1 as indicated:

5.2.3.1 PHS operation

SS and BS implementations are free to implement PHS in any manner as long as the protocol specified in this subclause is followed. Figure 11 illustrates the following procedure.

A packet is submitted to the packet CS. The SS applies its list of classification rules. A match of the rule shall result in an UL service flow and CID or STID+FID and may result in a PHS Rule. The PHS Rule provides PHSF, PHSI, PHSM, PHSS, and PHSV. If PHSV is set or not present, the SS shall compare the bytes in the packet header with the bytes in the PHSF that are to be suppressed as indicated by the PHSM. If they match, the SS shall suppress all the bytes in the UL PHSF except the bytes masked by PHSM. The SS shall then prefix the PDU with the PHSI and present the entire MAC SDU to the MAC SAP for transport on the UL.

When the MAC protocol data unit (MAC PDU) is received by the BS from the air interface, the BS MAC shall determine the associated CID or STID+FID by examination of the ~~g~~Generic MAC header or Advanced Generic MAC Header. The BS MAC sends the ~~PDU~~ SDU to the MAC SAP associated with that CID or STID+FID. The receiving packet CS uses the CID or STID+FID and the PHSI to look up PHSF, PHSM, and PHSS. The BS reassembles the packet and then proceeds with normal packet processing. The reassembled packet contains bytes from the PHSF. If verification was enabled, then the PHSF bytes equal the original header bytes. If verification was not enabled, then there is no guarantee that the PHSF bytes match the original header bytes.

A similar operation occurs on the DL. The BS applies its list of Classifiers classification rules. A match of the classification shall result in a DL service flow and a PHS rule. The PHS rule provides PHSF, PHSI, PHSM, PHSS, and PHSV. If PHSV is set or not present, the BS shall verify the Downlink Suppression field in the packet with the PHSF. If they match, the BS shall suppress all the bytes in the Downlink Suppression field except the bytes masked by PHSM. The BS shall then prefix the PDU with the PHSI and present the entire MAC SDU to the MAC SAP for transport on the DL.

The SS shall receive the packet based upon the CID or STID+FID Address filtering within the MAC. The SS receives the PDU and then sends it to the CS. The CS then uses the PHSI and CID or STID+FID to lookup PHSF, PHSM, and PHSS. The SS reassembles the packet and then proceeds with normal packet processing.

Figure 12 demonstrates packet suppression and restoration when using PHS masking. Masking allows only bytes that do not change to be suppressed. Note that the PHSF and PHSS span the entire suppression field, included suppressed and unsuppressed bytes.

5.2.4 IEEE 802.3/Ethernet-specific part

5.2.5 IP specific part

5.2.5.1 IP CS PDU format

Change the second paragraph of 5.2.5.1 as indicated:

ROHC (refer to RFC 3095) may be used instead of PHS to compress IP headers. The MS and the BS signal enabling of ROHC by setting bit 7 of Request/Transmission Policy (see 11.13.12) to 0. The AMS and the ABS signal enabling of ROHC by [FFS]. When ROHC is enabled for a service flow, the service flow constitutes what in RFC 3095 is referred to as a ROHC channel.

5.2.5.2 IP classification rules

Change 5.2.5.2 as indicated:

IP classification rules operate on the fields of the IP header and the transport protocol. ~~The~~ For SS and BS, the parameters (11.13.18.3.3.2 through 11.13.18.3.3.7 and 11.13.18.3.3.16) may be used in IP classification rules. For AMS and ABS, the parameters (FFS) may be used in IP classification rules.

[Insert Section 5.2.6 as indicated:]

5.2.6 Support for multiple protocols on the same flow

In order to transport several types of protocols over the same MAC connection, the Multiprotocol flow can be used. The receiver must identify the protocol to correctly forward the SDU. For instance, if the information carried by the SDU is a RoHC packet, it should be forwarded to the RoHC decompressor. The receiver does this according to the Protocol ID field which is the first byte of a Multiprotocol flow connection as depicted in Figure 18a and Figure 18b.

Protocol ID	Packet

Figure 18a—Multi-protocol flow PDU format without PHS

Protocol ID	PHSI	Packet

Figure 18b—Multi-protocol flow PDU format without PHS

Once the protocol type of an incoming packet is determined, the appropriate classification rules are applied to the packet and the correct service flow is identified. It is then optionally forwarded to the header suppression mechanism (PHS or RoHC) and then mapped MAC SAP using the format described in this section. The

Protocol ID content is set by the transmitter by the protocol identified before the classification rules were applied and according to the Table 2a.

The method by which the protocol of a packet introduced to the CS layer is identified is beyond the scope of this standard.

Table 2a—Possible values for Protocol ID field

Protocol ID	Meaning
1	Raw IP
2	IPv4
3	RoHC
4	IPv6
5..256	*Reserved*

6. MAC common part sublayer

6.3 Data/control plane

6.3.2 MAC PDU formats

6.3.2.1 MAC header formats

6.3.2.1.2 MAC header without payload

6.3.2.1.2.1 MAC signaling header type 1

6.3.2.1.2.1.1 Bandwidth request (BR) header

[Modify Table 8 as indicated:]

Table 8—BR header fields

Name	Length (bit)	Description
BR	19	Bandwidth request. The number of bytes of UL bandwidth requested by the SS. The BR is for the CID. The request shall be independent of the physical layer modulation and coding. In case of the Extended rtPS, the BS changes its grant size to the value specified in this field.
CID	16	Connection identifier.
EC	1	Always set to zero.
HCS	8	Header check sequence. Same usage as HCS entry in Table 5.
HT	1	Header type = 1.
Type	3	Indicates the type of BR header. In the case of the Extended rtPS, both Type 0 and Type 1 adhere to the BR definition above (change in grant size).

6.3.2.3 MAC management messages

RNG-REQ (ranging request) message

[Change the text below Table 43 as indicated:]

The following ~~parameters shall~~ parameter may be included in the RNG-REQ message when the SS is attempting initial entry to the network:

Requested Downlink Burst Profile

The following parameter shall be included in the RNG-REQ message when the SS is attempting initial entry to the network:

SS MAC Address

The following parameters shall be included in the RNG-REQ message when transmitted during SS initial entry to the network. The parameter shall be sent on the SSs basic connection or for OFDMA on the following initial ranging connection:

6.3.2.3.39 MOB-SLP-REQ (sleep request) message

[Modify section 6.3.2.3.39 as indicated:]

Power_Saving_Class_ID

Assigned power saving class identifier. The ID shall be unique within the group of power saving classes associated with the MS. This ID may be used in further MOB_SLP-REQ/RSP messages for activation/deactivation of power saving class.

Start_frame_number

~~Start frame number for first sleep window.~~

Represents the 7 least significant bits of the absolute frame number in which the first sleep window starts.

...

Number_of_CIDs

Number_of_CIDs = 0 means all unicast management/transport connections and multicast traffic CIDs associated with the MS at the time the MOB_SLP-REQ message is transmitted are added to the Power Saving Class.

CID

CIDs of all connections comprising the Power Saving Class. If Basic CID is included, it means that all MS management connections are included in the Power Saving Class. If CID=0 is included, that means all current transport connections at the time the MOB_SLP-REQ message is transmitted are added to the Power Saving Class.

The following TLV parameter may be included in MOB_SLP-REQ message transmitted when requesting an activation of power saving class. This TLV indicates the enabled action that MS performs upon reaching trigger condition in sleep mode.

Enabled-Action-Triggered

Indicates possible action upon reaching trigger condition.

The following TLV parameter may be included in MOB_SLP-REQ message transmitted when requesting an activation of power saving class. This TLV indicates that the unavailability interval of the activated PSC is to be used for coexistence purposes in the MS and the BS is requested to use coexistence behavior for the PSC.

Co-located-Coexistence-Enabled

This TLV indicates the PSC is also to support co-located coexistence.

The following TLV may be included in the MOB_SLP-REQ message:

Sleep mode functions enabled in H-FDD

This TLV indicates features that are to be used to support H-FDD operation.

The following TLV may be included in the MOB_SLP-REQ message:

Sleep mode functions enabled in full FDD

This TLV indicates features that are to be used to support full FDD operation.

The MOB_SLP-REQ shall include the following parameters encoded as TLV tuples:

HMAC/CMAC Tuple (see 11.1.2)

The HMAC/CMAC Tuple shall be the last attribute in the message.

6.3.2.3.40 MOB_SLP-RSP (sleep reponse) message

[Modify the description for 6.3.2.3.40 MOB_SLP-RSP (sleep response) message as follows:]

The following TLV parameter may be included in the MOB_SLP-RSP message transmitted by the BS.

Enabled-Action-Triggered (11.1.7.1)

This TLV indicates the enabled action that the MS performs upon reaching trigger condition in sleep mode.

Next Periodic Ranging (11.1.7.3)

This value indicates the offset of frame in which MS shall be ready to perform a periodic ranging with respect to the frame where MOB_SLP-RSP is transmitted.

Sleep mode functions enabled in H-FDD

This TLV indicates features that are to be used to support H-FDD operation.

The following TLV may be included in the MOB_SLP-REQ message:

Sleep mode functions enabled in full FDD

This TLV indicates features that are to be used to support full FDD operation.

6.3.2.11 DSA-RSPmessage

6.3.2.11.2 BS-initiated DSA

[Modify the paragraph as indicated:]

If a DSA-RSP with status success is sent and Service Flow Parameter TLVs are included, the only Service Flow Parameter TLVs that may be included shall be those specified under section 11.13.17 (ARQ TLVs for ARQ enabled connections), section 11.13.34 (PDU SN Extended Subheader for HARQ Reordering TLV), and those specified under section 11.13.36 (ROHC Parameter TLVs).

6.3.2.11.26 DREG-CMD (de/reregister command) message

[Modify Table 96 as indicated:]

Table 96—Action codes and actions

Action code (hexadecimal)	Action
00	SS shall immediately terminate service with the BS and should attempt network entry at another BS.
01	SS shall listen to the current BS but shall not transmit until a RES-CMD message or DREG-CMD message with action 02 or 03 is received.
02	SS shall listen to the current BS but only transmit on the basic and primary management connections.
03	SS shall return to normal operation and may transmit on any of its active connections.
04	This option is valid only in response to a DREG-REQ message with De-Registration Request Code = 0x00. The SS shall terminate current Normal Operations with the BS.
05	MS shall begin MS idle mode initiation. See 6.3.23.1.
06	This option is valid only in response to DREG-REQ message with De-Registration Request Code = 0x01. The behavior of MS to this action is described in 6.3.23.1.
07	MS shall send DREG-REQ with action 0x01 to request the BS to initiate idle mode. See 6.3.23.1.
~~07~~08-0xFF	*Reserved*

6.3.2.11.37 DREG-REQ (SS deregistration request) message

[Modify Table 109 and subsequent text as indicated:]

Table 109—DREG-REQ message format

Syntax	Size	Notes
DREG-REQ message format() {		
Management Message Type = 49	8	0x00 = SS deregistration request from BS and network 0x01 = Request MS deregistration from serving BS and initiation of MS idle mode. 0x02 = Response for the Unsolicited MS deregistration initiated by the BS. 0x03 = Reject for the unsolicited DREG-CMD with action code 0x05 or 0x07 (idle mode request) by the BS. This code is applicable only when MS has a pending UL data to transmit. 0x04-0xFF = *Reserved*
De-registration Request Code	8	
TLV encoded parameters	*Variable*	
}		

An SS shall generate DREG-REQ messages including the following parameters:

De-registration_Request_Code

Request code identifying the type of deregistration request:

0x00 = SS deregistration request from BS and network

0x01 = MS request for deregistration from serving BS and initiation of idle mode

0x02 = MS response for the unsolicited deregistration initiated by BS

0x03 = MS reject of unsolicited DREG-CMD signaling Idle Mode initiation

~~0x03~~ 0x04-0xFF = *Reserved*

6.3.2.11.42 MOB_NBR-ADV (neighbor advertisement) message

[Modify Table 144 as indicated:]

Table 144—MOB_NBR-ADV message format

Syntax	Size (bit)	Notes
MOB_NBR_ADV_Message_format() {		
Management Message Type = 53		

Table 144—MOB_NBR-ADV message format

Syntax	Size (bit)	Notes
Reuse factor for SBS CINR calculation for scan and handover	2	00 - Physical SBS CINR for scan or handover triggers shall be calculated according to the number of subcarriers indicated in the DL Frame Prefix "Used subchannel bitmap" field. If the number of used subcarriers is lower than or equal to one third of the total number of subcarriers, then CINR shall be computed according to the rule detailed in 8.4.12.3 for frequency reuse configuration = 3. Otherwise the CINR shall be computed according to the rule detailed in 8.4.12.3 for frequency reuse configuration = 1 10 - Physical SBS CINR for scan or handover triggers shall be calculated according to the rule detailed in 8.4.12.3 for frequency reuse configuration = 1 01 - Physical SBS CINR for scan or handover triggers shall be calculated according to the rule detailed in 8.4.12.3 for frequency reuse configuration = 3 11 - reserved
Skip-optional-fields bitmap	6	Bit [0]: if set to 1, omit Operator ID field. Bit [1]: if set to 1, omit NBR BS ID field. Bit [2]: if set to 1, omit HO process optimization field. Bit [3]: if set to 1, omit QoS related fields. Bit [4]-[5]: *Reserved*.

Table 144—MOB_NBR-ADV message format

Syntax	Size (bit)	Notes
~~Reuse factor for SBS CINR calculation for scan and handover~~	~~2~~	~~00 - Physical SBS CINR for scan or handover triggers shall be calculated according to the number of subcarriers indicated in the DL Frame Prefix "Used subchannel bitmap" field. If the number of used subcarriers is lower than or equal to one third of the total number of subcarriers, then CINR shall be computed according to the rule detailed in 8.4.12.3 for frequency reuse configuration = 3. Otherwise the CINR shall be computed according to the rule detailed in 8.4.12.3 for frequency reuse configuration = 1~~ ~~10 - Physical SBS CINR for scan or handover triggers shall be calculated according to the rule detailed in 8.4.12.3 for frequency reuse configuration = 1~~ ~~01 - Physical SBS CINR for scan or handover triggers shall be calculated according to the rule detailed in 8.4.12.3 for frequency reuse configuration = 3~~ ~~11 - reserved~~

6.3.2.11.55 OFDMA SUB-DL-UL-MAP message

[Modify the description of the field RCID_TYPE in SUB-DL-UL-MAP message in section 6.3.2.3.55 as follows]

RCID_TYPE

The RCID type used for RCID IEs specified in DL-MAP IEs that are described in this SUB-DL-UL-MAP. For the MAP IE containing RCID_Type field of its own (e.g., HARQ DL MAP IE, HARQ UL MAP IE), the RCID_Type in the corresponding MAP IE shall override the RCID_Type in this SUB-DL-ULMAP within the scope of the said MAP_IE.

6.3.5 Data/control plane

6.3.5.2 UL request/grant scheduling

6.3.5.2.2 Real-time polling service (rtPS)

[Modify the text in 6.3.5.2.2.1 as indicated:]

6.3.5.2.2.1 Extended rtPS

Extended rtPS is a scheduling mechanism which builds on the efficiency of both UGS and rtPS. The BS shall provide unicast grants in an unsolicited manner like in UGS, thus saving the latency of a BR. However, whereas UGS allocations are fixed in size, ertPS allocations are dynamic.

The BS may provide periodic UL allocations that may be used for requesting the bandwidth as well as for data transfer. By default, size of allocations corresponds to current value of Maximum Sustained Traffic Rate at the connection. The MS may request the BS to change ~~changing~~ the size of the UL allocation by indicating the desired UL allocation size ~~either by~~ using an Extended Piggyback Request field of the GMSH or the BR field of the MAC signaling headers as described in Table 7 or by sending a codeword (defined in 8.4.11.13) over CQICH. ~~The BS shall not change the size of UL allocations until receiving another bandwidth change request from the MS.~~ When the BR size is set to zero, the BS may provide allocations for only BR header or no allocations at all. In case that no unicast BR opportunities are available, the MS may use contention request opportunities for that connection, or send the CQICH codeword to inform the BS of its having the data to send. If the BS receives the CQICH codeword, the BS shall start allocating the UL grant corresponding to the current Maximum Sustained Traffic Rate value.

The mandatory QoS parameters are the Maximum Sustained Traffic Rate, the Minimum Reserved Traffic Rate, the Maximum Latency, the Request/Transmission Policy and Unsolicited Grant Interval (11.13.19).

The Extended rtPS is designed to support real-time service flows that generate variable-size data packets on a periodic basis, such as Voice over IP services with silence suppression.

6.3.20 Sleep mode for mobility-supporting MS

6.3.20.1 Introduction

[Modify the sixth paragraph as indicated:]

Power Saving class may be repeatedly activated and deactivated. Activation of certain Power Saving Class means starting sleep/listening windows sequence associated with this class.

The MS and BS shall discard all Power Saving Class parameters when any of the following events occur:

- MS completes HO to another BS.
- MS enters Idle mode
- The MS is deregistered from the Serving BS.

Algorithm of choosing Power Saving Class type for certain connections is outside of the scope of the standard. When a PSC I or PSC II is reactivated, the MS shall reset the sleep window size to the initial-sleep window size according to the definition of the PSC.

[Modify the tenth paragraph in section 6.3.20.1 as indicated:]

During the unavailability interval in DL (or UL), the BS shall not transmit to the MS; therefore, the MS may power down one or more physical operation components or perform other activities that do not require communication with the BS (e.g., scanning neighbor BSs, associating with neighbor BSs). If there is a unicast management/transport connection or a multicast traffic connection which is not associated with any active power saving class, the MS shall be considered available on permanent basis. The multicast traffic connection does not include MBS connection.

[Add a new section 6.3.20.10:]

6.3.20.10 Activation and transition of MS states

Table 201a summarizes the state transitions of a MS with active PSC/PSCs after the reception of one of the messages listed in the first column:

Table 201a—State transitions of an MS with active PSC/PSCs

New Message	Transition of an MS that is in Sleep Mode with an active PSC
MOB_SLP-RSP or DL sleep control extended subheader with new PSC activation	See 6.3.20. Remark: If the MS and BS activate a new PSC that replaces an existing PSC, then the new PSC is activated and the existing PSC is deactivated at start_frame_number defined in MOB_SLP-RSP or in DL sleep control extended subheader.
MOB_HO-REQ message	All PSCs are deactivated upon transmission or reception of the MOB_HO-REQ message. This shall apply also to the case that results in HO cancel.
DREG-REQ message to enter Idle mode	Sleep mode is deactivated upon completion of deregistration.

6.3.21 MAC HO procedures

6.3.21.1 Network topology acquisition

6.3.21.1.2 MS scanning of neighbor BSs

[Insert the following at the end of 6.3.21.1.2:]

Table 201b gives a summary about the state transitions that a MS with active scanning pattern shall perform after the reception of the messages listed in the first column.

Table 201b—State transitions of an MS with active scanning pattern

New Message	Transition of an MS that has a Scanning pattern
MOB_SLP-RSP or DL sleep control extended subheader.message with new PSC activation	Activation of a PSC cancels the entire scanning context. Note that the MS may perform scanning autonomously during the unavailability interval. Any active scanning shall be deactivated upon sleep entry, at start_frame_number defined in MOB_SLP-RSP or in DL sleep control extended subheader.
MOB_HO-REQ message	Scanning pattern is deactivated upon transmission or reception of the MOB_HO-REQ message.
DREG-REQ message to enter Idle mode	Scanning pattern should be deactivated upon completion of deregistration.

6.3.21.2 HO process

[Modify the text as indicated:]

6.3.21.2.1 Drops ~~during HO~~

A drop is defined as the situation where an MS has stopped communication with its serving BS. ~~(either in the DL or in the UL) before the HO process (6.3.21.2) has been completed.~~ A “drop during HO” is defined as the situation where the MS loses communication to a target BS during a handover attempt to this target BS.

An MS can detect a drop by its failure to demodulate the DL, or by exceeding the RNG-REQ retries limit ~~allowed for the periodic ranging mechanism~~. A BS can detect a drop when the Number of retries limit allowed on inviting ranging requests for the periodic ranging mechanism is exceeded. An MS can detect a drop during HO by its failure to demodulate the DL signals from this target BS, or by exceeding the RNG-REQ retries limit.

~~When the MS has detected a drop during network reentry with a target BS, it may attempt network reentry with its preferred target BS as through Cell Reselection (see 6.3.21.2.1), which may include resuming communication with the serving BS by sending MOB_HO-IND message with HO_IND type = 0b01 (HO cancel) or performing network reentry at the serving BS.~~

When the MS has detected a drop or a drop during HO, it may perform network reentry at a BS as described in 6.3.21.2.7. The BS preferred by the MS may be the serving BS.

~~The network reentry process at the serving BS is identical to the network reentry process at any other target BS, both for the serving BS and for the MS. If the serving BS has discarded the MS context, the network reentry procedure shall be the same as full network reentry with HO optimization rules and scenarios defined in 6.3.21.2.10.~~

If the MS performs network reentry, the MS shall perform CDMA ranging with a preferred target BS using codes from HO codes domain.

Upon the preferred target BS’s sending RNG-RSP with Ranging Status = success, the ~~target~~ BS shall provide CDMA A~~LLOC~~llocation IE with appropriate UL allocation for RNG-REQ from MS. MS shall send RNG-REQ with MAC address and HMAC/CMAC. Serving BSID TLV and Ranging Purpose Indication TLV Bit #0 set to 1 shall be included in RNG-REQ as well. The ~~target~~ BS may now identify that HO attempt by MS was not coordinated with the serving BS and may request all relevant MS context from the serving BS. Using this information, the ~~target~~ BS shall now send RNG-RSP with HO process optimization ~~bitmap~~TLV and network reentry may continue as in the typical, nondrop case.

The network reentry process at the serving BS is identical to the network reentry process at any other preferred target BS, both for the serving BS and for the MS (see 6.3.21.2.7). If the serving BS has discarded the MS context, the network re-entry procedure shall be the same as full network reentry with HO optimization rules and scenarios defined in 6.3.21.2.10.

When the serving BS has detected a drop, it shall react as if a MOB_HO-IND message has been received with HO_IND_type indicating serving BS release.

When the MS has detected a drop during HO, the MS may perform the HO Cancellation procedure specified in 6.3.21.2.3.

6.3.23 MS idle mode (optional)

6.3.23.1 MS idle mode initiation

[Modify the 1st paragraph in Section 6.3.23.1 as indicated:]

Idle mode initiation may begin after MS deregistration. During normal operation with its serving BS, an MS may signal intent to begin idle mode by sending a DREG-REQ message with the De-registration_Request_Code parameter = 0x01; request for MS deregistration from serving BS and initiation of MS idle mode. When the BS decides to reject MS-initiated idle mode request, the BS shall send a DREG-CMD with action code 0x06 in response to this DREG-REQ message. The BS may include REQ-Duration TLV in this DREG-CMD message. In this case, the MS may retransmit the DREG-REQ message after the expiration of REQ_Duration. If the MS does not receive the DREG-CMD message within T45 timer expiry after it sends the DREG-REQ message to the BS, the MS shall retransmit the DREG-REQ message as long as DREG Request Retry Count has not been exhausted. Otherwise, the MS shall reinitialize MAC.

If the BS decides to accept MS-initiated idle mode request, the BS shall send a DREG-CMD with action code 0x05 in response to this DREG-REQ message

Also, the BS shall start Management_Resource_Holding_Timer to maintain connection information with the MS as soon as it sends the DREG-CMD message with action code 0x05 to the MS. If Management_Resource_Holding_Timer has been expired, the BS shall release connection information with the MS.

[Add the following in Section 6.3.23.1 immediately after the third paragraph as indicated:]

When extended BS-initiated Idle Mode is supported by the MS and the BS, the BS may send a DREG-CMD message with Action Code set to 0x07 in an unsolicited manner, with or without the REQ-duration TLV, signaling the MS to initiate an Idle Mode request through a DREG-REQ message with De-Registration_Request_Code = 0x01 at REQ-duration expiration. If the REQ-duration TLV is not included, MS shall send the DREG-REQ message at the earliest possible time. The MS may include the Idle Mode Retain Information TLV in the DREG-REQ message.

Upon receiving a DREG-REQ message with De-Registration_Request Code = 0x01 from the MS, the BS shall transmit a DREG-CMD message with Action Code=0x05. If the DREG-REQ with De-Registration_Request Code = 0x01 included the Idle Mode Retain Information TLV, the BS DREG-CMD with Action Code set to 0x05 message shall also include this TLV. Upon the reception of the DREG-CMD with Action Code = 0x05 the MS shall enter Idle Mode.

The BS shall start the T50 timer at the REQ-duration timer expiration. If the BS does not receive a DREG-REQ with De-Registration_Request Code = 0x01 from the MS before T50 expiration, the BS may retransmit the DREG-CMD message with Action Code set to 0x07.

When extended BS-initiated Idle Mode is supported by the MS and the BS, the BS should not use the DREG-CMD message with Action Code 0x05 to request Idle Mode initiation.

[Modify the 4th paragraph in Section 6.3.23.1 as indicated:]

MS may reject the unsolicited Idle Mode request from BS when MS has a pending UL data. For this, MS shall send DREG-REQ with De-Registration_Request Code = 0x03 in response to the unsolicited DREG-CMD with ~~an~~ Action Code = 0x05 or 0x07. Upon receiving DREG-REQ with De-Registration_Request Code = 0x03, BS shall stop T50, T46 ~~timer~~ and Management Resource Holding ~~T~~timers and resume all connection information for MS.

6.3.27 Emergency service

[Modify the text in the 3rd paragraph of subclause 6.3.27 Emegency Service in IEEE 802.16-2009 as follows]

The BS may broadcast ESM(s) either through an MBS permutation zone or through a normal DL zone (e.g., PUSC, FUSC and so on). If the BS decides to broadcast the ESM(s) through the MBS permutation zone, BS shall transmit MBS_MAP_IE with indication of ESM existence in the MBS permutation zone (see 8.4.5.3.12). Even though an MS isnt watching MBS channel, the MS shall check at least the two parameters in an MBS_MAP IE (i.e., ~~the Macro diversity enhanced~~MBS permutation zone defined and the Existence of Emergency Service Message) if there is. If the MS detects existence of ESM(s) through MBS permutation zone when MS decodes MBS_MAP IE, the MS shall decode MBS_MAP message in order to identify the MBS data burst on which MAC PDU containing Emergency Service Message(s) will be transmitted.

8. Physical layer (PHY)

8.3 WirelessMAN-OFDM PHY

8.3.6 Map message fields and IEs

8.3.6.7 Reduced private maps

8.3.6.7.1 Reduced private DL-MAP

[Insert a new entry to Table 302 above the "Preamble Present" field:]

DIUC	4	-

8.4 WirelessMAN-OFDMA PHY

8.4.4 Frame structure

8.4.4.6 UL transmission allocations

[Modify Section 8.4.4.6 of IEEE 802.16-2009, page 715 line 12 as indicated:]

a) In each subchannel, the size of each continuous group of OFDMA symbols remaining after allocation of UIUC = 0, 11 (Extended-2 UIUC) with Type = 8, 12,13 regions shall be a multiple of three OFDMA symbols. For UIUC = 12, the sum of ranging allocations (in units of OFDMA symbols) shall be a multiple of 3 symbols. <u>If ranging regions overlap, the symbols are counted once towards the sum of the ranging allocations.</u>

b) The slot boundaries in all subchannels shall be aligned, i.e., if a slot starts in symbol k in any subchannel, then no slots are allowed to start at symbols $k + 1$, $k + 2$ at any other subchannel.

c) The number of UL symbols (excluding AAS preambles and Sounding zone (UIUC=13)) per zone shall be an integer multiple of slot duration."

8.4.5 Map message fields and IEs

8.4.5.4 UL-MAP IE format

8.4.5.4.11 CQICH allocation IE format

[Modify as indicated:]

Indicates whether an update to the report configuration exists in the IE. A value of 0 indicates that the SS shall use the configuration defined in the last received CQICH_Alloc_IE with the same CQICH_ID.

<u>The CQICH_Alloc_IE with Report configuration included = 0 shall not be transmitted after the expiration defined in the Duration field for the designated CQICH_ID.</u>

8.4.8 Space-time coding (STC) (optional)

8.4.8.3 STC for the optional zones in the DL

8.4.8.3.1 Symbol structure for optional AMC and optional FUSC

8.4.8.3.1.2 Allocation of data subchannels

8.4.8.3.1.2.1 STC mapping for optional AMC permutation

[Modify the second paragraph in section 8.4.8.3.1.2.1 as follows and insert Figure 274a:]

For 2-antenna matrix A in 8.4.8.3.3 the bursts are required to have six symbol granularity and both begin and end on a multiple of six symbol boundary counting from the beginning of the zone. In the first stage the data is first mapped frequency-first to each 2x3 slot, and frequency-first over the slots of the allocation as depicted in Figure 220. This implies that subchannels are allocated on slot by slot basis as indicated in Figure 274a. As a result of the 6+6n symbol granularity required, all non-HARQ burst allocations and all HARQ sub-burst allocations of matrix A are rectangular. Then at the second stage Matrix A encoding is performed over each pair of QAM symbols which were assigned to the same subcarrier index over two symbols. When 2-antenna matrix B is scheduled with 6+6n symbol per burst granularity (see section 11.8.3.5.5), the bursts are required to both begin and end on a multiple of 6 symbol boundary counting from the beginning of the zone. In case of matrix B with 6+6n symbol per burst granularity, all non-HARQ burst allocations and all HARQ sub-burst allocations are rectangular.

Ed: Figure provided in C802.16m-09/3011 is unclear and needs to be re-drawn, re-submitted.

Figure 274a—Illustration of data mapping rules

8.4.12 Channel quality measurements

8.4.12.3 CINR mean and standard deviation

[Modify 8.4.12.3 as indicated:]

[Replace Equation 156 with an equation identical to Equation 158.]

[Change the text below Equation 156 as indicated:]

CINR[k]is a linear measurement of CINR (derived by any mechanism that delivers the prescribed accuracy) for message k

α avgis an averaging parameter specified by the BS

$n$is the number of consecutive frames in which no measurement is made

10. Parameters and constants

10.1 Global Values

[Upate the table as indicated:]

Table 554—Parameters and constants

System	Name	Time Reference	Minimum Value	Default Value	Maximum Value
ABS	Neighbor List Update Interval	Time between Femto ABS neighbor list updates	10 minutes	60 minutes	1440 minutes
ABS	FFR Partition Update Interval	Time between FFR partition updates	1 minute	60 minutes	143200 minutes
BS	T50	See 6.3.23.1	100ms	250ms	500ms

11. TLV encodings

11.1.3 MAC version encoding

[Modify the contents of the TLV table as indicated:]

Type	Length	Value	Scope
148	1	Version number of IEEE 802.16 supported on this channel. 0: *Reserved* 1-7: Indicates conformance with an earlier and/or obsolete version of IEEE Std 802.16 8: Indicates conformance with IEEE Std 802.16-2009 9: Indicates conformance with IEEE Std 802.16-2009 and IEEE Std 802.16j-2009 10: Indicates conformance with IEEE Std 802.16-2009, IEEE Std 802.16j-2009 and IEEE Std 802.16m-2010 ~~9~~ 10-255: *Reserved*	PMP: DCD, RNG-REQ

[Change 11.7.7.1 as indicated]

11.7.7.1 CS type ~~Classification/PHS options and SDU encapsulation~~ support

This parameter indicates which CS type(s) ~~Classification/PHS options and SDU encapsulation~~ the SS and/or BS supports. By default, Packet, IPv4 and IEEE 802.3/Ethernet shall be supported, thus absence of this parameter in REG-REQ means that named options are supported by the SS. When the length field of the TLV is 2, it indicates that bits 16–31 should be considered to be equal to zero.

Bit values are set independent of each other. When multiple bit values are set to 1, the 802.16 entity is capable of having multiple concurrent service flows each with different CS Specification parameter (see 11.13.18.1) encodings as identified by the bit setting in this TLV.

11.7.8 SS capabilities encodings

11.7.8.11 Extended capability

[Modify the table as indicated:]

Type	Length	Value	Scope
49	1	Bit #0: Indicates the capability to support ARQ Map Last Bit concept and the optimized Sequence Block as defined in Table 169. The feature is enabled only in case both MS and BS support it. Bit #1: Indicates the capability to sup-port BS_Controlled_HO (see 6.3.21.2.2). If the MS does not support this capability, it may ignore the BS_Controlled_HO flag in the DCD. Bit #2: Indicates support for Group parameter Create/Change TLV (11.13.39) Bit #3: Indicates the capability to support extended BS-initiated idle mode (see section 6.3.23.1) Bits ~~3~~4-7: *Reserved*, set to zero.	REG-REQ, REG-RSP

11.8 SBC-REQ/RSP management message encodings

11.8.3 Physical parameters supported

11.8.3.5 WirelessMAN-OFDMA specific parameters

11.8.3.5.18 OFDMA parameter sets

[Modify the table for OFDMA PHY parameters set A as indicated:]

Sets	Items	Sub-items	References
OFDMA PHY parameter set A	Subscriber transition gap	SSTTG = 50 μsec	11.8.3.1
		SSTTG = 50 μsec	
	OFDMA SS demodulator	64 QAM	11.8.3.5.2
		CTC	
		HARQ Chase	
	OFDMA SS modulator	CTC	11.8.3.5.3
		HARQ Chase	
	OFDMA SS CINR measurement capabillity	Physical CINR measurement from the preamble	11.8.3.5.8
		Physical CINR measurement for a premutation zone from pilot subcarriers	
		Support for two concurrent CQI channels	
	OFDMA SS uplink power control support	Uplink open loop power control support	11.8.3.5.9
	OFDMA MAP capability	Extended HARQ IE capability	11.8.3.5.10
		Sub MAP capability for first zone	
	Uplink control channel support	Enhanced FAST_FEEDBACK	11.8.3.5.11
		UL ACK	
	OFDMA SS modulator for MIMO support	Capable of single antenna transmission	11.8.3.5.14

11.13 Service flow management encodings

11.13.17 ARQ TLVs for ARQ-enabled connections

11.13.17.3 ARQ_RETRY_TIMEOUT TLV

[Modify the text as indicated:]

The ARQ_RETRY_TIMEOUT TLV should account for the transmitter and receiver processing delays and any other delays relevant to the system.

TRANSMITTER_DELAY: This value is the sum of:

- the time between the moment a ARQ block becomes outstanding and the moment it reaches the antenna of the ARQ block receiver, and;

- the time between the moment the ARQ feedback reaches the antenna of the ARQ block transmitter and the moment the ARQ feedback is processed by the ARQ block transmitter;

as estimated by the ARQ block transmitter for the identified service flow. This TLV shall only be included in a DSA-REQ or a DSA-RSP message by the BS for DL service flows, and by the SS for UL service flows.

~~This is the total transmitter delay, including sending (e.g., MAC PDUs) and receiving (e.g., ARQ feedback) delays and other implementation dependent processing delays. If the transmitter is the BS, it may include other delays such as scheduling and propagation delay.~~

RECEIVER_DELAY: This value is the time between the moment the burst carrying the ARQ block arrives at the antenna of the ARQ block receiver and the moment an ARQ feedback is received at the antenna of the ARQ block transmitter, as estimated by the ARQ block receiver for the identified service flow. This TLV shall only be included in a DSA-REQ or a DSA-RSP message by the BS for UL service flows, and by the SS for DL service flows. ~~This is the total receiver delay, including receiving (e.g., MAC PDUs) and sending (e.g., ARQ feedback) delays and other implementation-dependent processing delays. If the receiver is the BS, it may include other delays such as scheduling and propagation delay.~~

The DSA-REQ message shall contain the values for these parameters, if the sender is requesting ARQ. The DSA-RSP message shall contain the values for these parameters if the sender of the corresponding DSA-REQ message requested ARQ and the sender of the DSA-RSP is accepting ARQ. When the DSA handshake is completed, each party shall calculate ARQ_RETRY_TIMEOUT TLV to be the sum of TRANSMITTER_DELAY and RECEIVER_DELAY.

11.13.18.1 CS Specification parameter

[Modify the table as indicated:]

Type	Length	Value	Scope
[145/146].28	1	0: GPCS (Generic Packet Convergence Sublayer) 1: Packet, IPv4 2: Packet, IPv6 3: Packet, IEEE 802.3/Ethernet[a] 4: Reserved 5: Packet, IPv4 over IEEE 802.3/Ethernet[a] 6: Packet, IPv6 over IEEE 802.3/Ethernet[a] 7: Reserved 8: Reserved 9: ATM 10: Reserved 11: Reserved 12: Reserved 13: Reserved 14: Packet, IP[b] 15: Multiprotocol flow ~~15~~16-255 Reserved	DSA-REQ

[Change 11.13.8.1 ('b' footnote) as indicated]

[b]SDUs for service flows of this CS type may carry either IPv4 or IPv6 in the ~~header-compressed~~ payload.

[Editor to move the first table on page 1315 of IEEE 802.16-2009, section 11.13.42 for Type value 52 to the end of section 11.13.41.]

11.16 Sleep mode management encodings

[Add a new TLV as indicated:]

Sleep mode functions enabled in full FDD

Type	Length	Value	Scope
3	1	Bit 0: If =1, MS will monitor Group #1 (default*) Bit1: If =1, MS will monitor Group #2 (default*) Bit 2-7: *Reserved*	MOB_SLP-REQ, MOB_SLP-RSP

*default condition is both Bit 0 = 1 and Bit 1 = 1. This default condition applies if this TLV is not included in the MOB_SLP-REQ/RSP messages.

For FDD MS only.

Used to specify the Map Relevance for a full FDD MS during Sleep Mode. When Bit 0 is set to 1, MS will monitor Group #1 for all power saving classes. When Bit 1 is set to 1, MS will monitor Group #2 for all power saving classes.

[Insert the following clause:]

16. Advanced Air Interface

16.1 Introduction

16.2 Medium access control

16.2.1 Addressing

The AMS has a global address and logical addresses that identify the AMS and connections during operation.

16.2.1.1 Global Address

16.2.1.1.1 MAC Address

Each AMS shall have a 48-bit universal MAC address, as defined in IEEE Std 802®-2001.

16.2.1.2 Logical Address

The following logical identifiers are defined in the following subsections.

16.2.1.2.1 Station Identifier (STID)

A 12-bit value that uniquely identifies an AMS in the domain of the ABS. The ABS shall assign a STID to each AMS during network entry as described in 16.2.15. The ABS may assign a new STID to an AMS during network reentry.

This subclause does not apply to the Multicast Station Identifier (see 16.2.1.2.5), which is used to support E-MBS described in 16.9.

16.2.1.2.1.1 Temporary Station Identifier (TSTID)

A STID is used temporarily to protect the mapping between the STID, which is used after network entry, and the AMS MAC Address. The ABS assigns and transfers a TSTID to the AMS by AAI_RNG-RSP during initial ranging procedure. During registration procedure the ABS assigns and transfers an STID to the AMS by encrypted AAI_REG-RSP. The ABS shall release the TSTID when it identifies that the AMS has successfully completed the registration procedure.

16.2.1.2.2 Flow Identifier (FID)

Each AMS connection is assigned a 4 bit FID that uniquely identifies the connection within the AMS. FIDs identify control connection and transport connections. DL and UL Transport FIDs are allocated from the transport FID space as defined in Table 652. An FID that has been assigned to one DL transport connection shall not be assigned to another DL transport connection belonging to the same AMS. An FID that has been assigned to one UL transport connection shall not be assigned to another UL transport connection belonging to the same AMS. An FID that has been used for a DL transport connection can be assigned to another UL transport connection belonging to the same AMS, or vice versa. Some specific FIDs may be pre-assigned. If the value is 0001 it indicates that the MPDU is signaling header. See Table 652 for the specific allocation of FIDs.

Table 652—Flow Identifiers

Value	Description
0000	Control FID (unicast control FID when PDU is allocated by unicast assignment A-MAP IE; broadcast control FID when PDU is allocated by broadcast assignment A-MAP IE)
0001	FID for Signaling Header
0010-1111	Transport FID

16.2.1.2.3 Deregistration Identifier (DID)

The DID shall uniquely identify the AMS within the set of paging group ID, paging cycle and paging offset.

16.2.1.2.4 Context Retention Identifier (CRID)

The network shall assign an CRID to each AMS during network entry or zone switch to Mzone. The AMS is identified by the CRID in coverage loss recovery and DCR mode, where the CRID allows the network to retrieve AMS context. The network may assign the AMS a new CRID if necessary.

16.2.1.2.5 Multicast Station Identifier (MSTID)

A 12-bit value that is used along with a 4-bits long FID (see 16.2.1.2.2) to uniquely identify a specific E-MBS flow in the domain of an E-MBS zone (see 16.9.3.2).

16.2.2 MAC PDU formats

MAC PDUs shall be of the form illustrated in Figure 385. Each PDU shall begin with a MAC header. The MAC PDU may also contain payload. The header may be followed by one or more extended headers. Extended headers shall not be present in a MAC PDU without payload.

Multiple MAC SDUs and/or SDU fragments from different unicast connections belonging to the same AMS can be multiplexed into a single MAC PDU. The multiplexed unicast connections shall be associated with the same security association.

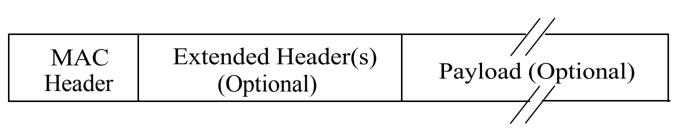

Figure 385—MAC PDU formats

16.2.2.1 MAC header formats

There are three defined MAC header formats: the Advanced Generic MAC Header, compact MAC header and the MAC signaling header. These three MAC header formats shall not be used on the same connection.

16.2.2.1.1 Advanced Generic MAC Header (AGMH)

The AGMH format is defined in Table 653.

Table 653—AGMH Format

Syntax	Size (bit)	Notes
Advanced Generic MAC Header() {		
Flow ID	4	Flow Identifier
EH	1	Extended header presence indicator; When set to ‘1’, this field indicates that an Extended Header is present following this AGMH.
Length	11	This field indicates the length in bytes of MAC PDU including the AGMH and extended header if present. If MLEH is present in a MPDU, Length field indicates 11 LSB of length in byte of MAC PDU.
}		

16.2.2.1.2 Compact MAC header (CMH)

The CMH is defined to support applications, such as VoIP, which uses small data packets and non ARQ connection. Extended header may be piggybacked on the CMH, if allowed by its length field. With the exception of extended headers, the CMH shall not require any other headers. The CMH is identified by the specific FID that is provisioned statically, or created dynamically via AAI_DSA-REQ/RSP.

The CMH format is defined in Table 654.

Table 654—CMH Format

Syntax	Size (bit)	Notes
Compact MAC Header() {		
Flow ID	4	Flow Identifier
EH	1	Extended header presence indicator; When set to ‘1’, this field indicates that an Extended Header is present following this CMH.
Length	7	This field indicates the length in bytes of MAC PDU including the CMH and extended header if present.
SN	4	MAC PDU payload sequence number increments by one for each MAC PDU (modulo 16).
}		

16.2.2.1.3 MAC Signaling Header

The signaling header shall be sent standalone or concatenated with other MAC PDUs in either DL or UL. If the AMS uses an anonymously assigned UL resource to send the signaling header, the AMS shall include the STID in the contents field of the signaling header. One FID is reserved for MAC signaling header. The value of Flow ID for MAC signaling header is 0001.

All MAC signaling header formats follow the layout defined in Table 655.

Table 655—MAC Signaling Header Format

Syntax	Size (bits)	Notes
MAC Signaling Header() {		
FlowID	4	Flow Identifier. Set to 0001
Type	4	MAC signaling header type
Contents	40	MAC signaling header contents
}		

Type field encodings are shown in Table 656.

Table 656—Type field encodings for MAC signaling header type

Type field (4 bits)	MAC Signaling Header Type
0000	BR with STID
0001	BR without STID
0010	Service specific BR without STID
0011	Sleep Control
0100	AMS Battery Level Report
0101- 1111	Reserved

16.2.2.1.3.1 BR with STID Header

When an AMS requests bandwidth through an anonymous UL resource, it shall transmit BR with STID signaling header on the anonymous UL resource. BR format with STID header is defined in Table 657.

Table 657—BR with STID header format

Syntax	Size(bit)	Notes
BR with STID () {		
FID	4	Flow Identifier. Set to 0001.
Type	4	MAC signaling header type = 0b0000
BR Size	19	Aggregated bandwidth request size in bytes
BR FID	4	The FID for which UL bandwidth is requested.
STID	12	STID of the AMS which requests UL bandwidth.
Reserved	5	Reserved. This field shall be filled by 0
}		

16.2.2.1.3.2 BR without STID Header

BR without STID Header is sent through dedicated UL resource assigned to the AMS. BR type shall be included to indicate whether BR type is increment or aggregate. BR format without STID header is defined in Table 658.

Table 658—BR without STID Header Format

Syntax	Size (bit)	Notes
BR without STID header() {		
FID	4	Flow Identifier. Set to 0001.
Type	4	MAC signaling header type = 0b0001
BR Type	1	Indicates whether the requested bandwidth is incremental or aggregate: 0: incremental. 1: aggregate.
BR Size	19	Bandwidth request size in bytes.
BR FID	4	The FID for which UL bandwidth is requested.
TI	1	0: No Tx Power report 1: Tx Power information present
If (TI = 1) {		
UL Tx Power	8	UL Tx power level in dBm for the burst that carries this header (as described in 11.1.1).
Reserved	7	Shall be filled by 0
} else {		
Reserved	15	Shall be filled by 0
}		

16.2.2.1.3.3 Service Specific BR without STID Header

Service Specific BR without STID Header is sent through dedicated UL resource assigned to the AMS, which needs to change the scheduling parameters of its service flow. BR type shall be included to indicate whether BR type is increment or aggregate. Service Specific BR without STID header format is defined in Table 659. If SCID change indicator is set to 1, the ABS shall send an acknowledgement to confirm the change of sleep mode configuration.

Table 659—Service Specific BR without STID Header Format

Syntax	Size (bit)	Notes
Service specific BR without STID header() {		
FID	4	Flow Identifier. Set to 0001.
Type	4	MAC signaling header type = 0b0010
BR Type	1	Indicates whether the requested bandwidth is incremental or aggregate. 0: incremental 1: aggregate
BR Size	19	Bandwidth request size in bytes.
BR FID	4	The FID for which UL bandwidth is requested.
if (scheduling type == aGP Service) {		
QoS parameter change indicator	1	QoS parameter change indicator 0: no change in QoS parameter 1: having changes in QoS parameter
SCID change indicator	1	
if (QoS parameter change indicator = 1){		
Running Grant Polling Interval (GPI)	6	Indicating new GPI (frames) to use for future allocation.
Reserved	9	
}else{		
QoS parameter set switch	1	0: primary QoS parameter set. 1: secondary QoS parameter set
If(SCID change indicator==1)		
{		
SCID	4	
Padding	9	
}else{		
Padding	13	
}		

Table 659—Service Specific BR without STID Header Format

Syntax	Size (bit)	Notes
}		
}		
else if (scheduling type == BE) {		
Minimum grant delay	6	Indicating minimum delay (frames) of the requested grant
Reserved	10	
}		
else {		
Reserved	16	Reserved. This field shall be filled by 0
}		
}		

16.2.2.1.3.4 Sleep Control header (SCH)

The Sleep Control header shall be used to convey control signaling related to sleep cycle operation by an ABS or AMS. The specific control provided by SCH is given in Table 660.

Table 660—Sleep Control header format

Syntax	Size (bit)	Notes
Sleep Control Header Format {		—
FID	4	Flow Identifier. Set to 0001.
Type	4	MAC signaling header type = 0b0011
SCH sub-type	3	0b000 = Listening Window control 0b001 = Resume Sleep Cycle Indication 0b010 = Sleep cycle configuration switch 0b011 = Sleep Cycle control 0b100 = Multi-Carrier Listening Window control 0b101~0b111 = *reserved*
Response Indication	1	0: This indicates the request 1: This indicates the response (i.e., acknowledgement) to the request
If (SCH sub-type == Listening Window Control) {	—	—

Table 660—Sleep Control header format

Syntax	Size (bit)	Notes
Listening Window End or Extension	1	0 = Listening Window End Indication 1 = Listening Window Extension Indication
if(Listening Window End or Extension==1){	—	—
Last frame of Extended Listening Window	7	LSB of frame sequence. Indicate the frame that extended listening window is terminated.
}	—	—
} else if(SCH sub-type == Resume Sleep Cycle Indication) {	—	—
Scheduled Sleep Cycle Interruption included	1	0 = no scheduled Sleep Cycle interruption is included with the Resume Sleep Cycle Indication 1 = scheduled Sleep Cycle interruption is included with the Resume Sleep Cycle Indication
if (Scheduled Sleep Cycle Interruption included == 1) {	—	—
Start Frame Offset for Scheduled Sleep Cycle Interruption	7	Number of frames in the future from the frame containing this SCH at which the scheduled Sleep Cycle interruption will occur. Frame offset is value of this field plus one (i.e., range is 1 to 128).
}	—	—
}	—	—
else if (SCH sub-type == Sleep cycle configuration switch){	—	—
SCID	4	SCID corresponds to the new sleep cycle setting to be switched
Start Frame Offset for new sleep cycle configuration	3	Least Significant 3 bits of Frame Number in which sleep cycle setting is to be applied.
}	—	—
else if (SCH sub-type == Sleep Cycle control) {		
Next Sleep Cycle Flag (NSCF)	2	0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 x previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = *Reserved*
if (NSCF == 0b10)		
{		

Table 660—Sleep Control header format

Syntax	Size (bit)	Notes
New Initial Sleep Cycle	4	When the current Sleep Cycle is reset, if this value is included, the current Sleep Cycle shall be reset to this value.
}		
}		
else if (SCH sub-type == Multi-Carrier Listening Window control) {		
Target Carrier Index Bitmap	4	If n_{th} bit is set to 1, it indicates that DL data transmission on the secondary carrier of which logical carrier index is equal to (n+1) ends.
}		
Padding	variable	For byte alignment
}	—	—

16.2.2.1.3.5 AMS Battery Level Report Header

The AMS Battery Level Report Header should be used to convey AMS battery level information from AMS to ABS. The specific information provided by AMS Battery Level Report Header is given in Table 661.

Table 661—AMS Battery Report header format

Syntax	Size (bit)	Notes
AMS Battery Level Report header () {	-	-
FID	4	Flow Identifier. This field indicates MAC signaling header
Type	4	MAC signaling header type = 0b0100
AMS Battery Status	1	0b0: The AMS is plugged into a power source 0b1: The AMS is not plugged into a power source
Battery Level Indication	1	0b0: The AMS is able to report detailed battery level. 0b1: The AMS is not able to report detailed battery level.
If (Battery Level Indication = 1) {		

Table 661—AMS Battery Report header format

Syntax	Size (bit)	Notes
AMS Battery Level	3	The field appears only when the Battery Level Indication is set to 1. 0b001: Battery level is between 75% and 100 % 0b010: Battery level is between 50% and 75 % 0b011: Battery level is between 25% and 50 % 0b100: Battery level is between 5 % and 25 % 0b101: Battery level is below 5 % 0b110 – 0b111: Reserved
Reserved	35	Shall be filled by 0
}		
else {		
Reserved	38	
}		
}		

16.2.2.2 Extended header formats

The inclusion of Extended Header group is indicated by EH bit in MAC Header. The extended header group (see Figure 386—), when used, shall always appear immediately after the MAC header. Extended header group shall not be encrypted. The fields of the extended header group format are defined in Table 662—.

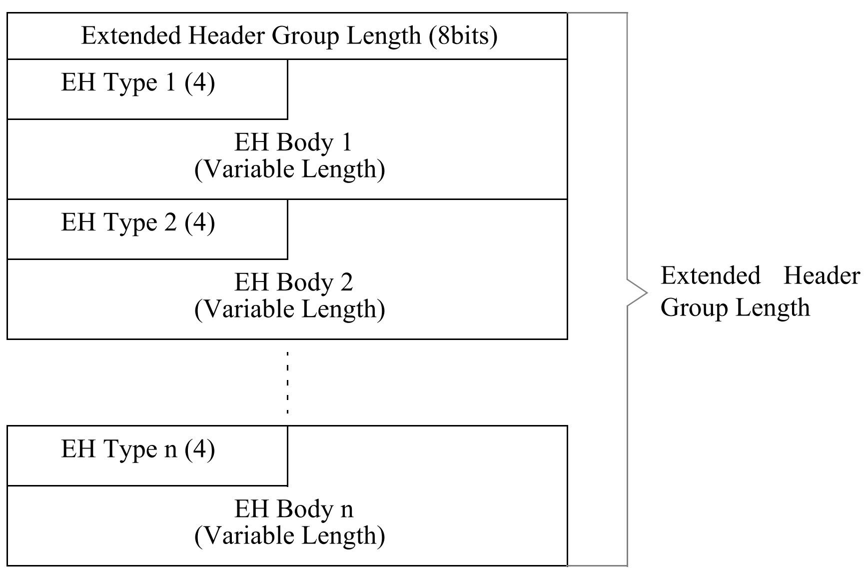

Figure 386—Extended Header Group Format

Table 662—Extended Header Group Fields

Syntax	Size (bit)	Notes
Extended header Group Length	8	The Extended header Group Length field indicates the total length in bytes of the extended header group, including all the extended headers and the Extended header Group length byte.
Extended header Type	4	Type of extended header as defined in Table 663.
Extended header Body	Variable	The size of the extended header is determined by extended header type as specified in Table 663. The extended header including the extended header type is byte aligned.

Table 663—Description of Extended Header Types

Extended Header Types	Names	Description
0b0110	Fragmentation and packing extended header	See 16.2.2.2.1
-	MAC Control extended header	See 16.2.2.2.2
0b0000	Multiplexing extended header	See 16.2.2.2.3
0b0001	Message ACK extended header	See 16.2.2.2.4
0b0010	Sleep Control extended header	See 16.2.2.2.5
0b0011	Correlation matrix feedback extended header	See 16.2.2.2.6
0b0100	MIMO feedback extended header	See 16.2.2.2.7
0b0101	Piggybacked bandwidth request extended header	See 16.2.2.2.8
0b0111	MAC PDU length extended header	See 16.2.2.2.9
0b1000	ARQ Feedback extended header	See 16.2.2.2.10
0b1001-0b1111	Reserved	

16.2.2.2.1 Fragmentation and packing extended header (FPEH)

The MAC PDU shall include FPEH when fragmentation or packing are applied to MAC PDU(s) with payload from a transport connection, or when a SN is applied to a MAC PDU with payload from a transport connection. The FPEH format is defined in Table 664. RI in FPEH is set to indicate that the payload contains ARQ sub-blocks. LSI and SSN shall be included in FPEH if RI bit set to 1.

Table 664—FPEH Format

Syntax	Size (bit)	Notes
FPEH() {		
Type	4	FPEH Type
FC	2	Fragmentation Control bits (see Table 665)
If (MAC Header == AGMH) {		
SN	10	SN is maintained per connection. For non ARQ connection, 'SN' represents the MAC PDU Payload Sequence Number and the 'SN' value increments by one (modulo 1024) for each MAC PDU. For ARQ connection, 'SN' represents the ARQ block sequence number.
AFP	1	ARQ feedback poll indicator 0 = No ARQ feedback poll 1 = ARQ feedback poll for the connection indicated in AGMH or MEH if multiplexing is used
RI	1	ARQ Re-arrangement information indicator 0= no ARQ re-arrangement 1= ARQ re-arrangement
if (RI == 1) {		
LSI	1	Last ARQ sub-block indicator 0 = indicating the last ARQ sub-block from the single ARQ block is not included in this MAC PDU 1 = indicating the last ARQ sub-block from the single ARQ block is included in this MAC PDU
SSN	11	SUB-SN of the first ARQ sub-block
}		
}		
Do {		
End	1	Indication of more information 0 = Indicating another 'Length' and 'End' fields are followed 1 = Indicating no more 'Length' and 'End' fields are followed
if (End == 0) {		

Table 664—FPEH Format

Syntax	Size (bit)	Notes
Length	11	This field indicates the length of SDU or SDU fragment in a MAC PDU payload. If a MAC PDU payload consists of 'N' SDU/SDU fragments, N-1 'Length' fields are present to represent the length of SDU/SDU fragment #1 to #N-1. No multiplexing: Length of last SDU/SDU fragment = Length of MAC PDU (given by length field in GMH/CMH & MLEH) - Length of GMH/CMH - Extended header group length (if present) - Length of PN& EKS (3bytes, if present) - Length of ICV (if present) - sum of length of SDU/SDU fragment s #1 to #N-1 With multiplexing: Length of last SDU/SDU fragment = Length of connection payload corresponding to this FPEH (see table 666, MEH format) - sum of length of SDU/SDU fragments #1 to #N-1
}		
} while (!End)		
Padding	variable	For byte alignment.
}		

Table 665—Encoding of FC field

FC	Meaning	Examples
00	The first byte of data in the MAC PDU payload is the first byte of a MAC SDU. The last byte of data in the MAC PDU payload is the last byte of a MAC SDU.	• One or Multiple unfragmented SDUs packed in an MAC PDU

Table 665—Encoding of FC field

FC	Meaning	Examples
01	The first byte of data in the MAC PDU payload is the first byte of a MAC SDU. The last byte of data in the MAC PDU payload is not the last byte of a MAC SDU.	• MAC PDU with only First fragment of an SDU • MAC PDU with one or more unfragmented SDUs, followed by first fragment of subsequent SDU
10	The first byte of data in the MAC PDU payload is not the first byte of a MAC SDU. The last byte of data in the MAC PDU payload is the last byte of a MAC SDU.	• MAC PDU with only Last fragment of an SDU • MAC PDU with Last fragment of an SDU, followed by one or more unfragmented subsequent SDUs
11	The first byte of data in the MAC PDU payload is not the first byte of a MAC SDU. The last byte of data in the MAC PDU payload is not the last byte of a MAC SDU.	• MAC PDU with only middle fragment of an SDU • MAC PDU with Last fragment of an SDU, followed by zero or more unfragmented SDUs, followed by first fragment of a subsequent SDU

16.2.2.2.2 MAC Control extended header (MCEH)

The MCEH shall be used when MAC PDU contains payload from a control connection. When message fragments belonging to two different control messages are being sent, the transmitter shall assign different Control Connection Channel ID (CCC ID)s to the MCEH of each MAC PDU. The MCEH format is defined in Table 666.

Table 666—MCEH Format

Syntax	Size (bit)	Notes
MCEH () {		
EC	1	Encryption Control indicator 0 = Payload is not encrypted 1 = Payload is encrypted
Control Connection Channel ID (CCC ID)	1	Channel ID to identify separate fragmentation / reassembly state machines 0: channel 1 1: channel 2
SN Indicator	1	0 = no FC and sequence number 1= FC and sequence number are followed
If (SN Indicator = 0) {		
Reserved	5	For byte alignment
else {		

Table 666—MCEH Format

Syntax	Size (bit)	Notes
Polling	1	0 = no acknowledgement required 1 = acknowledge required upon receiving the MAC message
FC	2	Fragmentation control (see Table 665)
SN	8	Payload sequence number
Reserved	2	For byte alignment
}		
}		

16.2.2.2.3 Multiplexing extended header (MEH)

The format of MEH is defined in Table 667. The MEH is used when payload from multiple connections associated with the same security association are multiplexed in the same MAC PDU. The AGMH carries the Flow ID corresponding to the payload of the first connection. MEH carries the Flow IDs corresponding to remaining connections. If both MEH and FPEH are present in a MPDU, then MEH shall appear before FPEH.

Table 667—MEH Format

Syntax	Size (bit)	Notes
MEH () {		
Type	4	MEH type
N_FI	4	Number of Flow information present in the MEH. If ‘n’ connections are multiplexed, ‘n-1’ Flow IDs and Lengths are present. .
for (*i* = 1; *i* <= *N_FI*; *i*++) {		
Flow ID	4	Flow Identifier. The ‘i’th Flow ID indicates the flow identifier of the ‘i+1’th connection.
LI	1	Length Indicator LI = 0 indicates that size of Length field is 11 bits LI = 1 indicates that size of Length field is 14 bits
If (LI == 0) {		

Table 667—MEH Format

Syntax	Size (bit)	Notes
Length	11	Length of the connection payload. The 'i'th length field indicates the length of the payload of the 'i+1'th connection. Length of first connection payload = Length of MAC PDU (given by length field in GMH & MLEH) - Length of GMH - Extended header group length (if present) - Length of PN& EKS (3bytes, if present) - Length of ICV (if present) - sum of 'n-1' Length fields
} else {		
Length	14	Length of the connection payload. The 'i'th length field indicates the length of the payload of the 'i+1'th connection. Length of first connection payload = Length of MAC PDU (given by length field in GMH & MLEH) - Length of GMH - Extended header group length (if present) - Length of PN& EKS (3bytes, if present) - Length of ICV (if present) - sum of 'n-1' Length fields
Reserved	1	
}		
}		
FPEH_MCEH_indicator bitmap	variable	The numbers of bits in FPEH_MCEH_indicator bitmap is equal to number of flows multiplexed in MAC PDU (i.e.N_FI +1). The most significant bit corresponds to the first connection payload. The least significant bit corresponds to the last connection payload A bit set to 1 in FPEH_MCEH_indicator bitmap indicates the presence of FPEH/MCEH. A bit set to 0 in FPEH_MCEH_indicator bitmap indicates the absence of FPEH/MCEH.
Reserved	variable	For byte alignment
}		

16.2.2.2.4 MAC Control Message ACK Extended Header (MAEH)

The MAEH format is defined in Table 668. This header may be used by ABS and AMS to indicate the reception of a specific, previously received MAC control message. When an ABS or AMS receives a MAC control message or MAC control message fragment with the Polling bit set to 1 in the MCEH, the ABS or AMS shall transmit an MAEH or AAI_MSG-ACK message as an acknowledgement after receiving the complete message with the SN of the MAC control message PDU or the SN of the last received fragment if fragmented.

Table 668—MAEH Format

Syntax	Size (bits)	Notes
MAEH () {		
Type	4	MAEH type
ACK_SN	8	SN retrieved from the MCEH of the MAC PDU with the Polling bit set to 1
Control Connection Channel ID (CCC ID)	1	Control Connection Channel ID (CCC ID) that the MAC management message is received.
Reserved	Variable	For byte alignment
}		

16.2.2.2.5 Sleep Control extended header (SCEH)

The Sleep Control extended header shall be used to convey control signaling related to sleep cycle operation by an ABS or AMS. The specific control provided by SCEH is given in Table 669.

Table 669—SCEH Format

Syntax	Size (bit)	Notes
Sleep Control Extended Header Format () {		
FID	4	Flow Identifier. This field indicates MAC signaling header
Type	4	MAC Signaling Header Type = 0b0011
SCEH sub-type	3	0b000 = Listening Window control 0b001 = Resume Sleep Cycle Indication 0b010 = Sleep cycle configuration switch 0b011 = Sleep Cycle control 0b100 = Multi-Carrier Listening Window control 0b101~0b111 = reserved
Response Indication	1	0: This indicates the request 1: This indicates the response (i.e. acknowledgment) to the request .

Table 669—SCEH Format

Syntax	Size (bit)	Notes
if (SCEH sub-type == Listening Window Control) {	-	-
Listening Window End or Extension	1	0 = Listening Window End Indication 1 = Listening Window Extension Indication
if (Listening Window End or Extension == 1) {		
Last frame of Extended Listening Window	7	LSB of frame sequence. Indicate the frame that extended listening window is terminated;
}	-	-
} else if (SCEH sub-type == Resume Sleep Cycle Indication) {	-	-
Scheduled Sleep Cycle Interruption included	1	0 = no scheduled Sleep Cycle interruption is included with the Resume Sleep Cycle Indication 1 = scheduled Sleep Cycle interruption is included with the Resume Sleep Cycle Indication
if (Scheduled Sleep Cycle Interruption included == 1) {		
Start Frame Offset for Scheduled Sleep Cycle Interruption	7	Number of frames in the future from the frame containing this SCEH at which the scheduled Sleep Cycle interruption will occur. Frame offset is value of this field plus one (i.e. range is 1 to 128).
}		
}		
else if (SCEH sub-type == Sleep Cycle configuration switch) {	-	-
SCID	4	SCID corresponds to the new sleep cycle setting to be switched.
Start Frame Offset for new sleep cycle configuration	3	Least Significant 3 bits of Frame Number in which sleep cycle setting is to be applied.
}	-	-
else if (SCEH sub-type == Sleep Cycle control) {		

Table 669—SCEH Format

Syntax	Size (bit)	Notes
Next Sleep Cycle Flag (NSCF)	2	0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 x previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = Reserved
if (NSCF == 0b10)		
{		
New Initial Sleep Cycle	4	When the current Sleep Cycle is reset, if this value is included, the current Sleep Cycle shall be reset to this value.
}		
}		
else if (SCH sub-type == Multi-Carrier Listening Window control) {		
Target Carrier Index Bitmap	4	If nth bit is set to 1, it indicates that DL data transmission on the secondary carrier of which logical carrier index is equal to (n+1) ends.
}		
Padding	variable	For byte alignment
}	-	-

16.2.2.2.6 Correlation Matrix Feedback Extended Header (CMFEH)

This Correlation matrix feedback extended header format is defined in Table 670. This extended header may be used by AMS as a response to a Feedback Polling A-MAP IE requesting the quantized transmit correlation matrix when the ABS is equipped with 2 or 4 transmit antennas. N_t is the number of transmit antennas at the ABS, indicated in S-SFH SP3.

Table 670—CMFEH Format

Syntax	Size (bit)	Notes
CMFEH() {		
Type	4	CMFEH type
For (i=1; i <= N_t; i++){		
i-th diagonal entry of correlation matrix	1	As defined in section 16.3.7.2.5.6
For (j=i+1; j<= N_t; j++){		
(i,j)-th entry of correlation matrix	4	As defined in section 16.3.7.2.5.6
}		
}		
Reserved	Variable	For byte alignment
}		

16.2.2.2.7 MIMO feedback extended header (MFEH)

This MIMO feedback extended header format is defined in Table 671 This header is used by AMS as a response to a Feedback Polling A-MAP IE requesting to feedback only the wideband information for MFM 0, 1, 4 or 7, or only the subband information for one subband for MFM 2, 3, 5 or 6. Variables $MaxM_t$, Codebook_subset, long period q and Measurement Method Indication are indicated in the Feedback Polling A-MAP IE. N_t is the number of transmit antennas at the ABS, indicated in S-SFH SP3. The number of subbands Y_{SB} is described in section 16.3.9.3.1.5. The MFEH shall be padded by zeros for byte alignment to 3 bytes.

The decimal value of wideband STC rate is encoded with 2 or 3 bits in binary representation, but its allowed values depend on Measurement Method Indication and $MaxM_t$. The decimal value of subband and wideband PMI is encoded with 4 or 6 bits in binary representation, but its allowed values depend on N_t and Codebook_subset. The decimal value of subband stream index is always encoded with 2 bits, but its allowed values depend on Measurement Method Indication and $MaxM_t$. The decimal value of logical subband index is always encoded with 5 bits, but its allowed values are limited to the interval [0, Y_{SB}-1].

Table 671—MFEH Format

Syntax	Size (bit)	Notes
MFEH() {		
Type	4	MFEH type
MFM	3	
If (MFM == 0){		
Wideband CQI	4	
Wideband STC rate	3	
Zero padding	10	
}		
If (MFM == 1){		
Wideband CQI	4	
Zero padding	13	
}		
If (MFM == 2){		
Subband index	5	
Subband CQI	4	
Subband STC rate	3	
Zero padding	5	
}		
If (MFM == 3 and N_t == 2 or 4){		
Subband index	5	
Subband CQI	4	
Subband STC rate	2	
Subband PMI	6	
}		
If (MFM == 3 and N_t == 8){		
Subband index	5	
Subband CQI	4	
Subband STC rate	3	
Subband PMI	4	
Zero padding	1	
}		

Table 671—MFEH Format

Syntax	Size (bit)	Notes
If (MFM == 4){		
Wideband CQI	4	
Wideband STC rate	3	
Wideband PMI	6	
Zero padding	4	
}		
If (MFM == 5){		
Subband index	5	
Subband CQI	4	
Subband stream index	2	
Zero padding	6	
}		
If (MFM == 6){		
Subband index	5	
Subband CQI	4	
Subband PMI	6	
Zero padding	2	
}		
If (MFM == 7){		
Wideband CQI	4	
Wideband PMI	6	
Zero padding	7	
}		
}		

16.2.2.2.8 Piggybacked bandwidth request extended header (PBREH)

PBREH shall be used when an AMS performs piggybacked bandwidth request for one or more flows. Table 672 is the format of PBREH.

Table 672—PBREH format

Syntax	Size (bit)	Notes
PBREH() {		
Type	4	PBREH type
Num_Of_PBR	4	Number of piggybacked BW request
For (i = 0 ; i < Num_Of_PBR ; i++) {		
FID	4	Flow identifier
Request type	1	0: aggregate 1: incremental
BR size	19	Amount of bandwidth requested
}		
}		

16.2.2.2.9 MAC PDU length extended header (MLEH)

The MAC PDU length extended header (MLEH) is added to MAC PDU when the MAC PDU length is greater than 2047 bytes. The MLEH if present in the MAC PDU, shall be the first extended header in the MAC PDU. The format of MLEH is defined in Table 673. The Length field in MLEH gives the 3 MSBs of extended length of MAC PDU. The length field in AGMH gives the 11 LSBs of extended length of MAC PDU.

Table 673—MLEH Format

Syntax	Size (bits)	Notes
MLEH (){		
Type	4	Length Extended header type
Length	3	The 3 bit length is to be appended as MSB to the 11 bit length field in AGMH : MPDU length = MLEH (length(3)) .. AGMH(Length(11)).
Reserved	1	Set to 0
}		

16.2.2.2.10 ARQ Feedback Extended Header (AFEH)

The format of ARQ feedback extended header is defined in Table 674. This header is used by an ARQ receiver to signal positive or negative acknowledgement.

Table 674—AFEH format

Syntax	Size (bit)	Notes
AFEH() {		
Type	4	AFEH type
ARQ Feedback IE(s)	variable	See 16.2.13.1.1
}		

16.2.3 MAC Control messages

The peer-to-peer protocol of MAC layers in ABS and AMS communicate using the MAC control messages to perform the control plane functions. MAC control messages shall be carried in a MAC PDU to be transported in broadcast, unicast or random access connections. There is a single unicast Control connection. HARQ shall be enabled for MAC control messages sent on the unicast Control connection. Encryption may be enabled for unicast MAC control messages. MAC control messages may be fragmented, but shall not be packed. Table 675 lists the MAC control messages that shall be defined in the ASN.1 format, as shown in <<<Appendix P>>>. The indication to the receiver whether the PDU is encrypted is indicated by the EC=1 in MCEH. Whether the encryption is applied on a MAC control message or not shall be determined by the message type and MAC procedure context, which is define in Table 675. A messages included in a PDU whose EC bit value does not match the combined message type and corresponding context defined in the Table 675 shall be discarded. Encrypted and non encrypted MAC control messages shall not be sent in the same PDU.

Table 675—MAC Control Messages

Message name	Message description	Security	Connection
AAI_SCD	System configuration descriptor	N/A	Broadcast
AAI_SII-ADV	Service Identity Information Advertisement	N/A	Broadcast
AAI_RNG-REQ	Ranging Request	Null: during ranging procedure when there is no SA already established or pre-updated. CMAC: all other cases	Initial Ranging or Unicast
AAI_RNG-RSP	Ranging Response	Null: during ranging procedure when there is no primary SA already established or pre-updated. Encrypted/ICV: all other cases in response to the AAI_RNG-REQ message	Initial Ranging or Unicast
AAI_RNG-ACK	Aggregated CDMA Ranging Acknowledge	N/A	Broadcast

Table 675—MAC Control Messages *(continued)*

Message name	Message description	Security	Connection
AAI_REG-REQ	Registration Request	Encrypted/ICV	Unicast
AAI_REG-RSP	Registration Response	Encrypted/ICV	Unicast
AAI_SBC-REQ	Basic Capability Request	null: during capability negotiation when there is no primary SA already established or pre-updated. Encrypted/ICV: all other cases	Unicast
AAI_SBC-RSP	Basic Capability Response	null: during capability negotiation when there is no primary SA already established or pre-updated. Encrypted/ICV: all other cases	Unicast
AAI_DREG-REQ	Deregistration Request	Encrypted/ICV	Unicast
AAI_DREG-RSP	Deregistration Response	Encrypted/ICV	Unicast
AAI_DSA-REQ	Dynamic Service Addition Request	Encrypted/ICV	Unicast
AAI_DSA-RSP	Dynamic Service Addition Response	Encrypted/ICV	Unicast
AAI_DSA-ACK	Dynamic Service Addition Acknowledge	Encrypted/ICV	Unicast
AAI_DSC-REQ	Dynamic Service Change Request	Encrypted/ICV	Unicast
AAI_DSC-RSP	Dynamic Service Change Response	Encrypted/ICV	Unicast
AAI_DSC-ACK	Dynamic Service Change Acknowledge	Encrypted/ICV	Unicast
AAI_DSD-REQ	Dynamic Service Deletion Request	Encrypted/ICV	Unicast
AAI_DSD-RSP	Dynamic Service Deletion Response	Encrypted/ICV	Unicast
AAI_DSX-RVD	DSx Received	Encrypted/ICV	Unicast
AAI_PKM-REQ	Privacy Key Management Request	before AK is derived at network entry: NULL after AK is derived at network entry and EAP-transfer message is enclosed: encryption/ICV after AK is derived at network entry and the other message is enclosed: CMAC	Unicast

Table 675—MAC Control Messages *(continued)*

Message name	Message description	Security	Connection
AAI_PKM-RSP	Privacy Key Management Response	before AK is derived at network entry: NULL after AK is derived at network entry and EAP-transfer message is enclosed: encryption/ICV after AK is derived at network entry and the other message is enclosed: CMAC	Unicast
AAI_ARQ-Feedback	Stand-alone ARQ Feedback	null	Unicast
AAI_ARQ-Discard	ARQ Discard	Encrypted/ICV	Unicast
AAI_ARQ-Reset	ARQ Reset	Encrypted/ICV	Unicast
AAI_SLP-REQ	Sleep Request	Encrypted/ICV	Unicast
AAI_SLP-RSP	Sleep Response	Encrypted/ICV	Unicast
AAI_TRF-IND	Traffic Indication	N/A	Broadcast
AAI_NBR-ADV	Neighbor Advertisement	Null: in unicast N/A: in broadcast	Unicast or broadcast
AAI_SCN-REQ	Scanning Interval Allocation Request	Encrypted/ICV	Unicast
AAI_SCN-RSP	Scanning Interval Allocation Response	Encrypted/ICV	Unicast
AAI_SCN-REP	Scanning Result Report	Encrypted/ICV	Unicast
AAI_HO-REQ	AMS Handover Request	Encrypted/ICV	Unicast
AAI_HO-CMD	ABS Handover Command	Encrypted/ICV	Unicast
AAI_HO-IND	AMS Handover Indication	Encrypted/ICV	Unicast
AAI_TRF_IND-REQ	Traffic indication request	Encrypted/ICV	Unicast
AAI_TRF_IND-RSP	Traffic indication response	Encrypted/ICV	Unicast
AAI_L2-XFER	AAI L2 Transfer	Encrypted/ICV	Unicast
AAI_PAG-ADV	BS Paging Advertisement	N/A	Broadcast
AAI_ULPC_NI	UL Noise and Interference Level Broadcast	N/A	Broadcast
AAI-MC-ADV	multicarrier Advertisement	N/A	Broadcast
AAI_MC-REQ	multicarrier Request	Null	Unicast
AAI_MC-RSP	multicarrier Response	Null	Unicast
AAI_CM-CMD	Carrier Management Command	Encrypted/ICV	Unicast
AAI_CM-IND	Carrier Management Indication	Encrypted/ICV	Unicast

Table 675—MAC Control Messages *(continued)*

Message name	Message description	Security	Connection
AAI_RES-CMD	Reset command	Before authentication :Null After authentication : Encrypted/ICV	Unicast
AAI_SingleBS_MIMO_FBK	Single-BS MIMO feedback	<TBD>	Unicast
AAI_MultiBS_MIMO_FBK	Multi-BS MIMO feedback	<TBD>	Unicast
AAI_DL_IM	Downlink interference mitigation parameter	N/A	Broadcast
AAI_MULTI_BS_MIMO-REQ	Multi-BS MIMO Request	<TBD>	Unicast
PGID_Info	Paging Group Advertisement	N/A	Broadcast
AAI_MultiBS_PMI_COM	Multi-BS PMI Combination		Unicast
AAI_GRP-CFG	Group Configuration	Encrypted/ICV	Unicast
AAI_FFR-CMD	FFR measurement report command	Encrypted/ICV	Unicast
AAI_FFR-REP	FFR measurement report	Encrypted/ICV	Unicast
AAI_UL_POWER_ADJUST	Uplink TX power adjustment	Encrypted/ICV	Unicast
AAI_UL_PSR_Config	Uplink Power Status Reporting Configuration	Encrypted/ICV	Unicast
AAI_UL_PSR	Uplink Power Status Report	Encrypted/ICV	Unicast
AAI_CLC-REQ	Co-located coexistence request	Encrypted/ICV	Unicast
AAI_CLC-RSP	Co-located coexistence response	Encrypted/ICV	Unicast
AAI_E-MBS-CFG	E-MBS Configuration	Null	Broadcast
AAI_LBS-ADV	LBS Advertisement	Null	Broadcast

16.2.3.1 AAI_RNG-REQ

An AAI_RNG-REQ message is transmitted by AMS at network entry, to which HARQ operation is applied. An AMS shall generate AAI_RNG-REQ message containing parameters according to the usage of the AAI_RNG-REQ message:

If required parameters cannot be transmitted and the AMS does not have an active STID assignment, the AMS shall request UL bandwidth by sending either a BR without STID header (refer to 16.2.2.1.3.2) or PBREH (refer to 16.2.2.2.8), if a fragment of the AAI_RNG-REQ is sent using the provided UL bandwidth. In response to the additional UL bandwidth request, the ABS should allocate UL bandwidth by sending a CDMA Allocation A-MAP IE still masked with the RA-ID and masking prefix indicator for the ranging code (refer to Table 'Description of CRC Mask').

The following parameters are included according to the usage of the AAI_RNG-REQ message:

Table 676—Parameters for AAI_RNG-REQ

Name	Value	Usage
AMSID*	It's the hash value of AMSID in order to protect AMS privacy, which is used for ABS to distinguish AMSs when more than one AMS send AAI_RNG-REQ message at the same time.	It shall be included when the AMS is attempting network entry without its STID/DID which the ABS/Paging Controller assigns.
MAC version	Version number of IEEE 802.16 supported by the AMS	
Ranging Purpose Indication	The presence of this item in the message indicates the following AMS action: If Bit#0 is set to 1, it indicates that the AMS is currently attempting HO reentry, or, in combination with a Paging Controller ID, indicates that the MS is attempting network reentry from idle mode to the BS. In this case, Bit#1 shall be 0. If Bit#1 is set to 1, it indicates that the AMS is initiating the idle mode location update process, or, in combination with CRID, it indicates that the AMS is initiating DCR mode extension. In this case, Bit#0 shall be 0. If Bit#2 is set to 1, ranging request for emergency call setup. When this bit is set to 1, it indicates AMS action of Emergency Call process. If Bit#4 is set to 1, it indicates that the AMS is attempting to perform location update due to a need to update service flow management encodings for E-MBS flows. If Bit #5 is set to 1, it indicates that the AMS is initiating location update for transmission to DCR mode from idle mode. If Bit #6 is set to 1 in combination with ID of the network entity that assigns/retains the context, it indicates that the AMS is currently attempting reentry from DCR mode. If Bit#7 is set to 1, it indicates that the AMS is currently attempting network reentry after experiencing a coverage loss. If Bit#8 is set to 1, it indicates that the AMS is currently attempting network reentry from a IEEE802.16e only Legacy BS	It shall be included when the AMS is attempting to perform reentry, HO, location update or DCR mode extension.
Serving BSID	The BSID of the AMS's previous serving ABS before incurring a coverage loss, or the BSID of the serving ABS to which the AMS is currently connected (has completed the registration cycle and is in normal operation). Inclusion of serving BSID in the AAI_RNG-REQ message signals to the target ABS that the AMS is currently connected to the network through the serving ABS and is in the process of HO network reentry.	It shall be included when the AMS is attempting to perform HO reentry. In case of performing Direct HO, this is the BSID of the previous serving Legacy BS.

Table 676—Parameters for AAI_RNG-REQ

Name	Value	Usage
CRID	AMS identifier which the AMS has been assigned for coverage loss or DCR mode and are currently maintained	It shall be included when the AMS is attempting to perform network reentry from coverage loss or DCR mode
STID	The STID which the AMS uses in the previous serving ABS.	It shall be included when the AMS is attempting to perform HO reentry
Previous CID	The CID which the AMS used in the previous serving BS	It shall be included when the AMS is attempting to perform Direct HO reentry
Paging Controller ID	The Paging Controller ID which the AMS currently maintains in idle mode.	It shall be included when the AMS is attempting to perform reentry or location update
Deregistration Identifier (DID)	The ID which the AMS is assigned for idle mode and currently maintains.	
PGID	The identification of the paging group that the AMS is previously belonging to.	
Paging Cycle	PAGING_CYCLE applied to the AMS	
Paging Offset	PAGING_OFFSET applied to the AMS	
Paging Cycle Change	PAGING_CYCLE requested by the AMS	It shall be included when the AMS in Idle Mode is attempting to change Paging Cycle during Location Update
Power Down Indicator	Indicates the AMS is currently attempting to perform location update due to power down.	It shall be included when the AMS is attempting to perform location update due to power down
NONCE_AMS	A freshly generated 64-bit random number used for PMK derivation	It shall be included when zone switching from LZone to MZone occurs.
NONCE_ABS	A 64-bit number transferred from ABS and used for PMK derivation	It shall be included when zone switching from LZone to MZone occurs.
AK_COUNT	The AMS's current value of the AK_COUNT, which is used to generate the security keys in the target ABS.	It shall be included during reentry, secure Location Update or HO
CMAC Tuple	If included, the CMAC Tuple shall be the last attribute in the message.	It shall be included when the AMS is attempting to perform Network Reentry from idle mode, Secure Location Update, or HO, or a reentry after incurring a coverage loss if the AMS has a CMAC tuple necessary to expedite security authentication.

Table 676—Parameters for AAI_RNG-REQ

Name	Value	Usage
LEGACY_CMAC_KEY_COUNT	The AMS's current value of the CMAC_KEY_COUNT, which was used at the previous serving Legacy BS.	It shall be included during Direct HO from a 16e only Legacy BS to the target ABS.
Legacy CMAC Tuple	If included, the CMAC Tuple shall be the last attribute in the message. *Note: This is not used to generate the security keys in the target ABS, This is only for security authentication	It shall be included when the AMS is attempting to perform Network Re-Entry from Direct HO, if the AMS has a CMAC tuple necessary to expedite security authentication. This CMAC is the CMAC tuple used in the previous serving Legacy BS.
AMS Mobility Information	0b00 = Slow 0b01 = Medium 0b10 = Fast 0b11 = Reserved	It may be included when the AMS is attempting to perform the location update
CSGID(s)	One or more identifiers for one or more CSG(s).	Sent by AMS to aid quick CSG membership detection by Femto ABS as well as to aid ABS reselection

16.2.3.2 AAI_RNG-RSP

An AAI_RNG-RSP, to which HARQ operation is applied, shall be transmitted by the ABS in response to a received AAI_RNG-REQ.

The AAI_RNG-RSP message shall be encrypted and not contain CMAC Tuple, when the ABS notifies the AMS through the HO Process Optimization parameter that the AAI_PKM-REQ/RSP sequence may be omitted for the current HO reentry attempt, or when the ABS wishes to respond to the acknowledged AAI_RNG-REQ message containing a valid CMAC.

The following parameters are included according to the usage of the AAI_RNG-RSP message:

Table 677—parameters for AAI_ RNG-RSP

Name	Value	Usage
Ranging Status	Used to indicate whether UL messages are received within acceptable limits by ABS. 1 = continue, 2 = abort, 3 = success	It shall be included in the AAI_RNG-RSP message
Temporary STID	Used for AMS identification until STID is assigned to the AMS during registration procedure.	It shall be included in the AAI_RNG-RSP message in response to the AAI_RNG-REQ message, which is not CMAC protected, when the AMS is not assigned its STID/DID yet.
AMSID*	A required parameter when the AMS confirms if the AAI_RNG-RSP is a response to the AAI_RNG-REQ message which the AMS sent.	
STID	AMS identification to be used in the target ABS	It shall be included in the AAI_RNG-RSP message during uncontrolled HO, NW reentry or Zone switching in case that the AAI_RNG-RSP is encrypted
Location Update Response	0x00= Success of Location Update 0x01= Failure of Location Update 0x02 = *Reserved* 0x03=Success of location update and DL traffic pending 0x04 = Allow AMS's DCR mode initiation request or DCR mode extension request 0x05 = Reject AMS's DCR mode initiation request or DCR mode extension request 0x06~0xFF: *Reserved*	It shall be included when an ABS sends an AAI_RNG-RSP message in response to an AAI_ RNG-REQ message used to perform location update or DCR mode initiation from Idle Mode or DCR mode extension.
Paging Cycle	New Paging Cycle of the AMS 0b0000 - 0b1111	It shall be included only if the Location Update Response is set to 0x00 (Success of Idle Mode Location Update) and the Paging Information has changed
Paging Group ID	New PGID of the AMS	
Paging Offset	New PAGING_OFFSET of AMS	
Paging Controller ID	The new Paging Controller ID which the AMS shall maintain in idle mode.	It shall be included only if the Location Update Response = 0x00 (Success of Idle Mode Location Update) and Paging Controller ID has changed
DID	The new DID which the AMS shall maintain in idle mode.	
HO Process Optimization	Bitmap definition is the same as in 16.2.3.11. Identifies reentry process MAC control messages that may be omitted during the current HO attempt due to the availability of MS service and operational context information obtained by means that are beyond the scope of this standard, and the MS service and operational status post-HO completion. The AMS shall not enter normal operation with target ABS until completing receiving all network reentry, MAC control message responses as indicated in HO process optimization.	It shall be included when the AMS is attempting to perform network reentry or HO and the target ABS wishes to identify reentry process MAC control messages that may be omitted during the current HO attempt
Neighbor station measurement report indicator	Perform Neighbor station measurement report if set to '1'	Identifies Neighbor station measurement report is required during current network entry for ARS

Table 677—parameters for AAI_ RNG-RSP

Name	Value	Usage
NONCE_AMS	The 64-bit NONCE_AMS transferred by AAI_RNG-REQ	It shall be included when zone switching from LZone to MZone occurs.
NONCE_ABS	The 64-bit NONCE_ABS transferred by AAI_RNG-REQ	It shall be included when zone switching from LZone to MZone occurs.

FID_update	Compound
	{
	SFID ;
	UD; // U: update, D : Delete
	If (UD==U) {
	Updated QoS Info ; //All the rules and settings that apply to the parameters when used in the DSC-RSP message apply to the contents encapsulated in this field.
	}
	}
		It shall be included if the ABS needs to update AMS's existing flows.
		FIDs which are not appeared in this field shall be regarded as guranteed by the ABS.

Unsolicit bandwidth indicator	If this is set to 1, then an ABS should allocate UL bandwidth for transmission or retransmission of MAC messages without request from AMS during network entry	It shall be included when AMS is attempting network entry
CLC-INFO	The information of co-located coexistence response (Table 690)	It shall be included when the AMS is attempting network reentry after HO if the AMS has any Type I or II CLC class active before handover. The Information Type field of CLC-INFO shall be set to 2 to indicate it provides CLC response information.
Redirection Info	ABSID, preamble index and center frequency for one or more neighbor ABSs of the serving ABS	Sent by serving ABS to aid cell reselection in the event the serving ABS is not able to allow the AMS to perform entry (due to various reasons such as high serving ABS load, non existence of CSG membership etc)
CRID	AMS identifier which the AMS has been assigned for coverage loss or DCR mode and are currently maintained	It shall be included when the AMS is attempting to perform network reentry from coverage loss or DCR mode or to perform network reentry/location update/zone-switch with assigning a new CRID
Ranging Request bit	If this is set to 1, AMS should send and AAI_RNG-CFM after a successful periodic ranging	It shall be included when serving ABS performs coverage loss detection procedure (16.2.26)

16.2.3.3 AAI_RNG-ACK

The AAI_RNG-ACK message is sent by the ABS in response to the CDMA ranging request during initial ranging, period ranging and HO ranging in order to provide PHY-level adjustment (e.g. timing offset, power level and frequency offset). In addition, it may also be transmitted asynchronously to send corrections based on measurements that have been made on other received data or MAC messages. As a result, the AMS shall be prepared to receive an AAI_RNG-ACK at any time, not just following a ranging preamble transmission. Upon reception of ranging codes, the AAI_RNG-ACK message is allocated by DL basic assignment A-MAP IE using broadcast STID. When the AAI_RNG-ACK message is sent unsolicitedly to specific user, the AAI_RNG-ACK message is allocated by DL basic assignment A-MAP IE with unicast STID. When the AMS receives an unsolicited AAI_RNG-ACK message, it shall reset the periodic ranging timer and adjust its PHY parameters as notified in the AAI_RNG-ACK message. If all the ranging statuses of the detected ranging preambles are equal to 'success', the AAI_RNG-ACK may be omitted by allocating UL resources with CDMA Allocation A-MAP IEs. The AAI_RNG-ACK shall include the following parameters:

Table 678—Parameters for AAI_RNG-ACK

Name	Value	Description
Management Message Type	AAI_RNG-ACK	
Unicast indication	If set to 1, this message is a unicast message; otherwise this is a broadcast message	
Frame identifier	The frame identifier is produced by concatenating the following two values: 1.The 2 least significant bits of the superframe number 2.The frame index within the superframe (ranging from 0b00 to 0b11).	Identifies the frame which contains the ranging opportunities to which this message refers.
RNG-ACK Bitmap	The size of this bitmap is decided by the number of ranging slots in the referenced frame. Each bit indicates the decoding status of the corresponding ranging opportunity. 0b0: No ranging code is detected; 0b1: At least one code is detected.	Shall be included when the AAI_RNG-ACK is sent with broadcast STID
Number of received codes		The number of ranging code indices detected in this corresponding ranging opportunity. Shall be included for each bit=0b1 in the RNG-ACK Bitmap when the AAI_RNG-ACK is sent with broadcast STID
Code Index		Code index received in this ranging opportunity. Shall be included for each received ranging codes if Number of received codes > 0 when the AAI_RNG-ACK is sent with broadcast STID
Ranging status	Used to indicated whether UL messages are received within acceptable limits by the ABS 0b01: continue 0b11: abort 0b00: success	When the AAI_RNG-ACK is sent with broadcast STID, the parameter shall be included for each received ranging code if Number of received codes > 0. When the AAI_RNG-ACK is sent with unicast STID, the parameter is included for the specific user.

Table 678—Parameters for AAI_RNG-ACK

Name	Value	Description
Adjustment parameters indication (API)	Bit#0: Time offset adjustment indication. Bit#1: Power level adjustment indication Bit#2: Frequency offset adjustment indication	When the AAI_RNG-ACK is sent with broadcast STID, this parameter shall be included for each received ranging code when Ranging status is 0b01. When the AAI_RNG-ACK is sent with unicast STID, the parameter is included for the specific user when Ranging status is 0b01, and in this case Bit#2 is always set to 0.
Timing offset adjustment	10 bits	Shall be included when Time offset adjustment indication bit is 1
Power level adjustment	3 bits	Shall be included when Power level adjustment indication bit is 1
Frequency offset adjustment	8 bits	Shall be included when Frequency offset adjustment indication bit is 1

16.2.3.4 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.

The AAI_SBC-REQ message shall be encrypted and not contain CMAC Tuple during HO reentry if authentication has been completed. In Table 679, the CAPABILITY_INDEX transmitted in the AAI_SBC-REQ message refers to the maximum "Capability Class" that the AMS can support. The maximum value of CAPABILITY_INDEX is denoted by [TBD] bits.

Table 679—AAI_SBC-REQ message format

Syntax	Size (Bits)	Notes
AAI_SBC-REQ_Message_Format() {		
Management Message Type = 26	8	
CAPABILITY_INDEX	TBD	
}		

The following parameters may be included and parameter sets are mapped to capability index (the mapping is TBD):

- Authorization policy support

- If Bit #0=0, EAP-based authorization is not supported;
- If Bit #0=1: EAP-based authorization is supported
- PN Window Size : Specifies the size capability of the receiver PN window. The receiver shall track PNs within this window to prevent replay attacks
- Auth type for EAP : Auth Type for EAP shall only be included when EAP-based authorization is supported.
  - If Bit #0=0, device authentication
  - If Bit #0=1, user authentication

16.2.3.5 AAI_SBC-RSP

An AAI_SBC-RSP message, to which HARQ operation is applied, is transmitted by ABS in response to a received AAI_SBC-REQ during initialization.

The AAI_SBC-RSP message shall be encrypted and not contain CMAC Tuple during HO reentry if authentication has been completed. In Table 680, the CAPABILITY_INDEX transmitted in the AAI_SBC-RSP message refers to the "Capability Class" that the ABS has allowed the AMS to use during the session. The value of CAPABILITY_INDEX signaled in the AAI_SBC-RSP message is numerically smaller than or equal to the CAPABILITY_INDEX signaled in the AAI_SBC-REQ message by the AMS.

Table 680—AAI_SBC-RSP message format

Syntax	Size (Bits)	Notes
AAI_SBC-RSP_Message_Format() {		
Management Message Type = 27	8	
CAPABILITY_INDEX	TBD	
}		

The following parameters may be included and parameter sets are mapped to cabability index(the mapping is TBD):

- Authorization policy support
  - If Bit #0=0, EAP-based authorization is not supported;
  - If Bit #0=1: EAP-based authorization is supported
- PN Window Size : Specifies the size capability of the receiver PN window. The receiver shall track PNs within this window to prevent replay attacks

16.2.3.6 AAI_SON-ADV message

This message is used by an ABS to broadcast relevant SON information for action types as defined below. This message contains the following parameters:

Table 681—title?

Name	Value	Usage
Action type	Used to indicate the purpose of this message 0b00: ABS Reconfiguration 0b01: ABS Restart 0b10: ABS Scanning 0b11: ABS Reliability	It shall be included in the AAI_SON-ADV message.
Unavailable start time (UST)	Start of unavailable time	If Action type = 0b00, 0b01, 0b10), it shall be included in the AAI_SON-ADV message. If Action type =0b11, it may be included in AAI_SON-ADV message.
Unavailable Time Interval (UTI)	Interval of unavailable time	
Reason	0x00: Power down 0x01: Power reduction 0x10: FA change 0x11:Bckhual link down	If Action type=0b11, it shall be included in the AAI_SON-ADV message.
Tx power reduction	dB value of Tx power reduction	If Reason = 0b01, it shall be included in the AAI_SON-ADV message.
FA index	FA index	If Reason = 0b10, it shall be included in the AAI_SON-ADV message.
Expected power down time or resource adjustment time or current FA downtime		If Action type = 0b11), it shall be included in the AAI_SON-ADV message.
Expected uptime or new FA uptime		If Action type = 0b11), it may be included in the AAI_SON-ADV message.
Recommended BSID list	Recommended BSID list	It may be included in AAI_SON-ADV message to help AMS to HO.

16.2.3.7 AAI_REG-REQ

An AAI_REG-REQ message is transmitted by AMS to negotiate general AMS capabilities and do registration during network entry.

The AAI_REG-REQ message shall be encrypted and not contain CMAC Tuple if authentication has been completed.

The following parameter is included in the AAI_REG-REQ message:

— AMS MAC address: This is used to derive security keys.

Table 682—Parameters for AAI_ REG-REQ

Name			Value
AMS capability negotiation parameters	ARQ parameters	ARQ_SN_MODULUS	the number of unique SN values; default =2^10
		ARQ_WINDOW_SIZE	the maximum number of ARQ blocks with consecutive SN in the sliding window of ARQ blocks
		ARQ_SUB_BLOCK_SIZE	ARQ sub-block length when ARQ block is fragmented into ARQ sub-blocks prior to retransmission with rearrangement
		ARQ_BLOCK_LIFETIME	the maximum time interval an ARQ block shall be managed by the transmitter ARQ state machine, once initial transmission of the block has occurred
		ARQ_RX_PURGE_TIMEOUT	the time interval the receiver shall wait after successful reception of a block that does not result in advancement of ARQ_RX_WINDOW_START, before advancing ARQ_RX_WINDOW_START
		MAXIMUM_ ARQ_BUFFER_SIZE	The maximum ARQ buffer size
	AMS DL HARQ buffering capability		Bits [6:0]: 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 paragraph 16.2.14.2.1.3.
	AMS UL HARQ buffering capability		Bits [6:0]: 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.
	AMS DL processing capability per sub-frame		Bits [6:0] The number that is higher by 1 than this field, is the steady amount of aggregated DL data information bits per sub-frame in units of 600 bytes that the AMS can process.
	AMS UL processing capability per sub-frame		Bits [6:0] The number that is higher by 1 than this field, is the steady amount of aggregated UL data information bits per sub-frame in units of 600 bytes that the AMS can process.
	Multicarrier capabilities		0b00: No MC modes 0b01: Multicarrier aggregation 0b10: Multicarrier switching 0b11: Both multicarrier aggregation and switching
	LBS Capabilities	Capability for supporting A-GPS method	0b0: no support 0b1: support
	Capabilities for interference mitigation support	DL PMI coordination capability	0: AMS is DL PMI coordination capable 1: AMS is not DL PMI coordination capable
		DL collaborative multi-BS MIMO capability	0: AMS is DL collaborative multi-BS MIMO capable 1: AMS is not DL collaborative multi-BS MIMO capable

Table 682—Parameters for AAI_ REG-REQ

Name		Value
	E-MBS capabilities	If Bit#0 is set to 1, it indicates E-MBS in Serving ABS only is supported If Bit#1 is set to 1, it indicates macro diversity multi ABS E-MBS is supported. If Bit#2 is set to 1, it indicates non-macro-diversity multi ABS E-MBS is supported. If all Bit#0~Bit#2 are set to 0, it indicates no E-MBS is supported.
Convergence sublayer capabilities	Classification/PHS options and SDU encapsulation support	Indicates which classification/PHS options and SDU encapsulation the AMS supports
	Maximum number of classification rules	Maximum number of admitted classification rules that the AMS supports.
	ROHC support	Indicates the level of ROHC support.
	PHS support	Indicates the level of PHS support.
	Supported-IP-Versions IE	Indicates whether the AMS supports IPv4, IPv6 or both. 0b00: reserved 0b01: IPv4 support 0b10: IPv6 support 0b11: both IPv4 and IPv6 support
Host configuration capabilities and parameters	Host-Configuration-Capability-Indicator IE	Indicates whether the AMS supports the capability of configuring host using the received parameters through the AAI_REG-RSP message. (One bit indicator) This shall be omitted if Requested-Host-Configurations IE is included in the message.
	Requested-Host-Configurations IE	Includes requested host configuration options in DHCP Options format. If included, this IE indicates that the AMS supports host configuration using AAI_REG-RSP message, and Host-Configuration-Capability-Indicator IE shall be omitted.
Notes If the Supported-IP-Versions IE indicates both IPv4 and IPv6 capable, it means the AMS supports dual stack of IPv4/IPv6.		

The following parameters may be included:

AMS Scanning Capability:

This field indicates properties of the AMS that the ABS needs to know for scanning purposes:

- Number of Center Frequencies AMS can scan during one scan iteration.

- Maximum number of preambles per Center Frequency AMS can scan during one iteration.

- Number of frames required to complete scanning of all preambles for a given frequency.

The length of the field is 3 Bytes, which are divided as follows:

- Bit 0-4: Indicates the maximum number of preambles using the same center frequency that AMS can scan within one frame
- Bit 5-7: Number of sub-frames the AMS requires to switch from the serving ABS to the first center frequency. This value is measured from the end of the last frame during which the AMS is connected to the S-ABS (and may have to receive/send data) until the beginning of the first frame in which a measurement of a neighboring ABS in a different center frequency can be performed.
  - 0b000 = 0 sub-frames
  - 0b111 = 7 sub-frames)
- Bits 8-10: The number of sub-frames the AMS requires to switch between center frequencies. This is the time duration (in sub-frames) between a sub-frame in which a center frequency was scanned until the beginning of a sub-frame in which a new center frequency can be scanned.
  - 0b000 = 0 sub-frames
  - 0b111 = 7 sub-frames)
- Bits 11-13: The number of sub-frames the AMS requires to switch from the last center frequency back to the serving ABS. This is the time duration (in sub-frames) between a frame in which a center frequency was scanned until the beginning of the first frame in which the AMS is available at the S-ABS and may receive/transmit data.
  - 0b000 = 0 sub-frames
  - 0b111 = 7 sub-frames)
- Bit 14-15: Minimum supported scan duration
  - (0b000 = no limit, 0b001= 1 sub-frame, 0b111= 7 sub-frames)
- Bit 16-23: Maximum supported scan duration
  - (0x0 = no limit
  - All other values: maximum scan duration in number of sub-frames))

16.2.3.8 AAI_REG-RSP

An AAI_REG-RSP message is transmitted by ABS in response to AAI_ REG-REQ message during initialization.

The AAI_REG-RSP message shall be encrypted and not contain CMAC Tuple if authentication has been completed.

The following parameter is included in the AAI_REG-RSP message:

— STID: AMS identifier which the ABS assigns to the AMS in place of the temporary STID which has been transferred by AAI-RNG-RSP message.

— CRID (Context Retention Identifier): AMS identifier which the AMS has been assigned for coverage loss or DCR mode

The following parameters may be included:

Table 683—Parameters for AAI_ REG-RSP message

Name			Value
AMS capability negotiation parameters	ARQ parameters	ARQ_SN_MODULUS	the number of unique SN values; default =2^10
		ARQ_WINDOW_SIZE	the maximum number of ARQ blocks with consecutive SN in the sliding window of ARQ blocks
		ARQ_SUB_BLOCK_SIZE	ARQ sub-block length when ARQ block is fragmented into ARQ sub-blocks prior to retransmission with rearrangement
		ARQ_BLOCK_LIFETIME	the maximum time interval an ARQ block shall be managed by the transmitter ARQ state machine, once initial transmission of the block has occurred
		ARQ_RX_PURGE_TIMEOUT	the time interval the receiver shall wait after successful reception of a block that does not result in advancement of ARQ_RX_WINDOW_START, before advancing ARQ_RX_WINDOW_START
		MAXIMUM_ ARQ_BUFFER_SIZE	The maximum ARQ buffer size
	Capabilities for interference mitigation support	DL PMI coordination capability	0: ABS is DL PMI coordination capable 1: ABS is not DL PMI coordination capable
		DL collaborative multi-BS MIMO capability	0: ABS is DL collaborative multi-BS MIMO capable 1: ABS is not DL collaborative multi-BS MIMO capable
		DL closed-loop multi-BS macro diversity capability	0: ABS is DL closed-loop multi-BS macro diversity capable 1: ABS is not DL closed-loop multi-BS macro diversity capable
		UL PMI combination capability	0: ABS is UL PMI combination capable 1: ABS is not UL PMI combination capable
	LBS Capabilities	Capability for support A-GPS method	0b0: no support 0b1: support
		TBD	TBD
	Multicarrier capabilities		0b00: No MC modes 0b01: Multicarrier aggregation 0b10: Multicarrier switching 0b11: Both multicarrier aggregation and switching
	E-MBS capabilities		If Bit#0 is set to 1, it indicates E-MBS in Serving ABS only is supported If Bit#1 is set to 1, it indicates macro diversity multi ABS E-MBS is supported. If Bit#2 is set to 1, it indicates non-macro-diversity multi ABS E-MBS is supported. If all Bit#0~Bit#2 are set to 0, it indicates no E-MBS is supported.
	Co-located coexistence capability supported		Indicates if co-located coexistence is supported.
	Capabilities for MIMO support		TBD

Table 683—Parameters for AAI_ REG-RSP message

Name		Value
Convergence sublayer capabilities	Classification/PHS options and SDU encapsulation support	indicates which classification/PHS options and SDU encapsulation the AMS supports
	Maximum number of classification rules	Maximum number of admitted classification rules that the AMS supports.
	ROHC support	Indicates the level of ROHC support.
	PHS support	Indicates the level of PHS support.
	Resource_Retain_Time	Number of frames that the serving ABS shall retain the AMS context.
	IP-Service-Type IE	Indicates which IP service will be used, the value is one of following: IPv4-Service IPv6-Service IPv4/IPv6-Dual-Mode-Service
Host configuration capabilities and its parameters	IPv4-Host-Address IE	The allocated IPv4 Host Address for the AMS. Size: 4 octet
	IPv6-Home-Network-Prefix IE	The allocated IPv6 Home Network Prefix for the AMS. Size: 8 octet
	Additional-Host-Configurations IE	Includes additional host configuration options in DHCP Options format as detailed in [3], [4]
Redirection Info	ABSID, preamble index and center frequency for one or more neighbor ABS	Sent by serving ABS to aid cell reselection in the event the serving ABS is not able to allow the AMS to perform entry.

16.2.3.9 AAI HO-IND

The AMS may send the AAI_HO-IND MAC control message in HO preparation, HO execution and HO cancellation. If Piggyback Extended Header is included in the AAI_HO-IND message, bandwidth request size should be transferred to the target ABS. The AAI_HO-IND message includes the following information:

Table 684—Parameters for AAI_HO-IND message

Name	Value	Usage
HO Event Code	0b00: Target ABS selection in case of multiple candidate T-ABSs. 0b01: All target ABSs in AAI_HO-CMD are unreachable. In this case, the AMS shall include a new target ABS that was not included in AAI_HO-CMD. 0b10: AMS unable to stay connected to serving ABS until expiration of disconnect time 0b11: HO cancel.	This is used to distinguish AAI_HO-IND among different scenarios
Target ABS ID		Shall be included when HO Event Code = 0b00 or 0b01

Table 684—Parameters for AAI_HO-IND message

Name	Value	Usage
Physical_Carrier_Index	Physical carrier index of the Target ABS where an AMS will perform network reentry procedure	May be included when the target ABS is a multi-carrier ABS and HO Event Code = 0b00

16.2.3.10 AAI_HO-REQ

In MS-initiated HO, the AMS shall send the AAI_HO-REQ to S-ABS to initiate the HO procedure. The following parameters shall be included in the AAI_HO-REQ message:

Table 685—Parameters for AAI_HO-REQ message

Name	Value	Usage
Report Metric	Bit #0: BS CINR mean Bit #1: BS RSSI mean Bit #2: Relative delay Bits #3-6: Reserved; shall be set to zero.	Bitmap indicator of trigger metrics that the AMS reports in this message.
N_New_BS_Index	Number of neighboring ABSs to be considered for HO, which are included in AAI_NBR-ADV message.	
Neighbor_ABS_ID		Shall be included for each recommended neighbor BS
ABS CINR mean		Shall be included if Report Metric Bit #0 is set to 1
ABS RSSI mean		Shall be included if Report Metric Bit #1 is set to 1
Relative delay		Shall be included if Report Metric Bit #2 is set to 1
Carrier Preassignment Indication	Indicates whether AMS needs preassignment of secondary carriers at the Target ABS.	May be included when Multi-Carrier Support = 1

16.2.3.11 AAI_HO-CMD

The S-ABS shall send AAI_HO-CMD to initiate the HO procedure, or to acknowledge the AAI_HO-REQ sent by the AMS. The AAI_HO-CMD message shall include the following parameters:

Table 686—Parameters for AAI_HO-CMD message

Name	Value	Usage
Mode	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 target ABS.	
HO Reentry Mode	1: the AMS maintains communication with Serving ABS while performing network reentry with the Target ABS (Mode=0b00); or the AMS maintains communication with MZone while performing network reentry with LZone in the same frame or on another carrier (Mode=0b01). 0: the AMS disconnects from the Serving ABS before performing network reentry with the Target ABS (Mode=0b00); or the AMS disconnects from the MZone before performing network reentry with the LZone (Mode=0b01).	Should be included when Mode = 0b00. Shall be included when Mode = 0b01.
HO Reentry Interleaving Interval	If HO Reentry Interleaving Interval > 0, the AMS performs network reentry to the target ABS within the HO Reentry Interleaving Interval and continues data transmission with the Serving ABS in the remaining time. If HO Reentry Interleaving Interval =0, the AMS performs multi-carrier EBB (Established Before Break) HO procedure per 16.2.8.2.9.2.2	Shall be included when HO Reentry Mode is set to 1
HO Reentry Iteration	The requested number of iterating HO Reentry Intervals by an AMS.	Shall be included when HO Reentry Interleaving Interval > 0
Disconnect time offset	Difference between Disconnect time and Action time in units of frames. The value of disconnect time shall be calculated for each T-ABS by adding/ subtracting this value with the value of Action time specified for this T-ABS. For HO_Reentry_Mode = 0, Disconnect time will be (Action time - Disconnect time offset); For HO_Reentry_Mode = 1, Disconnect time will be (Action time + Disconnect time offset).	Should be included when Mode = 0b00.
Resource_Retain_Time		Should be included when Mode = 0b00. Shall be included when Mode = 0b01.
Target ABS/YBS ID		Shall be included for each target ABS when Mode=0b00
Preamble Index	Preamble Index of Target ABS	Shall be included for each target ABS when Mode=0b00
FA index	FA Index of Target ABS	Shall be included for each target ABS when Mode=0b00
S-SFH change count	The change count of this BS's S-SFH IE	Shall be included for each target ABS when Mode=0b00

Table 686—Parameters for AAI_HO-CMD message

Name	Value	Usage
Action Time	(Mode=0b00) Action Time included in this message is the absolute frame number at the serving ABS (Mode=0b01) This value is defined as the frame number that AMS starts zone switch. Action Time included in this message is indicated by frame number	Shall be included for each target ABS when Mode=0b00. Shall be included when Mode = 0b01.
CDMA_RNG_FLAG		If CDMA_RNG_FLAG=0, CDMA based ranging shall be skipped. Otherwise, if set to 1, it indicates that ranging shall be done. This parameter shall be included for each target ABS when Mode=0b00.; It shall be included when Mode = 0b01.
Dedicated Ranging Code Flag	1	If set to 0, it indicates that no dedicated ranging code is provided. If set to 1, it indicates that no dedicated ranging code is provided. May be included when CDMA_RNG_FLAG=1
Dedicated Ranging Opportunity Flag	1	If set to 0, it indicates that no dedicated ranging opprotunity is provided. If set to 1, it indicates that no dedicated ranging opportunity is provided. May be included when CDMA_RNG_FLAG=1
Dedicated CDMA ranging code	5	Indicates the dedicated ranging code. Shall be included when Dedicated Ranging Code Flag =1
Ranging opportunity index	3	Indicates the index of the allocated ranging opportunity. Shall be included when Dedicated Opportunity Code Flag=1
Subframe Index	3	Indicates the subframe index of the allocated ranging opportunity. Shall be included when Dedicated Opportunity Code Flag=1
HO process optimization	For each bit location, a value of 0 indicates the associated reentry MAC control messages shall be required, a value of 1 indicates the reentry MAC control message may be omitted. Bit #0: Omit AAI_SBC-REQ/RSP MAC control messages during reentry processing Bit #1: Omit PKM Authentication phase Bit #2: Omit AAI_REG-REQ/RSP message and higher layer protocol triggering (for IP address refresh) during reentry processing. Bit #3: If Bit #3 = 1, Full service and operational state transfer or sharing between Serving BS and Target BS (All static and dynamic context, e.g., ARQ windows, state machines	Shall be included for each target ABS when Mode=0b00 When Bit #2 is set to 0 and IP address refresh is needed, the AAI_REG-REQ/RSP includes Host configuration capabilities and its parameters to provide IP address information.

Table 686—Parameters for AAI_HO-CMD message

Name	Value	Usage
Seamless HO	Indicates whether seamless HO is supported	
Ranging initiation deadline		Shall be included for each target ABS when Mode=0b00
Service level prediction	Indicates the level of service the AMS can expect from this ABS. The following encodings apply: 0 = No service possible for this AMS 1 = Some service is available for one or several service flows authorized for the AMS 2 = For each authorized service flow, a MAC connection can be established with QoS specified by the AuthorizedQoSParamSet. 3 = No service level prediction available.	Shall be included for each target ABS when Mode=0b00
Physical_Carrier_Index	Physical carrier index of the Target ABS where AMS will perform network reentry procedure.	Should be included for each target ABS which is multi-carrier ABS when Mode = 0b00
Carrier Preassignment Indication	1: information of pre-assigned secondary carriers by the target ABS is included in this message; 0: no pre-assigned secondary carrier	Shall be included for an AMS with multi-carrier capability when Mode = 0b00
N_Preassigned_Carriers	Number of pre-assigned secondary carriers at the target ABS. A value of 0 means no secondary is pre-assigned.	Shall be included when Carrier Preassignment Indication = 1
Pre-assigned secondary carrier information	Carrier information of each pre-assigned secondary carrier, which includes: Carrier Status Bitmap: indicating whether this pre-assigned carrier will be activated immediately after HO procedure is done; Physical carrier index of pre-assigned secondary carriers; Logical carrier index, which is assigned implicitly in the order of Carrier information of each pre-assigned secondary carriers.	Shall be included when N_Preassigned_Carriers > 0
LZone Presambile Index	LZone Preamble Index for AMS to switch from MZone to LZone	Shall be included when Mode = 0b01.
Pre allocated Basic CID	Used by the AMS to derive its own primary CID and transport CID in target YBS.	May be included when HO to a LZone or a YBS

16.2.3.12 AAI_NBR-ADV

AAI_NBR-ADV message may sort neighbor ABSs (RSs) according to their deployment types, which is categorized by the following parameters:

1) ABS type (macro, micro, macro hotzone, Femto, relay, legacy)

a) physical carrier index referring AAI_Global-Config message which provides carrier frequency, BW, CP info, TDD/FDD and related definitions (expected to be the same given carrier frequency)

a) MAC version

ABS determines and indicates the system configuration information included for each deployment type and their corresponding broadcast frequency.

To allow AAI_NBR-ADV fragmentation while providing flexibility for AMS HO operation without requiring acquisition of the whole AAI_NBR-ADV message, ABS always provides the total number of deployment types and total number of recommended T-ABS for each type. Each AAI_NBR-ADV fragment has corresponding indexes for each deployment type and each neighbor ABS. ABSs with identical type are listed in the AAI_NBR-ADV message in descending order of their cell coverage.

Each AAI_NBR-ADV message carries

- AAI_NBR-ADV change count
- number of total cell types
- segment information for this AAI_NBR-ADV message
- system information of ABSs from one or more cell types, which is of variable size.
- Starting ABS Index: Starting ABS Index is the index offset from the last ABS of the previous AAI_NBR-ADV segment. If this is the first AAI_NBR-ADV segment, the Starting ABS Index will be 0. Hence, each AAI_NBR-ADV segment has one Index which corresponds to the first ABS in that AAI_NBR-ADV segment.

For each cell type, shared configuration parameters are carried as follows

- IDcell range
- FA range

The IDcell range and FA ranges are optional fields, which can be used when the serving ABS chooses not to broadcast configuration information for each individual ABS within the cell type.

Within each cell type, if serving ABS chooses to broadcast configuration information for each individual ABS instead of specifying IDcell range and FA range, a list of ABSs are provided and the following parameters are carried for each ABS

- 48bit BS-ID
- ABS IDcell
- indication whether full system information or partial information is carried for this ABS, which includes
  - — SFH information
  - — ESI information
  - — Physical carrier index (6 bits, refer to the "physical carrier index" defined in AAI_Global-Config)
  - — Number of MAC protocol versions supported (4 bits)
  - — list of supported MAC protocol versions (4 bits per entry)

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 serving BS or the first BS/ABS in this cell type); and for Wireless-MAN-OFDMA reference system, only 48-bit BS-ID and Preamble index are included in AAI_NBR-ADV.

- SFH_encoding_format: Based on the present system information, the list of ABSs shall be categorized into three groups. The categorization is indicated by SFH_encoding_format parameter
  - — 0b00: full Subpacket information
  - — 0b01: delta encoding for which the first BS in this loop is used as reference BS
  - — 0b10: no SFH included
  - — 0b11: reserved

r

Table 687—AAI_NBR-ADV message format

Syntax	Size (bit)	Note
AAI_NBR-ADV_Message_format() {		
Management Message Type = NN	8	
Change Count	3	NBR-ADV Change Count
Cell type	3	Cell type in this message 0b000 macro 0b001 micro 0b010 macro hotzone 0b011 femto 0b100 relay 0b101-0b111 reserved
Total Number of AAI_NBR-ADV Segments	4	Total number of segments of AAI_NBR-ADV for this cell type
AAI_NBR-ADV Segment Index	4	Indicates current segment index of this message in the specific cell type
BS number M	8	Total number of BSs to be included in this AAI_NBR-ADV segment
Starting ABS Index	8	Starting ABS Index is the index offset from the last ABS of the previous AAI_NBR-ADV segment. If this is the first AAI_NBR-ADV segment, the Starting ABS Index will be 0. Hence, each AAI_NBR-ADV segment has one Index which corresponds to the first ABS in that AAI_NBR-ADV segment.
for (i=0; i<M; i++) {		
BSID	48	
Number of carriers (NC)		Number of carriers of the BS
for(j=0; j<NC; j++) {		
SA-PREAMBLE index	10	
A-PREAMBLE transmit power	8	
Physical carrier index	6	Refer to the physical carrier index in AAI_Global-Config message
MAC protocol versions	8	MAC protocol version of the BS Consistent with REV.2 definition, with new MAC protocol version 9 defined for 16m.
}		

Table 687—AAI_NBR-ADV message format

Syntax	Size (bit)	Note
SFH_encoding_format	2	0b00: full Subpkt information 0b01: delta encoding (the 1st BS in this cell type shall use full Subpkt encoding) 0b10: no SFH included 0b11: reserved For macrocell ABS, the bitmap shall be either 0b00 or 0b01
Control_bitmap	4	Each bit maps to one SFH subpacket or extended broadcast information. For macrocell ABS, the bitmap shall be 1111
If(SFH_encoding_format =00) {		//encoding format type-1
If(Control_bitmap[0] ==1){		
SFH Subpkt 1	88	//exclude those fields already in cell type info
}		
If(Control_bitmap[1] ==1){		
SFH Subpkt 2	88	//exclude those fields already in cell type info
}		
If(Control_bitmap[2] ==1){		
SFH Subpkt 3	88	//exclude those fields already in cell type info
}		
}		
If(SFH_encoding_format =01) {		
Delta information	variables	Delta encoding, w.r.t. the reference BS
}		
Neighbor-specific trigger TLVs	variables	Optional neighbor-specific triggers with encoding defined in Table 744—
}		
}		

16.2.3.13 AAI_SCN-REQ

An AAI_SCN-REQ message is transmitted by an AMS to request a scanning interval for the purpose of seeking available ABSs and/or WirelessMAN-OFDMA BSs and determining their suitability as targets for HO. An AMS may request a scanning interval during the scan interleaving interval.

Table 688—Parameters for AAI_SCN-REQ message

Name	Value	Usage
Scan duration	Duration (in units of AAI subframes) of the requested scanning period.	
Scan Purpose	0b0: scan BS(s) which is in the list of the AAI_NBR-ADV message 0b1: scan BS(s) which is not in the list of the AAI_NBR-ADV message	
Interleaving Interval	The period of AMS's normal operation which is interleaved between Scan Durations.	
Scan Iteration	The requested number of iterating scanning interval by an AMS.	
Recommended Start Frame indication	Indicates whether Recommended start super frame number field and Recommended start frame field are included	
N_Recommended_BS_Index_indication	Indicates whether N_Recommended_BS_Index field is included in this message	
N_Recommended_BS_Full_indication	Indicates whether N_Recommended_BS_Full field is included in this message.	
N_Recommended_Preamble_Index_indication	Indicates whether N_Recommended_Preamble_Index field is included in this message	
Recommended start super frame number	Represents the 6 least significant bits of the absolute super frame number for which the AMS recommends the first Scanning Interval to start. This field is set to 0 if an AMS has no preferred value.	Shall be included when Recommended Start Frame indication is set to 1
Recommended start frame number	Represents recommended start frame number within the super frame number which is indicated by Recommended start super frame number field. The value indicates: 0b00: The 1st frame in the super frame 0b01: The 2nd frame in the super frame 0b10: The 3rd frame in the super frame 0b11: The 4th frame in the super frame	Shall be included when Recommended Start Frame indication is set to 1

Table 688—Parameters for AAI_SCN-REQ message

Name	Value	Usage
N_Recommended_BS_Index	This is the number of neighboring BS to be scanned, which are included in AAI_NBR-ADV message. When an AMS receives AAI_SCN-RSP message from BS in response to AAI_SCN-REQ message, the AMS shall check whether Configuration Change Count stored by the AMS is the same as one included in AAI_SCN-RSP message sent by the ABS. If an AMS detects mismatch of Configuration Change Counts, it may retransmit AAI_SCN-REQ message to the ABS.	Shall be included when N_Recommended_BS_Index_indication is set to 1
Configuration Change Count for AAI_NBR-ADV	The value of Configuration Change Count in AAI_NBR-ADV message referred in order to compress neighbor BSID	
Neighbor_BS_Index	Based on the value of N_Recommended_BS_Index, BS index corresponds to position of BS in AAI_NBR-ADV message is included.	Shall be included when N_Recommended_BS_Index > 0
N_Recommended_BS_Full	Number of neighboring BS to be scanned, which are using full 48-bit BSID.	Shall be included when N_Recommended_BS_Full_indication is set to 1
Recommended BS ID	Based on the value of N_Recommended_BS_Full, identifiers of the BSs the MS plans to scan is included.	Shall be included when N_Recommended_BS_Full > 0
N_Recommended_ Preambe_Index	Number of preambles to be scanned	Shall be included when N_Preamble_Index_Indication is set to 1
Preamble Index	Based on the value of N_Recommended_BS_Full, identifiers of the BSs the MS plans to scan is included.	Shall be included when N_Recommended_Preamble_Index> 0
N_Recommended_Carrier_Index	Number of carriers to be scanned at each neighboring ABS.	May be included when N_Recommended_BS_Index > 0 or N_Recommended_BS_Full > 0
Recommended_Carrier_Index	Recommended physical carrier index for scan at each neighboring ABS.	Shall be included when N_Recommended_Carrier_Index > 0
N_Recommended_Carrier_Index_at_Serving_ABS	Number of physical carrier index of the serving ABS to be scanned	
Carrier index at serving ABS	Recommended physical carrier index to be used for scanning	Shall be included when N_Recommended_Carrier_Index_at_Serving_ABS > 0
CSGID(s)	One or more identifiers for one or more CSG(s)	Sent by AMS to aid ABS reselection

16.2.3.14 AAI_SCN-RSP

An AAI_SCN-RSP message shall be transmitted by the ABS either unsolicited or in response to an AAI_SCN-REQ message sent by an AMS. An ABS may transmit AAI_SCN-RSP to start AMS scan reporting with or without scanning interval allocation. If Scan Duration field contains a non-zero value, scanning interval pattern included in the AAI_SCN-RSP message replaces previous existing scanning interval pattern.

Table 689—Parameters for AAI_SCN-RSP message

Name	Value	Usage
Scan duration	Duration (in units of AAI subframes) of the requested scanning period.	
Scan Purpose	0b0: scan BS(s) which is in the list of the AAI_NBR-ADV message 0b1: scan BS(s) which is not in the list of the AAI_NBR-ADV message	-
Report mode	0b00:No report 0b01:Periodic report 0b10:Event-triggered report 0b11:One-time scan report	
Report metric	Bitmap indicator of trigger metrics that the serving ABS requests the AMS to report. The serving ABS shall indicate only the trigger metrics agreed during AAI_SBC-REQ/RSP negotiation. Each bit indicates whether reports will be initiated by trigger based on the corresponding metric: Bit 0: BS CINR mean Bit 1: BS RSSI mean Bit 2: Relative delay Bit 3: BS RTD Bits 4-5: Reserved; shall be set to zero	
Report period	The period of MS's report of scanning result when the MS is required to report the value periodically or one-time. The period is calculated from the start of the first scan duration. If the BS sends an unsolicited AAI_SCN-RSP message without assignment of a scanning interval and the scan duration is set to zero, the period is calculated from the frame the MS receives the AAI_SCN-RSP message. For MS scanning request denied by AAI_SCN-RSP with Scan Duration set to zero, Report period is the number of frames that BS suggests to MS before transmitting next AAI_SCN-REQ	
N_Recommended_BS_Index_indication	Indicates whether N_Recommended_BS_Index field is included in this message. This is valid only if Scan duration is not equal to zero.	
N_Recommended_BS_Full_indication	Indicates whether N_Recommended_BS_Full field is included in this message. This is valid only if Scan duration is not equal to zero.	

Table 689—Parameters for AAI_SCN-RSP message

Name	Value	Usage
Start super frame number	Represents the 6 least significant bits of the absolute frame number in which the first Scanning interval starts	Included only when Scan Duration > 0
Start frame number	Represents start frame number in the Start super frame number. 0b00: The 1st frame in the super frame 0b01: The 2nd frame in the super frame 0b10: The 3rd frame in the super frame 0b11: The 4th frame in the super frame	Included only when Scan Duration > 0
Interleaving Interval	The period of AMS's normal operation which is interleaved between Scan Durations.	Included only when Scan Duration > 0
Scan Iteration	The number of iterating scanning interval.	Included only when Scan Duration > 0
N_Recommended_BS_Index	Number of neighboring BS to be scanned, which are included in AAI_NBR-ADV message.	Included only when Scan Duration > 0
Configuration Change Count for AAI_NBR-ADV	The value of Configuration Change Count in AAI_NBR-ADV message referred in order to compress neighbor BSID	Included when N_Recommended_BS_Index > 0
Neighbor_BS_Index	Based on the value of N_Recommended_BS_Index, BS index corresponds to position of BS in AAI_NBR-ADV message is included.	Included when N_Recommended_BS_Index > 0
N_Recommended_BS_Full	Number of neighboring BS to be scanned, which are using full 48-bit BS ID.	Included when Scan Duration > 0
Recommended BS ID	Based on the value of N_Recommended_BS_Full, Recommended BS ID list for scan is included	Included when N_Recommended_BS_Full > 0
Preamble Index of Recommended BS ID	Preamble Index of Recommended BS ID	Shall be included when N_Recommended_BS_Full > 0
N_Recommended_Carrier_Index	Number of physical carriers to be scanned at each neighboring ABS.	May be included for a multi-carrier target ABS
Recommended_Carrier_Index	Recommended physical carrier index for scan at each neighboring ABS.	Included when N_Recommended_Carrier_Index > 0
Carrier index at serving ABS	Recommended physical carrier index to be used for scanning	May be included when the serving ABS is a multi-carrier ABS

16.2.3.15 AAI_SCN-REP

When the report mode is 0b10 (i.e., event triggered) in the most recently received AAI_SCN-RSP, the MS shall transmit a AAI_SCN-REP message to report the scanning results to its serving ABS after each scanning period if the trigger condition is met. For a periodic report (i.e., Report Mode is 0b01) and for One-time Scan Report (Report Mode is 0b11), the AMS reports the scanning results to its serving ABS at the time indicated in the AAI_SCN-RSP message except when it is in the scanning interval. For a periodic report (i.e., Report Mode is 0b01), the AMS stops reporting after all scanning intervals in the AAI-SCN-RSP message. The AMS shall include all available scanning results for the requested ABSs specified in the said AAI_SCN-RSP message. The MS may transmit an AAI_SCN-REP message to report the scanning results to its serving ABS at anytime.

Table 690—Parameters for AAI_SCN-REP message

Name	Value	Usage
Report mode	Action code for an AMS's scan report of its measurement 0: Event-triggered report 1: Periodic report according to Scan report period of AAI_SCN-RSP	
Report metric	Bitmap indicator of trigger metrics that the serving ABS requests the AMS to report. The serving ABS shall indicate only the trigger metrics agreed during AAI_SBC-REQ/RSP negotiation. For each bit location, a value of 0 indicates the trigger metric is not included, while a value of '1' indicates the trigger metric is included in the message. The bitmap interpretation for the metrics shall be: Bit 0: BS CINR mean Bit 1: BS RSSI mean Bit 2: Relative delay Bit 3: BS RTD Bits 4-5: Reserved; shall be set to zero	
N_Neighbor_BS_Index_indication	Indicates whether N_Neighbor_BS_Index field is included in this message	
N_Neighbor_BS_Full_indication	Indicates whether N_Neighbor_BS_Full field is included in this message.	
N_Scanned_Preamble_ Indices_indication	Indicates whether N_Scanned_Preamble_Indices field is included in this message.	
BS CINR mean	The BS CINR Mean parameter indicates the CINR measured by the AMS from the particular ABS. The value shall be interpreted as a signed byte with units of 0.5 dB. The measurement shall be performed on the subcarriers of the frame preamble that are active in the serving ABS's segment and averaged over the measurement period.	Included when Report metric Bit 0 = 1

Table 690—Parameters for AAI_SCN-REP message

Name	Value	Usage
BS RSSI mean	The BS RSSI Mean parameter indicates the Received Signal Strength measured by the AMS from the particular ABS. The value shall be interpreted as an unsigned byte with units of 0.25 dB, e.g., 0x00 is interpreted as -103.75 dBm. An MS shall be able to report values in the range -103.75 dBm to -40 dBm. The measurement shall be performed on the frame preamble and averaged over the measurement period.	Included when Report metric Bit 1 = 1
Relative delay	This parameter indicates the delay of neighbor DL signals relative to the serving BS, as measured by the MS for the particular BS. The value shall be interpreted as a signed integer in units of samples.	Included when Report metric Bit 2 = 1
BS RTD	The BS RTD parameter indicates the round trip delay (RTD) measured by the AMS from the particular ABS. RTD can be given by the latest time advance taken by MS. The value shall be interpreted as an unsigned byte with units of 1/Fs.	Included when Report metric Bit 3 = 1
N_Neighbor_BS_Index	Number of neighboring BS reported in this message and which are included in AAI_NBR-ADV message.	Included when N_Neighbor_BS_Index_indication = 1
Configuration Change Count for AAI_NBR-ADV	The value of Configuration Change Count in AAI_NBR-ADV message referred in order to compress neighbor BSID	Included when N_Neighbor_BS_Index_indication = 1
Neighbor_BS_Index	Based on the value of N_Neighbor_BS_Index, BS index corresponds to position of BS in AAI_NBR-ADV message is included.	Included when N_Neighbor_BS_Index > 0
N_Neighbor_BS_Full	Number of neighboring BS reported in this message that are using full 48 bits BS ID.	Included when N_Neighbor_BS_Full_indication = 1
Neighbor_BSID	Based on the value of N_Neighbor_BS_Full, full BSID (48-bit) is included.	Included when N_Neighbor_BS_Full > 0
N_FA_Index	Number of scanned FAs	Included when N_Scanned_Preamble_Indices_indication == 1
for (i=0; i<N_FA_Index; i++) {		
FA_Index	Scanned FA Index	
N_Scanned_Preamble_Indices	Number of scanned preambles reported in this message	

Table 690—Parameters for AAI_SCN-REP message

Name	Value	Usage
for (j=0; j<N_Scanned_ Preamble_Indices; j++) {		
Preamble_Index	Based on the value of N_Scanned_Preamble_Indices, preamble index (10-bit) is included	
Report_Value	Based on the value of Report metric.	
}		
}		
N_Recommended_Carrier_Index	Recommended physical carrier index for scan at each neighboring ABS.	May be included for a multi-carrier target ABS
Recommended_Carrier_Index	Recommended physical carrier index for scan at each neighboring ABS.	Included when N_Recommended_Carrier_Index > 0
Carrier index at serving ABS	Recommended physical carrier index to be used for scanning	May be included when the serving ABS is a multi-carrier ABS

16.2.3.16 AAI_CLC-REQ (Co-Located Coexistence Request)

The AMS send the AAI_CLC-REQ message to activate, terminate, or reconfigure one or several Type I, Type II, or/and Type III CLC classes. The AAI_CLC-REQ message is sent from the AMS to the ABS on the AMS's Control FID. The AMS may include CLC-INFO parameter fields.

Table 691—AAI_CLC-REQ message

Name	Size (bits)
Request Action	8
CLC-INFO	variable

Parameters shall be as follows:

Request Action

Bit #i of the field set to "0" indicates that AMS requests to terminate the existing CLC class with CLC ID = i, or the CLC class with CLC ID = i does not exist

Bit #i of the field set to "1" indicates that AMS requests to activate the CLC class with CLC ID = i if it does not exist. For existing CLC ID, AMS may keep existing configuration, request to re-configure or replace existing CLC class.

CLC-INFO

These parameters may be present more than once if AMS wants to include multiple CLC information fields (Table 693).

16.2.3.17 AAI_CLC-RSP (Co-Located Coexistence Response)

The ABS sends the AAI_CLC-RSP message to AMS on the AMS's Control FID in response to AAI_CLC-REQ.

Table 692—AAI_CLC-RSP message

Name	Size (bits)
CLC Response	variable

Parameters shall be as follows:

CLC Response

Parameters are listed in Table 696.

16.2.3.18 CLC-INFO

The CLC-INFO parameters are applicable to AAI_REG-RSP, AAI_RNG-REQ, AAI_RNG-RSP, AAI_CLC-REQ, AAI_SBC-REQ, AAI_SBC-RSP messages. The following sets of parameters may be included into the CLC-INFO parameters encodings.

Table 693—CLC-INFO parameters

Name	Size (bits)
Information Type	8
CLC Limit	variable
CLC Request	variable
CLC Response	variable
CLC Report	variable

Parameters shall be as follows:

Information Type

This field indicates which of the following fields are included.

CLC Limit

This field is present if (Information Type == 0), and may be used in AAI_REG-RSP message. Table 694 lists all the parameters that are applied.

CLC Request

This field is present if (Information Type == 1), and may be used in AAI_RNG-REQ, AAI_SBC-REQ, or AAI_CLC-REQ messages. Table 695 lists all the parameters that are applied. It may be present more than once if AMS wants to request for multiple CLC classes.

CLC Response

This field is present if (Information Type == 2), and may be used in AAI_RNG-RSP or AAI_SBC-RSP messages. Table 696 lists all the parameters that are applied.

CLC Report

This field is present if (Information Type == 3), and may be used in AAI_CLC-REQ message. Table 698 lists all the parameters that are applied.

Table 694—CLC Limit parameters

Name	Size (bits)
Type I Indicator	1
Type II Indicator	1
Active Class Limit	3
Active Ratio Limit	6
Active Interval Limit	5

Parameters in the CLC Limit field shall be as follows:

Type I Indicator

The bit field set to 1 indicates the CLC limits are provided for Type I CLC class

Type II Indicator

The bit field set to 1 indicates the CLC limits are provided for Type II CLC class

Active Class Limit

The field indicates the maximum number of active CLC classes of the type

Active Ratio Limit

The field indicates the maximum CLC active ratio. If the Active Ratio Limit is x, the maximum CLC active ratio shall be $x/100$.

Active Interval Limit

The field indicates the maximum CLC active interval. If the Active Interval Limit is x, and a frame consists of m AAI subframes, the maximum CLC active interval shall be x x m AAI subframes.

Table 695—CLC Request parameters

Name	Size (bits)
CLC Start Time parameters	8
Scheduling Impact	2
Flag	3
Reserved	3
Start AAI subframe Index	3
CLC active interval of Type I CLC class	8
CLC active cycle of Type I CLC class	21
CLC active bitmap of Type II CLC class with subtype 1	8
CLC active interval of Type II CLC class with subtype 2	8
CLC active cycle of Type II CLC class with subtype 2	8
CLC active cycle of Type II CLC class with subtype 3	2
Extended CLC active bitmap of Type II CLC class with subtype 3	variable
CLC active interval of Type III CLC class	8
padding for byte alignment	variable

CLC Start Time parameters

Its parameters are listed in Table 697.

Scheduling Impact

0b00 (default) = both DL and UL allocations are prohibited in CLC Active Interval

0b01 = only DL allocations are prohibited in CLC Active Interval

0b10 = only UL allocations are prohibited in CLC Active Interval

0b11 = reserved

Flag

0b000: Type I CLC class;

0b001: Type II CLC class subtype 1;

0b010: Type II CLC class subtype 2;

0b011: Type II CLC class subtype 3;

0b100: Type III CLC class

Others: reserved;

Start AAI subframe Index

This field is present if (Flag == 0b000) or (Flag == 0b010), and indicates the subframe index of the first subframe of the CLC active interval.

CLC active interval of Type I CLC class

This field is present if (Flag == 0b000), and indicates the number of AAI subframes of the CLC active interval for Type I CLC class

CLC active cycle of Type I CLC class

This field is present if (Flag == 0b000), and indicates the number of microseconds of the CLC active cycle for Type I CLC class

CLC active bitmap of Type II CLC class with subtype 1

This field is present if (Flag == 0b001), Setting a bit of the field to "1" indicates the corresponding AAI subframe in each frame is in CLC active interval

CLC active interval of Type II CLC class with subtype 2

This field is present if (Flag == 0b010), and indicates the number of AAI subframes of the CLC Active Interval for Type II CLC class with subtype 2

CLC active cycle of Type II CLC class with subtype 2

This field is present if (Flag == 0b010) and, and indicates the number of frames of the CLC Active Cycle for Type II CLC class with subtype 2

CLC active cycle of Type II CLC class with subtype 3

This field is present if (Flag == 0b011), and indicates the length of the CLC active cycle in the unit of frame. If the value of this field is x, the length of Extended CLC Active Bitmap is calculated as $x + 2$. This field shall be set to one of the following values: 0, 1, and 2.

Extended CLC active bitmap of Type II CLC class with subtype 3

This field is present if (Flag == 0b011). Setting a bit of the field to "1" indicates the corresponding AAI subframe in each CLC active cycle is in CLC active interval. If the CLC active cycle is x frames, and a frame consists of m AAI subframes, the length of this field shall be x x m.

CLC active interval of Type III CLC class

This field is present if (Flag == 0b100), and indicates the number of superframes of the CLC active interval for Type III CLC class

Table 696—CLC Response parameters

Name	Size (bits)
Confirmed Action	8
CLC Start Time parameters	8 x n

Confirmed Action

Bit #i of the field set to "0" indicates that ABS confirms the termination of the existing CLC class with CLC ID = i, or the CLC class with CLC ID = i does not exist.

Bit #i of the field set to "1" indicates that ABS confirms the activation of the CLC class with CLC ID = i. For existing CLC ID, the ABS confirms the existing configuration, the reconfiguration or the replacement if it is requested by the MS.

CLC Start Time parameters

This field is included for each Type II or III CLC class that ABS configures its starting time differently from what is recommended by AMS, and its parameters is listed in Table 697—. If the number of configured CLC classes is n, the size of this field is calculated as n x 8.

Table 697—CLC Start Time parameters

Name	Size (bits)
CLC ID	3
Start Superframe Number	3
Start Frame Index	2

Parameters shall be as follows:

CLC ID

An integer number (0~7) to uniquely identify a CLC class

Start Superframe Number

The 3 LSB of the superframe number of CLC start time

Start Frame Index

The frame index of CLC start time

Table 698—CLC Report parameters

Name	Size (bits)
Report Type	8
Interference Level	8

Parameters shall be as follows:

Report Type

This field indicates which of the following fields are included.

Interference Level

This field is present if (Report Type == 0), and indicates the average power level over one OFDMA symbol in unit of 1 dBm with the range from -127dBm to 127dBm received at the AMS from its co-located non 802.16 radios when they are active

16.2.3.19 AAI_FFR-CMD (FFR Command) Message

An AAI_FFR-CMD message shall be transmitted by the ABS to instruct the AMS to perform measurement over specific frequency partition(s). Table 699— lists the parameters to be included into the AAI_FFR-CMD message:

Table 699—AAI_FFR-CMD message format

Syntax	Size (bits)	Notes
AAI_FFR-CMD_Message_format() {	-	-
Control Message Type	8	-
Frequency Partition Bitmap	FPCT	Each bit indicates the interference statistics report status of corresponding Frequency Partition. 0b0:no report interference statistics 0b1: report interference statistics FPCT: the number of Frequency Partition defined in Table 777 to Table 781 Frequency Partition Bitmap shall contain at least one bit with value "1". The LSB indicates the lowest available FP and the MSB indicates the highest available FP where the size of an available FP is bigger than zero.
Reporting Type	4	Each bit indicates if one type of report is required to be sent by AMS. If one bit has value '1', it indicates the specific report type is required to be sent, otherwise it indicates the specific report type is not required to be sent. At least 1 bit needs to be set to value '1'. LSB#0: Interference-Mean LSB#1: Interference-Variance LSB#2: SINR-Mean LSB#3: SINR-Variance
Frame Offset	8	The offset (in units of frames) from the current frame in which the AAI_FFR-REP message shall be transmitted on the unsolicited UL resource.
Padding	Variable	if needed for alignment to byte boundary
}		

16.2.3.20 AAI_FFR-REP (FFR Report) Message

An AAI_FFR-REP message is sent by an AMS to report the interference statistics of frequency partition. Table 700 shows the parameters for AAI_FFR-REP message:

Table 700—AAI_FFR-REP message format

Syntax	Size (bits)	Notes
AAI_ FFR-REP _Message_format() {	—	—
Control Message Type	8	—
Frequency Partition Bitmap	FPCT	Each bit indicates the interference statistics report status of corresponding Frequency Partition. 0b0:no report interference statistics 0b1: report interference statistics FPCT: the number of Frequency Partitions defined in Table 777 to Table 781, Frequency Partition Bitmap shall have at least one bit having value '1'. The LSB indicates the lowest available FP and the MSB indicates the highest available FP where the size of an available FP is bigger than zero.
Reporting Type	4	Each bit indicates if one type of report is required to be sent by AMS. If one bit has value '1', it indicates the specific report type is required to be sent, otherwise it indicates the specific report type is not required to be sent. At least 1 bit needs to be set to value '1'. LSB#0: Interference-Mean LSB#1: Interference-Variance LSB#2: SINR-Mean LSB#3: SINR-Variance
for (n=0; n<N_Bitmap_1; n++) {		N_Bitmap_1: number of bit '1' in Frequency Partition Bitmap
If(LSB#0 in Reporting Type == 1){		
Interference Measurement Report for nth FP-Mean	8	Per subcarrier receiving power(Noise and intercell interference) -134dBm to -30dBm in units of 1dB. -134dBm is encoded as 0x00, -30dB is encoded as 0x68, 0x69 to 0xFF is reserved.
}		

Table 700—AAI_FFR-REP message format

Syntax	Size (bits)	Notes
If(LSB#1 in Reporting Type == 1){		
Interference Measurement Report for nth FP-Variance	4	0dB to 15dB in units of 1dB
}		
If(LSB#2 in Reporting Type == 1){		
SINR Measurement Report for nth FP– Mean	8	-16dB to 53dB in units of 0.5dB -16dB is encoded as 0x00, 53dB is encoded as 0x8A, 0x8B-0xFF are reserved
If(LSB#3 in Reporting Type == 1){		
SINR Measurement Report for nth FP–Variance	4	0dB to 15dB in units of 1dB
}		
Padding	variable	if needed for alignment to byte boundary
}		

16.2.3.21 AAI_DREG-REQ message

The following parameters shall be included in AAI_DREG-REQ message:

Control Message Type

De-registration_Request_Code

0x00: AMS deregistration request from ABS and network

0x01: request for AMS deregistration from serving ABS and initiation of AMS idle mode.

0x02: response for the unsolicited AAI_DREG-RSP message with action code 0x05 by the ABS.

0x03: reject for the unsolicited AAI_DREG-RSP message with action code 0x05 by the ABS. This code is applicable only when an AMS has a pending UL data to transmit.

0x04: request for AMS deregistration from servinng ABS to enter DCR mode

0x05-0x07: reserved

When De-registration_Request_Code is 0x01, the following parameters shall be included in the AAI_DREG-REQ message.

Idle Mode Retain Information element

Paging cycle request

When De-registration_Request_Code is 0x01, the following parameter may be included in the AAI_DREG-REQ message.

Mobility information

00: Fast

01: Medium

10: Slow

11: reserved

When De-registration_Request_Code is 0x04, the following parameters shall be included in the AAI_DREG-REQ message.

Idle Mode Retain Information element

16.2.3.22 AAI_DREG-RSP message

The following parameters shall be included in AAI_DREG-RSP message:

Control message type

Action code

0x00: AMS shall immediately terminate service with the ABS and should attempt network entry at another ABS.

0x01: AMS shall listen to the current ABS but shall not transmit until a RES-CMD message or AAI_DREG-RSP message with action code 0x02 or 0x03 is received.

0x02: AMS shall listen to the current ABS but only transmit on the control connection.

0x03: AMS shall return to normal operation and may transmit on any of its active connections.

0x04: This option is valid in response to a AAI_DREG-REQ message with De-Registration Request Code=0x00. The AMS shall terminate current Normal Operation with the ABS.

0x05: AMS shall begin idle mode initiation: a) to signal AMS to begin idle mode in unsolicited manner or b) to allow AMS to transmit AMS-initiated idle mode request at the REQ-Duration expiration

0x06: This option is valid only in response to a AAI_DREG-REQ message with De-Registration Code 0x01: a) to reject AMS-initiated idle mode request or b) to allow AMS to transmit AMS-initiated idle mode request at the REQ-Duration expiration

0x07: This option is valid in response to a AAI_DREG-REQ message with De-registration-request-code= 0x01.

0x08: This option is valid only in response to an AAI_DREG-REQ message with De-Registration Request Code 0x04 to allow retention of the AMS's connection information

0x09: This option is valid only in response to an AAI_DREG-REQ message with De-Registration Request Code 0x04 to reject retention of the AMS's connection information.

0x10-0x15: reserved

When the action code is set to 0x05 or 0x07, the following parameters shall be included in AAI_DREG-RSP message.

Paging information

Paging cycle

Paging offset (4bits)

0x00: 0 superframe

0x01: 8 superframes

0x02: 16 superframes

0x03: 32 superframes

0x04-0x0f: reserved

Paging group ID

Paging controller ID

Idle Mode Retain Information

Deregistration Identifier

When more than one paging groups are assigned to an AMS, multiple Paging group IDs and the same number of paging offsets that corresponds to the Paging group ID shall be included in the AAI_DREG-RSP message.

When the action code is set to 0x05 or 0x06 or 0x07, the following parameter may be included in the AAI_DREG-RSP message.

REQ-Duration.

When the action code is set to 0x08, the following parameters shall be included in AAI_DREG-RSP message.

Idle Mode Retain Information

Deregistration identifier (DID)

16.2.3.23 AAI_SLP-REQ

An AMS in Active Mode may use the AAI_SLP-REQ message with Request_Code = 0b01(i.e., Enter Sleep Mode) to request a permission to enter Sleep Mode. The AMS in Sleep Mode can change the Sleep Cycle settings by transmitting AAI_SLP-REQ with Operation = 0b10 (i.e., Change Sleep Cycle settings). The AMS in Sleep Mode can exit from Sleep Mode by transmitting AAI_SLP-REQ with Operation = 0b00 (i.e., Exit from Sleep Mode).

Table 701—parameters for AAI_ SLP-REQ

Name	Value	Usage
Operation	0b00 : Exit from Sleep Mode 0b01 : Enter Sleep Mode 0b10 : Change Sleep Mode 0b11 : Switch Sleep Cycle setting	This indicates operation request type of AAI_SLP-REQ message
SCID	0~15	Sleep Cycle ID. This field appears when **Operation** is not 0b00.
Start Frame Number	0~63	Least significant 6 bits of Frame Number. This field appears when Operation is not 0b00
TIMF	0~1	Traffic Indication Message Flag 0 : AAI_TRF-IND message is not sent for the AMS 1 : AAI_TRF-IND message is sent to the AMS during every Listening Window This field appears when **Operation** is 0b01 or 0b10.
LWEF	0~1	Listening window Extension Flag. This field appears when **Operation** is 0b01 or 0b10.

Table 701—parameters for AAI_ SLP-REQ

Name	Value	Usage
NSCF	0b00~0b11	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 x previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = Reserved This field appears when **Operation** is 0b01 or 0b10.
Initial Sleep Cycle	0~15	This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps sleep state in Sleep Mode (measured in frames). This field appears when **Operation** is 0b01 or 0b10.
Final Sleep Cycle	0~1023	This indicates assigned duration for the Final Sleep Cycle (measured in frames). This field appears when **Operation** is 0b01 or 0b10.
Listening Window	0~63	Assigned duration of AMS's default Listening Window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. This field appears when **Operation** is 0b01 or 0b10.
Listening subframe bitmap	Each bit in the bitmap indicates: 1: AMS wakes up at the specific AAI subframe 0: AMS does not wake up at the specific AAI subframe	The bitmap indicates the sub-frames in each frame where the AMS needs to remain awake The size of the bitmap equals to the number of AAI subframes of a frame. Bit #0 is mapped to the first AAI subframe. This field appears when **Operation** is 0b01 or 0b10.
New Initial Sleep Cycle	0~31	When the current Sleep Cycle is reset, if this value is included, the current Sleep Cycle shall be reset to this value. Otherwise, the current Sleep Cycle may be reset to Initial Sleep Cycle or may be updated to min (2 x Previous Sleep Cycle, Final Sleep Cycle). This field appears when **Operation** is 0b01 or 0b10 and NSCF equals to 0b10.
T_AMS	0~31	This timer is for Listening Window Extension of AMS. This field appears when **Operation** is 0b01 or 0b10 and **LWEF** equals to 1.

Parameters shall be as follows

Operation

This indicates operation request type of AAI_SLP-REQ message.

0b00 = AAI_SLP-REQ message is transmitted to exit from sleep Mode

0b01 = AAI_SLP-REQ message is transmitted to enter sleep Mode

0b10 = AAI_SLP-REQ message is transmitted to change the sleep Cycle change

0b10 = AAI_SLP-REQ message is transmitted to switch Sleep Cycle setting which has been negotiated since the AMS entered Sleep Mode

SCID

Assigned Sleep Cycle identifier. The ID shall be unique within the AMS. This ID may used in further AAI_SLP-REQ/RSP message for changing/switching the Sleep Cycle setting

LWEF

Listening window Extension Flag. If LWEF = 0, indicates that the Listening window is of fixed duration. Otherwise, it is extensible.

TIMF

1 = ABS is requested to transmit an AAI_TRF-IND message during the AMS's Listening Window. When the ABS has DL pending unicast traffic for the AMS, the ABS shall inform the AMS of positive traffic indication via AAI_TRF-IND message.

0 = Traffic Indication via AAI_TRF-IND is not required

NISCF

This indicates the inclusion of New Initial Sleep Cycle in AAI_SLP-REQ message.

Start_Frame_Number

Start frame number for first Sleep Cycle. This represents the 6 significant bits of frame number in which AMS wants to enter the first sleep state in Sleep Mode. .

Initial_Sleep_Cycle

This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps sleep state in Sleep Mode (measured in frames). The length of Initial Sleep Cycle shall be equal or longer than the default Listening Window.

Final Sleep Cycle

This indicates assigned duration for the Final Sleep Cycle (measured in frames).

Listening_Window

Assigned duration of AMS's default Listening Window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled

Listening sub-frame bitmap

The bitmap indicates the sub-frames in each frame where the AMS needs to remain awake. Most significant bit is mapped to the 1st AAI subframe.

If this value is set to 0xF, the AMS shall remain awake during entire sub-frames in each frame during Listening Window.

New Initial Sleep Cycle

When the current Sleep Cycle is reset, if this value is included, the current Sleep Cycle shall be reset to this value. Otherwise, the current Sleep Cycle shall be reset to Initial Sleep Cycle.

T_AMS

This timer is required in AMS for Listening Window Extension. If LWEF =1, it shall be included in AAI_SLP-RSQ.

16.2.3.24 AAI_SLP-RSP

The AAI_SLP-RSP message shall be sent from ABS to an AMS in response to an AAI_SLP-REQ message. The ABS may send the AAI_SLP-RSP message in unsolicited manner with Response_Code = 0b00 (i.e., Request by ABS in Unsolicited manner).

If the request sent by an AMS is rejected by an ABS, the AMS shall not retransmit the AAI_SLP-REQ message before the duration, indicated by the REQ_duration in AAI_SLP-RSP with Response_Code = 0b10 (i.e., Rejection of AAI_SLP-REQ), expires.

Table 702—parameters for AAI_ SLP-RSP

Name	Value	Usage
Response_Code	0b00 : Request by ABS in Unsolicited manner 0b01 : Approval of AAI_SLP-REQ 0b10 : Rejection of AAI_SLP-REQ 0b11 : Reserved	This indicates response type of AAI_SLP-RSP message.
Operation	0b00 : Exit Sleep Mode 0b01 : Enter Sleep Mode 0b10 : Change Sleep Mode 0b11 : Switch Sleep Cycle setting	This indicates operation type of AAI_SLP-RSP message. This field appears when Response_Code is 0b00 or 0b01.
SCID	0~15	Sleep Cycle ID This field appears when Response_Code is 0b00 or 0b01 and Operation is not 0b00.
CQI_Operation	0~2	0: the CQICH assigned to the AMS is kept 1: the CQICH is de-allocated at the frame specified by Start_Frame_Number 2: the CQICH is automatically de-allocated at the beginning of the sleep window whenever the CQICH is newly assigned to the AMS during the Listening Window. This field appears when Response_Code is 0b00 or 0b01 and Operation is not 0b00

Table 702—parameters for AAI_ SLP-RSP

Name	Value	Usage
Start Frame Number	0~63	Least Significant 6 bits of Frame Number. This field appears when Response_Code is 0b00 or 0b01 and Operation is not 0b00
TIMF	0~1	Traffic Indication Message Flag 0 : AAI_TRF-IND message is not sent for the AMS 1 : AAI_TRF-IND message is sent to the AMS during every Listening Window This field appears when Response_Code is 0b00 or 0b01 and Operation is 0b01 or 0b10.
LWEF	0~1	Listening window Extension Flag.. This field appears when Response_Code is 0b00 or 0b01 and Operation is 0b01 or 0b10.
NSCF	0b00~0b11	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 x previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = Reserved This field appears when Response_Code is 0b00 or 0b01 and Operation is 0b01 or 0b10.
Initial Sleep Cycle	0~15	This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps sleep state in Sleep Mode (measured in frames). This field appears when Response_Code is 0b00 or 0b01 and Operation is 0b01 or 0b10.
Final Sleep Cycle	0~1023	This indicates assigned duration for the Final Sleep Cycle (measured in frames). This field appears when Response_Code is 0b00 or 0b01 and Operation is 0b01 or 0b10.
Listening Window	0~63	Assigned duration of AMS's default Listening Window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. This field appears when Response_Code is 0b00 or 0b01 and Operation is 0b01 or 0b10.

Table 702—parameters for AAI_ SLP-RSP

Name	Value	Usage
Listening sub-frame bitmap	Each bit in the bitmap indicates: 1: AMS wakes up at the specific AAI subframe 0: AMS does not wake up at the specific AAI sub-frame	The bitmap indicates the sub-frames in each frame where the AMS needs to remain awake The size of the bitmap equals to the number of AAI subframes of a frame. This field appears when Response_Code is 0b00 or 0b01 and Operation is 0b01 or 0b10.
SLPID	0~1023	This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID and SLP Group ID while the AMS is still in sleep mode. This field appears when Response_Code is 0b00 or 0b01, Operation is 0b01 or 0b10 and TIMF equals to 1.
New Initial Sleep Cycle	0~63	When the current Sleep Cycle is reset, if this value is included, the current Sleep Cycle shall be reset to this value. Otherwise, the current Sleep Cycle may be reset to Initial Sleep Cycle or may be updated to min (2 x Previous Sleep Cycle, Final Sleep Cycle). This field appears when Response_Code is 0b00 or 0b01, Operation is 0b01 or 0b10 and NSCF equals to 0b10.
T_AMS	0~31	This timer is for Listening Window Extension of AMS. This field appears when Operation is 0b01 or 0b10 and LWEF equals to 1.
REQ_duration	0~255	Waiting value for the AAI_SLP-REQ message retransmission , which is the Least Significant 8 bits of Frame Number. This field appears when Response_Code is 0b10.

Response_Code

This indicates response type of AAI_SLP-RSP message.

0b00 = AAI_SLP-RSP message is transmitted in unsolicited manner

0b01 = AAI_SLP-RSP message is transmitted to approve the request sent by AMS

0b10 = AAI_SLP-RSP message is transmitted to reject the request sent by AMS

Operation

This indicates operation type of AAI_SLP-RSP message.

0b00 = Approves/Requests the exit from sleep Mode

0b01 = Approves/Requests entrance to sleep Mode

0b10 = Approves/Requests the change of an existing Sleep Cycle Setting

0b10 = Approves/Requests the switch of a Sleep Cycle setting which has been negotiated since the AMS entered Sleep Mode

SCID

Assigned Sleep Cycle Identifier. The ID shall be unique within the AMS. This ID may used in further AAI_SLP-REQ/RSP message for changing/switching the Sleep Cycle setting

LWEF

Listening window Extension Flag. If LWEF = 0, indicates that the Listening window is of fixed duration. Otherwise, it is extensible.

TIMF

1 = ABS will transmit an AAI_TRF-IND message during an AMS's Listening Window. When the ABS has DL pending data traffic for the AMS, the ABS shall inform the AMS of positive traffic indication via AAI_TRF-IND message.

0 = Traffic Indication via AAI_TRF-IND is disabled

NISCF

This indicates the inclusion of New Initial Sleep Cycle in AAI_SLP-RSP message.

Start_Frame_Number

Start frame number for first sleep window. This represents the 6 significant bits of frame number in which AMS enters the first sleep state in Sleep Mode.

Initial_Sleep_Cycle

This indicates an assigned duration for the initial sleep cycle during which an AMS keeps sleep state in Sleep Mode (measured in frames). The length of Initial Sleep Cycle shall be equal or longer than the default Listening Window.

Final Sleep Cycle

This indicates assigned duration for the final sleep cycle (measured in frames).

Listening_Window

Assigned Duration of AMS's default Listening Window (measured in frames). Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled.

Listening sub-frame bitmap

The bitmap indicates the sub-frames in each frame where the AMS needs to remain awake. Most significant bit is mapped to the 1st AAI subframe.

If this value is set to 0xF, the AMS shall remain awake during entire sub-frames in each frame during Listening Window.

SLPID

This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID and SLP Group ID while the AMS is still in sleep mode.

REQ-duration

Waiting value for the AAI_SLP-REQ message retransmission (measured in MAC frames) when AMS's request is rejected by ABS: the AMS may retransmit the AAI_SLP-REQ message after at least the frame designated by REQ-duration.

New Initial Sleep Cycle

When the current Sleep Cycle is reset, if this value is included, the current Sleep Cycle shall be reset to this value. Otherwise, the current Sleep Cycle shall be reset to Initial Sleep Cycle.

T_AMS

This timer is required in AMS for Listening Window Extension. If LWEF =1, it shall be included in AAI_SLP-RSP.

16.2.3.25 AAI_TRF-IND

This message, when present, is sent from the ABS to the AMSs. The message is sent in the first frame of AMS' Listening Window. An AMS, that has not been assigned a SLPID, shall ignore this message. The message indicates whether there is DL traffic for AMSs addressed by the AAI_TRF-IND message.

There are two formats for the AAI_TRF-IND message, indicated by the FRMT field. When FRMT = 0, and if the AMS does not find its own SLPID-Group Indication bit-map or Traffic Indication bit-map, the AMS shall consider it as a negative indication and may go back to sleep. When FRMT = 1, and if the AMS does not find its own SLPID in the AAI_TRF-IND message, the AMS shall consider it as a negative indication and may go back to sleep.

Table 703—AAI_TRF-IND message format

Name	Value	Usage
FRMT	0 : It indicates the SLPID bitmap-based traffic indication 1: It indicates the SLPID-based traffic indication	This indicates type of Traffic Indication in AAI_TRF-IND message.
SLPID Group Indication Bitmap	*32bits* *N*-th bit of SLPID-Group Indication Bitmap [MSB corresponds to N = 0] is allocated to SLPID Group that includes AMS with SLPID values from N*32 to N*32+31 0: There is no traffic for any of the 32 AMSs that belong to the SLPID-Group 1: There is traffic for at least one AMS in SLPID-Group.	This field appears when FRMT is set to 0. It indicates the existence of each SLPID group
Traffic Indication Bitmap	*Multiple of 32bits (i.e., 0 ~ 32*32bits)* Each Traffic Indication bitmap comprises multiples of 32-bit long Traffic Indication units. A Traffic Indication unit for 32 SLPIDs is added to AAI_TRF-IND message whenever its SLPID Group is set to 1 32 bits of Traffic Indication Unit (starting from MSB) are allocated to AMS in the ascending order of their SLPID values: 0: Negative indication 1: Positive indication	This field appears when FRMT is set to 0. It indicates the traffic indication for 32 AMSs in each SLPID group
Num_of_SLPIDs	0~63	This field appears when FRMT is set to 1. It indicates the number of SLPID included in AAI_TRF-IND message
SLPID	0~1023	This field appears when FRMT is set to 1. Each SLPID is used to indicate the positive traffic indication for an AMS

Parameters shall be as follows

FRMT

The FRMT field indicates one of the SLPID bit-map based format and the SLPID based format.

SLPID-Group Indication Bitmap

SLPIDs from 0 to 1023 are divided into 32 SLPID-Groups. Therefore, the respective SLPID-Group has the range as follows: SLPID-Group#0 (MSB) corresponds to SLPID = 0…31. SLPID-Group #1 corresponds to SLPID = 32…63. … SLPID-Group#31 corresponds to SLPID = 992…1023. SLPID-Group Indication Bitmap is a 32-bit field where each bit is assigned to the respective SLPID-Group. In other words, the MSB in the field is assigned to SLPID-Group#0, and subsequent bit relates to SLPID-Group #1, etc. The n-th bit (bn), n = 0~31, of SLPID-Group Indication Bitmap shall be interpreted in the following manner: bn = 0 means that there is no traffic for all the 32 AMS belonging to SLPID-Group #n. In this case, the AMS in sleep mode belonging to SLPID-Group #n may return to sleep mode. bn = 1 means that there exists traffic for one or more AMS belonging to SLPID-Group #n. In this case, the AMS in sleep mode belonging to SLPID-Group #n shall read its own Traffic Indication bit-map in AAI_TRF-IND message.

Traffic Indication bit-map

The Traffic Indication bit map comprises the multiples of 32-bit long Traffic Indication Unit for every SLPID-Group with SLPID-Group indication bit = 1. Bits in a 32-bit Traffic Indication unit (starting from MSB) are allocated to AMS to in ascending order of SLPIDs. Each bit signals traffic information for the corresponding AMS as follows:

0: Negative indication

1: Positive indication

Num_of_SLPID

The number of SLPID with positive indication.

SLPID

The SLPID for AMS which has DL pending traffic.

The AAI_TRF-IND may include the following parameters at end of AAI_SLP-REQ message.

SLPID_Update (see xxx)

The SLPID_Update provides a shorthand method for changing the SLPID used by the AMS in sleep mode operation. The SLPID_Update specifies a new SLPID that replaces an old SLPID. The SLPID_Update may contain multiple pairs of Old and New SLPID values for the AMSs. Those SLPID update will be applied from next Listening Window.

16.2.3.26 AAI_TRF_IND-REQ

If the TIMF is set to 1, the AMS shall receive AAI_TRF-IND message in the first frame during its own Listening Window. However, if the traffic indication message is lost or otherwise not detected by the AMS, the AMS shall stay awake for the rest of the Listening Window. If the AMS receives any unicast data during the listening window, then it shall assume that the traffic indication was positive. If the AMS receives neither the traffic indication message nor any unicast data in the Listening Window, the AMS shall send an AAI_TRF_IND-REQ message to the ABS in order to ask which kind of traffic indication (i.e., positive or negative traffic indication) the ABS sent to it. The ABS shall respond to the AMS by sending an AAI_TRF_IND-RSP with traffic indication for the AMS.

Table 704—AAI_TRF_IND-REQ message format

Name	Value	Usage
Frame_Number	0-15	This indicates the least significant 4 bits of frame number in which the AMS expected to receive the AAI_TRF-IND.

Parameters shall be as follows

Frame_Number

This indicates the least significant 4 bits of frame number in which the AMS expected to receive the AAI_TRF-IND.

16.2.3.27 AAI_TRF_IND-RSP

When the ABS receives AAI_TRF_IND-REQ message from an AMS, the ABS shall respond to the AMS by sending AAI_TRF_IND-RSP message with the traffic indication for the AMS. When the AMS receives AAI_TRF_IND-RSP from the ABS, the AMS shall update the current Sleep Cycle based on the Traffic_Indication in the AAI_TRF_IND-RSP.

Table 705—AAI_TRF_IND-RSP message format

Name	Value	Usage
Frame_Number	0-15	Least Significant 4 bits of Frame number
Traffic_Indication	0: Negative Traffic Indication 1: Positive Traffic Indication	It indicates the traffic indication which the ABS has transmitted to the AMS

Parameters shall be as follows

Frame_Number

This indicates the least significant 4 bits of frame number in which the ABS sent the AAI_TRF-IND message to the AMS.

Traffic_Indication

This indicates the traffic indication of which the ABS informed the AMS in the specified frame number.

0 = the ABS sent the negative traffic indication to the AMS in the frame

1 = the ABS sent the positive traffic indication to the AMS in the frame

16.2.3.28 L2 Transfer message (AAI_L2_XFER)

The AAI provides a generic MAC control message called AAI_L2_XFER. This message acts as a generic service carrier for various services including, but not limited to:

Device provisioning bootstrap message to AMS, GPS assistance delivery to AMS, ABS(es) geo-location unicast delivery to AMS, 802.21 MIH transfer, messaging service etc.

This container is also used for 16m messages that are not processed by the ABS or ARS, but are rather processed by network entities beyond the ABS or ARS.

The format of AAI_L2_XFER message is shown in Table 706—

Table 706—Format of the AAI_L2_XFER message

Control Message Type = TBD
Transfer-Type
Sub-Type
Type specific message payload

The enumeration of Transfer-Type is as follows:

a) Transfer-Type = 1; GNSS assistance (DL)
b) Transfer-Type = 2; LBS measurement [Terrestrial meas. and GNSS pseudo ranges] (UL)
c) Transfer-Type = 3; Device Bootstrap (DL/UL)
d) Transfer-Type = 4; WirelessMAN-OFDMA network boundary indication (DL)
e) Transfer-Type = 5; ORAT-MSG (DL)
   a) Sub-Type = 1: GERAN (GSM/GPRS/EGPRS)
   b) Sub-Type = 2: UTRAN
   c) Sub-Type = 3: E-UTRAN
   d) Sub-Type = 4: TDSCDMA
   e) Sub-Type = 5: CDMA2000
f) Transfer-Type = 6: SMS
   a) Sub-Type = SMS data
   b) Sub-Type = SMS confirmation
g) Transfer-Type = 7: MIH Frame
   i) Sub-Type =1 : ES/CS MIH Capability Discovery
   ii) Sub-Type =2 : Event Service
   iii) Sub-Type = 3 : Command Service
   iv) Sub-Type = 4 : Information Service
h) Transfer-Type = 8; ASN control messages for Relay support (DL/UL)
i) Transfer-Type = 9; Emergency Alert
j) Transfer-Type = 10-127; reserved

k) Transfer-Type = 128-255; Vendor specific types

Some of these messages have sub-types that are further defined in the type specific message payload. For example, for Transfer-Type=1, the GNSS assistance may be for GPS, Galileo or other satellite systems, which would be specified as sub-types of Transfer-Type=1.

16.2.3.29 AAI_System Configuration Descriptor (SCD) Message

An AAI_SCD shall be transmitted by the ABS at a periodic interval to define a system configuration.

```
-- ASN1START
AAI_SCDMessage :: SEQUENCE {
       Change Configuration Change          INTEGER (0 ~ 15)
       BS_Restart_Count                     INTEGER (0 ~ 15)
       SA_PreamblePartitionforBStype
       Trigger TLV encoding :: = SEQUENCE{}
       DefaultTrigger_Averagingparameter (usedc in equation (1)) :: = INTEGER (0..9)
       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
       NormalizedCINR :: = SEQUENCE {}
       OL_MIMO_Parameters :: = SEQUENCE {
              OL-Region-ON                  INTEGER (0..1) OPTIONAL
              OL-Rank1-Configuration        INTEGER (0..7) OPTIONAL
              SB-OL-Region-2Size            INTEGER (0..15) OPTIONAL
       }
       Parameters_GRA :: = SEQUENCE {}
       -- the periodicity of ranging channel for synchronized AMSs allocation (Table 893)
       -- This is ignored in Femtocell
       periodicityOfRngChSync    INTEGER (0..3),
       -- the parameter ks controlling the start root index of ranging preamble codes for
       synchronized AMSs. This is ignored in Femtocell
       cntlStartCodeOfRngChSync      INTEGER (0..15),
       -- the number of codes for periodic ranging (Table 891). This is ignored in Femtocell
       rangingPreambleCodeSync       INTEGER (0..3)
       ULPC_DataChannel_Parameters :: = SEQUENCE {
       --
              GAMMA_IOT_FP0                        INTEGER (0..15) OPTIONAL
              GAMMA_IOT_FP1                        INTEGER (0..15) OPTIONAL
              GAMMA_IOT_FP2                        INTEGER (0..15) OPTIONAL
              GAMMA_IOT_FP3                        INTEGER (0..15) OPTIONAL
```

```
                Alpha (a)                              INTEGER (0.. 7) OPTIONAL
                Beta (ß)                               INTEGER (0..1) OPTIONAL
                SINRmin_Data                           INTERGER (0..15) OPTIONAL
                SINRmax_Data                           INTERGER (0..15) OPTIONAL
        }
        ULPC_ControlChannel_Parameters :: = SEQUENCE {
                SINR_Target_HARQ      INTEGER (0..15) OPTIONAL
                SINR_Target_SyncRangingINTEGER (0..15) OPTIONAL
                SINR_Target_PFBCH     INTEGER (0..15) OPTIONAL
                SINR_Target_SFBCH_BASEINTEGER (0..15) OPTIONAL
                SINR_Target_SFBCH_DeltaINTEGER (0..7) OPTIONAL
                SINR_Target_BWRequest INTEGER (0..15) OPTIONAL
                GAMMA_IOT_SOUNDINGINTEGER (0..15) OPTIONAL
                SINRmin_SOUNDING      INTERGER (0..15) OPTIONAL
                SINRmax_SOUNDING      INTERGER (0..15) OPTIONAL
        }

        T_ReTx_Interval                       INTERGER (0..8)
        BR_Channel Configuration MIN Access ClassINTERGER (0..4) OPTIONAL
        --Sounding sequence
        -- D is decimation value for frequency division multiplexing
        -- P is maximum cyclic shift for code division multiplexing
        SoundingMultiplexingType              CHOICE {
                decimationValueD      ENUMERATED {decValueD0 (4), decValueD1 (6),
                                      decValueD2 (8), decValueD3 (9), decValueD4 (12),
                                      decValueD5 (16), decValueD6 (18), decValueD7 (36)},
                maxCyclicShiftIndexP  ENUMERATED {csIndexP0 (4), csIndexP1 (6),
                                      csIndexP2 (8), csIndexP3 (9), csIndexP4 (12),
                                      csIndexP5 (16), csIndexP6(18), csIndexP7(36)},
        }
        shiftValueUForSoundingSymbol  INTEGER (0...255),
        RELAY_Support_Parameters :: = SEQUENCE {
                        16m_Relay_zone_AMS_allocation_indicatorINTEGER (0..1) OPTIONAL
        }
}
-- ASN1STOP
```

16.2.3.30 AAI_UL Noise and Interference Level Broadcast Message

An AAI_ULPC_NI broadcast NI values for the UL power control.

```
-- ASN1START
AAI_ULPC_NIMessage ::= SEQUENCE {
```

Table 707—ULPC_DataChannel_Parameters Field Descriptions

Parameters	Description
GAMMA_IOT_FP0, GAMMA_IOT_FP1, GAMMA_IOT_FP2, GAMMA_IOT_FP3,	GAMMA_IOT (γ_{IOT}) is the fairness and IoT control factor, broadcast by the ABS. It has 4 bits to represent the value among {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5}. It is different for each frequency partition (FP0, FP1, FP2, FP3)
Alpha (α)	α is the factor according to the number of receive antennas at the ABS. It is 3 bits to express {1, 1/2, 1/4, 1/8, 1/16, 0, reserved, reserved
Beta(β)	β is set to be 0 or 1 by one bit, which is used to indicate disable or enable of the power de-boosting for uplink multi-stream transmission.
SINRmin_Data	SINRmin_Data is the SINR requirement for the minimum data rate expected by ABS. SINRmin_Data has 4 bits to represent the value in dB among{ ∞ ,-3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4}
SINRmax_Data	SINRmax_Data is the maximum SINR threshold defined by ABS. SINRmmax_Data has 4 bits to represent the value in dB among {10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 34, 36, 38, 40}

```
    UL_NI_Information :: = SEQUENCE {
        IOT_Sounding            INTEGER (0..127) OPTIONAL
        IOT_FP0                 INTEGER (0..127) OPTIONAL
        IOT_FP1                 INTEGER (0..127) OPTIONAL
        IOT_FP2                 INTEGER (0..127) OPTIONAL
        IOT_FP3                 INTEGER (0..127) OPTIONAL
    }
}
```

-- ASN1STOP

For the open-loop power control, UL noise and interference level shall be broadcast to AMSs in the given ABS coverage by ABS. All the UL noise and interference noise level are quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB.

The absolute power level of NI is transformed from IoT level as:

$$NI = P_{TN} + IoT + 10\log 10(\Delta f)$$

Where,

P_{TN} is the thermal noise power density in 0°C

Δf is the subcarrier spacing.

Table 708—ULPC_ControlChannel_Parameters Field Descriptions

Parameters	Description
SINR_Target_HARQ	SINR_Target_HARQ is the HARQ feedback channel target SINR value broadcasted by the ABS. It has 4 bits to represent the value among {-3.5, -3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4} dB
SINR_Target_SyncRanging	SINR_Target_SyncRanging is the synchronized channel target SINR value broadcasted by the ABS. It has 4 bits to represent the value 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
SINR_Target_PFBCH	SINR_Target_PFBCH is the P-FBCH target SINR value broadcasted by the ABS. It has 4 bits to represent the value among {-4.5, -4, -3.5, -3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3} dB
SINR_Target_SFBCH_BASE	SINR_Target_SFBCH_BASE is defined as 4 bits to represent {0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5} dB.
SINR_Target_SFBCH_Delta	SINR_Target_SFBCH_Delta is defined as 3 bits to represent {0, 0.20, 0.21, 0.22, 0.23, 0.24, 0.25, 0.26}
SINR_Target_BWRequest	SINR_Target_BWRequest is the bandwidth request channel target SINR value broadcasted by the ABS. It has 4 bits to represent the value among {-4.5, -4, -3.5, -3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3} dB
GAMMA_IOT_SOUNDING	GAMMA_IOT_SOUNDING is 4 bits to represent the value among {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5}.
SINRmin_SOUNDING	SINRmin_SOUNDING is the minimum SINR requirement for sounding expected by ABS. It has 4 bits to represent the value in dB among { -4, -3.5, -3, -2.5, -2. -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5}
SINRmax_SOUNDING	SINRmax_SOUNDING is the maximum SINR requirement for sounding expected by ABS. It has 4 bits to represent the value in dB among { 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20}

16.2.3.31 AAI_UL_POWER_ADJUST message

An AAI_UL_POWER_ADJUST message shall be transmitted by the ABS to control the transmit power level of AMS.

```
---ASN.1START
AAI_UL_POWER_ADJUST:: = SEQUENCE {
 OFFSET_DATA         INTEGER (0..63)
 OFFSET_CONTROLINTEGER (0..63)
```

```
}
---ASN.1STOP
```

Table 709—AAI_UL_POWER_ADJUST message Field Descriptions

Parameters	Description
OFFSET_DATA	OFFSET_DATA is the transmit power adjustment value transmitted by the ABS. It has 6 bits to represent the value among -15.5 to 16 dB with 0.5 dB step;
OFFSET_CONTROL	OFFSET_CONTROL is the transmit power adjustment value transmitted by the ABS. It has 6 bits to represent the value among -15.5 to 16 dB with 0.5 dB step;

16.2.3.32 AAI_Uplink Power Status Reporting Config (AAI_UL PSR_Config) message

An AAI_UL_PSR_Config message is used to config the AMS uplink power status reporting by unicasting. It is defined as:

```
---ASN.1START
AAI_UL_PSR_Config:: = CHOICE {
 Disable_ReportNULL,
 Enable_ReportSEQUENCE {
 Tx_Power_Report_Threshold_dBINTEGER (0..15)
 Tx_Power_Report_Minimum_IntervalINTEGER (0..15)
 Tx_Power_Report_Periodical_Interval INTEGER (0..15)
 }
}
---ASN.1STOP
```

Table 710—AAI_UL PSR_Config message Field Descriptions

Parameters	Description
Tx_Power_Report_Threshold_dB	Tx_Power_Report_Threshold_dB is a 4 bit unsigned integer value in 0.5 dB steps, the specific value "0b1111" shall be interpreted as "infinite"
Tx_Power_Report_Minimum_Interval	Tx_Power_Report_Minimum_Interval is coded by 4 bit unsigned integer values d representing 2^d frames, the specific value d=0b1111 shall be interpreted as "infinite"
Tx_Power_Report_Periodical_Interval	Tx_Power_Report_Periodical_Interval is coded by 4 bit unsigned integer values d representing 2^d frames, the specific value d=0b1111 shall be interpreted as "infinite"

16.2.3.33 AAI_Uplink Power Status Report (AAI_UL-PSR) message

An AAI_UL_PSR message is used by the AMS to report uplink power status to ABS. It is defined as:

```
---ASN.1START
AAI_UL-PSR:: = SEQUENCE {
Tx_Power_PSD_BaseINTEGER (0..255)
Tx_SIR_DownloadINTEGER (0..1024)
}
---ASN.1STOP
```

Table 711—AAI_UL-PSR message Field Descriptions

Parameters	Description
Tx_Power_PSD_Base	Tx_Power_PSD_Base ($PSD(base)$) is coded using 8 bits in 0.5 dBm steps ranging from -74 dBm (coded 0x00) to 53.5 dBm (coded 0xFF).
Tx_SIR_Download	Tx_SIR_Download (SIR_{DL}) is coded using 10 bits in 0.05 dB steps ranging from -10dB (coded 0x000) to 41.15 dB (coded 0x3ff)..

16.2.3.34 AAI_DL_IM Message

The AAI_DL_IM broadcast message may be transmitted by the ABS to define FFR and multi-BS MIMO parameters.

```
AAI_DL_IM ::= SEQUENCE {
    messageType                    OCTET STRING (SIZE(1)),
    -- ffrPartitionResouceMetric to fp3Power are only transmitted when FPCT > 1
    -- resourceMetricFP2 is transmitted only when FPS2 >0
resourceMetricFP2            INTEGER (0..15) OPTIONAL,
    -- resourceMetricFP3 is transmitted only when FPS3>0
 resourceMetricFP3            INTEGER (0..15) OPTIONAL,
fp2Power                      INTEGER (0..31) OPTIONAL,
    -- fp3Power is transmitted only when FPS3>0
fp3Power                      INTEGER (0..31) OPTIONAL,
-- bsSiInfo to tempBsIdSET are transmitted only when multi-BS MIMO is operated
```

```
bcSiInfo                        CHOICE {
-- in case of two transmit antenna, refer 16.3.7.2.5.6
twoTxBCSI                     BIT STRING (SIZE (8)),
-- in case of four or eight transmit antenna, refer 16.3.7.2.5.6
otherTxBCSI                   BIT STRING (SIZE (16))
 } OPTIONAL,
nipTh1                          INTEGER (0..15) OPTIONAL,
nipTh2                          INTEGER (0..15) OPTIONAL,
cinrTh                          INTEGER (0..15) OPTIONAL,
diversitySetNum                 INTEGER (0..15) OPTIONAL,
    -- Change count in AAI_NBR-ADV for the following BS_index. This
    -- is only transmitted only when diversitySetNum is higher than 0
changeCount             INTEGER (0..255) OPTIONAL,
    -- tempBsidSET is composed of diversitySetNum number of BS_indices.
    -- tempBsidSET is only transmitted only when diversitySetNum is
    -- higher than 0
tempBsidSET                     SEQUENCE {
bsidSet1                      INTEGER (0..255) OPTIONAL,
bsidSet2                      INTEGER (0..255) OPTIONAL,
bsidSet3                      INTEGER (0..255) OPTIONAL,
bsidSet4                      INTEGER (0..255) OPTIONAL,
bsidSet5                      INTEGER (0..255) OPTIONAL,
bsidSet6                      INTEGER (0..255) OPTIONAL,
bsidSet7                      INTEGER (0..255) OPTIONAL,
bsidSet8                      INTEGER (0..255) OPTIONAL,
bsidSet9                      INTEGER (0..255) OPTIONAL,
bsidSet10                     INTEGER (0..255) OPTIONAL,
bsidSet11                     INTEGER (0..255) OPTIONAL,
bsidSet12                     INTEGER (0..255) OPTIONAL,
bsidSet13                     INTEGER (0..255) OPTIONAL,
bsidSet14                     INTEGER (0..255) OPTIONAL,
bsidSet15                     INTEGER (0..255) OPTIONAL}
}
}
```

-- ASN1STOP

Table 712—Parameters for AAI_DL-IM Message

Name	Value	Usage
resourceMetricFP2	4	Resource_Metric_FP2 Resource Metric of the first power de-boosted frequency partition which is defined in Table 761. There is no this field if FPCT=1 which is defined in Table 777 to Table 781

Table 712—Parameters for AAI_DL-IM Message

Name	Value	Usage
resourceMetricFP3	4	Resource_Metric_FP3 Resource Metric of the second power de-boosted frequency partition which is defined in Table 761. There is no this filed if FPS3=0 which is defined in Table 777 to Table 781
fp2Power	5	FP2_power[dB] = 0b00000: -Inf Otherwise -10+(fp2Power-1)*0.5
fp3Power	5	FP3_power[dB] = 0b00000: -Inf Otherwise -10+(fp3Power-1)*0.5
bcSiInfo	8 bits for Nt=2 and 16 bits for Nt =4 or 8	BC_SI If LSB#n is '1', the nth codeword within the codebook or its subset is recommended, otherwise the codeword is restricted. The code books or its subset are defined in section 16.3.7.2.5.6 for Nt=2, 4 or 8 respectively.
nipTh1	4	NIP_th_1 The value shall be interpreted as unsigned 4bits with units of 0.5 dB, 0b0000 is interpreted as -7.5dB and 0b1111 is interpreted as 0.0dB NIP threshold for Single BS precoding with Multi-BS Coordination trigger
nipTh2	4	NIP_th_2 The value shall be interpreted as unsigned 4bits with units of 0.5 dB, 0b0000 is interpreted as -7.5dB and 0b1111 is interpreted as 0.0dB NIP threshold for DL Multi-BS Joint MIMO Processing trigger
cinrTh	4	CINR_th The value shall be interpreted as signed 4bits with units of 0.5 dB, 0b1111 is interpreted as -4.0dB and 0b0111 is interpreted as 3.5dB Used together with NIP_th_1 or NIP_th_2 for Multi-BS MIMO trigger
diversitySetNum	4	The number of ABSs coordinating with the serving ABS for single BS precoding with multi-BS coordination
changeCount	8	Change count in AAI_NBR-ADV for the following BS_index

Table 712—Parameters for AAI_DL-IM Message

Name	Value	Usage
tempBsidSET	8	Indicates diversity set members Refers to the ABS index of the AAI_NBR_ADV. Temp_BSID is derived from this BS_index. The Temp_BSID is the order of the ABSs in respect of the BS_index. The first Temp_BSID represents the ABS that is referred by the first BS_index in AAI_DL_IM message.
Change_count	8	Change count in AAI_NBR-ADV for the following BS_index
BS_index	8	Indicates diversity set members Refers to the ABS index of the AAI_NBR_ADV. Temp_BSID is derived from BS_index by TBD manner

16.2.3.35 AAI MSG-ACK

The ABS and AMS may use AAI_MSG-ACK to indicate the reception of a MAC control message. When receiving a message over control connection with Polling bit set to 1 in MCEH, the ABS and AMS shall transmit AAI_MSG-ACK as an acknowledgement to the reception of the message. The AAI_MSG-ACK shall include the following information:

- SN retrieved from MCEH of the received MAC PDU
- Control Connection Channel ID (CCC ID) that the MAC control message is received

16.2.3.36 AAI_NBR-REQ

An AMS may send the AAI_NBR-REQ message to request the AAI_NBR-ADV message. The request should not contain the BSIDs for which full information is already provided in the AAI_NBR-ADV message.

The AAI_NBR_REQ message shall include following parameters:

- LSB of Requested BS ID: 16 bits
  - 16-bit LSB of unique 48-bit identifier of neighbor BS

16.2.3.37 AAI_SingleBS_MIMO_FBK

The AAI_SingleBS_MIMO_FBK message format is defined in Table 713. This message is used by AMS as a response to a Feedback Polling A-MAP IE requesting to feedback the subband information for MFM 2, 3, 5 or 6. It is also used for the feedback of the transmit correlation matrix when the ABS is equipped with 8 transmit antennas. Variables $MaxM_t$, Codebook_subset, Codebook_mode, Num_best_subbands and Measurement Method Indication are indicated in the Feedback Polling A-MAP IE. N_t is the number of transmit antennas at the ABS, indicated in S-SFH SP3. Best_subbands_index is encoded as described in section 16.3.9.3.1.4. The feedback information reported in the AAI_SingleBS_MIMO_FBK message depends on currently assigned feedback processes and reporting times.

Table 713—AAI_SingleBS_MIMO_FBK message format

Syntax	Size (bit)	Notes
AAI_SingleBS_MIMO_FBK_Message_Format {		
MAC Control Message Type	8	
If (((MFM == 3) and (q > 0)) or ((MFM == 6) and (q > 0)) or ((MFM == 4) and (q > 0)) or ((MFM == 7) and (q > 0)))){		MFM and long period q are indicated in Feedback Polling A-MAP IEs relevant to currently assigned feedback processes
For (i=1; i<= N_t; i++){		
i-th diagonal entry of correlation matrix	1	As defined in section 16.3.7.2.5.6
For (j=i+1; j<= N_t; j++){		
(i,j)-th entry of correlation matrix	4	As defined in section 16.3.7.2.5.6
}		
}		
}		
MFM_bitmap	4	Bitmap to indicate the MFMs for which the AMS is sending feedback. It shall be consistent with current feedback allocations corresponding to the MFM requested by Feedback Polling IE. LSB #0: MFM 2 LSB #1: MFM 3 LSB #2: MFM 5 LSB #3: MFM 6
If (LSB #0 in MFM_bitmap == 1){		MFM 2 as specified in Feedback Polling A-MAP IE
Best_subbands_index	Variable	
STC_Rate	Variable	If Measurement Method Indication=0b0: $MaxM_t = 2$: 1 bit $MaxM_t = 3$ or 4: 2 bits $MaxM_t > 4$: 3 bits This field shall be omitted if Measurement Method Indication=0b1 or if $MaxM_t = 1$.
For (m=0; m < Num_best_subbands; m ++){		The subbands are sorted in order of increasing logical index
Subband CQI	4	MCS of m-th subband indicated by Best_subbands_index
}		
}		

Table 713—AAI_SingleBS_MIMO_FBK message format

Syntax	Size (bit)	Notes
If (LSB #1 in MFM_bitmap == 1){		MFM 3 as specified in Feedback Polling A-MAP IE
Best_subbands_index	Variable	
STC_Rate	Variable	$MaxM_t$ = 2: 1 bit $MaxM_t$ = 3 or 4: 2 bits $MaxM_t$ > 4: 3 bits This field shall be omitted if $MaxM_t$ = 1.
For (m=0; m < Num_best_subbands; m ++){		The subbands are sorted in order of increasing logical index
Subband CQI	4	MCS of m-th subband indicated by Best_subbands_index
Subband PMI	Variable	PMI of m-th subband indicated by Best_subbands_index N_t = 2: 3 bits N_t = 4 and Codebook_subset = 0b0: 6 bits N_t = 4 and Codebook_subset = 0b1: 4 bits N_t = 8: 4 bits
}		
}		
If (LSB #2 in MFM_bitmap == 1){		MFM 5 as specified in Feedback Polling A-MAP IE
Best_subbands_index	Variable	
For (m=0; m < Num_best_subbands; m ++){		The subbands are sorted in order of increasing logical index
Subband CQI	4	MCS of m-th subband indicated by Best_subbands_index
Stream index	Variable	Best stream index of m-th subband indicated by Best_subbands_index If Measurement Method Indication=0b0: $MaxM_t$ = 2: 1 bit $MaxM_t$ = 3 or 4: 2 bits If Measurement Method Indication=0b1: 1 bit
}		
}		
If (LSB #3 in MFM_bitmap == 1){		MFM 6 as specified in Feedback Polling A-MAP IE
Best_subbands_index	Variable	
For (m=0; m < Num_best_subbands; m ++){		The subbands are sorted in order of increasing logical index
Subband CQI	4	MCS of m-th subband indicated by Best_subbands_index

Table 713—AAI_SingleBS_MIMO_FBK message format

Syntax	Size (bit)	Notes
Subband PMI	Variable	PMI of m-th subband indicated by Best_subbands_index N_t = 2: 3 bits N_t = 4 and Codebook_subset = 0b0: 6 bits N_t = 4 and Codebook_subset = 0b1: 4 bits N_t = 8: 4 bits
}		
}		
}		

16.2.3.38 AAI_MultiBS_MIMO_FBK

The AAI_ MultiBS _MIMO_FBK message format is defined in Table 714. This message is used by AMS as a response to a Feedback Polling A-MAP IE requesting multi-BS MIMO feedback.

Table 714—AAI_MultiBS_MIMO_FBK message format

Syntax	Size (bit)	Notes
AAI_MultiBS_MIMO_FBK_Message_Format {		
MAC Control Message Type = xx		
if (ICT ==0b10 or 0b11){		Co-MIMO or CL-MD
CQI	4	
}		
for (*i* = 1; *i* <= N_multiBS_reports; *i*++) {		
if (ICT == 0b00 or 0b01){		
Temp_BSID	4	Diversity set member ID
}		
PMI	Variable	PMI from the rank-1 base codebook or base codebook subset N_t=2: 3 bits N_t=4: 4 bits N_t=8: 4 bits
If (ICT==0b00 or 0b01) {		

Table 714—AAI_MultiBS_MIMO_FBK message format

Syntax	Size (bit)	Notes
Additional measurement metric	2	SINR gain assuming the reported PMI set is coordinated. This can be used for resolving conflict from multiple AMS. 0b00: 0.25dB 0b01: 0.50dB 0b10: 1.00dB 0b11: above 1.50dB
PMI_subset_size	1	Indication whether 1 PMI or a PMI set is feedback 0b0: 1 PMI 0b1: multiple PMIs
If (PMI_subset_size == 0b1){		
PMI_coordination_subset	1	Set of PMIs from the rank-1 base codebook or base codebook subset 0b0: correlation level n1 (as defined in section 16.5.1.2.1) 0b1: correlation level n2 (as defined in section 16.5.1.2.1)
}		
}		
If (ICT==0b10 or 0b11) {		ICT is defined in Feedback Polling A-MAP IE
CPMI	3	Concatenating PMI for neighboring cells.
}		
}		
}		

16.2.3.39 AAI_MULTI_BS_MIMO-REQ

The AAI_MULTI_BS_MIMO-REQ message shall be transmitted by the AMS to report its preference on single BS precoding with Multi-BS MIMO coordination or multi-BS joint MIMO processing.

---ASN.1START

```
AAIMULTIBSMIMOREQ Message::SEQUENCE{
  Multi-BS MIMO Request  Boolean,
  NumBS                  INTEGER (1..8)
-- NIPParam shall be transmitted from strongest to weakest
  NIPList::=SEQUENCE (SIZE (1..NumBS)) OF NIPParam
  NIPParam::=SEQUENCE{
  Temp_BSID   INTEGER (0..15),
  NIPValue   INTEGER (0..15)
}
```

--ASN1STOP

Table 715—Parameters for AAI_MULTI_BS_MIMO-REQ message

Name	Value	Usage
Multi-BS MIMO Request		0: Single-BS precoding with Multi-BS Coordination 1: Multi-BS Joint MIMO Processing
NIP Value		Absolute NIP value encoded as difference to NIP_th_1 when Multi-BS MIMO Request = 0. The value shall be interpreted as unsigned 2bits with units of 0.5 dB, 0b00 is interpreted as NIP_th1 and 0b11 is interpreted as NIP_th1+1.5dB or higher Absolute NIP value encoded as difference to NIP_th_2 when Multi-BS MIMO Request = 1. The value shall be interpreted as unsigned 2bits with units of 0.5 dB, 0b00 is interpreted as NIP_th2 and 0b11 is interpreted as NIP_th2+1.5dB or higher
NumBS	3 bits	Number of base station which exceeds threshold
Temp_BSID	4 bits	Temp_BSID is broadcasted through AAI_DL_IM message

The AMS shall perform the averaging of NIP measurements according to equation (158) in 8.4.12.3.

16.2.3.40 AAI_MULTI_BS_MIMO-RSP

The AAI_MULTI_BS_MIMO-RSP message shall be transmitted by the ABS to AMS indicating which of the adjacent ABSs listed in previously broadcasted AAI_NBR-Adv message are involved in multiBS MIMO joint processing operation.

```
---ASN.1START
AAIMULTIBSMIMORSP Message::SEQUENCE{
  BitmapforinvolvedadjacentABSsinmultiBSMIMO BIT STRING (SIZE (8))

}
```

--ASN1STOP

Table 716—AAI_MULTI_BS_MIMO-RSP message format

Name	Value	Usage
Bitmap_for_involved_adjacent_ABSs _in_multiBS_MIMO	8	0: ABS is not involved in multiBS MIMO 1: ABS is involved in multiBS MIMO Each bit in this bitmap represents one ABS and the i-th bit (i=1,°¶,8) represents the neighboring ABS (listed in AAI_NBR-Adv message) with the i-th strongest channel to the AMS.

The AMS shall perform the averaging of NIP measurements according to equation (158) in 8.4.12.3.

16.2.3.41 Privacy key MAC Control messages(AAI_PKM-REQ/AAI_PKM-RSP)

PKMv3 employs two MAC message types: AAI_PKM-REQ (PKM request) and AAI_PKM-RSP (PKM response), as described in Table 864.

These MAC MAC Control message types distinguish between PKM requests (AMS-to-ABS) and PKM

Table 717—Privacy key management version 3 messages

Type Value	Message name	Message description
xx	AAI_PKM-REQ	Privacy key management request [AMS -> ABS]
yy	AAI_PKM-RSP	Privacy key management response [ABS -> AMS]

responses (ABS-to-AMS). Each message encapsulates one PKM message in the MAC Control message payload.

These MAC Control message types distinguish between PKM requests (AMS-to-ABS) and PKM responses (ABS-to-AMS). Each message encapsulates one PKM message in the MAC control message payload.

PKM protocol messages transmitted shall contain the following parameters. They are unicast control connection.

- Code : The Code field identifies the type of PKM packet. When a packet is received with an invalid code, it shall be silently discarded. The following Table 718 describes the PKM message codes.

Table 718—PKM v3 message types

Code	PKM message type	MAC control message name
1	PKMv3 Refresh-PMK	AAI_PKM-REQ
2	PKMv3 EAP-Transfer	AAI_PKM-REQ/ AAI_PKM-RSP
3	PKMv3 Key_Agreement-MSG#1	AAI_PKM-RSP
4	PKMv3 Key_Agreement-MSG#2	AAI_PKM-REQ
5	PKMv3 Key_Agreement-MSG#3	AAI_PKM-RSP
6	PKMv3 TEK-Request	AAI_PKM-REQ
7	PKMv3 TEK-Reply	AAI_PKM-RSP
8	PKMv3 TEK-Invalid	AAI_PKM-REQ/ AAI_PKM-RSP
9-16	reserved	--

- PKM Identifier: The PKM Identifier is used to match an ABS response to the AMS requests or an AMS response to the ABS requests.
AMS shall increment (modulo 256) the PKM Identifier field whenever it issues a new PKMv3 TEK-Request message, and ABS shall increment (modulo 256) the PKM Identifier field whenever it issues a new PKMv3 Key_Agreement-MSG#1.
For retransmissions, the Identifier field shall remain unchanged.
The Identifier field in PKMv3 EAP-Transfer, PKMv3 Refresh-PMK or PKMv3 TEK-Invalid messages which are redundant and don't affect any response messaging, shall be set to zero. The Identifier field in an ABS's AAI_PKM-RSP message shall match the Identifier field of the AAI_PKM-REQ message the ABS is responding to.
An ABS shall keep track of the PKM Identifier of its latest, pending PKMv3 Key_Agreement-MSG#1. The ABS shall discard PKMv3 Key_Agreement-MSG#2 messages with Identifier fields not matching that of the pending PKMv3 Key_Agreement-MSG#1. In addition, an AMS shall keep it, pending PKMv3 Key_Agreement-MSG#2. The AMS shall discard PKMv3 Key_Agreement-MSG#3 messages with Identifier fields not matching that of the pending PKMv3 Key_Agreement-MSG#2. An AMS shall keep track of the PKM Identifier of its latest, pending PKMv3 TEK-Request. The AMS shall discard PKMv3 TEK-Reply message with Identifier fields not matching that of the pending PKMv3 TEK-Request.

16.2.3.41.1 PKMv3 Refresh-PMK message

Refresh-PMK message may be used to trigger PMK update.(e.g., in case that CMAC_PN_* or AK_COUNT is exhausted, PMK update is required)

If ABS receives the Refresh-PMK message, it should initiate either reauthentication procedure or PMK update without reauthentication.

CMAC Digest and Key Sequence Number attributes shall be included in Refresh-PMK message.

Code: 1

Attributes are shown in Table 719.

Table 719—PKMv3 Refresh-PMK message attributes

Attribute	Contents
Key Sequence Number	Current PMK sequence number
CMAC digest	Message digest calculated using AK.

The CMAC Digest attribute shall be the final attribute in the message's attribute list. Inclusion of the CMAC Digest attribute allows the ABS to authenticate the PKMv3 Refresh-PMK message.

16.2.3.41.2 PKMv3 EAP-Transfer message

When an AMS has an EAP payload received from an EAP method for transmission to the ABS or when an ABS has an EAP payload received from an EAP method for transmission to the AMS, it encapsulates it in a PKMv3 EAP-Transfer message. In the case of re-authentication, all PKM messages containing a PKMv3 EAP-Transfer message shall beencrypted by the primary SA.

Code: 2

Attributes are shown in Table 720.

Table 720—PKMv3 EAP-Transfer message attributes

Attribute	Contents
EAP Payload	Contains the EAP authentication data, not interpreted in the MAC

The EAP Payload field carries data in the format described in section 4 of RFC 3748.

16.2.3.41.3 PKMv3 Key_Agreement-MSG#1 message

The ABS transmits the PKMv3 Key_Agreement-MSG#1 message as a first step in the 3-way key agreement handshake at initial network entry, at reauthorization, and at PMK update without reauthorization. The ABS shall send this message to the AMS after finishing authorization procedure(s) selected by the negotiated authorization policy support included in the basic capabilities negotiation.

It includes a random number challenge (i.e., NONCE_BS) to be returned by the AMS in the PKMv3 Key_Agreement-MSG#2 message. The ABS shall send this message to the AMS either when the ABS receives a PKMv3 CMAC-Invalid message or when authenticator relocation is occurred.

Code: 3

Attributes are shown in Table 721.

Table 721—PKMv3 Key_Agreement-MSG#1 message attributes

Attribute	Contents
NONCE_ABS	A freshly generated random number of 64 bits.
Key Sequence Number	Current PMK sequence number(included only when this message is CMAC protected)
CMAC digest	Message digest calculated using AK(included when AK is shared)

The CMAC Digest attribute shall be the final attribute in the message's attribute list, but in case that valid AK is not shared yet, PKMv3 Key_Agreement-MSG#1 message shall include NONCE_BS only. In case that valid AK is shared, its corresponding Key Sequence Number and CMAC Digest are included.

16.2.3.41.4 PKMv3 Key_Agreement-MSG#2 message

The AMS transmits the PKMv3 Key_Agreement-MSG#2 message after receiving PKMv3 Key_Agreement-MSG#1 message from the ABS. In case that an AK is already shared, the AMS transmits the PKMv3 Key_Agreement-MSG#2 message after successful CMAC value verification of PKMv3 Key_Agreement-MSG#1 message received from the ABS.

The AMS derives PMK and AK from MSK depending on NONCE_BS and NONCE_MS, which are shared by PKMv3 Key_Agreement-MSG#1 and PKMv3 Key_Agreement-MSG#2 messages.

If this PKMv3 Key_Agreement-MSG#2 message is being generated during initial network entry, then it contains security negotiation parameters.

Code: 4

Attributes are shown in Table 722.

The CMAC Digest attribute shall be the final attribute in the message's attribute list, which is derived from new AK.

16.2.3.41.5 PKMv3 Key_Agreement-MSG#3 message

The ABS transmits the PKMv3 Key_Agreement-MSG#3 message as a final step in the 3-way handshake key agreement after successful CMAC value verification of PKMv3 Key_Agreement-MSG#2 message received from the AMS.

On receiving PKMv3 Key_Agreement-MSG#2 message from the AMS, the ABS derives PMK and AK from MSK depending on NONCE_BS and NONCE_MS, which are shared by PKMv3 Key_Agreement-MSG#2 messages, and validate the CMAC value contained in PKMv3 Key_Agreement-MSG#2 message.

Code: 5

Table 722—PKMv3 Key_Agreement-MSG#2 message attributes

Attribute	Contents
NONCE_ABS	A freshly generated random number of 64 bits contained in PKMv3 Key_Agreement-MSG#1 message
NONCE_AMS	A freshly generated random number of 64 bits
PMK ID	PMK ID = Dot16KDF(PMK, 0b0000|PMK SN|NONCE_AMS|NONCE_ABS| "PMKID", 64). This is used to verify sync of PMK SN and the corresponding PMK
Key Sequence Number	New PMK sequence number
Security negotiation parameters	The requesting AMS's security capabilities (it should be included in case of key agreement during network entry only.) i.e., - size of ICV part in the AES-CCM 0 : 32bits (Max Invalid value is 4096) 1 : 64bits (Max Invalid valuse is not used) -PN window Size (Min:1, Max: 1024)
CMAC digest	Message digest calculated using new AK

Attributes are shown in Table 723.

Table 723—PKMv3 Key_Agreement-MSG#3 message attributes

Attribute	Contents
NONCE_ABS	A freshly generated random number of 64 bits contained in PKMv3 Key_Agreement-MSG#1 message.
NONCE_AMS	A freshly generated random number of 64 bits contained in PKMv3 Key_Agreement-MSG#2 message.
Key Sequence Number	New PMK sequence number
Key lifetime	MSK lifetime, this attribute is included only in case of key agreement following EAP-based authorization or EAP-based reauthorization procedures.

Table 723—PKMv3 Key_Agreement-MSG#3 message attributes

Attribute	Contents
Security negotiation parameters	The responding ABS's security capabilities (it should be included in case of key agreement during network entry only.) i.e., - size of ICV part in the AES-CCM 0 : 32bits (Max Invalid value is 4096) 1 : 64bits (Max Invalid valuse is not used) -PN window Size
CMAC digest	Message digest calculated using new AK.

The CMAC Digest attribute shall be the final attribute in the message's attribute list, which is derived from new AK.

16.2.3.41.6 PKMv3 TEK-Request message

The AMS transmits the PKMv3 TEK-Request message in order to ask the ABS what COUNTER_TEKs are currently managed.

Code: 6

Attributes are shown in Table 724.

The CMAC Digest attribute shall be the final attribute in the message's attribute list.

16.2.3.41.7 PKMv3 TEK-Reply message

The ABS transmits the PKMv3 TEK-Reply message in response to the PKMv3 TEK-Reply message.

Code: 7

Attributes are shown in Table 725.

l

Table 724—PKMv3 TEK-Request message attributes

Attribute	Contents
SAID	Security association identifier
Key Sequence Number	Current PMK sequence number
TEK refresh flag	This flag is set to "1" in the signal this request is for the first TEK after key agreement when both TEKs need to be updated one after another and set to "0" in any other case.
CMAC digest	Message digest calculated using AK.

Table 725—PKMv3 TEK-Reply message attributes

Attribute	Contents
SAID	Security association identifier
Key Sequence Number	PMK sequence number used for deriving current TEK_{ULE}
COUNTER_TEK	COUNTER_TEK used for deriving current uplink TEK
EKS	Encryption key sequence number for current uplink TEK
CMAC digest	Message digest calculated using AK.

The CMAC Digest attribute shall be the final attribute in the message's attribute list.

16.2.3.41.8 PKMv3 TEK-Invalid message

When the ABS detects that EKS is not sychronized yet, the ABS transmits the PKMv3 TEK-Invalid message in order for the AMS to send PKMv3 TEK-Request message to the ABS. If the AMS receives the PKMv3 TEK-Invalid message, it shall send the PKMv3 TEK-Request message.

Meanwhile, the AMS transmits the PKMv3 TEK-Invalid message in order to trigger TEK update. If the ABS receives the PKMv3 TEK-Invalid message, it discards current TEK_{DLE} and uses TEK_{ULE} as TEK_{DLE}, and derives a new TEK for TEK_{ULE}.

Code: 8

Attributes are shown in Table 726 .

Table 726—PKMv3 TEK-Invalid message attributes

Attribute	Contents
SAID	Security association identifier
Key Sequence Number	AK sequence number
CMAC digest	Message digest calculated using AK.

The CMAC Digest attribute shall be the final attribute in the message's attribute list.

16.2.3.42 AAI_ARQ-Feedback message

An AAI_ARQ-Feedback message is used for receiver to inform the reception status of a number of ARQ blocks or ARQ sub-blocks. ARQ feedback IE (see Table 760) is included in the AAI_ARQ-Feedback message.

Table 727—AAI_ARQ-Feedback message format

Syntax	Size (bits)	Notes
AAI_ARQ-Feedback_Message_Format() {		
MAC Control Message type = xx	8	
ARQ_Feedback_IE	variable	see Table 760
}		

16.2.3.43 AAI_ARQ-Discard message

The transmitter sends this message when it wants to skip a number of ARQ blocks. The procedure in the receiver after receiving an AAI_ARQ_Discard message is described in the <<15.3.8.7.3.3>>.

Table 728—AAI_ARQ-Discard message format

Syntax	Size (bits)	Notes
AAI_ARQ-Discard_Message_Format() {		
MAC Control Message type = xx	8	
Flow ID	4	Corresponding connection ID to perform ARQ block discard.
SN	10	ARQ block SN of the last block in the transmission window that the transmitter wants to discard.

Table 728—AAI_ARQ-Discard message format

Syntax	Size (bits)	Notes
Reserved	2	Shall be set to zero.
}		

16.2.3.44 AAI_ARQ-Reset message

The transmitter or receiver may send this message. The message is used in a dialog to reset the parent connection's ARQ transmitter and receiver state machines. The detail ARQ reset procedure is described in the <<15.3.8.7.4>>.

Table 729—AAI_ARQ-Reset message format

Syntax	Size (bits)	Notes
AAI_ARQ-Reset_Message_Format() {		
MAC Control Message type = xx	8	
Flow ID	4	Corresponding connection ID to perform ARQ reset procedure.
Type	2	0b00 = Original message from Initiator 0b00 = Acknowledgement from Responder 0b10 = Confirmation from Initiator 0b11 = *Reserved*
Reserved	2	Shall be set to zero
}		

16.2.3.45 DSx MAC Control Message

16.2.3.45.1 AAI_DSA-REQ

An AAI_DSA-REQ message is sent by an AMS or ABS to create a new service flow and may contain parameters for more than one service flow. An AMS or ABS shall generate AAI_DSA-REQ message, including the following parameters:

- Control Message Type : Type of AAI_DSA-REQ message.
- Service Flow Parameters : Specification of the service flow's traffic characteristics and scheduling requirements.
- Convergence Sublayer Parameter Encodings : Specification of the service flow's CS-specific parameters.

Following parameters may be included in the AAI_DSA-REQ message.

- SCID: To switch sleep cycle setting
- Predefined BR index: To use in 3-step Bandwidth Request procedure, only included in ABS initiated DSA-REQ

When an AMS commences E-MBS service flow, the following parameters shall be included in the AAI_DSA-REQ message.

- E-MBS Service: Indicates whether the MBS service is being requested or provided for the connection that is being setup.

When an ABS commences E-MBS service flow, the following parameters shall be included in the AAI_DSA-REQ message.

- E-MBS Service: Indicates whether the MBS service is being requested or provided for the connection that is being setup.

- E-MBS Zone ID: Indicates an E-MBS zone where the connection for associated service flow is valid.

- E-MBS Service Flow Parameter: Mapping of Multicast STID (MSTID) and FID are included.

- Physical Carrier Index: Target carrier which the AMS switches or is redirected by ABS to, only included in ABS initiated DSA-REQ.

After a successful DSA/DSC transaction, BR index mappings included in the AAI_DSA-REQ or AAI_DSC-REQ messages shall override previously defined BR index mappings for the same BR indices.

The FID for the transport connection shall not be present in the AMS-initiated AAI_DSA message; at the ABS, the service flow within the AAI_DSA-REQ message shall be assigned a unique FID for the transport connection, which will be sent back in the AAI_DSA-RSP message. AMS-initiated AAI_DSA-REQ messages may use the service class name in place of some, or all, of the QoS parameters.

ABS-initiated AAI_DSA-REQ messages for named service classes shall include the QoS parameter set associated with that service class. ABS-initiated AAI_DSA-REQ messages shall also include the Target SAID for the service flow.

16.2.3.45.2 AAI_DSA-RSP

An AAI_DSA-RSP message shall be generated in response to a received AAI_DSA-REQ message. An AMS or ABS shall generate AAI_DSA-RSP message, including the following parameters:

— Control Message Type : Type of AAI_DSA-RSP message.

— Confirmation Code : The appropriate confirmation code (CC) for the entire corresponding AAI_DSA-REQ.

— Service Flow Parameters : Specification of the service flow's traffic characteristics and scheduling requirements if the transaction is successful. The complete specification of the service flow shall be included in the AAI_DSA-RSP if it includes an expanded service class name.

— Convergence Sublayer Parameter Encodings : Specification of the service flow's CS-specific parameters if the transaction is successful.

In response to AAI_DSA-REQ message which contains SCID, the SCID may be included in AAI_DSA-RSP message as approval to ABS or AMS’s request. If AAI_DSA-RSP message doesn’t include SCID, the AMS shall regard its request as being failed.

In response to AAI_DSA-REQ message which contains 'Predefined BR index', the 'Predefined BR index' may be included in AAI_DSA-RSP message as approval to ABS or AMS’s request. If AAI_DSA-RSP message does not include 'Predefined BR index', the AMS shall regard its request to use the 'Predefined BR index' as being failed.

The ABS's AAI_DSA-RSP message for service flows that are successfully added shall contain a FID for the transport connection. The ABS's AAI_DSA-RSP message shall also include the Target SAID for the service flow. If the corresponding AAI_DSA-REQ message uses the service class name to request service addition, an AAI_DSA-RSP message shall contain the QoS parameter set associated with the named service class. If the service class name is used in conjunction with other QoS parameters in the AAI_DSA-REQ message, the ABS shall accept or reject the AAI_DSA-REQ message using the explicit QoS parameters in the AAI_DSA-REQ message. If these service flow encodings conflict with the service class attributes, the ABS shall use the AAI_DSA-REQ message values as overrides for those of the service class.

If an AMS's AAI_DSA-RSP with status success is sent and Service Flow Parameters are included, the only Service Flow Parameters that may be included shall be ARQ parameters for ARQ enabled connections).

When an AMS commences E-MBS service flow, the ABS shall include the following parameters in the AAI_DSA-RSP message.

- E-MBS Service: Indicates whether the MBS service is being requested or provided for the connection that is being setup.

- E-MBS Zone ID: Indicates an E-MBS zone where the connection for associated service flow is valid.

- E-MBS Service Flow Parameter: Mapping of Multicast STID (MSTID) and FID are included.

- Physical Carrier Index: Target carrier which the AMS switches or is redirected by ABS to, only included in ABS initiated DSA-REQ.

16.2.3.45.3 AAI_DSA-ACK

An AAI_DSA-ACK message shall be generated in response to a received AAI_DSA-RSP message. An AMS or ABS shall generate AAI_DSA-ACK message, including the following parameters:

— Control Message Type : Type of AAI_DSA-ACK message.

— Confirmation Code : The appropriate confirmation code (CC) for the entire corresponding AAI_DSA-RSP.

16.2.3.45.4 AAI_DSC-REQ

AAI_DSC-REQ message is sent by an AMS or ABS to dynamically change the parameters of an existing service flow. An AMS or ABS shall generate AAI_DSC-REQ message, including the following parameters:

— Control Message Type : Type of AAI_DSC-REQ message.

— Service Flow Parameters : Specifies the service flow's new traffic characteristics and scheduling requirements. The admitted and active QoS parameter sets currently in use by the service flow. If the DSC message is successful and it contains service flow parameters, but does not contain replacement sets for both admitted and active QoS parameter sets, the omitted set(s) shall be set to null. The service flow parameters shall contain a FID.

Following parameters may be included in the AAI_DSC-REQ message.

— SCID: To switch sleep cycle setting

— Predefined BR index: To use in 3-step Bandwidth Request procedure

An AAI_DSC-REQ message shall not carry parameters for more than one service flow.

16.2.3.45.5 AAI_DSC-RSP

An AAI_DSC-RSP message shall be generated in response to a received AAI_DSC-REQ message. An AMS or ABS shall generate AAI_DSC-RSP message, including the following parameters:

- Control Message Type : Type of AAI_DSC-RSP message.
- Confirmation Code : The appropriate confirmation code (CC) for the entire corresponding AAI_DSC-REQ.
- Service Flow Parameters : Specification of the service flow's traffic characteristics and scheduling requirements if the transaction is successful. The complete specification of the service flow shall be included in the AAI_DSC-RSP only if it includes an expanded service class name. If a service flow parameter set contained a service class name and an admitted QoS parameter set, the AAI_DSC-RSP shall include the QoS parameter set corresponding to the named service class. If specific QoS parameters were also included in the classed service flow request, these QoS parameters shall be included in the AAI_DSC-RSP instead of any QoS parameters of the same type of the named service class.
- Convergence Sublayer Parameter Encodings : Specification of the service flow's CS-specific parameters if the transaction is successful.

In response to AAI_DSC-REQ message which contains SCID, the SCID may be included in AAI_DSC-RSP message as approval to ABS or AMS's request. If AAI_DSC-RSP message doesn't include SCID, the AMS shall regard its request as being failed.

In response to AAI_DSC-REQ message which contains 'Predefined BR index', the 'Predefined BR index' may be included in AAI_DSC-RSP message as approval to ABS or AMS's request. If AAI_DSC-RSP message does not include 'Predefined BR index', the AMS shall regard its request as being failed.

16.2.3.45.6 AAI_DSC-ACK

An AAI_DSC-ACK message shall be generated in response to a received AAI_DSC-RSP message. An AMS or ABS shall generate AAI_DSC-ACK message, including the following parameters:

- Control Message Type : Type of AAI_DSC-ACK message.
- Confirmation Code : The appropriate confirmation code (CC) for the entire corresponding AAI_DSC-RSP.

16.2.3.45.7 AAI_DSD-REQ

An AAI_DSD-REQ message is sent by an AMS or ABS to delete an existing service flow. An AMS or ABS shall generate AAI_DSD-REQ message, including the following parameters:

- Flow ID : Flow identifier to be deleted.
- Control Message Type : Type of AAI_DSD-REQ message.

The SCID may be included in AAI_DSD-REQ to switch Sleep Cycle setting.

16.2.3.45.8 AAI_DSD-RSP

An AAI_DSD-RSP message shall be generated in response to a received AAI_DSD-REQ message. An AMS or ABS shall generate AAI_DSD-RSP message, including the following parameters:

- Flow ID : Flow identifier from the AAI_DSD-REQ to which this response refers.
- Control Message Type : Type of AAI_DSD-RSP message.
- Confirmation Code : The appropriate confirmation code (CC) for the entire corresponding AAI_DSD-REQ.

In response to AAI_DSD-REQ message which contains SCID, the SCID may be included in AAI_DSD-RSP message as approval to ABS or AMS's request. If AAI_DSD-RSP message doesn't include SCID, the AMS shall regard its request as being failed.

16.2.3.46 AAI-RNG-CFM

The AMS shall send the AAI-RNG-CFM message to the ABS upon successful ranging initiated by an unsolicited AAI-RNG-RSP message with the Ranging Request bit to be one. It shall include the below parameters:

— STID of the AMS.

Additionally, the AAI- RNG-CFM message shall always include an MCEH with the polling bit set to 1.

16.2.3.47 AAI_MultiBS_PMI_COM

The AAI_ MultiBS _PMI_COM message format is defined in Table 730—. This message is used by ABS to indicate AMS the PMImin and PMI combination ratio.

Table 730—AAI_MultiBS_PMI_COM message format

Name	Length (bits)	Description
AAI_MultiBS_PMI_COM_Message_Format {		
Control Message Type = xx		
PMIMin	4 to 6	PMI from the rank-1 base codebook£¨generates minimum interference for the neighboring ABS.
PCR	2	PMI combination ratio
}		

16.2.3.48 Group Configuration MAC Control Message (AAI_GRP-CFG)

Group Configuration MAC Control message is used for group management when using Group Resource Allocation. This message is used to inform an AMS that it has been added to or deleted from a GRA group.

```
-- Group Configuration Message
AAI-GRP-CFG ::= SEQUENCE {
    messageType                    OCTET STRING (SIZE(1)),

    -- identify the flow to be added or deleted
flowId                         INTEGER (0..15),

-- Signals whether the group corresponds to DL allocations or UL allocations.
dlUlIndicator                  ENUMERATED {
                                 dlAllocation (0),
```

```
                                ulAllocation (1)
                                }

    -- present when a flow is added to a GRA
    graInfoForAddedFlow       GroupRsrcAllocInfo OPTIONAL
    }

GroupRsrcAllocInfo ::= SEQUENCE {
    -- ID of the group to which the flow is added
    groupId                        BIT STRING (SIZE(12)),

-- Defines number of subframes spanned by the allocated resource
-- If number of DL AAI subframes, D is less than number of UL AAI
-- subframes, U, and dlUlIndicator = 0b1, then longTtiIndicator = 0b1.
    longTtiIndicator               ENUMERATED {
                                     oneSubframe (0),
                                     fourSubframe (1)
                                     } DEFAULT oneSubframe,

    -- the periodicity with which the corresponding GRA A-MAP IE will be
    -- transmitted.
    periodicity                    ENUMERATED {
                                     oneFrame   (0),
                                     twoFrame   (1),
                                     fourFrame  (2),
                                     eightFrame (3)},

    -- Signals the 2-bit MIMO mode set corresponding to this group.
    mimoModeSet                    ENUMERATED {
                                     mode0     (0),
                                     mode1and2 (1),
                                     mode2     (2),
                                     mode2and4 (3)},

   -- The size of user bitmap in bits. The size determines the maximum
   -- number of flows that can be supported in one group
    userBitmapSize                 ENUMERATED {
                                     four      (0),
                                     eight     (1),
                                     mode2     (2),
                                     mode2and4 (3)},

    -- Signals index of the flow in group's user bitmap
    userBitmapIndex                INTEGER (0..31),

    -- Signals the starting ACID of the range of ACIDs assigned to the
    -- GRA flow
```

```
    initialAcid                     INTEGER (0..15),

    -- The number of ACIDs assigned to the GRA flow
    numberOfAcid                    INTEGER (0..7),
    burstSizeList                   BurstSizeList OPTIONAL,
    resourceBitmapList              ResourceBitmapList OPTIONAL
    }

BurstSizeList ::= SEQUENCE (SIZE (1..4)) OF INTEGER (0..31)

ResourceBitmapList ::= SEQUENCE (SIZE (1..4)) OF ResourceBitmap

ResourceBitmap::= SEQUENCE {
    resourceInclusionBitmap        BIT STRING {
                                      b0 (0),  -- Bitmap to signal which
                                      b1 (1),  -- 8 resource sizes are
                                      b2 (2),  -- supported in the group
                                      b3 (3),  -- out of the range of
                                      b4 (4),  -- [1,16] LRUs supported
                                      b5 (5),  -- for GRA. If nth bit n
                                      b6 (6),  -- the bitmap is set to1,
                                      b7 (7),  -- it signals that are
                                      b8 (8),  -- source size of n LRUs
                                      b9 (9),  -- is supported in the
                                      b10 (10),   -- group.
                                      b11 (11),
                                      b12 (12),
                                      b13 (13),
                                      b14 (14),
                                      b15 (15)} (SIZE(16)) OPTIONAL
}
```

Table 731—AAI-GRP-CFG conditions

Attributes	Conditions
graInfoForAddedFlow	Present when a flow is added to a group.
burstSizeList	Present when the HARQ burst sizes are different from the last GRA allocation for this flow.
resourceBitmapList	Present when the resource sizes are different from the the last GRA allocation for this flow.

The Group Configuration MAC Control message signals all the information necessary for the AMS to receive allocations as part of a group via GRA (when the Deletion Flag is set to 0). The encoding of HARQ burst sizes and resource sizes supported in the group is determined as follows. The Group Configuration

MAC control message signals four HARQ burst sizes. These burst sizes are assigned 2 bits code in increasing order from 00 to 11 in the order in which they appear in the message.

Similarly, 3-bit resource size codes from 000 to 111 are assigned to the supported resource sizes in increasing order. The Resource size inclusion bitmap should have only 8 bits set to 1 and the rest to 0.

16.2.3.49 AAI_RES-CMD (Reset command)

The AAI_RES-CMD message shall be transmitted by the ABS to force the AMS to reset itself, reinitialize its MAC, and repeat initial system access. This message may be used if an AMS is unresponsive to the ABS or if the ABS detects continued abnormalities in the UL transmission from the AMS. It contains no information except MAC message name.

16.2.3.50 AAI_SII-ADV (Service Identity Information)

An ABS may use the AAI_SII-ADV message to broadcast a list of Network Service Provider (NSP) Identifiers. Assignment method, administration, and usage of NSP IDs are outside the scope of this standard. The list of NSP IDs to be included in this message and the message transmission frequency are programmable. The following parameters may be included in the AAI_SII-ADV message; at least one shall be included in an AAI_SII-ADV message.

Table 732—Parameter for AAI_SII-ADV message

Name	Value
NSP List	List of one or more Network Service Provider 24 bit Identifiers.
Verbose NSP Name List	List of the verbose names of the NSPs. The value of Verbose NSP Name List is a compound list of verbose NSP name lengths and verbose NSP names. The order of the Verbose NSP Name Lengths and Verbose NSP Names presented shall be in the same order as the NSP IDs presented in the NSP List.

16.2.3.51 AAI_MC-REQ (multicarrier Request) Message

The Multi-Carrier Request Message (AAI_MC-REQ) is sent by an AMS to an ABS to request the list of Assigned Carriers. The AMS cannot send the AAI_MC-REQ message until it receives the AAI_MC-ADV message from its serving ABS. According to the multi-carrier configuration supported by serving ABS, which is indicated in AAI_MC-ADV, the AMS shall determine the subset of carriers which it can simultaneously support under its hardware capability. Then AMS will send AAI_MC-REQ message to the serving ABS and include sets of physical carrier index to inform ABS this information.

Table 733—AAI_MC-REQ message format

Field	Size (bits)	Notes
MAC Control Message Type		
Number of Candidate Combinations (N)	4	
For (i=0, i<N; i++) {		
Number of Candidate Assigned Carrier (Nc)	3	
For (j=0, j<Nc; j++) {		
Physical Carrier Index	6	The carriers AMS can simultaneously support
}		
}		
Support of data transmission over guard sub-carrier	1	0b0 = not supported 0b1=support

16.2.3.52 AAI_MC-RSP (multicarrier Response) Message

Based on information provided by the AMS in the AAI_MC-REQ message, the ABS shall respond to the AMS through the AAI_MC-RSP message to provide the AMS with information about its assigned carriers. The following are the parameters shall be included in the AAI_MC-RSP message:

Table 734—AAI_MC-RSP message format

Field	Size (bits)	Notes
MAC Control Message Type		
Number of Candidate Combinations (N)	4	
For (i=0, i<N; i++) {		
Number of Candidate Assigned Carrier (Nc)	3	
}		
Support of data transmission over guard sub-carrier	1	0b0 = not supported 0b1=support

The AAI_MC-RSP (multicarrier Response) Message is typically sent to the AMS in response to the AAI_MC-REQ message, but it may also be sent by the ABS to an AMS to update the list of assigned carriers in unsolicited manner.

16.2.3.53 AAI_Global-Config (global carrier configuration) Message

The AAI_Global-Config message provides the carrier information for all available carriers in the network. The ABS transmits the AAI_Global-Config message to an AMS right after network entry completes.

Table 735—AAI_Global-Config MAC Control Message Format

Field	Size (bit)	Description
MAC Control Message Type	8	
Number of Carrier Groups	4	Groups of contiguous carriers
For (i=0; i< Number of Carrier Groups; i++){		
Multi-Carrier Configuration Index Across the Network	6	Index associated to Table 770
Start Frequency Assignment Index	6	Frequency Assignment Index of the first carrier in carrier group #i
Number of Carriers	6	
For(j=0;j<Number of Carriers; j++) {		
Physical Carrier Index	6	Index of the physical carrier
Duplexing Mode	1	"0" for TDD "1" for FDD
}		
}		
Physical Carrier Index of current carrier	6	The carrier that broadcasts this message; the physical carrier index refers to AAI_Global-Config message

16.2.4 Construction and Transmission of MAC PDUs

Figure 387 illustrates the various functional blocks involved in the construction of MAC PDU, input and output of each functional block, and sequence in which these functions are applied during the construction of MAC PDUs of various types of connections i.e., ARQ connection, non ARQ connection and control connection. The construction of a MAC PDU is illustrated in Figure 388 below.

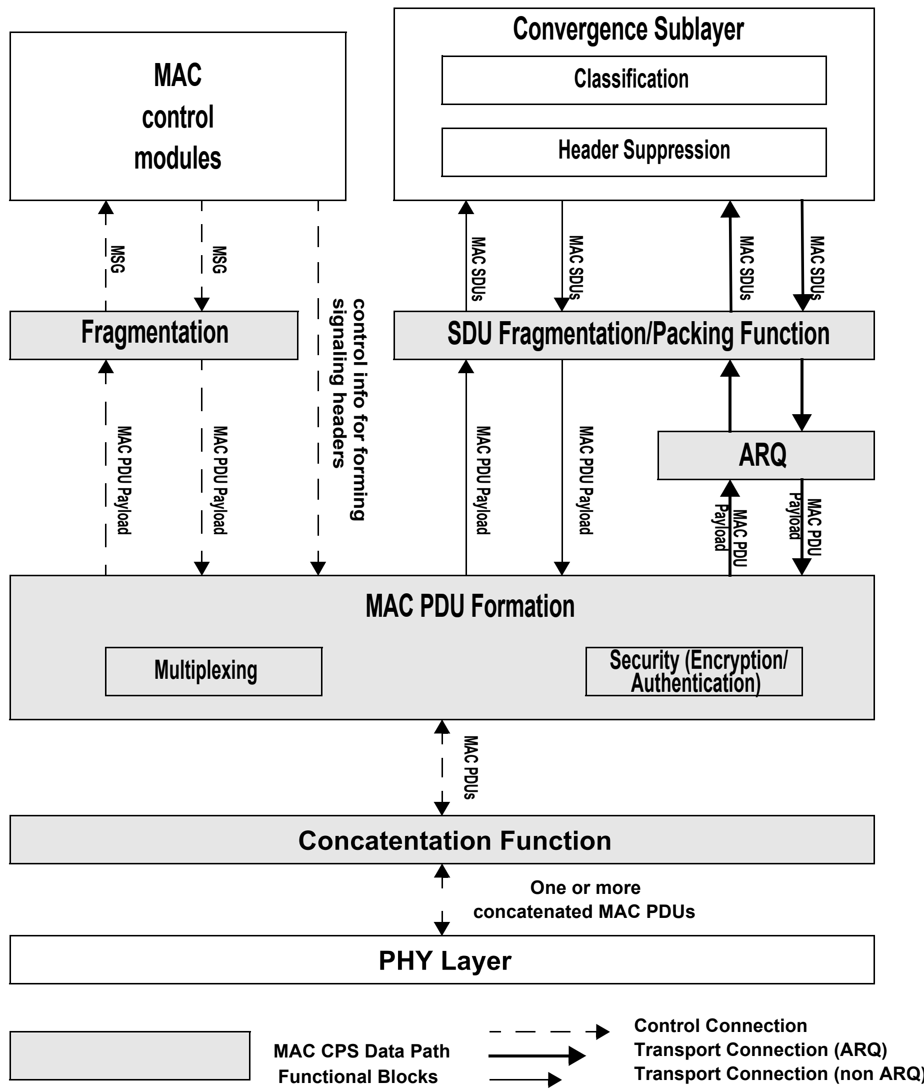

Figure 387—Data Path Functional Blocks involved in construction of MAC PDUs

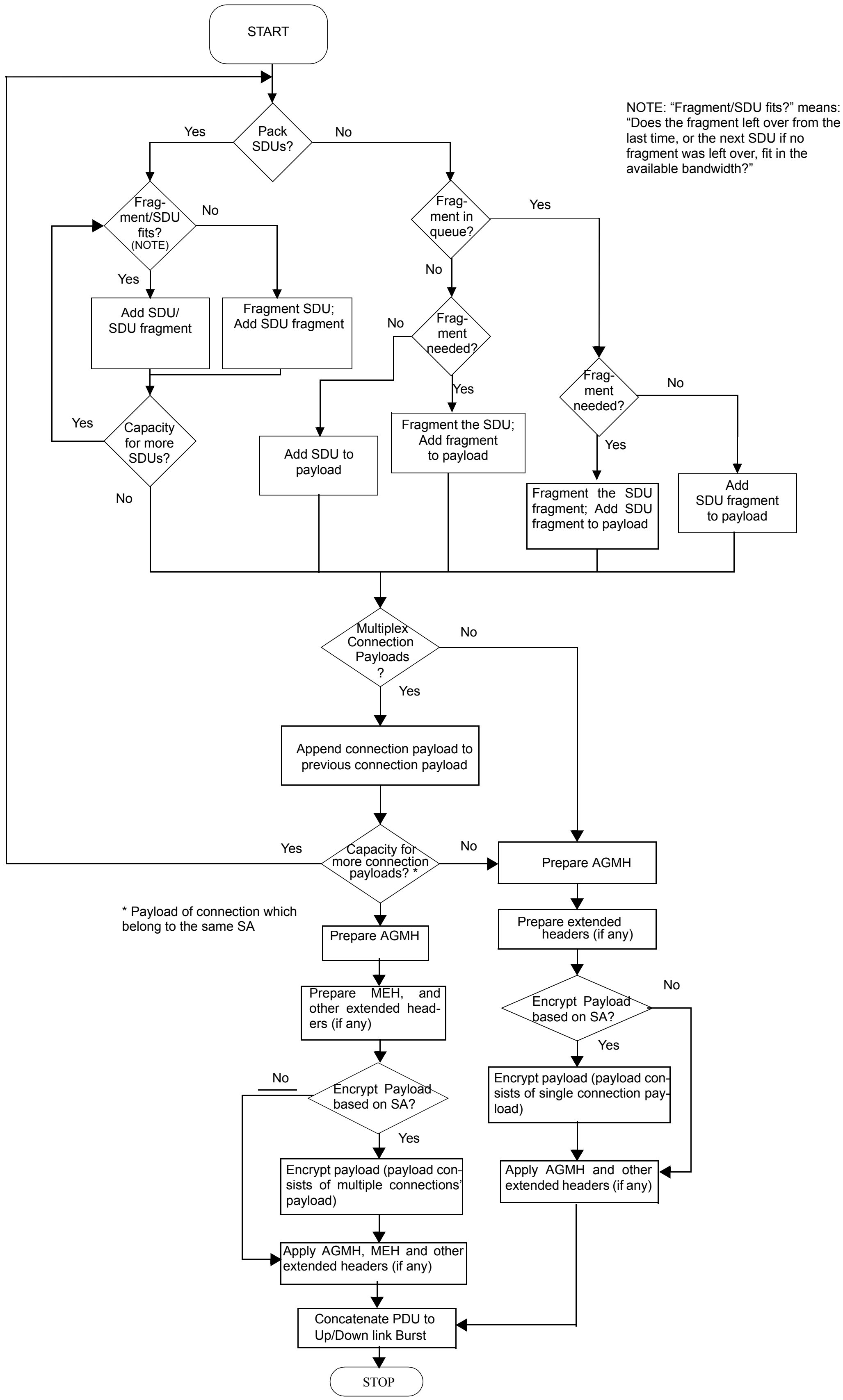

Figure 388—Construction of a MAC PDU for transport connections

16.2.4.1 Convention

The MAC data shall be transmitted in accordance with the following rules:

a) Fields of MAC messages and TLV encodings are transmitted in the same order as they appear in the corresponding tables in this standard.

b) Fields of MAC messages and fields of TLV encodings, which are specified in this standard as binary numbers, are transmitted as a sequence of their binary digits, starting from MSB. Bit masks (for example, in ARQ) are considered numerical fields. TLV encodings are transmitted in the order of Type, Length and Value. If the Value of a TLV or a field within the TLVs Value is explicitly specified as a numbered sequence of bits, then the order of transmission shall be from highest sequence number to lowest sequence number. For signed numbers MSB is allocated for the sign. Length field in the "definite form" of ITU-T X.690 is also considered a numerical field.

c) Fields specified as SDUs or SDU fragments (for example, MAC PDU payloads) are transmitted in the same order of bytes as received from upper layers.

d) Fields specified as strings are transmitted in the order of symbols in the string.

In cases c) and d), bits within a byte are transmitted in the order "MSB first."

16.2.4.2 Multiplexing

Multiple connections' payload associated with same security association can be multiplexed and encrypted together in a MAC PDU. If 'n' connections are multiplexed, one MEH and 0 to 'n' FPEH and/or MCEH shall be present in a MAC PDU. The AGMH (as defined in 16.2.2.1.1) and the MEH (as defined in 16.2.2.2.3) carries the information about the Flow Ids and Lengths of the connection payloads.The FPEH and MCEH carries the information about the transport and control connection payload respectively. For example multiple connections' payloads which are encrypted using AES CCM can be multiplexed and encrypted together in a MPDU. Figure 389 illustrates the multiplexing of two connection payloads which are associated with same security association (i.e., AES CCM).). FPEHx and FPEHy in Figure 389 carry the information about the SDU/SDU fragments in the Payload-X and Payload-Y respectively. Figure 390 illustrates the usage of FPEH/MCEH together with MEH in a MAC PDU.

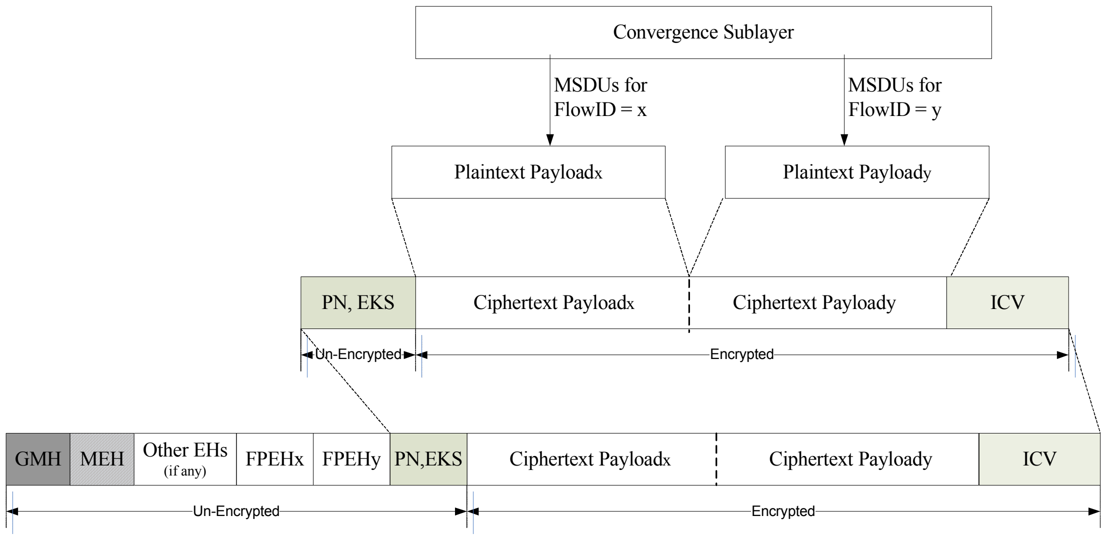

Figure 389—Multiplexing of connection payload associated with same SA

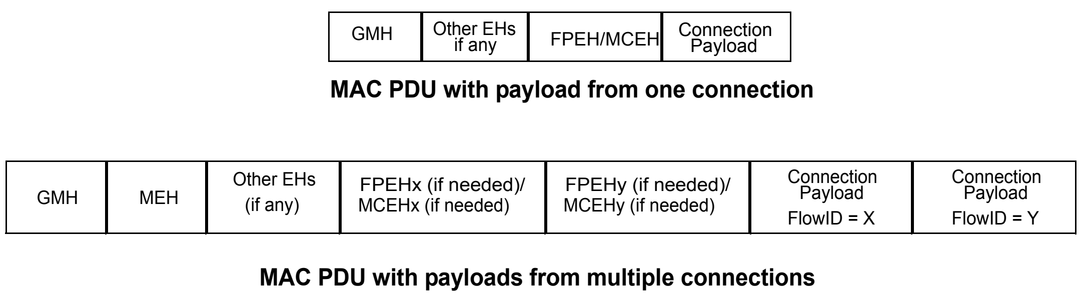

Figure 390—Usage of FPEH/MCEH and MEH in MAC PDU

16.2.4.3 Concatenation

Multiple MAC PDUs may be concatenated into a single transmission in either the UL or DL directions. For AMS attached to ABS, each MAC PDU in UL/DL burst is uniquely identified by Flow ID.

Figure 391 illustrates the concept for an UL burst transmission. Since the MAC SDUs in MAC PDU are identified by the Flow ID in the AGMH and MEH (in case of multiplexing), the receiving MAC entity is able to present the MAC SDU (after reassembling the MAC SDU from one or more received MAC PDUs) to the correct instance of the MAC SAP. MAC control messages, user data (from one or more connections), and BR MAC PDUs may be concatenated into the same transmission.

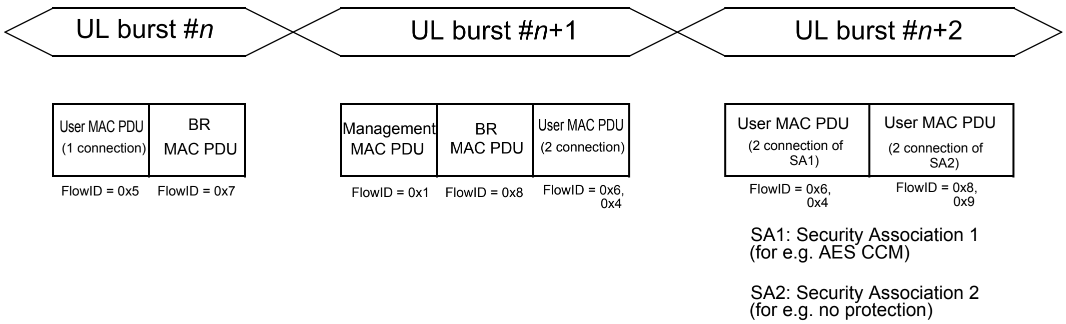

Figure 391— MAC PDU concatenation showing example Flow IDs

16.2.4.4 Fragmentation

Fragmentation is the process by which a MAC SDU (or MAC control message) is divided into one or more MAC PDUs. Capabilities of fragmentation and reassembly are mandatory.

16.2.4.4.1 Transport Connections

For transport connections, theFPEH (as defined in 16.2.2.2.1) shall be present in the MAC PDU with MAC SDU fragments. THe FPEH provides the information about the SDU fragment. SN in FPEH is used for sequencing the SDU fragments and Fragmentation control (FC) bits in FPEH, are used to tag the SDU fragments with respect to their position in the parent SDU.

16.2.4.4.1.1 Non-ARQ Transport Connections

For non-ARQ transport connections, fragments are transmitted once and in sequence. The SN assigned to each connection PDU carrying SDU fragment allows the receiver to recreate the original payload and to detect the loss of any intermediate fragments. A connection may be in only one fragmentation state at any given time. Upon loss, the receiver shall discard all SDU fragments on the connection until a new first SDU fragment is detected or a non-fragmented SDU is detected.

16.2.4.4.1.2 ARQ-enabled Transport Connections

For ARQ connections, fragments are transmitted in sequence. The SN assigned to each ARQ PDU carrying SDU fragment allows the receiver to recreate the original payload and to detect the loss of any intermediate fragments.

16.2.4.4.2 Control Connections

For control connections, the MCEH (as defined in 16.2.2.2.2) shall be present in the MAC PDU with MAC control message fragment. The MCEH provides the information about the control message fragment. SN and Control Connection Channel ID (CCC ID) in MCEH are used for sequencing the control message fragments, Fragmentation Control (FC) bits in MCEH, are used by the receiver to identify the control message fragments of a control message. Sequence number shall be maintained independently for each Control Connection Channel ID (CCC ID).

Upto two control message can be in fragmentation state at any given time. The SN and Control Connection Channel ID (CCC ID) assigned to each control connection PDU carrying control message fragment allows the receiver to recreate the original payload and to detect the loss of any intermediate fragments. Upon loss of a control message fragment on a Control Connection Channel ID (CCC ID), the receiver shall wait for the lost control message fragments on that Control Connection Channel ID (CCC ID) until a new first control message fragment is detected or a new non-fragmented control message is detected on the same Control Connection Channel ID (CCC ID).

16.2.4.5 Packing

MAC may pack multiple MAC SDUs of the same connection into a single MAC PDU. The transmitting side has full discretion whether to pack a group of MAC SDUs in a single MAC PDU. The capability of unpacking is mandatory. The packing and fragmentation mechanisms for both the non-ARQ and ARQ connections are specified in 16.2.4.5.1 and 16.2.4.5.2 respectively.

16.2.4.5.1 Packing for non-ARQ Connections

A MAC PDU containing a packed sequence of variable-length MAC SDUs is constructed as shown in Figure 392. Note that non-fragmented MAC SDUs and MAC SDU fragments may both be present in the same MAC PDU. The MAC attaches a FPEH (defined in 16.2.2.2.1) in the MAC PDU.

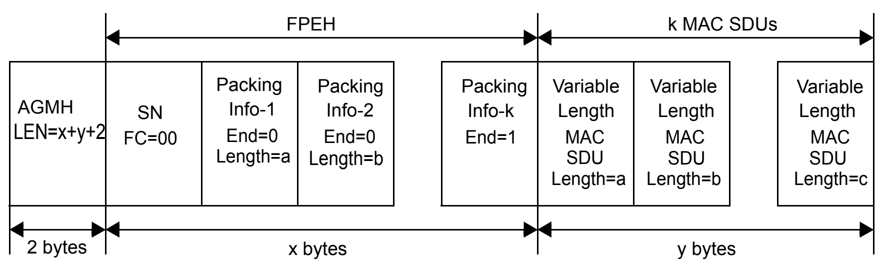

Figure 392— Packing variable length MAC SDUs into a single MAC PDU

The fragmentation control bits shall be set according to the rules defined in Table 665. Packing with fragmentation is illustrated in Figure 393.

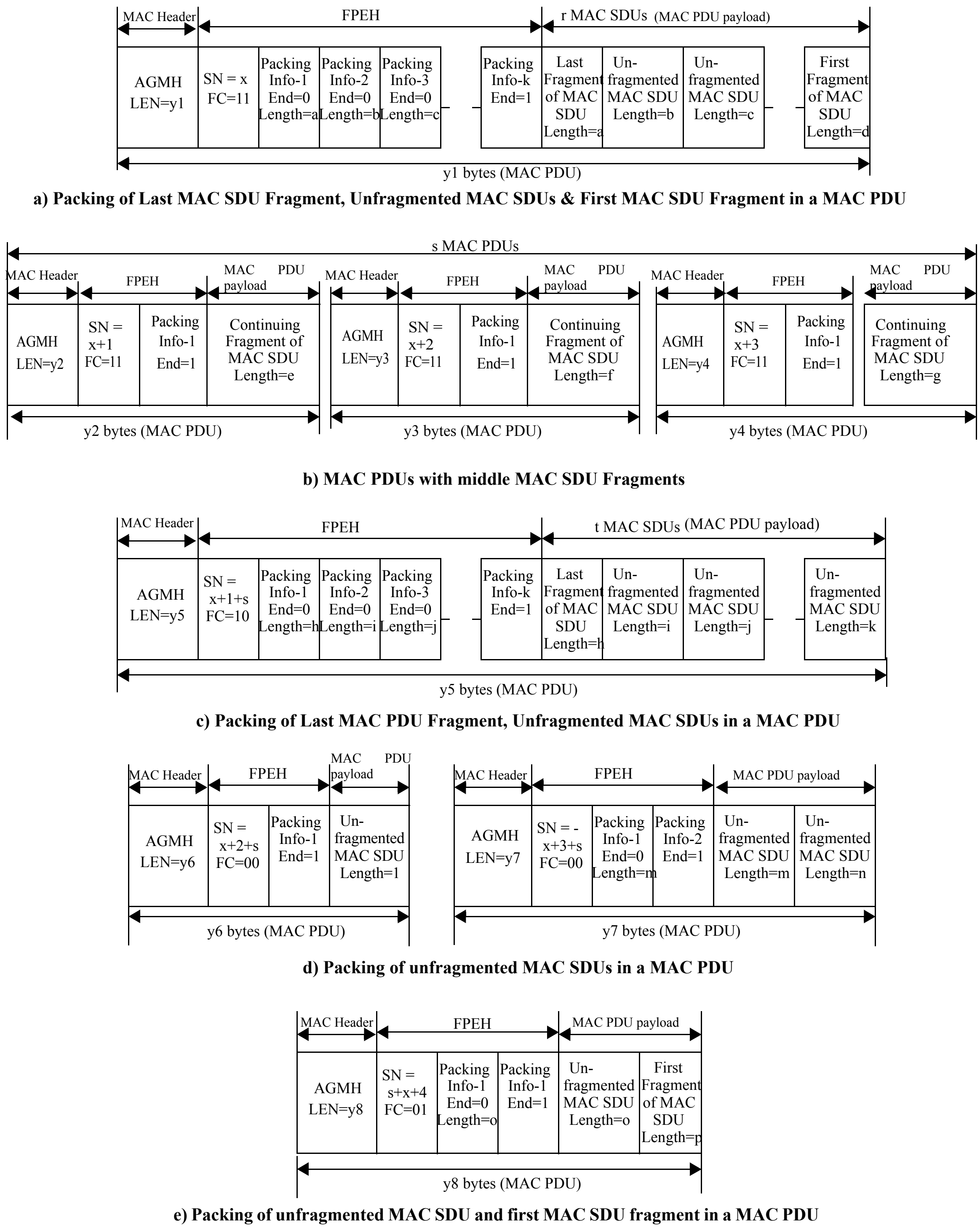

Figure 393—Packing with fragmentation

16.2.4.5.2 Packing for ARQ Connections

The use of FPEH for ARQ-enabled connections is similar to that for non-ARQ connections as described 16.2.4.5.1. The transmitting side has full discretion whether to pack a group of MAC SDUs and/or fragments in a single MAC PDU. The SN of the FPEH shall be used by the ARQ protocol to identify and retransmit ARQ blocks.

16.2.4.6 Encryption of MAC PDUs

When transmitting a MAC PDU on a connection that is mapped to an SA, the sender shall perform encryption and data authentication of the MAC PDU payload as specified by that SA. When receiving a MAC PDU on a connection mapped to an SA, the receiver shall perform decryption and data authentication of the MAC PDU payload, as specified by that SA.

The Advanced Generic MAC Header and extended headers shall not be encrypted. The receiver determines whether the payload in the MAC PDU is encrypted or not from the Flow ID in the AGMH for the transport connections. The encryption information needed to decrypt a payload at the receiving station is present at the beginning and at the end of the connection payload. For example in case of AES CCM, PN & EKS are present at the beginning of connection payload and ICV is appended at the end of the connection payload in MAC PDU as shown in Figure 394.

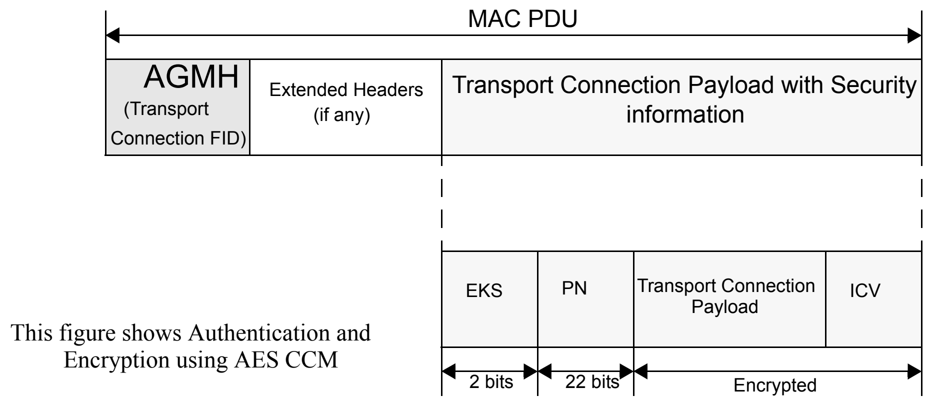

Figure 394—MAC PDU with Transport Connection Payload

If multiple connection payloads are transmitted in same burst and the connections are mapped to same SA then multiple connection payload may be multiplexed before encryption and multiplexed payload is encrypted together. The receiver shall perform the decryption and data authentication on the multiplexed payload, as specified by the SA. The receiver determines whether the payloads in the MAC PDU is encrypted or not from the Flow ID in the AGMH for the transport connections. The encryption information needed to decrypt the multiplexed payload at the receiving station is present at the beginning of the first connection payload and at the end of the last connection payload. For e.g. in case of AES CCM, PN & EKS are present at the beginning of connection payload 1 and ICV is appended at the end of the connection payload n in MAC PDU as shown in Figure 395.

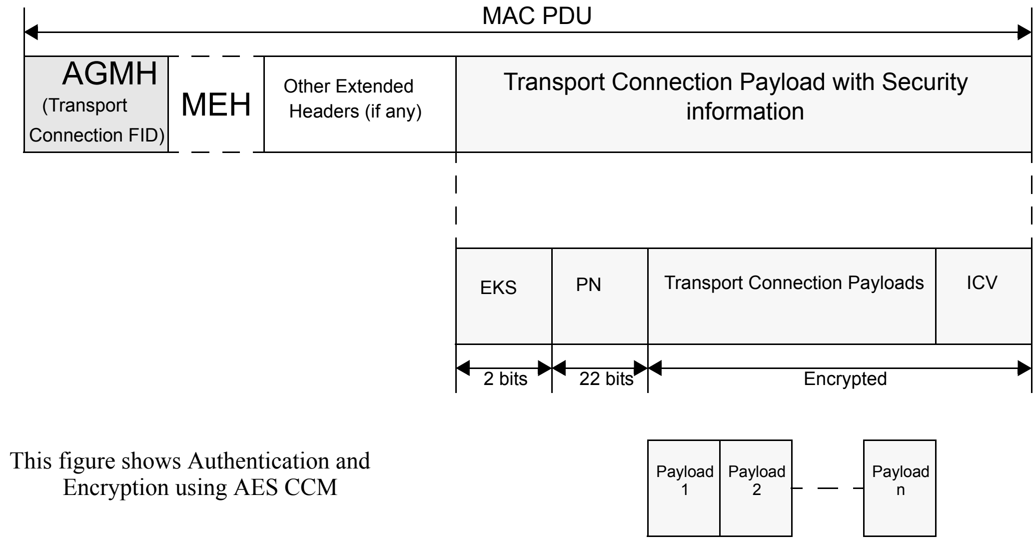

Figure 395—MAC PDU with Multiple Transport Connection Payload

16.2.4.7 Padding

Within the data burst, the unused portion shall be initialized to a known state. If the size of the unused portion is only one byte then the unused byte is set to 0xF0. If the size of the unused portion is greater than or equal to two bytes, the unused first byte is set to 0xF0 and and the remaining unused bytes are set to 0x00.

16.2.5 AAI Security

16.2.5.1 Security Architecture

The security functions provide subscribers with privacy, authentication, and confidentiality across the AAI network. It does this by applying cryptographic transforms to MAC PDUs carried across connections between AMS and ABS.

The security architecture of WirelessMAN-OFDMA Advanced System consists of the following functional entities; the AMS, the ABS, and the Authenticator as shown in the Figure 396.

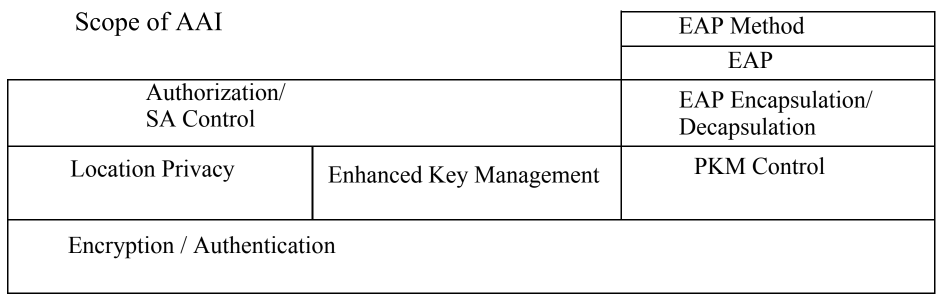

Figure 396—Security Functions

Within AMS and ABS the security architecture is divided into two logical entities:

- Security management entity
- Encryption and integrity entity

Security management entity functions included:

- Overall security management and control
- EAP encapsulation/decapsulation: This stack provides the interface with the EAP layer, in which the EAP based authentication is used as an authorization policy between an AMS and an ABS.
- Privacy Key Management (PKM) control: This stack controls all security components. Various keys are derived and generated in this stack. Privacy key management protocol version 3(PKM v3) defines how to control all security components(e.g. such as derivation/ update/usage of keys)
- Authorization and Security Association (SA) control: This stack controls the authentication state machine and the traffic encryption key state machine.
- Location privacy: This stack processes the location privacy related messages.

Encryption and integrity protection entity functions included:

- Transport data encryption/authentication processing: This stack encrypts or decrypts the transport data and executes the authentication function for the traffic data.
- Control message authentication processing: This stack executes message authentication function such as CMAC.
- Control message confidentiality protection: This stack encrypts or decrypts the control message and executes the authentication function for the control message.

16.2.5.2 Key Management Protocol (PKMv3)

16.2.5.2.1 Key Management

WirelessMAN-OFDMA Advance System uses the PKM protocol to achieve:

- Transparent exchange of authentication and authorization messages
- Key agreement

- Security material exchange

PKM protocol provides mutual authentication and establishes shared secret between AMS and ABS. The shared secret is then used to exchange or drive other keying material. This two-tiered mechanism allows the frequent traffic key refreshing without incurring the overhead of computation intensive operations.

16.2.5.2.1.1 Key Derivation

The PKMv3 key hierarchy defines what keys are present in the system and how keys are generated. The EAP based authentication process yields the Master Key (MSK). All other PKMv3 keys are derived directly/indirectly from the MSK.

The MSK is the shared key that is derived in the course of executing the EAP methods. The Pairwise Master Key (PMK) is derived from the MSK and this PMK is used to derive the Authorization Key (AK). The AK is used to derive other keys:

- Traffic Encryption Key (TEK)
- Cipher-based Message Authentication Code (CMAC) key

After completing the (re)authentication process, key agreement is performed to derive a PMK and an AK, and to verify the newly created PMK and AK and exchange other required security parameters.

Key derivation is performed using AES-CMAC based dot16KDF as defined in 7.5.4.6.1.

16.2.5.2.1.1.1 PMK Derivation

After successful EAP authentication was completed the MS (supplicant), AAA and authenticator holds a 512bit MSK key (that was transferred to the authenticator from AAA using EAP attributes).

Once EAP authentication completed successfully, the BS starts a key agreement 3-way handshake to derive fresh PMK in both MS and authenticator.

The key agreement 3-way handshake is defined in section 16.2.5.2.1.4 which includes NONCEs exchange that are used as input for PMK derivation.

The PMK derivation is done:

PMK=Dot16KDF (MSK, NONCE_MS|NONCE_BS|"PMK",160).

Where:

NONCE_MS – a random number generated by MS and send to the BS during key agreement.
NONCE_BS – a random number generated by BS and send to MS during key agreement.

The PMK is derived after each successful authentication (nw-entry and re-authentication) and has the same lifetime as MSK. The PMK can be updated by the key agreement procedure based on the same MSK without re-authentication, and has the same remaining lifetime as MSK.

The MSK may be used as a source for more keying material required by the NW.

16.2.5.2.1.1.2 AK derivation

AK is derived from PMK and it belongs to a pair of AMS and ABS.

The AK derivation is done:

AK = Dot16KDF (PMK, AMSID*|ABSID|AK_COUNT|"AK", 160)

Where:

- AMSID* - a permutation of AMSID (i.e., AMS MAC address) sent by AMS to ABS in initial AAI_RNG-REQ message, this is used to bind the key to the AMSID and AMSID* is derived from the formula AMSID* = Dot16KDF(AMSID |80-bit zero padding, NONCE_AMS ,48).
- AK_COUNT - a counter which is used to ensure different AKs for the same ABS-AMS pairs across handovers. After (re)authentication the counter value is set to "0".

16.2.5.2.1.1.2.1 AK_COUNT_ management

The AMS shall maintain an AK_COUNT counter for each PMK context, and the Authenticator is assumed to maintain an AK_ COUNT counter for each PMK context, which is normally kept synchronized with the corresponding counter at the AMS.

During zone switching Key count (i.e either CMAC_KEY_COUNT or AK_COUNT) is reset to zero at the target zone (see 16.2.5.2.1.5.6 and 16.2.5.2.1.5.7).

The value of this counter maintained by the AMS is denoted as $AK\_ COUNT_M$ and the value maintained by the Authenticator is denoted as $AK\_ COUNT_N$. Each AK context that an ABS maintains has an AK_COUNT value, which is denoted AK_COUNT_B.

16.2.5.2.1.1.2.2 Maintenance of AK_COUNTM by the AMS

Upon successful completion of the key agreement, the AMS shall derive a new PMK and initiate a new AK_COUNT counter and set its value to zero. In particular, this shall occur upon reception of the key_agreement-MSG#1 message. The AMS shall initiate either re-authentication or new key agreement before the AK_COUNT_M reaches its maximum value of 65535. The AMS shall manage a separate AK_COUNT_M counter for every active PMK context.

Specifically, during re-authentication or key agreement, the old AK_COUNT_M (corresponding to the old PMK) shall be used for CMAC generation of MAC control messages before the new PMK and AK are activated, while the new AK_COUNT_M shall be used for CMAC generation for key_agreement-MSG#2 and key_agreement-MSG #3 messages.

16.2.5.2.1.1.2.3 AK_COUNT LOCK state

When the AMS decides to reenter the network or perform Secure Location Update (immediately prior to transmitting an AAI_RNG-REQ for reentry or Secure Location Update to a first preferred ABS), or handover to a target ABS (immediately prior to transmitting AAI_RNG-REQ for handover to a first target ABS. in case of seamless HO, immediately prior to access the target ABS), the AMS shall perform the following steps in the stated order:

1) If the AMS is handing over to a target ABS, it shall cache the current AK context and SA context used at the serving BS.
2) The AMS shall increment once the AK_COUNT_M counter.
3) The AMS shall enter the AK_COUNT LOCK state.

For each ABS to which it sends an AAI_RNG-REQ message for the first time while in the AK_COUNT LOCK state, the AMS shall derive new AK context and SA context based on the AK_COUNT_M value.

While in the AK_COUNT LOCK state, the AMS shall cache the AK context and SA context corresponding to each preferred or target ABS to which it has sent an AAI_RNG-REQ message. The AMS shall update and use these cached values for any subsequent message exchange with the same target or preferred ABS while in the AK_COUNT LOCK state.

When the AMS has completed network reentry at a preferred ABS or has completed handover to a target ABS (in either case establishing the preferred ABS or target ABS as the new serving ABS) or the AMS has completed Secure Location Update, or the AMS cancels handover and remains connected to its current serving ABS, the AMS shall exit the AK_COUNT LOCK state.

Upon exit of the AK_COUNT LOCK state, the AMS may purge the cached AK context and SA context for all ABSs other than the serving ABS.

16.2.5.2.1.1.2.4 Processing of AK_COUNT_B by the ABS (informative)

The ABS may possess one or more AK contexts associated with the AMS, each of which includes the value of AK_COUNT_B. This value shall be maintained as specified in subsequent paragraphs of this section.

Upon successful completion of the (re)authentication, the ABS shall obtain new AK during key agreement procedure. In particular, this shall occur upon reception of the key_agreement-MSG#2 message. The ABS shall manage a separate AK_COUNT_B for every AK context it is maintaining.

Specifically, during re-authentication or PMK update, the old AK_COUNT_B (corresponding to the old PMK) shall be used for CMAC generation of MAC control messages before the new AK is activated, while the new AK_COUNT_B shall be used for CMAC generation for key_agreement-MSG#2 and key_agreement-MSG #3 messages.

Upon receiving the AAI_RNG-REQ message from the AMS containing the AK_COUNT, the ABS shall compare the received AK_COUNT value, which is AK_COUNT_M, with AK_COUNT_B, if ABS has AK context.

- If $AK\_COUNT_M < AK\_COUNT_B$, the ABS shall process the message as having an invalid CMAC tuple and send an AAI_RNG-RSP message requesting re-authentication; see subclauses 6.3.23.8.2.1 and 6.3.21.2.7.
- If $AK\_COUNT_B < AK\_COUNT_M$, the ABS shall request and get an AK context, which corresponds to both AK SN in the CMAC tuple and AK_COUNT_M, from the authenticator. ABS shall generate the CMAC_KEY_* and validate the received AAI_RNG-REQ message. If it is valid, the ABS shall set $AK\_COUNT_B = AK\_COUNT_M$, update AK context and SA context based on the AK, and send the AMS an AAI_RNG-RSP message encrypted by the newly generated TEK.
- If the CMAC value is not valid, the ABS shall send an AAI_RNG-RSP message requesting re-authentication; refer to subclauses 6.3.23.8.2.1 and 6.3.21.2.7.
- If $AK\_COUNT_B = AK\_COUNT_M$, the ABS shall validate the received AAI_RNG-REQ using the cached AK context. If the CMAC value is valid, the ABS shall send the encrypted AAI_RNG-RSP message to the AMS allowing legitimate entry. If the CMAC value is invalid, the ABS shall send an AAI_RNG-RSP message requesting re-authentication; refer to subclauses 6.3.23.8.2.1 and 6.3.21.2.7.

Upon receiving the AAI_RNG-REQ message from the AMS containing the AK_COUNT, if ABS has no AK context, it shall request an AK context, which corresponds to both AK SN in the CMAC tuple and AK_COUNT_M, to the authenticator.

- If $AK\_COUNT_M < AK\_COUNT_N$, the authenticator shall let the ABS send an AAI_RNG-RSP message requesting re-authentication; see subclauses 6.3.23.8.2.1 and 6.3.21.2.7.
- If $AK\_COUNT_M >= AK\_COUNT_N$, the authenticator shall reply AK context to the ABS. ABS shall generate the CMAC_KEY_* and validate the received AAI_RNG-REQ message. If it is valid, the ABS shall set $AK\_COUNT_B = AK\_COUNT_M$, update AK context and SA context based on the AK, and send the AMS an AAI_RNG-RSP message encrypted by the newly generated TEK. If the CMAC value is not valid, the ABS shall send an AAI_RNG-RSP message requesting re-authentication; refer to subclauses 6.3.23.8.2.1 and 6.3.21.2.7.

During seamless HO preparation, ABS obtains AK context based on AK_COUNT_N from the authenticator and the ABS shall set $AK\_COUNT_B = AK\_COUNT_N$.

Once the AMS has completed network reentry, cancelled handover, or completed Secure Location Update, the ABS is assumed to inform the Authenticator and send to it the value of AK_COUNT_M.

The ABS shall cache the AK context in case it receives subsequent MAC control messages from the AMS. When the ABS can determine that the AMS has exited the AK_COUNT LOCK state associated with AK_COUNT_M and if it is not serving the AMS, it may purge the cached AK context.

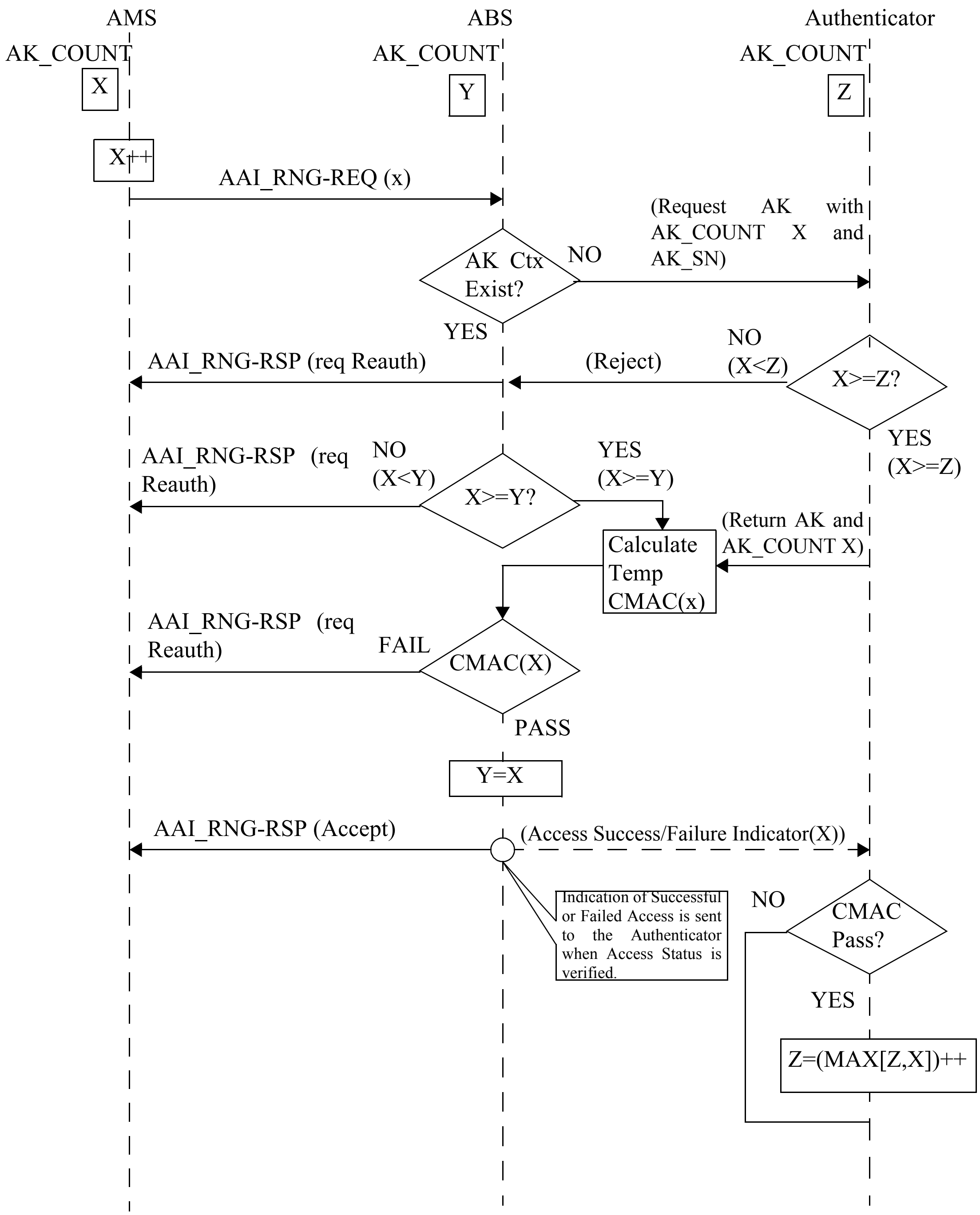

Figure 397—AK_COUNT Management

16.2.5.2.1.1.3 CMAC key derivation

CMAC keys are derived from AK and used for message authentication in some of the control messages.

There are 2 CMAC keys one used for UL and one for DL.

The keys derivation is done:

CMAC_KEY_U| CMAC_KEY_D = Dot16KDF (AK, “CMAC_KEYS”, 256).

Each key is 128 bit in size.

All this keys are derived every time a new AK is derived.

16.2.5.2.1.1.4 TEK derivation

TEK is the transport encryption key used to encrypt data.

TEK is managed within an SA where each SA contains 2 TEKs.The TEK is derived at AMS and ABS by applying identity parameters to a key derivation function. All PKMv3 key derivations are based on the Dot16KDF algorithm, which is the same as the AES-CMAC based Dot16KDF algorithm (see 7.5.4.6.1).

The TEK derivation is done:

TEK_i = Dot16KDF (AK, SAID |COUNTER_TEK=i|”TEK”, 128),

Where:

SAID is the security association that the TEK belongs to.

COUNTER_TEK is a counter used to derive different TEKs for the same SAID, the value of the counter is changed every time a new TEK need to be derived within the time the same AK is valid. Each SA shall hold two TEKs in every given time; these two TEKs will be derived from two consecutive counter values.

Every time a new AK is derived this counter is reset.

New TEK(s) are derived in the following cases:

- During initial network entry, handover reentry, location update, or network reentry from idle mode where new AK was derived, both TEKs are derived, counter is reset and the values 0 and1 are used for TEK derivation and the value of EKS for each TEK is same as the value of the COUNTER_TEK which was used to generate the TEK.
- TEK PN space exhausted and there is a need to refresh TEK only (not AK) – in this case COUNTER_TEK will be increased by 1 and a new TEK will be derived.
- Right after re-authorization or PMK update where new AK was derived, new TEKs are derived and updated according to the subclause 16.2.5.2.1.5.3.

TEK lifetime is identical to AK lifetime.

16.2.5.2.1.2 Key Hierarchy

Figure 398 outlines the process to calculate the AK when only EAP-based authentication exchange has taken place, yielding an MSK: Figure 399 outlines the unicast key hierarchy starting from AK

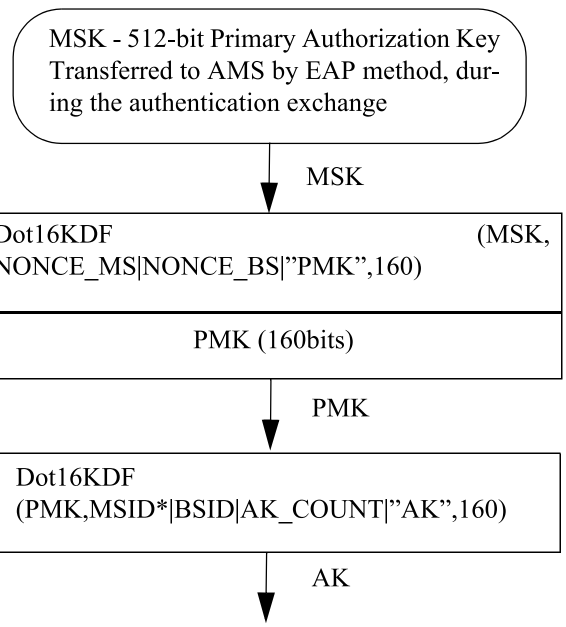

Figure 398—AK from PMK

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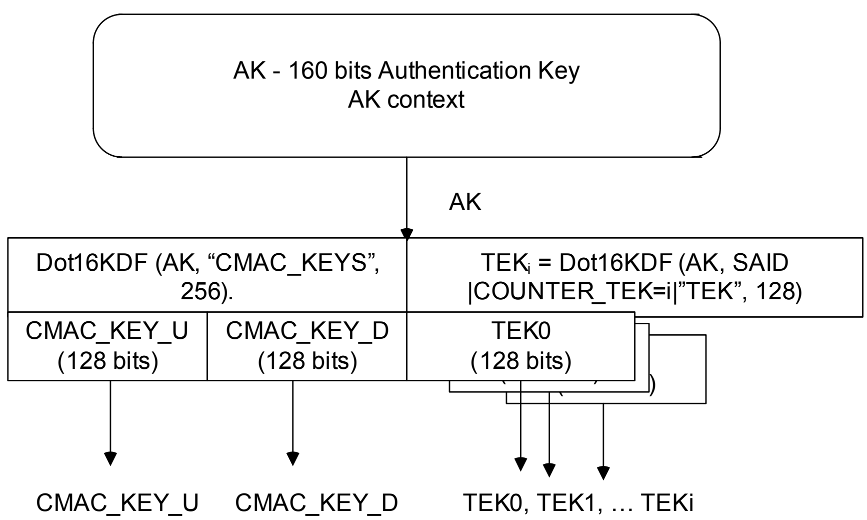

Figure 399—CMAC key and TEK derivation from AK

16.2.5.2.1.3 Maintenance of PMK and AK, PMK and AK switching methods

The active PMK and AK are maintained as follows:

a) PMK context management - An AMS and an Authenticator cache a new PMK context upon successful completion of key agreement procedure. Upon caching a new PMK for a particular AMS and completing TEK update procedure (updating both TEKs in each SA to be derived from the new PMK), any older PMK for that AMS (as well as all associated derived keys) shall be discarded. For the case of full re-authentication or PMK update through key-agreement, deletion of old PMKs is done after full TEK update following the switchover mechanism described in this sub clause.

b) AK activation and deactivation. Successful completion of the key agreement 3-way handshake causes the activation of the AK associated with the new PMK on any BS under the current Authenticator (i.e., when the AMS hands over or re-enters a target ABS, and the key agreement 3-way handshake associated with the newest PMK has completed successfully at former ABS under the target ABS's Authenticator, the AK associated with the newest PMK and the target ABS is used without a new key agreement 3-way handshake at the target ABS). If CMAC_PN or AK_COUNT reach their maximum value, the associated AK as well as PMK becomes permanently deactivated. The ABS and AMS shall maintain the AK context as long as they retain the AK. Once the key agreement 3-way handshake begins, the ABS and AMS shall use the new AK matching the new PMK context for the key agreement MSG#2 and key agreement MSG#3 messages. The other MAC control messages shall continue to use the old AK until the key agreement completes successfully. Upon successful completion of the key agreement 3-way handshake, CMAC key from the new AK shall be used. The old AK matching the old PMK context may be used for receiving packets before completion of TEK update procedure following the key agreement 3-way handshake.

16.2.5.2.1.4 Key agreement

The key agreement procedure takes place immediately following authentication/re-authentication or when PMK update is required without re-authentication.

It includes exchange of parameters between the AMS and ABS including NONCEs which are used to derive the PMK from the MSK which was created during authentication.

All other keys are derived from PMK right after or in other situation that requires it like HO or location update/reentry from idle.

The key agreement procedure (as shown in Figure 400) includes the following steps:

- EAP authentication completes (Authenticator got "EAP Success" from AAA and sent it to AMS).
- The ABS sends AAI_PKM_RSP (key agreement MSG#1) to the AMS, after protecting it with the CMAC tuple if ABS already has an AK shared with the AMS. The message includes a random NONCE_ABS.
- Receiving the key agreement MSG#1, the AMS derives all security keys from newest MSK, created by the last EAP authentication and other parameters including AMSID*, the NONCE_ABS and a random NONCE_AMS as defined in 16.2.5.2.1.1 and sends AAI_PKM-REQ (key agreement MSG#2) including the NONCE_ABS and a random NONCE_AMS to the ABS. The AAI_PKM-REQ is integrity protected (CMAC digest using the derived CMAC keys) but not encrypted. If the AMS receives another MSG#1 before sending MSG#2 it shall ignore and discard it.
- Receiving the key agreement MSG#2, the ABS takes the NONCE_AMS, calculates the keys and shall confirm that the supplied PMKID refers to the PMK that it has. If the PMKID is unrecognized, the ABS shall ignore the key agreement MSG#2. The ABS shall verify the CMAC. If the CMAC is verified then the ABS knows it has the same keys which are bound to the AMSID and ABSID, the keys are also fresh due to the 2 NONCE values in the derivation function. If the CMAC is invalid, the ABS shall ignore the key agreement MSG#2. The ABS shall verify that the NONCE_ABS in the key agreement MSG#2 matches the value provided by the ABS in the key agreement MSG#1. If the NONCE_ABS value does not match, the ABS shall ignore the key agreement MSG#2. If the ABS does not receive the key agreement MSG#2 from the AMS within Key Agreement Timeout, it shall resend the previous key agree-

ment MSG#1 up to KeyAgreementMSG#1MaxResends times. If the ABS reaches its maximum number of resends, it shall initiate another full authentication or drop the AMS.

- Upon successful validation of the key agreement MSG#2, the ABS shall send to the AMS AAI_PKM-RSP (key agreement MSG#3) that includes the NONCE_AMS, NONCE_ABS, the supported SAIDs (0x1 or 0x2 or both) and CMAC digest to prove the possession of the keys and their freshness.
- Receiving the key agreement MSG#3, the AMS verifies the CMAC and derive the TEKs for the supported SAIDs. If the CMAC is invalid, the AMS shall ignore the key agreement MSG#3. The AMS shall verify that the NONCE_AMS in the key agreement MSG#3 matches the value provided by the AMS in the key agreement MSG#2. If the NONCE_AMS value does not match, the AMS shall ignore the key agreement MSG#3. If the AMS does not receive key agreement MSG#3 from the ABS within Key Agreement Timeout, it shall resend the key agreement MSG#2. The AMS may resend the key agreement MSG#2 up to Key Agreement MSG#2 MaxResends times. If the AMS reaches its maximum number of resends, it shall initiate another full NW entry or attempt to connect to another ABS.

In case of initial network entry, once key agreement is completed successfully, the AMS sends to the ABS AAI_REG-REQ that includes the real AMSID as defined in 16.2.15.6.

Note that supplying the AMSID to the ABS allows, among other used of AMSID, for the NW elements to calculate AMSID* whenever a new AK needs to be derived from PMK (HO for example).

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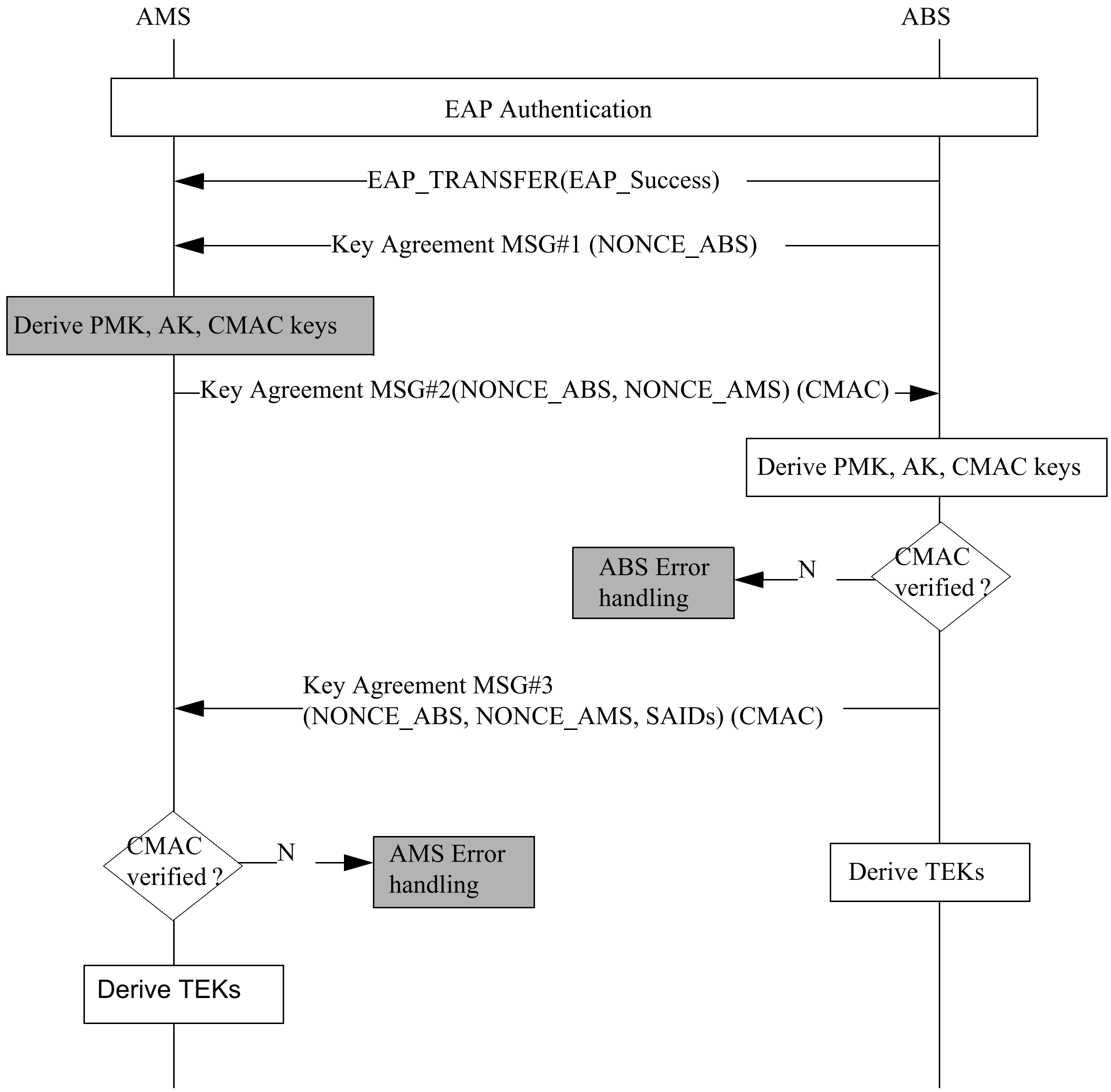


Figure 400—Key agreement procedure

16.2.5.2.1.5 Key Usage

16.2.5.2.1.5.1 TEK usage

Each SA maintains 2 TEKs marked as DLE (used to be called “old” in IEEE802.16eREV2) and ULE (used to be called “new”).

The TEK_{DLE} key is used for encrypting DL data by the ABS and the TEK_{ULE} key is used for encrypting UL data by the AMS, the decryption is done according to the EKS so basically in transition times were the ABS derived a new TEK_{ULE} and set the TEK_{DLE} = old TEK_{ULE}, then the ABS TEK_{DLE} and MS TEK_{ULE} are the same TEK with same EKS and both can transfer data securely using the same TEK (until TEK update happens from AMS side and AMS is re-synced on new TEK_{ULE}).

Each TEK has its own PN counter size 22bits.

The PN space is spread between the DL traffic and UL traffic as defined in 16eREV2, where the lower PN (0x000000-0x1FFFFF) space is used for DL, and upper PN space (0x200000-0x3FFFFF) is used for UL.

16.2.5.2.1.5.2 TEK update

The TEK update is triggered by either TEK_{DLE} or TEK_{ULE} is running out the relevant PN space. In particular ABS derives new TEK either when the DL PN space of TEK_{DLE} or the UL PN space of TEK_{ULE} is exhausted. The AMS requests key update when the PN space of its TEK_{ULE} is exhausted or the AMS detects that its TEK_{ULE} is being used for downlink traffic as well.

The threshold value of PN exhaustion is different between the ABS and AMS (the AMS's threshold for PN exhaustion is higher than that for the ABS) to ensure the ABS derives new TEK prior to AMS requesting the key update, thus ensuring minimal protocol overhead.

The TEK maintenance follows the procedure described in the following example.

- Assume the system starts with ABS using $TEK_{DLE}=TEK_0$ for DL traffic and AMS using $TEK_{ULE}=TEK_1$ for UL traffic.
- The ABS monitors its $TEK_{DLE}=TEK_0$ DL PN usage and $TEK_{ULE}=TEK_1$ UL PN usage and when one of them becomes its threshold, updates it derives TEK_2 and set $TEK_{DLE} = TEK_1$ and $TEK_{ULE} = TEK_2$ while discarding TEK_0.(note that after this both DL and UL traffic is done using TEK_1).
- The AMS shall monitor $TEK_{ULE}=TEK_1$in its downlink traffic. Once the downlink traffic is received with this key, the AMS knows that ABS derived new TEK and should update its TEK_{ULE} for uplink traffic with the key update procedure (see Figure 401). After the successful update $TEK_{DLE}=TEK_1$ and $TEK_{ULE}=TEK_2$.
- The AMS shall also monitor TEK_{ULE} both DL and UL PN usages. In the event that one of the PN spaces runs out (in the case more UL than DL it may happen that ABS derived new TEK but AMS could not identify it due to lack of DL traffic) The AMS shall trigger the key update procedure to update TEK_{ULE}

The key update procedure is shown in Figure 401. The AMS shall send in the request message with the associated SAID. The ABS shall indicate the EKS, AKSN and COUNTER_TEK in the reply message. If the

COUNTER_TEK/EKS are updated, the MS updates its TEK accordingly. If the COUNTER_TEK/EKS are not updated, it means the ABS did not derived new TEK yet and the AMS shall maintain current TEKs.

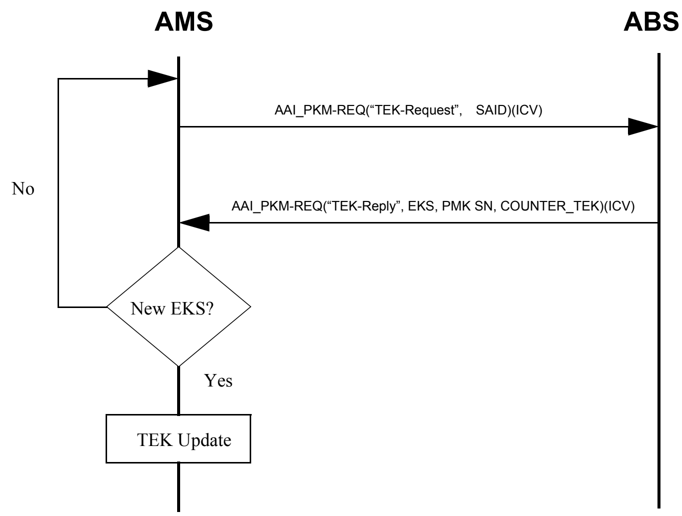


Figure 401—MS TEK_{ULE} update procedure

16.2.5.2.1.5.3 TEK update after PMK refersh (Full re-authentication or only Key agreement)

The PMK refresh is done via key-agreement three-way handshaking (following EAP re-authentication or standalone) similar to that defined in Figure 400—. Note that for PMK refresh, i) after the key agreement, the AK_{OLD} is still valid and ii) only one new TEK is derived right after key agreement. The detail procedure is as follows

- Key agreement finishes with generation of AK_{NEW}, but AK_{OLD} is still valid.
- Right after Key agreement, ABS updates its TEK_{DLE} with TEK_{ULE} and derives new TEK_{ULE} from AK_{NEW}
- Right after the AMS realizes key agreement finished successfully it starts the TEK_Reauth_Timer which once expired - the ABS is already expected to derive a fresh TEK_{ULE} from the new AK (at this point, TEK_{DLE} is still derived from the old AK) Once the timer expires or the AMS realizes ABS uses its TEK_{ULE} in the DL (if AMS monitors this event), the AMS initiates TEK update procedure in order to obtain new TEK_{ULE}, this procedure is done using the new AK SN in TEK-Request = in which the TEK refresh flag is set to "1" in order to signal the ABS that this is the first TEK update after re-authentication.
- The ABS is expected to responds with the sequence number of AK_{NEW} (which is used in both CMAC and TEK) and AMS can know it needs to derive its TEK_{ULE} from AK_{NEW}
- After TEK update procedure with the AMS was completed and the ABS knows the AMS possesses TEK_{ULE} derived from the new AK,(either by using it in UL or by receiving another TEK_request with the TEK refresh flag set to "0") , it should derive another new TEK and change TEK_{ULE} to be marked as TEK_{DLE} and then mark the new TEK as a TEK_{ULE} and discards all keys dependent on AK_{OLD}, and then it can discard AK_{OLD} as well.
- After obtaining the first TEK from the new AK, the AMS initiates another key update procedure (with the re-authentication flag not set) using the new AK seq-number to obtain the second TEK EKS derived from new AK.

16.2.5.2.1.5.4 Key update during Handover

During Handover (with handover process optimization bitmap bit#1=1 "omit PKM authentication phase"), AK, CMAC keys and TEKs shall be derived by the target ABS and AMS respectively as described in 16.2.5.2. In particular,

- In AK derivation, the AK_COUNT is managed on AMS and target ABS sides in the same way as in Section 16.2.5.2.1.3.
- In TEK derivation, COUNTER_TEK is set to be 0 and 1, in order to generate two new TEKs to be used at the target ABS. Corresponding EKS is also reset to be 0 and 1 respectively.

When Seamless_Handover Flag = 1 in AAI_HO-CMD, the AMS and target ABS may use derived TEKs for the target ABS to resume data communications before network reentry procedure finishes.

When the Network_Reentry_Mode = 1, for which the AMS is to maintain communications with serving ABS during network reentry at the target ABS, the AMS shall manage two set of key context for AK, CMAC keys and TEKs, where the context associated with the serving ABS is used to maintain communications with serving ABS until Disconnection Time, and the "new" context associated with the target ABS is used to perform required network reentry procedures with target ABS. The AMS discards key context associated with the serving ABS when the network reentry procedure finishes. The serving ABS discards this MS's key context (along with other MAC context associated with the AMS) upon either the expiration of Resource_Retain_Time or a HO-Complete signaling from target ABS via backbone.

16.2.5.2.1.5.5 Key usage during Location Update and Network reentry from Idle mode

During Location Update or Network reentry from idle mode, AK, CMAC keys and TEKs shall be derived by the network and AMS respectively if the AMS and the network share valid security context (e.g. PMK).

In particular,

- In AK derivation, the AK_COUNT is managed on AMS and network sides in the same way as in Section 16.2.5.2.1.1.2.1.
- In TEK derivation, COUNTER_TEK is set to be 0 and 1, in order to generate two new TEKs to be used at the preferred target ABS. Corresponding EKS is also reset to be 0 and 1 respectively.

16.2.5.2.1.5.6 Key update during zone switching from LZone to MZone

ABS shall include Nonce_BS in the zone switch information.

AMS shall perform key agreement and network reentry procedure in MZone to derive new PMK, AK, CMAC keys and TEKs to be used in MZone as follows.

- AMS derives new PMK, based on the NONCE_ABS and a NONCE_AMS. (key agreement MSG#1 is omitted since the zone switching information containing the NONCE_ABS can be regarded as a key agreement challenging message.)
- On calculating AMSID*, AMS derives new AK and its CMAC key and TEK based on the new PMK.
- AMS sends AAI_RNG-REQ message containing key agreement MSG#2 attributes (e.g. NONCE_ABS, NONCE_AMS and CMAC digest, which is based on the new CMAC key.)
- On receiving the AAI_RNG-REQ message, network entities derive new PMK, AK and CMAC keys. ABS validates the AAI_RNG-REQ by CMAC tuple. If the CMAC is valid, ABS derives new TEKs and responds with AAI_RNG-RSP message containing key agreement MSG#3 attributes (e.g. NONCE_ABS and NONCE_AMS) where the AAI_RNG-RSP is transferred in encrypted manner by the new TEK.
- If the AMS decrypts and decodes successfully the AAI_RNG-RSP message, then the AMS regards it as completion of a successful key agreement procedure.

16.2.5.2.1.5.7 Key update during zone switch from MZone to LZone

Based on the current active PMK_{MZONE}, new PMK to be used in Lzone is derived (e.g., PMK_{LZONE} = Dot16KDF(PMK_{MZONE},"PMK for LZONE")), and CMAC_KEY_COUNT is set to 0.

New AK, KEK, CMAC keys are derived, based on PMK_{LZONE}, according to Section 7.2.2.2. New TEKs are derived according to Section 7.2.2.2 if in AAI_HO-CMD message Seamless HO is set to 1. Otherwise TEKs to be used in LZone are obtained via TEK transfer encrypted by KEK. The AMS shall also manage the old security context used to maintain communications in MZone before zone switching to LZone finishes.

16.2.5.2.2 SA Management

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 736—)

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 fragment extended header is used only for control flows. The EC bit in the Fragment extended header is used to indicate whether the PDU contains control message encrypted based on security level. Whether each control message is encrypted or not is decided based on the security level which the message is associated with.

If authorization is performed successfully, SAID 0x01 is applied to flows for confidentiality and integrity, and SAID 0x02 for confidentiality only. SAID 0x01 shall be applied to control flows as defined inTable 675. 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 (See Table 736).

Table 736—SA mapping with protection level

SAID	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
0x03-0xFF		Reserved	

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 16.2.5.4.4).

16.2.5.2.2.1 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.

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 16.2.5.3.3).

16.2.5.2.3 Cryptographic Methods

16.2.5.2.3.1 Payload encryption methods

AES-CCM is used to encrypt unicast control connections. Unicast transport connections may be encrypted with AES-CTR or AES-CCM .

16.2.5.2.3.1.1 AES-CCM

PDU payload format

The MAC PDU payload shall be prepended with a 2-bit EKS and a 22-bit PN (Packet Number). The EKS and PN shall not be encrypted. The plaintext PDU shall be encrypted and authenticated using the active TEK, according to the CCM specification. This includes appending an integrity check value (ICV) to the end of the payload and encrypting both the plaintext payload and the appended ICV where the size of ICV is decided by either 4 or 8 byte during key agreement procedure in network entry.

The ciphertext message authentication code is transmitted so that byte index 0 (as enumerated in NIST Special Publication 800-38) is transmitted first (i.e., LSB first). The processing yields a payload that is 7 or 11 bytes longer than the plaintext payload.

Packet number (PN)

The PN associated with an SA shall be set to 1 when the SA is established and when a new TEK is installed. After each PDU transmission, the PN shall be incremented by 1. Any pair value of {PN, TEK} shall not be used more than once for the purposes of transmitting data. The AMS shall ensure that a new TEK is derived in both sides before the PN on either TEK for downlink or TEK for uplink reaches maximum value 0x1FFFFF or 0x3FFFFF, respectively. If the PN on either TEK for downlink or TEK for uplink reaches maximum value 0x1FFFFF or 0x3FFFFF, respectively, without new TEKs being installed, transport communications on that SA shall be halted until new TEKs are installed.

CCM algorithm

The NIST CCM specification defines a number of algorithm parameters. Those parameters shall be fixed to specific values as follows.

'Tlen' shall equal 64 and t shall equal 8, meaning, the number of bytes in the message authentication field shall be set to 8. Consistent with the CCM specification, the 3-bit binary encoding [(t–2)/2)] of bits 5, 4, and 3 of the Flags byte in B0 shall be 011.

The size q of the Length field Q shall be set to 2. Consistent with the CCM specification, the 3-bit binary encoding [q-1] of the q field in bits 2, 1, and 0 of the Flags byte in B0 shall be 001.

The length a of the associated data string A shall be set to 0.

The NONCE shall be 13 bytes long as shown in Figure 402. Bytes 0 through 1 shall be set to the 2 bytes of MAC header. If a 2-byte Advanced Generic MAC Header (AGMH) leads payload, then that field is filled with AGMH. But if a 2-byte compact MAC header (CMH) leads payload, then that field is filled with the CMH. Bytes 2 through 3 shall be set to the STID and FID, which MSB 12bits are for STID and LSB 4 bits are for FID. While STID and FID are not assigned yet, STID ‘000000000000’ and FID ‘0000’ shall be used. When the multiplexed MAC PDU is encrypted, FID of the first-come payload is applied to the field. Bytes 4 through 9 are reserved and shall be set to 0x00000000. Bytes 10 through 12 shall be set to the value of the EKS and PN.

Byte Number	0 1	2 3	4 9	10 12
Field	MAC Header	ST ID and Flow ID	Reserved	EKS and Packet Number
Contents	AGMH or CMH	STID | FID	0X000000000000	EKS | PN

Figure 402—NONCE construction

Consistent with the CCM specification, the initial block B0 is formatted as shown in Figure 403—.

Byte Number	0	1 13	14 15
Byte significance			MSB LSB
Number of bytes	1	13	2
Field	Flag	NONCE	L
Contents	0x19	As specified in Figure 402	Length of Plaintext Payload

Figure 403—Initial CCM Block B0

Note the ordering of the L value is MSB first, consistent with the NIST CCM specification.

Consistent with the NIST CCM specification, the counter blocks CTRj are formatted as shown in Figure 404.

Byte Number	0	1 13	14	15
Byte significance			MSB	LSB
Number of bytes	1	13	2	
Field	Flag	NONCE	Counter	
Contents	0x1	As specified in Figure 402	j	

Figure 404—Construction of counter blocks CTR_j

Receive Processing rules

On receipt of a PDU the receiving AMS or ABS shall decrypt and authenticate the PDU consistent with the NIST CCM specification configured as specified above.

Packets that are found to be not authentic shall be discarded.

Receiving ABS or AMSs shall maintain a record of the highest value PN receive for each SA.

The receiver shall maintain a PN window whose size is specified by the PN_WINDOW_SIZE parameter for SAs. Any received PDU with a PN lower than the beginning of the PN window shall be discarded as a replay attempt. The receiver shall track PNs within the PN window. Any PN that is received more than once shall be discarded as a replay attempt. Upon reception of a PN, which is greater than the end of the PN window, the PN window shall be advanced to cover this PN.

TEK update should be completed before MPDUs with ICV error are detected over the MaxInvalid times for the same TEK.

If AMS recognizes that TEK_{DLE} update is required due to ICV errors, it initiates TEK update by sending a PKMv3 TEK-Invalid message to the ABS. On receiving the PKMv3 TEK-Invalid message, the ABS discards current TEK_{DLE} and uses TEK_{ULE} as TEK_{DLE}, and derives a new TEK for TEK_{ULE}.

If ABS recongizes that TEK_{ULE} update is required due to ICV errors, it initiates PMK update by sending PKMv3 Key_Agreement-MSG#1. Then PMK and AK are refreshed and finally the TEKs are updated also.

When the ABS detects that EKS is not sychronized yet, the ABS transmits the PKMv3 TEK-Invalid message in order for the AMS to send PKMv3 TEK-Request message to the ABS. On receiving the PKMv3 TEK-Request message, the ABS responds with a PKMv3 TEK-reply message notifying the current TEKs.

16.2.5.2.3.1.2 AES-CTR

The MAC PDU payload shall be prepended with a 2-bit EKS and a 22-bit PN. The EKS and PN shall not be encrypted. Construction of the counter blocks is same as counter blocks of AES-CCM.(i.e. the counter blocks CTRj and NONCE are formatted as shown in Figure 404 and Figure 402, respectively.)

16.2.5.2.3.2 Calculation of Cipher-based message Authentication Code (CMAC)

An ABS or AMS may support MAC control message integrity protection based on CMAC-together with the AES block cipher. The CMAC construction as specified in NIST Special Publication 800-38B shall be used.

The calculation of the keyed hash value contained in the CMAC Digest attribute and the CMAC Tuple shall use the CMAC algorithm with AES. The DL authentication key CMAC_KEY_D shall be used for authenticating messages in the DL direction. The UL authentication key CMAC_KEY_U shall be used for authenticating messages in the UL direction. UL and DL message authentication keys are derived from the AK (see 16.2.5.2.1.4 for details).

The CMAC Packet Number Counter, CMAC_PN_*, is a 3-byte sequential counter that is incremented for each MAC Control Message which contains a CMAC Tuple or CMAC Digest TLV in the context of UL messages by the AMS, and in the context of DL messages by the ABS.

If STID is not assigned yet then STID '000000000000' should be used. The CMAC_PN_* is part of the CMAC security context and shall be unique for each MAC control message with the CMAC tuple or digest. Any tuple value of {CMAC_PN_*, CMAC_KEY_*} shall not be used more than once. Either the reauthorization process or PMK update without reauthorization should be initiated (by ABS or AMS) to establish a new PMK/AK before the CMAC_PN_* reaches the end of its number space.

The CMAC digest shall be calculated over a field consisting of the PMK ID followed by the CMAC_PN_*, expressed as an unsigned 24-bit number, followed by the 12-bit STID and 4-bit FID on which the message is sent, followed by 16-bit of zero padding (for the header to be aligned with AES block size) and followed by the entire MAC control message with the exception of the CMAC tuple or digest.

The LSBs of the digest shall be truncated to yield 64-bit length digest.

Note: This is different from the recommendation in NIST special publication 800-38B where the MSB is used to derive the CMAC value.

i.e., if CMAC_KEY_* is derived from AK:

CMAC value <= Truncate(CMAC (CMAC_KEY_*, PMK ID | CMAC_PN |STID|FID|24-bit zero padding | MAC_Control_Message), 64) , where STID '000000000000' should be used if STID is not assigned yet.

Only CMAC_PN that arrives in order can be accepted. MAC control messages with out-of-order CMAC_PN shall be discarded.

16.2.5.2.4 AMS Authentication state machine

The PKMv3 authentication state machine consists of six states and 18 events (including receipt of messages and events from other FSMs) that may trigger state transitions and send events/messages. The authentication state machine is presented in both a state flow diagram (Figure 406—) and a state transition matrix (Table 737—). The state transition matrix shall be used as the definitive specification of protocol actions associated with each state transition.

The PKMv3 Authentication process has 2 phases: EAP phase and key agreement phase.

The EAP phase is controlled by the EAP_FSM as defined in RFC3748 and RFC4173 and it is out of scope in this standard.

The Authentication FSM is responsible for all PKMv3 phase excluding the actual EAP exchange, it is also responsible for communicates with other FSMs in the system using events.

The relationships between the security related FSMs in the system are as described in the Figure 405—.

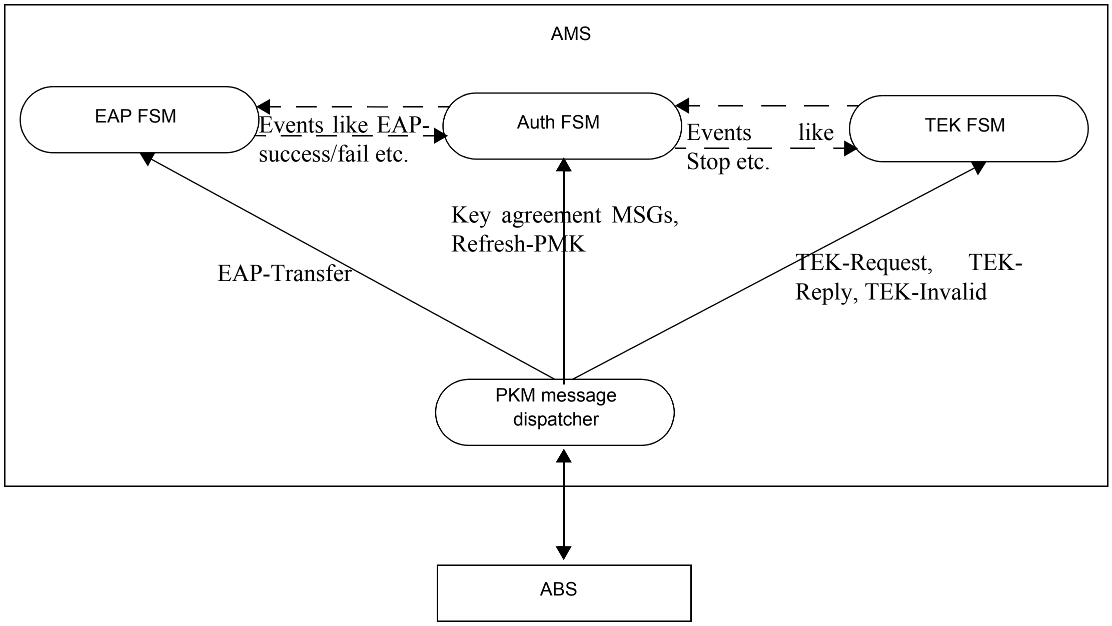
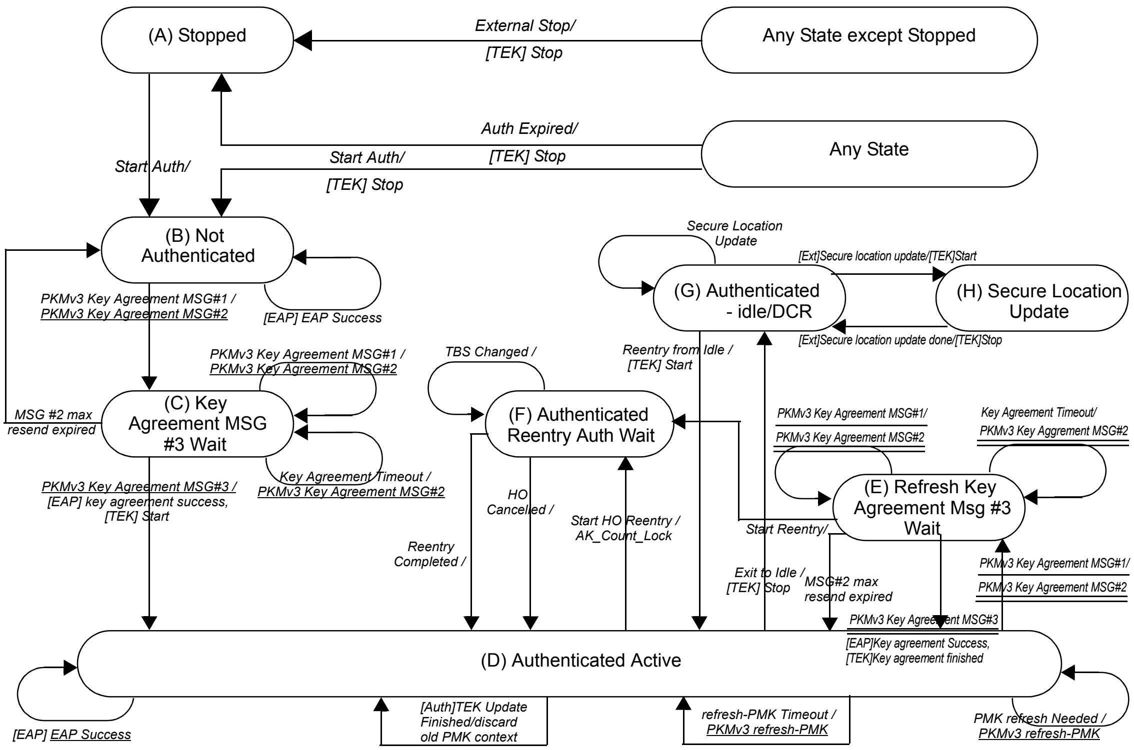


Figure 405—System Relationships in Security Related FSM

Through operation of an Authentication state machine, the AMS attempts to get authenticated with the NW, maintain this authentication and support Authentication context switching for Re-authentication, PMK refresh, HO, zone switching and Idle situations. The state machine takes care of requesting the BS to renew the key hierarchy before it expires either by initiating re-authentication or PMK refresh only. it also supports key derivations according to definitions for optimized re-entry for HO, for location update and idle.

The optimized re-entry/Location update support is done in a special state in which the NW connection is suspended and therefore re-authentication can't occur, the triggers for re-authentication continue to work in this state but the initiation is done only after returning to an authenticated state.



Legend:

Normal Text	No CMAC
Underlined Text	CMAC with current PMK
Double Underlined Text	CMAC with new PMK, all other messages with current PMK

Figure 406—Authentication State Machine for PKMv3

Table 737—Authentication FSM State Transition Matrix for PKMv3

Event or receive message	State							
	(A) Stopped	(B) Not Authenticated	(C) Key Agreement MSG #3 Wait	(D) Authenticated Active	(E) Refresh Key Agreement MSG #3 Wait	(F) Authenticated Reentry Auth Wait	(G) Authenticated idle/ DCR	(H) Secure Location Update
(1) Start Auth	Not Authen-ticated					Not Authen-ticated	Not Authen-ticated	

Table 737—Authentication FSM State Transition Matrix for PKMv3

Event or receive message	State							
	(A) Stopped	(B) Not Authenticated	(C) Key Agreement MSG #3 Wait	(D) Authenticated Active	(E) Refresh Key Agreement MSG #3 Wait	(F) Authenticated Reentry Auth Wait	(G) Authenticated idle/ DCR	(H) Secure Location Update
(2) PKMv3 Key Agreement MSG #1		Key Agreement MSG #3 Wait	Key Agreement MSG #3 Wait	Refresh Key Agreement MSG #3 Wait	Refresh Key Agreement MSG #3 Wait			
(3) PKMv3 Key Agreement MSG #3			Authenticated Active		Authenticated Active			
(4) EAP Success		Not Authenticated		Authenticated Active				
(5) Key Agreement Timeout			Key Agreement MSG #3 Wait		Refresh Key Agreement MSG #3 Wait			
(6) Key Agreement MSG #2 max resend elapsed			Not Authenticated		Authenticated Active			
(7) Key Context Refresh needed				Authenticated Active				
(8) Start Reentry				Authenticated Reentry Auth Wait	Authenticated Reentry Auth Wait			
(9) refresh-PMK timeout				Authenticated Active				
(10) HO cancelled						Authenticated Active		
(11) TBS change						Authenticated Reentry Auth Wait		

Table 737—Authentication FSM State Transition Matrix for PKMv3

Event or receive message	State							
	(A) Stopped	(B) Not Authenticated	(C) Key Agreement MSG #3 Wait	(D) Authenticated Active	(E) Refresh Key Agreement MSG #3 Wait	(F) Authenticated Reentry Auth Wait	(G) Authenticated idle/ DCR	(H) Secure Location Update
(12) Reentry Completed						Authenticated Active		
(13) Auth Expired				Stopped	Stopped	Stopped	Stopped	
(14) EAP Fail				Authenticated Active				
(15) External Stop		Stopped	Stopped	Stopped	Stopped	Stopped		
(16) Exit to Idle				Authenticated Idle	Authenticated Idle			
(17) ReEntry from Idle							Authenticated Active	
(18) [Ext]Secure Location Update							Secure location update	
(19) TEK update finished				Authenticated Active				
(20)[Ext] Secure location update done								Authenticated idle

16.2.5.2.4.1 States

Stopped: This is the initial state of the FSM. Nothing is done in this state.

Not Authenticated: The Authentication FSM is not authenticated and waiting for an MSK from the EAP FSM and start of key agreement,

Key Agreement MSG #3 Wait: The Authentication FSM holds all key hierarchy derived from MSK and is waiting to receive MSG#3 in order to validate the keys with the BS:

- Resend MSG#2 if valid MSG#3 was not received within Key Agreement Timer.
- Resend MSG#2 if MSG#1 with same NONCE received again (reset resend counter).
- Discard MSG#3 received with invalid CMAC

Authenticated Active: The AMS has successfully completed EAP-based authentication and key agreement and has valid Key context derived from the MSK received from the EAP FSM. All SAs are created and TEK FSM is active for each SA:

- PMK or its derivatives (not including TEK) is about to expire and the AMS sends refresh-PMK, and refresh-PMK timer starts
- refresh-PMK timer is expired and the AMS sends refresh-PMK.
- AK_Count/ CMAC_PN_* is about to be exhausted and the AMS sends refresh-PMK
- All management messages are protected as defined in table 673.
- Received messages without valid encryption/CMAC are discarded.
- Manage two key Context during transition period between 2 key agreements.

Refresh Key Agreement MSG #3 Wait: The Authentication FSM holds all key hierarchy derived from newest MSK (in parallel to active context used for ongoing operation) and is waiting to receive MSG#3 in order to validate the keys with the BS:

- Resend MSG#2 if valid MSG#3 was not received within Key Agreement Timer.
- Resend MSG#2 if MSG#1 with valid CMAC (using active CMAC key) is received (reset resend counter).
- Discard MSG#3 received with invalid CMAC (using newest CMAC key)

Authenticated Reentry Authentication Wait: In this state the Authentication FSM has the context of the target ABS. The AMS should have the PMK context of the target ABS in this state before it sends an AAI_RNG-REQ message with CMAC during HO or reentry from coverage loss

- Caches AK context of all TBSs until reentry completed or HO canceled.
- Create new context and key hierarchy for the TBS whenever TBS changes (if context is not cached).
- Maintain AK_COUNT LOCK state

Authenticated Idle/DCR: In this state the Authentication FSM caches the PMK context and derives the appropriate key hierarchy for the TBS in case of re-entry from idle or DCR mode.

Secure Location Update: In this state the system is active for short period of sending location update and for that TEKs need to be derived so TEK FSM is started.

16.2.5.2.4.2 Messages

PKMv3 Key Agreement MSG #1: The first message of Key Agreement. It is sent from the ABS to the AMS after EAP-based authentication has finished or once the ABS decides to renew the KEY context for PMK and derived keys and it is protected by CMAC using CMAC_KEY_D of the active Key context if there is one (it is not protected for initial key agreement).

PKMv3 Key Agreement MSG #2: The second message Key Agreement. It is sent from the AMS to the ABS as a response to a valid PKMv3 Key Agreement MSG #1, it is protected by CMAC using CMAC_KEY_U of the newest EAP-based authentication (same as active if only key agreement happens or new MSK in case of full EAP re-auth)

PKMv3 Key Agreement MSG #3: The last message of Key Agreement. It is sent from the ABS to the AMS as a response to a valid PKMv3 Key Agreement MSG #2 and it is protected by CMAC-Digest using CMAC_KEY_D of the newest EAP-based authentication.

PKMv3 refresh-PMK: The message used by the AMS to request the ABS to renew all the key hierarchy (PMK and derivatives) either by initiating full EAP-based re-authentication or just new key agreement. If new key agreement is not completed within fresh key agreement timer (TBD), the AMS may re-send refresh-PMK.

PKMv3 EAP Transfer: This message is bidirectional and used for transmission of EAP packet. This message is sent unprotected in "Not Authenticated" state. In Authenticated Active state, the message SHALL be encrypted

16.2.5.2.4.3 Events

Start Authentication: After completion of basic capabilities negotiation, this event is generated to start the Authentication state machine. It is also issued when the HO Process Optimization Bit #1 of the AAI_RNG-RSP message is set to one (i.e. 'omit PKM authentication phase') during HO or network reentry.

EAP Success: EAP FSM generates this event to notify the Authentication FSM that it received EAP Success message from the authenticator.

Key Agreement Timeout: This event is generated when the AMS does not receive PKMv3 Key Agreement MSG #3 from the ABS within Key Agreement Timer after transmitting a PKMv3 Key Agreement MSG #2. The AMS resends the PKMv3 Key Agreement MSG #2 up to Key Agreement MSG#2 Max Resends times.

Key Agreement MSG #2 max resends elapsed: The Authentication state machine generates this event when the AMS has transmitted the PKMv3 Key Agreement MSG #2 up to Key Agreement MSG #2 Max Resends times and Key Agreement Timer expires.

Key context refresh Needed: An internal event to trigger a message to the ABS requesting for a new key agreement with/out re-authentication per ABS decision. This event can be derived from several sources such as Authentication Grace Timeout or other reason that makes authentication close to expiration.

Start HO Reentry: An event to inform the Authentication FSM that AMS is in reentry phase. The FSM should derive the new AK context for the target ABS.

refresh-PMK Timeout: A timer event that causes the AMS to resend a PKMv3 refresh-PMK message in order to ask the ABS to refresh the key hierarchy from PMK and down. This event is used in the case that key agreement is not completed successfully during refresh-PMK timer from transmitting the PKMv3 refresh-PMK message. This timer is active only after key context refresh needed event occurred.

Reentry Completed: An event to notify the Authentication FSM that reentry has finished successfully. This event is issued when the AMS receives an AAI_RNG-RSP message including HO Process Optimization Bit #1 set to one (i.e. 'omit PKM authentication phase') during HO or network re-entry from Idle mode

HO Canceled: An event to notify the Authentication FSM that HO was canceled. The cached AK context for the serving ABS should be retrieved.

TBS (Target ABS) changed: An Event to notify the Authentication FSM that it needs to generate the AK context for the new target ABS.

Authentication Expired: This event indicates the AK context became obsolete due to the expiration of AK lifetime.

EAP Failure: This event indicates EAP-failure has been received from the NW.

External Stop: The event to stop the Authentication FSM and terminate connection with ABS.

[Auth] TEK update finished: The event received from TEK FSM to notify the Auth FSM that PMK context of old PMK can be discarded

NOTE-The following events are sent by an authentication state machine to the EAP state machine:

[EAP] key agreement completed: sent to the EAP FSM once key agreement is completed which means that new authentication is valid and old keys may be discarded.

NOTE-The following events are sent by an Authentication state machine to the TEK state machine:

[TEK] Stop: Sent by the Authentication FSM to an active (non-START state) TEK FSM to terminate the FSM and remove the corresponding SAID's keying material from the AMS's key table.

[TEK] Start: Sent by the Authentication FSM to a nonactive (STOP state), but valid TEK FSM.

[TEK] Key agreement finished: sent from Auth FSM after re-auth key agreement finished to trigger TEK FSM to renew both TEKs from new AK.

NOTE-The following events are sent by an external state machine to the TEK state machine:

Exit to idle: sent by the idle FSM when the AMS exit to idle mode

Reentry from idle: sent by idle FSM when AMS return from idle/DCR to active mode

[Ext] Secure location update: send by the paging FSM when secure location update is required.

[Ext] Secure location update: send by paging FSM when secure location update done and the Auth FSM back to idle.

16.2.5.2.4.4 Parameters

Key agreement Timer: The timer which expires if the AMS does not receive a PKMv3 Key Agreement MSG #3 after sending a PKMv3 Key Agreement MSG #1.

Refresh-PMK timer: Timeout period between sending PKMv3 Refresh-PMK messages from Authenticated active state.

16.2.5.2.4.5 Actions

Actions taken in association with state transitions are listed by <Start State> (<rcvd message>) --> <End state>:

1-A: Stopped (Start Auth) ?> Not Authenticated

a) Enable PKMv3 EAP-Transfer messages to be transferred.

1-F: Authenticated Reentry Authentication Wait (Start Auth) -> Not Authenticated

a) Stop TEK FSMs

b) Re-initialize the Authentication FSM

c) Enable PKMv3 EAP-Transfer messages to be transferred.

1-G: Authenticated Idle/DCR (Start Auth) -> Not Authenticated

a) Stop TEK FSMs

b) Re-initialize the Authentication FSM

c) Enable PKMv3 EAP-Transfer messages to be transferred.

2-B: Not authenticated (Key Agreement MSG#1) -> Key Agreement MSG#3 Wait

a) Obtain MSK from EAP FSM .

b)Derive all Key hierarchy (PMK, AK,CMAC key, TEK), *c) Send Key Agreement MSG#2 with CMAC*

d) Start Key Agreement Timer

2-C: Key Agreement MSG#3 Wait (Key Agreement MSG#1) -> Key Agreement MSG#3 Wait

a) Send Key Agreement MSG#2

b) Start Key Agreement Timer .

2-D: Authenticated Active (Key Agreement MSG#1) -> Refresh Key Agreement MSG#3 Wait

a) Obtain MSK from EAP FSM .

b)Derive all Key hierarchy (PMK, AK,CMAC key, TEK),

c) Send Key Agreement MSG#2 with CMAC

d) Start Key Agreement Timer

2-E: Refresh Key Agreement MSG#3 Wait (Key Agreement MSG#1) -> Refresh Key Agreement MSG#3 Wait

a) Send Key Agreement MSG#2

b) Start Key Agreement Timer .

3-C: Key Agreement MSG#3 Wait (Key Agreement MSG#3) -> Authenticated Active

a) Stop Key Agreement Timer

b) Start TEK FSM per negotiated SA

c) Start Authentication Grace Timer

d) Notify EAP FSM that authentication was completed

3-E: Refresh Key Agreement MSG#3 Wait (Key Agreement MSG#3) -> Authenticated Active

a) Stop Key Agreement Timer

b) Trigger TEK FSMs to update TEK to new AK

c) Start Authentication Grace Timer

d) Notify EAP FSM about authentication completion.

e) Notify TEK FSMs about key agreement finish so they will be aboe to obtain TEKs from new AK

4-B: Not authenticated (EAP Success) -> Not authenticated

a) Obtain MSK

4-D: Authenticated Active (EAP Success) -> Authenticated Active

a) Obtain MSK

5-C: Key Agreement MSG#3 Wait (Key Agreement Timeout) -> Key Agreement MSG#3 Wait

a) Send Key Agreement MSG#2

b) Start Key Agreement Timer .

5-E: Refresh Key Agreement MSG#3 Wait (Key Agreement Timeout) -> Refresh Key Agreement MSG#3 Wait

a) Send Key Agreement MSG#2

b) Start Key Agreement Timer .

6-C: Key Agreement MSG#3 Wait (Key Agreement MSG #2 max resend elapsed) -> Not authenticated

6-E: Refresh Key Agreement MSG#3 Wait (Key Agreement MSG #2 max resend elapsed) -> Authenticated Active

7-D: Authenticated Active (Key context refresh needed) -> Authenticated Active

a) Send refresh-PMK Message

b) Start refresh-PMK Timer

8-D: Authenticated Active (Start Reentry) -> Authenticated Reentry Authentication Wait

a) Generate AK Context and all derived keys for Target ABS

b) Enter AK_COUNT LOCK state

8-E: Refresh Key Agreement MSG#3 Wait (Start Reentry) -> Authenticated Reentry Authentication Wait

a) Generate AK Context and all derived keys for Target ABS

b) Enter AK_COUNT LOCK state

c) Remove all refresh key agreement created context

9-D: Authenticated Active (refresh-PMK Timeout) -> Authenticated Active

a) Send refresh-PMK Message

b) Start refresh-PMK Timer

10-F: Authenticated Reentry Authentication Wait (HO canceled) -> Authenticated Active

a) Remove AK context of all Target ABS

b) Retrieve AK context of Serving ABS

c) Update PMK context with AK key counter value

d) Exit AK counter lock state

11-F: Authenticated Reentry Authentication Wait (HO canceled) -> Authenticated Reentry Authentication Wait

a) Cache AK context of former Target ABS

b) Retrieve or generate if not cached AK context of new Target ABS

12-F: Authenticated Reentry Authentication Wait (Reentry Completed) -> Authenticated Active

a) mark AK context of last Target ABS as Serving ABS

b) Delete AK context of all cached Target ABSs

c) Update PMK context with AK_COUNT value

d) Exit AK_COUNT LOCK state

13-D,E,F: Any state with valid authentication (Authentication expired) -> Stopped

a) Stop TEK FSMs

b) Delete all authentication context

c) Stop authentication FSM

14-D: Authenticated Active (EAP Failure) -> Authenticated Active

15-B,C,D,E,F,G: Any state (External stop) -> Stopped

a) Stop TEK FSMs if active

b) Delete all authentication context

c) Stop authentication FSM

16-D: Authenticated Active (Exit to Idle) -> Authenticated Idle *a) Stop TEK FSM*

16-E: Refresh key agreement MSG#3 wait (Exit to Idle) -> Authenticated Idle

a) Stop TEK FSM

17-G: Authenticated idle/DCR (Re-entry from idle) -> Authenticated Active

a) Update AK context with AK_COUNT

b) Notify PMK context about AK_COUNT updated value

c) Derive AK context and all sub keys

d) Start TEK FSM

18-G: Authenticated idle ([Ext]Secure location update) -> Secure Location update

a) Update AK context with AK_COUNT

b) Notify PMK context about AK_COUNT updated value

c) Derive AK context and all sub keys

d) Start TEK FSM

19-D: Authenticated active (TEK update finished) -> Authenticated Active

a) If all TEK FSMs reported TEK update finished'delete old PMK context

20-H: Secure Location Update ([Ext]Secure location update done) -> Authenticated idle/DCR

a) Stop TEK FSM

16.2.5.2.5 TEK state machine

The AMS TEK state machine of 16m consists of six states and eight events (including messages) which will trigger state transitions. The TEK FSM is presented in both a state flow diagram (Figure 407—) and a state transition matrix (Table 738—).

TEK FSM under shaded states in Figure 407—has valid SA Context.

The Authentication FSM starts an independent TEK FSM for each of its authorized SAIDs. As mentioned in [1], the AMS maintains two active TEKs for each SAID.

For the TEK update of a given SAID, the ABS includes in its Key Response with parameters such as EKS, PMK Seq_Num, COUNTER_TEK. The BS encrypts DL traffic with TEK_{DLE} and decrypts UL traffic according to the EKS bit, depending upon which of the two keys the AMS used at the time. The AMS encrypts UL traffic with TEK_{ULE} and decrypts DL traffic according to the EKS bit. See <<15.2.5.2.4>> [1] for details on AMS and ABS key usage requirements.

Through operation of a TEK FSM, the AMS attempts to keep the SAID related TEK Context synchronized with the ABS. TEK state machine issues TEK-REQ message to update the related TEK Context for the indicated SAID whenever required. When AMS receives a TEK-RSP message and there is a new COUNTER_TEK (not maintained by the AMS at the moment), AMS shall always update its records with the TEK Context contained in the TEK-RSP message for the associated SAID.

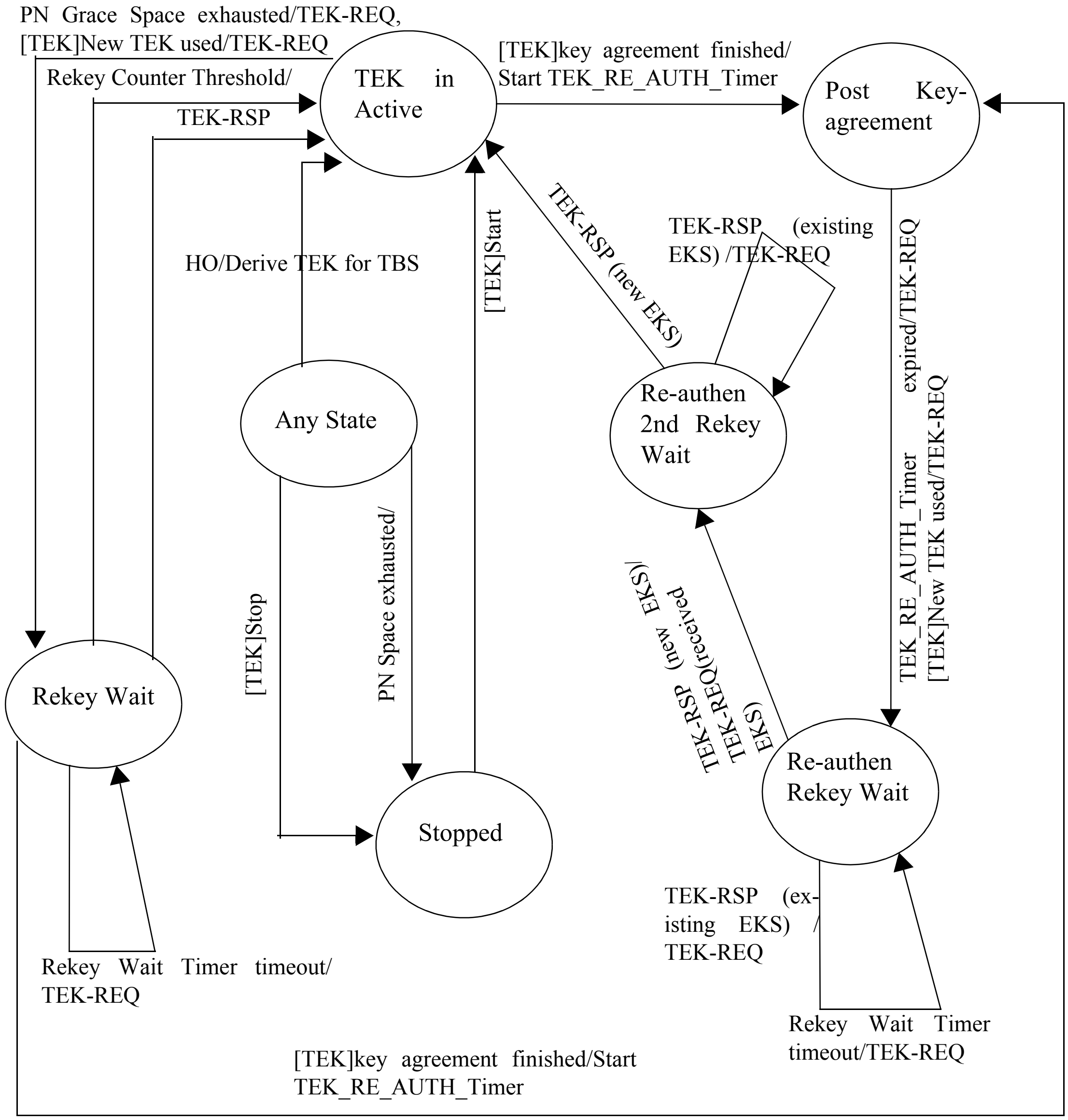


Figure 407—TEK State Machine for PKMv3

Table 738—TEK FSM State Transition Matrix for PKMv3

Event or Rcvd Message	State					
	(A) Stopped/ Idle	**(B) TEK in Active**	**(C) Rekey Wait**	**(D) Post key agreement**	**(E) Re-auth Rekey Wait**	**(F) Re-auth 2nd Rekey Wait**
(1) [TEK]Stop		Stopped/idle	Stopped/idle	Stopped/idle	Stopped/idle	Stopped/idle

Table 738—TEK FSM State Transition Matrix for PKMv3

Event or Rcvd Message	State					
	(A) Stopped/ Idle	(B) TEK in Active	(C) Rekey Wait	(D) Post key agreement	(E) Re-auth Rekey Wait	(F) Re-auth 2nd Rekey Wait
(2) [TEK]Start	TEK in Active					
(3) [TEK]Key agreement Finished		Post Key agreement	Post Key agreement			
(4)TEK-RSP (existing EKS)			TEK in Active		Re-auth Rekey Wait	Re-auth 2nd Rekey Wait
(5) TEK-RSP (newer EKS)			TEK in Active		Re-auth 2nd Rekey Wait	TEK in Active
(6) New TEK used		Rekey Wait	Rekey Wait	Re-auth Rekey Wait	Re-auth 2nd Rekey wait	
7) PN Space Exhausted		Stopped/idle	Stopped/idle	Stopped/idle	Stopped/idle	Stopped/idle
8) PN Grace space exhausted		Rekey Wait	Rekey Wait			
(9) Rekey Counter threshold			TEK in Active			
(10) Rekey Wait Timer timeout			Rekey Wait		RE-Authen Rekey Wait	Re-auth 2nd Rekey wait
(11) TEK Re-Auth timer expired				RE-Authen Rekey Wait		

16.2.5.2.5.1 States

Stopped: This is the initial state of TEK FSM, No resources are assigned to or used by the FSM in this state - e.g., all timers are off, and no processing is scheduled.

This state is used before there are valid TEKs and when TEKs are not active like idle, DCR etc

TEK in Active: The AMS has valid SA Context for the associated SAID and is not waiting for any TEK-RSP message and AMS is in active/HO mode under this state.

Rekey Wait: The AMS has valid SA Context for the associated SAID and is waiting for TEK-RSP message for regular TEK update for this SAID. AMS is in active mode under this state.

Post key agreement: This is a transition state after re-authentication to let the BS time to derive first TEK from new AK, in this state all TEKs are active and the AMS waits for the timer to expire so it can send

TEK_REQ to the ABS. While in this state the AMS SHALL discard all received TEK_RSP messages from ABS

Re-auth Rekey Wait: After key agreement with associated AK refresh, AMS have send TEK_RSP and stays in this state to waits for TEK-RSP message to refresh its TEK_{ULE} derived from new AK. AMS is in active mode under this state.

Re-auth 2nd Rekey Wait: When receiving the TEK-RSP message and AMS successfully refresh its first TEK_{ULE} associated with new AK, AMS shall transfer to this state to wait for the second refreshed TEK from new AK. This state is different than normal Rekey wait in the sense that the MS SHALL not leaves this state without refreshing the second TEK from new AK.

16.2.5.2.5.2 Messages

TEK-REQ: refer to section 16.2.3.41.6

TEK-RSP: refer to section 16.2.3.41.7

16.2.5.2.5.3 Events

[TEK]Stop: Sent by the Authorization FSM to TEK FSM to terminate TEK FSM and remove the corresponding SAID's TEK Context from the AMS's key table.

[TEK]Start: Sent by the Authorization FSM to TEK FSM or a new TEK FSM to activate the TEK FSM for the associated SAID.

[TEK] New TEK used: This event MAY be triggered by the Data Path function (it is implementation specific weather to monitor this event or not) when current PMK is valid and the AMS realizes that ABS uses its TEK_{ULE} in the DL,. Once the active TEK FSM receives this event, it shall start to update the related TEK.

[TEK] Key Agreement Finished: This event is sent from the Authentication FSM to trigger the TEK update after re-auth procedure.

[Auth] TEK update finished: This event is sent to the Authentication FSM to notify that both TEK are updated with new AK and old AK context can be discarded.

PN space exhausted: This event is triggered when the PN space for the current TEK in use is exhausted.

PN grace space exhausted: This event is triggered when the PN reached its grace space and triggers TEK update procedure.

Rekey Counter threshold: This event is triggered when the number of times AMS retries TEK-REQ exceeds the maximal Rekey Counter threshold. The AMS shall continue using its current TEK.

Rekey Wait Timer timeout: This event is triggered when AMS does not receive TEK-RSP by the Rekey Wait Timer expiration.

TEK Re-Auten Timer exhausted: This event trigger the AMS to request for a new KEY after key agreement.

16.2.5.2.5.4 Parameters

All configuration parameter values take the default values from Table xxx or may be specified in Auth Reply message.

PN Grace Space:

PN Grace Space is set to the value smaller than the maximum number of the PN Space to guarantee that AMS can update related TEK between the interval of PN Grace Space and PN Space gracefully.

It takes the default value from Table XXX.

Rekey Wait Timer:

The timer for TEK FSM to receive TEK-RSP message after sending out TEK-REQ message.

It takes the default value from Table xxx or may be specified in a configuration setting within the Auth Reply message and is the same across all SAIDs (see 11.9.18.6).

Rekey Counter:

The counter for re-sending the TEK-REQ if AMS doesn't receive the TEK-RSP by the Rekey Wait Timer for the SA.

The initial value is 0. It shall be increased by 1 for each re-sending. The threshold takes the value from Table XXX.

TEK Re-Authen Timer:

The timer fro the AMS to wait after key agreement before sending the key request to the ABS, this timer is used to allow the BS time to derived the new key before asking for it.

The value of this timer is taken from XXXX>

16.2.5.2.5.5 Actions

Actions taken in association with state transitions are listed by <state> (<event>) --> <state>:

1-B,C,D,E,F: Any state ([TEK]stop) -> Stopped

a) Remove TEK Context for the related SAID

b) Clear UL/DL PN number

2-A: Stopped ([TEK]start) -> TEK in Active

a) Generate TEK context for the related SAID

b) Set TEK counter to 0

c) Set PN for each TEK to 1

3-B: TEK in Active ([TEK] Key agreement Finished) -> Post key agreement

a) Start TEK re-Authen Timer

3-C: Rekey wait ([TEK] Key agreement Finished) -> Post key agreement

a) Start TEK re-Authen Timer

4-C: Rekey wait (TEK-RSP with existing EKS) -> TEK in Active

4-E: Re-auth Rekey wait (TEK-RSP with existing EKS) -> Re-auth Rekey wait

a) Reset Rekey Wait Timer

b) Sent TEK-REQ

4-F: Re-auth 2nd Rekey wait (TEK-RSP with existing EKS) -> Re-auth 2nd Rekey wait

a) Reset Rekey Wait Timer

b) Send TEK-REQ

5-C: Rekey wait (TEK-RSP with newer EKS) -> TEK in Active

a) Turn off Rekey timer/counter

b) Install received TEK

5-E: Re-auth Rekey wait (TEK-RSP with newer EKS) -> Re-auth 2nd Rekey wait

a) Turn off Rekey timer/counter

b) Install received TEK

16.2.5.3 Privacy

16.2.5.3.1 AMS identity privacy

AMS identity privacy support is the process of protecting the identity of AMS so that AMS MAC Address (ie., AMSID) is not revealed via air interface. To protect AMSID a hash value of the real AMSID (i.e. AMSID*) is defined as follows:

AMSID*=Dot16KDF(AMSID|80-bit zero padding, NONCE_AMS, 48)

- NONCE_AMS is a random of 48-bit generated by AMS before sending AAI_RNG-REQ message, and transmitted to ABS during the following Key Agreement procedure. If the AMS doesn't receive a successful AAI_RNG-RSP from the ABS, the AMS should re-generate a NONCE_AMS and re-derive the AMSID*, and then send another AAI_RNG-REQ with it to the ABS.

16.2.5.3.2 AMS location privacy

AMS location privacy support is the process of protecting the mapping between AMS MAC address and STID so that intruders cannot obtain the mapping information between the MAC address and STID. To protect the mapping between STID and AMS MAC address, a TSTID is assigned during initial ranging process, and is used until STID is allocated.

The STID is assigned during registration process after successful completion of initial authentication/authorization process, and is encrypted during transmission. The temporary STID is released after STID is securely assigned. The STID is used for all remaining transactions. The detailed procedures are described as follows:

AMS generates a new NONCE_AMS and derive AMSID*, then it sends AAI_RNG-REQ carrying the AMSID* to ABS. When ABS receives the AAI_RNG-REQ, it returns AAI_RNG-RSP containing temporary STID (instead of STID) and the AMSID* which the AMS sent. After being assigned, the temporary STID is used for the subsequent network entry procedures until STID is allocated. The real AMSID is transmitted to ABS in AAI_REG-REQ message in an encryption manner. As a response to the AAI_REG-RSP, a STID is assigned and transferred to the AMS through the encrypted AAI_REG-RSP. Once the AMS receives the STID via AAI_REG-RSP, it releases the temporary STID. The STID is then used for remaining transactions. Figure 408 shows the overall network entry procedures.

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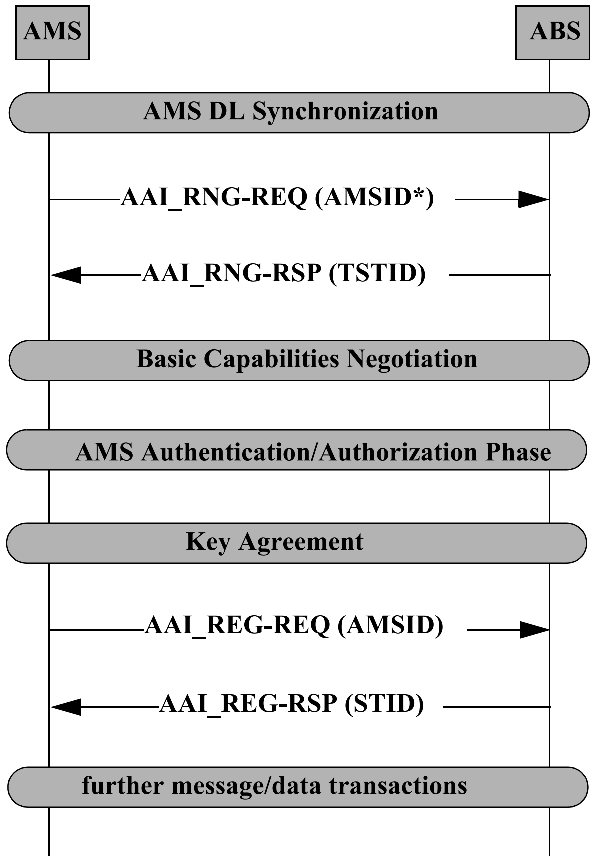


Figure 408—Network Entry Procedure to Support AMS Location Privacy in IEEE 802.16m

16.2.5.3.3 Control Plane Signaling Protection

AAI supports the confidentiality protection as well as integrity protection over MAC control messages. Specifically, encryption is selectively applied to the control messages whenever confidentiality protection is required. The encrypted unicast control messages shall be mapped to the primary SA. The selective confidentiality protection over control messages is the mandatory feature of 16m and the negotiated keying materials/ciphersuites are used to encrypt the control messages.

The selective confidentiality protection over control messages is indicated by the EC bit in the MCEH. Contrary to the transport flows where the established SA is applied to all data, the primary SA is selectively applied to the control messages. EC bit in the MCEH is used only for control flows to indicate whether PDU contains the control message that is encrypted based on control message type and its usage. In particular, whether control message is encrypted or not is decided on the security level with which the message is associated.

The selective protection over MAC control messages is made possible after the successful completion of local TEK derivation.

Figure 409 shows the three levels of protection over control messages.

No protection; If AMS and ABS have no shared security contexts or protection is not required, then the control messages are neither encrypted nor authenticated. The control messages before the authorization phase also fall into this category.

CMAC based integrity protection; CMAC Tuple is included as the last attribute of MAC control message. CMAC protects the integrity of entire control messages. Actual control message is plain-text

AES-CCM based authenticated encryption; ICV part of the encrypted MAC PDU is used for the integrity protection about the payload of control messages as well as AGMH.

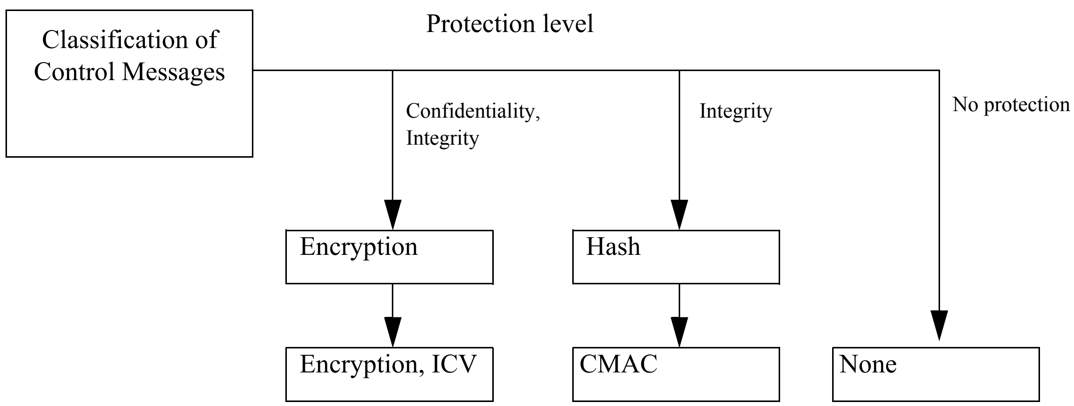


Figure 409—Flow of AAI Selective Control Message Protection

16.2.5.4 Security Context

The 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.

16.2.5.4.1 MSK context

The MSK context includes all parameters associated with the MSK. This context is created when EAP Authentication completes.

The MSK context is described in Table 739.

Table 739—The MSK context

Parameter	Size(bit)	Usage
MSK	512	The key yielded from the EAP authentication
MSK SN	4	MSK sequence number, when the EAP-based authentication is achieved and a key is generated. The 2 LSbs are the sequence counter. And the 2 MSbs set to 0. The initial value shall be set to zero. For each update, the value shall be increased by 1 mod 4.
MSK Lifetime	32	The time this MSK is valid. Before this expires re-authentication is needed.

This context is created upon completion of successful re/authentication and discarded when no longer valid or if key-agreement procedure was not completed for 120 seconds. It is created by the AMS and Authenticator when authenticating in LZONEs or MZONEs and must be maintained across zone switches.

The MSK lifetime shall be transferred from the EAP method and could also be configured by the AAA Server.

The life time may be enlarged using the key lifetime attribute in Key_Agreement-MSG#3 message during key agreement procedure following EAP-based authorization or EAP-based reauthorization procedures.

If the ABS needs to refresh the key it should initiate re-authentication to create a new one.

16.2.5.4.2 PMK context

The PMK context includes all parameters associated with the PMK. This context is created during a key agreement procedure and cached after successful key agreement procedure.

Two PMK contexts may exist in parallel in the AMS and Authenticator in transition phases were new PMK is created but the current PMK is still in use.

The PMK context is described in Table 740.

Table 740—The PMK context

Parameter	Size(bit)	Usage
PMK	160	The key is created during key agreement procedure.
PMK SN	4	PMK SN is the serial number assigned to a given PMK by the AMS in the key agreement; it is included in CMAC tuple to identify the used PMK.
PMK Lifetime	32	PMK Lifetime=MSK Lifetime
PMKID	64	PMKID = Dot16KDF(PMK, 0b0000|PMK SN|NONCE_AMS|NONCE_ABS| "PMKID", 64) The PMK SN in the Dot16KDF function is encoded in MSB first order. This is used in key agreement to verify sync of assignment SN to PMK
NONCE_AMS	64	The Random NONCE received from the AMS in the key-agreement that was done in order to create this PMK.
NONCE_ABS	64	The Random NONCE sent by the ABS in the key-agreement that was done in order to create this PMK. The ABS should not use same NONCE_ABS in more than one key-agreement procedure
AK_COUNT	16	Value of the Entry Counter that is used to guarantee freshness of computed CMAC_KEY_* with every entry and provide replay protection. This counter is maintained across zone switch (LZONE and MZONE) to ensure replay protection when switching to LZONE multiple times within the validly period of MSK

16.2.5.4.3 AK context

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

An AMS may manage several AK contexts in parallel in transition phases.

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

The AK context is described in Table 741.

Table 741—The AK context

Parameter	Size(bit)	Usage
AK	160	The key derived from PMK
AK Lifetime	32	AK Lifetime=PMK Lifetime
PMKID	64	The ID of the PMK used to derive this AK
PMK SN	4	The sequence number of PMK used to derive this AK.
CMAC_KEY_U	128	The key which is used for signing UL MAC control messages.
CMAC_PN_U	24	Used to avoid UL replay attack on the control connection before this expires, reauthorization is needed. The initial value of CMAC_PN_U is zero and the value of CMAC_PN_U is reset to zero whenever AK_COUNT is increased.
AK_COUNT	16	A value used to derive the AK
CMAC_KEY_D	128	The key which is used for signing DL MAC control messages.
CMAC_PN_D	24	Used to avoid DL replay attack on the control connection before this expires, reauthorization is needed. The initial value of CMAC_PN_D is zero and the value of CMAC_PN_D is reset to zero whenever AK_COUNT is increased.
Next available counter_TEK	16	The counter value to be used in next TEK derivation, after derivation this is increased by 1.

16.2.5.4.4 SA context

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

The SA context holds 2 TEK contexts and additional information that belongs to the SA itself.

16.2.5.4.4.1 TEK Context

The TEK context includes all relevant parameters of a single TEK and is described in Table 742.

16.2.5.4.4.2 SA Context

The SA context is described in Table 743.

Table 742—The TEK context

Parameter	Size(bit)	Usage
TEK	128	Key used for encryption or decryption of MPDUs from FIDs associated with the corresponding SA
EKS	2	Encryption key sequence number
PMK SN	4	The sequence number of PMK used to derive this TEK.
COUNTER_TEK	16	The counter value used to derive this TEK
TEK lifetime	32	TEK lifetime=MSK lifetime
TEK_PN_U	22	The PN used for encrypting UL packets. After each MPDU transmission, the value shall be increased by 1. (0x300000-0x4FFFFF)
TEK_PN_D	22	The PN used for encrypting DL packets. After each MPDU transmission, the value shall be increased by 1. (0x00000000-0x2FFFFF)
PN Window Size	As negotiated in key agreement	The receiver shall track the PNs received inside PN window

Table 743—The SA context

Parameter	Size(bit)	Usage
SAID	8	The identifier of this SA, which describes the applied en/decryption method and TEK contexts.
TEK_{DLE} context	Sizeof(TEK Context)	TEK context used for downlink encryption and decryption.
TEK_{ULE} Context	Sizeof(TEK Context)	TEK context used for uplink encryption and decryption.

16.2.6 MAC HO procedures

This subclause specifies the HO procedures for the AAI. An AMS/ABS shall perform HO using the procedures defined in 16.2.6

16.2.6.1 Network topology acquisition

16.2.6.1.1 Network topology advertisement

An ABS shall periodically broadcast the system information of the neighboring ABSs using an AAI_NBR-ADV message. A broadcast AAI_NBR-ADV message may include the information of Open Subscriber Group Femto and/or macro hotzone ABSs, but shall not include information of neighbor Closed Subscriber Group (CSG) Femto. A broadcast AAI_NBR-ADV message may omit information of neighbor cells with cell bar information=1 in its S-SFH.

A serving ABS may unicast the AAI_NBR-ADV message to an AMS upon reception of the AAI_NBR-REQ message or in unsolicited manner. The AAI_NBR-ADV message may include parameters required for cell selection e.g., cell load and cell type. The ABS may broadcast different fragments of AAI_NBR-ADV message over multiple MAC PDU's.

16.2.6.1.2 AMS scanning of neighbor ABSs

The scanning procedure provides the opportunity for the AMS to perform measurement and obtain necessary system configuration information of the neighboring cells for handover decision. An ABS may allocate time intervals to an AMS to seek and monitor suitability of neighbor ABSs as targets for HO. Such time interval during which the AMS scans neighbor ABS while not available to serving ABS is referred to as a scanning interval. The ABS may specify the different trigger parameter values based on the target ABSs or ABS types in the AAI_SCD message. The ABS may specify the target ABS types the AMS shall scan, and/or averaging parameters that override the value defined in the AAI_SCD message.

The AMS may use any unavailable interval to perform autonomous scanning

An AMS shall be capable of performing intra-frequency preamble measurement without dedicated allocations for scanning .

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 may prioritize the scanning candidates by presenting the candidate ABSs in descending order of priority in the AAI_SCN-RSP message. The AMS should follow the order of scanning as suggested in the AAI_SCN-RSP message.

An AMS measures the signal from selected scanning candidate ABSs and reports the measurement result back to the serving ABS according to report mode and report parameters defined by the serving ABS.

An AMS may request an allocation of a scanning interval to an ABS by sending the AAI_SCN-REQ message to the serving ABSs. Upon reception of the AAI_SCN-REQ message, the ABS shall respond with an AAI_SCN-RSP message. The AAI_SCN-RSP message shall either grant the requesting AMS a scanning interval or deny the request. The serving ABS may also send unsolicited AAI_SCN-RSP message to initiate AMS scanning.

16.2.6.2 Trigger condition definitions

The S-ABS may define trigger conditions for the following actions:

1) Conditions that define when the AMS shall initiate scanning procedure

a) Conditions that define when the AMS shall report scanning measurement results to the serving ABS

a) Conditions that define when AMS shall initiate HO by sending AAI_HO-REQ.

a) Conditions for defining when a target ABS is unreachable

a) Conditions for defining when AMS is unable to maintain communication with the serving ABS

a) Conditions for HO cancellation

The trigger TLV (type xx) in Table xxx is encoded using the description in Table 744. The trigger TLV for another ABS type (which includes ABS type parameter: such as macro, macro hot-zone, Femto and relay, etc) is encoding using the description in Table XY

Table 744—Trigger TLV Description

Name	Type	Length (Bytes)	Value
Type/Function/Action	xx.1	1	See Table 745—for description
Trigger Value	xx.2	1	Trigger value is the value used in comparing measured metric for determining a trigger condition
Trigger averaging parameter	xx.3	1	The averaging parameter used for averaging this trigger metric according to equation (1). 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 0x10 to 0xFF: reserved
ABS type	xy.1	1	ABS type of target ABS for this Trigger TLV: (Macro Hot-zone ABS, Femto ABS, etc.)

Table 744—Trigger TLV Description

Name	Type	Length (Bytes)	Value
Type/Function/Action	xy.2	1	See Table YY for description
Trigger Value	xy.3	1	Trigger value is the value used in comparing measured metric for determining a trigger condition.
Trigger averaging parameter	xy.4	1	The averaging parameter used for averaging this trigger metric according to equation (1) for target 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

The Type/function/action byte field of the trigger description in Table 744 is described in Table 745.

Metric averaging is performed according to (1)

Let $x[k]$ be the metric the AMS is required to average (e.g. RSSI) for the k-th measurement, expressed in linear units. Then $\hat{x}[k]$, the averaged metric expressed in linear units, equals:

$$\hat{x}[k] = \begin{cases} x[0] & k = 0 \\ (1-\alpha avg)^{n+1}\hat{x}[k-1] + (1-(1-\alpha avg)^{n+1})x[k] & k > 0 \end{cases} \quad (1)$$

Where:

αavg = trigger averaging parameter in relevant trigger TLV. If this field is not present, the default trigger averaging parameter in AAI_SCD is used.

n = number of consecutive frames in which no measurement was made

In frames in which no measurement is made, the AMS shall report the latest averaged results.

Table 745—Trigger; Type/Function/Action Description

Name	Size (Bit)	Value
Type	2(MSB)	Trigger metric type: 0x0: CINR metric 0x1: RSSI metric 0x2: RTD metric 0x3: Metric = Number of consecutive P-SFHs missed
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 serving ABS metric by relative value 0x4: Metric of neighbor ABS is less than serving ABS metric by relative value 0x5: Metric of serving ABS greater than absolute value 0x6: Metric of serving ABS less than absolute value 0x7: Reserved NOTE-0x1-0x4 not applicable for RTD trigger metric NOTE-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 or 0x6, 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 NOTE-Type 0x3 can only be used together with function 0x5 or function 0x6
Action	3(LSB)	Action performed upon reaching trigger condition: 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: If this ABS is the serving ABS(meaning the AMS is unable to maintain communication with the ABS), AMS sends AAI_HO-IND with code 0x03 to the serving ABS and proceeds as specified in section <<15.2.5.2.4>>. If this ABS is a target ABS, 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 target ABSs included in AAI-HO-CMD during HO execution. The specific actions are described in section <<15.2.5.2.4>>. 0x5: Cancel HO 0x6 and 0x7: Reserved NOTE-0x3 is not applicable when neighbor ABS metrics are defined (i.e., only Function values 0x5 or 0x6 are applicable).

The ABS may define complex trigger conditions by including multiple Trigger TLV encodings in the same compound TLV. In this case, all included triggers shall have the same Action code (as defined in Table 744). The AMS shall perform a logical AND of all the conditions in a complex trigger condition and invoke the action of the trigger only when all trigger conditions are met.

Whenever the condition of a simple trigger or all the conditions of a complex trigger are met, the AMS shall invoke the action of the trigger. If multiple trigger conditions are met simultaneously the AMS shall invoke the action of at least one of the triggers for which the trigger condition was met. Action 0x2: Respond on trigger with AAI_HO-REQ takes precedence over actions 0x1 and 0x3

The ABS may define neighbor-specific triggers by including neighbor-specific trigger TLVs in the AAI_NBR-ADV message. The AMS evaluates neighbor-specific triggers only for the specific neighbor BS metric.

Neighbor-specific trigger TLVs use the format in Table 744—, where only function types 0x1, 0x2, 0x3 and 0x4 and actions types 0x1 and 0x2 are allowed. When present, neighbor-specific handover triggers override any general trigger TLVs (define in the AAI_SCD message) of the same type, function and action.

16.2.6.3 HO procedure

The subclause defines the HO procedure in which an AMS transfers from the air-interface provided by one ABS to the air-interface provided by another ABS.

16.2.6.3.1 HO Framework

The handover procedure is divided into three phases, namely, HO initiation, HO preparation and HO execution. When HO execution is complete, the AMS is ready to perform Network reentry procedures at target ABS. In addition, HO cancellation procedure is defined for AMS to cancel the HO procedure.

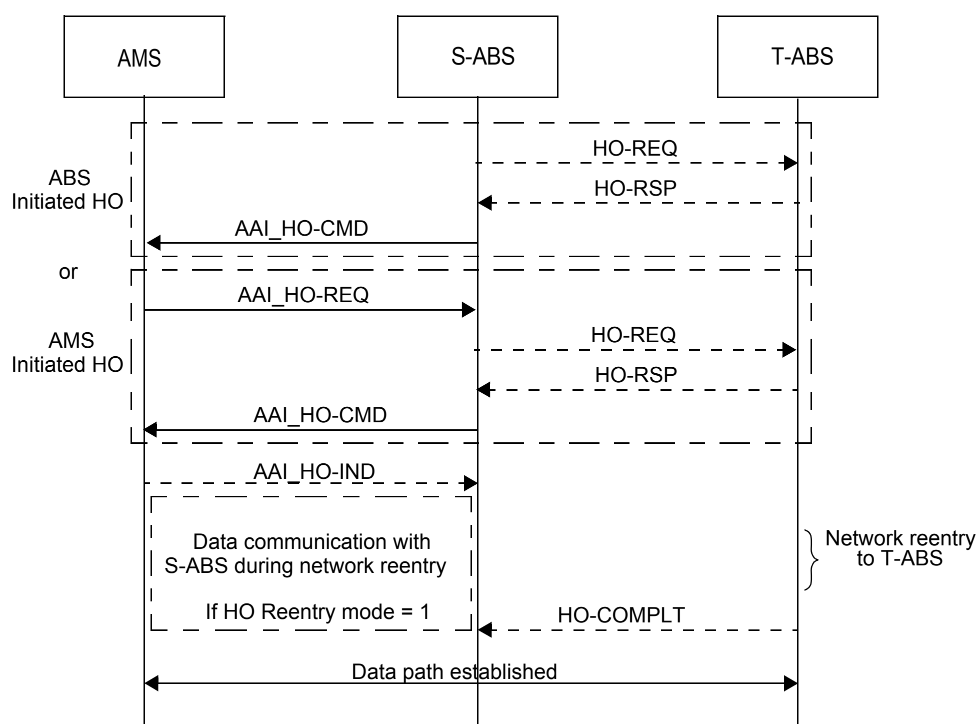


Figure 410—Generic HO Procedure

16.2.6.3.2 HO decision and initiation

Either the AMS or the serving ABS may initiate handover. If the serving ABS defines trigger conditions for initiating handover, the AMS shall initiate a handover when one or more of the trigger conditions is met.

When HO is initiated by AMS, an AAI_HO-REQ message is sent by the AMS to start the HO procedure. In case of ABS initiated HO, HO preparation is performed before HO initiation, and an AAI_HO-CMD message is sent by the ABS to initiate the HO procedure. For ABS-initiated HO, an ABS shall set Polling bit to 1 in MCEH of the AAI_HO-CMD message. Upon receiving AAI_HO-CMD message the AMS shall acknowledge it according to the procedure defined in 16.2.21, so that the ABS confirms whether the AMS receives the AAI_HO-CMD message correctly or not.

During handover initiation, the serving ABS may indicate whether the AMS can maintain communication with the serving ABS while performing network reentry with the target ABS by setting the HO_Reentry_Mode in AAI_HO-CMD to 1. If the AMS is not expected to maintain communication with the serving ABS while performing network reentry in the target ABS, the HO_Reentry_Mode is set to 0.

The AMS shall not perform HO to a cell with Cell Bar bit=1 in its S-SFH. The “Cell Bar” bit, when set, indicates that an AMS should not perform network entry or re-entry to this cell.

16.2.6.3.3 HO Preparation

During HO preparation phase, the serving ABS communicates with target ABS(s) selected for HO. The AAI-HO_CMD message should not include an ABS with cell bar information =1. A Femto ABS shall follow the handover procedure described in section 16.4.8. The target ABS may obtain AMS information from the serving ABS via backbone network for HO optimization.

During HO preparation phase, the target ABS may allocate a dedicated ranging code and dedicated ranging opportunity to the AMS via the serving ABS through the AAI_HO-CMD message, indicated by both Dedicated_Ranging_Code_Flag and Dedicated_Ranging_Opportunity_Flag. The dedicated code and opportunity is assigned to the AMS until the Ranging Initiation Deadline. The AMS may reuse the pre-assigned dedicate ranging code and opportunity during network re-entry. If the AMS fails to perform ranging before expiration of Ranging Initiation Deadline it shall stop using the dedicated code and opportunity but randomly pick a ranging code if further ranging is necessary. The target ABS shall select the dedicated ranging code from the group of codes which are allocated for dedicated handover ranging purpose.

Information regarding AMS identity (e.g.STID) and security context should be pre-updated during HO preparation. Any mismatched system information between AMS and the target ABS, if detected, may be provided to the AMS by the Serving ABS during HO preparation. If pre-allocated at target ABS, the serving ABS shall include an STID to be used at target ABS in the AAI_HO-CMD message. The pre-allocated STID shall be used in the target ABS by the AMS to communicate with the target ABS. The FIDs which 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 target ABS, this shall also be indicated in the AAI_HO-CMD message.

If HO_Reentry_Mode is set to 1, the serving ABS shall negotiate with the target ABS the EBB HO parameters. In the single carrier handover case, the EBB HO parameters include HO_Reentry_Interleaving_Interval and HO_Reentry_Iteration for the AMS to communicate with the serving ABS during network reentry. In the multicarrier handover case, the EBB_HO parameters include the carrier information in the target ABS for the AMS performing network reentry while continuing communication with the serving ABS concurrently.

When only one target ABS is included in the AAI_HO-CMD message, the HO preparation phase completes when serving ABS informs the AMS of its handover decision via an AAI_HO-CMD message. When multiple target ABSs are included in the AAI_HO-CMD message, the HO preparation phase completes when the AMS informs the ABS of its target ABS selection via an AAI_HO-IND message with HO Event code 0b00. The AAI_HO-CMD message shall include Action Time of each target 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 target ABS which is the time instant when the data communication with the Serving ABS will be terminated. 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 AAI_HO-CMD message indicates if the static and/or dynamic context and its components of the AMS are available at the target 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.

16.2.6.3.4 HO Execution

HO execution starts with AAI_HO-CMD message and ends at AMS's beginning to perform network reentry at Action Time. If HO_Reentry_Mode is set to 0, The serving ABS stops sending DL data and providing UL allocations to the AMS after the disconnect time derived from Action Time and Disconnect Time Offset included in the AAI_HO-CMD message or upon receiving AAI_HO-IND with HO Event Code 0b10, whichever occurs first. If HO_Reentry_Mode is set to 1, the serving ABS stops sending DL data and providing UL allocations to the AMS after the disconnect time, upon receiving AAI_HO-IND with HO Event Code 0b10 or after receiving HO completion confirmation from target ABS, whichever occurs first.

If HO_Reentry_Mode is set to 0, at the Disconnect Time, the serving ABS shall start the Resource Retain Timer counting down from value Resource_Retain_Time provided by ABS in AAI_REG-RSP or AAI_HO-CMD messages.

The default Resource_Retain_Time indicated in AAI_REG-RSP is used unless AAI_HO-CMD provides Resource_Retain_Time. If AAI_HO-CMD includes Resource_Retain_Time, the value included in AAI_HO-CMD shall be used instead of the value included in AAI_REG-RSP. The serving ABS shall retain the context of the AMS including connections, states of MAC state machine, and untransmitted/unacknowledged data associated with the AMS for service continuation until the expiration of the Resource_Retain_Time.

If the AAI_HO-CMD message includes only one target ABS, the AMS shall execute the HO as directed by the ABS, unless, during HO execution or network reentry, the AMS finds that the target ABS is unreachable. The serving ABS defines conditions based on which the AMS decides if it is unable to maintain communication with the serving ABS. If the AMS decides, based on these conditions, that it cannot maintain communication with the serving ABS until the expiration of Disconnect Time, the AMS may send an AAI_HO-IND message with HO Event Code 0b10 to the serving ABS. If the AAI_HO-CMD message includes more than one target ABSs, the AMS shall select one of these targets and inform the S-ABS of its selection by sending an AAI_HO-IND message with HO Event Code 0b00 to the S-ABS before the expiration of Disconnect Time.

The serving ABS defines conditions based on which the AMS decides when a target ABS among those that are included in the AAI_HO-CMD message is unreachable. These conditions are defined as triggers with action code 0x4, as specified in section 16.2.6.2.

If the AAI_HO-CMD message includes no target ABS, or if all the target ABSs that are included in the AAI_HO-CMD message are unreachable as defined above, the AMS shall inform the serving ABS of it's preferred target ABS by sending the AAI_HO-IND message with HO Event Code 0b01 before expiration of Disconnect Time. If a serving ABS receives the AAI_HO-IND message with HO Event Code 0b01, it shall respond to the AMS by sending AAI_HO-CMD with a target ABS which may include the target ABS proposed by the AMS in the AAI_HO-IND message. The AMS shall wait until receiving the AAI_HO-CMD message before expiration of Disconnect Time unless the AMS cannot maintain communication with the serving ABS as defined above. If the AMS has no preferred target ABS, it may perform HO cancellation as described in section 16.2.6.3.6. If the AAI_HO-CMD message includes no target ABS, or all the target ABSs that are included in the AAI_HO-CMD message are unreachable, the Disconnect Time defines the deadline by which the AMS shall respond by sending AAI_HO-IND to the serving ABS.

An AMS may request bandwidth for the residual data in the buffer before the Disconnect Time. The serving ABS may send information about any unallocated requested bandwidth to the target ABS over the backhaul so that the target ABS may allocate uplink resource immediately after receiving the dedicated ranging code from the AMS or after Action Time if CDMA ranging is omitted.

16.2.6.3.5 Network Reentry

16.2.6.3.5.1 CDMA-based HO Ranging Procedure

The serving ABS indicates in the AAI_HO-CMD how CDMA HO ranging shall be performed by AMS during network reentry, as shown in Figure 411.

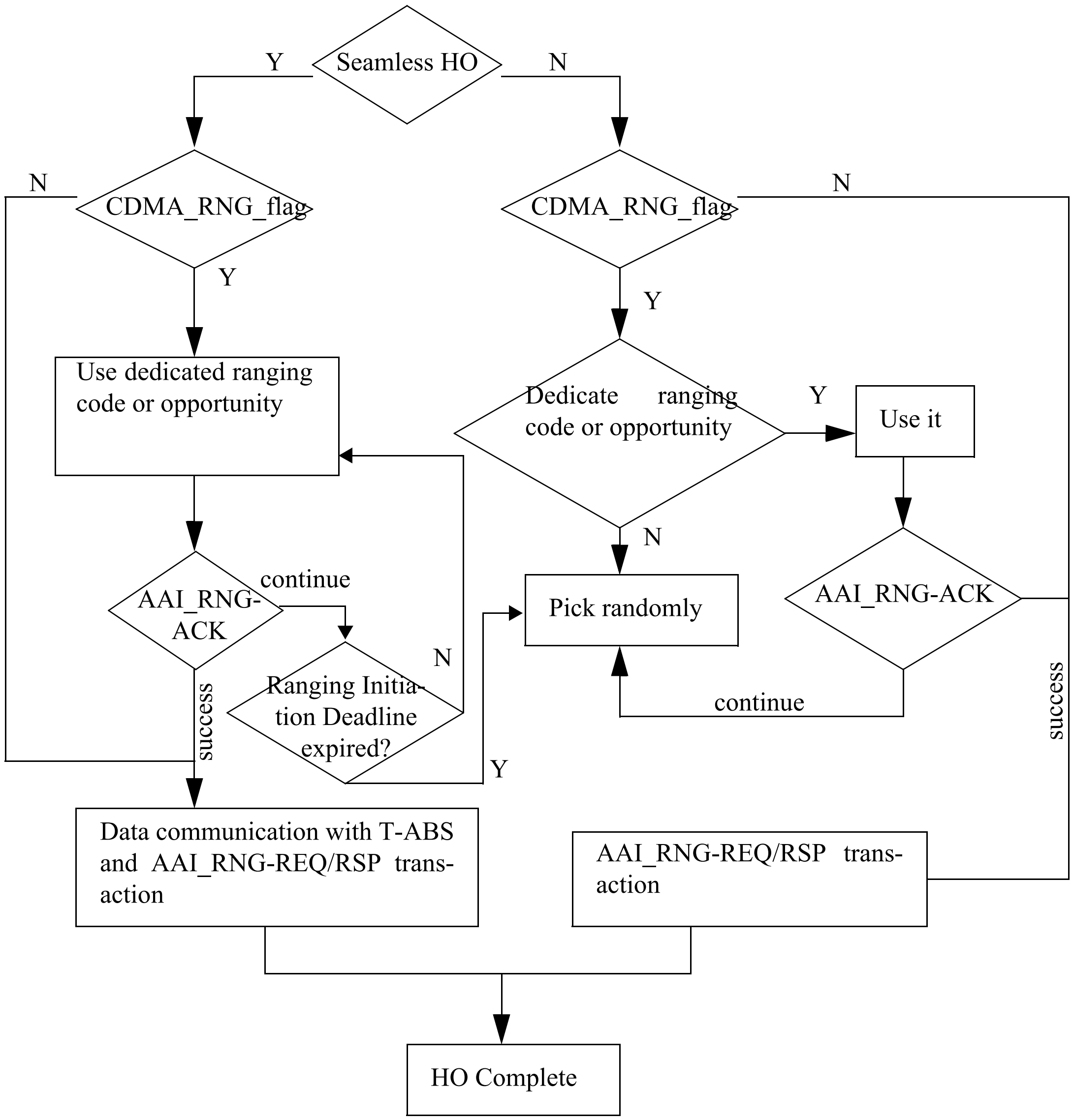


Figure 411—MS State machine during HO network reentry

If the serving ABS indicates in AAI_HO-CMD that CDMA-based HO ranging is not omitted by setting CDMA_RNG_FLAG=1 and a dedicated ranging code/opportunity is assigned to the AMS by target ABS, the AMS shall transmits the dedicated ranging code to the target ABS during network reentry. A serving ABS may schedule a ranging channel for handover purpose only if Ranging channel allocation periodicity in S-SFH SP1 is not set to 0 (i.e., every frame). If a ranging channel is scheduled by the target ABS for handover purpose only, the serving ABS shall also inform the AMS about the resource allocation of the ranging channel, and the ranging opportunity index where the ranging opportunity is located via the AAI_HO-CMD message. In such case, the AMS should use that ranging channel in order to avoid excessive multiple access interference. Upon reception of the dedicated ranging code and if ranging is successful, the target ABS shall allocate uplink resources for AMS to send AAI_RNG-REQ message and/or UL data. If the target ABS does not receive the dedicated ranging code within Ranging_Initiation_Deadline Timer, the target ABS shall discard the pre-assigned STID of the AMS.

If CDMA-based HO ranging is not omitted and if an AMS does not have a dedicated ranging code or a dedicated ranging opportunity at the target ABS, the AMS shall transmit a random handover ranging code at the earliest available ranging opportunity.

If the serving ABS determines that the AMS will be sufficiently synchronized with the target ABS and indicates in AAI_HO-CMD that CDMA based ranging can be skipped while performing network entry at the target ABS by setting CDMA_RNG_FLAG=0, the AMS shall apply the independently calculated adjustments when starting network entry at the target ABS by comparing A-Preamble signal timing measurements of the target ABS to serving ABS measurements. If the 'CDMA_RNG_FLAG' is set to 0, the target ABS shall allocate the UL resource for AAI_RNG-REQ after the Action Time. The Ranging_Initiation_Deadline - Action Time provides a bounded interval during which the MS may expect UL resource allocation for AAI_RNG-REQ.

Regardless of whether CDMA ranging is omitted or not, the serving ABS may send AAI_RNG-ACK message with timing/power adjustment parameters for which the MS shall apply for subsequent uplink transmissions. The serving ABS may also send AAI_RNG-ACK message with ranging status "continue" so that the AMS shall perform CDMA ranging with randomly selected HO ranging code in the next earliest ranging opportunity to adjust its uplink transmission timing/power properly. The ABS may dynamically allocate additonal ranging opportunities for the purpose of CDMA HO ranging.

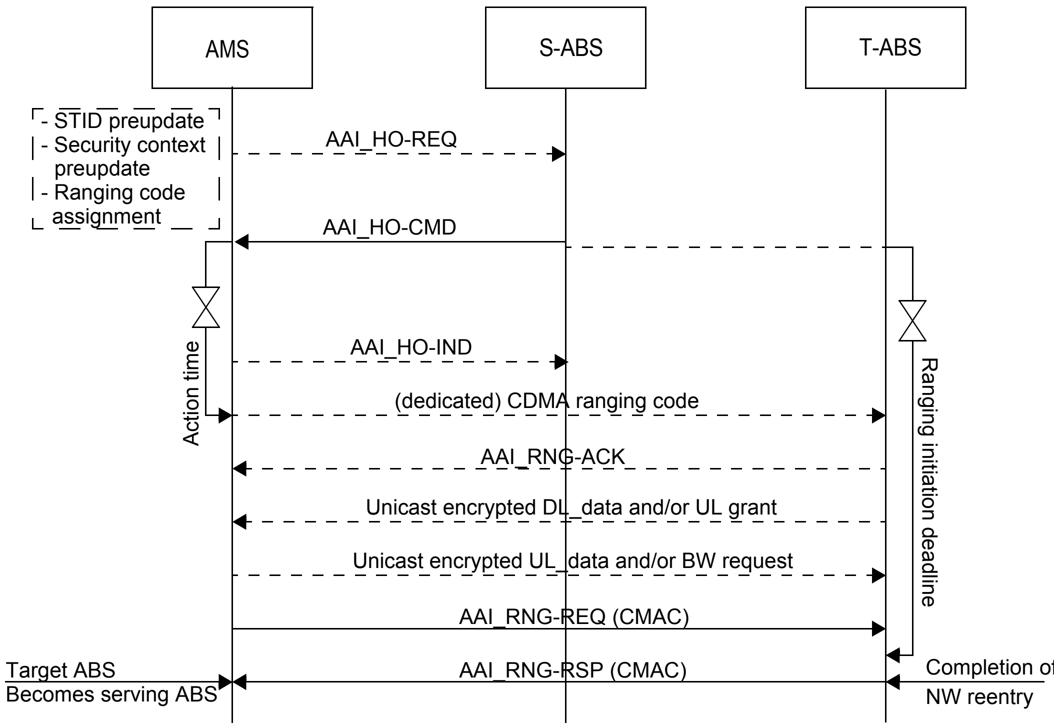
16.2.6.3.5.2 Network Reentry Procedure

The network reentry procedure with the target ABS may be optimized by target ABS possession of AMS information obtained from serving ABS over the backbone network.

At the Action Time specified in the AAI_HO-CMD message, the AMS performs network reentry at the target ABS.

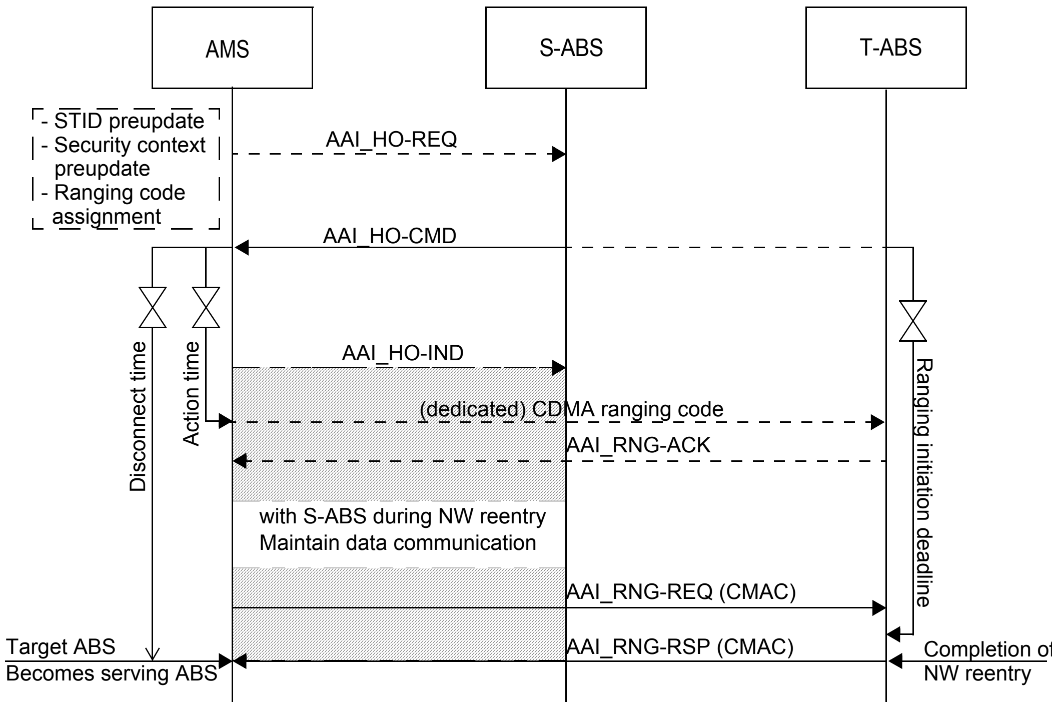
If HO_Reentry_Mode is set to 1, the AMS performs network reentry with the target ABS at Action Time while continuously communicating with the serving ABS. However, the AMS stops communication with serving ABS after network reentry at target ABS is completed. In addition, AMS does not exchange data with target ABS prior to completion of network reentry. If HO_Reentry_Interleaving_Interval > 0, the AMS communicates with the serving ABS during HO_Reenry_Interleaving_Interval, and with the target ABS using the remaining communication opportunity. If HO_Reentry_Interleaving_Interval = 0, AMS performs Multi-carrier EBB HO reentry procedure per 16.2.8.2.9.2. Upon completion of network reentry, the target ABS informs the serving ABS to stop allocating resources to the AMS and release AMS context.

The network reentry procedure is depicted in Figure 412 (HO_Reentry_Mode = 0) and Figure 413 (HO_Reentry_Mode = 1) respectively. This procedure corresponds to the block arrow entitled "Network reentry" in Figure 410 and is described in detail in the following.



Network reentry procedure with HO_Reentry_Mode set to 0. Messages depicted with dotted lines are transmitted only in certain HO scenarios. The dashed line (optional) AAI_RNG-ACK carries time adjustment parameters, etc.

Figure 412—Network reentry procedure with HO_Reentry_Mode set to 0



Messages depicted with dotted lines are transmitted only in certain HO scenarios.
The dashed line (optional) AAI_RNG-ACK carries time adjustment parameters, etc.

Figure 413—Network reentry procedure with HO_Reentry_Mode set to 1

During network reentry, the AMS is required to initiate the AAI_RNG-REQ/RSP message transaction by sending an AAI_RNG-REQ message before the deadline specified by the "Ranging Initiation Deadline" attribute included in AAI_HO-CMD message during handover preparation. The time is measured from the time the AAI_HO-CMD message is transmitted. If the target ABS does not receive an AAI_RNG-REQ message from the AMS within the deadline defined by the "HO Ranging Initiation Deadline" attribute, the target ABS considers the HO as failed and stops allocating bandwidth to the AMS. It is recommended that the ABS allows time equal to T3 timer (Table 553) before it reuses the STID that was allocated to the AMS. The AMS considers the HO as failed if it does not transmit AAI_RNG-REQ message before the deadline. If the AMS transmits AAI_RNG-REQ within the deadline, it may still consider the HO as failed if it does not receive an AAI_RNG-RSP within T3 after the last transmission or retransmission of AAI_RNG-REQ that was performed within the deadline. When the AMS considers the HO as failed, it invalidates the pre-allocated STID. In all cases, even when the AAI_RNG-REQ/RSP message transaction is initiated before the deadline, the HO is considered failed if the AAI_RNG-REQ/RSP procedure fails.

If data packets are exchanged between AMS and target ABS before the AAI_RNG-REQ/RSP transaction is completed, the recipient (AMS or target ABS) should store the received data packets and not release them to the upper layers until the sender is authenticated. If the data packets belong to a service flow associated with an SA that supports data authentication (as indicated by the data authentication algorithm identifier in the cryptographic suite of the SA) the receiver can authenticate the sender by verifying that the ciphertext authentication code included in each data packet was produced with the TEK associated with this SA. If the data packets belong to a service flow associated with an SA that does not support data authentication the receiver can authenticate the sender when the AAI_RNG-REQ/RSP transaction completes successfully. In all cases, if the sender is authenticated, the decrypted data packets are released to the upper layer in the recipient, and if the sender is not authenticated the data packets are discarded.

If data packets are exchanged between AMS and target ABS before the AAI_RNG-REQ/RSP transaction is completed, the *sender* (AMS or target ABS) should store the sent data packets and not discard them before the *receiver* is authenticated. If a service flow from the receiver exists and that service flow is associated with the primary SA that supports data authentication, the sender can authenticate the receiver by verifying that the ICV of the data packet received was generated using the TEK associated with the primary SA. Alternatively, the sender can authenticate the other side (the receiver) when the AAI_RNG-REQ/RSP transaction completes successfully. In all cases, if the sender fails to authenticate the other side, then it shall consider all sent packets as never transmitted and retransmit them to a new ABS or AMS when a new connection is established; If the sender successfully authenticates the other side, the sender shall discard the packets that were sent and stored.

The AAI_RNG-REQ/RSP transaction for HO is shown in Figure 413. The AMS shall initiate the AAI_RNG_REQ/RSP transaction by transmitting an AAI_RNG-REQ message to the target ABS before the deadline specified by the "Ranging Initiation Deadline" attribute included in AAI_HO-CMD message during handover preparation. The AAI_RNG-REQ message shall include STID, AK_COUNT and a CMAC tuple, but not include AMS MAC address or previous serving ABSID. When ABS receives the AAI_RNG-REQ message including a valid CMAC tuple, the ABS shall respond to the AAI_RNG-REQ message by transmitting encrypted AAI_RNG-RSP message. The AAI_RNG-RSP message shall be addressed to the AMS's STID.

After AMS finish network reentry with the target ABS, the target ABS becomes the serving ABS of the AMS.

In the case of an uncoordinated handover, the AAI_RNG-REQ message shall include the former serving BSID and previously used STID if the resource retain timer is not expired. When ABS receives the AAI_RNG-REQ message including a valid CMAC tuple, the ABS shall respond to the AAI_RNG-REQ message by transmitting encrypted AAI_RNG-RSP message including a STID for the AMS.

16.2.6.3.6 HO cancellation

After HO is initiated, the handover could be canceled by AMS at any phase during HO procedure. The HO cancellation is initiated before the expiration of the Resource_Retain_Time. An AMS requests HO cancellation to the serving ABS by sending the AAI_HO-IND with HO Event Code 0b11 (HO cancel) with its current CMAC KEY COUNT after Disconnect Time. The serving ABS shall explicitly acknowledge to the HO cancellation message upon receiving it through the AAI_MSG-ACK message. The AAI_MSG-ACK message is triggered by setting Polling bit to 1 in MCEH of the AAI_HO-IND message. After the HO cancellation is processed, the AMS and serving ABS resume their normal operation.

The network can advertise HO cancellation trigger conditions. When one or more of these trigger conditions are met the AMS cancels the HO.

16.2.6.3.7 Drops during HO

A drop during Handover is defined as the situation where an AMS experiences coverage loss with its serving ABS (either in the DL or in the UL) before the normal HO procedures with the serving ABS has been completed or where an AMS experiences coverage loss with target ABS before the network reentry procedure with the target ABS has been completed.

An AMS can detect a drop by FFS. An ABS can detect a drop by FFS.

When the AMS has detected a drop during network reentry with a target ABS, it may attempt network reentry with its preferred target ABS as through Cell Reselection, which may include resuming communication with the serving BS by sending AAI_HO-IND message with HO Event Code = 0b11 (HO cancel) or performing network reentry at the serving BS.

The network reentry process at the serving ABS is identical to the network reentry process at any other target ABS, both for the serving ABS and for the AMS. If the serving ABS has discarded the AMS context, the network reentry procedure shall be the same as full network reentry.

16.2.6.4 Handover between WirelessMAN-OFDMA Advanced and Reference Systems

16.2.6.4.1 Handover from WirelessMAN-OFDMA Reference to Advanced System

16.2.6.4.1.1 Network Topology Acquisition

16.2.6.4.1.1.1 Network Topology Advertisement

A WirelessMAN-OFDMA BS shall broadcast the system information of the LZone of its neighboring ABS using MOB_NBR-ADV message. This system information is used to facilitate AMS and WirelessMAN-OFDMA MS synchronization with the LZone of neighboring ABS without the need to monitor transmission from the neighboring ABS for DCD/UCD broadcasts.

The support of WirelessMAN-OFDMA advanced system in the neighbor ABS is indicated in the MAC version TLV in the MOB_NBR-ADV message transmitted in either the WirelessMAN-OFDMA BS or the LZone of the ABS.

An ABS uses one reserved bit in FCH to indicate the presence of its MZone, as defined in 16.10.1.1.

The MAC version may be used for AMS to distinguish between WirelessMAN-OFDMA Reference System and WirelessMAN-OFDMA Advanced co-existing System. A MAC version of 10 indicates an ABS of WirelessMAN-OFDMA Reference/Advanced co-existing system.

The AMS may acquire full system information by scanning of target WirelessMAN-OFDMA Advanced only System.

16.2.6.4.1.1.2 AMS Scanning

The AMS shall follow the same scanning procedure as defined in section 6.3.21.1.2.

In addition, an AMS may use the scanning interval to perform a scanning for the MZone of a neighboring WirelessMAN-OFDMA Advanced/WirelessMAN OFDMA Reference co-existence System.

16.2.6.4.1.2 Handover Procedure

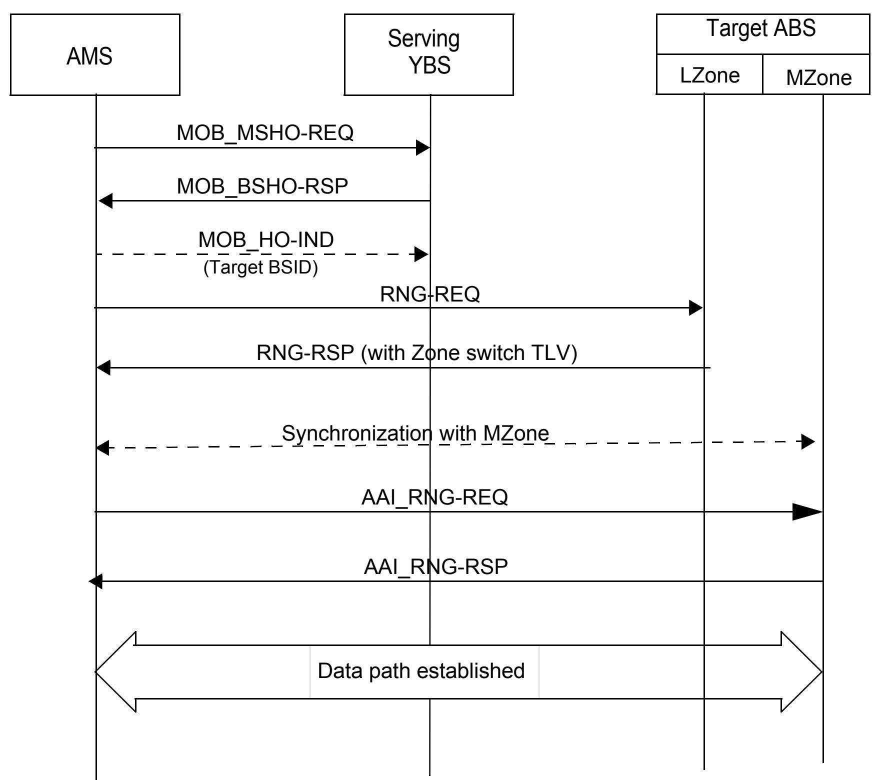
An AMS performs handover from a WirelessMAN-OFDMA BS to an ABS either by using zone switching based handover process or direct handover process. The detailed procedures for zone switch based handover and direct handover are described in 16.2.6.4.1.2.1 and 16.2.6.4.1.2.2 respectively. The zone switching based handover is applicable to the ABS supporting WirelessMAN-OFDMA Reference System/WirelessMAN-OFDMA Advanced co-existing System. The direct handover based handover is applicable to the ABS which only supports WirelessMAN-OFDMA Advanced System. An ABS may also decide to keep an AMS in the LZone of a WirelessMAN-OFDMA Reference System/WirelessMAN-OFDMA Advanced co-existing System.

16.2.6.4.1.2.1 Zone Switch based Handover Procedure

The zone switch based HO begins with a decision for an AMS to HO from the serving WirelessMAN-OFDMA BS to the LZone of a target ABS. The HO decision, initiation and cancellation follow the same procedures as defined in section 6.3.21.2. Zone Switch is initiated either by AMS or ABS while the final decision shall be made by ABS. In case of an AMS initiated zone switch, the AMS transmits an RNG-REQ message with the 'Ranging purpose indicator' bit #5 set to 1, which implies the zone switch request. Upon reception of such RNG-REQ message, the ABS sends a RNG-RSP message including the zone switch TLV.

The AMS performs network reentry in the LZone of the target ABS following the same procedures as defined in section 6.3.21.2.7. In addition, upon knowing the AMS capability of supporting WirelessMAN-OFDMA Advanced System based on the MAC version obtained either from the RNG-REQ sent from AMS in the LZone or from the serving ABS over the backbone, the ABS may direct the AMS to switch from LZone to MZone during or after AMS network reentry to the LZone.

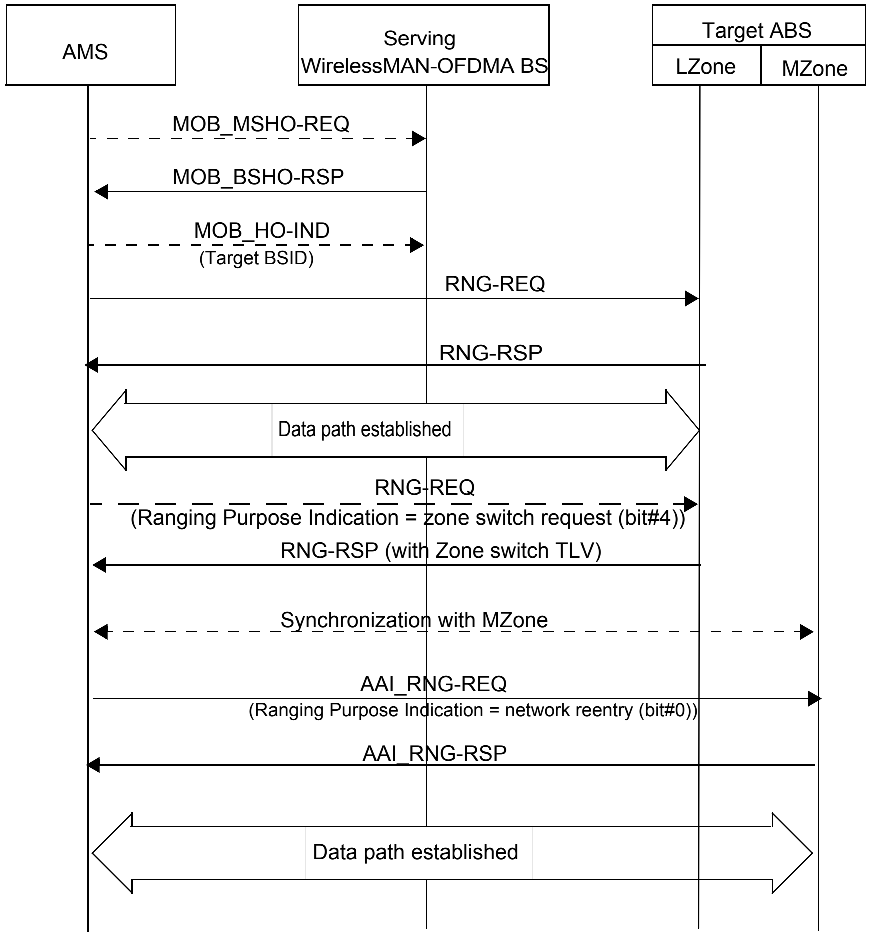
In case zone switch from Lzone to Mzone during network reentry is required, during an AMS performing network reentry in LZone, the ABS directs the AMS to stop the LZone network reentry and switch from LZone to MZone immediately by transmitting the RNG-RSP message containing Zone Switch TLV, as shown in Figure 414.



The T-ABS instructs the AMS to switch zones through RNG-RSP with Zone switch TLV before completion of network reentry at LZone.

Figure 414—Handover procedure from YBS to ABS

If the ABS decides to switch the AMS to MZone after AMS finishes the network reentry in the LZone, it sends an unsolicited RNG-RSP with Zone Switch TLV in LZone, as shown in Figure 415—.



The T-ABS instructs the AMS to switch zones after completion of network reentry at Lzone.

Figure 415—Handover procedure from WirelessMAN-OFDMA BS to ABS

The Zone Switch parameters shall include the followings and are coded as TLV tuples as defined in 16.10.2.1:

- MZone A-Preamble index.
- Time offset between LZone and MZone
- Action Time: Action time of zone switch from LZone to MZone. AMS performs zone switch at Action Time. If HO_Reentry_Mode=0, ABS stops all resource allocation for the AMS at LZone.
- Zone Switch Mode: If set to 1, the AMS maintains its data communication with the ABS in LZone while performing network reentry in MZone; otherwise it breaks data communication in LZone before performing network reentry in MZone.
- NONCE_ABS: It is used to derive a new PMK to be used in Mzone.

The Zone Switch TLV may also include the following:

- Temporary STID for being used in MZone

— Ranging initiation deadline: Valid time for Temporary STID. Shall be included if Temporary STID is included.

After receiving zone switch command through RNG-RSP in LZone, the AMS performs network reentry in MZone by performing DL synchronization with the MZone and listening to the ABS's SFH to acquire the system information of the MZone. The AMS maintains its normal operation in LZone (e.g., exchanging user data with the ABS in LZone) while performing network reentry in MZone if data path in LZone has been established before the start of zone switch operation and Zone Switch Mode is set to 1 in the Zone Switch TLV.

The AMS shall append CMAC tuple to the AAI_RNG-REQ message if the security context is available for the MZone. The ABS then responds with the AAI_RNG-RSP message. If the CMAC tuple in the AAI_RNG-REQ message is valid, the ABS shall respond to the AMS with the encrypted AAI_RNG-RSP message. If the CMAC in the AAI_RNG-REQ message is invalid or not included, the ABS shall trigger the AMS to initiate network entry procedure.

The AMS shall request UL bandwidth to send the AAI_RNG-REQ by using the pre-assigned STID if it is provided while in LZone. Upon reception of such BR, the ABS provides a UL grant for AMS to send AAI_RNG-REQ message. After receiving the AAI_RNG-REQ the target ABS responds with the AAI_RNG-RSP message.

The AMS shall also perform capability negotiation during network reentry in MZone through the exchange of AAI_SBC-REQ/RSP message and AAI_REG-REQ/RSP message. AMS context mapping from LZone to MZone is performed by the ABS per section 16.2.6.4.2.3.

16.2.6.4.1.2.2 Direct Handover Procedure

An AMS served by a WirelessMAN-OFDMA BS may discover an AAI only ABS and decide to directly HO to this ABS. The AMS may obtain target AAI only ABS information by blind scanning. In this case, the AMS performs network reentry procedure to the target ABS per section 16.2.6.3.5.2. To indicate a Direct HO, the Ranging_Purpose_Indicator is set to 'Direct HO' in the AAI_RNG-REQ message. Also, the AMS's CMAC tuple used in the previous WirelessMAN OFDMA Reference System shall be included in the AAI_RNG-REQ message to allow the target ABS retrieve AMS's context and authenticate the AMS. If the target ABS has no capability of authenticating an AMS by its CAMC tuple used at a WirelessMAN OFDMA Reference System, ABS shall indicate the AMS to perform initial network entry by appropriately setting the HO process optimization flags in the AAI_RNG-RSP message. Otherwise, the AMS shall perform network reentry procedure as described in Figure 416—.

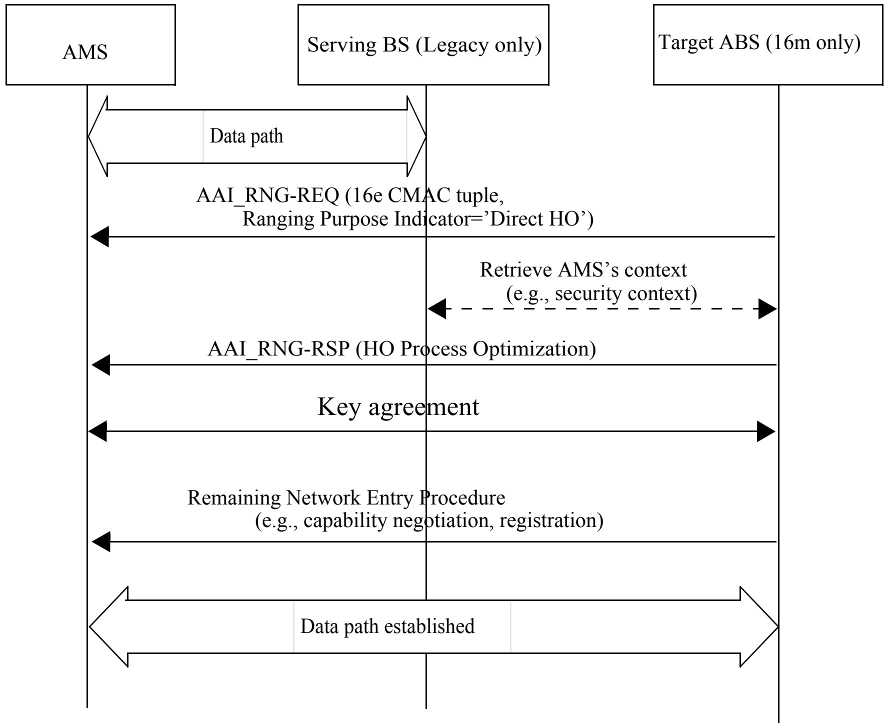


Figure 416—Direct HO procedure from WirelessMAN-OFDMA Reference System to a WirelessMAN-OFDMA Advanced Only System

16.2.6.4.1.3 Context Mapping

With zone switch based handover, the context management process from serving WirelessMAN-OFDMA BS to the LZone of target ABS follows section 6.3.21.2.8.1. The following section describes the context mapping from the LZone to the MZone of the target ABS during network reentry procedure in the MZone in the case of zone switch based handover.

16.2.6.4.1.3.1 MAC Identifiers

The FIDs for the control connections are set to xxx automatically. The FIDs for the transport connections are sequentially derived starting from yyy for all of the transport CIDs used in LZone. The AMS autonomously updates its Flow IDs in the ascending order from the first transport Connection ID.

16.2.6.4.2 Handover from Advanced WirelessMAN-OFDMA System to WirelessMAN-OFDMA Reference System

Handover of an AMS/WirelessMAN-OFDMA MS from LZone of an ABS to LZone of neighboring ABS or a WirelessMAN-OFDMA BS follows the same HO procedure defined in section 6.3.21.2. The following section only defines the handover procedure for an AMS from MZone of the serving ABS to a target WirelessMAN-OFDMA BS.

16.2.6.4.2.1 Network Topology Acquisition

16.2.6.4.2.1.1 Network Topology Advertisement

In the WirelessMAN-OFDMA Reference System/WirelessMAN-OFDMA Advanced co-existing System, an ABS shall broadcast the system information of its neighboring WirelessMAN-OFDMA BS and LZone of ABS in its LZone using MOB_NBR-ADV message, and an ABS shall broadcast the existence of its neighboring WirelessMAN-OFDMA BS and LZone of ABS in its MZone using AAI_NBR-ADV. An AMS by reading the indication of existence of neighbor WirelessMAN-OFDMA BS or LZone of ABS in AAI_NBR-ADV, always obtains the neighbor WirelessMAN-OFDMA BS information from the MOB_NBR-ADV message transmitted in its serving ABS LZone.

16.2.6.4.2.1.2 AMS Scanning

The scanning procedure for an WirelessMAN-OFDMA MS/AMS served in LZone of an ABS follow the procedure as defined in section 6.3.21.1.2. The scanning procedure for an AMS served in MZone of an ABS follows the procedure defined in section <<15.2.5.1.2>>.

16.2.6.4.2.2 Handover Procedure

The handover procedure for WirelessMAN-OFDMA MS/AMS served in LZone of an ABS shall follow the procedure defined in section 6.3.21.2. This section specifies the handover process for an AMS served in MZone of the serving ABS to a target WirelessMAN-OFDMA BS.

An AMS uses information acquired from an AAI_NBR-ADV message for cell reselection. The serving ABS may schedule scanning intervals for AMS to conduct cell reselection activity. The cell reselection procedure follows the same procedure defined in section 6.3.21.2.1.

The AMS or the ABS initiates and executes the handover using AAI_HO-REQ or AAI_HO-CMD per section 16.2.6 (intra-16m HO), if the selected target ABS is a WirelessMAN-OFDMA BS. The ABS may allocate Basic CID to the AMS to be used in target WirelessMAN-OFDMA BS through the AAI-HO-CMD message. Based on the Basis CID, the AMS can derive its primary management CID and transport CIDs autonomously in the target WirelessMAN-OFDMA BS as defined in section 6.3.21.2. If the AMS information is required to be transferred to the target ABS for handover optimization, the serving ABS shall map the AMS context to the format in WirelessMAN-OFDMA Reference System per section <<15.2.5.3.2.2.4>>, and provide it to the target WirelessMAN-OFDMA BS over the backbone. In addition, the serving ABS may indicate the time of the fast ranging opportunity negotiated with the potential target WirelessMAN-OFDMA BSs in the AAI_HO-CMD message. The AMS and target WirelessMAN-OFDMA BS use fast ranging opportunity as defined in section 6.3.21.2.4. Handover cancellation procedure is performed per section <<15.2.5.2.6>>.

The AMS follows the same network reentry procedure to the target WirelessMAN-OFDMA BS as defined in section 6.3.21.2.7.

16.2.6.4.2.3 Context Mapping

16.2.6.4.2.3.1 MAC Identifiers

The control connections with Flow ID (0b0000) are mapped to Basic CID and Primary Management CID respectively. If the Basic CID is allocated to the AMS by the target WirelessMAN-OFDMA BS and provided to the AMS via the serving ABS using AAI_HO-CMD message, the AMS shall derive the Primary Management CID based on the procedure defined in section 6.3.21.2.11. The connection with Flow ID yy is mapped to the first transport connection. The AMS derives the first transport CID based on the procedure defined in section 6.3.21.2, and it autonomously updates its remaining transport CIDs in the ascending order from Flow ID ID_{yy}. If the Basic CID is not provided to the AMS via the serving ABS using AAI_HO-CMD message, the AMS obtains its basic, primary management and transport CIDs from the target WirelessMAN-OFDMA BS at the network re-entry phase as specified in section 6.3.21.2. The Station Identifier is released after the AMS handover to the target WirelessMAN-OFDMA BS.

16.2.6.4.2.4 Handover from AAI only ABS to WirelessMAN-OFDMA BS

An AMS served by an AAI only ABS may discover and handover to a WirelessMAN-OFDMA BS. The existence of neighbor WirelessMAN-OFDMA BS is indicated by the AAI-NBR-ADV message from the serving AAI only ABS. The AMS scans neighbor WirelessMAN-OFDMA BS based on the indication information. After the target WirelessMAN-OFDMA BS is determined, the AMS leaves WirelessMAN-OFDMA Advance System per Section 16.2.6.3, and starts WirelessMAN-OFDMA System network reentry procedure to the target BS. Specifically, In the AAI_HO-CMD sent in MZone for the HO procedure, HO reentry mode shall be 0 (unless it is a MC HO) and no dedicated ranging code is assigned for the network reentry in WirelessMAN-OFDMA BS.

The context mapping follows the procedure in 16.2.6.4.2.3.

16.2.6.4.2.5 Zone switch from MZone to LZone

The ABS indicates zone switch of AMSs that currently operate in the MZone for several reasons, such as load balancing purposes. The AAI_HO-CMD message is used to trigger the zone switch from MZone to LZone when HO Mode=0b01. When the AMS is instructed by the ABS to perform zone switch from MZone to LZone, the AMS is provided with LZone information in prior, such as CID, security parameters or capability information via the AAI-HO-CMD message in the MZone. In this case, when HO_Reentry_Mode is set to one, the AMS maintains communication with MZone until the network reentry is finished in the LZone.

16.2.6.5 Handover between Wireless-OFDMA Advanced System and Other RAT Systems

16.2.6.5.1 Inter-RAT Capability Negotiation

AMS's capabilities for inter-RAT operation can be negotiated with ABS during network entry through AAI_SBC-REQ/RSP

Negotiated Inter-RAT capability is used to decide which other RAT information can be provided, and to make sure handover procedure will be initiated only with supported other RATs.

AAI-SBC-REQ/RSP may include the following parameters for inter-RAT capability negotiation.

Table 746—Inter-RAT capability parameters

Name	Type	Length	Value	Scope
Inter-RAT Operation Mode	TBD	1	Bit 0: single radio mode operation for inter RAT handover Bit 1: multi radio mode operation for inter RAT handover Bit 2-7: Reserved, set to zero	AAI_SBC-REQ
Supported Inter-RAT type	TBD	1	1 indicates support, 0 indicates not support: bit #0: 802.11 bit #1: GERAN(GSM/GPRS/EGPRS) bit #2: UTRAN bit #3: E-UTRAN bit #4: CDMA 2000 bit #5-7: Reserved, set to zero	AAI_SBC-REQ AAI_SBC-RSP
MIH Capability Supported	TBD	TBD	Indicates the capability of IEEE 802.21 Media Independent Handover Services. The detail value is TBD	AAI_SBC-REQ AAI_SBC-RSP

16.2.6.5.2 Inter-RAT Handover Procedure

16.2.6.5.2.1 Network topology acquisition

WirelessMAN-OFDMA Advanced systems advertise information about other RATs (such as RAT Type,pre-registration supported, RAN information etc.) to assist the AMS with network discovery and selection. WirelessMAN-OFDMA Advanced systems provide a mechanism for AMS to obtain information about other access networks in the vicinity of the AMS from an ABS either by making a query or listening to a system information broadcast. This mechanism can be used both before and after AMS authentication. WirelessMAN-OFDMA Advanced system may obtain the other access network information (such as RAT Type, pre-registration supported, RAN information etc.) from an information server.

The ABSs may also indicate the boundary area of the WirelessMAN-OFDMA Advanced network by advertising a network boundary indication using AAI_L2_XFER message. Upon receiving the network boundary indication and/or measured signal quality from serving ABS is below an inter-RAT scanning threshold, the AMS may query for RAP (Radio Access Point) information of another RAT and/or perform channel measurement on the other RATs.

The information may be restricted to specific access technologies, based on the AMS's current location and preferences.

16.2.6.5.2.1.1 Passive Other RAT Discovery

ABS may broadcast information such as the presence of another RAT and/or RAN information of another RAT. Upon receiving such information, the AMS may obtain the RAP information of other RAT from an information server, and start scanning process.

The AAI_L2_XFER message may include the following:

- RAT Type: This field specifies air interface technology type.
- Pre-registration supported: This field indicates whether pre-registration is supported or not for Inter RAT handover.

- PHY Profile ID: The PHY Profile ID contains the information related to scan the corresponding RAP. The contents of PHY profile ID are TBD.
- Network boundary indication: This field indicates the whether the ABS which is sending this message is located in the boundary area of the AAI network or not.
- RAN Information: The RAN information specifies information for different radio access networks with various RATs defined by different standard bodies
- RAP Information: The RAP information specifies information for different radio access points (such as carrier frequency, BSID, preamble).

16.2.6.5.2.1.2 Active Other RAT Discovery

16.2.6.5.2.1.2.1 Active Other RAT Discovery with MIHF Support

The AAI entity may send or receive a generic MAC container to or from the peer AAI entity in order to convey MIHF frames carrying the 802.21 MIH protocol messages. When MIH query capability during network entry is enabled, which is notified with MIH Capability Supported TLV in AAI_SBC-REQ/RSP, PKM messages may be used to exchange MIH frames for MIH queries. The AMS may submit an MIH query by sending a AAI_PKM-REQ message with MIH Initial Request code containing an MIHF frame encapsulating the query. Upon receiving this message the ABS acknowledges the request by sending an AAI_PKM-RSP message with MIH Acknowledge code. This message does not contain the response to the MIH query, but contains a Cycle TLV which indicates when the response is expected to be ready for delivery to the AMS. This message also contains a Query ID, which the AMS may use to correlate the query with the response, and the delivery method (unicast or broadcast) that the ABS should use. When a unicast delivery method has been negotiated, then if the ABS is ready to transmit the MIH response, the ABS shall allocate bandwidth for the AMS in the A-MAP in the MAC frame indicated by the Cycle TLV. Upon receiving this UL allocation, the AMS shall transmit at least a Bandwidth request PDU. If the AMS has no data to transmit, the BR field of the Bandwidth request PDU shall be set to 0. The ABS may use the receipt of the Bandwidth request PDU to assert the continued presence of the AMS. If the AMS does not send at least a Bandwidth Request PDU, the ABS shall abort the network entry procedure for the AMS, otherwise it shall send an AAI_PKM-RSP message with MIH Comeback Response code containing the encapsulated MIH response. The MIH Comeback Response message shall also contain the Query ID previously sent in the MIH Acknowledge message, which the AMS may use to correlate the MIH response with the MIH query. When a broadcast delivery method has been negotiated, then if the ABS is ready to transmit the MIH response, the ABS shall transmit an AAI_SII-ADV message containing the MIH response in the MAC frame indicated by the Cycle TLV. If the ABS is not ready to transmit the MIH response at the time indicated by the Cycle TLV, the AMS and ABS shall wait for another cycle and repeat the procedures specified in the preceding paragraph. The maximum number of times the AMS and ABS shall perform those procedures is determined by the MIH max cycles system parameter.

16.2.6.5.2.1.2.2 Active Other RAT Discovery Using AAI Scanning

AMS shall initiate other RAT discovery using scanning procedure. The single radio AMS shall negotiate scanning procedure before scanning commencement. If location information of AMS and other RATs is available, the AMS may transmit its location information with scanning request message and the network may respond with recommended RAT information based on the AMS's location information.

16.2.6.5.2.1.2.3 Generic Active Network Discovery and Selection Procedure

During the target RAT selection process, the AMS may communicate with an information repository using its 16m connection to obtain operator-defined rules and preferences that affect the inter-RAT handoff decisions. The handoff policy may be pre-provisioned in the AMS and may be updated when AMS requests the information repository for network discovery and selection information. The target RAT discovery and selection procedure is shown in Figure 417.

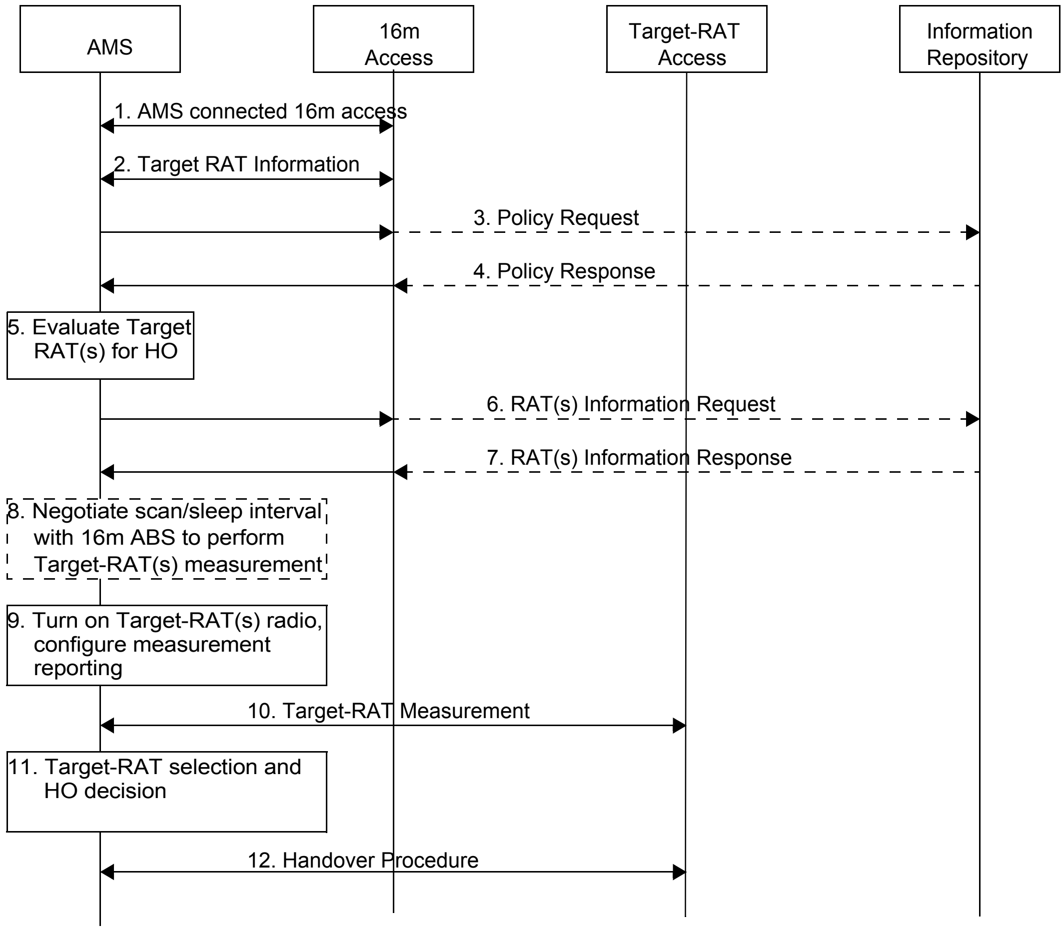


Figure 417—Generic target RAT discovery and selection procedure

1) The AMS is connected to 16m access network

2) The AMS learns about the presence of other-RAT(s) in SFH and then obtains the system parameters and configuration information from the Multi-RAT information MAC control message.

3) The AMS requests inter-RAT handover policy from the information repository.

4) The information repository provides the updates inter-RAT handover policy to the AMS.

5) The AMS evaluates target RATs for handover

6) The AMS requests more information from the information repository. This can be a unicast information retrieval using MIH messages.

7) The information repository provides information about target RATs as requested by the AMS.

8) In the single radio case, the AMS negotiates with the AAI ABS about scan/sleep intervals so that it can evaluate the link connections at target RATs.

9) The device turns on the other radios and configures measurement reporting for target RATs.

10) The device conducts measurements and these reports are sent by the AMS to the 16m ABS for evaluation.

11) The AMS in conjunction with ABS and target access conducts the handover procedure.

16.2.6.5.2.2 Generic inter RAT HO procedure

The WirelessMAN-OFDMA Advanced system may forward handover related messages with other access technologies such as IEEE 802.11, 3GPP and 3GPP2. The specifics of these handover messages may be defined elsewhere, e.g., IEEE 802.21.

16.2.6.5.2.2.1 Generic Other RAT MAC container

Generic Other RAT MAC container is used to convey other RAT control messages which are defined in elsewhere, e.g., 3GPP, 3GPP2.

16.2.6.5.2.2.2 Measurements

While the AMS is attached to the AAI network and is in active mode, the AMS may need to perform radio measurements on other RATs when directed by the AAI network. The AAI network will provide the AMS required neighbor cell list information and measurement controls. When needed the AAI ABS will be responsible for configuring and activating the measurements on the AMS via dedicated signaling message with appropriately defined IEs.

For single-radio AMSs, measurement gaps are needed to allow the AMS to switch to the other RAT and do radio measurements. These measurement gaps may be AMS controlled or network-controlled. In case of network-controlled scenarios the AAI ABS is responsible for configuring the gap pattern and providing it to the AMS through dedicated signaling. AMSs can send the bandwidth request to the serving ABS to request to terminate the measurement and resume original DL and UL transmission. Upon receiving the bandwidth request, ABS could also grant additional UL resources to AMS for make measurement report. AMSs with a dual receiver can perform measurements on other RATs neighbor cells without tuning away from the AAI network.

In order to assist the AAI ABS, the AMS shall inform the system of its gap-related capabilities. This capability needs to be transferred along with other AMS capabilities. The AMS needs to indicate if it has a dual receiver. In cases that the measurement gaps are not required, the AAI ABS can configure measurements on cells of other RATs without the need to configure measurement gaps. No DL gap patterns will be required for AMSs which are capable of simultaneous reception on the involved frequency bands. No UL gap patterns will be required for AMSs which are capable of simultaneous transmission in one access and conducting measurements on another access.

16.2.6.5.2.2.2.1 Scanning

When AMS's location information is available, ABS may provide neighbor other RAT information based on the AMS's location information. The AMS conducts scanning of neighboring target RAT cells for handover decision. Scanning is triggered by

- AMS: when serving channel quality on current RAT falls below a certain threshold
- ABS: the serving ABS may direct AMS to perform scanning via scanning control signaling

16.2.6.5.2.2.2.2 Measurement parameters

The AMS may measure the following parameters when considering handover to IEEE 802.11:

- RSSI: received Signal Strength Indicator

The AMS may measure the following parameters when considering handover to 3GPP/3GPP2 RATs:

- RSSI: received Signal Strength Indicator
- RSRP: Reference Signal Received Power

16.2.6.5.2.2.2.3 Measurement Reporting

After completion of scanning, AMS may report scanning results to a serving ABS via AAI_SCN-REP.

16.2.6.5.2.3 Enhanced inter-RAT HO procedure

16.2.6.5.2.3.1 Dual Transmitter/Dual Receiver Support

An AMS with dual radio support may connect to both an ABS and a PoA (Point of Attachment) operating on other RAT simultaneously during handover. The second RF is enabled when inter RAT handover is initiated. The network entry and connection setup process with the target PoA are all conducted over the secondary radio interface. The connection with the serving ABS is kept alive until handover completes.

In this mode a dual radio device may receive and transmit simultaneously on both the radios. Since both radios may be active simultaneously, these types of devices may connect to target network to prepare resources while maintaining the connection with source network during handover.

16.2.6.5.2.3.2 Single Transmitter/Single Receiver Support

An AMS with a single RF may connect to only one RAT at a time. Once target RAT preparation is completed the AMS may switch from source RF to target RF and complete network entry in target RAT. Only one RF is active at any time during the handover

In this mode a single radio device can receive and transmit on one radio at a time. Since only one radio may be active at any given time, these types of devices use the serving radio and connection with serving network to prepare the target network for handover. Control signaling messages for the target RAT are exchanged between the single radio device and the target RAT, by encapsulating the target RAT signaling messages in a serving 802.16m MAC container.

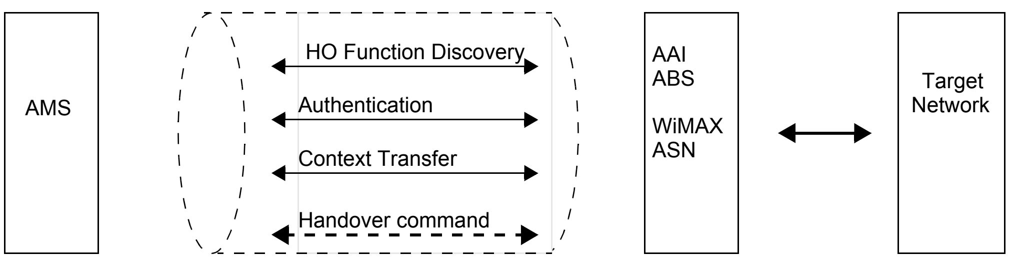


Figure 418—Control Signaling through MAC Container

16.2.6.5.2.3.2.1 Handover Execution & Completion

Once an AMS decides to perform other RAT handover, the AMS requests other RAT handover from the serving ABS. Upon receiving handover response from the ABS, the AMS switches its radio over to the target RAT and turns off the serving 16m radio.

16.2.7 Persistent Scheduling in the Advanced Air Interface

Persistent allocation is a technique used to reduce assignment overhead for connections with periodic traffic pattern and with relatively fixed payload size. To allocate resources persistently to a single connection, the ABS shall transmit the DL Persistent Allocation A-MAP IE for DL allocations and the UL Persistent Allocation A-MAP IE for UL allocations. The configuration parameters of the persistently allocated resource shall be maintained by the ABS and AMS until the persistent assignment is de-allocated, changed, or an error event occurs. Persistent scheduling does not include special arrangements for HARQ retransmission of data initially transmitted using persistently allocated resources. Resources for retransmissions can be allocated one at a time as needed using a DL Basic Assignment A-MAP IE or a UL Basic Assignment A-MAP IE.

16.2.7.1 Allocation Mechanism

For persistent allocation in the DL/UL, the ABS shall transmit the DL/UL Persistent Allocation A-MAP IE. Allocation of the persistently assigned resource begins in the DL/UL AAI subframe that is referenced by the DL/UL Persistent Allocation A-MAP IE and repeats after an allocation period that is specified in the DL/UL Persistent Allocation A-MAP IE. The configuration parameters of the persistently allocated resource are maintained as per the DL/UL Persistent Allocation A-MAP IE. The values of ACID and *N_ACID* configured in the DL/UL Persistent Allocation A-MAP IE are used together to specify an implicit cycling of HARQ channel identifiers. At the initial transmission with the DL/UL Persistent Allocation A-MAP IE, the ACID of the HARQ burst is set to the value specified in the *Initial_ACID* field of the DL/UL Persistent Allocation A-MAP IE. From the next new transmission, the ACID of the HARQ burst is incremented by 1, and cycled within the range of [*Initial_ACID*, Mod (*Initial_ACID* + *N_ACID*-1, 16)], where the *Initial_ACID* is the starting ACID value at the initial transmission. If the retransmission process for the previous HARQ burst is not completed before a new HARQ burst with the same ACID is transmitted, the retransmission process for the previous HARQ burst is terminated and the new HARQ burst overrides it.

In order to facilitate link adaptation and avoid resource holes, the configuration parameters of a persistently allocated resource can be changed. To change a persistent assignment, the ABS shall transmit the DL Persistent Allocation A-MAP IE for DL reallocation and the UL Persistent Allocation A-MAP IE for UL reallocation respectively. If an AMS has an existing persistent allocation in a particular AAI subframe and receives a new persistent allocation in the same AAI subframe, the new persistent allocation replaces the original allocation (i.e., the original persistent allocation is de-allocated).

When the ABS sends a Persistent Allocation A-MAP IE to reallocate a persistently assigned resource, a different HARQ feedback channel must be assigned in the Persistent Allocation A-MAP IE used for reallocation. Reception of an ACK in the newly assigned HARQ feedback channel for the persistently assigned resource with the changed attributes will confirm that the reallocation A-MAP IE was received correctly.

16.2.7.2 Deallocation Mechanism

For de-allocation of persistent allocations in the DL/UL, the ABS shall transmit the DL/UL Persistent Allocation A-MAP IE. When the Allocation Period is set to 0b00 in the DL/UL Persistent Allocation A-MAP IE, the assigned persistent resource in DL/UL Persistent Allocation A-MAP IE is de-allocated in referenced DL/UL AAI subframe and the ABS and AMS terminate the persistent allocation.

When the ABS sends a PA A-MAP IE to de-allocate a persistently assigned resource, a different HARQ feed-back channel must be assigned in the Persistent Allocation A-MAP IE used for de-allocation. Reception of an ACK in the newly assigned HARQ feedback channel for de-allocating a persistently assigned resource will confirm that the Persistent Allocation A-MAP IE that signaled the de-allocation was received correctly.

16.2.7.3 HARQ Retransmissions

Asynchronous HARQ retransmission is used for downlink persistent allocations. The DL Basic Assignment A-MAP IE shall be transmitted to signal control information for HARQ retransmission. Synchronous HARQ retransmission is used for uplink persistent allocations. The UL Basic Assignment A-MAP IE may be transmitted to signal control information for HARQ retransmission.

16.2.7.4 Error Handling Procedure

For transmissions with HARQ enabled, an ACK is transmitted to acknowledge the successful decoding of a data burst, or a NACK is transmitted to notify failure in decoding a burst transmitted on the DL/UL. If an ACK for the data burst identified by the DL Persistent Allocation A-MAP IE is detected in the assigned HARQ Feedback channel, the ABS assumes that the DL Persistent Allocation A-MAP IE is correctly received by AMS. If the initial data burst identified by the UL Persistent Allocation A-MAP IE is successfully decoded, the ABS assumes that the UL Persistent Allocation A-MAP IE is correctly received.

When NULL detection is used, in the absence of an ACK or a NACK in the HARQ feedback channel assigned in the DL Persistent Allocation A-MAP IE for the data burst, the ABS assumes that the AMS has not received the DL Persistent Allocation A-MAP IE and the same DL Persistent Allocation A-MAP IE may be transmitted again.

In the case of de-allocation of persistent allocations in the DL/UL, the ABS shall transmit a HARQ Feedback Allocation in the DL/UL Persistent Allocation A-MAP IE. This allocation is used to identify the HARQ channel in which the ACK for the DL/UL Persistent Allocation A-MAP IE signaling the de-allocation is transmitted. In the absence (NULL detection) of an ACK, the ABS assumes that the AMS has not received the DL/UL Persistent Allocation A-MAP IE, and the same DL/UL Persistent Allocation A-MAP IE that signaled the de-allocation may be transmitted again.

In the absence of the UL data burst in the resource assigned by the UL Persistent Allocation A-MAP IE, the UL data burst transmitted by the AMS is not successfully decoded at the ABS, but may be detected as a NULL. In such a case, the ABS assumes that the AMS has not received the UL Persistent Allocation A-MAP IE and the ABS may transmit the same UL Persistent Allocation A-MAP IE again. In order to ensure that resource assignment information for subsequent persistent allocations is received correctly, if the initial data burst identified by the UL Persistent Allocation A-MAP IE cannot be decoded successfully after N_MAX_ReTX HARQ retransmissions, and no subsequent persistent allocation is decoded successfully, the same UL Persistent Allocation A-MAP IE may be transmitted again.

16.2.8 Multicarrier operation

16.2.8.1 Multicarrier Types and Operational Modes

The carriers involved in multicarrier mode of operation from an AMS point of view are of two types:

- A primary carrier is a carrier used by the ABS to exchange traffic and PHY/MAC control signaling (e.g., MAC control messages) with an AMS. An ABS may be deployed with multiple carriers but each AMS in the ABS has only one primary carrier which is also used when AMS is operating in single carrier mode.
- Secondary carriers are additional carriers which the AMS may use for traffic, only per ABS's specific commands and rules received on the primary carrier.

For both FDD and TDD mode, the carrier refers to a downlink or uplink physical frequency channel. Physical carrier index is the index for the available carriers of an ABS, which is sorted from lower frequency to higher frequency.

In the multicarrier operation a common MAC can utilize radio resources in the primary carrier and one or more of the secondary carriers, while maintaining full control of AMS mobility, state and context through the primary carrier.

Based on the primary and/or secondary usage and target services, the carriers of a multicarrier system may be configured differently as follows:

- Fully configured carrier: A standalone carrier for which all control channels including synchronization, broadcast, multicast and unicast control signaling are configured. Fully configured carrier supports both single carrier AMS and multicarrier AMS.
- Partially configured carrier: A carrier configured for downlink only transmission in TDD or a downlink carrier without paired UL carrier in FDD mode. . Such supplementary carriers may be used only in conjunction with a primary carrier and cannot operate standalone to offer AAI services for an AMS. Whether a carrier is fully configured or partially configured is indicated using Advanced Preamble of the carrier. The AMS shall not attempt network entry or handover to partially configured carrier. In multicarrier aggregation, the UL control channels corresponding to the secondary partially configured carriers shall be located in distinct non-overlapping control regions in the UL of the primary carrier. The AMS shall use the UL control channels on the primary carrier to feedback HARQ ACK/NACK and channel quality measurements corresponding to transmission over DL only secondary carrier.

A primary carrier is fully configured while a secondary carrier may be fully or partially configured depending on deployment scenarios. A secondary carrier for an AMS, if fully configured, may serve as primary carrier for other AMS's. Multiple AMSs, each with a different primary RF carrier may also share the same secondary carrier. The following multicarrier operation modes are identified, which may all or independently be supported:

- multicarrier Aggregation: The multicarrier mode in which the AMS maintains its physical layer connection and monitors the control signaling on the primary carrier while processing data on the secondary carrier. The resource allocation to an AMS may span across a primary and multiple secondary carriers. Link adaptation feedback mechanisms should incorporate measurements relevant to both primary and secondary carriers. In this mode the system may assign secondary carriers to an AMS in the downlink and/or uplink asymmetrically based on system load (i.e., for static/dynamic load balancing), peak data rate, or QoS demand.
- multicarrier Switching: The multicarrier mode in which the AMS switches its physical layer connection from the primary to the secondary carrier per ABS' instruction. The AMS connects with the secondary carrier for the specified time period and then returns to the primary carrier. When the AMS is connected to the secondary carrier, the AMS is not required to maintain its transmit or receive through the primary carrier. This mode is used for switching to partially configured carriers(s) or fully configured carrier to receive E-MBS.

The following is common to all multicarrier modes of operation:

- The system defines N standalone fully configured RF carriers; each configured with all synchronization, broadcast, multicast and unicast control signaling channels needed to support an AMS in single carrier mode. Each AMS in the cell is connected to and its state being controlled through only one of the fully configured carriers designated as its primary carrier.
- The system may also define M (M >= 0) partially configured RF carriers, which can only be used as secondary carriers along with a primary carrier, for downlink only data transmissions.
- The set of all supported radio carriers in an ABS is called Available Carriers.
- The Available Carriers may be in different parts of the same spectrum block or in non-contiguous spectrum blocks.
- In addition to information about the (serving) primary carrier an ABS, also provides AMSs with some configuration information about its available carriers through such primary carrier. Through such messaging the ABS informs AMS's of the presence, bandwidth, duplexing, and location in the spectrum for all available carriers to help AMS prepare for any operation involving multiple carriers. The primary carrier may also provide an AMS the extended information about the configuration of the secondary carrier.

16.2.8.2 MAC operation

16.2.8.2.1 Addressing

A multicarrier supporting ABS or AMS follows the same MAC addressing mechanism defined in 16.2.1.

16.2.8.2.2 Security

A multicarrier supporting AMS follows the same security procedure defined in 16.2.5. All the security procedures between an AMS and an ABS are performed using the AMS's primary carrier. The security context created and maintained by the procedures is managed per ABS through the primary carrier.

16.2.8.2.3 Network Entry

The network entry in multicarrier mode is the same as single carrier mode as defined in 16.2.15, where the AMS and ABS also indicate their support for multicarrier modes during the registration. An AMS can only perform network entry (or network reentry) procedures with a fully configured carrier. Once the AMS detects the A-PREAMBLE on a fully configured carrier, the AMS may proceed with reading SFH or Extended system parameters and system configuration information.

During the initial network entry, AMS will inform ABS of its support of multicarrier transmission by AAI_REG-REQ message and the ABS will indicate if it supports any of multicarrier modes for that AMS through AAI_REG-RSP message. The basic multicarrier capability exchange uses a two bit code in AAI_REG-REQ/RSP message with the following indications:

Table 747—Multicarrier capability in AAI_REG-REQ/RSP message

b1, b2	Multicarrier Capabilities
00	No MC modes
01	Basic MC mode
10	Multicarrier Aggregation
11	Multicarrier Switching

The Basic MC mode involves AMS awareness of multicarrier operation at the ABS which includes support for Primary Carrier Changes as defined in section 16.2.8.2.11.2 as well as optimized scanning of carriers involved multicarrier operation defined in section 16.2.8.10.

Support for Both Multicarrier Aggregation and Switching does not imply E-MBS support, which is negotiated separately.

The procedure for initialization of an AMS, following network entry, to prepare for subsequent multicarrier operation shall be as shown in Figure 419. This procedure includes

- Obtaining the multicarrier configuration for available carriers at the ABS
- Obtaining information about Assigned Carriers consisting of two steps

1. Provide ABS with information on AMS's supportable carriers and their combined multicarrier configurations
2. Obtain information about the subset of available carrier, hereby referred to as the Assigned Carriers, which ABS may utilize in subsequent multicarrier operation for that AMS.

The AMS does not perform any MAC or PHY processing on an assigned carrier until such carrier is activated per ABS's direction.

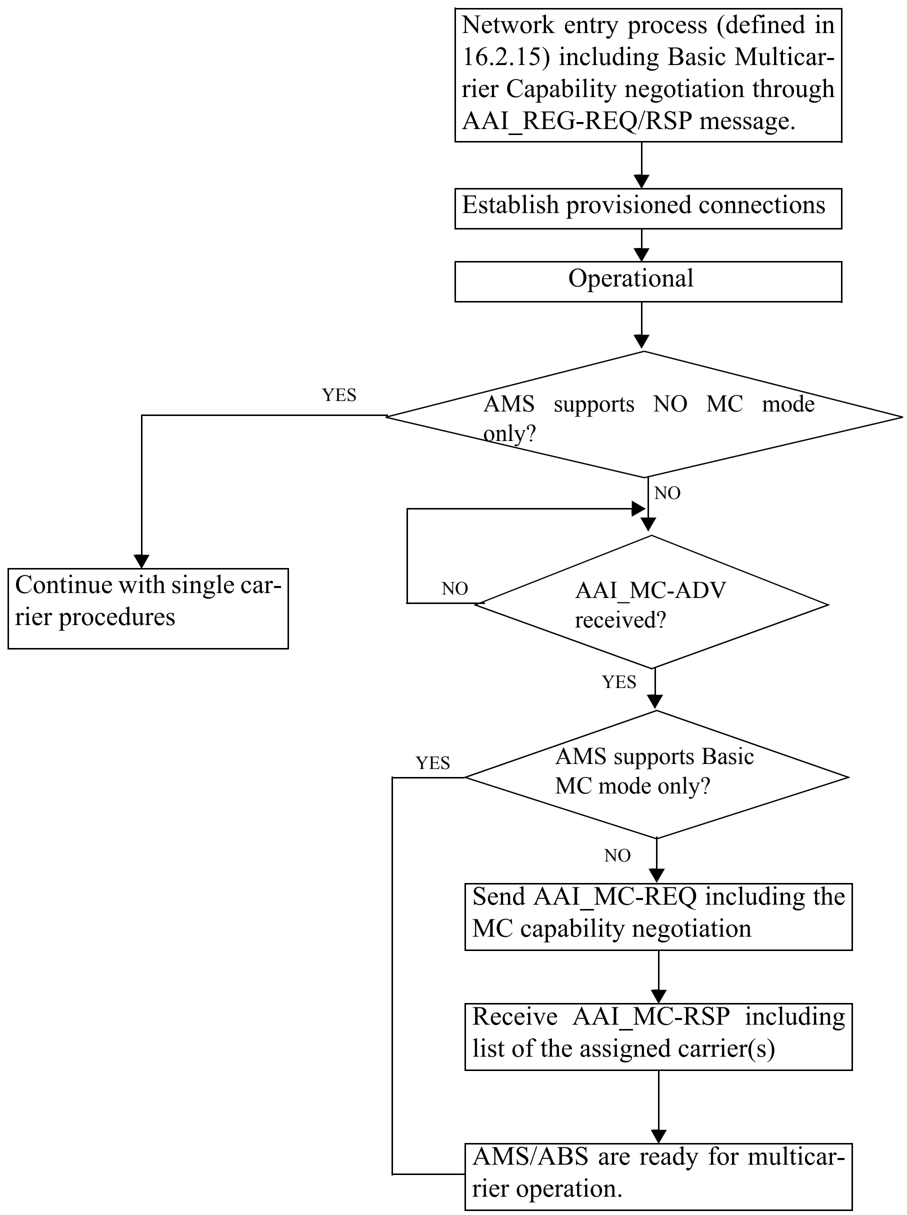


Figure 419—AMS initialization overview to support multicarrier transmission

16.2.8.2.3.1 AMS's Obtaining MC Configuration

The ABS will broadcast the SFH on each carrier with the format defined in 16.3.6.2.1. The ABS shall also provide the AMS with basic radio configuration for all available carriers in the ABS through the AAI_MC-ADV message. This message is periodically broadcast by the ABS, which includes the multicarrier mode and the configurations supported by the ABS. The multicarrier configuration information is relevant to and shall be used by all AMSs in any of multicarrier modes or in single carrier mode.

16.2.8.2.3.1.1 AAI_MC-ADV (multicarrier Advertisement) Message

The MC ABS shall periodically broadcast AAI_MC-ADV message for the reception by all AMSs.

Table 748—AAI_MC-ADV MAC Control Message Format

Field	Size (bit)	Descrpition
MAC Control Message Type	8	
Multi-carrier configuration change count	4	Incremented by 1 upon each update.
Serving BS Carrier Number	3	
Serving BS Uniformity Flag	1	0: All Carriers supported by serving ABS have the same Protocol Version, SFH_Info 1: otherwise
Physical Carrier Index of current carrier	6	The carrier that ABS broadcast this message; the physical carrier index refers to AAI_Global-Config message
MAC Protocol version	8	Consistent with REV.2 definition, with new MAC protocol version 9 defined for 16m
For(i=1;i<=Serving BS Carrier Number-1; i++){		
Physical carrier index	6	//physical carrier index in AAI_Global-Config message
SA-Preamble Index	10	
if (Serving BS Uniformity Flag==1) {		
MAC Protocol Version	8	Consistent with REV.2 definition, with new MAC protocol version 9 defined for 16m
SFH_encoding_format	1	0b0: full Subpkt information 0b1: delta encoding, w.r.t. the current carrier
Control_bitmap	4	Each bit maps to one SFH subpacket or extended broadcast information
If (SFH_encoding_format==00) {		
If (Control_bitmap[0]==1){		
SFH Subpkt 1	88	

Table 748—AAI_MC-ADV MAC Control Message Format

Field	Size (bit)	Descrpition
}		
If (Control_bitmap[1]==1){		
SFH Sub-pkt 2	88	
}		
If (Control_bitmap[2]==1) {		
SFH Sub-pkt 3	88	
}		
}		
If (SFH_encoding_format==01) {		
Delta information	variables	Delta encoding, w.r.t. the current carrier
}		
}		
}		

16.2.8.2.3.2 Secondary Carrier Assignment

After the initial network entry procedure defined in 16.2.8.2.3 and obtaining the information about the ABS's multicarrier configurations, the AMS shall send AAI_MC-REQ message to the ABS if the AMS and the ABS both support multicarrier transmission. The AMS shall inform the ABS its capability on multicarrier support by the parameters defined in the AAI_MC-REQ message. Based on AMS's multicarrier capabilities informed in the AAI_MC-REQ message, the ABS shall reply the AAI_MC-RSP message to assign one or more carriers from its available carriers to the AMS as the assigned secondary carriers.

16.2.8.2.4 Ranging

In some cases, the AMS may not be able to communicate with the ABS over the secondary carrier(s) without ranging to adjust time/frequency synchronization and power for the carrier(s). If the channel correlations between the primary and the secondary carriers are very high, the transmission parameters of the secondary carrier(s) could be quite similar with those of primary carrier. If the AMS already completed the network entry with the ABS over the primary carrier, it does not need to perform the initial ranging over the secondary carrier(s). Therefore, only the periodic ranging instead of initial ranging may be performed over the secondary carrier(s). Once the secondary carriers are activated, the AMS may perform the periodic ranging over the active secondary carrier(s) if directed by the ABS in AAI_CM-CMD at secondary carrier activation

When the AMS omit the ranging for the secondary carrier(s), the AMS may use the same timing, frequency and power adjustment parameters for the secondary carrier(s) as in the primary carrier for initial transmission. The AMS may perform the fine timing, frequency and power adjustment on the secondary carrier(s) through measuring the synch channel and/or pilot on the secondary carrier(s).

CDMA initial/periodic ranging with a fully configured carrier shall be the same as defined in 6.3.10.3.1, 6.3.10.3.2[1]. Periodic ranging may only be performed on the activated secondary carrier(s) if directed by the ABS in AAI_CM-CMD at secondary carrier activation. CDMA handover ranging shall be done only with one of the fully configured carriers of target ABS.

16.2.8.2.5 MAC PDU processing

The construction and transmission of MAC PDU is the same as that in single carrier operation. For each service flow the ARQ operates for a common MAC as defined in 16.2.13.

16.2.8.2.5.1 MAC segmentation

MAC data (<<15.3.2.6>>) shall be processed as defined for single carrier physical layer operation and can be mapped to data region (<<15.3.2.6>>) in one of primary or secondary carriers. The A-MAP IE shall be sent through the carrier where the OFDMA data region is located. The A-MAP IE is the same as the one defined in <<15.3.6.5.2>>.

16.2.8.2.6 Bandwidth Request and Resource Allocation

16.2.8.2.6.1 Bandwidth Request

All bandwidth requests are transmitted on the AMS's primary carrier following the same procedures as defined in 16.2.11. Bandwidth request using piggyback may be transmitted in MAC PDUs over the secondary carrier(s) as well as the primary carrier.

16.2.8.2.6.2 Resource Allocation

The ABS may allocate downlink or uplink resources which belong to a specific carrier or a combination of multiple carriers based on available resources, QoS requirements and other factors. The multicarrier resource assignment for carrier aggregation can use the same A-MAP IE's as single carrier mode, where A-MAP messages for each active carrier are transmitted in the respective carrier.

16.2.8.2.7 QoS and connection management

The STID and all FIDs assigned to an AMS are unique identifiers for a common MAC and used over all the carriers of the AMS. The service setup/change messages (i.e., DSx messages) are transmitted only through the AMS's primary carrier. The service flow is defined for a common MAC entity and AMS's QoS context represented by an SFID is applicable across primary carrier and secondary carrier(s) and collectively applied to all carriers of the AMS.

16.2.8.2.8 DL CINR report operation

An ABS may assign FastFeedback channels to each carrier of an AMS. When FastFeedback channel is assigned, the AMS reports CINR for a carrier over the assigned FastFeedback channel of the corresponding carrier. ABS may also direct AMS to report CINRs of active carriers through FastFeedback channel(s) on the primary carrier at the feedback region as defined in Section 16.3.8.3.3. When measurement/report MAC messages are used for DL CINR report operation, the messages are transmitted on the AMS's primary carrier. The measurement/report MAC message may contain CINR reports for all carriers or for each carrier of the AMS.

16.2.8.2.9 Handover

The multicarrier handover (MCHO) is defined as the handover procedure which involves multiple radio carriers. An AMS with multicarrier capability may follow the single-carrier handover procedure per section 16.2.6. It may also decide to perform MCHO procedure as defined in this section.

16.2.8.2.9.1 Network topology acquisition

16.2.8.2.9.1.1 Network topology advertisement

The AAI_NBR-ADV message shall carry neighbor ABS's multicarrier configuration information to facilitate AMS's scanning of neighbor ABSs' fully configured carriers.

16.2.8.2.9.1.2 AMS scanning of target carriers

The AMS with multicarrier capability may perform the single-carrier scanning procedure per section 16.2.6.1.2. It may also perform multicarrier scanning procedure, i.e., scanning procedure which involves multiple radio carriers, as defined in this subsection.

The AMS may scan the carriers of Neighboring ABSs indicated in AAI_NBR-ADV as directed by AAI_SCN-RSP. The AMS may also scan other fully configured carriers of the serving ABS which are not in use by the AMS. Figure 420 illustrates the example message flows for neighbor ABS advertisements and scanning of fully configured carriers of serving and neighbor ABSs.

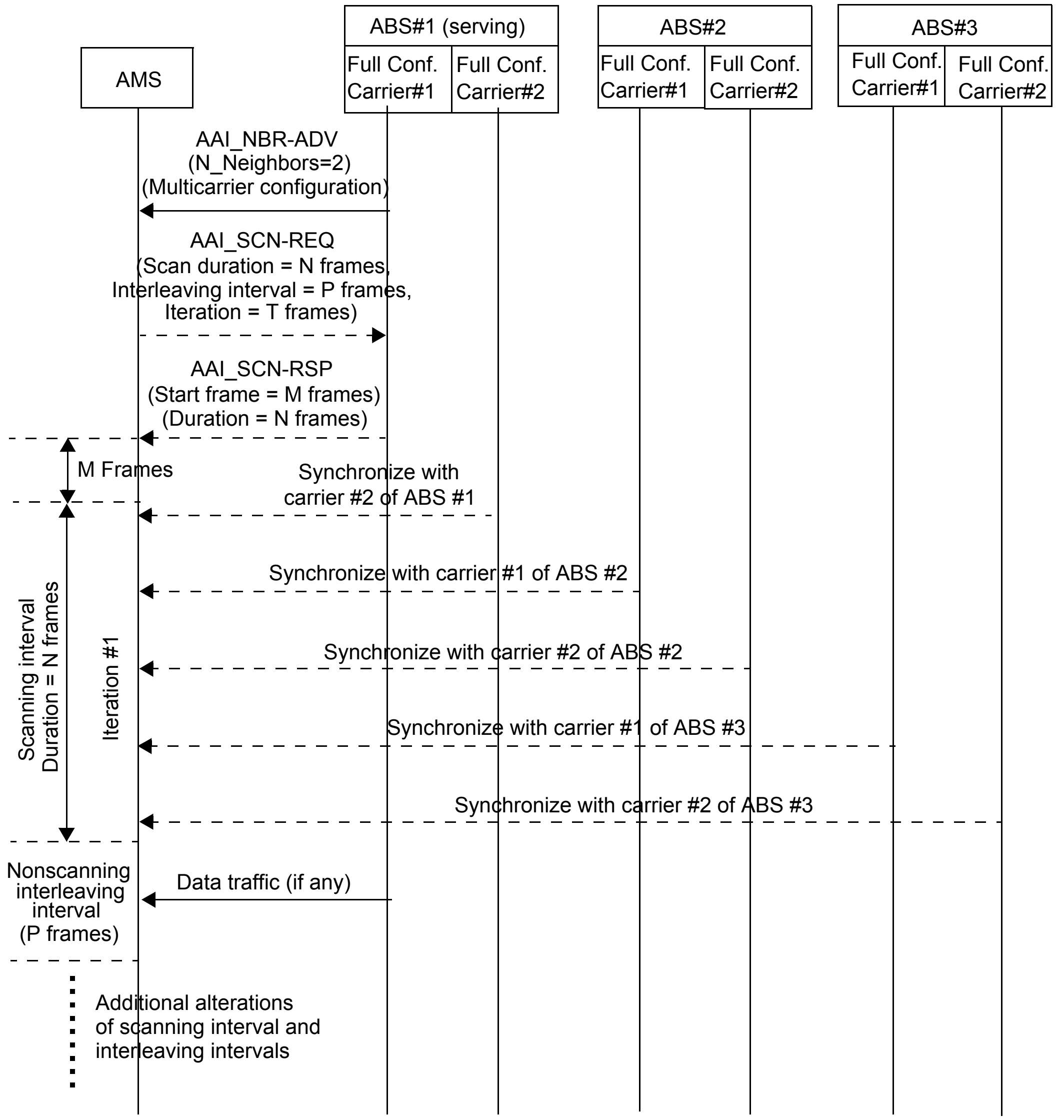


Figure 420—Neighbor ABS advertisement and scanning of serving and neighbor ABSs

An AMS capable of concurrently processing multiple radio carriers may perform scanning with neighbor ABSs using one or more of its available radio carriers without interruption to its normal communication with the serving ABS on the primary carrier and/or secondary carriers. In this case, the AMS and the ABS may negotiate through AAI_SCN-REQ/RSP messages the radio carriers to be assigned for scanning operations to avoid resource allocation on those carriers, as illustrated in Figure 421. The carrier index will be included in AAI_SCN-REQ/RSP/REP message.

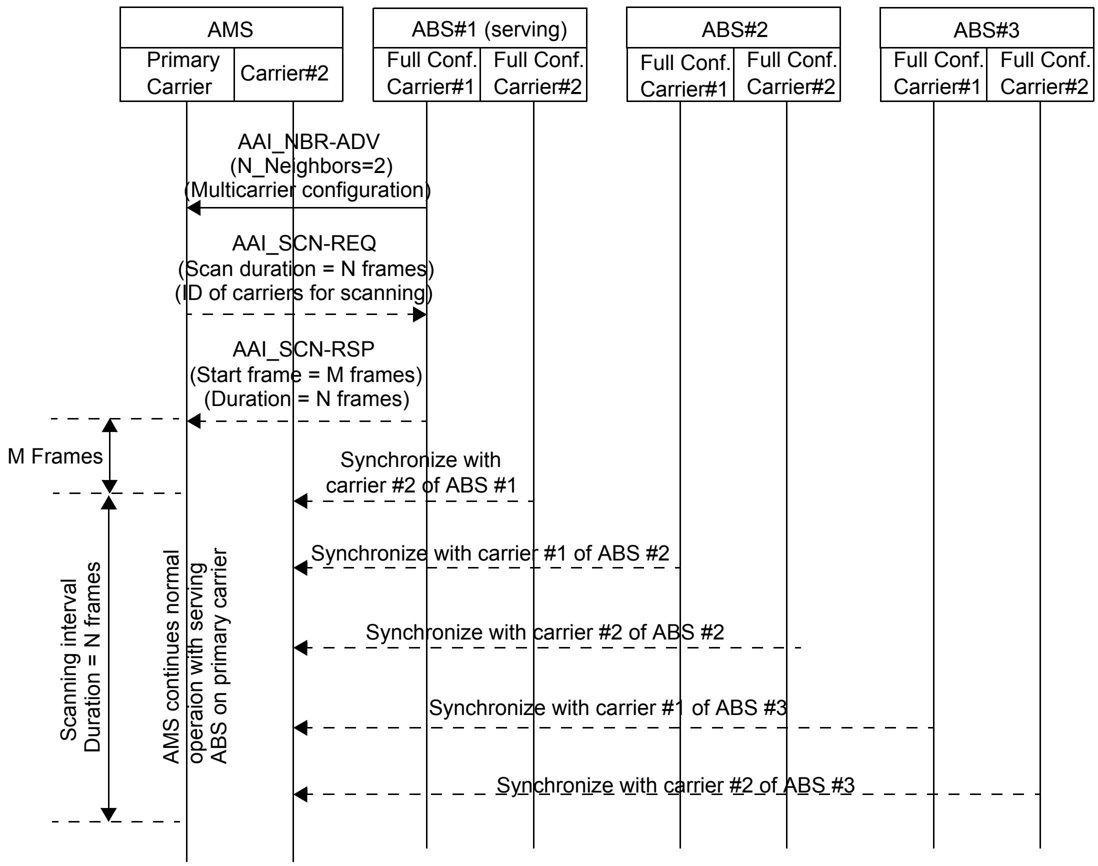


Figure 421—Scanning while maintaining communication with serving ABS

16.2.8.2.9.2 Multicarrier handover (MCHO) procedure

The multicarrier handover (MCHO) is defined as the handover procedure which involves multiple radio carriers, which includes multi-carrier EBB HO and HO with secondary carrier pre-assignment as described in this section. For an AMS supporting basic MC mode handover from one carrier to another carrier of the same ABS, the handover procedure follows the primary carrier change procedure per 16.2.8.2.11.2.

16.2.8.2.9.2.1 MCHO preparation

An AMS in multicarrier operation follows the handover operations defined in 16.2.6.3. MAC control messages in relation with handover preparation and initiation between the AMS and the serving ABS are transmitted over the primary carrier of the AMS.

During HO preparation, the AMS may request or be requested by the serving ABS to perform MCHO procedure through AAI_HO-REQ/AAI_HO-CMD messages. The serving ABS informs the AMS the carrier information (e.g. target primary carrier index) of the target ABSs through AAI_HO-CMD message. The serving ABS may communicate with the target ABS(s) to help the AMS obtain the assigned secondary carriers before handover execution. The serving ABS will forward the information received from AAI_MC-REQ message to the target ABS(s) for secondary carrier pre-assignment. The serving ABS will reply the secondary carrier pre-assignment results to the AMS if Carrier_Preassignment_Indication is set to 1 in the AAI_HO_CMD message.

16.2.8.2.9.2.2 MCHO execution and network reentry with HO_Reentry_Mode=1

The AMS with multicarrier capability follows the network reentry procedure per section 16.2.6.3.5. When HO_Reentry_Mode is set to 1 and HO_Reentry_Interleaving_Interval is set to 0, the AMS performs network reentry to the target ABS on one carrier and maintains normal communication with the serving ABS on another carrier not performing network reentry procedure. The AMS may use the original primary carrier for network reentry to the target ABS, as illustrated in Figure 422. It may also use another carrier different from its original primary carrier for network reentry procedures, as illustrated in Figure 423. In this case, Disconnect_time should be long enough that network reentry procedure to target ABS can be completed prior to the expiration of Disconnect_time. In case of AAI_HO-CMD message with multiple target ABS and carriers, the physical index of each candidate carrier provided by each target ABS should also be indicated in the AAI_HO-CMD message The AMS may inform the serving ABS through AAI_HO-IND the carrier to be used for network reentry operations to avoid resource allocation by the serving ABS on that carrier.

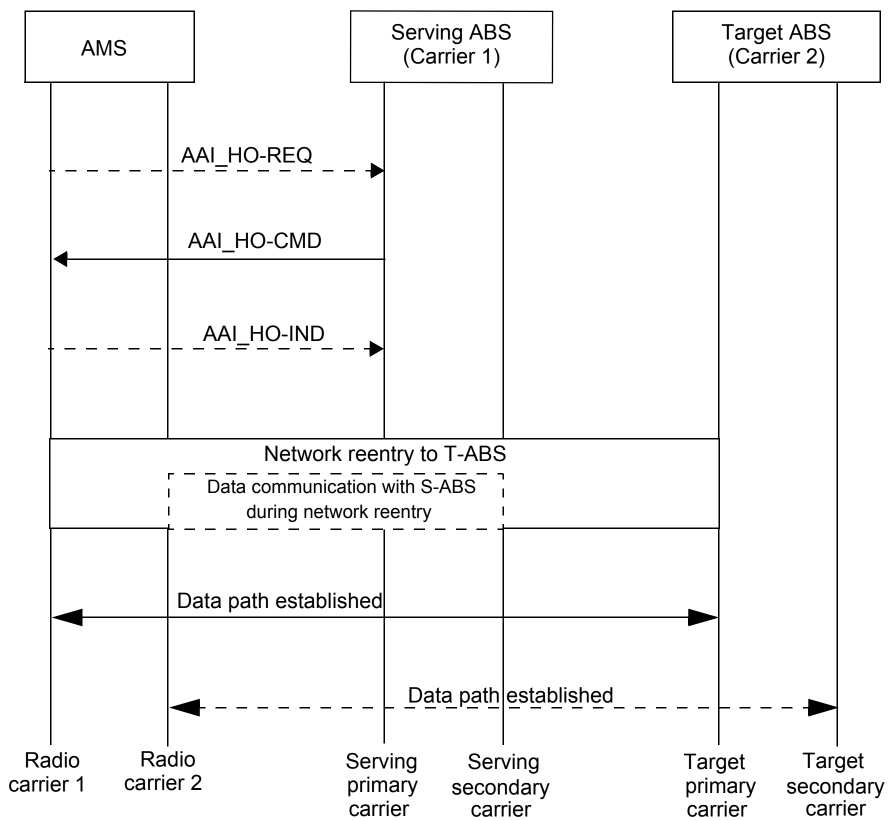


Figure 422—Multicarrier HO with network reentry on the target ABS

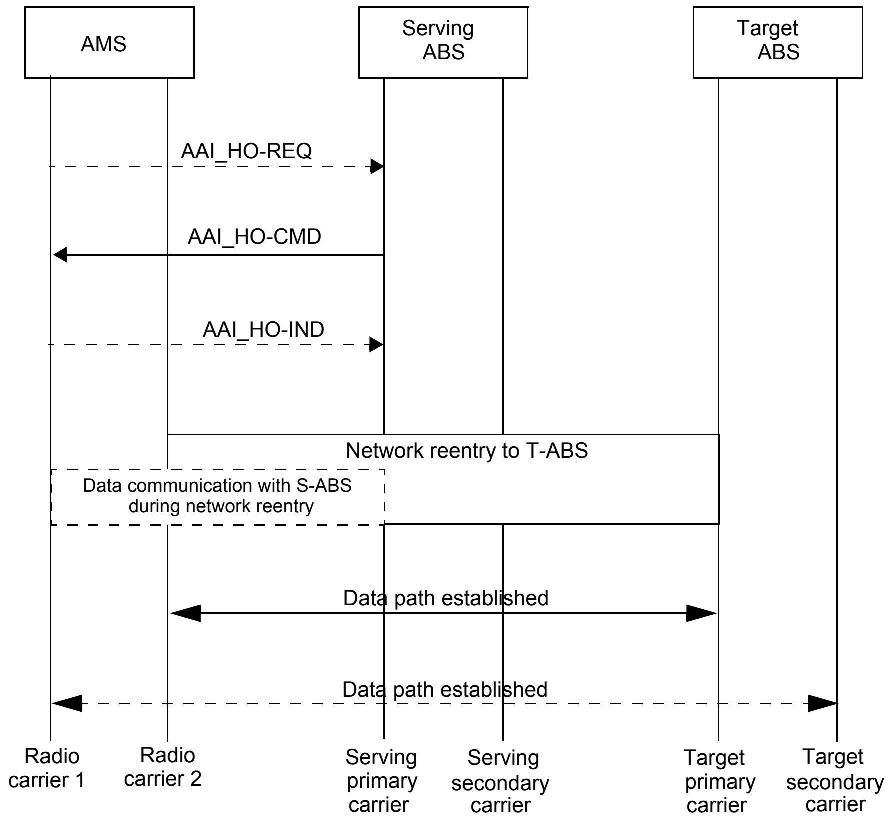


Figure 423—A call flow for multicarrier HO in which the AMS performs network reentry on the target primary carrier which is different from the serving primary carrier

From AMS point of view, if network entry is completed (see 16.2.6), the AMS shall stop communicating with the serving ABS. Then, the AMS may send UL data or BW-REQ message to the target ABS.

HO with secondary carrier pre-assignment

The serving ABS may negotiate with the target ABS for secondary carrier pre-assignment as illustrated in Figure 424. When Carrier_Preassignment_Indication is set to 1 in the AAI_HO-CMD message, the pre-assignment information is forwarded from the Target ABS(s) via backbone to the Serving ABS, and then sent to the AMS by the serving ABS through AAI_HO-CMD message, and part of the pre-assigned secondary carriers (indicated by the Carrier Status Bitmap) may be activated right after network reentry. The target ABS may start transmitting data on such activated secondary carrier(s) if the AMS sends AAI_CM-IND message to the target ABS after network reentry. Before secondary carrier pre-assignment, the serving ABS shall forward the multicarrier capability of the AMS to the target ABS(s) via backbone.

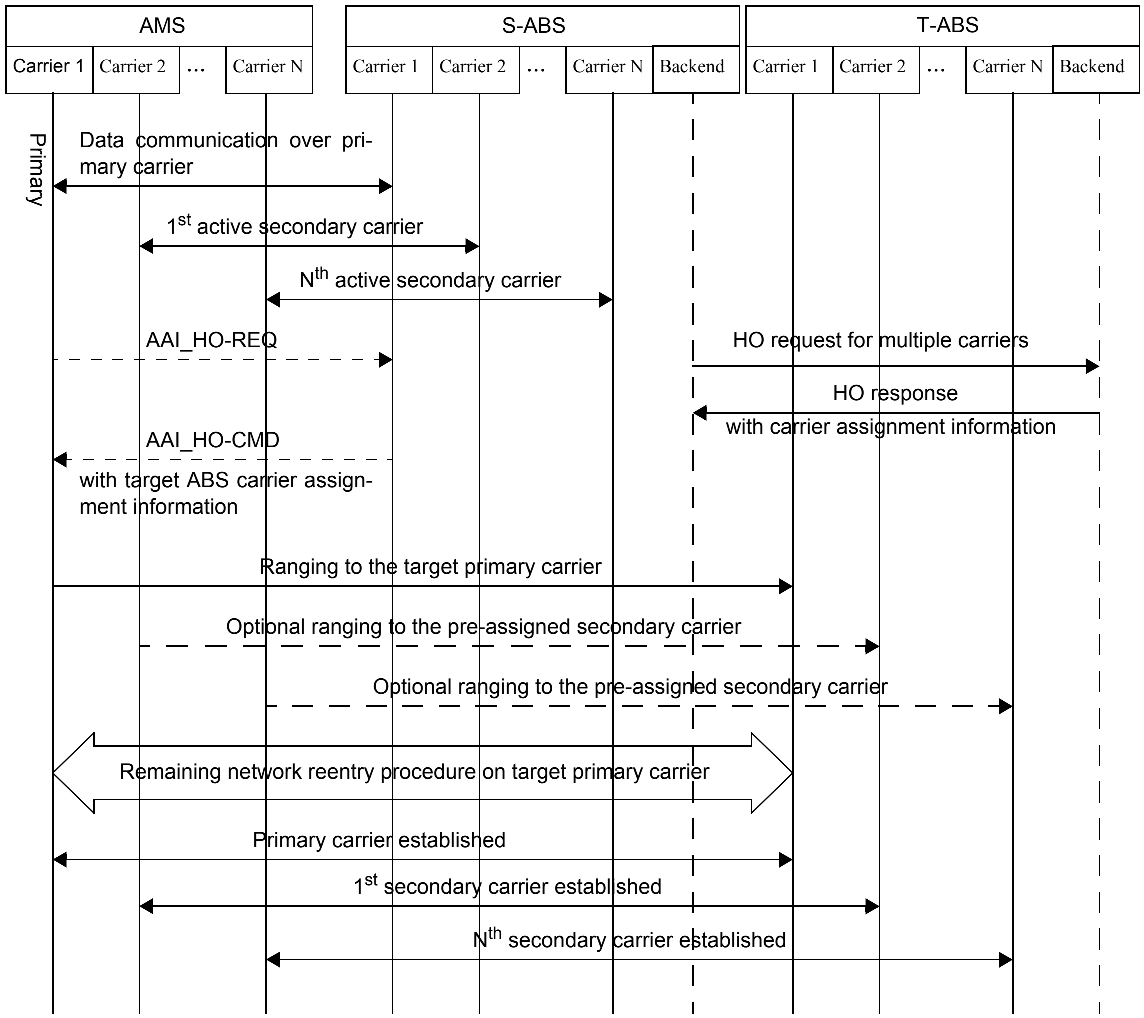


Figure 424—A call flow for multicarrier HO with secondary carrier pre-assignment

When Carrier_Preassignment_Indication is set to 0 in the AAI_HO-CMD message, the AMS follows the operation of secondary carrier assignment (see 16.2.8.2.3.2) and carrier activation (see 16.2.8.2.11.1) after the AMS completes its network reentry with the target ABS.

16.2.8.2.10 Power Management

The AMS is only assigned to one or more secondary carrier during the active/normal mode. Therefore, the power saving procedures in OFDMA multicarrier mode of operation are the same as single carrier mode and all messaging including idle mode procedures and state transitions are handled by the primary carrier.

16.2.8.2.10.1 Sleep mode

When an AMS enters sleep mode, the AMS negotiates its sleep mode parameters (i.e., Sleep Window and Listening Window configuration) with an ABS. The negotiated parameters of sleep mode are applied to an AMS over all the active carriers. The messages and procedures before entering sleep mode and during sleep mode are processed over the primary carrier. Note that the serving ABS may request the AMS to change its primary carrier upon entering the sleep mode or during the Listening Window using AAI_CM-CMD message for load balancing, power saving, or alleviating signaling overhead.

At the beginning of the Listening Window, data transmission over all the active carriers of the AMS is allowed. The AMS, if the traffic indication is enabled monitors the traffic indication message with its primary carrier. Upon receiving negative traffic indication in the traffic indication message, the AMS goes back to sleep. If positive traffic indication is received, the AMS continues to receive any DL data on all the active carrier(s). Following the traffic indication, the ABS may send a Sleep Control Extended Header via the primary carrier to terminate data transmission over some active secondary carrier(s).

If the traffic indication is disabled, data transmission and allocation follows the normal operation during the Listening Window. In this case, the AMS monitors the active carriers during the Listening Window, and the ABS may allocate the DL data on the primary carrier and the active secondary carrier(s), and the AMS receives the data on the primary carrier and the active secondary carrier(s) during the Listening Window. If the traffic indication is disabled, when the DL data transmission on the active secondary carrier(s) is completed, the ABS may instruct the AMS to end data transmission over the active secondary carrier(s) through the Sleep Control Extended Header which is transmitted in the primary carrier during Listening Window. If the ABS receives the bandwidth request from the AMS during Listening Window, it shall regard that DL/UL data transmission over all active carriers is allowed during the Listening Window.

When an AMS is in the Sleep Window, and if AMS has pending UL traffic, it may transmit bandwidth request on the primary carrier. If the ABS receives the bandwidth request from the AMS, it shall regard that DL/UL data transmission over all active carriers is allowed. After completing UL traffic transmission, the normal sleep cycle operation of the AMS is resumed and all the active carriers shall use the sleep cycle setting.

16.2.8.2.10.2 Idle mode

A multicarrier supporting AMS in idle state follows the same procedures defined in 16.2.17.

In a multi-carrier system the PGID_Info message is transmitted in all the carriers. The AAI_PAG-ADV message for an AMS shall be transmitted in only one of the carriers. An idle mode AMS determines the carrier index for monitoring the paging message within AMS's paging-listening interval where its paging message is transmitted using the following equations:

$$\text{Paging carrier index} = \text{DID modulo N} \quad (2)$$

The value of N is the number of carriers per PGID or a set of PGIDs in an ABS that are used for transmitting paging message for idle mode AMS(s). This can be all the carriers or a subset of carriers used by a multicarrier ABS. Paging carrier indication bit is used to specify if a carrier is a paging carrier or not. When the Paging carrier indication =1, then the corresponding carrier is paging carrier. The Paging carrier indication of different carriers is included in the PGID_Info message and may be included in the AAI_NBR-ADV message or the AAI_MC-ADV message.

When an idle mode AMS moves to a new ABS and determines that the SFH change count of the new ABS is same as the information it received through the AAI_NBR-ADV message, then the AMS may use the paging carrier indication received through AAI_NBR-ADV message if this paging carrier indication is included in the AAI_NBR-ADV message.

The AAI_PAG-ADV message is transmitted in one or more of the frames starting from the second subframe in the super-frame.

For an E-MBS AMS the AAI_PAG-ADV message may be transmitted in the same carrier as the dedicated carrier for E-MBS. In this case, the AMS does not use (2).

An AMS may perform Location Update process to acquire its preferred carrier for the idle mode support when AMS cannot find the paging carrier.

16.2.8.2.11 Carrier management

16.2.8.2.11.1 Secondary Carrier Activation/De-activation

The activation or deactivation of secondary carrier(s) is decided by the ABS based on QoS requirement, load condition of carriers and other factors. The ABS activates and/or deactivates secondary carrier with the AAI_CM-CMD MAC control message. The ABS sends the AAI_CM-CMD MAC control message on the primary carrier and includes the following information:

- Indication Type per DL/UL: Activation, Deactivation
- List of Secondary Carriers: (referred by logical carrier index)
- Ranging indicator for the activated carrier

The ABS sends the AAI_CM-CMD message with Polling set to 1 in MCEH and the AMS, upon receiving the AAI_CM-CMD message, transmits an AAI_MSG-ACK message or Message ACK EH to inform that the AAI_CM-CMD message has been successfully received. The AMS transmits the AAI_CM-IND MAC control message through the primary carrier, where this message confirms with the ABS that the AMS has successfully activated/deactivated the carriers listed in the AAI_CM-CMD message. In case of activation, the AAI_CM-IND message is sent by the AMS when DL/UL of the newly activated carrier is ready to be used to transport data traffic.

When AMS performs secondary carrier activation while AMS supports data transmission over both the primary carrier and secondary carrier with single radio transceiver, the AMS reconfigures its hardware setting (e.g. RF center frequency). After completing the hardware reconfiguration and synchronization on the new carrier, AMS notifies the ABS its readiness of the new carrier by sending AAI_CM-IND message and then resume communication with ABS.

After the ABS receives the AAI_CM-IND MAC control message, the ABS may start transmitting data on such active secondary carrier(s).

16.2.8.2.11.2 Primary Carrier Change

The Primary Carrier change involves changing the serving carrier for an AMS in a multicarrier ABS without changing the MAC layer security and mobility contexts and unlike normal inter-FA handover. An AMS which is Multicarrier Aware shall support primary carrier change. The ABS may instruct the AMS, through the AAI_CM-CMD MAC control message on the current primary carrier, to change its primary carrier to one of the assigned fully configured carriers within the same ABS for load balancing purpose, carriers' varying channel quality or other reasons. When an AMS receives the AAI_CM-CMD MAC control message with Polling set to 1 in MCEH, the AMS transmits the AAI_MSG-ACK message or Message ACK EH in response to the AAI_CM-CMD message and the AMS disconnects control signal on the serving carrier and switches to the target fully configured carrier at action time specified by the ABS. The action time in the AAI_CM-CMD message shall be set to the value more than the retransmission timer for AAI_CM-CMD message.

If the AMS supports carrier aggregation mode and the target carrier is one of the active secondary carriers of the AMS, the AMS may receive data and control signal on the target carrier immediately after switching. Otherwise, the AMS first reconfigures its hardware setting (e.g. RF center frequency) and switches to target carrier. If Ranging indicator in the AAI_CM-CMD message is set to '1', the AMS shall perform the periodic ranging procedure with the target carrier. After successfully completing this action, the AMS shall transmit an AAI_CM-IND message to notify its readiness of the target carrier to the ABS. The ABS may transmit data and control signal after the AAI_CM-IND message is received from the AMS through the target primary carrier. Given that a common MAC manages both serving and target primary carriers, network reentry procedures at the target primary carrier is not required. The ABS may direct an AMS to change the primary carrier without scanning. For the multi-carrier supported AMS, the logical carrier indices of the serving and target primary carrier are swapped after the primary carrier change.

The AMS may perform scanning on other assigned carriers which are not serving the AMS in an unsolicited manner or by the instruction of the ABS. The AMS reports the scanning results back to the serving ABS, which may be used by the ABS to determine the carrier for the AMS to switch to. In this case, if the target carrier is not currently serving the AMS, the AMS may perform synchronization with the target carrier if required.

The AAI_CM-CMD MAC control message for the primary carrier change is transmitted on the primary carrier and shall include the following information:

- Target primary carrier index
- Indication of the next state of serving primary carrier: if the AMS does not support carrier aggregation, this filed shall be always set to ‘0’
- Action Time
- Ranging indicator

The serving primary carrier will be kept active or deactivated depending on the indication of the next state of serving primary carrier.

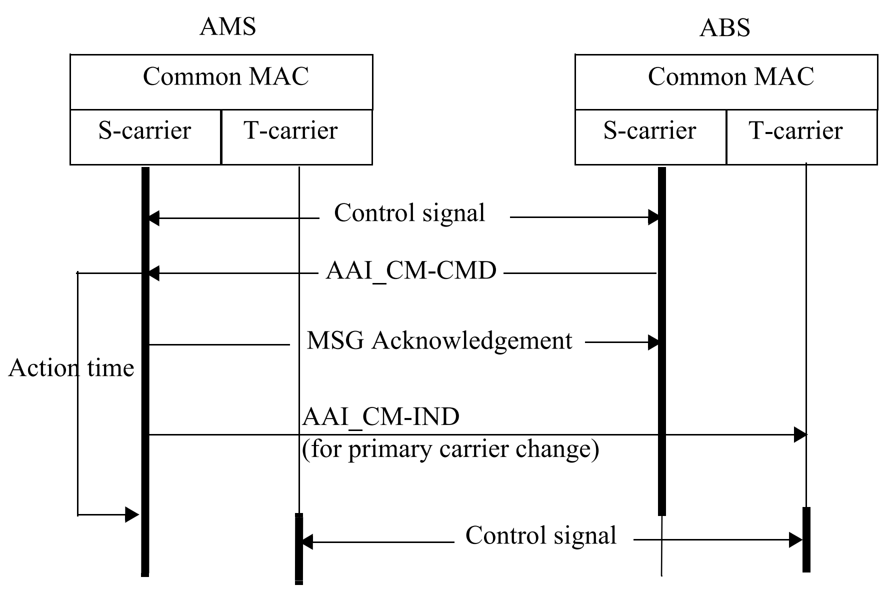


Figure 425—Primary carrier change procedure when target carrier is one of the active carrier

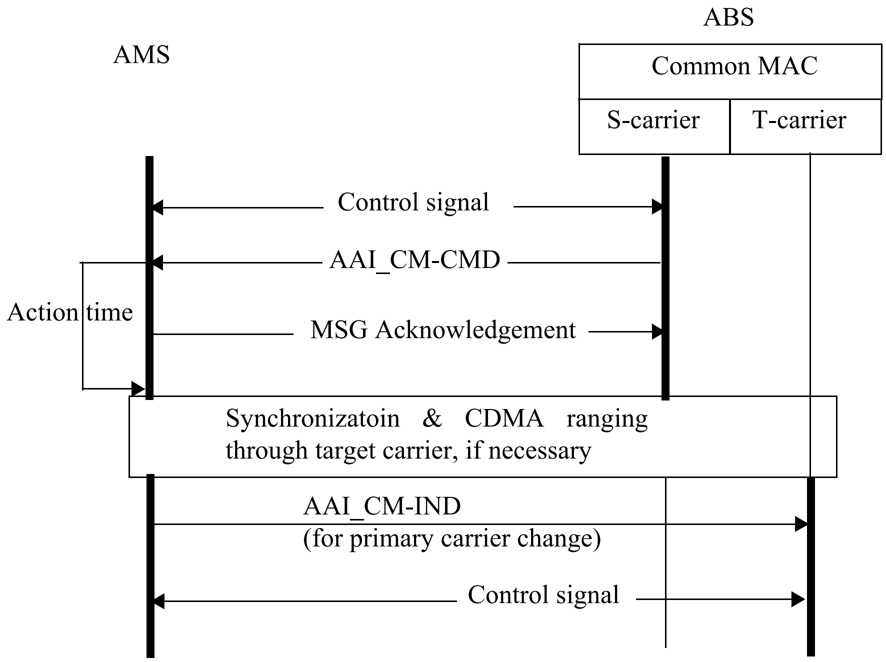


Figure 426—Primary carrier change procedure when target carrier is one of the inactive carrier

16.2.8.2.11.3 Multicarrier Aggregation

The ABS activates one or more assigned secondary carriers of an AMS through an AAI_CM-CMD message. The ABS may make concurrent resource allocation using A-MAP on multiple active carriers, including primary carrier. The Multicarrier allocation and aggregation may be used independently in the downlink or uplink and the ABS performs the operations based on QoS, loading and AMS's capabilities.

The AMS in multicarrier aggregation mode is assigned the same STID to be used across primary and secondary carriers. The AMS supporting Multicarrier aggregation mode shall monitor all active carriers and follow the resource allocations while in active mode.

When supported by AMS, serving and target ABS the carrier aggregation mode may be maintained during the handover procedure through secondary carrier pre-assignment procedure per 16.2.8.2.9.

16.2.8.2.11.4 Primary to Secondary Carrier Switching

Primary to secondary carrier switching in multicarrier mode is used for E-MBS only. The E-MBS operation on the multi-carrier deployment is defined in 16.9.2.1

16.2.8.2.11.5 MAC Control Messages for Carrier Management

16.2.8.2.11.5.1 Carrier Management Command (AAI_CM-CMD) MAC control message

An AAI_CM-CMD message shall be transmitted by an ABS to initiate a carrier management procedure, such as carrier activation/deactivation and primary carrier change. In order to respond to a received AAI_CM-CMD MAC control message, the AMS shall transmit the AAI_CM-IND MAC control message.

The ABS shall transmit the AAI_CM-CMD with Polling set to 1 in MCEH and start retransmission timer for the AAI_CM-CMD when transmitting the AAI_CM-CMD message as described in 16.2.21. If the ABS successfully receives the acknowledgement message (i.e., AAI_MSG-ACK message or Message ACK extended header) before expiration of the retransmission timer, the ABS stops the timer and performs the procedure corresponding to the action code. Otherwise, the ABS may retransmit AAI_CM-CMD message.

The format of the AAI_CM-CMD MAC control message is shown in Table 749—.

Table 749—AAI_CM-CMD MAC Control Message Format

Field	Size (bit)	Description
AAI_Carrier Management Command Control Message Format(){		
Control message type	8	AAI_CM-CMD
Action code	1	0: Secondary carrier management 1: Primary carrier change
If(Action code==0){		This message is for secondary carrier activation and/or deactivation
Indication Type	2	For Activation and/or Deactivation Bit#0:0:No actoin, 1:Activation Bit#1: 0: No action, 1: Deactivation
If(Indication Type#0==1){		
Num of target carrier	3	The number of to be activated carrier(s)
For(i=0;i<Num of target carrier;i++){		
Target carrier index	3	Target logical carrier index for activation
Activation of DL/UL	1	0: Both DL/UL are activated. 1: DL is activated but UL is not activated.
Ranging indicator	1	Ranging indicator for target carrier 0: No initial or periodic ranging is required for the target carrier 1: Periodic ranging is required for the target carrier.

Table 749—AAI_CM-CMD MAC Control Message Format

Field	Size (bit)	Description
}		
}		
If(Indication Type #1==1){		
Num of target carrier	3	The number of deactivated carrier(s)
For(i=0;i<Num of target carrier;i++){		
Target carrier index	3	Target logical carrier index for deactivation
Deactivation of DL/UL	1	0: Both DL/UL are deactivated. 1: UL is deactivated but DL is kept active.
}		
}		
}		
If(Action code==1){		This message is for primary carrier change
Physical carrier index of Target carrier	6	Physical carrier index of target carrier for primary carrier change If the AMS supports multicarrier operation, the carrier shall be one of the assigned carriers.
Action Time	3	LSB bits of Superframe number at the time to switch to the target carrier This value shall be set to the value more than the retransmission timer for AAI_CM-CMD message
Next state of serving primary carrier	1	0: serving carrier will be deactivated after primary carrier change; If the AMS does not support carrier aggregation, this field shall be always set to '0'. 1: serving carrier is kept active after primary carrier change
Ranging indicator	1	Ranging indicator for target carrier '0': No ranging is required for the target carrier '1': Periodic ranging is required for the target carrier
}		
}		

16.2.8.2.11.5.2 Carrier Management Indication (AAI_CM-IND) MAC control message

An AAI_CM-IND message shall be transmitted by an AMS to inform the ABS of the readiness of target carrier when the AMS is instructed to newly activate the target carrier(s) in an AAI_CM-CMD message with action code=0 or when the target carrier in an AAI_CM-CMD message with action code=1 has not been an active carrier.

The format of the AAI_CM-IND MAC control message is shown in Table 750—.

Table 750—AAI_CM-IND MAC Control Message Format

Field	Size (bit)	Description
Control message type	8	AAI_CM-IND
Action code	1	0: Secondary carrier managment 1: Primary carrier change

16.2.9 Group Resource Allocation

Group Resource Allocation mechanism allocates resources to multiple users as a group in order to save control overhead. Group Resource Allocation may be used for connections with a periodic traffic pattern and with relatively fixed payload size.

16.2.9.1 Grouping Mechanism

Grouping criteria include MIMO modes and HARQ burst sizes. As a result, every group may correspond to a given set of MIMO modes, and HARQ burst sizes.

An AMS may be assigned to a DL and/or a UL group. Each DL or UL group is identified by a unique 12-bit Group ID, which is chosen from the same number space as Station ID 16.2.1.2.1.

16.2.9.2 Group Configuration

Dynamic changes within the limited set of MIMO modes and HARQ data burst sizes are facilitated within a group.

The ABS configures a Group MIMO Mode Set for each group among the predefined candidate sets listed in Table 751 for the downlink andTable 752 for the uplink. When an AMS is added into the group, the configured Group MIMO Mode Set ID is indicated through Group Configuration MAC control message. The assigned MIMO mode to an AMS in the group shall be chosen from the configured set.

Table 751—DL MIMO mode set candidates

MIMO Mode Set ID	DL Group MIMO mode set	SM Restriction
0b00	Mode 0	N/A
0b01	Mode 0, Mode 1	$M_t = 2$
0b10	Mode 2	$M_t = 1$
0b11	reserved	N/A

Table 752—UL MIMO mode set candidates

MIMO Mode Set ID	UL Group MIMO mode set	SM Restriction
0b00	Mode 0	N/A
0b01	Mode 0, Mode 1	$M_t = 2$
0b10	Mode 2	$M_t = 1$
0b11	*reserved*	N/A

The ABS configures a HARQ Burst Size Set for each group Each HARQ burst size set supports four HARQ burst sizes. The Group Configuration MAC control message signaled to an AMS contains the HARQ burst sizes assigned to its group. The assigned HARQ burst size to AMS in the group shall be chosen from the configured set.

The four burst sizes in the set are chosen from the burst sizes defined in 753. The table also lists the corresponding 5-bit codes that will be used to signal these burst sizes in the Group Configuration MAC control message. Note that these burst sizes are the first 32 sizes supported in the PHY layer as defined in Table 922 of section 16.3.11.1.2.

Table 753—Burst Sizes Supported in GRA and corresponding Codes

Burst Size (bytes)	Code	Burst Size (bytes)	Code
6	00000	44	10000
8	00001	50	10001
9	00010	57	10010
10	00011	64	10011

Table 753—Burst Sizes Supported in GRA and corresponding Codes

Burst Size (bytes)	Code	Burst Size (bytes)	Code
11	00100	71	10100
12	00101	80	10101
13	00110	90	10110
15	00111	100	10111
17	01000	114	11000
19	01001	128	11001
22	01010	144	11010
25	01011	164	11011
27	01100	180	11100
31	01101	204	11101
36	01110	232	11110
40	01111	264	11111

16.2.9.3 Group Management

16.2.9.3.1 Addition of AMS to a Group

Addition of an AMS to a group occurs when group resource allocation is initialized for the AMS or when an AMS in a group moves to another group. For inclusion, all the group information that is required to interpret resource assignment information from Group Resource Allocation A-MAP IE shall be signalled to an AMS. The information is transmitted through a unicast Group Configuration MAC control message. Note that the addition of a flow to a group for Group Resource Allocation does not preclude the use of individual or dynamic allocations for packets of that flow.

16.2.9.3.1.1 ABS Operation

When an ABS decides to use group resource allocation for an AMS, the ABS adds the AMS into an appropriate group among existing groups. If the existing groups are not appropriate to the AMS, the ABS may form a new group. ABS shall indicate group configuration information via Group Configuration MAC control message which includes the Group ID of the group to which the AMS is added and the assigned User Bitmap Index to the AMS.

The addition of AMS to a group shall apply starting at least one frame following the frame in which the ABS receives a successful acknowledgement from the AMS for the Group Configuration MAC control message. Once the AMS is added to the group, resources used for initial transmission of an HARQ data burst may be allocated as part of the group until the AMS is deleted from the group.

16.2.9.3.1.2 AMS Operation

Upon receiving Group Configuration MAC control message, the AMS knows the group ID of the group to which it is added, the periodicity of group resource allocation and the AMS's index in the group's user bitmap. In addition, the AMS receives the required information to interpret the assigned MIMO mode, HARQ burst size and resource size from the bitmaps in the corresponding Group Resource Allocation A-MAP IE. Once the AMS successfully acknowledges a Group Configuration MAC control message, starting the next frame, the AMS shall monitor its allocation in the corresponding Group Resource Allocation A-MAP IE until it is deleted from the group.

When an AMS is added to a group, the AMS shall be assigned a set of consecutive ACIDs to be used for group allocations. This set of ACIDs is determined by the parameters *Initial_ACID* and *N_ACIDs* signaled in the Group Configuration MAC control message. The set of allowable ACIDs belong to the range [*Initial_ACID, Mod(Initial_ACID+N_ACIDs-1,16)*], where the operation Mod(x,y) is the remainder of division of x by y. For integers x and y, Mod(x,y) lies between 0 and y-1.

16.2.9.3.2 Deletion of AMS from a Group

The ABS may delete an AMS from a group when one or more of the following conditions applies: (i) all the GRA-enabled connections are terminated (ii) the MIMO mode/HARQ burst size suitable for the AMS no longer belongs to the MIMO Mode Set/HARQ burst size set corresponding to the group.

16.2.9.3.2.1 ABS Operation

ABS may delete multiple AMSs from a group in a AAI subframe. The deletion information shall be signaled individually to each AMS via the Group Configuration MAC control message. The deletion can be signaled explicitly by setting the Deletion Flag field in the control message to 1. The deletion from the current group can be implicit if the flow is reassigned to a group by setting the Deletion Flag to 0.

Once the Group configuration MAC control message for deletion is sent to an AMS, no allocations shall be provided to the AMS in the group in the subsequent frames. After sending the deletion information, the ABS shall wait for an ACK from the AMS. The ABS shall not allocate the corresponding bitmap position to another AMS until an ACK for deletion has been received.

16.2.9.3.2.2 AMS Operation

After decoding a Group Configuration MAC control message, if an AMS finds that it has been deleted from the group, then it shall stop expecting allocations in that group after the AAI subframe in which deletion information was sent. The AMS shall send an ACK to the ABS signaling that the AMS has successfully received the Group Configuration MAC Control message.

16.2.9.4 Normal Operation

An ABS shall provide contiguous allocations to the AMSs belonging to a group, which have the corresponding bit in the user bitmap set to '1'. The order of resource allocation shall be the same as the order in which they appear in the group's user bitmap. If there is no transmission for a given AMS in a certain AAI subframe, then the ABS shall set the corresponding bit in the user bitmap to '0'.

When an AMS receives a Group Resource Allocation IE in which the corresponding bit in user bitmap is set to '1', then the AMS shall decode the remaining bitmaps to determine other attributes of the allocated resource. An AMS shall determine the location of its allocation by counting the resource allocation sizes of other AMSs appearing before it in the user bitmap. If an AMS does not receive the Group Resource Allocation IE in any of the AAI subframes of a frame in which the IE was expected, then the AMS shall assume no allocations for the group in that frame.

The ACID corresponding to a resource allocated to an MS in a given frame is not explicitly signaled in the Group Resource Allocation A-MAP IE. The ACIDs for an AMS implicitly cycle in the ACID range defined in section 16.2.9.3.1.2. The ACID for an allocation shall be determined using the following formula.

$$\text{ACID} = \text{Mod}(Initial\_ACID + \text{Mod}(\text{ floor}(Frame\_Number / Allocation\_Period), N\_ACID), 16) \quad (3)$$

where,

ACID = ACID used for current allocation
Initial_ACID = Initial ACID parameter signaled in the Group Configuration MAC Control Message
Periodicity = Periodicity of group resource allocation in terms of number of frames signaled in the Group Configuration MAC Control Message
N_ACIDs = Number of ACIDs assigned to the AMS for group resource allocation, signaled in the Group Configuration MAC Control Message
Frame_Number = Current frame number, which is given by Equation (4) below

The *Frame_Number* parameter is determined as

$$Frame\_Number = Superframe\_Number * 4 + Frame\_Offset \quad (4)$$

Where *Superframe_Number* is the current superframe number and *Frame_Offset* is the offset of the current frame with respect to the start of the corresponding superframe and $0 \le Frame\_Offset \le 3$. The Frame_Number parameter corresponds to the frame in which the Group Resource Allocation A-MAP IE is transmitted.

If the calculated ACID is still performing retransmissions of a previous packet, then the previous packet shall be dropped and the ACID shall be freed for the new allocation. The packet drop shall happen in the frame in which Group Resource Allocation A-MAP IE is received.

16.2.9.4.1 Bitmaps in Group Resource Allocation

The ABS uses bitmaps to signal resource allocation information for AMSs within a group. These bitmaps are sent in the Group Resource Allocation A-MAP IE. The first bitmap is the User Bitmap which uses 1 bit per AMS to signal which users are scheduled in the frame. The user bitmap size can be 8, 16 or 32 bits. Each AMS belonging to the group shall be assigned a unique index in the User Bitmap of that group. The bitmap size for a given group shall remain fixed. As AMSs are deleted from the group, some bit indices in the user bitmap may become empty or unassigned. These empty bits may be assigned to new users as they are added to the group.

In addition to the user bitmap, a second bitmap called the MIMO Bitmap is used to indicate the assigned MIMO mode, when multiple MIMO modes and SM parameters are supported in the group. The MIMO Bitmap is only required for certain MIMO mode sets and may not always be transmitted. The existence of MIMO bitmap and the number of bits per scheduled AMS in the MIMO Bitmap are listed in Table 754 and Table 755.

Table 754— MIMO Bitmap Information for DL

MIMO Mode Set	Existence of MIMO Bitmap	Number of Bit Per Scheduled AMS	MIMO Mode Indication
0b00	No	N/A	OL SU-MIMO (SFBC with non-adaptive precoder)
0b01	Yes	1	0b0: OL SU-MIMO (SFBC with non-adaptive precoder) 0b1: OL SU-MIMO (SM with non-adaptive precoder) with M_t=2
0b10	No	N/A	CL SU-MIMO with M_t=1

Table 755—MIMO Bitmap Information for UL

MIMO Mode Set	Existence of MIMO Bitmap	Numberof Bit Per Scheduled AMS	MIMO Mode Indication
0b00	No	N/A	OL SU-MIMO (SFBC with non-adaptive precoder)
0b01	Yes	1	0b0: OL SU-MIMO (SFBC with non-adaptive precoder) with M_t=2 0b1: OL SU-MIMO (SM with non-adaptive precoder) with M_t=2
0b10	No	N/A	CL SU-MIMO with M_t=1, TNS=2

The third bitmap is the Resource Allocation bitmap which uses 2 bits per AMS to signal HARQ burst size and 3 bits per AMS to signal the Resource Size for the scheduled AMS in the AAI subframe or extended AAI subframe that are scheduled in the frame. The resource size refers to the number of LRUs allocated to the AMS. The resource size supported in GRA is limited to 16 LRUs. Each group supports eight resource sizes for each burst size supported in the group. The set of resource sizes for each burst size belong to the range [1,16] LRUs. The set of HARQ burst sizes and resource sizes supported in the group is signaled in the Group Configuration MAC control message. AMS i calculates the starting location of its own resources in the AAI subframe as follows.

$$R_i = R_0 + \sum_{j=1}^{j<i} L_j$$

Where R0 is the resource offset of the group as signalled in the DL/UL Group Resource Allocation A-MAP IE and Lj is the resource size in LRUs of the AMS in the group whose user bitmap index is j.

Examples of utilizing the bitmaps are shown in Figure 427 and Figure 428.

[

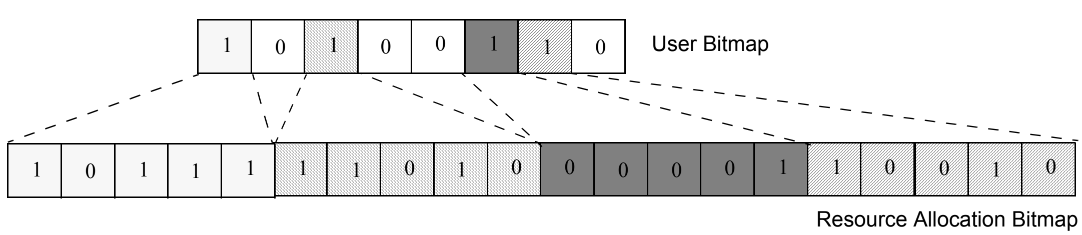


Figure 427—Example of Bitmaps with Group MIMO Mode Set: DL (0b00, 0b10), UL(0b00, 0b10)

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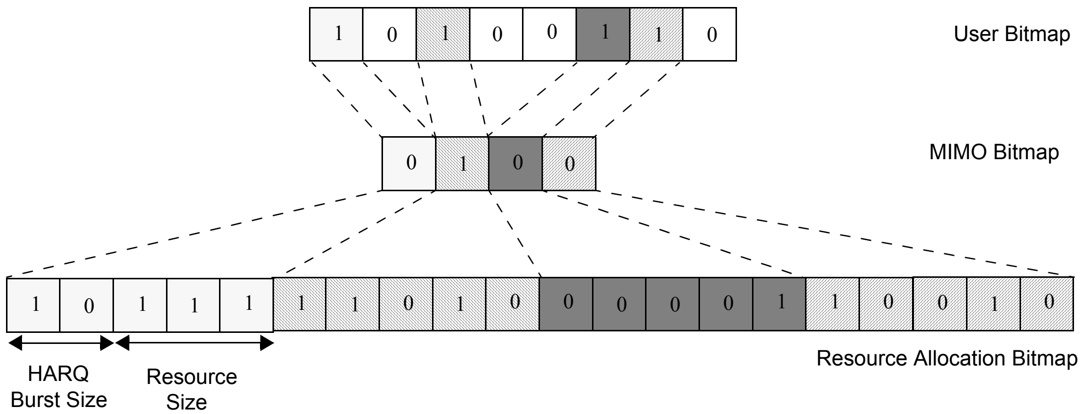


Figure 428—Example of Bitmaps for Group MIMO Mode Set: DL (0b01), UL(0b01)

16.2.10 Connection Management

Connection is a mapping between MAC peers of an ABS and one or more AMSs. When the mapping applies to ABS and one AMS, the connection is a unicast connection. Otherwise it is a multicast or broadcast connection. Messages sent over unicast connections are distinguished by the 16-bit CRC masking in the unicast assignment A-MAP IEs using the STID as specified in 16.3.6.5.2.4.

Broadcast connections are intended for reception by all AMS that may be listening, not to any specific AMS. Messages sent over broadcast connections are distinguished by the 16-bit CRC masking in the broadcast assignment A-MAP IEs as specified in 16.3.6.5.2.4.

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 including upper layer signaling messages such as DHCP, etc., and data plane signaling such as ARQ feedback. MAC control message shall never be transferred over transport connection, and user data (except SMS over AAI_RNG-REQ/RSP and AAI_L2-XFER) shall never be transferred over the control connections.

16.2.10.1 Control connections

One pair of bi-directional (DL/UL) unicast control connections are automatically established when an AMS performs initial network entry. When FID is required to be present in a control connection, the FID value shall be set to the unicast or broadcast control FID value (see Table 652—).

Once the TSTID is allocated to the AMS, the control connections are established automatically. FIDs for the control connections shall never be changed during WirelessMAN-OFDMA Advanced System handover or network reentry.

16.2.10.2 Transport connections

All the user data communications are in the context of transport connections. A transport connection is uni-directional and established with unique FID assigned using DSA procedure per section <<15.2.z.3>>. If a Group parameter Create/Change TLV is included in a DSA message (see 11.13.39) it may indicate whether the grouped transport connections are coupled to be considered together in admission. Each transport connection is associated with an active service flow to provide various levels of QoS required by the service flow. The transport connection is established when the associated active service flow is admitted or activated, and released when the associated service flow becomes inactive. Once established, the FID of the transport connection is not changed during WirelessMAN-OFDMA Advanced System handover.

To reduce bandwidth usage, the ABS and AMS may establish/change/release multiple connections using a single message transaction on a control connection.

Transport connections can be pre-provisioned or dynamically created. Pre-provisioned connections are those established by system for an AMS during the AMS network entry. On the other hand, ABS or AMS can create new connections dynamically if required. A connection can be created, changed, or torn down on demand.

16.2.11 Bandwidth Request and Allocation Mechanism

16.2.11.1 Bandwidth Request

Bandwidth Requests (BR) refer to the mechanism that AMSs use to indicate to the ABS that they need UL bandwidth allocation. The AMS shall use a contention-based random access based BR preamble sequence and an optional quick access message on BR channel, a BR signaling header, a piggybacked bandwidth request carried in an Extended Header in the MAC PDU or a bandwidth request using fast feedback channel. The BR from AMS shall indicate the requested data in units of bytes exclusive of any header, security or other MAC PDU overhead and PHY overhead that may be applied during transmission over the air interface.

An AMS requests UL bandwidth on a per-connection basis. In addition, the AMS may request bandwidth for multiple connections in one piggyback BR.

16.2.11.1.1 Contention-based random access bandwidth request

The ABS may advertise a minimum access class in the BR Channel Configuration MIN Access Class element within the AAI_SCD. If no minimum access class is advertised in the AAI_SCD that means that all access classes are allowed. An access class is assigned to a service flow via DSx MAC control messages during service flow establishment / modification. When an AMS has information to send and decides to use the contention-based random access bandwidth request, the AMS shall check if the information the AMS has to send is for an access class with priority higher than or equal to the minimum access class advertised by BR channel configuration in the AAI_SCD. If it is not (the minimum access class is not sufficiently low such that the AMS access class is allowed), then the AMS shall wait until the BR channel configuration in the AAI_SCD advertises a minimum access class, which is less than or equal to the access class of the data and the AMS. When the AMS access class is allowed, the AMS shall set its internal backoff window equal to Bandwidth request backoff start (or Ranging for initial ranging) and send a bandwidth request when the backoff timer expires.

As specified in 16.3.9.2.5, bandwidth request channel and bandwidth request preamble sequences shall be used for contention-based random access BRs. Each BR channel indicates a BR opportunity.

The AMS decides whether to send BR preamble sequence only or to send BR preamble sequence together with quick access message for the random access based BR procedure.

The 3-step random access based BR procedure is illustrated in Figure 429. At step 1, the AMS shall transmit a BR preamble sequence and a quick access message on a randomly selected opportunity. At lease one BR-ACK A-MAP IE shall be sent in the next DL frame if the ABS detects at least one BR preamble sequence in the BR opportunities in the previous frame. The ABS may send multiple BR-ACK A-MAP IEs, with each BR-ACK A-MAP IE containing its own bitmap relating to the preamble sequences being acknowledged/ granted in this message alone. Each AMS should try to decode all BR-ACK MAP-IEs in the next DL frame after it transmitted a BR preamble sequence. In this case if no BR-ACK A-MAP IEs are not sent in the next DL frame, the AMS considers it as an implicit-NACK and may restart BR procedure.

The BR-ACK A-MAP IE indicates

— The decoding status of each BR opportunity in the previous frame (no or at least one BR preamble sequence is detected). Each BR-ACK A-MAP IE contains its own bitmap relating only to the preamble indices being acknowledged/granted in this message.
— The correctly received BR preamble sequences in the BR opportunities of the previous UL frame being acknowledged/granted in this message, and
— The decoding status of the quick access message for each correctly received BR preamble sequence being acknowledged/granted in this message.

If the BR-ACK Bitmap(s) indicates no BR preamble sequence is detected at the BR opportunity selected by the AMS, or the AMS's BR preamble sequence is not included at the selected BR opportunity in the BR-ACK A-MAP IE(s), the AMS shall consider that it has received a Negative-ACK. The AMS shall wait until the last DL subframe of a frame before deciding it has received an implicit Negative-ACK.

Upon successfully decoding the quick access message, the ABS may provide an UL grant to the AMS, using the STID and the BR index provided in the quick access message.

The AMS shall start the BR timer at the DL frame which is right after the UL frame in which the AMS sent the BR if the AMS receives neither any UL grant nor Negative-ACK. If the BR-ACK A-MAP IE indicates successful reception of BR preamble sequence and quick access message, the BR Timer value shall be set to the Differentiated BR timer acquired during the DSx transaction. For all other cases, the BR Timer value shall be fixed.

The AMS shall stop the BR timer upon reception of the UL grant.

The AMS considers the BR as failed and may restart the BR procedure (according to the rules defined later in this section) when any of the following conditions is met:

1) AMS receives a Negative-ACK;
2) The BR timer expires.

When an AMS restarts BR procedure, the AMS shall randomly select a number within its backoff window specified by the connection priority. This random value indicates the number of contention transmission opportunities that the AMS shall defer before transmitting. The connection priority is defined by the tuple of contention window parameters and the number of retries. The ABS transmits initial connection priority parameters - initial and maximum window sizes and backoff window scaling factor - in DSx-REQ and/or DSx-RSP messages

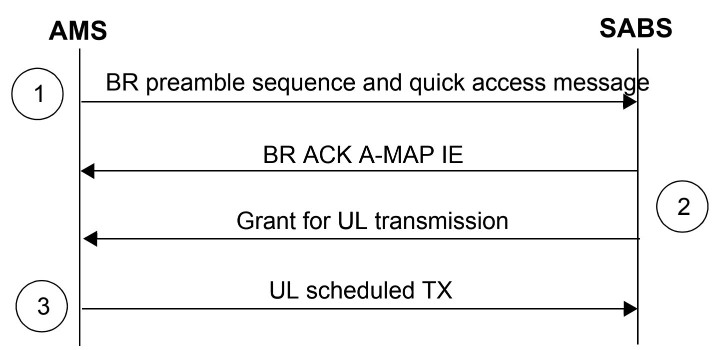


Figure 429—3-step random access BR procedure

During the 3-step BR procedure of Figure 429, if the ABS is unable to decode the quick access message, the ABS falls back to the 5-step BR procedure illustrated in Figure 430. In that case, in Step 2, the ABS shall provide an UL grant to the AMS using a BR ACK A-MAP IE or CDMA Allocation A-MAP IE. The maximum HARQ retransmission of the allocation mode through the BR ACK A-MAP IE or CDMA Allocation A-MAP IE is set to the default value defined in section 16.2.14.2. In Step 3, the AMS transmits a standalone BR header.

In case of the 5-step procedure, the AMS shall start the BR timer after sending BR header in Step 3. The BR Timer value shall be set to the Differentiated BR timer acquired during the DSx transaction.

The AMS shall stop the BR timer upon reception of the UL grant.

The AMS may restart (according to the rules defined later in this section) the BR procedure if BR timer is expired, or the AMS receives a negative acknowledgement that is generated locally at the AMS.

When the AMS restarts the BR procedure, the AMS shall follow a binary exponential backoff algorithm, i.e., doubles its backoff window and randomly selects a number within the new backoff window. This random value indicates the number of contention transmission opportunities that the AMS shall defer before transmitting a new bandwidth request preamble sequence.

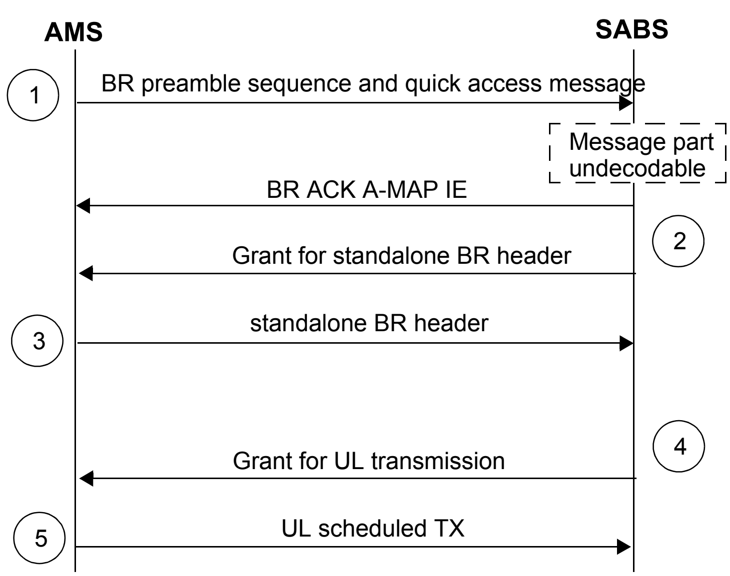


Figure 430—Example of 5-step random access BR procedure

In the regular 5-step random access BR procedure, an AMS shall send a BR preamble sequence only. If the AMS receives neither any UL grant nor Negative-ACK at the next DL frame after it has transmitted the BR preamble sequence, a fixed value of BR timer shall be activated. The rest of the BR procedure shall be the same as the fallback 5-step procedure of Figure 430.

16.2.11.1.2 Standalone Bandwidth Request Header

Standalone bandwidth request header is used by AMS to send bandwidth request in step 3 in the 5-step contention-baesd random access BR procedure, or as a response to the polling from the ABS. The AMS can use any UL resource allocated to itself to send the standalone BR header.

16.2.11.1.3 Piggybacked Bandwidth Request

Piggybacked bandwidth request is used by the AMS to request for bandwidth for the same or different connection, to which the user data in the MAC PDU is mapped to. It is carried in the extended header.

16.2.11.1.4 Bandwidth Request using FFB

Bandwidth request can also be sent from an AMS to the ABS through P-FBCH. Two P-FBCH codewords are reserved for the AMS to send a BR indication flag and an ertPS/aGPS BR flag. In order to maintain operation of link adaptation mechanisms at the ABS and adequate CINR reporting, the AMS shall not transmit either one of the BR codewords on two consecutive P-FBCH allocations that are allocated to it.

16.2.11.1.4.1 Indication flag feedback

An AMS can send an indication flag on the P-FBCH. The indication flag is used by the AMS to indicate to the ABS its intention to request UL allocation without the need to perform the random access bandwidth request. The codeword 0b111110 is used for that purpose. After receiving the indication flag from the AMS, the ABS may allocate the required UL resource to the AMS.

16.2.11.1.4.2 ertPS/aGP Service BR

If an AMS has ertPS connections, the AMS may inform the serving ABS of the existence of pending ertPS data. If an AMS has aGP Service connections, the AMS may inform the serving ABS of the existence of pending aGP Service data related to primary QoS parameters. The codeword 0b111111 is used for those purposes.

If the ABS receives the codeword (i.e., 0b111111) on P-FBCH from the AMS, the ABS should make UL allocation as follows:

1) If an AMS has ertPS connections only, the ABS should allocate for the AMS an UL burst corresponding to the largest Maximum Sustained Traffic Rate of the AMS's stopped ertPS UL service flows.

2) If an AMS has aGP Service connections only, the ABS should change allocation for the AMS UL bursts corresponding to the Primary service flow QoS parameter set of the AMS's aGP Service UL service flow, which has the largest Grant_Size_primary among all aGP Service flows.

3) If an AMS has both ertPS and aGP Service connections, the ABS should allocate for the AMS UL bursts corresponding to the largest Maximum Sustained Traffic Rate of the AMS's ertPS and aGP Service UL service flows.

If an AMS has ertPS connections, this codeword also implicitly indicates the stopped ertPS UL service flow to resume.

16.2.11.1.5 Bandwidth request message format

16.2.11.1.5.1 Quick access message format

When a 3-step BW-REQ procedure is used, in step-1 the quick access message carries 12 bit information including AMS addressing information with quick access sequences carrying additional 4-bit BW-REQ information.

The following parameters are carried in step-1 of 3-step BW-REQ procedure. Detailed encoding method is provided in the section <<15.3.9.1.5>>.

- STID (12 bits)
- Predefined BR index (4 bits): The mapping between 'predefined BR index' and 'BR size & QoS level' is done during DSx procedure. 'BR size' and 'QoS level' is determined based on the QoS parameters of the flow in the DSx messages. 'BR size' is in unit of bytes and is mapped to Maximum Traffic Burst parameter, and 'QoS level' is mapped to UL Grant Scheduling Type parameter.

16.2.11.1.5.2 Bandwidth request header format

When the standalone Bandwidth Request Header is transmitted in step 3 in the 5-step contention-based random access BR procedure, it shall contain the following parameters:

- STID of the AMS
- FID of the requesting connection
- Aggregate bandwidth to request

When the standalone Bandwidth Request Header is transmitted using the UL grant specifically for the AMS (e.g., polling from ABS), it may request bandwidth for one flow or multiple flows if allowed by space; it may request GPI change for aGP service or minimum delay of the requested grant for BE, and it may contain the following parameters. An ABS should use the size of single flow standalone bandwidth request header as the minimum allocation size for polling allocation.

- FID of the requesting connection
- Aggregate or incremental bandwidth to request for one or multiple flows
- New GPI value for aGP service or minimum delay of the requested grant for BE
- GPI change indicator for aGP service

16.2.11.1.5.3 Piggyback bandwidth request extended header format

Piggybacked bandwidth request shall contain the FID of the requesting connection and the aggregate bandwidth to request. Multiple requests can be included in one piggybacked bandwidth request.

16.2.11.2 Grant

In the contention-based random access bandwidth request procedure, the grant for BR header is allocated by CDMA Allocation A-MAP IE, which is shown in Table 755. CDMA Allocation A-MAP IE is used for UL allocation of bandwidth to a user that requested bandwidth using a ranging preamble code or BR preamble code. The AMS decodes the IE and checks the MCRC by its specific 15-bit RA-ID and 1-bit Masking Prefix Indicator. The RA-ID is derived from the AMS' random access attributes (i.e., superframe number (LSB 5bits), frame_index (2 bits), ranging preamble code/BR preamble code index (6 bits) and opportunity index (2 bits)) as defined below:

RA-ID = (LSB 5bits of superframe number | frame_index | preamble_code_index | opportunity_index)

The maximum number of the HARQ retransmission is set to the default value defined in section 16.2.14.2. HARQ retransmission control information cannot be changed during retransmission process.

16.2.12 Quality of Service (QoS)

16.2.12.1 Global Service classes

Global service class name is a rules-based, composite name parsed in a variable number of information fields of format,

- for I=1, format is ISBRLSPS1R and length is five bytes;
- for I=0 and S2=0 or 1, format is ISBRLSPS1S2R and length is five bytes;
- for I=0 and S2=2 or 3, format is ISBRLSPS1S2S3R and length is six bytes;
- for I=0 and S2=4, format is ISBRLSPS1S2S3S5R and length is six bytes;
- for I=0 and S2=5, format is ISBRLSPS1S2L1S3S4R and length is seven bytes;
- for I=0 and S2=6, format is ISBRLSPS1S2L1S4R and length is seven bytes;
- for I=0 and S2=7, format is ISBRLSPS1S2L1S3S6S7S8S9S10R and length is eleven bytes.

Table 756—Global Service Class Name Information Field Parameters

Position	Name	Size (bits)	Value
I	Uplink / Downlink indicator	1	0 = uplink; 1 = downlink
S	Maximum sustained traffic rate per flow	6	Extensible look-up Table 187 (value 0b111111 indicates TLV to follow)
B	Maximum traffic burst	6	Extensible look-up Table 187 (value 0b111111 indicates TLV to follow)
R	Minimum reserved traffic rate	6	Extensible look-up Table 187 (value 0b111111 indicates TLV to follow)
L	Maximum latency	6	Extensible look-up Table 188 (value 0b111111 indicates TLV to follow)
S	Fixed-length versus variable length SDU indicator	1	0 = variable length; 1 = fixed length
P	Paging preference	1	0 = No paging generation 1 = Paging generation
S1	Request/Transmission Policy	8	(Refer to 11.13.11)
S2	Uplink Grant Scheduling Type	3	(Refer to 11.13.10) 1 = Undefined 2 = BE 3 = nrtPS 4 = rtPS 5 = ertPS 6 = UGS 7 = aGP Service This field is included when I=0
L1	Tolerated Jitter	6	Extensible look-up Table 188 (value 0b111111 indicates TLV to follow). This is available only for Uplink Grant Scheduling Type = ertPS, or UGS. This field is included when I=0 and S2 =5 or 6.

Table 756—Global Service Class Name Information Field Parameters

Position	Name	Size (bits)	Value
S3	Traffic Priority	3	(Refer to 11.13.5) This is used only for Uplink Grant Scheduling Type = rtPS, ertPS, nrtPS or BE.This field in included when I=0 and S2=2 or 3 or 4 or 5.
S4	Unsolicited Grant Interval	6	Extensible look-up Table 189 (value 0b111111 indicates TLV to follow) This is available only for Uplink Grant Scheduling Type = ertPS, or UGS.This field is included when I=0 and S2=5 or 6.
S5	Unsolicited Polling Interval	6	Extensible look-up Table 189 (value 0b111111 indi-cates TLV to follow). This is available only for Uplink Grant Scheduling Type = rtPS.This field is included when I=0 and S2=4.
S6	Primary GPI	6	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I=0 and S2=7.
S7	Primary Grant Size	6	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I=0 and S2=7.
S8	Secondary GPI	6	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I=0 and S2=7.
S9	Secondary Grant Size	6	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I=0 and S2=7.
S10	Adaptation Method	3	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I=0 and S2=7.
R	Padding	variable	Padding bits to ensure byte aligned. Shall be set to zero.

Maximum sustained traffic rate per flow

A parameter that defines the peak information rate of the service. The rate is expressed in bits per second and pertains to the service data units (SDUs) at the input to the system. Explicitly, this parameter does not include transport, protocol, or network overhead such as MAC headers or CRCs, or non-payload session maintenance overhead like SIP, MGCP, H.323 administration, etc. This parameter does not limit the instantaneous rate of the service since this is governed by the physical attributes of the ingress port. However, at the destination network interface in the uplink direction, the service shall be policed to conform to this parameter, on the average, over time. The time that the traffic rate is averaged over shall be defined during service negotiation. On the network in the downlink direction, it may be assumed that the service was already policed at the ingress to the network. If this parameter is set to zero, then there is no explicitly mandated maximum rate. The maximum sustained traffic rate field specifies only a bound, not a guarantee that the rate is available. The algorithm for policing this parameter is left to vendor differentiation and is outside the scope of the standard.

16.2.12.2 Service Flow Management

In addition to the legacy scheduling services described in 6.3.5, AAI supports adaptation of service flow (SF) QoS parameters.One or more QoS parameter set(s) may be defined during the initial service negotiation, e.g., a mandatory primary SF QoS parameter set, and an optional secondary SF QoS parameter set, etc. Each SF QoS parameter set defines a set of QoS parameters. If multiple SF QoS parameter sets are defined, each of them corresponds to a specific traffic characteristic for the user data mapped to the same service flow. When QoS requirement/traffic characteristics for UL traffic changes, the ABS may autonomously perform adaptation by either changing the SF QoS parameters or switching among multiple SF QoS parameter sets. The AMS may also request the ABS to perform adaptation using explicit signaling. The ABS then allocates resource according to the adapted SF QoS parameters.

The value of FID field specifies the FID assigned by the ABS to a service flow of an AMS with a non-null AdmittedQosParamSet or ActiveQosParamSet. The 4-bit value of this field is used in BRs and in MAC PDU headers. This field shall be present in a ABS-initiated AAI_DSA-REQ or AAI_DSC-REQ message related to establishing an admitted or active service flow. This field shall also be present in AAI_DSA-RSP and AAI_DSC-RSP messages in response to AMS-initiated AAI_DSA-REQ and AAI_DSC-REQ messages related to the successful establishment of an admitted or active service flow.

AAI_DSA-REQ/RSP shall include the MAC Header type field to indicate which MAC header format is to be used for such service flow. When MAC Header type = 0, the given service flow shall use AGMH. When MAC Header type = 1, the given service flow shall use CMH.

16.2.12.3 Scheduling services

Scheduling services represent the data handling mechanisms supported by the MAC scheduler for data transport on a connection. Each service flow is associated with a single scheduling service as in WirelessMAN-OFDMA reference system. A scheduling service is determined by a set of SF QoS parameters that quantify aspects of its behavior. These parameters are established or modified using service flow management procedures.

16.2.12.3.1 Adaptive granting and polling service

The set of QoS parameters associated with adaptive granting and polling services are categorized into primary QoS parameters and secondary QoS parameters. The ABS may grant or poll AMS periodically and may negotiate only primary SF QoS parameters, or both primary and secondary QoS parameters with the AMS. Initially, ABS uses primary SF QoS parameters including Primary Grant and Polling Interval (GPI) and Primary Grant Size. When both primary and secondary QoS parameters are negotiated, primary QoS parameters shall have more stringent QoS requirements than secondary QoS parameters. The admission control shall be done by considering the most stringent QoS requirement defined by the primary QoS parameters. The secondary QoS parameters are the minimal QoS guarantees that the scheduling service shall always provide.

During the service, the traffic characteristics and QoS requirement may change, for example silence-suppression enabled VoIP alternates between talk spurt and silence period, which triggers adaptation of the scheduling service state machine as described below. Adaptation of scheduling state includes switching between using primary and using secondary SF QoS parameters or changing of GPI/Grant size to values within the QoS flexibility range, i.e., without exceeding the maximal QoS requirement or violating the minimal QoS guarantee, that are defined by the primary or secondary SF QoS parameters when the traffic can be characterized bymore than two QoS states.

Depending on the adaptation method specified during the service flow negotiation, the grant size or GPI can be changed by ABS automatically upon detecting certain traffic condition, or can be triggered by explicit signaling from AMS, such as Bandwidth request signaling header, quick access message in BR channel or Fastfeedback Channel.

There are three adaptation methods:

- **Implicit**: upon detecting of certain traffic condition with respect to a pre-negotiation SF QoS parameter set, ABS automatically changes GPI and/or Grant size; or switches between GPI_primary/ Grant_Size_primary and GPI_secondary/Grant_Size_secondary if secondary SF QoS parameter set is defined.
- **Explicit, sustained**: GPI and grant size change is triggered by explicit signaling from AMS such as bandwidth request signaling header, quick access message in BR channel, or fast feedback channel. Such change is sustained until next change request. If GPI_secondary/Grant_Size_secondary is defined, GPI and grant size switches between GPI_primary/ Grant_Size_primary and GPI_secondary/ Grant_Size_secondary as requested by the explicit signaling; otherwise, GPI and grant size changes as indicated by QoS requirement carried in the explicit signaling as mechanisms mentioned above. If an AMS has requested a change in GPI or grant size (different than GPI_Primary and Grant_size_primary respectively), when this AMS performs handover to another ABS it should retransmit the GPI and grant size request to the target ABS after network reentry is completed.
- **Explicit, one time only**: GPI and grant size change is triggered by explicit signaling from AMS such as in bandwidth request signaling header, quick access message in BR channel, or fast feedback channel. Such change is one-time only. If GPI_secondary/Grant_Size_secondary is defined, GPI and grant size one-time switches from GPI_primary/ Grant_Size_primary to GPI_secondary/Grant_Size_secondary; otherwise, GPI and grant size changes as indicated by QoS requirement carried in the explicit signaling as mechanisms mentioned above.

Table 757— describes the SF QoS parameters for Adaptive grant and polling scheduling service (aGP service).

Table 757—SF QoS parameters for aGP service scheduling service

Information Elements	Notes
Maximum latency (unsigned int)	
Tolerated Jitter (unsigned int)	
Minimum reserved traffic rate (unsigned int)	
Maximum sustained traffic rate (unsigned int)	
Traffic Priority (unsigned int)	
Request/Transmission Policy (unsigned int)	
if (uplink service flow) { (Boolean)	
Scheduling Type (unsigned int)	aGP service
GPI_primary (unsigned int)	Primary GPI used initially
Grant_size_primary (unsigned int)	Primary grant size. If the primary grant size equals to x bytes (the newly defined bandwidth request header size), this indicates a primarily polling based service; otherwise, it is primarily granting based service.
GPI_secondary (unsigned int)	Secondary GPI (optional)

Table 757—SF QoS parameters for aGP service scheduling service

Information Elements	Notes
Grant_Size_secondary (unsigned int)	Secondary grant size (optional). If the secondary grant size is defined and equals to x bytes (the newly defined bandwidth request header size), this indicates a secondarily polling based; otherwise, it is a secondarily granting based service.
Adaptation Method (unsigned int)	• Implicit adaptation • Explicit adaptation, sustained • Explicit adaptation, one time only
Padding	Padding bits to ensure byte aligned. Shall be set to zero.
}	

The mandatory QoS parameters of aGP Service are the Maximum Sustained Traffic Rate, the Request/Transmission Policy, Primary GPI and Primary Grant Size.

16.2.12.3.1.1 Handover Support

During AMS handover from Mzone/ABS to LZone/WirelessMAN-OFDMA BS, an ABS should map an aGP service flow to a service flow of legacy scheduling type.

An aGP service flow should be mapped to an ertPS service flow or a rtPS service flow based on the value of ‘GrantSize_primary’. If ‘GrantSize_primary’ value is equal to the bandwidth request header size, an aGP service flow should be mapped to a rtPS service flow. Otherwise, an aGP service should be mapped to an ertPS service flow.

Table 758—mapping from aGP service to ertPS/rtPS

AAI aGP service flow	Mapped legacy service flow	
QoS Parameters	Scheduling type	QoS Parameters
Adaptation Method = Implicit adaptation or Explicit adaptation - sustained or Explicit adaptation - one time only GrantSize_primary != x bytes (the newly defined bandwidth request header size	ertPS	• UGI = Primary GPI • and map equally all the other common QoS parameters between ertPS and aGP service
Adaptation Method = Implicit adaptation or Explicit adaptation - sustained or Explicit adaptation - one time only GrantSize_primary = x bytes (the newly defined bandwidth request header size)	rtPS	• UGI = Primary GPI • and map equally all the other common QoS parameters between rtPS and aGP service

16.2.12.4 Emergency Service Flow

Service flow parameters for emergency service may be pre-defined in the system. When default service flow for emergency service flow is predefined, an emergency FID for the default service flow is either predefined or allocated by the ABS. During the network entry, the ABS shall allocate the emergency service FID through AAI_RNG-RSP upon receiving emergency service indicator in the AAI_RNG-REQ. During the connected state, if an emergency FID is not pre-defined, the ABS shall allocate the emergency service FID through AAI_DSA-RSP upon receiving the emergency service indication in the AAI_DAS-REQ.

16.2.12.5 Emergency Service Notification during initial ranging

The AMS may request for Emergency Service flow setup during initial ranging process by including an Emergency Service Indicator in the AAI_RNG-REQ message. Default service flow parameters are defined for emergency service flow.

If the emergency service flow parameters are pre-defined, the AMS transmits the emergency message using the emergency FID without going through the complete service flow setup through DSA transaction. The ABS grants resources according to the default service flow parameters defined for emergency service. If no default service flow parameters are defined for the emergency service, the AMS and the ABS shall establish the emergency service flow via DSA transaction.

If a service provider wants to support National Security/emergency Preparedness (NS/EP) priority services, the ABS uses its own algorithm as defined by its local country regulation body. For example, in the US the algorithm to support NS/EP is defined by the FCC in Hard Public Use Reservation by Departure Allocation (PURDA).

16.2.12.6 Emergency Service Notification during connected state

When an AMS requests for Emergency Service in the connected state and default service flow parameters are defined for the emergency service, the AMS shall send a bandwidth request using the emergency service FID without going through the complete service flow setup through DSA transaction. When an AMS requests for Emergency Service in the connected state and no default service flow parameters are defined for the emergency service, the AMS shall establish the emergency service flow using service flow setup procedure and include the emergency service notification in the AAI_DSA-REQ.

16.2.12.7 Emergency Alert Service

Emergency alert service is defined as a service that would provide the public with alerts on imminent emergency events, such as earthquake, storm, etc. The alerts would target subscribers in a specific geographical location. The emergency alert service includes the transmissions of emergency information. The emergency information is broadcasted through AAI_L2-XFER.

16.2.12.8 Service Flow/Convergence Sublayer Parameters

Table 759defines the parameters associated with UL/DL scheduling for a service flow.

Table 759—Service flow/convergence sublayer parameters

Fields	Size (bits)	Description
Flow ID	4	An identifier of a service flow
Uplink/Downlink Indicator	1	Whether parameters are for uplink or for downlink

Table 759—Service flow/convergence sublayer parameters

Fields	Size (bits)	Description
Differentiated BR timer	6	Grant reception timeout before contention-based BR is attempted again for the service flow. Value of range 1 ~ 64 frame(s)
MAC in-order delivery indicator	1	Indicate whether or not the order of delivery in non-ARQ connection is preserved by the MAC. 0 : not preserved 1 : preserved
GPI primary	TBD	
Grant size primary	TBD	Primary grant size. If the primary grant size equals to x bytes (the newly defined bandwidth request header size), this indicates a primarily polling based service; otherwise, it is primarily granting based service.
GPI secondary	TBD	
Grant size secondary	TBD	Secondary grant size (optional). If the secondary grant size is defined and equals to x bytes (the newly defined bandwidth request header size), this indicates a secondarily polling based; otherwise, it is a secondarily granting based service.
Adaptation method	TBD	— Implicit adaptation — Explicit adaptation, sustained — Explicit adaptation, one time only
Service Class Name	16 ~ 1024	Refer to 11.13.3
QoS Parameter Set Type	3	Refer to 11.13.4
Traffic Priority	3	Refer to 11.13.5
Access Class	2	This parameter specifies the priority assigned to a service flow. This priority is used in prioritizing access requests as described in paragraph 16.2.11.1.1.
Maximum Sustained Traffic Rate	6	Refer to 11.13.6
Maximum Traffic Burst	6	Refer to 11.13.7
Minimum Reserved Traffic Rate	6	Refer to 11.13.8
Vendor-Specific QoS Parameter	variable	Refer to 11.13.10
Uplink Grant Scheduling Type	3	Refer to 11.13.11. In addition to the legacy scheduling services described in 11.13.11, aGP Service is supported.
Request/Transmission Policy	8	Refer to 11.13.12
Tolerated Jitter	6	Refer to 11.13.13
Maximum Latency	6	Refer to 11.13.14
Fixed-length versus Variable-length SDU Indicator	1	Refer to 11.13.15

Table 759—Service flow/convergence sublayer parameters

Fields	Size (bits)	Description
SDU Size	8	Refer to 11.13.16
Target SAID	16	Refer to 11.13.17
ARQ Enable	1	Refer to 11.13.17.1
ARQ_WINDOW_SIZE	16	Refer to 11.13.17.2
ARQ_BLOCK_LIFETIME	16	Refer to 11.13.17.4
ARQ_SYNC_LOSS_TIMEOUT	16	Refer to 11.13.17.5
ARQ_RX_PURGE_TIMEOUT	16	Refer to 11.13.17.7
RECEIVER_ARQ_ACK_PROCESSING TIME	8	Refer to 11.13.17.9
ARQ_SUB_BLOCK_SIZE	8	
ARQ_ERROR_DETECTION_TIMEOUT	16	
ARQ_FEEDBACK_POLL_RETRY_TIMEOUT	16	
CS Specification	variable	Refer to 11.13.19
Unsolicited Grant Interval	6	Refer to 11.13.20
Unsolicited Polling Interval	6	Refer to 11.13.21
MBS service	2	Refer to 11.13.23
Global Service Class Name	variable	Refer to 11.13.24
Type of Data Delivery Services	3	Refer to 11.13.25
SDU Inter-arrival Interval	16	Refer to 11.13.26
Time Base	16	Refer to 11.13.27
MBS zone identifier assignment	8	Refer to 11.13.29
Paging Preference	1	Refer to 11.13.30
SN Feedback Enabled	1	Refer to 11.13.31
HARQ Service Flows	1	Refer to 11.13.32
Authorization Token	variable	Refer to 11.13.34
HARQ Channel Mapping	variable	Refer to 11.13.35
PDU SN Extended Subheader for HARQ Reordering	2	Refer to 11.13.36
MBS contents ID	variable	Refer to 11.13.37
ROHC Parameter Payload	variable	Refer to 11.13.38
Packet Error Rate	8	Refer to 11.13.39

Table 759—Service flow/convergence sublayer parameters

Fields	Size (bits)	Description
PSC assignment	3	Refer to 11.13.40
Emergency Indication	1	Indicates the associated flow is used for emergency purposes.
MAC Header Type	1	Indicates whether AGMH or CMH is presented at the start of MPDUs of the service flow 0 = AGMH (Advanced Generic MAC Header) 1 = CMH (Compact MAC header)

16.2.12.8.1 Flow ID (FID)

The value of this parameter specifies the FID assigned by the ABS to a service flow. The ABS shall use this parameterization to assign FIDs in ABS-initiated AAI_DSA-REQ messages and in its AAI_DSA-RSP to AMS-initiated AAI_DSA-REQ messages. The FID shall be used for DSx message signaling as the identifier for a service flow.

16.2.12.8.2 Uplink/Downlink Indicator

The value of this parameter specifies whether a service flow is for uplink or for downlink. If the service flow is for uplink, the value of this parameter is set to 0. Otherwise, it is set to 1. The Uplink/Downlink Indicator shall be used for DSx message signaling as the indicator of uplink/downlink for a service flow.

16.2.12.8.3 Differentiated BR timer

This parameter is negotiated upon connection setup or during operation, based on other service flow parameters such as Uplink Grant Scheduling Type, Maximum Latency and so on. The AMS-initiated AAI_DSA-REQ message may contain the suggested value for this parameter. The ABS-initiated AAI_DSA-REQ and AAI_DSA-RSP message shall contain the confirmation value or an alternate value for this parameter. An AMS and ABS may send AAI_DSC-REQ message to dynamically change the parameters of an existing service flow. The ABS shall send AAI_DSC-RSP message containing the confirmation value or an alternate value for this parameter in response to a received AAI_DSC-REQ. The value of this parameter is the number of frames before contention-based BR is attempted again for the service flow. The ABS should try to allocate UL grant within the confirmed value of this parameter when it receives BR for the service flow during the contention-based BR procedure.

16.2.13 ARQ mechanism

ARQ may be enabled on a per-connection basis. ARQ parameters shall be specified and negotiated during connection setup.

A connection shall not have a mixture of ARQ and non-ARQ traffic. The scope of a specific instance of ARQ is limited to one unidirectional flow.

16.2.13.1 ARQ block usage

16.2.13.1.1 Initial transmission

An ARQ block is generated from one or multiple MAC SDU(s) or MAC SDU fragment(s) of the same flow. ARQ blocks is variable in size.

ARQ block is constructed by fragmenting MAC SDU or packing MAC SDUs and/or MAC SDU fragments. The fragmentation or packing information for the ARQ block is included in MAC PDU using a FPEH.

When transmitter generates a MAC PDU for transmission, MAC PDU payload may contain one or more ARQ blocks. If the MAC PDU payload contains traffic from a single connection, PDU payload itself shall be a single ARQ block. If traffic from multiple ARQ connections is multiplexed into one MAC PDU, the MAC PDU payload contains multiple ARQ blocks. The number of ARQ blocks in a MAC PDU payload shall be equal to the number of ARQ connections multiplexed in the MAC PDU.

The ARQ blocks of a connection are sequentially numbered. The ARQ block SN (sequence number) is included in MAC PDU using a FPEH. The original MAC SDU ordering shall be maintained.

16.2.13.1.2 Retransmission

When an ARQ block transmission fails in the initial transmission, a retransmission is scheduled with or without re-arrangement.

In case of ARQ block retransmission without rearrangement, the MAC PDU shall contain the same ARQ block and corresponding fragmentation and packing information, which was used in the initial transmission.

In case of ARQ block retransmission with rearrangement, a single ARQ block shall be fragmented into a sequence of multiple ARQ sub-blocks. The size of ARQ sub-block is defined by ARQ_SUB_BLOCK_SIZE (see 16.2.13.3.3), which is fixed in size. The last ARQ sub-block of the ARQ block may be smaller in size than ARQ_SUB_BLOCK_SIZE. ARQ sub-blocks are sequentially numbered using ARQ block SUB_SN (SSN). ARQ sub-block and SSN are is maintained during retransmission. When a MAC PDU payload is constrructed from one or more ARQ sub-blocks, it shall include FPEH(see 16.2.2.2.1) which includes SDU and ARQ information about the MAC PDU payload

Figure 431 illustrates ARQ block initial transmission and retransmissions; two options for retransmission are presented-with and without rearrangements of the failed ARQ block.

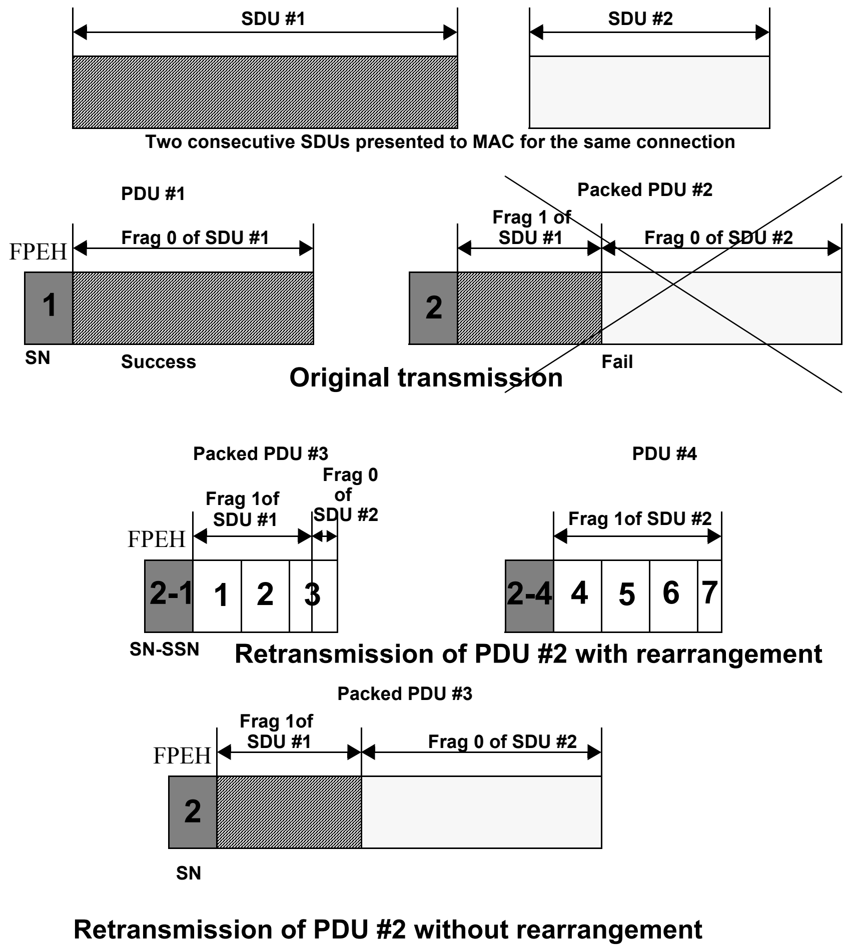


Figure 431—ARQ block initial transmission and retransmission

16.2.13.2 ARQ feedback

16.2.13.2.1 ARQ feedback IE

Table 760 defines the ARQ Feedback IE. It is used by the receiver to signal positive or negative acknowledgments for ARQ block and sub-blocks. ARQ feedback IEs in Table 760 may be transported either as a part of extended header ("piggybacked") within a MAC PDU or a standalone MAC control message.

Table 760—ARQ feedback IE format for ARQ block

Syntax	Size (bits)	Notes
ARQ_feedback_IE(LAST){	variable	
Last	1	0 = More ARQ Feedback IE in the list 1 = Last ARQ Feedback IE in the list
Flow ID	4	The ID of the flow being referenced
FLAG	1	0 = Cumulative ACK 1 = Selective ACK MAP existence
SN	10	FLAG = 0, ARQ block up to and including SN has been received successfully. FLAG = 1, ARQ block less than SN has been received successfully.
if(FLAG==1){		
NSI	1	NACK Suspended Indicator 0 = Bit marked '0' in the following Selective ACK MAP represents a ARQ block NACK 1 = Bit marked '0' in the following Selective ACK MAP represents that ARQ block NACK decision is suspended (i.e. ARQ_ERROR_DETECTION_TIMER is running for corresponding ARQ block).
EXT	1	Extension for ARQ sub-block indication 0= No ARQ sub-block ACK/NACK indication 1= ARQ sub-block ACK/NACK indication follows
Selective ACK MAP	5	Each bit represents ACK or NAK of corresponding ARQ block. '0' is NAK and '1' is ACK. First MSB of first Selective ACK MAP1 represents ACK or NAK information of SN. Contiguous bits after first MSB of first ACK MAP are corresponding to contiguous SN.
FLAG	1	0 = No more selective ACK MAP and FLAG 1 = Another set of selective ACK MAP and FLAG follows
while(FLAG==1){		
Selective ACK MAP	7	Each bit represents ACK or NAK of corresponding ARQ block. '0' is NAK and '1' is ACK. Selective ACK MAP represents ACK or NAK information of ARQ blocks after first selective ACK MAP.
FLAG	1	0 = No more selective ACK MAP and FLAG 1 = Another set of selective ACK MAP and FLAG follows
}		
if(EXT==1){		

Table 760—ARQ feedback IE format for ARQ block

Syntax	Size (bits)	Notes
SEM	variable	Sub-block-Existence Map The numbers of SEM bits are same as NACKed ARQ blocks in the Selective ACK MAP.Each bit represents the existence of partially nacked ARQ blocks or completely nacked ARQ blocks. 1 = Partially nacked ARQ block (the ARQ block has some sub-blocks which have received correctly) 0 = Completely nacked ARQ blocks(the ARQ block has no sub-blocks which have received correctly)
For(i=0;Num_SN;i++) {		Num_SN is the number of bits equal to 1 in the SEM field
do{		If NSI bit set to '0', all ARQ sub-blocks that are not listed the Start_SSN and Num_SSN in 'do loop' are considered as NACK. If NSI bit set to '1', All ARQ sub-blocks that are not listed the Start_SSN and Num_SSN in 'do loop' are considered that ARQ sub-block NACK decision is suspended.
START_SSN	11	Start of ARQ sub-block SN which was received correctly.
Num_SSN	11	Number of consecutive ARQ sub-blocks which were received correctly from START_SSN onwards
End	1	0 = One more set of START_SSN, NUM_SSN and End fields 1 = There are no more START_SSN, NUM_SSN and End fields
}while(End ==0)		
}		
Padding	variable	For Byte alignment
}		
}		
}		

16.2.13.2.2 ARQ feedback poll

Transmitter uses ARQ feedback poll to update the reception status of the transmitted ARQ blocks. The ARQ feedback poll is sent using a FPEH. When transmitter sends ARQ feedback poll, ARQ_Polling_Timeout is started. If there is no ARQ feedback from the recevier during ARQ_Polling_Timeout, the transmitter may retry the ARQ feedback poll. Transmitter shall perform ARQ feedback poll when ARQ buffer is full or the last ARQ block in the "not sent" state is sent.

In downlink, an ABS may assign unsolicited bandwidth using A-MAP for the AMS to send the cumulative ACK information as an ARQ feedback. When the unsolicited bandwidth is granted to AMS, AMS should send ARQ feedback. If the granted bandwidith is not enough for sending ARQ feedback IE for cumulative ACK information, MS should send BW request header instead of sending ARQ feedback.

16.2.13.2.3 ARQ feedback triggering conditions

The receiver shall send an ARQ feedback when at least one of the following conditions is met:

- An ARQ feedback poll is received from the transmitter.
- An ARQ block is declared as an error by the receiver.
- An ARQ Discard message is received from the transmitter.

16.2.13.3 ARQ parameters and timers

16.2.13.3.1 ARQ_SN_MODULUS

ARQ_SN_MODULUS is equal to the number of unique SN values, i.e., 2^(10).

16.2.13.3.2 ARQ_WINDOW_SIZE

ARQ_WINDOW_SIZE is defined in 6.3.4.3.2.

16.2.13.3.3 ARQ_SUB_BLOCK_SIZE

ARQ_SUB_BLOCK_SIZE is the ARQ sub-block length when an ARQ block is fragmented into a sequence of multiple ARQ sub-blocks prior to retransmission with rearrangement. The last ARQ sub-block of an ARQ block may be smaller in size than ARQ_SUB_BLOCK_SIZE.

16.2.13.3.4 4 ARQ_BLOCK_LIFETIME

ARQ_BLOCK_LIFETIME is defined in 6.3.4.3.3.

16.2.13.3.5 ARQ_RX_PURGE_TIMEOUT

ARQ_RX_PURGE_TIMEOUT is defined in 6.3.4.3.6

16.2.13.3.6 ARQ_MAX_ BUFFER_SIZE

The ARQ_MAX_BUFFER_SIZE is the maximum size of the buffer (in bytes) that the AMS is able to allocate for all ARQ connections. The AMS shall inform this parameter to the ABS during capability negotiation.

16.2.13.3.7 ARQ_SYNC_LOSS_TIMEOUT

ARQ_SYNC_LOSS_TIMEOUT is defined in <<<6.3.4.3.5>>>

16.2.13.3.8 ARQ_ERROR_DETECTION_TIMEOUT

An ARQ block may arrive due to out-of order due to HARQ retransmission. ARQ_ERROR_DETECTION_TIMEOUT is the time duration for which the receiver shall wait before declaring an ARQ block as being in error. For example if ARQ block SN #n arrives before #n-1, this timer starts for ARQ block SN # n-1 in the receiver. When the timer expires, the ARQ block SN #n-1 is declared as being in error in the receiver.

16.2.13.3.9 ARQ_FEEDBACK_POLL_RETRY_TIMEOUT

ARQ_FEEDBACK POLL_RETRY_TIMEOUT is the time duration for which transmitter shall wait an ARQ feedback from receiver after an ARQ feedback poll. When the timer expires, transmitter may retry ARQ feedback poll.

16.2.13.4 ARQ state machine variables

All ARQ state machine variables in the transmitter and receiver are set to zero when a connection setup or an ARQ reset occurs.

16.2.13.4.1 ARQ_TX_WINDOW_START

ARQ_TX_WINDOW_START is used in the transmitter ARQ state machine and represents the lower edge of the ARQ window in the transmitter in that all the ARQ blocks up to (ARQ_TX_WINDOW_START - 1) are regarded as positively acknowledged.

16.2.13.4.2 ARQ_TX_NEXT_SN

ARQ_TX_NEXT_SN is used in a transmitter ARQ state machine and corresponds to the lowest ARQ SN of the next ARQ block to be sent by the transmitter. ARQ_TX_NEXT_SN is a value in the interval ARQ_TX_WINDOW_START to (ARQ_TX_WINDOW_START + ARQ_WINDOW_SIZE).

16.2.13.4.3 ARQ_RX_WINDOW_START

It is used in a receiver ARQ state machine and represents the lower edge of ARQ window in the receiver in that all the ARQ blocks up to (ARQ_RX_WINDOW_START - 1) are regarded as correctly received.

16.2.13.4.4 ARQ_RX_HIGHEST_SN

It is used in a receiver ARQ state machine and corresponds to the highest ARQ SN of ARQ block received, plus one. ARQ_RX_HIGHEST_SN is a value in the interval ARQ_RX_WINDOW_START to (ARQ_RX_WINDOW_START + ARQ_WINDOW_SIZE).

16.2.13.5 ARQ operation

16.2.13.5.1 Sequence number comparison

The ARQ SN comparison procedure is the same as defined in section <<<6.3.4.6.1>>>.

16.2.13.5.2 Transmitter operation

16.2.13.5.2.1 Transmitter state machine

Each ARQ enabled connection shall have an independent ARQ state machine. The ARQ state transitions shall be ARQ block based.(i.e., not based on the ARQ sub-block).

An ARQ block may be in one of the following five states-not-sent, outstanding, waiting-for-retransmission, discard, and done state.

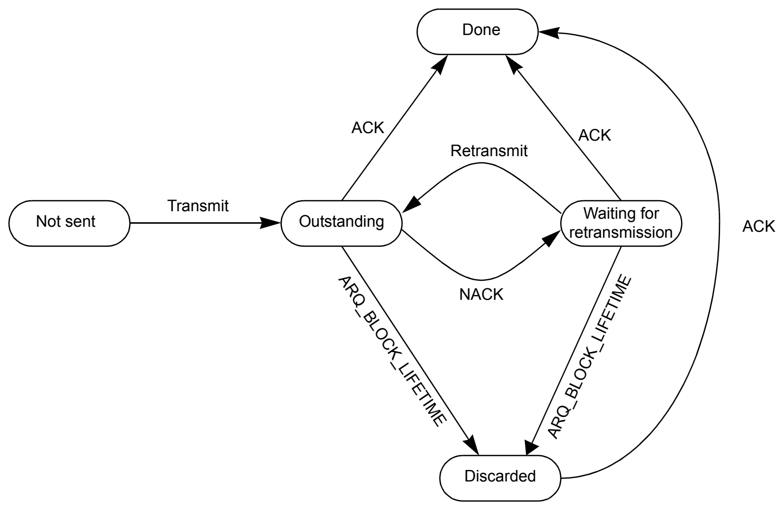


Figure 432—ARQ Tx block states

Any ARQ block in the buffer begins from "not-sent" state before being transmitted. ARQ block formation continues with a connection's "not-sent" MAC SDUs. The transmitter builds each ARQ block using the rules for fragmentation and packing. As each "not-sent" ARQ block is formed and constructs a MAC PDU, ARQ block is assigned the current value of ARQ_TX_NEXT_SN, which is then incremented by one.

When an ARQ block is initially transmitted, the ARQ_BLOCK_LIFETIME timer is started for this ARQ block and the ARQ block state transits from "not-sent" state to "outstanding" state.

While an ARQ block is in "outstanding" state, the transmitter waits for an acknowledgement. If a positive acknowledgement (ACK) arrives, the ARQ block state transits to the "done" state. If ARQ block is negatively acknowledged (NACK or Local NACK), the ARQ block state transits to "waiting-for-retransmission" state. If the ARQ_BLOCK_LIFETIME period expires, the ARQ block state transits to "discard" state.

While an ARQ block is in "waiting-for-retransmission" state, transmitter prepares for ARQ block retransmission. If ARQ block is re-transmitted, the ARQ block state transits to "outstanding". If a positive acknowledgement (ACK) arrives, the ARQ block state transits to the "done" state. If the ARQ_BLOCK_LIFETIME period expires, the ARQ block state transits to "discard" state.

While ARQ block is in "discard" state, the transmitter sends Discard message (see 16.2.3.43) and waits for the acknowledgement from the receiver. If a positive acknowledgement (ACK) of the ARQ block corresponding to the Discard message arrives, the ARQ block state transits to "done" state.

When ARQ block is in "done" state, the transmitter shall flush the ARQ block and remove the timers and state variables associated with the flushed ARQ block.

For a given connection the transmitter shall first handle (transmit or discard) blocks in "waiting-for-retransmission" state and only then blocks in "non-sent" state. Blocks in "outstanding" or "discarded" state shall not be transmitted. When blocks are retransmitted, the block with the lowest BSN shall be retransmitted first.

16.2.13.5.2.2 ARQ feedback processing

In response to the transmitted ARQ block, the transmitter receives ARQ feedback IE sent by the receiver. The ARQ feedback IE may include either a positive (ACK) or a negative acknowledgement (NACK). Optionally, when ARQ and HARQ interaction (see <<15.2.14.5>>) is enabled, the ARQ feedback may also be received in the form of a local NACK, which is a negative acknowledgement that is generated locally at the transmitter. When local NACK occurrs in a certain ARQ block, ARQ NACK of the corresponding ARQ block should be ignored until HARQ transmission is finished.

When transmitter receives an ARQ feedback IE, the transmitter shall check the validity of the SN of the ARQ blocks being acknowledged. If the ARQ SN is in the interval ARQ_TX_WINDOW_START to ARQ_TX_NEXT_SN - 1 (inclusive) then the ARQ SN is valid; otherwise it is invalid and shall be ignored by transmitter.

If the SN is valid and the ARQ feedback IE includes Cumulative ACK, the transmitter shall consider all the ARQ blocks in the interval ARQ_TX_WINDOW_START to SN (Inclusive) as positively acknowledged, and set the ARQ_TX_WINDOW_START to SN+1.

If the SN is valid and the ARQ feedback IE includes a selective ACK MAP, it shall consider all ARQ blocks in the interval ARQ_TX_WINDOW_START to SN (not inclusive) as positively acknowledged, and set the ARQ_TX_WINDOW_START to SN. The selective ACK MAP is processed from left to right (MSB to LSB) and the left most bit indicates SN. Each bit in the selective ACK MAP that is set to '1'indicates that the corresponding ARQ block has been received correctly. Each bit that is set to "0" in the selective ACK MAP indicates that the corresponding ARQ block has been received incorrectly. If 'NSI' is set to '1', all bits set to "0" in the selective ACK MAP, transmitter ignore all bits set to "0" in the selective ACK MAP and transmitter only considers bits set to "1" in the selective ACK MAP. If ARQ feedback IE includes selective ACK MAP and "EXT" field set to 1, the transmitter shall process ARQ feedback information of ARQ sub-blocks. "Num_SSN" represents the number of ARQ sub-blocks which has been received correctly from "START_SSN" onwards. If 'NSI' is set to '1', transmitter only considers correctly received ARQ sub-blocks.

16.2.13.5.3 Receiver operation

16.2.13.5.3.1 Receiver state machine

ARQ state machine procedure in a receiver is defined in Figure 52 (6.3.4.6.3). In the figure, BSN equal to SN.

When a MAC PDU is received, receiver checks a FPEH and obtains all ARQ block information for ARQ operation. After receiver knows ARQ SN and corresponding ARQ block in the MAC PDU, state machine adds SN to list of SN to be acknowledged. State machine checks whether the SN which falls in the ARQ window range (ARQ_RX_WINDOW_START + ARQ_WINDOW_SIZE). If ARQ SN is not valid, receiver discards the corresponding ARQ block.

If ARQ SN is valid, but the corresponding ARQ block is already received, state machine resets ARQ_RX_PURGE_TIMEMOUT and discards the ARQ block. If an ARQ block is received and it is valid and not duplicated, receiver state machine begin to update ARQ state.

The procedure of ARQ state update is as follows. If SN is equal or larger than ARQ_RX_HIGHEST_SN, receiver updates ARQ_RX_HIGHEST_SN as SN+1. If SN is less than ARQ_RX_HIGHEST_SN and more than ARQ_RX_WINDOW_START, receiver state variables are not changed. If SN is not equal to ARQ_RX_WINDOW_START, ARQ_RX_PURGE_TIMEOUT for this SN shall be (re)set. If SN is less than ARQ_RX_HIGHEST_SN and equal to ARQ_RX_WINDOW_START, ARQ_RX_WINDOW_START is advanced to the next lowest numbered ARQ block that has not been received. The ARQ_SYNC_LOSS_TIMEOUT shall be (re)set. After finishing ARQ state update, ARQ block is stored in the receiver buffer.

16.2.13.5.3.2 Error detection and ARQ feedback generation

When an ARQ block arrives out of sequence, then each ARQ block with an intermediate SN is declared as missing and the ARQ_ERROR_DETECTION_ TIMEOUT for every missing ARQ block is started. If the missed block does not arrive within ARQ_ERROR_DETECTION_TIMEOUT, the receiver declares the corresponding ARQ block as an error.

The receiver shall send ARQ feedback corresponding to each ARQ block using the ARQ feedback IE (see 16.2.13.2.1). ARQ feedback is sent when 1) an ARQ feedback poll is received from the transmitter or 2) when receiver detects an ARQ block error or 3) when discard message is received from the transmitter.

If all the ARQ blocks in the ARQ window have been received correctly, the ARQ feedback IE should contain a cumulative ACK. If one or more ARQ blocks in the ARQ window have an error, the ARQ feedback IE should contain a selective ACK MAP for indicating the error.

16.2.13.5.3.3 ARQ discard message reception

When a discard message is received from the transmitter with a valid ARQ SN, the receiver shall discard the ARQ blocks specified by valid ARQ SN and advance ARQ_RX_WINDOW_START to the SN of the first block not yet received after the SN provided in the Discard message, and mark all not received blocks in the interval from the previous to new ARQ_RX_WINDOW_START values as received for ARQ Feedback IE reporting.

16.2.13.5.3.4 ARQ block purge procedure

When a block does not result in an advance of the ARQ_RX_WINDOW_START, the ARQ_RX_PURGE_TIMEOUT for that block shall be started. When the value of the timer for a block exceeds ARQ_RX_PURGE_TIMEOUT, the timeout condition is marked. When the timeout condition is marked, ARQ_RX_WINDOW_START is advanced to the SN of the next block not yet received after the marked block. Timers for delivered blocks remain active and are monitored for timeout until the SN values are outside the receiver ARQ window.

When ARQ_RX_WINDOW_START is advanced, any SN values corresponding to blocks that have not yet-been received residing in the interval between the previous and current ARQ_RX_WINDOW_START value shall be marked as received and the receiver shall send an ARQ Feedback IE to the transmitter with the updated information. Any blocks belonging to complete SDUs shall be delivered. Blocks from partial SDUs shall be discarded.

16.2.13.5.3.5 SDU reconstruction and in-order delivery

MAC SDU at the receiver is reconstructed from the received ARQ blocks. MAC SDUs shall be delivered to the upper layers in-order. Only completely reconstructed MAC SDU shall be delivered to the upper layers.

Whenever a complete SDU is reconstructed from the ARQ blocks, the receiver shall check if there are any incomplete SDUs in front of the newly reconstructed SDU in the order of the components ARQ block SNs. If so, the receiver does not deliver the complete SDU until the incomplete SDUs are recovered or explicitly skipped.

16.2.13.5.4 ARQ Reset procedure

The ARQ reset procedures defined in figures 50 and 51(see 6.3.4.6.2) shall be supported by both the ARQ receiver and ARQ transmitter. Each side (receiver or transmitter) may initiate an ARQ reset procedure when ARQ Synchronization loss (see <<15.3.8.7.5>>) happens or for any other implementation specific reason. When ARQ reset error happens during the ARQ reset procedure, the ABS or AMS may reinitialize its MAC.

16.2.13.5.5 ARQ Synchronization loss

Synchronization of the ARQ state machines is governed by ARQ_SYNC_LOSS_TIMEOUT timer managed by the transmitter and receiver state machines. Each time ARQ_TX_WINDOW_START is updated in the transmitter or ARQ_RX_WINDOW_START is updated in the receiver, the ARQ_SYNC_LOSS_TIMEOUT timer is set to zero. When the ARQ_SYNC_LOSS_TIMEOUT timer expires at the transmitter or receiver, the transmitter or receiver declares ARQ synchronization loss.

16.2.13.5.6 ARQ buffer management

When transmitting a new ARQ block, the ABS should ensure that the size of the new ARQ block does not exceed ARQ_MAX_BUFFER_SIZE – ARQ_BUFFER_USED. ARQ_BUFFER_USED is defined as the sum of ARQ_BUFFER_USED_PER_FLOW for all the ARQ enabled flows for the AMS. ARQ_BUFFER_USED_PER_FLOW is calculated as the occupied buffer size of ARQ transmitter window (ARQ_TX_WINDOW_START to ARQ_TX_NEXT_SN-1(inclusive)).

If the ARQ blocks, with SN smaller than ARQ_TX_WINDOW_START, are part of same SDU as the first ARQ block in the ARQ transmitter window, then those ARQ blocks shall be included in the calculation of ARQ_BUFFER_USED_PER_FLOW.

16.2.14 HARQ Functions

HARQ shall be used for unicast data traffic in both downlink and uplink. The HARQ shall be based on a stop-and-wait protocol. ABS and AMS shall be capable of maintaining multiple HARQ channels. DL HARQ channels are identified by downlink HARQ channel identifier (ACID). UL HARQ channels are identified by uplink HARQ channel identifier (ACID).

16.2.14.1 HARQ subpacket generation and transmission

Generating the HARQ subpackets shall follow 16.3.11 Channel coding and HARQ . The received subpackets shall be combined by the FEC decoder as part of the decoding process.

Incremental redundancy (IR) is mandatory, with Chase combining as a special case of IR. For IR, each subpacket contains the part of codeword determined by a subpacket identifier (SPID).

The rule of subpacket transmission is as follows:

For downlink,

a) At the first transmission, ABS shall send the subpacket labeled 0b00.

b) ABS may send one among subpackets labeled 0b00, 0b01, 0b10 and 0b11 in any order.

For uplink,

a) At the first transmission, AMS shall send the subpacket labeled 0b00.

b) AMS shall send one among subpackets labeled 0b00, 0b01, 0b10 and 0b11 in sequential order.

In order to specify the start of a new transmission, one-bit HARQ identifier sequence number (AI_SN) is toggled on every new HARQ transmission attempt on the same ACID. If the AI_SN changes, the receiver treats the corresponding HARQ attempt as belonging to a new encoder packet and discards previous HARQ attempt with the same ACID.

16.2.14.2 Generic HARQ signaling and timing

16.2.14.2.1 HARQ Signaling

16.2.14.2.1.1 Downlink

Upon receiving a DL Basic Assignment A-MAP IE, AMS attempts to receive and decode the data burst as allocated to it by the DL Basic Assignment A-MAP IE . If the decoding is successful, AMS shall send a positive acknowledgement to ABS; otherwise, AMS shall send a negative acknowledgement to ABS.

The process of retransmissions shall be controlled by ABS using the ACID and AI_SN fields in the DL Basic Assignment A-MAP IE. If the AI_SN field for the ACID remains same between two HARQ bursts allocation, it indicates retransmission. Through the DL Basic Assignment A-MAP IE for retransmission, ABS may allocate different resource allocation and transmission format. If AI_SN field for the ACID is toggled, i.e., from 0 to 1 or vice versa, it indicates the transmission of a new HARQ burst, and the retransmission process for the previous HARQ burst with the same ACID is terminated if the retransmission process is in progress.

For an AMS operating over carriers with a sum of FFT sizes that is 2048 subcarriers or less, in DL, the maximum number of total HARQ channels per AMS is 16. For an AMS operating over carriers with the sum of FFT sizes that is larger than 2048 subcarriers, in DL, the maximum number of total HARQ channels per AMS is floor(16 * sum of FFT sizes of all used carriers /2048). The delay between two consecutive HARQ transmissions of the same data burst shall not exceed the maximum T_ReTx_Interval. The number of retransmissions of the same data burst shall not exceed the maximum DL_N_MAX_ReTx. The values for DL_N_MAX_ReTx are 4 or 8. The default value is 4. The ABS may configure a maximum number of DL HARQ retransmission via S-SFH SP1 IE.

The timing for transmitting DL Basic Assignment A-MAP IE, DL HARQ subpacket, and HARQ feedback in UL are described in 16.2.14.2.2.

16.2.14.2.1.2 Uplink

Upon receiving a UL Basic Assignment A-MAP IE, AMS shall transmit the subpacket of HARQ data burst through the resource assigned by the UL Basic Assignment A-MAP IE.

ABS shall attempt to decode the data burst. If the decoding is successful, ABS shall send a positive acknowledgement to AMS; otherwise, ABS shall send a negative acknowledgement to AMS.

Upon receiving the negative acknowledgement, AMS shall trigger retransmission procedure.

In the retransmission procedure, if AMS does not receive a UL Basic Assignment A-MAP IE for the HARQ data burst in failure, AMS shall transmits the next subpacket through the resources assigned to the latest subpacket transmission with the same ACID as specified in Table 751 for FDD and Table 753 for TDD, respectively. A UL Basic Assignment A-MAP IE may be sent to signal control information for retransmission with the corresponding ACID and AI_SN being not toggled. Upon receiving the UL Basic Assignment A-MAP IE, AMS shall perform the HARQ retransmission as instructed in this UL Basic Assignment A-MAP IE. As an example, ABS may change the resource index of the HARQ data burst or may command to skip retransmission in the corresponding AAI subframe. If AI_SN field for the ACID is toggled, i.e., from 0 to 1 or vice versa, it indicates the transmission of a new HARQ burst, and the retransmission process for the previous HARQ burst with the same ACID is terminated if the retransmission process is in progress.

For an AMS operating over carriers with sum of FFT sizes that is 2048 sub-carriers or less, in UL, the maximum number of total HARQ channels per AMS is 16. For an AMS operating over carriers with sum of

FFT sizes that is larger than 2048 sub-carriers, in UL, the maximum number of total HARQ channels per AMS is floor(16 * sum of FFT sizes of all used carrier /2048). The number of retransmissions of the same data burst shall not exceed the maximum UL_N_MAX_ReTx. The values for UL_N_MAX_ReTx are 4 or 8. The default value is 4. The ABS may configure a maximum number of UL HARQ retransmission via S-SFH SP1 IE.

The timing for transmitting UL Basic Assignment A-MAP IE, UL HARQ subpacket, and HARQ feedback in DL are described in 16.2.14.2.2.

16.2.14.2.1.3 DL HARQ buffering capability

The AMS shall report its buffering capability by stating the steady amount of information bits in 4800 byte units it can receive while providing the aimed combining gain in the following benchmark scenario:

- The reception errors of each FEC block transmitted are identical and independent (e.g., each of the AMS antennas is connected through an attenuator to 1 of the ABS antennas)
- Frame is entirely DL with 8 subframes.
- A number of HARQ channels (or, 8 ACIDs) are evenly distributed over a frame (that is, one ACID per each subframe) each with the same amount of information bits carried over and the same HARQ channels (ACIDs) are allocated over frames.
- Each burst is always transmitted with the same constellation (or, modulation order) and over the same amount of LRUs.
- Burst error rate of the first HARQ transmission can be up to 50%.
- The SPID increases by 1 circularly every retransmission.
- DL HARQ retransmission time delay of 5msec

Where the aimed combining gain is:

- The error rate of second transmission is not higher than 5%

"Buffer overflow" is defined as a condition of no available buffer for storing soft bits of a failed burst. Upon buffer overflow the AMS should indicate to the ABS the overflow condition with EDI (Event Driven Indication) as defined in paragraph 16.3.9.3.1. The EDI shall be transmitted at the first fast feedback opportunity the AMS is allocated following the AMS DL processing time from the overflow condition. Even upon buffer overflow event, the AMS shall attempt to receive DL HARQ bursts allocated to itself and to transmit the appropriate HARQ feedback to the ABS.

Upon reception of overflow EDI from the AMS, the ABS may consider as a worst case assumption that all soft bits of bursts that the AMS failed to receive, in their last transmission, are not buffered at the AMS. Consequently, to make sure that the systematic bits are used for decoding by the AMS, the ABS may retransmit with SPID=0 for the failed bursts that were transmitted only 1 time.

The ABS may consider the overflow indications from the AMS when selecting the amount of information bits, the SPID or the MCS of the bursts transmitted to that AMS. Clearly, the ABS may also consider the HARQ feedbacks from the AMS for different retransmissions when selecting the amount of information bits, the SPID or the MCS of the bursts transmitted to it.

16.2.14.2.1.4 UL HARQ buffering capability

The AMS shall report the amount of information bits in 4800 bytes units it can buffer in the UL. The ABS shall not exceed this buffer.

16.2.14.2.2 A-MAP relevance and HARQ timing

Transmissions of Assignment A-MAP IE, the HARQ subpacket, and the corresponding feedback shall be in accordance to a pre-defined timing. In UL, retransmission of the HARQ subpacket shall also follow a pre-defined timing.

Each transmission time is represented by frame index and AAI subframe index. The frame index shall range from 0 to 3. In FDD, the index of DL or UL AAI subframe shall range from 0 to *F*-1, where *F* is the number of AAI subframes per frame. In TDD, the index of DL AAI subframe shall range from 0 to *D*-1, where *D* is the number of DL AAI subframes per frame, and the index of UL AAI subframe shall range from 0 to *U*-1, where *U* is the number of UL AAI subframes per frame.

To determine A-MAP relevance and HARQ timing, DL HARQ feedback offset z, UL HARQ Tx offset v and UL HARQ feedback offset w shall be set. In DL HARQ transmission, the DL Rx processing time $T_{\text{DL\_Rx\_Processing}}$ at AMS shall be considered for the DL HARQ feedback offset(z). In UL HARQ transmission, UL Tx processing time $T_{\text{UL\_Tx\_Processing}}$ at AMS and the UL Rx processing time $T_{\text{UL\_Rx\_Processing}}$ at ABS are considered for the UL HARQ Tx offset(v) and the UL HARQ feedback offset(w), respectively.

For F= 8 in FDD or D + U = 8 in TDD, both $T_{\text{DL\_Rx\_Processing}}$ and $T_{\text{UL\_Tx\_Processing}}$ at AMS are 3 AAI subframes. The $T_{\text{UL\_Rx\_Processing}}$ at ABS is 3 or 4 AAI subframes broadcast via S-SFH SP1 IE.

16.2.14.2.2.1 FDD

16.2.14.2.2.1.1 Downlink

In DL HARQ transmission, DL Basic Assignment A-MAP IE, the HARQ subpacket, and the corresponding feedback shall follow the timing defined in Table 761.

Table 761—FDD DL HARQ timing

Content	AAI Subframe Index	Frame Index
Assignment A-MAP IE Tx in DL	l	i
HARQ Subpacket Tx in DL	$m = l$	i
HARQ feedback in UL	$n = ceil(m + F/2) mod F$	$j = \left(i + floor\left(\frac{ceil(m + F/2)}{F}\right) + z\right) mod 4$

DL HARQ subpacket transmission corresponding to a DL Basic Assignment A-MAP IE in *l*-th DL AAI subframe of the *i*-th frame shall begin in the *m*-th DL AAI subframe of the *i*-th frame. A HARQ feedback for the DL HARQ subpacket shall be transmitted in the *n*-th UL AAI subframe of the *j*-th frame. The AAI subframe index *m, n* and frame index *j* shall be determined by using *l* and *i*, as shown in Table 761—. Note that the AAI subframe index *l* shall range from 0 to $F - 1$.

DL HARQ feedback offset *z* shall be set to 1 only if a time gap from completion of the HARQ subpacket transmission to its feedback time derived with *z* = 0 is shorter than $T_{\text{DL\_Rx\_Processing}}$. Otherwise, *z* shall be set to 0. This rule shall be also applied to the long TTI transmission:

$$z = \begin{cases} 0, & \text{if}((ceil(F/2) - N_{TTI}) \geq T_{\text{DL\_Rx\_Processing}}) \\ 1, & \text{else} \end{cases}$$

where N_{TTI} is the number of AAI subframes which a HARQ subpacket spans; i.e., 1 for the default TTI and 4 for the long TTI in FDD. The index *m* in Table 761 indicates the first AAI subframe which a long TTI subpacket spans.

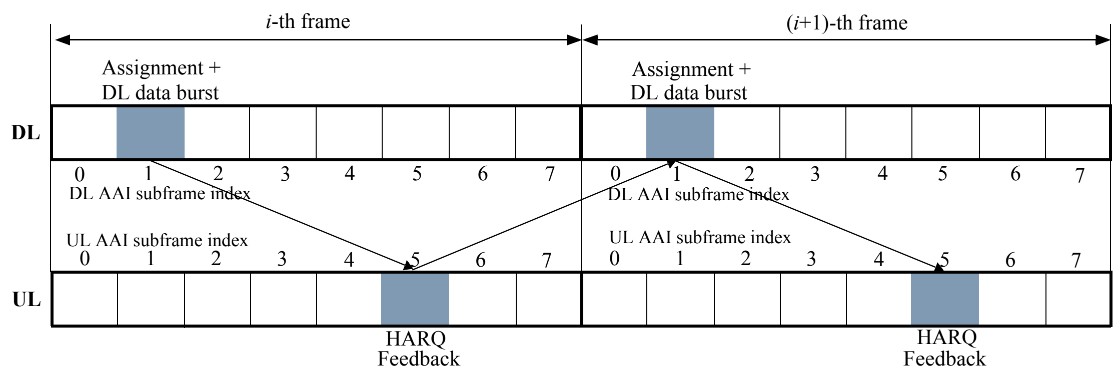


Figure 433—Example of FDD DL HARQ timing for 5, 10 and 20 MHz channel bandwidths

Figure 433 shows an example of the timing relationship between a DL Basic Assignment A-MAP IE, a DL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in FDD frame structure, for 5, 10 and 20 MHz channel bandwidths. In this example, $T_{\text{DL\_Rx\_Processing}}$ is 3 AAI subframes.

16.2.14.2.2.1.2 Uplink

In UL HARQ transmission, UL Basic Assignment A-MAP IE, the HARQ subpacket, the corresponding feedback, and retransmission of the HARQ subpacket shall follow the timing defined in Table 762.

Table 762—FDD UL HARQ timing

Content	AAI Subframe Index	Frame Index
Assignment A-MAP Tx IE in DL	l	i
HARQ Subpacket Tx in UL	$m = n$ where $n = ceil(l + F/2) mod F$	$j = \left(i + floor\left(\frac{ceil(l + F/2)}{F}\right) + v\right) mod 4$
HARQ feedback in DL	l	$k = \left(j + floor\left(\frac{(m + F/2)}{F}\right) + w\right) mod 4$
HARQ Subpacket ReTx in UL	m	$p = \left(k + floor\left(\frac{ceil(l + F/2)}{F}\right) + v\right) mod 4$

UL HARQ subpacket transmission corresponding to a UL Basic Assignment A-MAP IE in *l*-th DL AAI subframe of the *i*-th frame shall begin in the *m*-th UL AAI subframe of the *j*-th frame. A HARQ feedback for the UL HARQ subpacket shall be transmitted in the *l*-th DL AAI subframe of the *k*-th frame. When the UL HARQ feedback indicates a negative-acknowledgement, retransmission of the UL HARQ subpacket shall begin in the *m*-th UL AAI subframe of the *p*-th frame. The AAI subframe index *m, n* and frame index *j, k, p* shall be determined by using *l* and *i*, as shown in Table 762. Note that the AAI subframe index *l* shall range from 0 to $F-1$.

UL HARQ transmission offset *v* shall be set to 1 only if a time gap from completion of the UL Basic Assignment A-MAP IE transmission to the HARQ subpacket transmission time derived with *v* = 0 is shorter than $T_{\text{UL\_Tx\_Processing}}$. Otherwise, *v* shall be set to 0:

$$v = \begin{cases} 0, & \text{if}((ceil(F/2)-1) \geq T_{\text{UL\_Tx\_Processing}}) \\ 1, & \text{else} \end{cases}$$

UL HARQ feedback offset *w* shall be set to 1 only if a time gap from completion of the HARQ subpacket transmission to its feedback time derived with *w* = 0 is shorter than $T_{\text{UL\_Rx\_Processing}}$. Otherwise, *w* shall be set to 0. This rule shall be also applied to the long TTI transmission:

$$, = \begin{cases} 0, & \text{if}((floor(F/2)-N_{TTI}) \geq T_{\text{UL\_Rx\_Processing}}) \\ 1, & \text{else} \end{cases}$$

where N_{TTI} is the number of AAI subframes which a HARQ subpacket spans; i.e., 1 for the default TTI and 4 for the long TTI in FDD. The index *m* in Table 762 indicates the first AAI subframe which a long TTI subpacket spans.

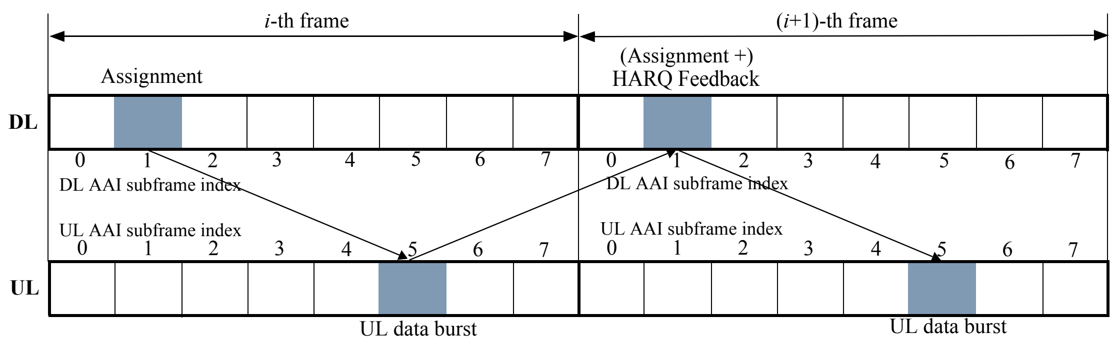


Figure 434—Example of FDD UL HARQ timing for 5, 10 and 20 MHz channel bandwidths

Figure 434 shows an example of the timing relationship between a UL Basic Assignment A-MAP IE, a UL HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission in FDD frame structure, for 5, 10 and 20 MHz channel bandwidths. In this example, $T_{\text{UL\_Tx\_Processing}}$ and $T_{\text{UL\_Rx\_Processing}}$ are 3 AAI subframes.

16.2.14.2.2.2 TDD

16.2.14.2.2.2.1 Downlink

DL HARQ subpacket transmission corresponding to a DL Basic Assignment A-MAP IE in *l*-th DL subframe of the *i*-th frame shall begin in the *m*-th DL subframe of the *i*-th frame. A HARQ feedback for the DL HARQ subpacket shall be transmitted in the *n*-th UL subframe of the *j*-th frame. The subframe index *m*, *n* and frame index *j* shall be determined by using *l* and *i*, as shown in Table 763—.

Table 763—TDD DL HARQ timing

Content	AAI Subframe Index	Frame Index
Assignment A-MAP IE Tx in DL	l	i
HARQ Subpacket Tx in DL	$m = l$	i
HARQ feedback in UL	For $D > U$ $n = \begin{cases} 0, \text{ for } 0 \le m < K \\ m - K, \text{ for } K \le m < U + K \\ U - 1, \text{ for } U + K \le m < D \end{cases}$ where $K = floor((D-U)/2)$	$j = (i+z) mod\ 4$ where $z = \begin{cases} 0, if(D - m - N_{TTI} + n) \ge T_{\text{DL\_Rx\_Processing}} \\ 1, \text{ else} \end{cases}$
	For $D \le U$ $n = m - K$ where $K = -ceil((U-D)/2)$	

Where:

D - is the number of downlink subframes as defined by the frame configuration table

U - is the number of uplink subframes as defined by the frame configuration table

l - is the reference to the DL subframe, starting from 0 for the first downlink subframe and numbering up to D-1, where the A-MAP is transmitted

m - is the reference to the DL subframe, starting from 0 for the first downlink subframe and numbering up to D-1, where HARQ subpacket begins its transmission

n - is the reference for the UL subframe, starting from 0 for the first uplink subframe and numbering up to U-1, where the HARQ acknowledgement is sent

N_{TTI} is the number of AAI subframes which a HARQ subpacket spans; i.e., 1 for the default TTI and D for long TTI in TDD DL

$T_{\text{DL\_Rx\_Processing}}$ -is the data burst processing time required by the mobile and measured in sub-frames

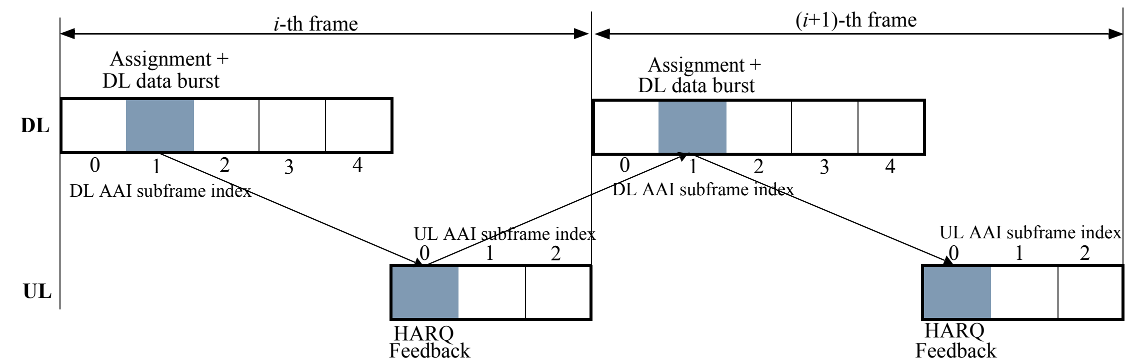


Figure 435—Example of TDD DL HARQ timing for 5, 10 and 20 MHz channel bandwidths

Figure 435 shows an example of the timing relationship between a DL Basic Assignment A-MAP IE, a DL HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission in TDD frame structure, for 5, 10 and 20 MHz channel bandwidths. In this example, $T_{DL\_Rx\_Processing}$ is 3 AAI subframes.

16.2.14.2.2.2.2 Uplink

In UL HARQ transmission, UL Basic Assignment A-MAP IE, the HARQ subpacket, the corresponding feedback, and retransmission of the HARQ subpacket shall follow the timing defined in Table 764—.

Table 764—TDD UL HARQ timing

Content	AAI Subframe Index	Frame Index
Assignment A-MAP IE Tx in DL	l	i
HARQ Subpacket Tx in UL	For $D \geq U$ $$m = \begin{cases} 0, & \text{for } 0 \leq l < K \\ l-K, & \text{for } K \leq l < U+K \\ U-1, & \text{for } U+K \leq l < D \end{cases}$$	$j = (i+v) mod\ 4$
	For $1 < D < U$ $$m = \begin{cases} 0,\ldots, \text{ or } l-K, & \text{for } l = 0 \\ l-K, & \text{for } 0 < l < D-1 \\ l-K, \ldots, \text{or} U-1, & \text{for } l = D-1 \end{cases}$$	
	For $D = 1$ $$m = 0,\ldots, \text{ or } U-1 \text{ for } l = 0$$	
HARQ feedback in DL	l	$k = (j+1+w) mod\ 4$

Table 764—TDD UL HARQ timing

Content	AAI Subframe Index	Frame Index
HARQ Subpacket ReTx in UL	m	$p = (k+v) mod\ 4$

UL HARQ subpacket transmission corresponding to a UL Basic Assignment A-MAP IE in *l*-th DL AAI subframe of the *i*-th frame shall begin in the *m*-th UL AAI subframe of the *j*-th frame. A HARQ feedback time for the HARQ subpacket shall be transmitted in the *l*-th DL AAI subframe of the *k*-th frame. When the UL HARQ feedback indicates a negative acknowledgement, retransmission of the UL HARQ subpacket shall begin in the *m*-th UL AAI subframe of the *p*-th frame. The AAI subframe index *m*, *n* and frame index *j*, *k*, *p* shall be calculated as shown in Table 764—. In the table, if *D* is less than *U*, $K = -ceil((U-D)/2)$. Otherwise, $K = floor((D-U)/2)$. Note that the AAI subframe index *l* shall range from 0 to $D-1$.

When a UL Basic Assignment A-MAP IE in the *l*-th DL AAI subframe of the *i*-th frame indicates the long TTI transmission, the UL HARQ subpacket transmission shall begin in the 0-th UL AAI subframe of the *j*-th frame. A HARQ feedback for this long TTI transmission shall be transmitted in the *l*-th DL AAI subframe of the *k*-th frame. When the UL HARQ feedback indicates a negative acknowledgement, retransmission of the UL HARQ subpacket shall begin in the 0-th UL AAI subframe of the *p*-th frame. The frame index *j*, *k*, *p* shall be calculated according to equation in Table 764, with replacing the AAI subframe index *m* by 0.

UL HARQ transmission offset *v* shall be set to 1 only if a time gap from completion of the UL Assignment A-MAP IE transmission to the HARQ subpacket transmission time derived with *v* = 0 is shorter than $T_{\mathrm{UL\_Tx\_Processing}}$. Otherwise, *v* shall be set to 0:

$$v = \begin{cases} 0, & \text{if}(D - l - 1 + m) \ge T_{\mathrm{UL\_Tx\_Processing}} \\ 1, & \text{else} \end{cases}$$

UL HARQ feedback offset *w* shall be set to 1 only if a time gap from completion of the HARQ subpacket transmission to its feedback time derived with *w* = 0 is shorter than $T_{\mathrm{UL\_Rx\_Processing}}$. Otherwise, *w* shall be set to 0. This rule shall be also applied to the long TTI transmission:

$$w = \begin{cases} 0, & \text{if}(U - m - N_{TTI} + l) \ge T_{\mathrm{UL\_Rx\_Processing}} \\ 1, & \text{else} \end{cases}$$

where N_{TTI} is the number of AAI subframes which a HARQ subpacket spans; i.e., 1 for the default TTI and *U* for the long TTI in TDD UL. The index *m* in Table 764— indicates the first AAI subframe which a long TTI subpacket spans.

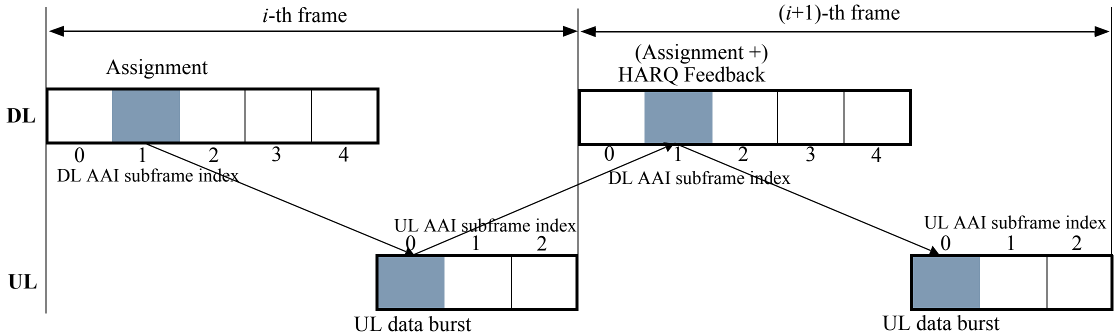


Figure 436—Example of TDD UL HARQ timing for 5, 10 and 20 MHz channel bandwidths

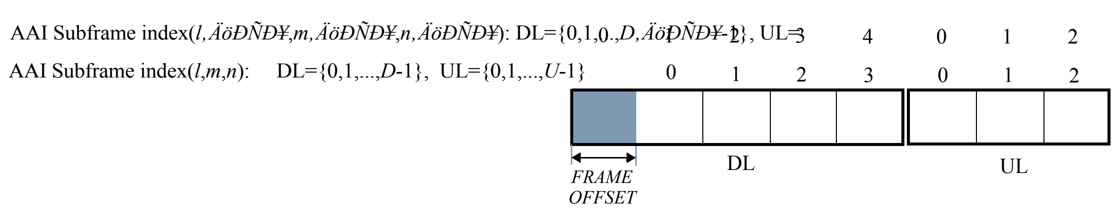
Figure 436 shows an example of the timing reclationship between a UL Basic Assignment A-MAP IE, a UL HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission in TDD frame structure, for 5, 10 and 20 MHz channel bandwidths. In this example, $T_{\text{UL\_Tx\_Processing}}$ and $T_{\text{UL\_Rx\_Processing}}$ are 3 AAI subframes.

16.2.14.2.2.2.3 HARQ Timing in frame structure supporting the WirelessMAN-OFDMA frames

The A-MAP relevance and HARQ timing defined in 16.2.14.2.2.2 shall be applied to the frame structure supporting the WirelessMAN-OFDMA TDD frames in <<15.3.3.4.1>>.

AAI subframes in the frame supporting the WirelessMAN-OFDMA TDD frames shall be indexed as follows: the DL AAI subframe index shall range from 0 to *D*-1, where D is the number of DL AAI subframes dedicated to the Advanced Air Interface operation in frame. The UL AAI subframe index shall range from 0 to *U*-1, where *U* is the number of UL AAI subframes dedicated to the Advanced Air Interface operation in frame.

Figure 437 shows an example of AAI subframe indexing for 5, 10 and 20 MHz channel bandwidths. In this example, the ratio of whole DL AAI subframes to whole UL AAI subframes, *D*' : *U*' is 5 : 3. FRAME_OFFSET is 1, and UL AAI subframes of the WirelessMAN-OFDMA and the Advanced Air Interface are frequency-division multiplexed. Then, the ratio of DL to UL AAI subframes for the Advanced Air Interface, *D* : *U* is 4 : 3. The AAI subframe index, *l*, *m*, and *n* are the renumbered index of *l*', *m*', and *n*', respectively.



Example showing a frame structure supporting the WirelessMAN-OFDMA frame

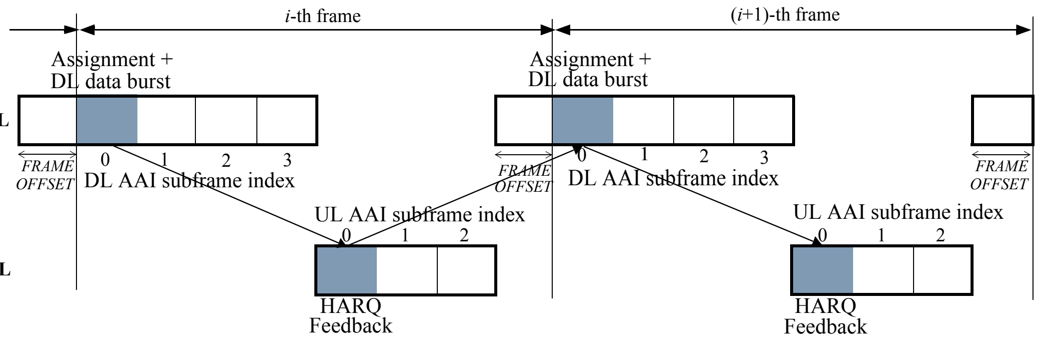
Figure 437— Example of AAI subframe indexing

The same equations and rule in Table 763— and Table 764— shall be applied for deciding HARQ timing with l, m, n, D, and U, except that l', m', n', D', and U' shall be used to set z, v, and w, as follows:

$$z = \begin{cases} 0, & \text{if } ((D' - m' - N_{TTI} + n') \geq T_{\text{DL\_Rx\_Processing}}) \\ 1, & \text{else} \end{cases} \quad (172)$$

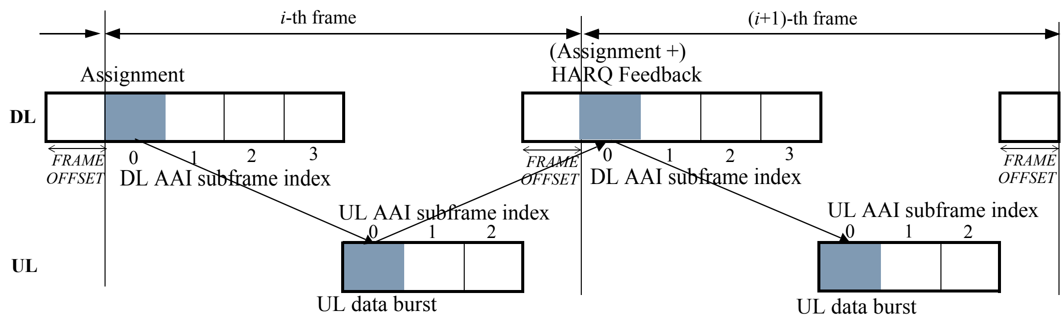
$$v = \begin{cases} 0, & \text{if } ((D' - l' - 1 + m') \geq T_{\text{UL\_Tx\_Processing}}) \\ 1, & \text{else} \end{cases} \quad (173)$$

$$w = \begin{cases} 0, & \text{if } ((U' - m' - N_{TTI} + l') \geq T_{\text{UL\_Rx\_Processing}}) \\ 1, & \text{else} \end{cases} \quad (174)$$



Example showing a frame structure supporting the WirelessMAN-OFDMA frame

Figure 438— Example of TDD DL HARQ timing



Example showing a frame structure supporting the WirelessMAN-OFDMA frame

Figure 439— Example of TDD UL HARQ timing

Figure 438 and Figure 439 show examples of the DL and UL timing relationships between a Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission, for 5, 10 and 20 MHz channel bandwidths. The ratio of whole DL AAI subframes to whole UL AAI subframes, D' : U' is 5 : 3. In this example, FRAME_OFFSET is 1, UL AAI subframes of the WirelessMAN-OFDMA and the Advanced Air Interface are frequency-division multiplexed, the ratio of DL to UL AAI subframes for the Advanced Air Interface, D : U is 4 : 3, and $T_{DL\_Rx\_Processing}$, $T_{UL\_Tx\_Processing}$ and $T_{UL\_Rx\_Processing}$ are 3 AAI subframes.

16.2.14.3 Group Resource Allocation HARQ signaling and timing

16.2.14.3.1 Downlink

Upon receiving a DL Group resource allocation A-MAP IE, the scheduled AMS attempts to decode the data burst intended for it. If the decoding is successful, AMS shall send a positive acknowledgement to ABS; otherwise, AMS shall send a negative acknowledgement to ABS.

With DL group resource allocation, the HARQ retransmissions shall be allocated individually. HARQ retransmissions shall be done by using a DL Basic Assignment A-MAP IE, as described in 16.2.14.2.1.1. This DL Basic Assignment A-MAP IE shall carry the same ACID as the one used by the DL Group resource allocation A-MAP IE for the first HARQ subpacket transmission.

16.2.14.3.2 Uplink

Upon receiving a UL Group resource allocation A-MAP IE, AMS shall transmit the subpacket of HARQ data burst through the resource assigned by the UL Group resource allocation A-MAP IE.

ABS shall attempt to decode the data burst. If the decoding is successful, ABS shall send a positive acknowledgement to AMS; otherwise, ABS shall send a negative acknowledgement to AMS.

With UL group resource allocation, the HARQ retransmissions shall be allocated individually. HARQ retransmissions shall be done as described in 16.2.14.2.1.2. When a UL Basic Assignment A-MAP IE is sent, the UL Basic Assignment A-MAP IE shall carry the same ACID as the one used by the UL Group resource allocation A-MAP IE for the first HARQ subpacket transmission.

16.2.14.4 Persistent Allocation HARQ signaling and timing

16.2.14.4.1 Downlink

Upon receiving a DL persistent allocation A-MAP IE, AMS attempts to decode the data burst at every periodic AAI subframe specified in the DL persistent allocation A-MAP IE. If the decoding is successful, AMS shall send a positive acknowledgement to ABS; otherwise, AMS shall send a negative acknowledgement to ABS.

With DL persistent allocation, HARQ retransmissions shall be done by using a DL Basic Assignment A-MAP IE, as described in 16.2.14.2.1.1.

16.2.14.4.2 Uplink

Upon receiving a UL persistent allocation A-MAP IE, AMS shall transmit the subpacket of HARQ data burst through the assigned resource at every periodic AAI subframe specified in the UL persistent allocation A-MAP IE.

ABS shall attempt to decode the data burst. If the decoding is successful, ABS shall send a positive acknowledgement to AMS; otherwise, ABS shall send a negative acknowledgement to AMS.

With UL persistent allocation, HARQ retransmissions shall be done as described in 16.2.14.2.1.2.

16.2.14.5 HARQ and ARQ Interactions

When both ARQ and HARQ are applied for a flow, HARQ and ARQ interactions described here may be applied to the corresponding flow.

The HARQ entity in the transmitter declares a HARQ data burst failure when a HARQ data burst will no longer be retransmitted and has not been positively acknowledged by the receiver. In this case the HARQ entity in the transmitter shall inform to the ARQ entity in the transmitter about the failure of the HARQ data burst. In response to the information provided by the HARQ entity, The ARQ entity in the transmitter can then initiate retransmission of the ARQ blocks that correlate to the failed HARQ data burst.

16.2.14.6 Combined feedback scheme for ROHC and HARQ

When both HARQ and ROHC are applied for a flow, the cross layer design between HARQ and ROHC (Combined feedback scheme for ROHC and HARQ) may be applied to the corresponding flow.

If the HARQ entity in the transmitter receives the feedback from the HARQ entity in the receiver, it shall report the HARQ feedback to the ROHC compressor which replaces ROHC feedback explicit feedback mechanisms.

Once the ROHC compressor receives the HARQ feedback it will estimate the decompression state; determine its own adjusted compression rate state based on the HARQ feedback information and the context of the ROHC packet transmissions. The compressor transmits ROHC packets according to the adjusted compression rate state, and at the same time informs the lower layers to do operations such as: adding header information to the MAC packets in the cache, discarding the MAC packets or HARQ data burst in the cache, etc.

Capability to support combined feedback scheme for ROHC and HARQ shall be negotiated between ABS and AMS during the network entry procedure.

16.2.15 Network Entry and Initialization

The procedure for initialization of an AMS is shown in Figure 440. This figure shows the overall flow between the stages of initialization in an AMS. This figure does not include error paths and is shown simply to provide an overview of the process.

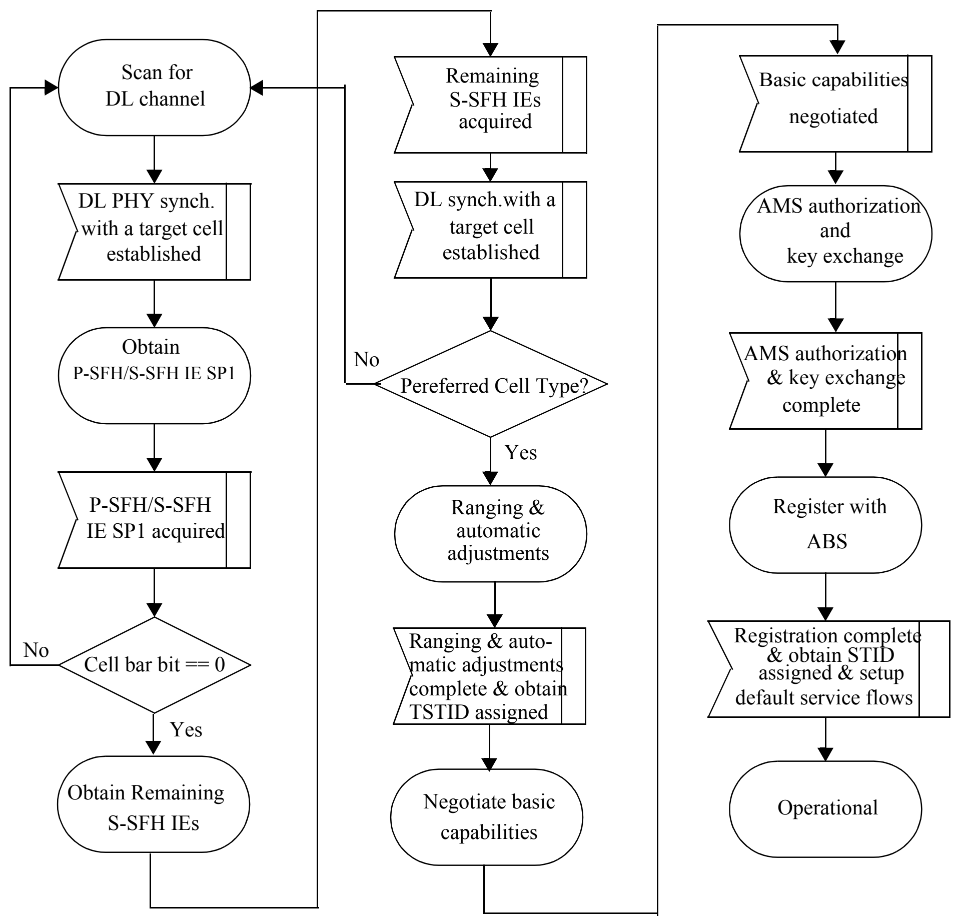


Figure 440—AMS Initilaization Overview

Systems shall support the applicable procedures for entering and registering a new AMS to the network. The procedure for initialization of an AMS shall be divided into the following steps:

a) Scan for DL channel and establish DL PHY synchronization with the ABS
b) Obtain DL/UL parameters (from P-SFH/S-SFH IEs etc.) and establish DL synchronization
c) Perform ranging and automatic adjustment
d) Negotiate basic capability
e) Perform AMS authorization and key exchange

f) Perform registration, and setup default service flows (i.e. pre-provisioned service flows).

Figure 441 and Figure 442 describe the state machine of the AMS and ABS for the initial NW entry process respectively.

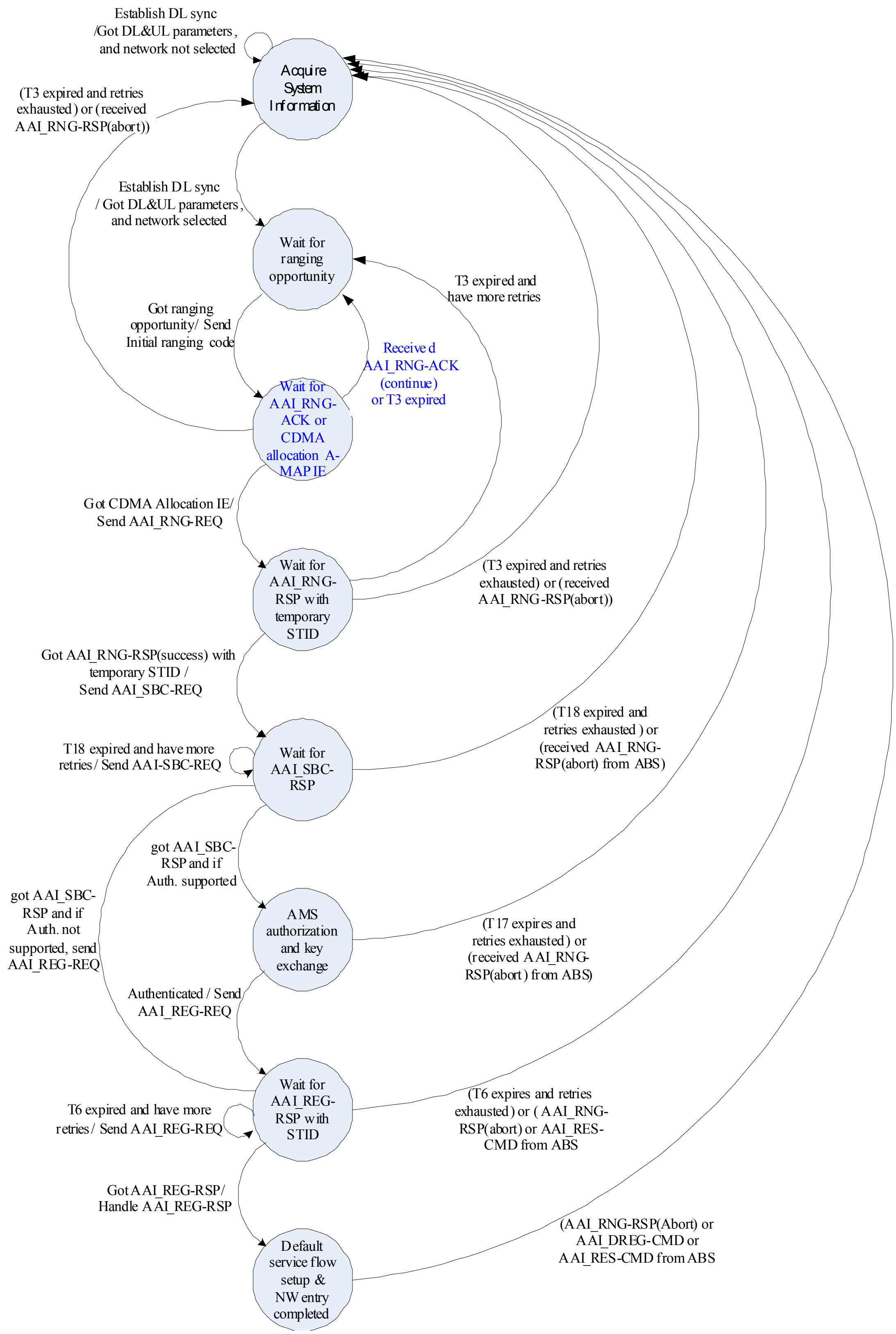


Figure 441—State machine of the AMS for the initial NW entry process

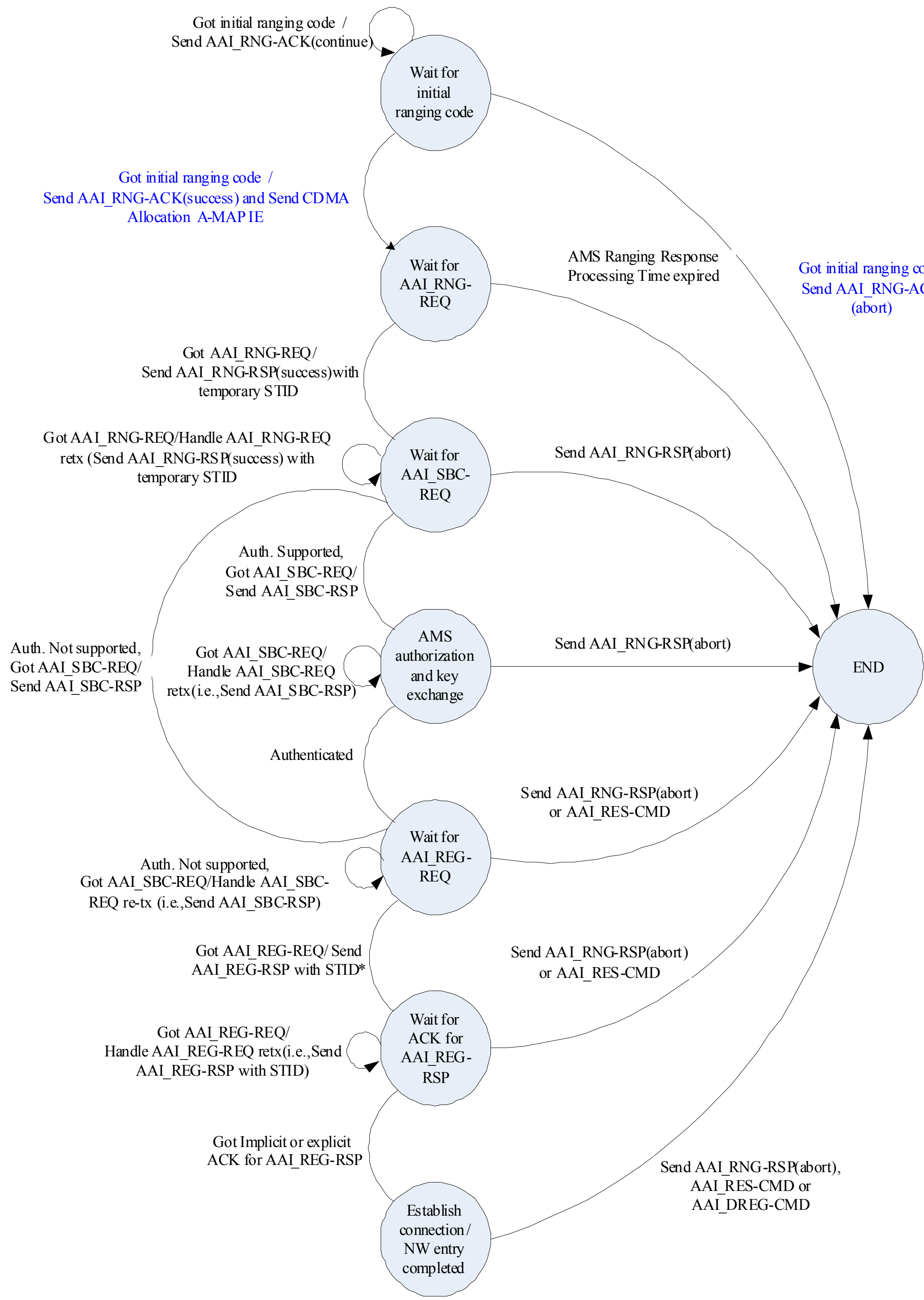


Figure 442—State machine of the ABS for the initial NW entry process

During network entry, ABS may allocate an UL bandwidth for transmission or retransmission of MAC messages, the size of which is predefined, without a bandwidth request from AMS by setting an unsolicited bandwidth indicator in an AAI_RNG-RSP message to the AMS. If the unsolicited bandwidth indicator is enabled, ABS should allocate UL bandwidth within the predefined time duration in order to transmit or retransmit subsequent MAC messages during network entry.

AMS should monitor the A-MAP IE during the predefined time duration for possible bandwidth allocation without performing any bandwidth request. If the AMS fails to identify allocated bandwidth within the predefined time duration, the AMS may perform contention based bandwidth request. When the allocated resource is not sufficient for transmission of MAC messages, the AMS shall send a bandwidth request. To reduce latency, a piggyback bandwidth request is used for this purpose.

When AMS sends an MAC message in a different size from the predefined, AMS should notify the ABS of its size in the previous message defined for the network entry procedure, so that ABS can allocate precise bandwidth to the AMS.

Each AMS contains the following information when shipped from the manufacturer:

- A 48-bit universal MAC address (per IEEE Std 802-2001) assigned during the manufacturing process. This is used to identify the SS to the various provisioning servers during initialization.
- Security information as defined in Clause 7 (e.g., X.509 certificate) used to authenticate the AMS to the security server and authenticate the responses from the security and provisioning servers.

16.2.15.1 AMS DL PHY synchronization.

On initialization or after signal loss, the AMS shall acquire the DL PHY synchronization by A-Preamble. The detailed procedure for DL PHY synchronization is described in section 16.3.6.1.

The AMS shall have nonvolatile storage in which the last operational parameters are stored and, when the AMS needs to acquire DL PHY synchronization, it may at first try synchronizatioin using the stored DL channel information. But if the trial fails, the AMS shall begin to scan the possible channels of the DL frequency band of operation until it finds a valid DL signal.

16.2.15.2 AMS obtaining DL/UL parameters

For initial network entry, once the AMS has achieved DL PHY synchronization with an ABS, the AMS shall decode the P-SFH and S-SFH in order to obtain the necessary system information containing the DL and UL parameters for the initial network entry. Based on the network information such as NSP list which may be obtained from AAI_SII-ADV message, the AMS shall decide whether to continue the network entry process with this ABS or to scan for other ABSs. If the AMS reads cell_bar=1 in SFH, this means this cell does not allow access of new AMS and the AMS shall select a different cell to restart network entry procedure.

If the AMS succeeds to decode the essential system information, the AMS is DL synchronized with the ABS.

16.2.15.3 Initial ranging and automatic adjustments

After DL synchronization, the AMS shall attempt to perform initial ranging with the ABS. If the ranging procedure is successfully completed, the AMS is UL synchronized with the ABS and obtains TSTID from the ABS. The TSTID is used until the ABS assigns the AMS an STID through registration procedure.

Ranging is the process of acquiring the correct timing offset, frequency offset and power adjustments so that the AMS's transmissions are aligned with the ABS, and they are received within the appropriate reception thresholds.

An AMS that wishes to perform initial ranging shall take the following steps:

- The AMS, after acquiring downlink synchronization and uplink transmission parameters, shall select one ranging opportunity based on the random backoff. The random backoff shall use a binary truncated exponent algorithm. After selecting the ranging opportunity, the AMS shall choose a ranging preamble code (from the Initial Ranging domain) using a uniform random process. The AMS shall send the selected ranging preamble code to the ABS in the selected ranging opportunity.
- The ABS should respond with an AAI_RNG-ACK message in a predefined, subsequent DL AAI subframe as defined in 16.2.3.3. The AAI_RNG-ACK message provides responses to all the successfully received and decoded ranging preamble codes in all the ranging opportunities in a previous UL AAI subframe. If all the decoded ranging preamble codes prove 'success' status and the ABS provides UL BW allocation for each ranging preamble codes before the predefined DL AAI subframe that AAI_RNG-ACK is to be transmitted , the AAI_RNG-ACK may be omitted. If the AMS finds in the RNG-ACK bitmap that no ranging preamble code has been successfully decoded in the ranging opportunity selected by the AMS, or it does not find either a response in the AAI_RNG-ACK message or UL BW allocation to its ranging preamble code, the AMS considers its initial ranging request is failed and restarts the initial ranging procedure.
  There are three possible ranging status responses from ABS to AMS provided in the AAI_RNG-ACK message:
  - continue: the ABS provides the needed adjustments (e.g., time, power, and possibly frequency corrections) and a status notification of "continue".
  - success: the ABS provides a status notification of "success", but may have adjustment suggestions to the AMS if necessary. With IR status successs, the ABS shall provide the AMS an UL BW allocation for the AMS to send AAI RNG-REQ message.
  - abort: the ABS requests the AMS to abort the ranging process.
- Based on the received response of ranging status, the AMS performs the followings.
  - Upon receiving a Continue status notification and parameter adjustments in the AAI_RNG-ACK message, the AMS shall adjust its parameters accordingly and continue the ranging process as done on the first entry (using random selection rather than random backoff) with ranging preamble code randomly chosen from the initial ranging domain sent on the initial ranging region.
  - Upon receiving a Success status notification, the AMS shall wait for the ABS to provide UL BW allocation. If the AMS has not received CDMA Allocation A-MAP IE for UL BW allocation by T3 after sending a ranging preamble code, it restarts the initial ranging procedure or, if 'ranging retries' is exhausted, it retries DL PHY synchronization. When receiving an UL BW allocation, the AMS shall send the AAI_RNG-REQ message. If the granted BW allocation cannot accommodate the entire AAI_RNG-REQ message, the AMS may fragment the AAI_RNG-REQ message to fit the provided BW allocation, and requests additional UL bandwidth through either BR without STID header (refer to 16.2.2.1.3.2) or PBREH as defined in 16.2.2.2.8 for the remaining fragments. In response to the PBREH, the ABS shall provide UL BW allocation through CDMA Allocation A-MAP IE, which is identified by the same RA-ID used for the previous BW allocation. The RA-ID is used until AAI_RNG-RSP tranmission is completed, but if AMS does not receive UL bandwidth allocation in T3 or the AAI_RNG-REQ/RSP transaction is not completed in 128 frames, it sends ranging code to perform ranging procedure again.
- ABS assigns and transfers a TSTID by AAI_RNG-RSP message when ranging status is success. Initial ranging process is over after receiving the AAI_RNG-RSP message. The TSTID is used until STID is newly assigned and received at successful registration. If the AMS has not received AAI_RNG-RSP by T3 after sending an AAI_RNG-REQ, it restarts the initial ranging procedure or, if 'ranging retries' is exhausted, it retries DL PHY synchronization.

16.2.15.4 Basic Capability Negotiation

Immediately after completion of ranging, the AMS informs the ABS of its basic capabilities by transmitting an AAI-SBC-REQ message. A "Capability Class" is defined as a unique set of functions, configuration parameters, air-interface protocol revision, and/or services that can uniquely describe a mobile station implementation or configuration while operating in the network. The AMS, by default, shall support the basic capabilities associated with "Capability Class 0". If the AMS is capable of supporting higher revisions of physical layer or medium access control layer protocols or further wishes to use enhanced features, it shall send an AAI_SBC-REQ message to the ABS indicating the highest "CAPABILITY_INDEX" that it can support. The CAPABILITY_INDEX = 0 indicates the default capability index and basic feature set or configuration parameters and may not need to be signaled.

Upon receipt of the AAI_SBC-REQ message containing the "CAPABILITY_INDEX" from the AMS, the ABS determines whether it could allow or could support the requested feature set or MAC and/or PHY protocol revisions. If the ABS does support or can allow the use of enhanced features, it shall respond with an AAI_SBC-RSP message to inform the AMS of its decision. The ABS shall only signal a "CAPABILITY_INDEX" which is numerically smaller than or equal to that requested by the AMS.

The higher numeric values of "CAPABILITY_INDEX", the more enhanced features or higher protocol revisions are used. The "CAPABILITY_INDEX" values range from 0 to N, where N denotes the maximum CAPABILITY_INDEX value. The features and configuration parameters included in the baseline capability class shall be sufficient to meet the minimum performance requirements of the standard.

In case of failure in any stages of operation, the AMS and ABS shall fall back to "Capability Class 0" and restart negotiations for a new "Capability Class", if necessary.

Figure 443 shows the MAC control messages exchanged over the advanced air-interface and the relationship between the Capability Classes.

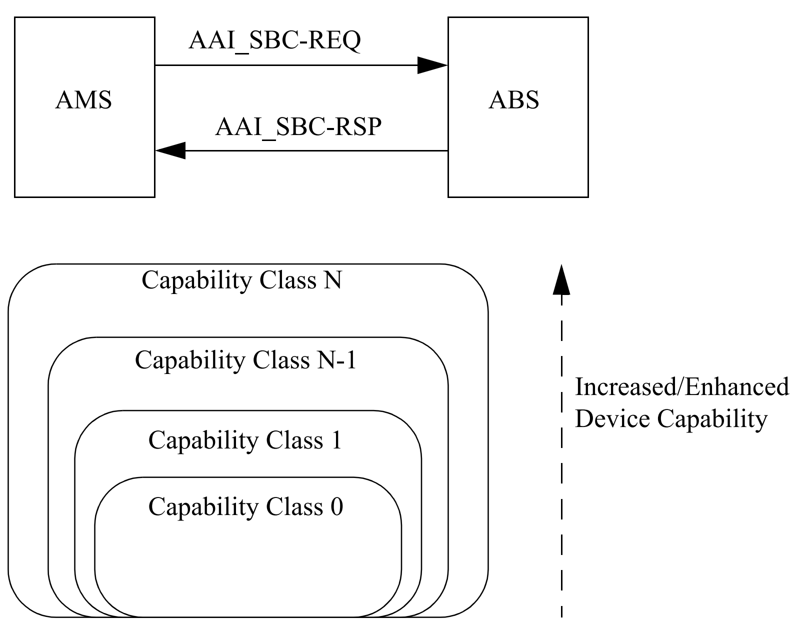


Figure 443—AAI_SBC-REQ/RSP messages over the air-interface and relationship between capability classes

16.2.15.5 AMS authorization and key exchange

If authorization support is enabled in basic capability negotiation, the ABS and AMS shall perform authorization and key exchange through EAP-based authentication (IETF RFC 3748) and key agreement procedure(see 16.2.5.2.1.4). If this procedure completes successfully, all parameters for TEK generation are shared, and TEKs are derived at each side of AMS and ABS. If authorization support is disabled, the step of AMS authorization and key exchange shall be skipped.

16.2.15.6 Registration

Registration is the process by which the AMS is allowed to enter into the network.

After authorization and key exchange are finished, the AMS informs the ABS of its capabilities and requests the registration for entry into the network by AAI_REG-REQ. If an ABS receives an AAI_REG-REQ, the ABS shall respond with AAI_REG-RSP.

In AAI_REG-REQ, the AMS informs the ABS of its capability parameters to be negotiated except those capabilities already negotiated with the ABS through AAI_SBC-REQ/RSP messages. In AAI_REG-RSP, the ABS responds with the accepted capability parameters. If the AMS omits some capability parameters in the AAI_REG-REQ, the ABS considers AMS follows the default values for those parameters and, if acceptable, ABS may omit those parameters applying default value in its AAI_REG-RSP.

The ABS shall allocate and transfer a STID to the AMS through encrypted AAI_REG-RSP message. The temporary STID, which was allocated during initial ranging procedure, is discarded when the ABS recognizes that the AMS received the AAI_REG-RSP messages successfully. The AAI_REG-RSP message contains the CRID, where the network retains the AMS contexts including the CRID and AMS MAC address.

Upon successful registration, a DL and UL FID are assigned to the AMS without using the DSA procedure in order to activate one preprovisioned service flow for each UL and DL FID which can be used for upper layer signaling (e.g. DHCP).

During the registration procedure, the AMS and the ABS shall negotiate IP versions and may negotiate host configuration parameters. The AMS shall inform the supported IP version(s) (for example, IPv4, IPv6 or both) to the network through the ABS by including the Supported-IP-Versions IE in the AAI_REG-REQ message. After the network selects one of the supported IP version(s), the ABS shall inform the AMS of the selected IP service type (for example, IPv4 only, IPv6 only or IPv4/IPv6 dual mode) by including the IP-Service-Type IE in the AAI_REG-RSP message.

The AMS may indicate its capability of configuring host parameters (for example, host address or home network prefix) and request the additional parameters (for example, DNS Server Address) to the network through the ABS by including the Host-Configuration-Capability-Indicator IE in the AAI-REG-REQ message.

If the AMS indicates its capability of configuring host parameters, the ABS shall include either the IPv4-Host-Address IE or the IPv6-Home-Network-Prefix IE or both and the requested host configuration parameter(s) in the AAI-REG-RSP message. If the AMS does not indicate its capability of configuring host parameters, the ABS shall not include any of those host configuration parameters in the AAI_REG-RSP message assuming that the AMS will be configured by using upper layer protocol.

If the AMS wants to configure additional host configuration parameters, the AMS may indicate those parameters by including Requested-Host-Configurations IE in AAI_REG-REQ message. If AMS indicates additional host configuration parameters or the network decides to configure additional host configuration parameters, ABS may include Additional-Host-Configurations IE in AAI_REG-RSP message.

The format of the value field of Requested-Host-Configurations IE and Additional-Host-Configurations IE is defined in RFC2132[1] for IPv4, RFC3315[2] for IPv6. Note that list of parameters can be found in [3], [4].

16.2.16 Sleep Mode

Sleep Mode in connected state is a sort of sub-state in which an AMS conducts pre-negotiated periods of absence from the serving ABS air interface. Sleep Mode can be activated through explicit signaling when an AMS is in Active Mode. During the activation of Sleep Mode, the AMS is provided with a series of Sleep Cycles that typically consists of a Listening Window followed by a Sleep Window.

During Sleep Window in Sleep Mode, the ABS shall not transmit DL unicast MAC PDU to the AMS; therefore the AMS may power down one or more physical operation components or perform other activities that do not require communication with the ABS.

During Listening Window, the AMS is expected to receive all DL transmissions same way as in the state of normal operations. AMS shall ensure that it has up-to-date system information for proper operation. The synchronization and system configuration information acquisition and verification may be done by AMS waking up at the Super Frame Header just prior to the frame in which its listening window is located to ensure that the Super Frame number and the S-SFH Change Count are as expected. Upon wakeup from sleep state, if the AMS detects that it is not synchronized, then it shall stay awake until the AMS is successfully synchronized with the serving ABS. If the AMS detects another ABS than the serving ABS, then it shall exit sleep mode and perform Network reentry as described in 16.2.15 or 16.2.6.3.5. If the AMS detects that the information it has is not up-to-date, then it shall not transmit in the Listening Window until it receives the up-to-date system information.

The length of successive Sleep Cycles may remain constant or may be adaptive based on traffic conditions. Sleep Windows and Listening Windows may also be dynamically adjusted for the purpose of data transportation as well as MAC control signaling transmission. The AMS may send and receive data and MAC control signaling without deactivating the Sleep Mode.

For each AMS, the AMS and ABS shall keep up to 16 previous used Sleep Cycle settings and associated SCIDs.

If an AMS request to switch Sleep Cycle setting to the previous Sleep Cycle setting by the AAI_SLP-REQ including associated SCID, the ABS shall respond with the AAI_SLP-RSP including approval or other SCID. Per AMS, a single Sleep Cycle setting shall be applied across all the active connections of the AMS, and is indicated by the Sleep Cycle ID (SCID).

16.2.16.1 Sleep Mode initiation

Sleep Mode activation/entry may be initiated either by an AMS or an ABS. When an AMS in the Active mode decides to enter the Sleep Mode, it shall negotiate parameters of the Sleep Cycle with the ABS. ABS makes the final decision regarding the AMS request and instructs the AMS to enter Sleep Mode. The negotiation of Sleep Cycle setting is performed by the exchange of corresponding MAC control messages AAI_SLP-REQ and AAI_SLP-RSP or Service Flow control messages. Sleep Cycle parameters can be included in the Service Flow control messages

The AMS may initiate the negotiation by sending an AAI_SLP-REQ message and shall expect an AAI_SLP-RSP message from the serving ABS in response. Alternatively, the ABS may initiate the negotiation by sending an unsolicited AAI_SLP-RSP message to the AMS. In this case, the ABS should request the AMS to send acknowledgment(i.e., AAI_MSG-ACK) to the AAI_SLP-RSP.

In the event that the ABS-initiated request (i.e., Unsolicited Sleep response) and an AMS-initiated request for Sleep Mode entry is being handled concurrently, the ABS-initiated request shall take precedence over the AMS-initiated Request. In this case, even though the AMS receives the ABS-initiated request while it is waiting for AAI_SLP-RSP message in response to AAI_SLP-REQ, the AMS shall stop the remaining procedure of the AMS-initiated request and continue with the ABS-initiated request. The ABS shall ignore an AMS's request if the ABS has already initiated a change request.

16.2.16.2 Sleep Mode operation

16.2.16.2.1 Sleep Cycle operations

The period of the Sleep Cycle is measured in units of frames. A sleep cycle is the sum of a Sleep Window and a Listening Window. The first sleep cycle on entry to Sleep Mode from Active Mode contains only a sleep window which equals to the Initial Sleep Cycle.

A Sleep Cycle shall begin with a Listening Window. A Sleep Window shall follow the Listening Window and shall continue to the end of the current Sleep Cycle if the Listening Window does not occupy the full Sleep Cycle. If the Listening Window of a Sleep Cycle is neither extended nor terminated early, its length shall be equal to the value of the Default Listening Window parameter, which is set during the initiation of Sleep Mode or may be changed during a Sleep Cycle update. The ABS may negotiate with the AMS that the AMS only needs to wake up in certain AAI subframes during each frame in the listening window. The AMS shall perform synchronization prior to the scheduled listening window.

The AMS's exact mechanism for maintaining synchronization with the ABS, based on the preamble, is implementation-specific.

The length of the Listening Window length within a Sleep Cycle may be dynamically extended, as specified in section 16.2.16.2.3.2.

The length of a Sleep Cycle may be changed implicitly. If there is negative indication in the traffic indication message or if there is no data traffic during the Listening Window or if the NSCF is set to 0b01, the AMS and ABS shall update the length of the Sleep Cycle as follows:

Current Sleep Cycle = min(2 x Previous Sleep Cycle, Final Sleep Cycle)………………….(x)

The value of the Default Listening Window shall remain unchanged when Sleep Cycle is changed implicitly according to Equation (x).

The parameters associated with Sleep Cycle operation are specified as follows:

- Default Listening Window: length of the Default Listening Window
- Initial Sleep Cycle: length of initial Sleep Cycle
- Final Sleep Cycle: length of final Sleep Cycle
- Starting Frame Number: The number of the frame where the Sleep Cycle setting is requested to start to take effect.

Other parameters:

- Listening window Extension Flag (LWEF):

  If LWEF = 0, indicates that the Listening window is of fixed duration.

  If LWEF = 1, indicates that the Listening window can be extended and is of variable duration
- Traffic Indication Message Flag (TIMF)

If TIMF = 0, then a Traffic Indication Message is never sent

If TIMF = 1, then a Traffic Indication Message is sent every Listening window

When TIMF=0 and AMS does not receive any traffic in the listening interval, the AMS shall stay awake for the rest of the Listening Window.

When Final Sleep Cycle is equal to or larger than 2 times the Initial Sleep Cycle, the length of Sleep Cycle exponentially doubles until the Final Sleep Cycle is reached. This Sleep Cycle operation is suitable for BE-traffic scenario. If the traffic indication message is positive for the AMS, then the length of the current Sleep Cycle shall be determined based on the value of NSCF which was included in the AAI_SLP-RSP or SCH or SCEH. The Sleep Cycle could be the different length according to the Next Sleep Cycle Flag (NSCF) within the AAI_SLP-REQ/RSP message, SCH or SCEH. If the NSCF is set to 0b00 then the Initial Sleep Cycle is always the same as the first Initial one. When the NSCF is set to 0b01 then current sleep cycle is doubled in previous sleep cycle.

When NSCF is set to 0b10, during sleep mode initiation the AMS negotiates with the ABS the new initial sleep cycle value to be used after positive traffic indicator.

When Final Sleep Cycle is equal to the Initial Sleep Cycle, the length of Sleep Cycle is fixed. This Sleep Cycle operation is suitable for "real-time traffic-only" or "real-time and BE-traffic mixed" scenario.

16.2.16.2.2 Sleep Window operations

During the Sleep Window, the AMS is unavailable to receive any DL data and MAC control signaling from the serving ABS. The AMS may perform power-down or autonomous scan or any other autonomous operations that do not involve the reception of DL transmissions. Handling of control signaling during sleep mode is specified in 16.2.16.2.6.

The protocols and procedures relating to interruptions of normal Sleep Cycle operation are provided in 16.2.16.2.6.

16.2.16.2.3 Listening Window operations

During the Listening Window, the AMS shall be available to receive DL data and MAC control signaling from ABS. AMS may also send data if any uplink data is scheduled for transmission. If the Traffic Indication is enabled, the AMS shall receive and decode a traffic indication message sent by an ABS during the Listening Window. Otherwise, the AMS shall ignore the traffic indication message.

Listening window is measured in units of frames. By default, the length of a Listening Window shall be governed by the Default Listening Window parameter.

At an AMS, a Listening Window shall end on encountering one of the following conditions:

- on reception of a SCH or SCEH from the ABS to terminate the Listening Window
- on reaching the end of the current nominal end of the Listening Window (the nominal end is the length of the Default Listening Window parameter if the Listening Window is not extended; if extended, the nominal end is length after adjusting for the length of the last extension)
- on reaching the end of the Sleep Cycle.

At the serving ABS, a Listening Window shall end on encountering one of the following conditions:

- on transmission of a SCH or SCEH to the AMS to terminate the Listening Window
- on reaching the end of the current nominal end of the Listening Window (the nominal end is the length of the Default Listening Window parameter if the Listening Window is not extended; if extended, the nominal end is length after adjusting for the length of the last extension)

- on reaching the end of the Sleep Cycle.

After termination (by explicit signaling or implicit method) of a Listening Window, the Sleep Window of the Sleep Cycle shall begin and shall continue to the end of the Sleep Cycle.

16.2.16.2.3.1 Traffic Indication

Traffic Indication is sent for one or a group of AMS using the AAI_TRF-IND message.

The AAI_TRF-IND message shall be transmitted as described in 16.3.6.5.2.1.

If the traffic indication is enabled for an AMS with SLPID assigned, the AMS shall wait for a traffic indication message. Upon receiving the traffic indication message, the AMS shall check whether there is positive traffic indication (e.g. by the SLPID-Group Indication bit-map and Traffic Indication bit-map or the SLPID assigned to it).

If the AMS receives a negative traffic indication, then it shall end the Listening Window and proceed with Sleep Window operation for the remainder of the Sleep Cycle, unless the AMS has UL signaling or traffic pending for transmission. If the ABS transmits a negative indication to the AMS, the ABS shall not transmit any DL data traffic to the AMS during the remaining part of the Listening Window, unless there are UL bandwidth requests or UL MAC PDU sent from the AMS which have not been fulfilled.

If the ABS sends a positive indication to a specific AMS, the ABS shall transmit at least one DL MAC PDU to the AMS during the AMS's Listening Window.

If the traffic indication message is lost or otherwise not detected by the AMS, the AMS shall stay awake for the rest of the Listening Window. If the AMS receives any unicast data during the listening window, then it shall assume that the traffic indication was positive. If the AMS receives neither the traffic indication message nor any unicast data in the Listening Window, the AMS shall remain awake until it receives its own traffic indication using AAI_TRF_IND-REQ/RSP exchange. The AMS shall then send an AAI_TRF_IND-REQ message to ask the ABS what was the traffic indication for the AMS. The ABS shall respond to the AMS by unicasting an AAI_TRF_IND-RSP message containing the traffic indication for that AMS. On receiving the the traffic indication, the AMS shall behave in accordance with the traffic indication.

16.2.16.2.3.2 Listening Window extension

The length of the Listening Window of a Sleep Cycle may be extended beyond the value of the Default Listening Window parameter setting. The maximum length of a Listening Window shall be bounded by the length of the Sleep Cycle in which the Listening Window exists. The extension of the Listening Window may be done via implicit or explicit means.

The Listening Window can be extended implicitly if one of the following conditions is true:
- Exchange of new MAC PDU between an AMS and an ABS
- Pending HARQ retransmission in UL or DL
- AMS sends a bandwidth request

The AMS shall maintain an inactivity timer during Listening window called the T_AMS timer, a similar timer is maintained by the ABS called the T_ABS timer. The value of T_ABS timer shall be less than or the same as T_AMS timer.

AMS shall not sleep if any of the following condition is true:
- — The Listening Window has not been explicitly terminated
- — The T_AMS timer has not expired

— The T_HARQ_Retx timer has not expired
— The number of retransmissions of the UL HARQ burst has not reached the maximum number of HARQ retransmission attempts
— The default Listening Window has not ended.

The rules regarding the starting/restarting of T_AMS timer and the T_HARQ_Retx timer at the AMS are as follows:

- If there is a transmission of new DL/UL MAC PDU between an AMS and an ABS, the T_AMS timer shall be started. If AMS receives a HARQ ACK or DL MAC PDU or Assignment-A-MAP IE from an ABS, the AMS shall restart the T_AMS timer.
- If there is NAK for HARQ retransmission in UL or DL, the T_HARQ_Retx timer for the associated HARQ process shall be started/restarted. If there is an ACK for HARQ retransmission in UL or DL, the T_HARQ_Retx timer for the associated HARQ process shall be set to zero.
- If there is an NAK for UL HARQ transmission, the AMS shall not sleep until an ACK is received or the maximum retransmissions of the HARQ burst are exhausted.
- If T_HARQ_ReTx expires and number of retransmissions of the DL HARQ burst is less than the maximal retransmission number, the AMS shall restart the T_HARQ_ReTx timer and increases the retransmission number by one.

ABS shall consider the associated AMS is in the wakeup state if any of the following condition is true:

— The Listening Window has not been explicitly terminated
— The T_ABS timer has not expired
— The T_HARQ_Retx timer has not expired
— The number of retransmissions of the DL HARQ burst has not reached the maximum number of HARQ retransmission attempts
— The default Listening Window has not ended.

The rules regarding the starting/restarting of T_ABS timer and the T_HARQ_Retx timer at the ABS are as follows:

- If there is a transmission of new DL/UL MAC PDU between an AMS and an ABS, the T_ABS timer shall be started. If ABS receives a HARQ ACK or UL MAC PDU from an AMS, the ABS shall restart the T_ABS timer for the AMS.
- If there is NAK for HARQ retransmission in UL or DL, the T_HARQ_Retx timer for the associated HARQ process shall be started/restarted. If there is an ACK for HARQ retransmission in UL or DL, the T_HARQ_Retx timer for the associated HARQ process shall be set to zero.
- If there is an NAK for UL HARQ transmission. the ABS shall not consider that AMS has entered the sleep until it transmits the maximum number of HARQ retransmission. If the maximum retransmissions of the HARQ burst are exhausted, the ABS considers that AMS has entered the sleep.

The T_AMS timer is negotiated between the AMS and the ABS through AAI_SLP-REQ/RSP exchange. The ABS shall set the T_ABS timer by referring to the negotiated T_AMS timer.

After the default listening window ends, if the T_ABS timer expires and the number of DL HARQ retransmission is exhausted for DL of the AMS, the ABS shall either retransmit the HARQ-failed MAC PDU or regard the AMS as returning to sleep (i.e., the Sleep Window starts).

In order to provide scheduling flexibility and to take advantage of radio link conditions and to reduce control signaling latency of AMSs, the Listening Window may also be extended explicitly. The ABS may send an explicit signaling in Sleep Control Extended header or Sleep Control header including the number of frame for extended listening window to control extension of Listening Window during the Default Listening Window. Upon receiving the explicit signaling, the AMS shall either extend its Listening Window until the frame specified in signaling or terminate the listening window. The AMS may also send an explicit signaling in Sleep Control Extended header or Sleep Control header including the number of frame for extended listening window to control extension of Listening Window during the Default Listening Window. Upon receiving the explicit signaling to extend Listening Window, the AMS shall extend its Listening Window until the frame specified in signaling or terminate the listening window.

The ABS may send an explicit indication using Sleep Control Extended Header or Sleep Control Header to terminate the current Listening Window. The AMS may send an explicit indication using Sleep Control Extended Header or Sleep Control Header to terminate the current Listening Window. In this case, the ABS shall regard the AMS as returning to sleep (i.e. the Sleep Window starts). When an ABS has a last PDU in the DL buffer during the listening window, the ABS may transmit an explicit indication using Sleep Control Extended Header or Sleep Control Header provided that it allows to terminate the current Listening Window. In this case, the ABS shall regard the AMS as returning to sleep (i.e., the Sleep Window starts).

16.2.16.2.4 Sleep Mode parameter update

The AMS or the ABS may dynamically change the active Sleep Cycle settings without exiting Sleep Mode.

The Sleep Cycle setting update may be accomplished by the AMS sending an AAI_SLP-REQ message or SCH/SCEH with request to re-activate a previously defined sleep cycle or change the sleep parameters of existing SCID. Changing the sleep parameters of existing SCID overrides the old parameters. On receipt of an AAI_SLP-REQ requesting Sleep Cycle setting change, the ABS shall respond with an AAI_SLP-RSP message to confirm the change along with the start frame number, or to propose alternate settings, or to deny the requested change. At the frame specified by Start_Frame_Number, the newly updated sleep cycle settings shall be applied. Alternatively, the ABS may initiate a Sleep Cycle parameter change by sending an unsolicited AAI_SLP-RSP or SCH/SCEH message to the AMS. In this case, the ABS shall request the AMS to send acknowledgment using AAI_MSG-ACK or MAEH to the AAI_SLP-RSP. The Sleep Cycle change/switching may be performed with the exchange of Service Flow Control message when the AMS is in Sleep Mode. In case that the AMS in Sleep Mode sends an AAI_DSx-REQ with Sleep Cycle Setting (refer to Table 766), the ABS shall regards Sleep Cycle Setting included in the AAI_DSx-REQ as negotiation of Sleep Cycle parameters in AAI_SLP-REQ. If the ABS decides to accept sleep cycle setting, the ABS shall include the Response Code = 0b01 (i.e., Approval) with the parameters which are different from the AMS's request. Otherwise, the ABS shall either omit the entire Sleep Cycle Setting or include both the Response Code = 0b10 (i.e., Reject) and REQ_duration in AAI_DSx-RSP message, as rejection of the AMS’s request. If the ABS rejects Sleep Cycle setting negotiation while accepting creation/change/deletion of service flow, the ABS or AMS may initiate another Sleep Mode transaction to change/switch Sleep Cycle setting by AAI_SLP-REQ/RSP. On the other hand, if the ABS sends the AMS an AAI_DSx-REQ with Sleep Cycle Setting, the AMS shall regard Sleep Cycle Setting in the AAI_DSx-REQ as negotiation of Sleep Cycle parameters in unsolicited AAI_SLP-RSP. Therefore, the AMS shall apply the Sleep Cycle setting sent in the frame specified by Start_Frame_Number in Sleep Cycle setting included in the AAI_DSx-REQ sent by ABS.

If DSx transaction is failed with Confirmation Code = Non-zero, the AMS and the ABS shall ignore the Sleep Cycle setting in AAI_DSx-REQ/RSP message, as well.

Table 765—Sleep Cycle Setting

Name	Type	Length	Value
Sleep Cycle Setting	[145./146].x	Variable	Sleep Cycle Setting may be included in AAI_DSx-REQ/RSP message for changing/switching Sleep Cycle parameters. It contains part of sub-parameters which are defined in Table 766

Table 766—Sleep Cycle parameters in Sleep Cycle Setting

Name	Type	Length	Value
Operation	[145./146].x.1	1	Refer to Table 701 and Table 702
SCID	[145./146].x.2	1	Refer to Table 701 and Table 702
Start Frame Number	[145./146].x.3	1	Refer to Table 701 and Table 702
LWEF	[145./146].x.4	1	Refer to Table 701 and Table 702
TIMF	[145./146].x.5	1	Refer to Table 701 and Table 702
NISCF	[145./146].x.6	1	Refer to Table 701 and Table 702
Initial Sleep Cycle	[145./146].x.7	1	Refer to Table 701 and Table 702
Final Sleep Cycle	[145./146].x.8	2	Refer to Table 701 and Table 702
Listening Window	[145./146].x.9	1	Refer to Table 701 and Table 702
New Initial Sleep Cycle	[145./146].x.10	1	Refer to Table 701 and Table 702
T_AMS	[145./146].x.11	1	Refer to Table 701 and Table 702
Response_Code	[145./146].x.12	1	Refer to Table 702
SLPID	[145./146].x.13	2	Refer to Table 702
REQ_duration	[145./146].x.14	1	Refer to Table 702

In the event that an ABS-initiated request (i.e., Unsolicited Sleep response) and an AMS-initiated request for Sleep Cycle setting change or switch are being handled concurrently, the ABS-initiated request shall take precedence over the AMS-initiated Request. Therefore, if the AMS receives the ABS-initiated request while it is waiting for AAI_SLP-RSP message in response to AAI_SLP-REQ, the AMS shall stop the remaining procedure of the AMS-initiated request and continue with the ABS-initiated request. The ABS shall ignore an AMS-initiated request if it has initiated a change request.

16.2.16.2.5 CQI operation during Sleep Mode

In case of a CQI_Operation in AAI_SLP-RSP = 0b00, the CQICH assigned to the AMS is kept. In this case, the MS shall transmit CQI on the CQICH to the BS during the Listening Window.

In case of the CQI_Operation = 0b01, the CQICH is de-allocated at the frame specified by Start_Frame_Number in AAI_SLP-RSP.

In case of the CQI_Operation = 0b10, whenever the CQICH is newly assigned to the AMS during the Listening Window, the allocated CQICH is automatically de-allocated at the beginning of Sleep Window.

16.2.16.2.6 Interruptions to Normal Sleep Cycle Operation

Events specified in Subclauses <<15.2.x.x.2.5.1>> and <<15.2.x.x.2.5.2>> can interrupt the normal operation of Sleep Cycles without de-activating sleep mode.

16.2.16.2.6.1 Sleep Operation During Control Signaling Transactions

During a control signaling transaction between an ABS and AMS, the AMS shall remain awake after it has transmitted any UL signaling to which the ABS is expected to respond unless it is instructed by ABS to resume normal Sleep Cycle operation. The UL signaling for which this shall be applicable includes any type of ranging, any request type signaling header and any MAC control message requiring ABS response. The AMS shall remain in the listening mode until the occurrence of one of the following events:

- the expected response is received from the ABS
- the required timeout waiting for the ABS response has been reached
- the ABS has indicated a return to normal Sleep Cycle operation by sending sleep control information with Resume Sleep Cycle Indication set to the AMS.

On the occurrence of any of these events, the AMS shall return to normal Sleep Cycle operation after accounting for the time elapsed during the control signaling transaction. The length and phase of the Sleep Cycles are not impacted by the interruption.

If normal Sleep Cycle operation is resumed via the ABS sending Resume Sleep Cycle Indication to the AMS, the ABS may send the expected control signaling response in a Listening Window of a normal Sleep Cycle or in a specific scheduled Sleep Cycle interruption. When a scheduled Sleep Cycle interruption is used, the ABS may specify the starting time of the scheduled Sleep Cycle interruption relative to Resume Sleep Cycle Indication Sleep Control Extended Header or Sleep Control Header along with Resume Sleep Cycle Indication. If the scheduled Sleep Cycle interruption has not been cancelled, the AMS shall be in a listening mode regardless of its current Sleep Cycle state from the specified start time of the scheduled Sleep Cycle interruption until either the AMS receives the expected ABS response or times out waiting for the response. At the end of the scheduled Sleep Cycle interruption, normal Sleep Cycle operation shall resume after accounting for the time elapsed during the scheduled Sleep Cycle interruption. The occurrence of a scheduled Sleep Cycle interruption does not impact the length and phase of the Sleep Cycle(s) to which it coincides.

16.2.16.2.6.2 Sleep Operation With Reception of Broadcast/Multicast Transmissions

The timings of broadcast/multicast transmissions are governed by control signaling specific to the type of broadcast/multicast traffic. The AMS is made aware of when it needs to be listening in order to receive these transmissions via specific signaling related to the broadcast/multicast transmission. The AMS shall be able to receive such pre-scheduled DL transmissions independently of normal Sleep Cycle operation. The AMS may not wake up at the frame specified by the ABS for the reception of broadcast/multicast message.

16.2.16.3 Sleep Mode termination

Sleep Mode termination can be initiated by either the AMS or the ABS. If AMS-initiated, then the AMS shall send an AAI_SLP-REQ message with de-activation request and subsequently the ABS shall respond with the AAI_SLP-RSP message. The ABS may also send an unsolicited AAI_SLP-RSP message to de-activate Sleep Mode. In this case, the ABS shall request the AMS to send acknowledgment using AAI_MSG-ACK or MAEH to the AAI_SLP-RSP. When the AMS successfully exits from Sleep Mode, the

AMS and ABS shall keep sleep mode context until Resource Retain Time expires. Sleep Mode shall be implicitly terminated when an AMS successfully achieves idle mode, handover, or scanning mode transaction by explicit signaling.

In the event that the ABS-initiated request (i.e., Unsolicited Sleep response) and an AMS-initiated request for Sleep Mode exit is being handled concurrently, the ABS-initiated request shall take precedence over the AMS-initiated Request. In this case, even though the AMS receives the ABS-initiated request while it is waiting for AAI_SLP-RSP message in response to AAI_SLP-REQ, the AMS shall stop the remaining procedure of the AMS-initiated request and continue with the ABS-initiated request. The ABS shall ignore an AMS request if it has initiated a change request.

16.2.17 Idle mode

An ABS may be a member of one or more paging groups that may have different paging cycles and paging offsets. When AMS operating in legacy mode select the mixed ABS as a preferred ABS, AMS may stay in the Lzone and perform the legacy Idle Mode operation. If an AMS in Idle Mode decides to change its operation mode, the AMS shall perform network reentry from Idle Mode in the new operation mode. The change includes the AMS moves between BSs operating in different mode or switches from LZone to MZone of a mixed mode ABS. And the decision may be based on the detection of a new operation mode. When an AMS is paged in the Lzone of a mixed mode ABS, the AMS shall perform the network reentry in the LZone of the ABS and may switch to the MZone of the ABS using Lzone to Mzone handoff procedures as defined in 16.2.6.4.1.2.1.

An AMS may be assigned to one or more paging groups. If an AMS is assigned to multiple paging groups, it may be assigned multiple paging offsets within a paging cycle where each paging offset corresponds to a separate paging group. The AMS is not required to perform location update when it moves within its assigned paging groups. The assignment of multiple paging offsets to an AMS allows the AMS to monitor paging message at different paging offset when the AMS is located in one of its paging groups.

When an AMS is assigned to more than one paging groups, one of the AMS's paging groups is called the primary paging group and rest of the assigned paging groups are called secondary paging groups. When an AMS is assigned to one paging group, the paging group is considered as a primary paging group. The paging offset associated with the primary paging group is called the primary paging offset, while the paging offsets associated with secondary paging groups are called secondary paging offsets.

When the AMS is assigned to multiple paging groups with the same paging cycle and different paging offsets, the primary paging offset is less than the secondary paging offset. The distance between two adjacent paging offsets should be long enough so that the ABS can (i) send a paging message to the AMS in the primary paging offset within the paging cycle, (ii) when the AMS is in the primary paging group, receive a response to the paging message by the AMS before the secondary paging offset, and (iii) retransmit the paging message to the AMS at the secondary offset within the same paging cycle only if a response to the paging message in the primary paging offset is not received.

An AMS determines if it is within its primary paging group or within a secondary paging group by monitoring the PGIDs advertised by its preferred ABS during a paging listening interval. If the AMS determines that it is in its primary paging group, the AMS wakes up at its primary paging offset and responds to paging messages that are sent in the primary paging offset and are addressed to it. If the AMS determines that multiple secondary paging groups are present, the AMS wakes up at the shortest paging offset and responds to paging messages that are sent in during this paging offset and are addressed to it. If the AMS determines that none of the paging groups it has been assigned to are present, the AMS shall perform a location update.

16.2.17.1 Idle mode initiation

Idle mode for an AMS is initiated either by the AMS or by its serving ABS.

In the event that the ABS-initiated request (i.e., Unsolicited AAI_DREG-RSP) and an AMS-initiated request for Idle Mode entry is being handled concurrently, the ABS-initiated request shall take precedence over the AMS-initiated Request. In this case, even though the AMS receives the ABS-initiated request while it is waiting for AAI_DREG-RSP message in response to AAI_DREG-REQ, the AMS shall stop the remaining procedure of the AMS-initiated request and continue with the ABS-initiated request. The ABS shall ignore an AMS's request if the ABS has already initiated an idle mode initiation request.

16.2.17.1.1 AMS initiated

In case of AMS initiated idle mode entry, an AMS may signal intent to begin idle mode by sending a AAI_DREG-REQ message with the De-registration_Request_Code parameter = 0x01; request for AMS deregistration from serving ABS and initiation of AMS idle mode. The AMS may request the paging controller to retain specific AMS service and operational information for idle mode management purposes through inclusion of the Idle Mode Retain Information element in the AAI_DREG-REQ control message. When the ABS decides to allow AMS-initiated idle mode request, the ABS shall send a AAI_DREG-RSP with action code 0x07 in response to the AAI_DREG-REQ message. When the ABS decides to reject AMS-initiated idle mode request, the ABS shall send a AAI_DREG-RSP with action code 0x06 in response to this AAI_DREG-REQ message. ABS may include REQ-Duration TLV in this AAI_DREG-RSP message. In this case, the AMS may retransmit the AAI_DREG-REQ message after the expiration of REQ_Duration. If the AMS does not receive the AAI_DREG-RSP message within T45 timer expiry after it sends the AAI_DREG-REQ message to the ABS, the AMS shall retransmit the AAI_DREG-REQ message as long as DREG Request Retry Count has not been exhausted. Otherwise, the AMS shall reinitialize MAC and perform network reentry with its preferred ABS. Also, the ABS shall start Management_Resource_Holding_Timer to maintain connection information with the AMS as soon as it sends the AAI_DREG-RSP message with action code 0x07 to the AMS. If Management_Resource_Holding_Timer has been expired, the ABS shall release connection information with the AMS. The operation of idle mode entry during AMS initiated idle mode is shown in Figure 444 and Figure 445.

AMS may include its mobility information in the AAI_DREG-REQ message.

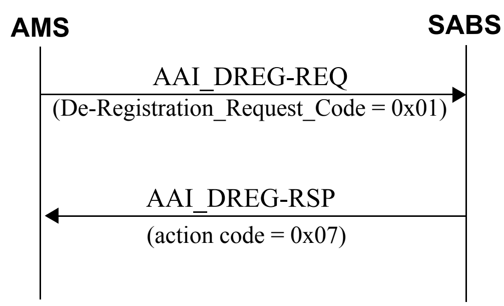


Figure 444—Call flow for AMS initiated idle mode entry

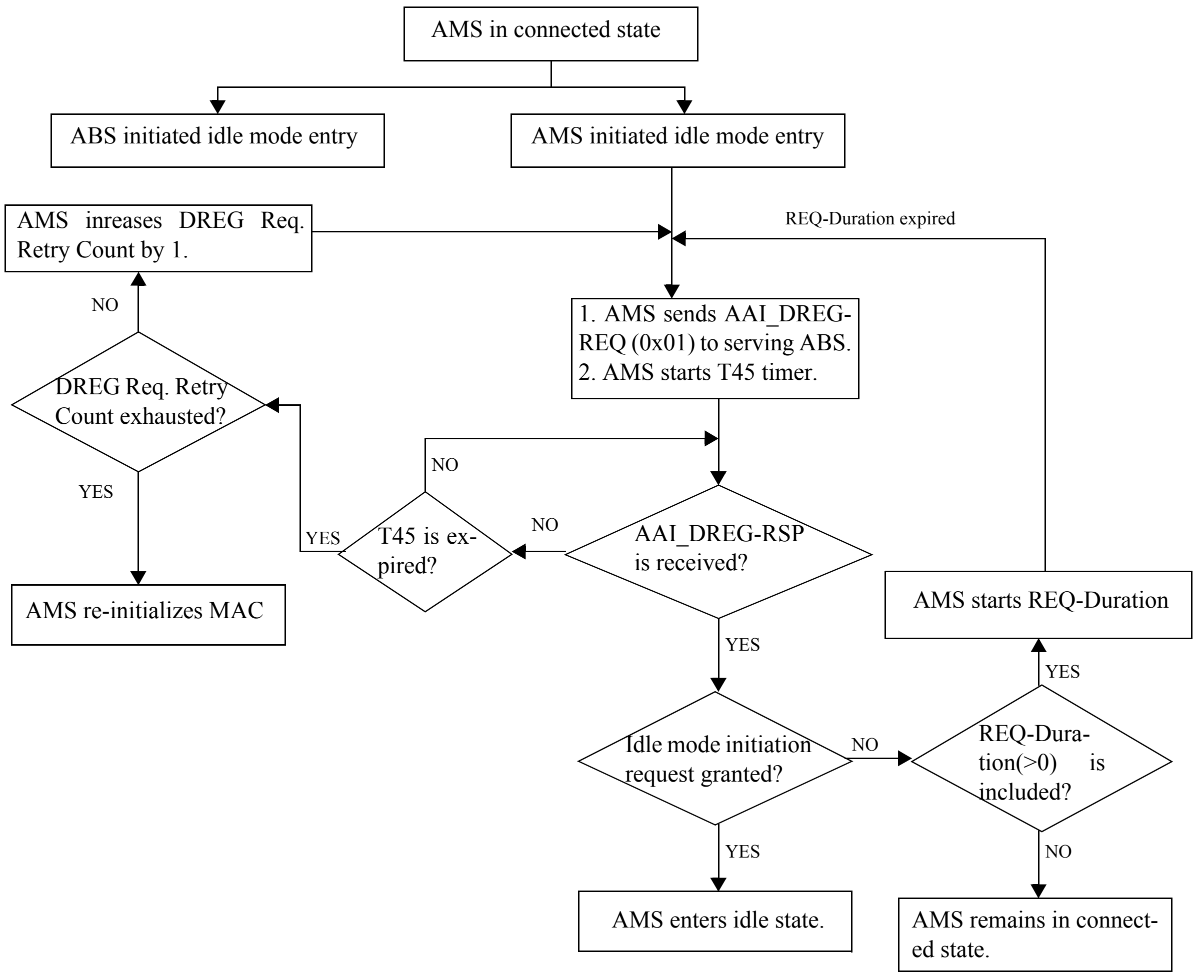


Figure 445—Procedures during AMS initiated idle mode entry

16.2.17.1.2 ABS initiated

Using ABS initiated idle mode entry, a serving ABS may signal for an AMS to begin idle mode by sending an AAI_DREG-RSP message with action code 0x05 in unsolicited manner. This unsolicited AAI_DREG-RSP may include REQ-Duration TLV. When an AMS receives an unsolicited AAI_DREG-RSP without REQ_Duration TLV, the AMS shall immediately start the idle mode initiation procedures. In this case of ABS-initiated idle mode, after sending the AAI_DREG-RSP message with action code 0x05, the serving ABS shall start T46 timer as well as Management_Resource_Holding_Timer at the same time. If the ABS does not receive the AAI_DREG-REQ message with the De-registration_Request_Code parameter = 0x02 or the AAI_DREG-REQ message with the De-registration_Request_Code parameter = 0x03 from the AMS in response to the unsolicited AAI_DREG-RSP message with action code 0x05 within T46 timer expiry, the ABS shall retransmit the AAI_DREG-RSP message with action code 0x05 in unsolicited manner as long as DREG command retry count has not been exhausted. When the AMS sends the AAI_DREG-REQ message with the De-registration_Request Code parameter = 0x02 in response to the unsolicited AAI_DREG-RSP message with action code 0x05, the AMS shall send AAI_DREG-REQ message with polling bit set to 1 in MCEH. The AMS shall not enter idle mode immediately after sending a message indicating that it will enter idle mode, because that message could get lost in the air link. Rather, the AMS shall wait for AAI_MSG-ACK message from the ABS. If the AMS detects the AAI_MSG-ACK message, the AMS shall enter idle mode. Otherwise, the AMS shall send the same AAI_DREG-REQ message with the request for the AAI_MSG-ACK message again. If the AMS has a pending UL data to transmit, it shall send AAI_DREG-REQ message with De-registration_Request Code parameter = 0x03 in response to the unsolicited AAI_DREG-RSP message with action code 0x05 by the ABS. These procedures are illustrated in Type 1 in Figure 446, Figure 447 and Figure 448.

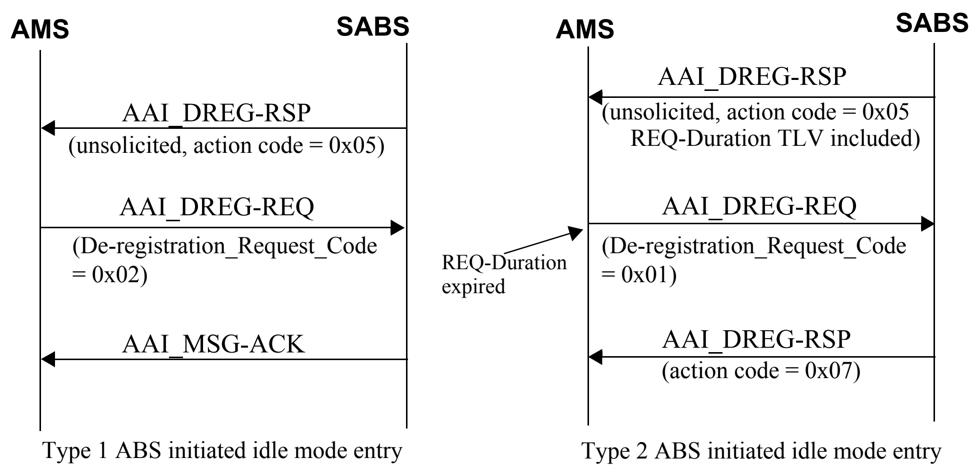


Figure 446—Call flow for ABS initiated idle mode entry

As another case of ABS initiated Idle Mode, the serving ABS may also include a REQ-duration TLV with an Action Code = 0x05 in the AAI_DREG-RSP, signaling for an AMS to initiate an Idle Mode request through a AAI_DREG-REQ with De-registration_Request_Code = 0x01, request for AMS De-Registration from serving ABS and initiation of AMS Idle Mode, at REQ-duration expiration. In this case, ABS shall not start T46 timer. AMS may include Idle Mode Retain Information TLV with in AAI_DREG-REQ message with De-Registration_Request Code = 0x01 transmitted at the REQ-duration expiration. If the ABS receives the AAI_DREG-REQ with De-registration_Request_Code=0x01, the ABS shall transmit another AAI_DREG-RSP message with Action Code=0x07 including Idle Mode Retain Information TLV. These procedures are illustrated in Type 2 in Figure 446, Figure 449 and Figure 450.

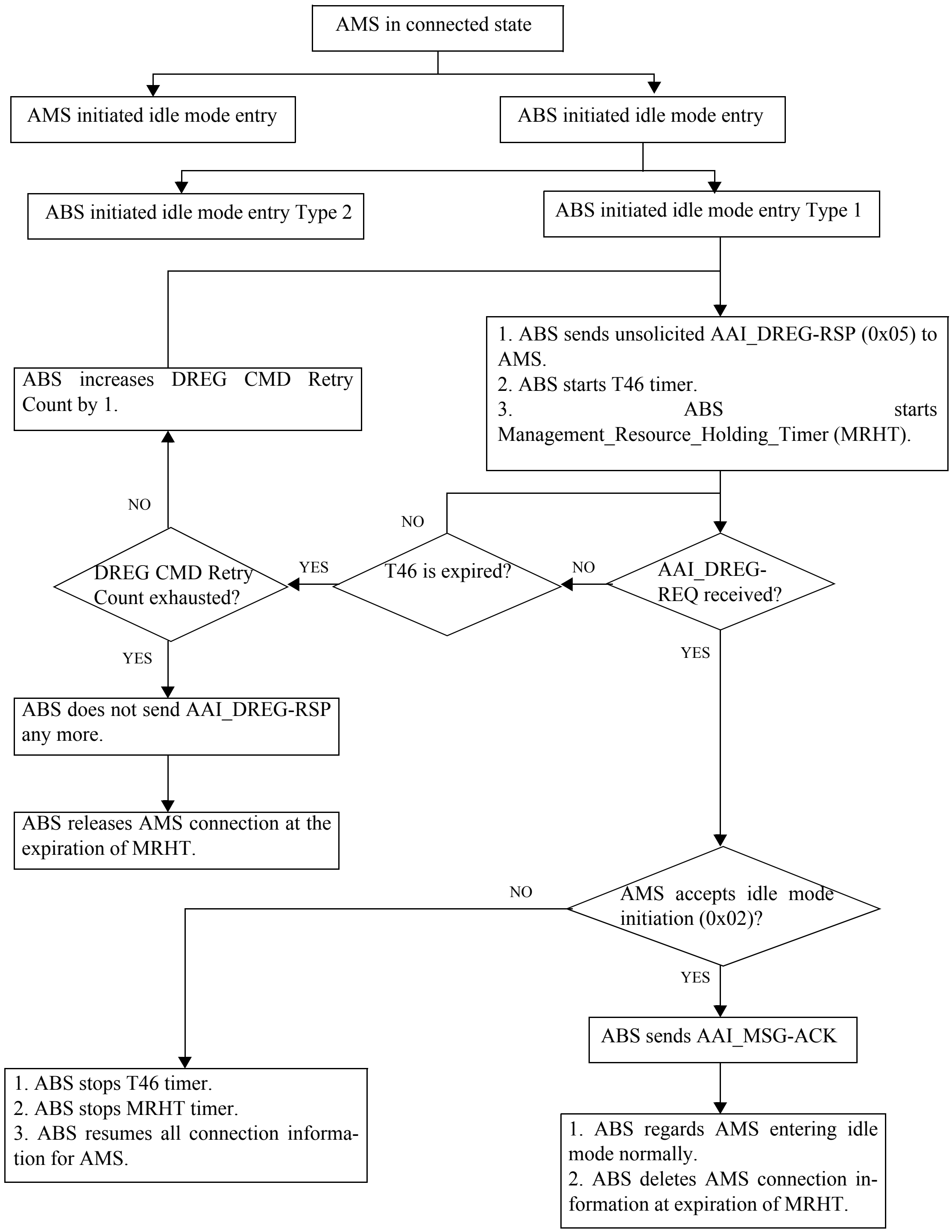


Figure 447—ABS Procedures during Type 1 ABS initiated idle mode entry

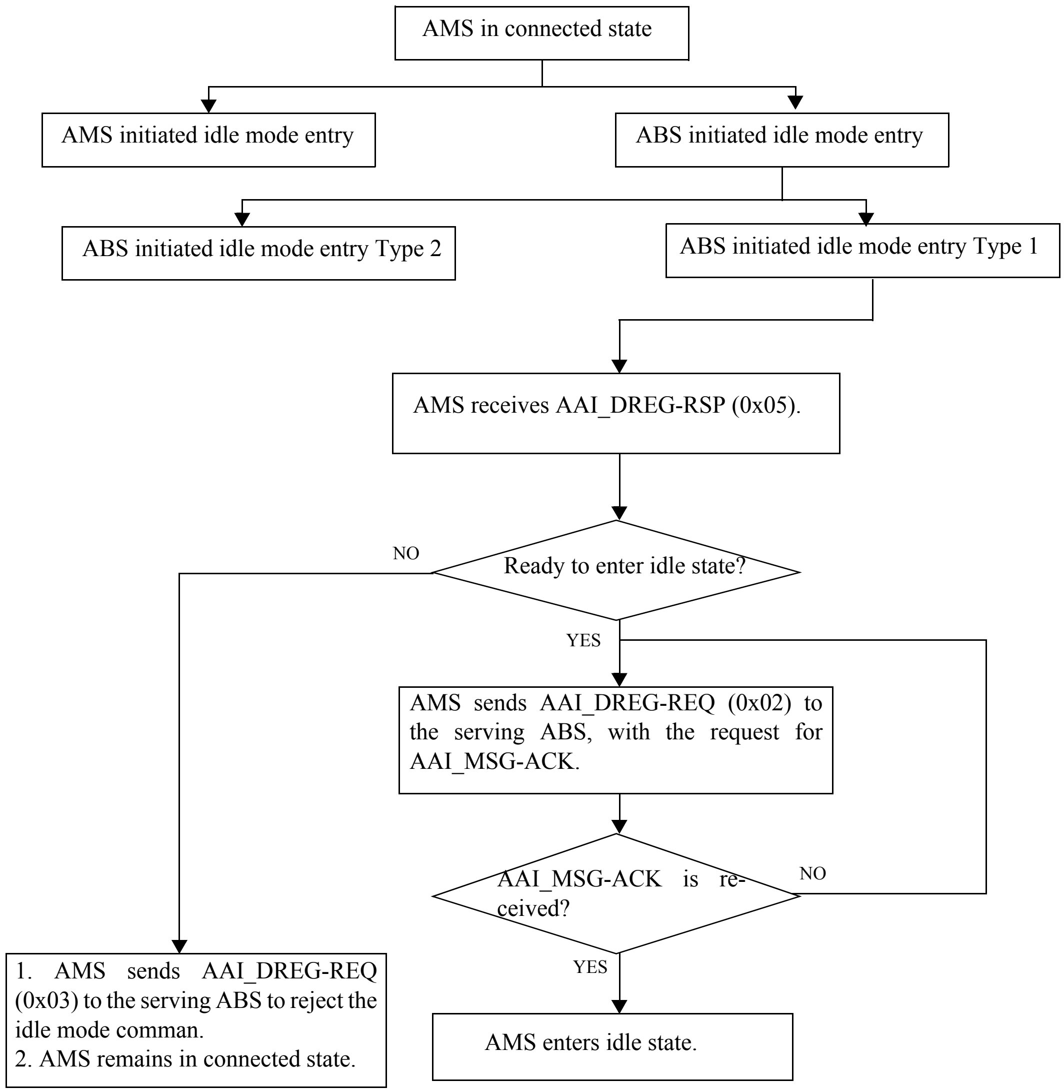


Figure 448—AMS Procedures during Type 1 ABS initiated idle mode entry

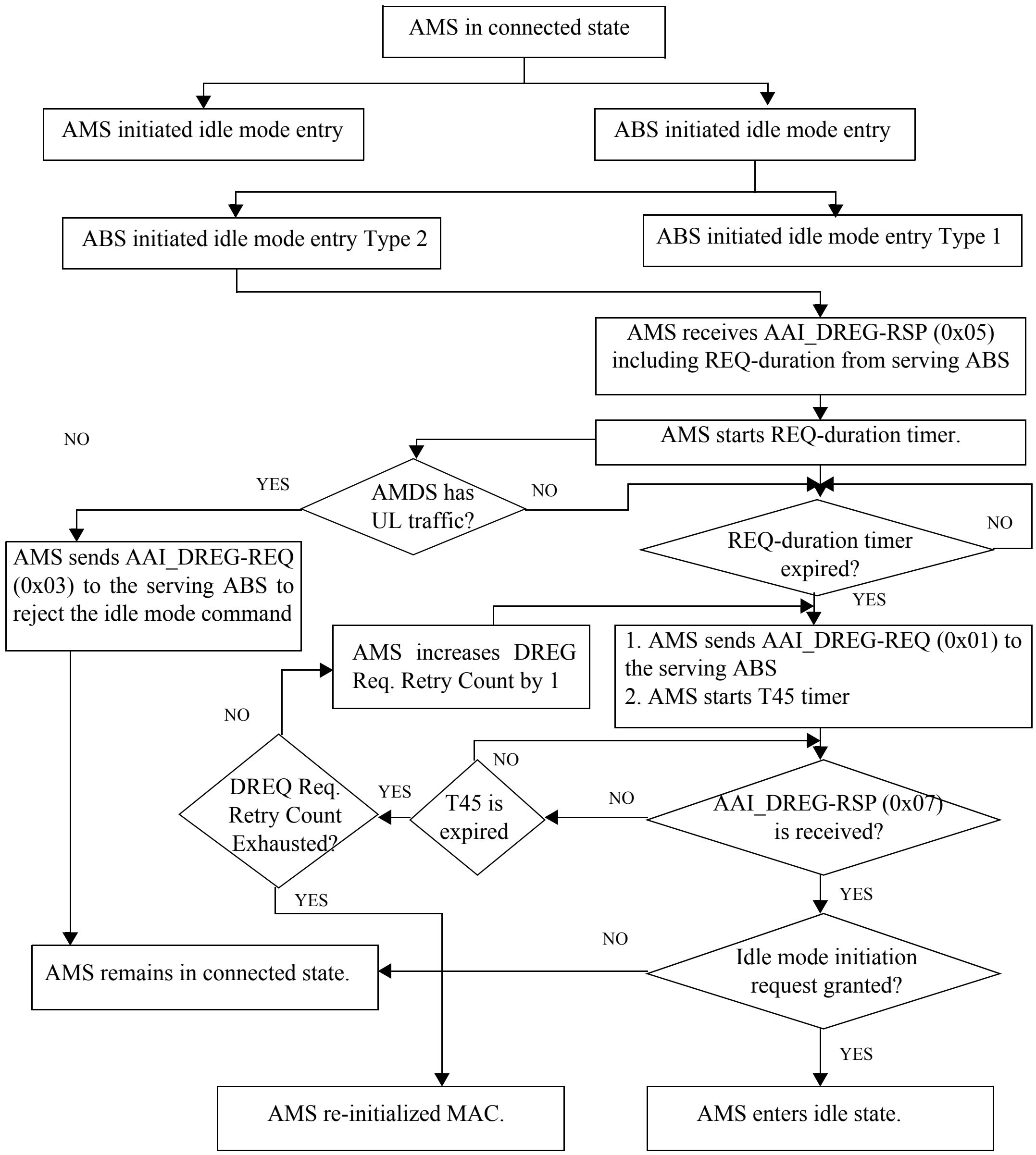


Figure 449—AMS Procedures during Type 2 ABS initiated idle mode entry

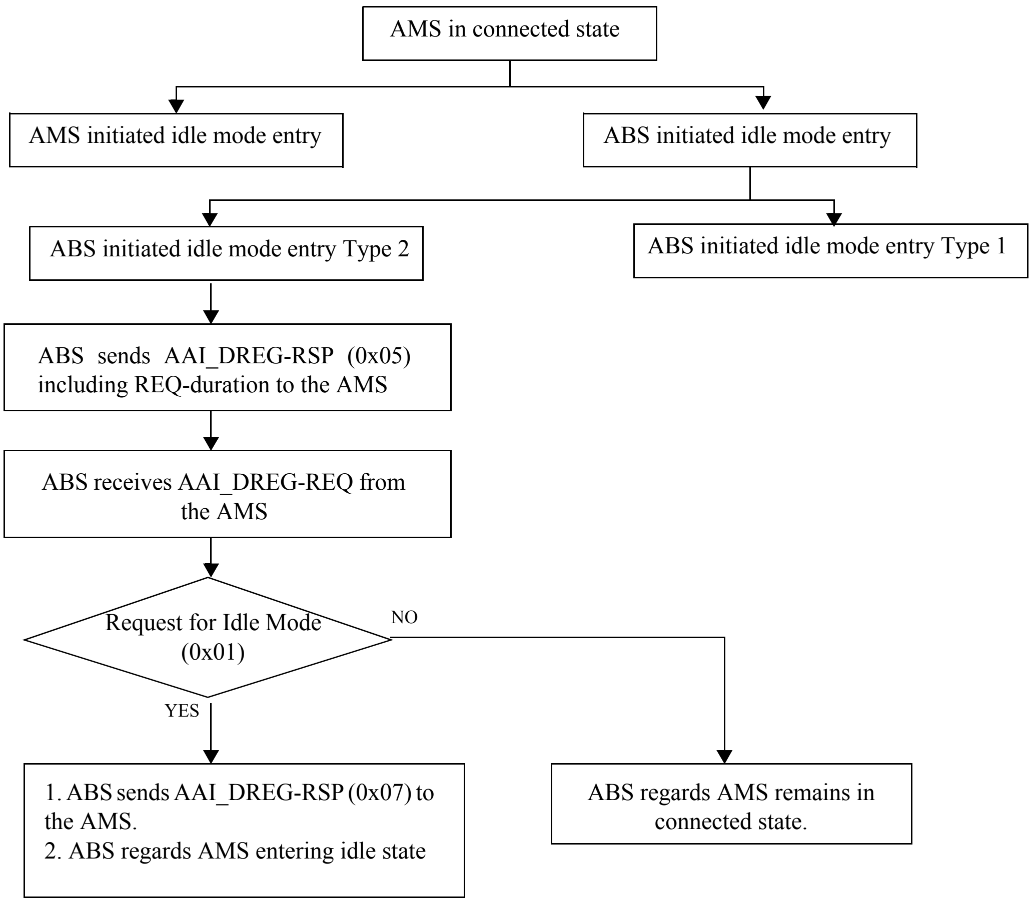


Figure 450—ABS Procedures during Type 2 ABS initiated idle mode entry

16.2.17.2 Operation during Idle mode

16.2.17.2.1 Broadcast paging message

A Paging message is an AMS notification message which either indicates the presence of DL traffic pending for the specified AMS or it is intended to poll an AMS and request a location update without requiring a full network entry. In addition, an emergency alert indicator is included in the paging message to notify the idle AMSs reception of the emergency information. Upon reception of the emergency alert indicator that is set to '1', the AMS shall decode the A-A-MAP to obtain the emergency information.

A single Paging message may include the information for multiple AMSs.

Paging message includes identification of the AMSs to be notified of DL traffic pending, location update.

The Paging message also includes an action code directing each AMS notified via the inclusion of its identifier as appropriate:

- 0b0: Perform network reentry
- 0b1: Perform ranging to establish location

An AMS shall terminate idle mode and reenter the network if it decodes a paging message that contains the AMS's identification and action code 0b0 (Re-enter Network). In the event that an AMS decodes a paging message that contains the AMS's identification and action code 0b1, it performs ranging for location update. When the AMS decodes a paging message that does not include its identification, it means that the AMS is not being paged and the AMS may enter its next paging unavailable interval.

The ABS shall transmit the paging message within a frame known to both the ABS and the AMS. The remaining message, if any, shall be transmitted in the very next AAI subframe of the frame. If the overflow happens in the last DL AAI subframe of a frame, then the remaining message is transmitted in the next frame. The extension of paging listening interval shall be indicated by the extension flag in the paging message. Thus, in this case, an idle mode AMS remains awake and monitors the subsequent AAI subframe or frames for paging message. After receiving the complete paging message, the idle mode AMSs returns to paging unavailable interval if the AMS is not paged.

Table 767—Parameters for AAI_PAG-ADV message format

Name	Value	Usage
Paging_Group_IDs bitmap	Each bit in the bitmap indicates: 0: the paging information for the corresponding PGID is not included 1: the paging information for the corresponding PGID is included	The size of Paging_Group_IDs bitmap equals to the number of paging group IDs in the PGID_Info message.
Num_AMSs	Number of paged AMSs in a particular paging group	For each non-zero bit in the Paging_Group_IDs bitmap, there shall be one Num_AMSs.
Deregistration Identifier	0~1023	Deregistration Identifier and Paging Cycle are used to identify each paged AMS.
Paging Cycle	0b0000~0b1111	Deregistration Identifier and Paging Cycle are used to identify each paged AMS.
Action Code	0b0 = Perform network reentry 0b1 = Perform ranging to establish location	Paging action instruction to each paged AMS.
Extension Flag	0 = There is no remaining part of this paging message 1 = The remaining part of this paging message will be transmitted in the subsequent frame or sub-frame	If the ABS cannot transmit the entire paging message in a predetermined region, the Extension Flag will be set to 1. Then the remaining part of the paging message is transmitted in the earliest subsequent frame or sub-frame.
Emergency Alert Indication	0 = There is no emergency information 1 = There is emergency information	If the emergency alert indicator is set to '1', the AMS shall decode the A-A-MAP to obtain the emergency information.

16.2.17.2.2 Operation during paging unavailable interval

An ABS shall not transmit any DL traffic or paging message to the AMS during paging unavailable interval.

During paging unavailable interval, the AMS may power down, scan neighbor ABSs, select a preferred ABS, conduct ranging, or perform other activities for which the AMS will not guarantee availability to any ABS for DL traffic.

An AMS may reselect its preferred ABS during paging unavailable interval by evaluating and selecting an ABS with the best air interface DL properties which may include the RSSI, CINR, cell type and the available radio resources, etc.

At evaluation and selection of the preferred ABS, the AMS shall synchronize and decode the SFH (superframe header) for the preferred ABS and extract the super-frame number to determine the time that is remaining until the next regular paging listening interval for the preferred ABS. The calculated time until the next regular paging listening interval shall be the paging unavailable interval.

16.2.17.2.3 Operation during paging listening interval

The AMS derives the start of the paging listening interval based on the paging cycle and paging offset. The paging listening interval shall comprise of the superframe whose superframe number $N_{superframe}$ meets the condition.

$$N_{superframe} \text{ modulo PAGING\_CYCLE == PAGING\_OFFSET}$$

The length of the paging listening interval is one superframe per paging cycle.

At the beginning of the paging listening interval, the AMS shall scan and synchronize on the A-PREAMBLE of its preferred ABS and decode the P-SFH of the ABS.

The ABS shall transmit the PGID_Info at a predetermined location in the paging listening interval in order to advertise the paging group(s) that is supported by the ABS. The PGID_Info shall be transmitted by the ABS regardless of whether or not there any notifications for AMSs.

The ABS transmits the PGID_Info right after SFH and A-MAP of the 1st AAI subframe during AMS's paging listening interval as shown in Figure 451. The PGID_Info shall be transmitted as described in the section <<16.3.6.5.2.1>>.

The PGID_Info shall be present before any AAI_PAG-ADV message in the superframe. The PGID_Info includes the PGID(s) that the ABS belongs to.

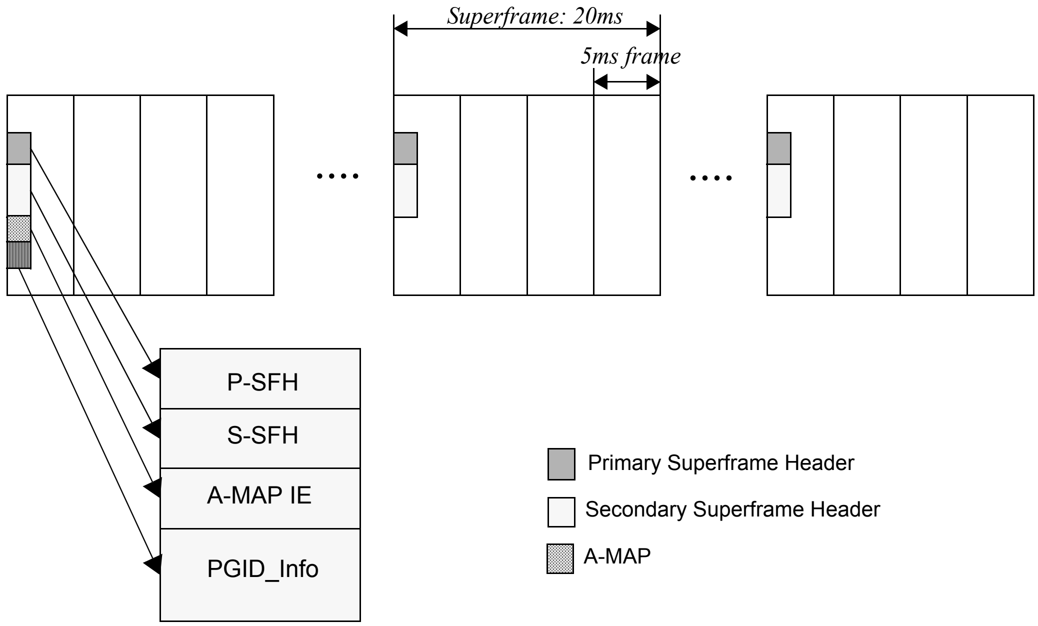


Figure 451—Transmission of PGID_Info

The PGID_Info format is presented in Table 768.

Table 768—PGID_Info Format

Name	Value
Num_PGIDs	Number of paging groups in the ABS
PGID	Identifier of paging group ($0\sim2^{16}$)
m	Time domain hash parameter (1 ~ 4) used to determine the frame number of a superframe for paging message transmission of an idle mode AMS.

The AMS shall determine whether it exists in the same paging group at the preferred ABS as it has most recently belonged using the PGID_Info.

If the AMS determine that its paging group has changed, the AMS shall perform idle mode location update as described in section 16.2.23.

If the P-SFH indicates a change in essential system parameters and system configuration information, the AMS shall acquire the latest essential system parameters and system configuration information when the system information is broadcast by the ABS.

The AMS shall monitor pre-determined frame for paging message. The pre-determined frame $N_{paging\ frame}$ for an AMS is implicitly determined as follows:

$N_{paging\ frame}$ = AMS's deregistration identifier mod m,

where m=1 or 2 or 3 or 4

m is indicated by an ABS using the PGID_Info message.

If AMS's identification is included in the paging message, the AMS shall perform network reentry or location update depending on the notification in the paging message. Otherwise, the AMS may return to the paging unavailable interval.

16.2.17.3 Idle mode termination

Idle mode may only be terminated through

- AMS reentry to the network
- Paging controller detection of AMS unavailability through repeated, unanswered paging messages
- Expiration of the idle mode timer
- AMS enters DCR mode from Idle mode

An AMS may terminate idle mode at any time. For the termination of the idle mode, the AMS performs network reentry with its preferred ABS as described in section 16.2.17.5. If the preferred ABS has Cell Bar bit=1 in its S-SFH, the AMS should re-select other ABS for network re-entry.

16.2.17.4 Location update

Location update comprises condition evaluation and update processing.

16.2.17.4.1 Location update trigger conditions

An AMS in idle mode shall perform a location update process operation if any of the location update trigger condition is met. There are four location update evaluation conditions: paging group based update, timer based update, power down update and MBS update. AMS may also perform location update process at will.

When an AMS performs location update, the AMS may include Paging Cycle Change TLV in RNG-REQ message to change the paging cycle. An ABS may also change AMS's paging cycle by requesting the AMS to perform location update using the paging message with action code = 0b1 (i.e., Perform ranging to establish location and acknowledge message). Whether an AMS has requested or an ABS has initiated, the ABS shall include appropriate Paging Information in the RNG-RSP message, in response to RNG-REQ message including Paging Cycle Change TLV sent by the AMS during Location Update.

An AMS may inform its mobility (slow, medium, fast) during location update procedure. The AMS mobility information may be used to assign new paging group(s) to the AMS.

During location update, AMS may update deregistration identifier, paging cycle and paging offset.

16.2.17.4.1.1 Paging group based update

An AMS shall perform Location Update process when an AMS detects the current paging group is not in its assigned paging group. The AMS shall detect the change of the paging groups by monitoring the PG IDs, which are transmitted by the preferred ABS during the paging listening interval. If none of the PG ID(s), to which the AMS belongs, is detected, the AMS shall determine that the paging group(s) has changed and perform a Location Update.

ABSs and Idle Mode AMSs may belong to multiple paging groups. In case an AMS belongs to multiple paging groups, it starts Paging Group Location Update Timer (PG_LU_TIMER) when it leaves primary paging group and enters a secondary paging group. An AMS performs the paging group location update after PG_LU_TIMER expires and may inform its mobility (slow, medium, fast) to ABS. Based on the AMS mobility information, the ABS may assign new paging group(s) of different size(s) to AMS.

If the AMS returns to the primary paging group before the expiration of PG_LU_TIMER, it releases the timer and does not perform location update.

16.2.17.4.1.2 Timer based update

An AMS shall periodically perform location update process prior to the expiration of the idle mode timer. At every location update including the paging group location update, the idle mode timer is reset to 0 and restarted.

16.2.17.4.1.3 Power down update

An AMS shall attempt to complete a location update once as a part of its orderly power down procedure. This mechanism enables network entity to update the AMS's exact status and to delete all information for the AMS and discontinue idle mode paging control for the AMS at the time of power down. At the time of successful power down location update, the paging controller shall release all idle mode retaining information related to the AMS.

16.2.17.4.2 Location update process

If an AMS in idle mode determines or elects to update its location, depending on the security association the AMS shares with the preferred ABS, the AMS shall use one of two processes: secure location update process or unsecure location update process. After synchronization with its preferred ABS and getting P-SFH, if the AMS finds that it does not have the updated information after comparing the system configuration change count, the AMS needs to get the S-SFH or extended system parameters and system configuration information from the preferred ABS.

If the AMS shares a valid security context with the preferred ABS so that the AMS includes a valid CMAC Tuple in the AAI_RNG-REQ message, then the AMS shall conduct initial ranging with the ABS by sending a AAI_RNG-REQ message including Ranging Purpose Indication set to Location Update Request and Paging Controller ID and the CMAC Tuple.

If the ABS evaluates the CMAC Tuple as valid and supplies a corresponding authenticating CMAC Tuple, then the ABS shall reply with an encrypted AAI_RNG-RSP message including the Location Update Response completing the location update process. If paging group has changed, then the ABS shall include Paging Group ID in the AAI_RNG-RSP message.

If the AMS and the ABS do not share a current, valid security context, or if the ABS for any reason has elected to instruct the AMS to use Unsecure Location Update, they shall process Location Update using the Network Reentry procedure from Idle Mode.

16.2.17.5 Network reentry from idle mode

For the network reentry from idle mode, the AMS shall initiate network reentry with the ABS by sending a ranging sequence from Handover Ranging domain. When the ranging processs is successful, the AMS sends an AAI_RNG-REQ message including the Ranging Purpose Indication set to network reentry from idle mode and Paging Controller ID. If the AMS shares a valid security context with the ABS so that the AMS includes a valid CMAC Tuple in the AAI_RNG-REQ message, then the AMS shall conduct initial ranging with the ABS by sending a AAI_RNG-REQ message including CMAC Tuple. If the ABS evaluates the CMAC Tuple as a valid and supplies a corresponding authenticating CMAC Tuple, then the ABS shall reply with an encrypted AAI_RNG-RSP message. The network reentry procedure may be shortened if the ABS possesses AMS's information which may be obtained from paging controller or other network entity over the backbone network.

16.2.17.6 Idle Mode Support for MBS

16.2.17.6.1 MBS location update

An AMS in idle mode, with one or more MBS service flows, shall perform a location update process when the AMS detects a change in the MBS Zone unless the AMS already has the MBS information in the target MBS zone. The AMS detects the change of MBS Zone by monitoring the MBS zone identifier list which is transmitted by the preferred ABS. If the MBS zone identifier list detected does not include the MBS zone identifiers for all MBS flows to which the AMS belongs, the AMS shall determine that the MBS Zone has changed.

Idle Mode Support for SON/Femto is specified in 16.4.9.

16.2.18 Deregistration with content retention (DCR) mode

Deregistration with content retention (DCR) mode is a mode in which an AMS is deregistered from the network while its context is kept in a network entity until the Resource Retain Time is valid.

While the Resource Retain Time is valid, the network retains AMS's information which is used to expedite AMS's network reentry.

CRID is used to uniquely identify the DCR mode AMSs.

16.2.18.1 DCR initiation in connected state

AMS may initiate DCR mode by transmitting an AAI_DREG-REQ message with the Deregistration_Request_Code parameter= 0x04; request for AMS deregistration from serving ABS and retention of AMS's connection information. The AMS may request the network to retain specific AMS service and operational information for DCR mode management purposes through inclusion of the Idle Mode Retain Information element in the AAI_DREG-REQ. When the ABS decides to allow AMS's DCR mode request, the ABS shall send an AAI_DREQ-RSP with action code 0x08 in response to the AAI-DREG-REQ message. When ABS decides to reject AMS's DCR mode request, the ABS shall send an AAI_DREQ-RSP with action code 0x09 in response to the AAI_DREG-REQ message.

16.2.18.2 DCR mode initiation from idle mode

AMS may initiate DCR mode in idle mode state by performing the location update with ranging purpose code Bit#5 is set to 1 in AAI_RNG-REQ message for transition to DCR mode.

When the ABS decides to allow AMS's DCR mode request, the ABS shall send a AAI_RNG-RSP with action code 0x04. When ABS decides to reject AMS's DCR idle mode request, the ABS shall send an AAI_RNG-RSP with action code 0x05.

Upon successful DCR mode change request, the network shall initiate DCR mode operation by retaining AMS's information until the Resource Retain Time is valid. At the time of DCR mode change, the CRID shall be used to uniquely identify DCR mode AMS.

16.2.18.3 DCR mode extension

An AMS in DCR mode can extend its Resource Retain Time by sending a AAI_RNG-REQ message with ranging purpose code Bit#1 is set to 1 in combination with CRID to extend the timer before it expires. When the ABS decides to allow AMS's extension request, the ABS shall send an AAI_RNG-RSP with location update response=0x04 in response to the AAI_RNG-REQ message. The ABS may also reject AMS's extension request, in this case, the ABS shall send an AAI_RNG-RSP with location update response=0x05 in response to the AAI_RNG-REQ message. Upon receiving the rejected indication in AAI_RNG-RSP, the AMS shall perform reentry to the network as defined in section 16.2.18.4.

16.2.18.4 Network reentry from DCR mode

For the network reentry from DCR mode, the AMS shall initiate network reentry with the ABS by sending an AAI_RNG-REQ message with ranging purpose code Bit#6 is set to 1 and the CRID. Rest of reentry procedure shall be performed same as network reentry from idle mode described in section 16.2.17.5.

16.2.18.5 DCR mode termination

DCR mode may only be terminated through:
- AMS reentry to the network
- Expiration of the Resource Retain Time

16.2.19 Co-Located Coexistence (CLC)

AMS conducts pre-negotiated periodic absences from the serving ABS to support concurrent operation of co-located non 802.16 radios, e.g. IEEE 802.11, IEEE 802.15.1, etc., and the time pattern of such periodic absence is referred by ABS and AMS as CLC class.

Terminologies used in this section:
- CLC active interval: the time duration of a CLC class designated for co-located non 802.16 radio activities
- CLC active cycle: the time interval of the active pattern of a CLC class repeating
- CLC active ratio: the time ratio of CLC active intervals to CLC active cycle of a CLC class
- CLC start time: the start time of a CLC class
- number of active CLC classes: the number of active CLC classes of the same type of an AMS

There are three types of CLC classes, and they differ from each other in terms of the time unit of CLC start time, active cycle and active interval, as shown in Table 769—. Support of all three types of CLC classes is mandatory for ABS, and optional for AMS.

Table 769—Time unit of CLC class parameters

	CLC active cycle	CLC active interval	CLC start time
Type I	microsecond	AAI subframe	AAI subframe
Type II	frame	AAI subframe	frame
Type III	not applicable	superframe	superframe

AMS shall determine CLC active interval and CLC active cycle based on the activities of its co-located non 802.16 radios and its 802.16 performance requirements. AMS shall determine CLC start time of Type I CLC class. ABS shall determine CLC start time of Type II or III CLC class.

Type I CLC class is recommended for non 802.16 radio activity that is low duty cycle, and may not align with 802.16 frame boundary. Otherwise, Type II CLC class is recommended for better scheduling flexibility. Type III CLC class is recommended for continuous non-802.16 radio activity that lasts long time, e.g. seconds.

The serving ABS manages each type of CLC class with the following three limits:

- R_i : maximum CLC active ratio (%)
- T_i : maximum CLC active interval
- N_i : maximum number of active CLC classes

Here i is set to 1, 2, and 3 to indicate Type I, II, and III CLC class, respectively.

ABS may include the CLC Limits in AAI_REG-RSP. The higher value of a limit indicates better support for non-AAI radio activities. The CLC limits, if set, shall be no less than the default values in Table 770. If not specified in AAI_REG-RSP, the CLC limits shall assume the values in Table 770.

Table 770—Default Value of CLC limits

	N_i	R_i	T_i
Type I	1	5%	8 AAI subframes (5ms)
Type II	1	30%	64 AAI subframes (40ms)
Type III	not applicable	not applicable	150 superframes (3 second)

The serving ABS shall not schedule A-MAP, data, and HARQ feedback of the AMS's allocations in the CLC active interval of an active CLC class. Whether only DL or only UL or both are prohibited depends on the configuration of the CLC class. The default is both DL and UL allocations are prohibited.

The ABS and AMS should set the starting time of a CLC class appropriately to prevent its CLC active interval from overlapping with SFH (super-frame header) as much as possible.

The ABS shall not schedule a Long TTI allocation when a CLC active interval overlaps with any part of the Long TTI allocation.

Any part of a previously scheduled persistent allocation that overlaps with a pre-negotiated CLC active interval shall not be transmitted in the designated resource. Since both the ABS and AMS have full knowledge of CLC activity, the ABS and AMS shall skip such a transmission that was scheduled during the CLC active interval. Non-persistent scheduling with all the attributes of the skipped allocation may be used to transmit such data at the next available opportunity. Subsequent persistent allocations that do not overlap with the CLC interval shall retain the attributes that were assigned in the Persistent Allocation A-MAP IE until an explicit de-allocation or re-allocation occurs. Implicit ACID cycling shall continue with the original pattern and the ACID corresponding to the skipped allocation is skipped in order to maintain the cycle.

When a pre-negotiated CLC active interval overlaps with any part of the initial transmission of a group resource allocation, the ABS shall not schedule the allocation in the designated resource and the GRA transmission shall be scheduled at the next available opportunity.

Any part of a synchronous HARQ retransmission that overlaps with a pre-negotiated CLC active interval shall not be transmitted in the designated resource. Since both the ABS and AMS have full knowledge of CLC activity, the ABS and AMS shall skip the retransmission that occurs in the CLC active interval, and continue to maintain the original timing relationship for all subsequent retransmissions. The retransmission number is incremented for the skipped retransmission.

Figure 452 illustrates the protocol for a skipped HARQ retransmission. In the example shown, the 1st retransmission is scheduled to occur in a CLC active interval. The 1st retransmission is skipped and the allocation originally scheduled for the 2nd retransmission is then used for the 1st retransmission. The allocation originally scheduled for the 3rd retransmission will be used for the 2nd retransmission and so on.

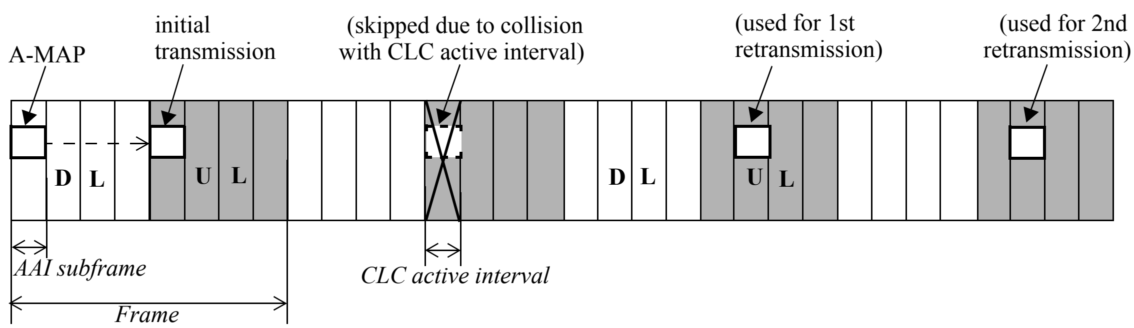


Figure 452—Skipping for Synchronous HARQ due to Collision with CLC Active Interval

The serving ABS shall accept the request from the AMS to activate a CLC class, and honor it (i.e., not unsolicited deactivate or change it after activation) if the requested CLC class meets the CLC limits. Otherwise, if the requested CLC class does not meet the CLC limits, the serving ABS may reject or accept the request, and even if the requested CLC class is accepted initially, the serving ABS may deactivate it at any time by sending unsolicited CLC Response. The process of determining whether a CLC class meets the CLC limits for Type I, II, and III classes is specified in 16.2.12.

The AMS, if needed, shall request to activate only one Type I or II CLC class during Basic Capability Negotiation. In this case, the CLC class parameters shall be set within the default CLC limits as shown in Table 770. The AMS may request to active one or several Type I or II CLC classes in the connected state. The AMS shall request to activate Type III CLC class only in the connected state. After the currently active Type III CLC class ends, the AMS shall wait for at least 5 minutes to request another Type III CLC class.

The AMS shall wait for at least 1 second to send new CLC Request since its last successful reception of CLC Response.

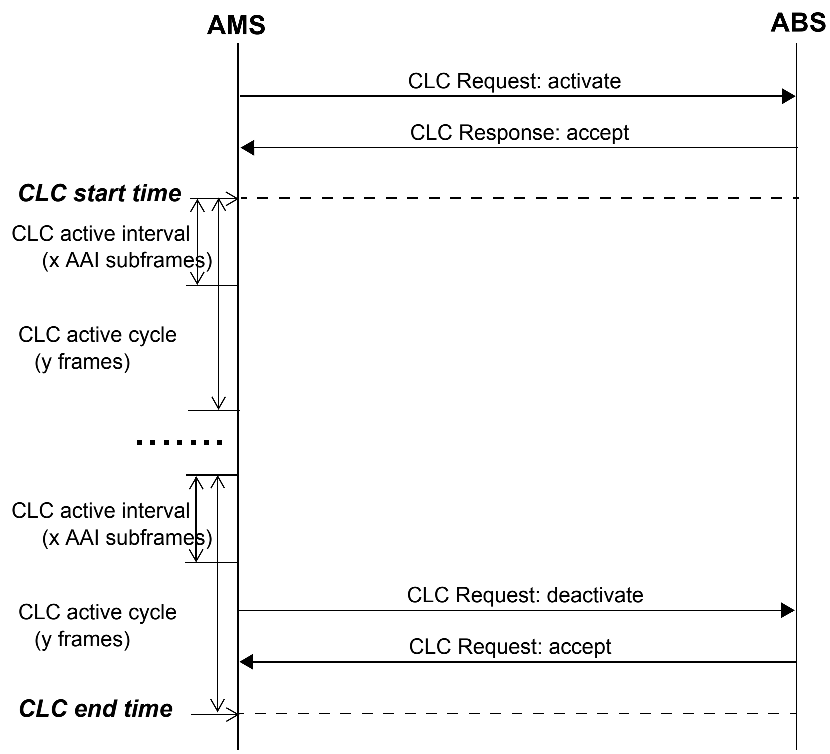


Figure 453—CLC Request / Response Exchange

The serving ABS should send CLC Response before the CLC start time defined in CLC Request. If the AMS receives CLC Response, or the ABS sends CLC Response, after the starting time of the CLC class that it activates, the ABS and the AMS shall consider the CLC class as active and starting at the beginning of the next CLC active cycle. If the class is Type III, the ABS and the AMS shall consider the CLC class starting immediately and ending at the ending superframe calculated with CLC start time and CLC active interval as defined in CLC Request.

An active CLC class shall remain active until it has been deactivated by the AMS no matter whether the AMS is in active mode, sleep mode, or scanning mode. The AMS may skip scanning operation in a scan interval if it overlaps with a CLC active interval. The AMS and the serving ABS shall locally deactivate all CLC classes after the AMS enters idle state.

The AMS shall locally terminate the active Type III CLC class at the Disconnect Time or upon transmission of AAI_HO-IND with code 0b10. The AMS shall also locally suspend all active Type I and II CLC classes at the Disconnect Time or upon transmission of AAI_HO-IND with code 0b10, and reactivate them with the new serving ABS. During HO preparation, the new serving ABS may obtain information on active CLC classes from the serving ABS via backbone network. The CLC active cycle and interval parameters shall remain the same. The new serving ABS shall set the Super Frame Number of the start time to the suggested value in CLC Request from the AMS in case of an uncoordinated handover, or in case of a coordinated handover, to the beginning of the next CLC active cycle based on the information obtained from the previous serving ABS via the backbone network. For Type II class, the new serving ABS may set the Start Frame Index of the start time different from the value in the AMS's CLC Request or from the previous serving ABS. For Type I class, the new serving ABS shall keep the Start Frame Index the same as suggested by the AMS or obtained from the previous serving ABS. The ABS shall send the start time information to the AMS in AAI_RNG-RSP during network reentry for fast reactivation if the AMS supports CLC mode. The AMS and the serving ABS shall automatically reactivate the suspended CLC classes if the handover is cancelled.

The AMS may use the CLC Report to provide ABS information about the characteristics of its co-located non-AAI radio activities.

The AMS shall wait for at least 100ms to send new CLC Request since its last successful transmission of CLC Request.

Figure 453— shows an example of CLC Request / Response exchange for activating and deactivating a Type II CLC class.

16.2.19.1 Type I CLC Class

The parameters for Type I CLC class (settings) are specified as follows:

- S_1 : start superframe number
- F_1 : start frame index
- f_1 : start AAI subframe index
- a_1 : time duration of CLC active intervals in each cycle (AAI subframe)
- b_1 : time duration of CLC active cycle (microsecond)

The combination of the start superframe number and the start frame index indicates in which frame the first CLC active cycle starts. The start AAI subframe index further indicates in which AAI subframe the first CLC active cycle of a Type I CLC class starts in a frame.

The following parameters are needed in addition to N_1, R_1, and T_1 in determining whether a Type-I CLC class meets the CLC limits:

- n_1 : number of currently active Type-I CLC classes for the requesting AMS
- s: latency limit (millisecond)
- d: latency margin (millisecond)
- m: total number of AAI subframes in a frame

The latency limit indicates the minimum value of the Maximum Latency parameter and the Tolerated Jitter parameter of all active service flows of the requesting AMS. It shall assume infinite if none of the active service flows of the requesting AMS has explicitly configured the Maximum Latency parameter or the Tolerated Jitter parameter. The latency margin provides additional time for meeting the Maximum Latency and Tolerated Jitter requirement of all active service flows of the requesting AMS, and shall be set to 10ms.

The default value of m is 8. m is 7 and 6 for 8.75MHz and 7MHz frame structure, respectively.

A Type-I CLC class meets the CLC limits, if all following conditions are met:

- $a_1 \le min(T_1, (s-d)/5 \times m)$
- $n_1 < N_1$
- $a_1/(m \times floor(b_1/5000)) \le R_1$

Figure 454— shows an example of Type I CLC class.

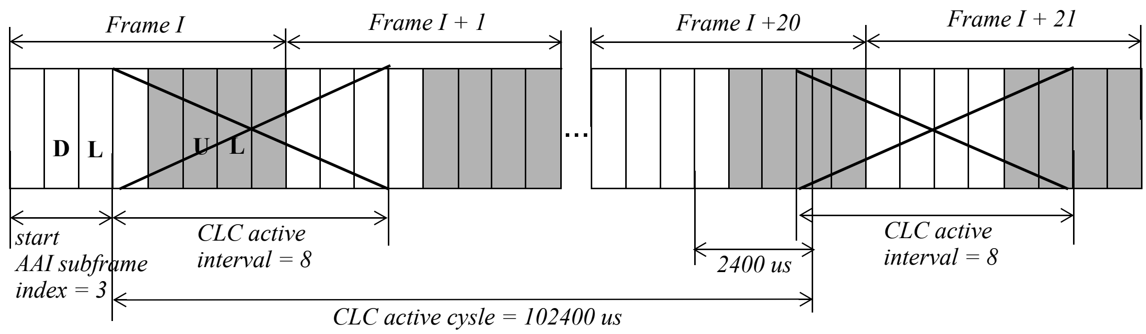


Figure 454—Type I CLC Class Example (a_1=8, b_1=102400)

16.2.19.2 Type II CLC Class

The parameters for Type II CLC class (settings) are specified as follows:

- S_2 : start superframe number
- F_2 : start frame index
- a_2 : time duration of CLC active intervals in each cycle (AAI subframe)
- b_2 : time duration of CLC active cycle (frame)

The combination of the start superframe number and the start frame index indicates in which frame the first CLC active cycle starts.

The following parameters are needed in addition to N_2 , R_2 , T_2 in determining whether a Type-II CLC class meets the CLC limits:

- n_2 : number of currently active Type II CLC classes for the requesting AMS
- s: latency limit (millisecond)
- d: latency margin (millisecond)
- m: total number of AAI subframes in a frame

AMS may use one of the following three subtypes to configure a Type II CLC Class, depending on the length of CLC Active Cycle, see Table 771. Support of Extended CLC Active Bitmap is optional for ABS.

Table 771—Type II CLC Class Subtype

Subtype	CLC Active Cycle (frame)	Information Elements
1	1	• CLC Active bitmap
2	>1	• CLC Active interval • CLC Active Cycle
3	2, 3, or 4	• Extended CLC Active bitmap

16.2.19.2.1 Type II CLC Class - Subtype 1

If CLC active cycle is one frame, the AMS shall use CLC Active Bitmap to configure a Type II CLC class. The bitmap setting is in unit of bit for indicating the CLC active interval within the designated frame, where the field set to "1" indicates the corresponding AAI subframe is CLC active interval. The first LSB of CLC Active Bitmap corresponds to the last AAI subframe of each frame. If a frame consists of m AAI subframes, the AMS and the serving ABS shall consider the first m-1 LSBs of the field, and never configure the first AAI subframe of a frame to be CLC active interval. There may be more than one inconsecutive CLC active intervals in each CLC active cycle.

A Type-II CLC class with Subtype 1 meets the CLC limits, if all the following conditions are met:

- $n_2 < N_2$
- $a_2 / m \le R_2$

Wherein, a_2 is set to the total number of "1" bits in CLC Active Bitmap.

Figure 455— shows an example of Type II CLC class with Subtype 1.

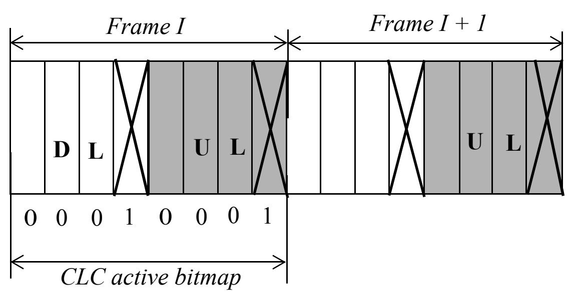


Figure 455—Example of Type II CLC Class Subtype 1 (a_2=2)

16.2.19.2.2 Type II CLC Class - Subtype 2

If CLC active cycle is more than one frame, the AMS should use Subtype 2 to configure a Type II CLC class.

A Type-II CLC class with Subtype 2 meets the CLC limits, if all following conditions are met:

- $a_2 \le min(T_2, (s - d) / 5 \times m)$
- $n_2 < N_2$
- $a_2 / (m \times b_2) \le R_2$

Figure 456— shows an example of Type II CLC class with Subtype 2.

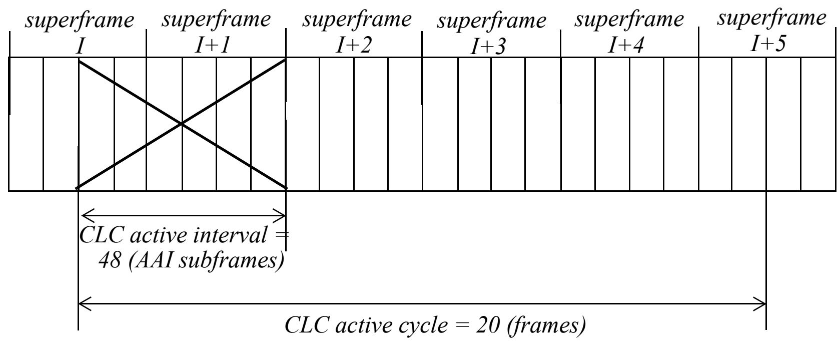


Figure 456—Example of Type II CLC Class Subtype 2 (a_2=48, b_2=20)

16.2.19.2.3 Type II CLC Class - Subtype 3

If Extended CLC Active Bitmap is enabled at ABS and CLC active cycle is 2, 3, or 4 frames, the AMS may use Subtype 3 to configure a Type II CLC class. The AMS shall never configure the first AAI subframe of a frame to be CLC active interval if Subtype 3 is used.

A Type-II CLC class with Subtype 3 meets the CLC limits, if all the following conditions are met:

- $n_2 < N_2$
- $a_2 / (m \times b_2) \leq R_2$

Wherein, a_2 is set to the total number of "1" bits in Extended CLC Active Bitmap, and b_2 is set to the bitmap length in bytes.

Figure 457— shows an example of Type II CLC class with subtype 3.

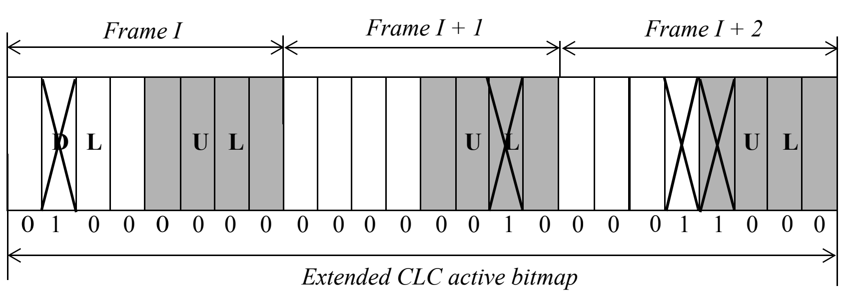


Figure 457—Example of Type II CLC Class Subtype 3 (a_2=4, b_2=3)

16.2.19.3 Type III CLC Class

The parameters for Type III CLC class (settings) are specified as follows:

- S_3 : start superframe number
- a_3 : time duration of the CLC active interval (superframe)

A Type-III CLC class meets the CLC limits, if all following conditions are met:

- $a_3 \le T_3$
- The AMS only has Best-Effort service flows active.

16.2.20 Interference Mitigation Mechanism

16.2.20.1 DL FFR

Fractional Frequency Reuse (FFR) techniques allow different frequency reuse factors to be applied over different frequency partitions. The maximum number of frequency partition is four. Note that the frequency partition is defined in 16.3.5.2.3.

The frequency partition boundary is aligned with PRU units. The frequency partitions are indexed from lowest Logical Resource Unit (LRU) index to highest LRU index. It always starts from reuse-1 partition if exists and then followed by the three reuse-3 partitions or two reuse-2 partitions depending on the value of DFPC and system bandwidth. They are numbered as frequency partition 0 (FP_0), which is the reuse-1 partition, frequency partition 1 (FP_1), which is the power boosted frequency partition, frequency partition 2 (FP_2), which is the first power de-boosted frequency partition, and frequency partition 3 (FP_3) which is the second power de-boosted frequency partition and FP3 doesn't exist for reuse-2. The frequency partition configuration is signaled using DFPC field in S-SFH SP2.

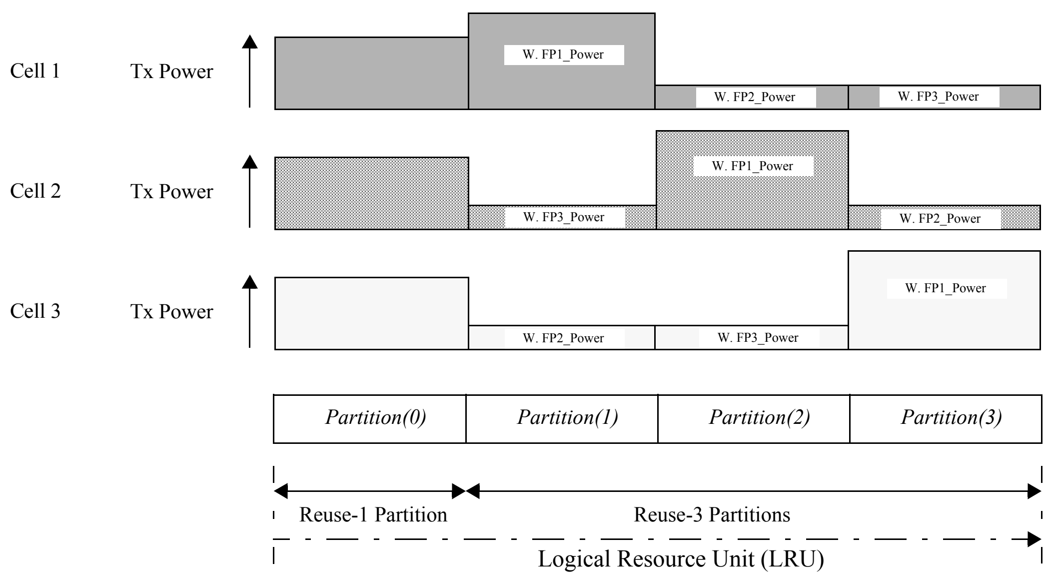


Figure 458—Basic concept of fractional frequency reuse for reuse-3 scenario

The boosted frequency partition is the partition whose power level is FP1_power. Each partition may have different power level per cell. The transmission power level on different frequency partitions is decided by ABS and signaled using AAL_DL_IM MAC management message or S-SFH SP3.

When FFR is applied in the cell (i.e., FPCT>1), the different FFR power pattern is used by different ABSs. When FPCT=4, for example, each ABS chooses one of the three FFR patterns (cell 1, cell 2 and cell 3 pattern) as shown in Figure 458 (when FPCT=3 and FPS_3>0, , the same FFR patterns exist only excluding FP_0). The index of FFR power pattern is set by a particular ABS with its Segment ID. That is, each ABS adopts the FFR power pattern corresponding to the Cell k in Figure 458 and k is decided by the following equation:

k = Segment ID + 1

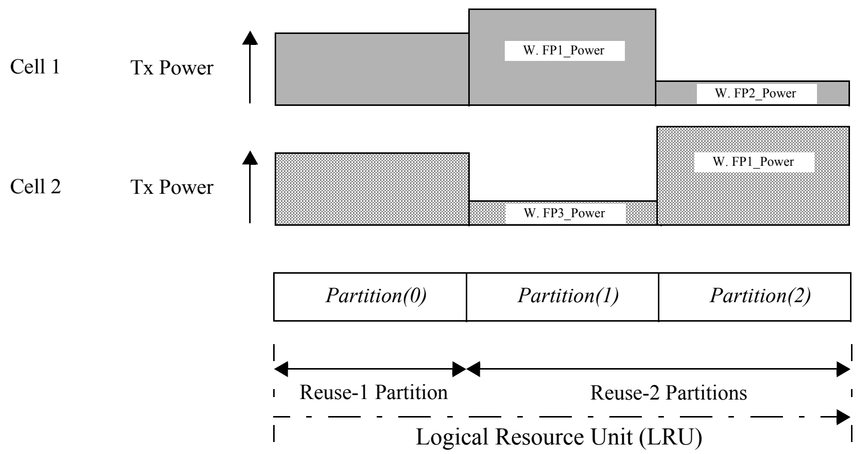


Figure 459—Basic concept of fractional frequency reuse for reuse-2 scenario

When FPCT=3 and FPS_3=0, for example, each ABS chooses one of the two FFR patterns (cell 1 and cell 2 pattern) as shown in Figure 459 (when FPCT=2, the same FFR patterns exists only excluding FP_0). The index of FFR power pattern is set by a particular ABS with its cell ID. That is, each ABS adopts the FFR power pattern corresponding to the Cell k in Figure 454 and k is decided by the following equation:

k = floor(IDcell/384) + 1

16.2.20.1.1 DL/UL Signaling

When supporting FFR operation, the AMS shall be capable to measure the interference statistics over specific frequency partitions for evaluating the preferred frequency partition. AMS shall be capable to report the preferred frequency partition through the fast feedback channel.

ABS can instruct AMS to feedback interference and/or SINR measurement for one or more frequency partitions through AAI_FFR-CMD message. AMS should report interference and/or SINR measurement for one or more frequency partitions through AAI_FFR-REP message as a response to AAI_FFR-CMD message. For MFM 0, 1, 4 and 7, ABS can instruct AMS to feedback wideband CQI and STC rate for one active frequency partition using Feedback Allocation A-MAP IE. For MFM 0 and 1, ABS can instruct AMS to feedback wideband CQI and STC rate for one more alternative frequency partition in addition to the active frequency partition by puncturing every 2q-th short period report for the active frequency partition. If ABS cannot serve the AMS by the recommended frequency partition, ABS can base on the interference statistics reported by AMS using AAI_FFR-REP to schedule DL data transmission.

AAI_DL_IM message or S-SFH SP3 includes resource metric information, as shown in Table 772, which is needed for AMS to select DL frequency partition in case of distributed permutation, or to select subband in case of localized Permutation.

Table 772—Resource metric information

Syntax	Size (bits)	Notes
Content format () {		
If (FPCT >= 3 and FPS_3>0) {		Reuse-3
for (i = 2; $i \leq 3$ **; i++) {**		

Resource_Metric FP_i	4	Resource metric for the two power de-boosted frequency partitions in reuse 3 frequency region.
		
		The resource metric of two power de-boosted frequency partitions is defined as a fractional number *x* between 0 and 1. It is encoded as an unsigned integer *y* from 0 to 15, and:
		
		if 0 <= *x* <0.5:
		y = floor(*x*/0.125)
		if 0.5 <= *x* < 0.8:
		y = floor(*x*-0.5)*8/0.3 + 4
		otherwise:
		y = floor((*x*-0.8)/0.05) + 12
		
		When AMS receives the quantized resource metric of two power de-boosted frequency partitions, it will decode the resource metric as below:
		if $0 \leq y < 4$:
		x = (y+1) *0.125
		if $4 \leq y < 12$:
		x = (y-3)*0.3/8 + 0.5
		if $12 \leq y \leq 15$:
		x=(y-11)*0.05 +0.8
		
		Resource metric of frequency partition FP_0 (reuse-1 partition) has fixed value equal to 1. Resource metric of frequency partition FP_1 with power boosting is calculated as following:
		Resource_Metric_FP_1 = 3- Resouce_Metric_FP_2 - Resouce_Metric_FP_3;

}		
} else if (FPCT>1 and FPS_3=0) {		Reuse-2
Resource_Metric_FP_2	4	Resource metric for the power de-boosted frequency partition in reuse 2 frequency region. The encoding method is the same as Resource_Metric_FP_2 and Resource_Metric_FP_3 for reuse-3. The resource metric for the power boosted frequency partition is as following: Resouce_Metric_FP_1=2- Resouce_Metric_FP_2
}		
}		

A Preferred Frequency Partition Indicator (PFPI) is required for AMS using Distributed Permutation to feedback its preferred partition. The PFPI is defined in PFBCH for PFBCH encoding type 0, 1, and 3, using 4 codewords with index 58 to 61. AMS can send PFPI to ABS in unsolicited manner. The PFPI sent in short report period with PFBCH encoding type 0, 1 and 3 indicates the new preferred active frequency partition by AMS. The PFPI sent in long report period with PFBCH encoding type 0, 1 and 3 indicates the new preferred alternative frequency partition by AMS. AMS will continue reporting CQI for one active frequency partition or one active frequency partition and one alternative frequency partition commanded by the latest Feedback Allocation A-MAP IE until ABS send a new Feedback Allocation A-MAP IE to reconfigure it.

Each frequency partition's power differences relative to the reference power level are broadcasted in AAI_DL_IM message.

16.2.20.1.2 Operation procedure

16.2.20.1.2.1 Broadcast and Update of DL FFR Information by ABS

FFR partition information is broadcasted in S-SFH SP2, and the resource metric is broadcasted in AAI_DL_IM message.

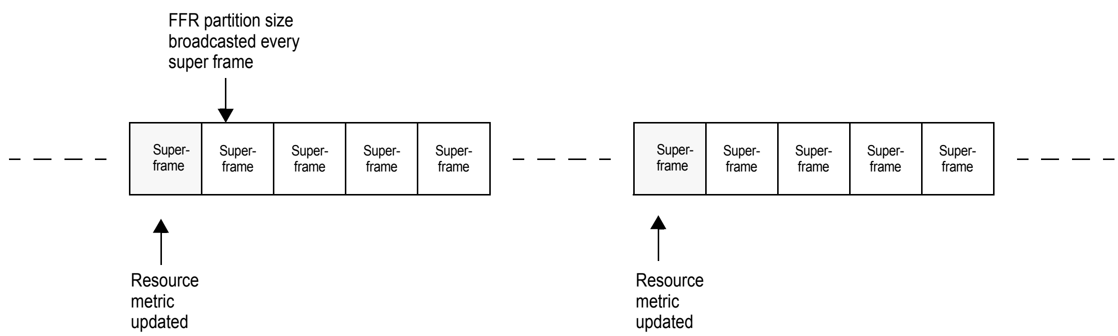


Figure 460—FFR partition size and resource metric

16.2.20.1.2.2 Feedback of Preferred Frequency Partition by AMS

In case of Distributed permutation, AMS sends Preferred Frequency Partition Indicator (PFPI) through PFBCH to ABS to indicate its preferred FFR partition, if it is different from the current FFR partition.

ABS may send a new Feekdbac allocation IE to respond to PFPI by AMS. After AMS receives a Feedback allocation IE, AMS shall send CQI report to ABS according to the new configuration.

Two examples of above operation procedure are illustrated in the following figures:

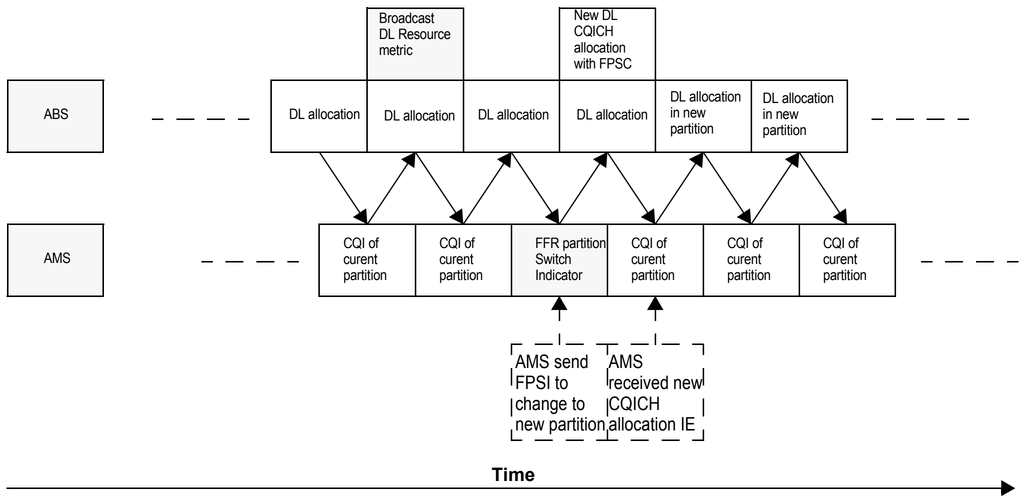


Figure 461—Example where AMS sends PFPI and ABS agrees to change FFR partition

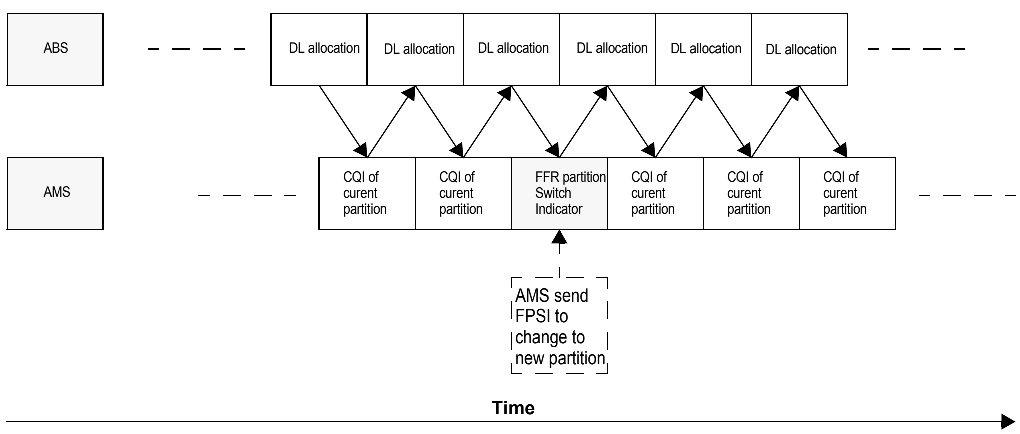


Figure 462—Example where AMS sends PFPI and ABS refuses to change FFR partition

16.2.20.1.2.3 Initial Frequency Partition at System entry

When AMS enters a system with FPCT>1, it initially uses the frequency partition indicated by ABS. Once the AMS has received the first superframe with resource metric information, it will start to use the resource metric to recommend its preferred partition to ABS in case of Miniband CRU/DRU, or select the preferred subbands in case of Subband CRU.

16.2.20.1.2.4 Frequency Partition Selection by AMS in case of Miniband CRU/DRU

AMS selects the preferred frequency partition follows.

AMS estimates average SINR on each frequency partition, and then computes the expected spectral efficiency (SE) for each partition. For example, the expected SE can be computed based on data rate, PER, and partition BW of one frequency partition as follows.

— Expected_SE = Data_Rate * (1-PER)/BW

The data rate is a function of average SINR per partition and is determined according to the modulation and coding rate selected by Link Adaptation procedure.

— Data_Rate is the uncoded data in length of bit transmitted on one or more Resource Unit(s) (RU) in the frequency partition.
— PER is the AMS estimated Packet Error Rate on the same RU(s).
— BW is the time and frequency resource occupied by the same RU(s).

AMS then calculates the normalized SE(i) of frequency partition (i) as follows:

— Normalized_SE(i) = Expected_SE(i) / Resource_Metric(i)

AMS compares the Normalized_SE(i) of all partitions, and selects the Partition with maximum Normalized_SE(i) as the Preferred Frequency Partition (PFP). The Normalized SE(i) can be smoothed (filtered) to avoid rapid changes in partition selection. If the PFP is different from previous partition choice, and has relatively stable higher normalized SE, AMS should send a PFPI through PFBCH to recommend the FP as its PFP..

16.2.20.1.2.5 Subband Partition Selection by AMS in case of Subband CRU

When AMS is using subband CRU, and Best-M feedback is enabled, it indicates to ABS its preferred subbands for downlink transmission. ABS can allocate DL resources in this preferred subband, and also can allocate DL transmission in other subband as needed.

AMS selects the preferred subband as follows.

AMS estimates average SINR on each subband of all frequency partition, and then computes the expected spectral efficiency (SE) for each subband. For example, the expected SE can be computed based on data rate, PER, and partition BW of each subband as follows.

— Expected_SE = Data_Rate * (1-PER)/BW

The Data Rate is a function of average SINR per subband and is determined according to the modulation and coding rate selected by Link Adaptation procedure.

— Data_Rate is the uncoded data in length of bit transmitted on the or more Resource Unit(s) (RU) in the subband.
— PER is the AMS estimated Packet Error Rate on the same RU(s).
— BW is the time and frequency resource occupied by the same RU(s).

AMS then calculates the normalized SE of each subband as follows.

— Normalized_SE(m) = Expected_SE(m) / Resource_Metric(i).

Here, 'i' is the frequency partition index of the corresponding subband 'm'. AMS then selects the subband with maximum Normalized_SE(m).

16.2.20.2 UL FFR

UL FFR allows the system to designate a different UL IoT control parameter, i.e., γ_{IoT} per frequency partition. Note that the UL frequency partition is defined in 16.3.8.2.3.

For UL FFR, the ABSs shall be capable to measure the interference statistics over each frequency partition. In order to support UL FFR, the ABS transmits necessary information. UL FFR configuration including the number of frequency partitions and size of each frequency partition is broadcasted through S-SFH. The S-SFH SP2 IE related to UL FFR is given in 16.3.6.5.1.2. The UL frequency partition configuration (UFPC) information is given in 16.3.8.2.3. Also, UL IoT control parameter for each frequency partition is broadcasted as shown in 16.2.3.29 through ABI.

UL IoT control parameter, γ_{IoT}, signalled through ABI, is used in ULPC based on cell-specific FFR pattern. When UL FFR is applied in the cell (i.e., UFPCT>1), the different FFR pattern is used by different cells. When UFPCT=4, for example, each cell chooses one of the three FFR patterns (sector 1, sector 2 and sector 3 pattern) as shown in Figure 463 (when UFPCT=3, the same FFR patterns shown in Figure 463 are used only excluding FP0). The index of FFR pattern is set by a particular cell with its IDCell. That is, each cell adopts the FFR pattern corresponding to the pattern k decided by the following equation:

k = Segment_ID + 1

Figure 463 shows an illustration of UL FFR when UPFCT is four

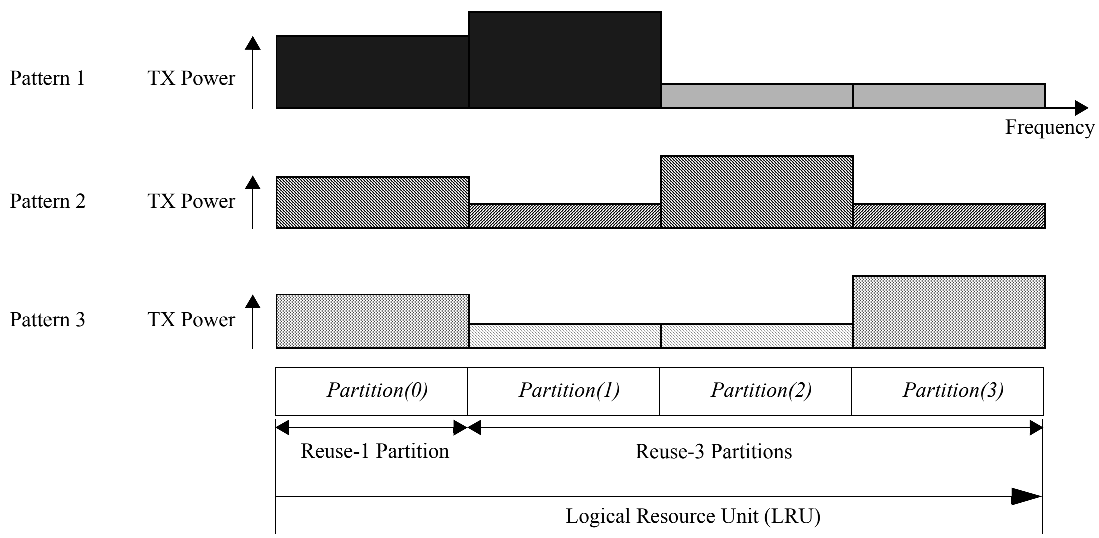


Figure 463—The basic concept of UL FFR

16.2.20.3 FFR Partition Configuration

The FFR partition configuration should be semi-static and not be changed frequently. The interval between two FFR partition changes is determined by the FFR Partition Update Interval parameters, as defined in Table 554. At each FFR Partition Update Interval, ABS should report to the upper entity the following information - BSID, the number of MS in the BS, MS location distribution, and MS UL/DL SINR distributions, UL / DL traffic distribution, ABS's transmission power of each frequency partition, UL IoT control parameter γ_{IoT} per FFR partition (as defined in 16.2.20) that are to be used to calculate the FFR partitions size, Power Levels, Relative Load indicator, and Reference UL IoT control parameter γ_{IoT} for each partition that will be used for FFR partition configuration.

16.2.21 MAC Management Reliability

All MAC control messages shall be fragmentable. HARQ shall be applied to all the unicast MAC control messages. Retransmission timers shall be defined for MAC control messages which require reliable transmission. Retransmission timer is started when MAC control message transmission is initiated by the transmitter to wait for the response message (for example, AAI_RNG-RSP is a response message for AAI_RNG-REQ). The retransmission timer is stopped if the response message is received from the receiver. If Local NAK for MAC control message is enabled and if the HARQ process is terminated with an unsuccessful outcome before the expiration of the retransmission timer, the transmitter may initiate retransmission of the complete control message or the control message fragment, transmitted in the failed HARQ burst. During retransmission of the control message fragment initiated by Local NACK, the transmitter shall retransmit the control message fragment with same information (MCEH and payload) as was transmitted during the initial transmission.

The transmitter may request receiver to send a MAC layer acknowledgement to determine the status of the transmitted control message. When a MAC layer acknowledgement is used, the transmitter shall set the Polling bit to 1 in MCEH of the MAC PDU containing the complete control message or the last pending fragment of the control message. The transmitter shall start an ACK timer immediately after the transmission of the MAC PDU with polling bit set to 1 in MCEH to wait for AAI_MSG-ACK message or Message ACK extended header. If the local NACK is received for a MAC PDU carrying the MCEH with polling bit set to 1, the transmitter shall set the polling bit to 1 in MCEH while retransmitting the MAC PDU containing the last pending fragment. The ACK timer is stopped if the local NACK is received. The ACK timer stopped by local NACK shall be started again while retransmitting the last pending fragment. The ACK timer is stopped if AAI_MSG-ACK message or Message ACK extended header is received from the receiver. If the ACK timer expires before an acknowledgement is received or the retransmission timer expires, the transmitter may initiate the retransmission of the entire message. The transmitter shall stop the ACK timer if the retransmission timer expires. The transmitter shall reset the retransmission timer, if it initiates the retransmission, after the ACK timer or retransmission timer expiry.

If a receiver receives control message or control message fragment in a MAC PDU with Polling bit set to 1 in MCEH, the receiver shall respond with an AAI_MSG-ACK message or a Message ACK extended header to indicate the reception of the complete control message. For the fragmented control messages, the receiver shall send AAI_MSG-ACK message or a Message ACK extended header after receiving all fragments of the control message.

16.2.22 Power Management for the Active Mode

Enhanced power savings for an AMS in active mode may be supported. In this mode, the ABS may allocate resources, adjust operation modes, and set transmission parameters to optimize energy savings at the AMS.

An AMS may report its battery level when the battery level changes. The AMS shall cancel the previous battery report as soon as its battery level has returned to a certain threshold, or as soon as the AMS is plugged in a charger.

Power update mechanism as specified in section 8.4.10.3 may be used when an ABS receives an AMS's battery level report and the ABS supports power management in Active Mode.

16.2.23 Update of S-SFH IEs

The S-SFH subpacket (SP) IEs (i.e., S-SFH SP1 IE, SP 2 IE and SP3 IE) are transmitted by ABS at the scheduled period of each SP, respectively, with different periodicity (i.e., $T_{SP1} < T_{SP2} < T_{SP3}$). This SP scheduling periodicity information is transmitted in the S-SFH SP3 IE. Otherwise, an AMS may implicitly know each S-SFH SP IE's scheduling period by receiving each subsequent S-SFH SP IE.

Every superframe, the ABS transmits P-SFH IE containing the S-SFH Scheduling information bitmap, S-SFH change count, S-SFH SP change bitmap, and Start super-frame offset where new S-SFH information is used. The S-SFH change count shall remain unchanged as long as all of the values (except MSB of super-frame number in S-SFH SP1 IE) of S-SFH SP IEs remain unchanged. The S-SFH change count shall be incremented by 1 modulo 16 whenever any of the values (except MSB of superframe number in S-SFH SP1 IE) of S-SFH IEs changes. The changed S-SFH SP IE(s) shall be transmitted at the scheduled superframes of period corresponding to each S-SFH SP IE.

If the AMS determines that the "S-SFH change count" field in P-SFH has not changed, then the AMS determines that it has up to date information.

When the AMS learns the super-frame number where S-SFH contents has changed, it uses the "Rate of change of S-SFH Info" field in S-SFH SP3 to determine the super-frame number until which the contents of this S-SFH remain the same. For example, when "Rate of change of S-SFH Info" field in S-SFH SP3 specifies that the contents of the S-SFH IE remains same over 32 * the periodicity of S-SFH SP1 superframes.

Each bit of the S-SFH SP change bitmap indicates the changing status of the corresponding S-SFH SP IE in association with the S-SFH change count. The bit # 0 (LSB), bit #1 and bit #2 (MSB) are mapped to S-SFH SP1 IE, S-SFH SP 2 IE and S-SFH SP3 IE, respectively. If any of the values (except MSBs of superframe number in S-SFH SP1 IE) of an S-SFH SP IE are changed, the bit corresponding to the changed S-SFH SP IE is toggled.

The Start super-frame offset where new S-SFH information is used in the P-SFH IE is used to indicate which S-SFH change count shall be considered for applying the system parameters in the S-SFH SPx IEs.

According to the S-SFH change count, S-SFH SP change bitmap, and Start super-frame offset where new S-SFH information, AMS knows if it is needed to decode S-SFH IE in the current superframe to update the system parameters broadcasted within the S-SFH SP IE, and the AMS may decide to disregard the S-SFH IE with the presumption of there being no change in S-SFH SP IE compared to that already stored in the AMS.

AMS shall compare values of each S-SFH change count in the last received P-SFH IE and the last stored P-SFH IE whenever it receives P-SFH IE.

a) If there is no difference of two S-SFH change counts, AMS may not decode S-SFH IE in the superframe.
b) Else, AMS shall check that change bits are toggled as the value of the difference.
    1) If the number of toggled bits in the last received S-SFH SP change bitmap is the same as the difference, AMS shall update the S-SFH SP IE(s) whose bit of the S-SFH SP change bitmap is toggled. Additionally, AMS shall update SCD change count and S-SFH SP change bitmap.
    2) Else, AMS shall update all S-SFH SP IEs, SCD change count and S-SFH SP change bitmap.

If the S-SFH SP IE indicated by S-SFH scheduling information corresponds to the changed S-SFH SP IE as indicated in the S-SFH change bitmap, the AMS shall decode the following S-SFH SP IE and store the parameters in association with the current S-SFH change count. The AMS shall update and store all the changed S-SFH SP IEs associated the increment of S-SFH change count at the scheduled superframe for each S-SFH SP IE.

16.2.24 Short Message Service

In connected mode, AAI_L2-xfer is used to send/receive SMS and SMS confirmation. In idle mode, Short Message Service information may be included in an AAI_RNG-REQ/RSP message. The maximum size of the short message body is 140 bytes. This parameter may be included only when the action code of AAI_PAG-ADV indicates location update or when the AAI_RNG-REQ with Ranging Purpose Indication Bit#1 is set to 1.

When UL SMS is included in an AAI_RNG-REQ message with Ranging Purpose Indication Bit#1=1, an AAI_RNG-RSP is transmitted as a confirmation of the SMS.

When an AAI_RNG-RSP message includes DL SMS, an AAI_MSG-ACK message is sent as a confirmation of the DL SMS. The ABS grants a CDMA Allocation A-MAP IE for the AAI_MSG-ACK in unsolicited manner by an ACK timer, where MCRC is masked with the same RA-ID as in CDMA Allocation A-MAP IE for the AAI_RNG-REQ message. When the AMS receives the AAI_RNG-RSP with the DL SMS, the AMS starts the ACK timer and waits the CDMA Allocation A-MAP IE to send the AAI_MSG-ACK message.

Table 773—Short message service

Name	Value	Usage
SMS	Short Message content up to the size of 140 bytes	Used to carry short text message

16.2.25 Coupled Group parameter Create/Change TLV

The Qty Couple SFID request compound TLV is used when the requested SFIDs are coupled during DSA procedure and should be considered together for creation of SFIDs. This TLV may be used instead of Qty SFID request TLV (11.13.39).

Table 774—Coupled group parameter create/change

Name	Type	Length	Value
Qty Coupled SFID request	[145/146].50.x	1	Qty Coupled SFID request is the quantity of coupled UL and DL unicast service flows of an MS, of the same common parameter set configuration. Used only as the last attribute of a Group parameter Create/Change TLV, and only in a DSA-REQ

16.2.26 Coverage loss

An AMS may lose signal temporarily due to various reasons, such as entering into an area without coverage and fading. A coverage loss refers to such a situation.

16.2.26.1 Coverage loss detection at ABS and ABS's behavior

For each AMS, the ABS shall maintain a timer called active_ABS_timer. The timer starts upon the completion of the initial network entry, identified by the completion of AAI_REG-REQ/AAI_REG-RSP handshake, or the completion of network reentry, according to the HO Process Optimization in AAI_RNG-RSP message. The timer is reset whenever the ABS receives any data (e.g., MPDU or feedback information) from the AMS.

Upon each expiration of the active_ABS_timer, to check whether an AMS is still alive, the ABS shall grant UL burst to the AMS and the AMS shall transmit a padding PDU or an MPDU on the UL grant.

If the ABS does not receive padding PDU or MPDU on a predetermined number of successive UL grants (e.g., 10), the ABS shall send an unsolicited AAI_RNG-RSP message to request the AMS to perform ranging, as described below.

The ABS shall send unsolicited AAI_RNG-RSP message to request the AMS to perform ranging using periodic ranging codes by setting the Ranging Request bit to one. Upon receiving an AAI-RNG-CFM message with AMS's STID, which indicates a successful periodic ranging initiated by this unsolicited AAI-RNG-RSP, the ABS shall restart the active_ABS_timer. If the ABS does not receive the AAI_RNG-CFM message upon the expiration of some timer (the value of this timer is TBD), the ABS shall start the Resource Retain Time.

Once Resource Retain Time is started, the ABS shall not restart the active-ABS-timer.

Upon expiration of the Resource Retain Time, the ABS considers that the AMS is not in the network anymore, and releases AMS's dynamic context and moves AMS's static context to the network entity that stores AMS's context.

If the ABS receives backbone context request for the AMS during coverage loss detection or before expiration of Resource Retain Time, the ABS considers that the AMS is performing network reentry due to link loss in AMS. The ABS in this case, shall provide the AMS's context to the network, in response to the backbone context request.

In case of a HO, if the ABS does not receives a HO completion notification from network within the Ranging_Initiation_Deadline via the backbone network, the ABS shall initiate the coverage loss detection procedure described in 16.2.26.2 (i.e., the unsolicited UL grant and start of the active_ABS_timer at the same time)

16.2.26.2 Coverage loss detection at AMS and AMS's behavior

The AMS can detect a coverage loss when it loses PHY synchronization or DL synchronization or UL synchronization, i.e., if the AMS cannot decode a predetermined number of contiguous (e.g., 5) SFHs, the AMS shall regard it as Link Loss from the ABS.

The AMS upon receiving an unsolicited AAI_RNG-RSP message with Ranging Request bit to be one which indicates that the ABS requests ranging procedure to detect coverage loss, the AMS shall perform periodic ranging. Upon successful ranging initiated by an unsolicited AAI_RNG-RSP message with Ranging Request bit to be one, indicated by receiving an AAI_RNG-ACK message with a success status and corresponding periodic ranging code, the AMS shall request bandwidth and send back a AAI_RNG-CFM message that includes its STID. Upon exhausted HARQ retransmissions of the AAI_RNG-CFM message, the AMS considers that the ABS considers that the AMS is not with the ABS anymore, and the AMS shall perform coverage loss recovery procedure as indicated in Section 16.2.26.3.

16.2.26.3 Coverage loss recovery procedure

Upon detection of a coverage loss, the AMS scans for a new channel. After achieving PHY synchronization and DL synchronization with the discovered ABS, which could be its previous serving ABS before the coverage loss, the AMS shall perform network reentry if the AMS has been getting the information about previous Serving ABS (e.g., serving ABSID) as indicated below. Otherwise, the AMS shall perform initial network entry.

During the network reentry, the AMS shall perform CDMA ranging using HO ranging codes. Upon the discovered ABS's sending AAI_RNG-ACK with success status, the ABS shall provide a UL BW allocation. When receiving the UL BW allocation, the AMS shall send the AAI_RNG-REQ message, with the bit#7 = 1 in the Ranging Purpose Indication parameter (i.e., indicating a network reentry after a coverage loss). If the

AMS shares valid security context, the AMS shall include its CRID in AAI_RNG-REQ protected with a CMAC derived from new AK.

After receiving the AAI_RNG-REQ message, the discovered ABS identifies AMS's reentry attempt after a coverage loss and checks its context availability. The discovered ABS may request AMS's context over backbone network which is beyond the scope of this standard. Based on AMS's relevant context retained at the network, the target ABS shall place in AAI_RNG-RSP an HO Process Optimization parameter indicating which reentry MAC control messages may be omitted. The AMS shall complete the processing of all indicated messages before entering normal operation with target ABS.

16.3 Physical layer

16.3.1 Introduction

The Advanced Air Interface is designed for NLOS operation in the licensed frequency bands below 6 GHz.

The Advanced Air Interface supports TDD and FDD duplex modes, including H-FDD AMS operation. Unless otherwise specified, the frame structure attributes and baseband processing are common for all duplex modes.

The Advanced Air Interface uses OFDMA as the multiple access scheme in the downlink and uplink.

16.3.2 OFDMA symbol description, symbol parameters and transmitted signal

16.3.2.1 Time domain description

Inverse-Fourier-transforming creates the OFDMA waveform; this time duration is referred to as the useful symbol time T_b. A copy of the last T_g of the useful symbol period, termed CP, is used to collect multipath, while maintaining the orthogonality of the tones. Figure 464 illustrates this structure.

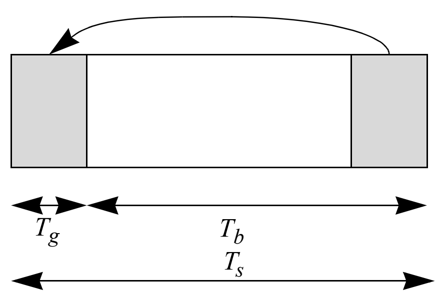


Figure 464—OFDMA symbol time structure

16.3.2.2 Frequency domain description

The frequency domain description includes the basic structure of an OFDMA symbol.

An OFDMA symbol is made up of subcarriers, the number of which determines the FFT size used. There are several subcarrier types:

- Data subcarriers: for data transmission
- Pilot subcarriers: for various estimation purposes
- Null carrier: no transmission at all, for guard bands and DC carrier

The purpose of the guard bands is to enable the signal to naturally decay and create the FFT “brick wall” shaping.

16.3.2.3 Primitive parameters

The following four primitive parameters characterize the OFDMA symbol:

- BW: The nominal channel bandwidth.
- N_{used}: Number of used subcarriers (which include the DC subcarrier).
- n: Sampling factor. This parameter, in conjunction with BW and N_{used} determines the subcarrier spacing and the useful symbol time. This value is given in Table 775 for each nominal bandwidth.
- G: This is the ratio of CP time to “useful” time. The following values shall be supported: 1/8, 1/16, and 1/4.

16.3.2.4 Derived parameters

The following parameters are defined in terms of the primitive parameters of 16.3.2.3:

- N_{FFT}: Smallest power of two greater than N_{used}
- Sampling frequency: $F_s = \text{floor}(n \cdot BW / 8000) \times 8000$
- Subcarrier spacing: $\Delta f = F_s / N_{FFT}$
- Useful symbol time: $T_b = 1 / \Delta f$
- CP time: $T_g = G \cdot T_b$
- OFDMA symbol time: $T_s = T_b + T_g$
- Sampling time: T_b / N_{FFT}

Values of the derived parameters and the primitive parameters above are specified in Table 775. Tone dropping based on 10 and 20 MHz systems can be used to support other various bandwidths.

Table 775—OFDMA parameters

The nominal channel bandwidth, BW (MHz)			5	7	8.75	10	20
Sampling factor, n			28/25	8/7	8/7	28/25	28/25
Sampling frequency, F_s (MHz)			5.6	8	10	11.2	22.4
FFT size, N_{FFT}			512	1024	1024	1024	2048
Subcarrier spacing, Δf (kHz)			10.94	7.81	9.77	10.94	10.94
Useful symbol time, T_b (µs)			91.4	128	102.4	91.4	91.4
CP ratio, G = 1/8	OFDMA symbol time, T_s (µs)		102.857	144	115.2	102.857	102.857
	FDD	Number of OFDMA symbols per 5ms frame	48	34	43	48	48
		Idle time (µs)	62.857	104	46.40	62.857	62.857
	TDD	Number of OFDMA symbols per 5ms frame	47	33	42	47	47
		TTG + RTG (µs)	165.714	248	161.6	165.714	165.714
CP ratio, G = 1/16	OFDMA symbol time, T_s (µs)		97.143	136	108.8	97.143	97.143
	FDD	Number of OFDMA symbols per 5ms frame	51	36	45	51	51
		Idle time (µs)	45.71	104	104	45.71	45.71
	TDD	Number of OFDMA symbols per 5ms frame	50	35	44	50	50
		TTG + RTG (µs)	142.853	240	212.8	142.853	142.853
CP ratio, G = 1/4	OFDMA symbol time, T_s (µs)		114.286	160	128	114.286	114.286
	FDD	Number of OFDMA symbols per 5ms frame	43	31	39	43	43
		Idle time (µs)	85.694	40	8	85.694	85.694
	TDD	Number of OFDMA symbols per 5ms frame	42	30	37	42	42
		TTG + RTG (µs)	199.98	200	264	199.98	199.98
Number of guard sub-carriers		Left	40	80	80	80	160
		Right	39	79	79	79	159
Number of used sub-carriers			433	865	865	865	1729
Number of physical resource unit (18x6) in a type-1 AAI subframe.			24	48	48	48	96

Values of the derived parameters and the primitive parameters based on tone dropping from 10 and 20 MHz are specified in Table 776 to support various bandwidths.

Table 776—OFDMA parameters for tone dropping support

The nominal channel bandwidth, *BW* (MHz)			x (5 < x < 10)	Reference BW:10	y (10 < y < 20)	Reference BW:20
Sampling factor, *n*			28/25	28/25	28/25	28/25
Sampling frequency, F_s (MHz)			11.2	11.2	22.4	22.4
FFT size, N_{FFT}			1024	1024	2048	2048
Subcarrier spacing, Δf (kHz)			10.94	10.94	10.94	10.94
Useful symbol time, T_b (µs)			91.4	91.4	91.4	91.4
CP ratio, *G* = 1/8	OFDMA symbol time, T_s (µs)		102.857	102.857	102.857	102.857
	FDD	Number of OFDMA symbols per 5ms frame	48	48	48	48
		Idle time (µs)	62.857	62.857	62.857	62.857
	TDD	Number of OFDMA symbols per 5ms frame	47	47	47	47
		TTG + RTG (µs)	165.714	165.714	165.714	165.714
CP ratio, *G* = 1/16	OFDMA symbol time, T_s (µs)		97.143	97.143	97.143	97.143
	FDD	Number of OFDMA symbols per 5ms frame	51	51	51	51
		Idle time (µs)	45.71	45.71	45.71	45.71
	TDD	Number of OFDMA symbols per 5ms frame	50	50	50	50
		TTG + RTG (µs)	142.853	142.853	142.853	142.853
CP ratio, *G* = 1/4	OFDMA symbol time, T_s (µs)		114.286	114.286	114.286	114.286
	FDD	Number of OFDMA symbols per 5ms frame	43	43	43	43
		Idle time (µs)	85.694	85.694	85.694	85.694
	TDD	Number of OFDMA symbols per 5ms frame	42	42	42	42
		TTG + RTG (µs)	199.98	199.98	199.98	199.98

Given the nominal channel bandwidth except 5/7/8.75/10/20 MHz from PA-Preamble, the number of used subcarriers and the number of guard subcarriers shall be determined by searching the appropriate BW range of the given channel bandwidth from Table 777 and Table 778.

Table 777—OFDMA parameters for 2048 FFT when tone dropping is applied

BW Range, *x* (MHz)	Number of guard subcarriers		Number of used subcarriers	Number of PRUs (N_{PRU})
	Left	Right		
20.0>*x*>=19.2	196	195	1657	92
19.2>*x*>=18.4	232	231	1585	88
18.4>*x*>=17.5	268	267	1513	84
17.5>*x*>=16.7	304	303	1441	80
16.7>*x*>=15.9	340	339	1369	76
15.9>*x*>=15.0	376	375	1297	72
15.0>*x*>=14.2	412	411	1225	68
14.2>*x*>=13.4	448	447	1153	64
13.4>*x*>=12.5	484	483	1081	60
12.5>*x*>=11.7	520	519	1009	56
11.7>*x*>=10.9	556	555	937	52
10.9>*x*>10.0	592	591	865	48

Table 778—OFDMA parameters for 1024 FFT when tone dropping is applied

BW Range, x (MHz)	Number of guard subcarriers		Number of used subcarriers	Number of PRUs (N_{PRU})
	Left	Right		
10.0>x>=9.2	116	115	793	44
9.2>x>=8.4	152	151	721	40
8.4>x>=7.5	188	187	649	36
7.5>x>=6.7	224	223	577	32
6.7>x>=5.9	260	259	505	28
5.9>x>5.0	296	295	433	24

16.3.2.5 Transmitted signal

Equation (175) specifies the transmitted signal voltage to the antenna, as a function of time, during any OFDMA symbol.

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{\substack{k=-(N_{used}-1)/2 \\ k \neq 0}}^{(N_{used}-1)/2} c_k \cdot e^{j2\pi k \Delta f (t - T_g)} \right\} \tag{175}$$

where

t is the time, elapsed since the beginning of the subject OFDMA symbol, with $0 < t < T_s$.

c_k is a complex number; the data to be transmitted on the subcarrier whose frequency offset index is k, during the subject OFDMA symbol. It specifies a point in a QAM constellation.

T_g is the guard time.

Δf is the subcarrier frequency spacing.

f_c is radio carrier frequency.

16.3.2.6 Definition of basic terms on the transmission chain

The basic terms related with the transmission chain are defined as illustrated in Figure 465.

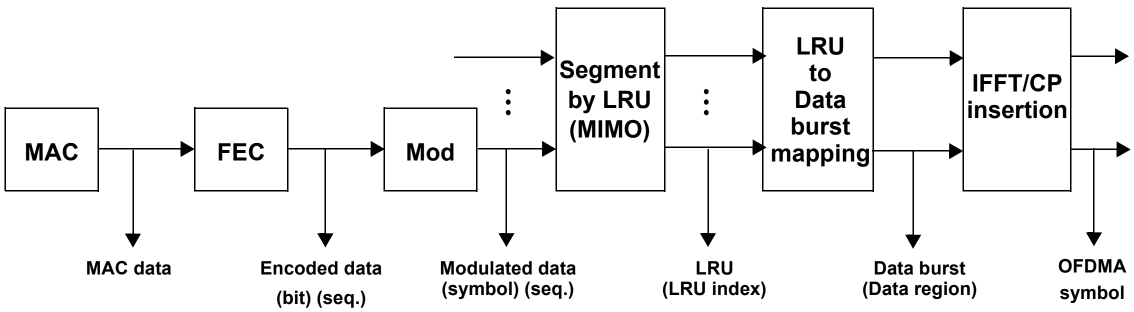


Figure 465—Definition of basic terms on the transmission chain

16.3.3 Frame structure

16.3.3.1 Basic frame structure

The advanced air interface basic frame structure is illustrated in Figure 466. Each 20 ms superframe is divided into four equally-sized 5 ms radio frames. When using the same OFDMA parameters as in Table 775 with the channel bandwidth of 5 MHz, 10 MHz, or 20 MHz, each 5 ms radio frame further consists of eight AAI subframes for G = 1/8 and 1/16. For G = 1/4, the 5 ms radio frame consists of seven AAI subframes. With the channel bandwidth of 8.75 MHz, the 5 ms radio frame consists of seven AAI subframes for G = 1/8 and 1/16, and six AAI subframes for G = 1/4. With the channel bandwidth of 7 MHz, the 5 ms radio frame consists of six AAI subframes for G = 1/16, and five AAI subframes for G = 1/8 and G = 1/4. An AAI subframe shall be assigned for either DL or UL transmission. There are four types of AAI subframes:

1) type-1 AAI subframe which consists of six OFDMA symbols,
2) type-2 AAI subframe which consists of seven OFDMA symbols,
3) type-3 AAI subframe which consists of five OFDMA symbols, and
4) type-4 AAI subframe which consists of nine OFDMA symbols. This type shall be applied only to an UL AAI subframe for the 8.75MHz channel bandwidth when supporting the WirelessMAN-OFDMA frames.

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

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

A data burst shall occupy either one AAI subframe (i.e. the default TTI transmission) or contiguous multiple AAI subframes (i.e. the long TTI transmission). Any 2 long TTI bursts allocated to an AMS shall not be partially overlapped, i.e. any 2 long TTI bursts in FDD shall either be over the same 4 subframes or without any overlap.The long TTI in FDD shall be 4 AAI subframes for both DL and UL. For DL (UL), the long TTI in TDD shall be all DL (UL) AAI subframes in a frame.

For an AMS operating over carriers with sum of FFT sizes that is 2048 sub-carriers or less, the ABS may allocate it up to 4 DL HARQ bursts (using DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent Allocation A-MAP IE or Group Resource Allocation A-MAP IE) per AAI subframe per AMS. The ABS shall not allocate more than 4 DL HARQ bursts per AAI subframe per AMS. Here, a long TTI burst shall be counted as one burst for each and every AAI subframe that the long TTI burst spans.

For an AMS operating over carriers with sum of FFT sizes that is larger than 2048 sub-carriers, the ABS may allocate it with an amount of bursts that is: floor(4*sum of FFT sizes of all used carriers/2048).

ABS shall not allocate more than 1 broadcast data burst (using Broadcast Assignment A-MAP IE) and 1 E-MBS burst (using E-MBS A-MAP IE) per AAI subframe. Here, a long TTI burst shall be counted as one burst for each and every AAI subframe that the long TTI burst spans.

For an AMS operating over carriers with sum of FFT sizes that is 2048 sub-carriers or less, the ABS may allocate it up to 3 UL HARQ bursts per UL AAI subframe with either UL Basic Assignment A-MAP IE, UL Sub-band Assignment A-MAP IE, UL Persistent Allocation A-MAP IE or Group Resource Allocation A-MAP IE. This limitation is regardless of the DL AAI subframes in which the UL assignment A-MAP IEs are transmitted. Here, a long TTI burst shall be counted as one burst for each and every AAI subframe in which it is transmitted.

If the AMS operates over carriers with sum of FFT sizes that is larger than 2048 sub-carriers, the ABS may allocate it with an amount of bursts that is: floor(3*sum of FFT sizes of all used carriers/2048).

AMS shall support one additional UL transmission allocated by either CDMA Allocation A-MAP IE or by BR-ACK A-MAP IE, per AAI sub-frame and shall support one separate HARQ channel for this allocation. If AMS is allocated with CDMA Allocation A-MAP IE or with BR-ACK A-MAP IE, while such previous allocation is still under HARQ retransmission process, the new allocation shall override the previous one.

The ABS shall not allocate to an AMS more than 2 concurrent DL allocations that are either group resource allocations or persistent allocations. In other words the ABS may allocate either 2 DL group resource allocations, 2 DL persistent allocations, 1 DL group resource allocation and 1 DL persistent allocation, or 1 DL allocation of these types to any specific AMS.

The ABS shall not allocate to an AMS more than 2 concurrent UL allocations that are either group resource allocations or persistent allocations. In other words the ABS may allocate either 2 UL group resource allocations, 2 UL persistent allocations, 1 UL group resource allocation and 1 UL persistent allocation, or 1 UL allocation of these types to any specific AMS.

Every superframe shall contain a superframe header (SFH). The SFH shall be located in the first DL AAI subframe of the superframe, and shall include broadcast channels.

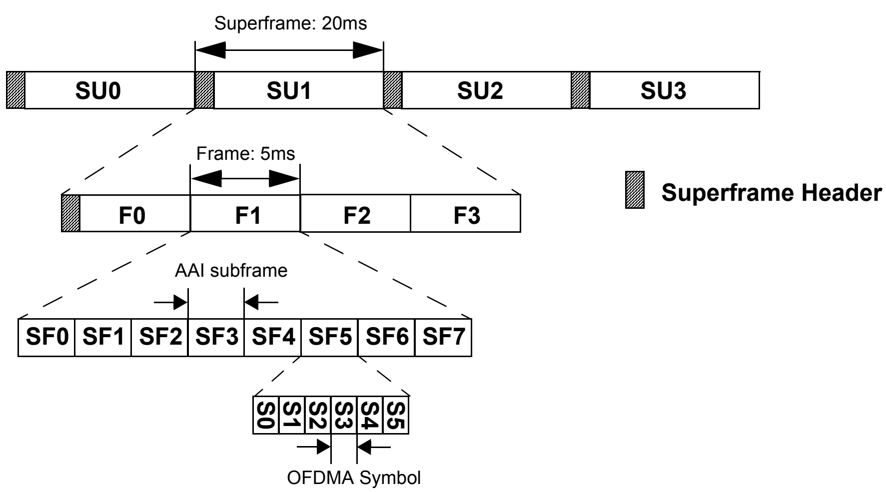


Figure 466—Basic frame structure for 5, 10 and 20 MHz channel bandwidths

16.3.3.2 Frame structure for CP = 1/8 T_b

16.3.3.2.1 FDD frame structure

An ABS supporting FDD mode shall be able to simultaneously support half duplex and full duplex AMSs operating on the same RF carrier. The AMS supporting FDD mode shall use either H-FDD or FDD.

The FDD frame shall be constructed on the basis of the basic frame structure defined in 16.3.3.1. In each frame, all AAI subframes are available for both DL and UL transmissions. The DL and UL transmissions are separated in the frequency domain.

An FDD AMS is able to receive a data burst in any DL AAI subframe while accessing an UL AAI subframe at the same time. For an H-FDD AMS, either transmission or reception, but not both, is allowed in each AAI subframe. In addition, the allocation of AAI subframe for transmission and reception shall provide idle subframes in order for an H-FDD AMS to receive the SFH or A-Preamble and to secure the transition gaps between transmission and reception. Then, the ABS shall schedule the AAI subframes for an H-FDD AMS, excluding the first, second, and the last AAI UL subframes with the associated DL subframes connected in HARQ-timing as specified in 16.2.14.2.2.1.

The idle time specified in Table 775 shall be placed at the end of each FDD frame as shown in Figure 467.

Figure 467 illustrates an example of FDD frame structure, which is applicable to the nominal channel bandwidth of 5, 10, and 20 MHz with G = 1/8.

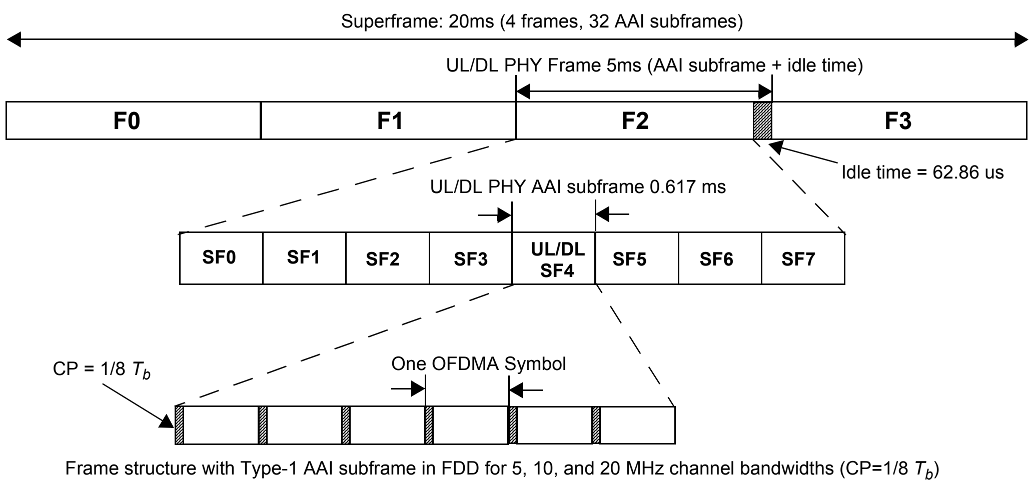


Figure 467—Frame structure with Type-1 FDD AAI subframe

Figure 468 illustrates an example of FDD frame structure, which is applicable to the nominal channel bandwidth of 7 MHz with G = 1/8. Four AAI subframes among five AAI subframes are type-2 AAI subframes, and the other AAI subframe is a type-1 AAI subframe.

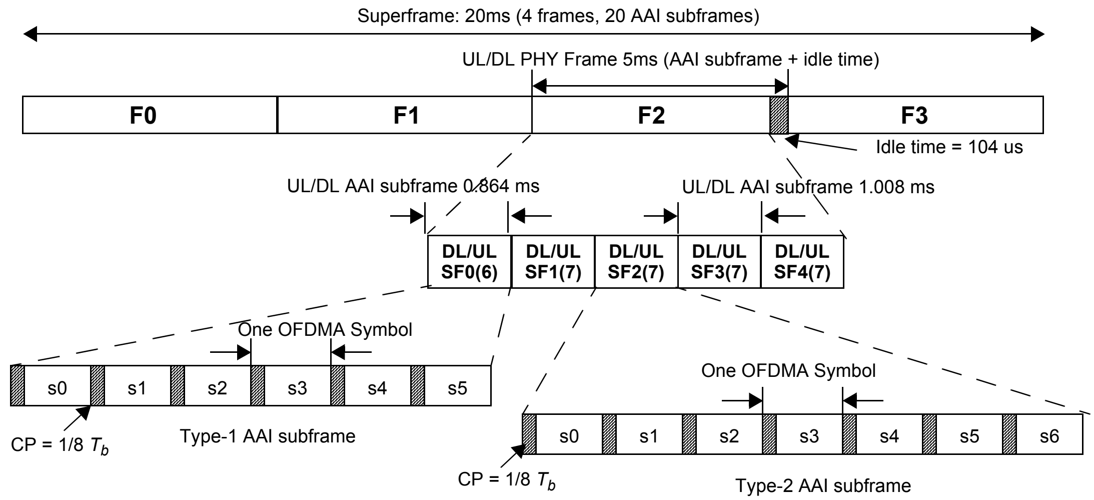
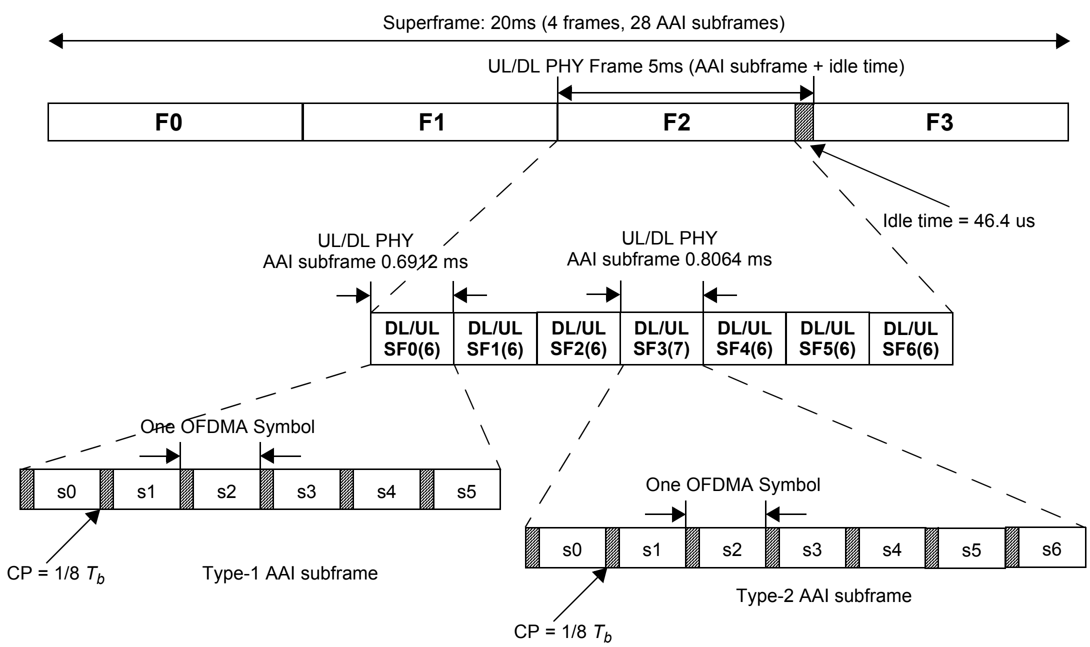


Figure 468—Frame structure for 7 MHz FDD mode (*G*=1/8)

Figure 469 illustrates an example FDD frame structure, which is applicable to the nominal channel bandwidth of 8.75 MHz with G = 1/8. In Figure 469 the fourth AAI subframe is a type-2 AAI subframe and the other AAI subframes are type-1 AAI subframes.



Frame structure with Type-1 and Type-2 AAI subframes in FDD for 8.75 MHz channel bandwidths (CP=1/8 T_b)

Figure 469—Frame structure for 8.75 MHz FDD mode (*G*=1/8)

16.3.3.2.2 TDD frame structure

The TDD frame shall be constructed on the basis of the basic frame structure defined in 16.3.3.1.

In a TDD frame with DL to UL ratio of *D* : *U*, the first contiguous *D* AAI subframes and the remaining *U* AAI subframes are assigned for DL and UL, respectively, where *D* + *U* = 8 for 5, 10 and 20 MHz channel bandwidths, *D* + *U* = 7 for 8.75 MHz channel bandwidth, and *D* + *U* = 5 for 7 MHz channel bandwidth. The ratio of *D* : *U* shall be selected from one of the following values: 8:0, 6:2, 5:3, 4:4, or 3:5 for 5, 10 and 20 MHz channel bandwidths, and 3:2 or 2:3 for 7 MHz channel bandwidth and 5:2, 4:3, or 3:4 for 8.75 MHz channel bandwidth.

In each frame, the TTG and RTG shall be inserted between the DL and UL switching points.

Figure 470 illustrates an example of TDD frame structure with D:U = 5:3, which is applicable to the nominal channel bandwidths of 5, 10, and 20 MHz with G = 1/8. In Figure 470 the last DL AAI subframe, i.e. DL SF4, is a type-3 AAI subframe and the other AAI subframes are type-1 AAI subframes. TTG and RTG are 105.714 µs and 60µs, respectively.

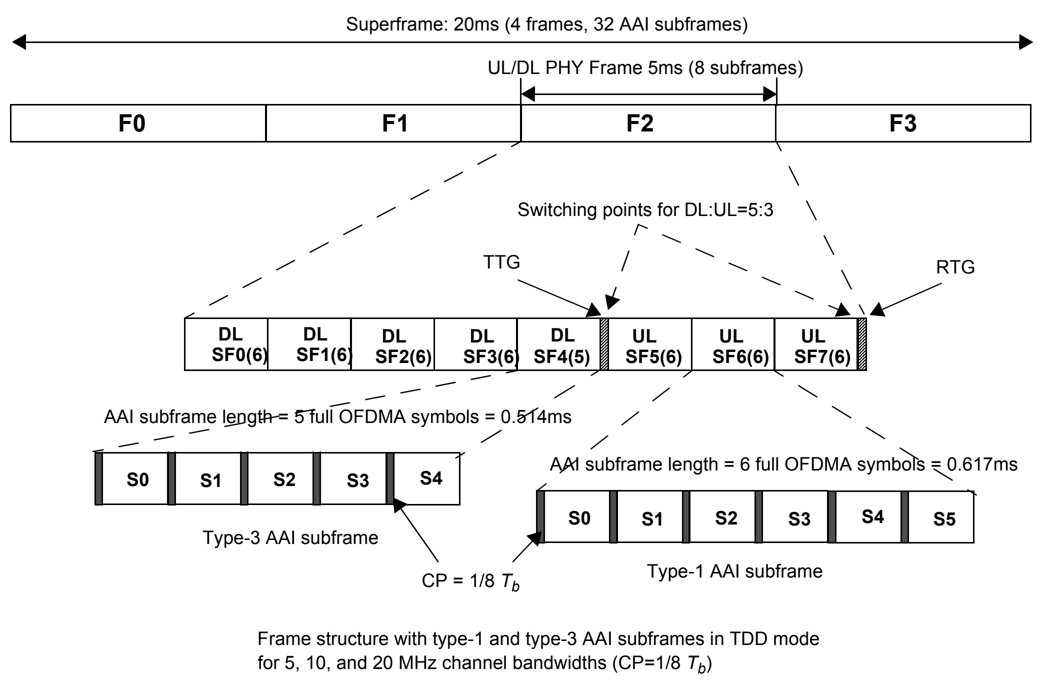


Figure 470—Frame structure for 5/10/20 MHz mode

Figure 471 illustrates an example TDD frame structure with D:U = 3:2, which is applicable to the nominal channel bandwidths of 7 MHz with *G* = 1/8. Three AAI subframes among five AAI subframes are type-2

AAI subframes, and the other two AAI subframes are the type-1. The TTG and RTG are 188µs and 60µs, respectively.

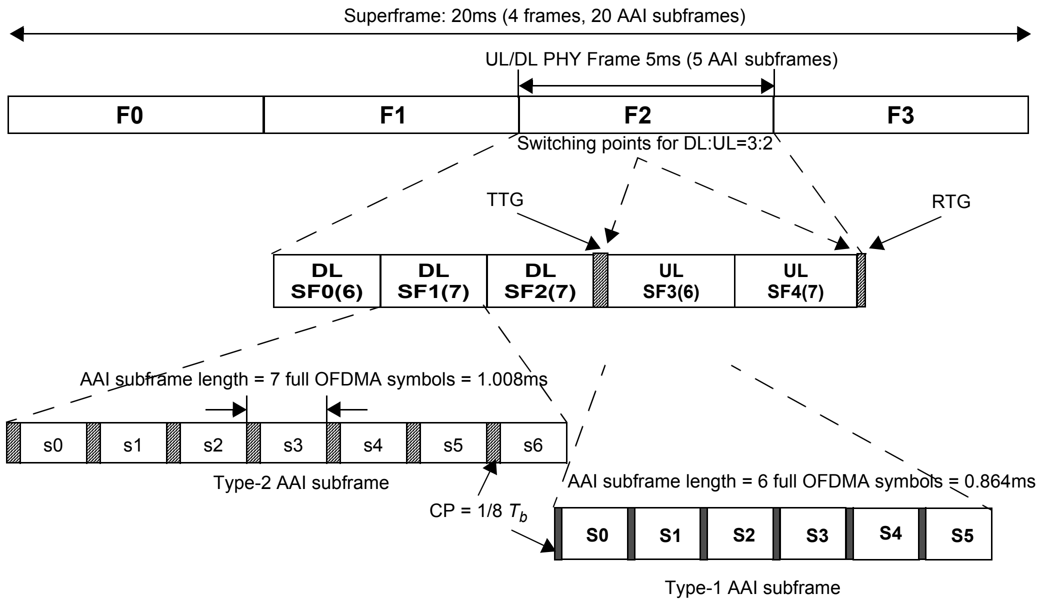


Figure 471—Frame structure for 7MHz TDD mode

Figure 472 illustrates an example TDD frame structure with D:U =5:2, which is applicable to the nominal channel bandwidths of 8.75 MHz with G = 1/8. In Figure 472 all seven AAI subframes in a frame are type-1 AAI subframes. TTG and RTG are 87.2 µs and 74.4µs, respectively.

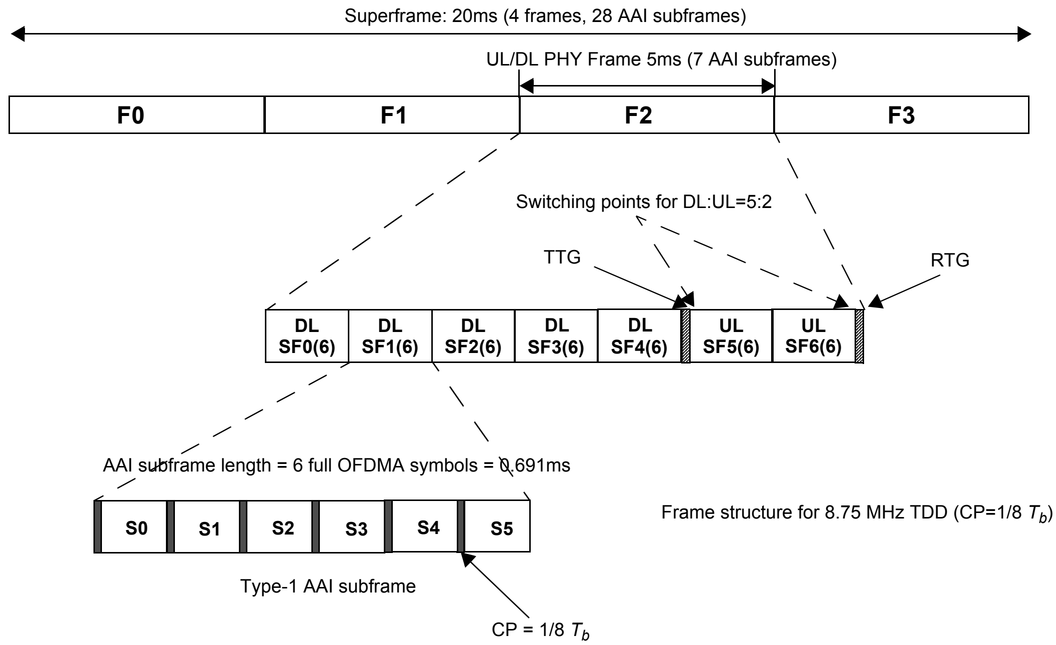
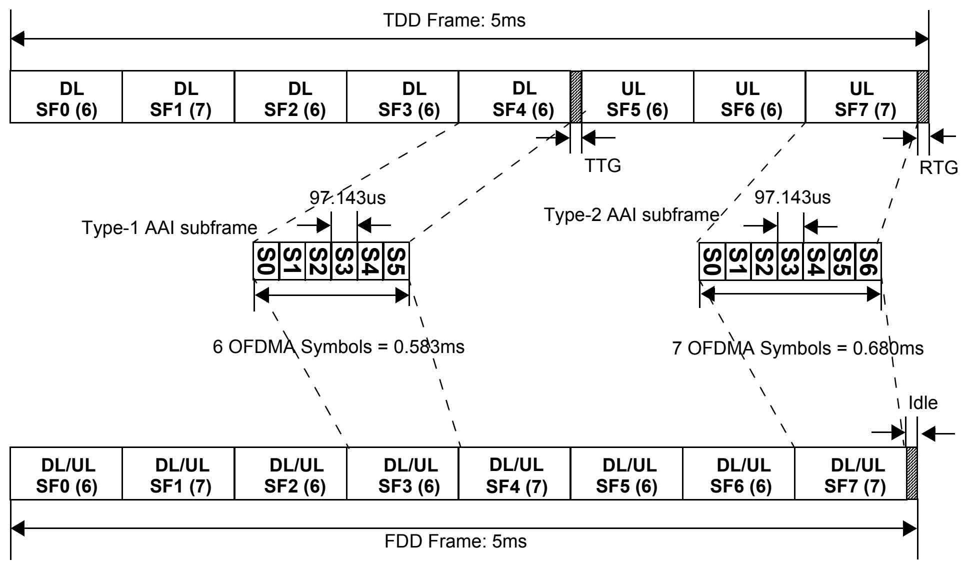


Figure 472—Frame structure for 8.75MHz TDD mode

16.3.3.3 Frame structure for CP = 1/16 T_b

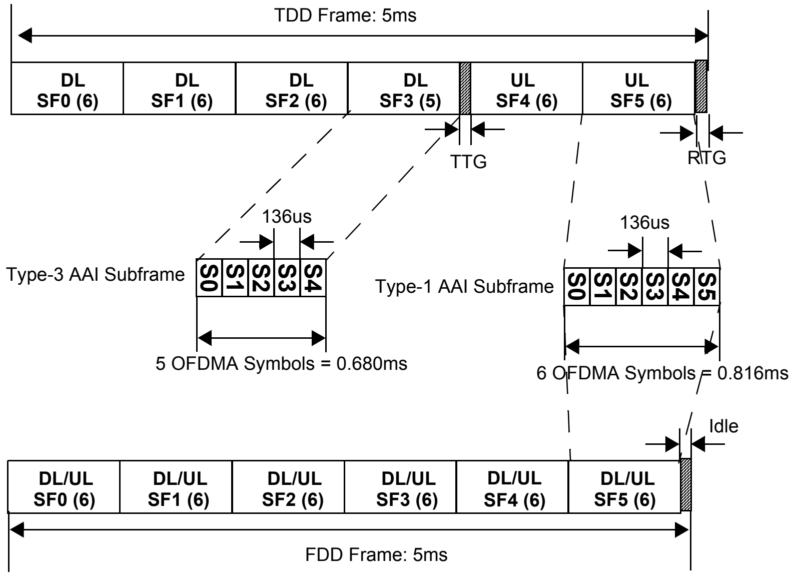
For channel bandwidths of 5, 10, and 20 MHz, an FDD frame shall have five type-1 AAI subframes and three type-2 AAI subframes , and a TDD frame shall have six type-1 AAI subframes and two type-2 AAI subframes. The AAI subframe preceding a DL to UL switching point shall be a type-1 AAI subframe. In the TDD frame, the second and last AAI subframes within each frame shall be type-2 AAI subframes. In the FDD frame, the second, fifth, and last AAI subframes within each frame shall be type-2 AAI subframes. Figure 473 illustrates an example of TDD and FDD frame structure for 5, 10, and 20 MHz channel bandwidths with a CP of 1/16 T_b. Assuming OFDMA symbol duration of 97.143 µs and a CP length of 1/16 T_b, the length of type-1 and type-2 AAI subframes are 0.583 ms and 0.680 ms, respectively. TTG and RTG are 82.853 µs and 60 µs, respectively.



TDD and FDD frame structure with a CP of 1/16 T_b (DL to UL ratio of 5:3).

Figure 473—Frame structures for 5, 10, and 20 MHz of TDD and FDD mode (G=1/16)

For a channel bandwidth of 7 MHz, a frame shall have six type-1 AAI subframes for FDD, and five type-1 AAI subframes and one type-3 AAI subframes for TDD. In the TDD frame, the AAI subframe preceding a DL to UL switching point is a type-3 AAI subframe. Figure 474 illustrates an example of TDD and FDD frame structure for the 7 MHz channel bandwidth with a CP of 1/16 T_b. Assuming OFDMA symbol duration of 136 µs and a CP length of 1/16 T_b, the length of type-1 and type-3 AAI subframes are 0.816 ms and 0.680 ms, respectively. TTG and RTG are 180µs and 60µs, respectively.



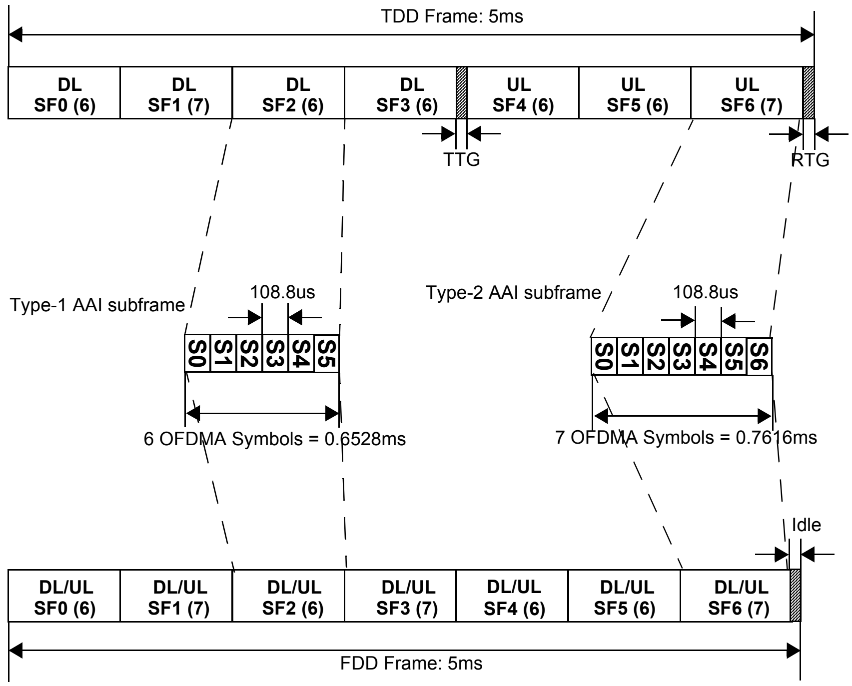
TDD and FDD frame structure for 7MHz channel with a CP of 1/16 T_b (DL to UL ratio of 4:2).

Figure 474—Frame structures for 7MHz TDD and FDD modes (G=1/16)

For a channel bandwidth of 8.75 MHz, a frame shall have four type-1 AAI subframes and three type-2 AAI subframes for FDD, and five type-1 AAI subframes and two type-2 AAI subframes for TDD.

In the TDD frame, the second and last AAI subframes within each frame shall be type-2 AAI subframes. In the FDD frame, the second, fourth, and last AAI subframe within each frame shall be type-2 AAI subframes.

Figure 475 illustrates an example of TDD and FDD frame structure for the 8.75 MHz channel bandwidth with a CP of 1/16 T_b. Assuming OFDMA symbol duration of 108.8 µs and a CP length of 1/16 T_b, the length of type-1 and type-2 AAI subframes are 0.6528 ms and 0.7616 ms, respectively. TTG and RTG are 138.4 µs and 74.4µs, respectively.



TDD and FDD frame structure for 8.75MHz channel with a CP of 1/16 T_b (DL to UL ratio of 4:3).

Figure 475—Frame structures for 8.75MHz TDD and FDD modes (*G*=1/16)

16.3.3.4 Frame structure for CP = 1/4 T_b

The frame structure for a CP length of 1/4 T_b shall consist of type-1 and type-2 AAI subframes. For a channel bandwidth of 5, 10 or 20 MHz, an FDD frame shall have six type-1 AAI subframes and one type-2 AAI subframe. A TDD frame shall have seven type-1 AAI subframes.

Figure 476 illustrates an example of TDD and FDD frame structure with DL/UL ratio = 4:3 for the 5, 10, or 20 MHz channel bandwidth with a CP of 1/4 T_b. Assuming an OFDMA symbol duration of 114.286 μs and a CP length of 1/4 T_b ,the length of type-1 and type-2 AAI subframes are 0.6857 ms and 0.80 ms, respectively. TTG and RTG are 139.988 μs and 60 μs, respectively.

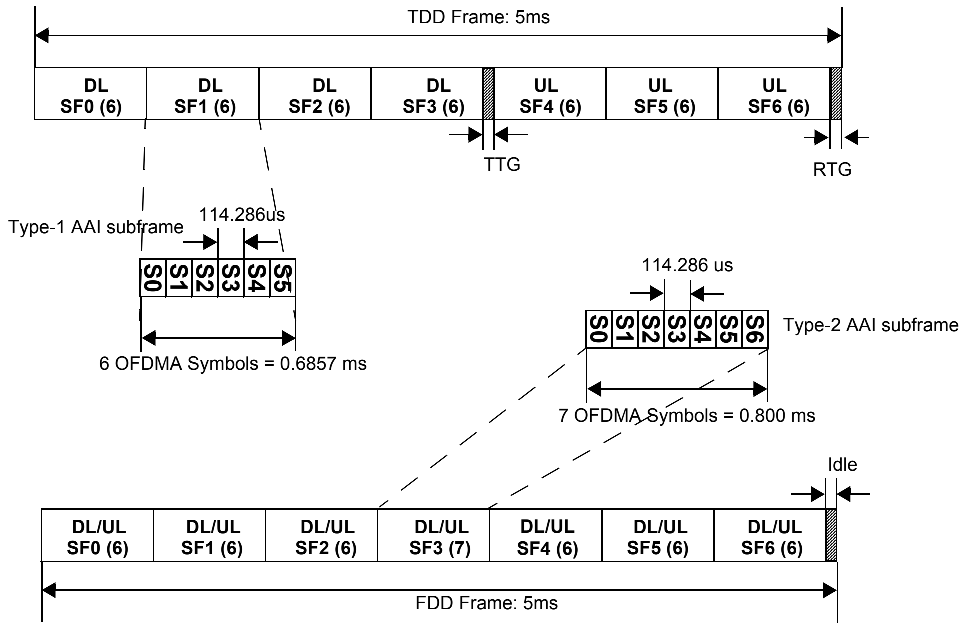


Figure 476—Frame structures for 5, 10, and 20 MHz of TDD and FDD modes (*G*=1/4)

For a channel bandwidth of 7MHz, an FDD frame shall have four type-1 AAI subframes and one type-2 AAI subframe. And a TDD frame shall have five type-1 AAI subframes.

Figure 477 illustrates an example of TDD and FDD frame structure with DL/UL ratio = 3:2 for the 7 MHz channel bandwidth with a CP of 1/4 T_b. Assuming OFDMA symbol duration of 160 μs and a CP length of 1/4 T_b the length of type-1 and type-2 AAI subframes are 0.960 ms and 1.120 ms, respectively. TTG and RTG are 140 μs and 60 μs, respectively.

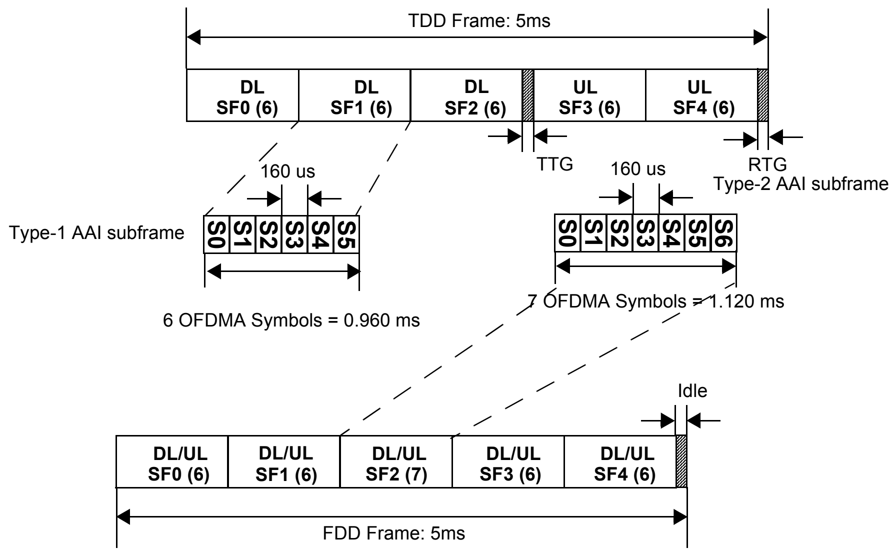


Figure 477—Frame structures for 7 MHz TDD and FDD modes (*G*=1/4)

For a channel bandwidth of 8.75MHz, an FDD frame shall have three type-1 AAI subframes and three type-2 AAI subframes. And a TDD frame shall have five type-1 AAI subframes and one type-2 AAI subframe.

Figure 478 illustrates an example of TDD and FDD frame structure with DL/UL ratio = 4:2 for the 8.75 MHz channel bandwidth with a CP of 1/4 T_b. Assuming an OFDMA symbol duration of 128 μs and a CP length of 1/4 T_b the length of type-1 and type-2 AAI subframes are 0.768 ms and 0.896 ms, respectively.

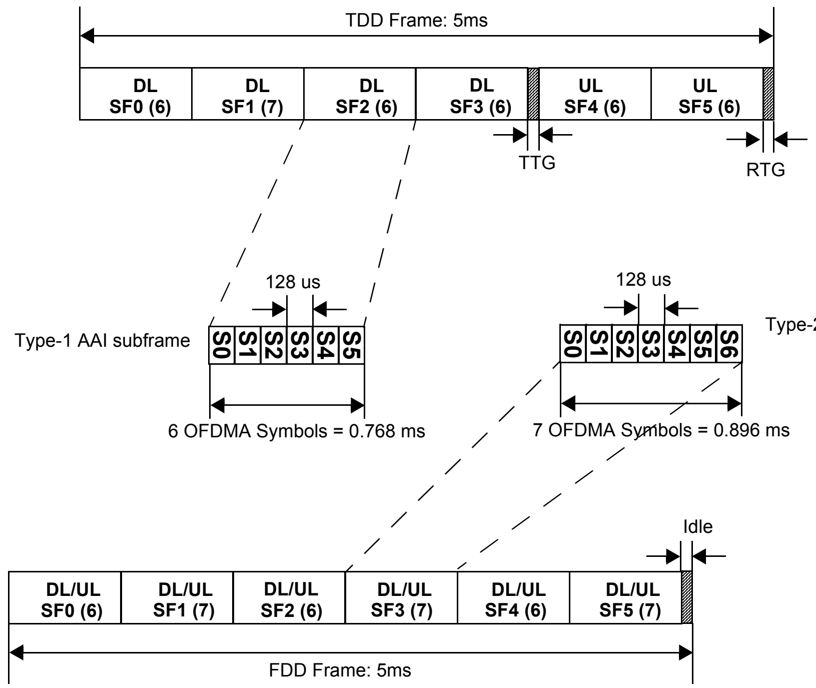


Figure 478—Frame structures for 8.75 MHz TDD and FDD modes (*G*=1/4)

16.3.3.5 Frame structure supporting WirelessMAN-OFDMA

16.3.3.5.1 TDD frame structure

The WirelessMAN-OFDMA and the Advanced Air Interface frames shall be offset by a fixed number of AAI subframes, FRAME_OFFSET = 1,2, … ,K as shown in Figure 479 and Figure 480. The FRAME_OFFSET of different ABSs shall be the same wthin the same deployment region. When the Advanced Air Interface frames support the WirelessMAN-OFDMA for 5, 10, 20MHz channel bandwidths, all AAI subframes in the Advanced Air Interface DL Zone are type-1 AAI subframes. The number of symbols in the first WirelessMAN-OFDMA DL Zone is 5+6·(FRAME_OFFSET-1). When the Advanced Air Interface frames support the WirelessMAN-OFDMA for the 8.75 MHz channel bandwidth with 15 UL OFDM symbols and for the 7 MHz channel bandwidth with 12 UL OFDM symbols, all AAI subframes in the Advanced Air Interface DL Zone are type-1 AAI subframes. The number of symbols in the first WirelessMAN-OFDMA DL Zone is 3+6·(FRAME_OFFSET - 1) for 8.75 MHz and 9+6·(FRAME_OFFSET - 1) for 7 MHz. The maximum value of parameter K is equal to the number of DL AAI subframes minus two. The minimum value of FRAME_OFFSET shall be two for 8.75 MHz channel bandwidth, and the minimum value of FRAME_OFFSET shall be one for other bandwidths.

In the DL, a subset of DL AAI subframes is dedicated to the WirelessMAN-OFDMA operation to enable one or more WirelessMAN-OFDMA DL time zones. The subset includes the first WirelessMAN-OFDMA DL time zone to support the transmission of the preamble, FCH and MAP, which are defined in 8.4.

The subset of DL AAI subframes dedicated to the WirelessMAN-OFDMA operation should comprise either one group of contiguous DL AAI subframes or two separate groups of contiguous DL AAI subframes. When comprising the two separate groups, the second group shall include the last DL AAI subframe.

Data bursts for the WirelessMAN-OFDMA MSs shall not be transmitted in the DL AAI subframes for operation of the Advanced Air Interface. Those DL AAI subframes shall be indicated as a DL time zone by transmitting an STC_DL_ZONE_IE() with the Dedicated Pilots field set to 1, as defined in Table 328, in the DL-MAP messages.

Bursts for AMS can be scheduled in either zone (Advanced Air Interface DL Zone or WirelessMAN OFDMA DL Zone) according to the mode (Advanced Air Interface or WirelessMAN-OFDMA) with which the AMS is connected to the ABS, but not in both zones at the same time.

In the UL, the two configurations are applicable:

1) FDM mode: A group of subcarriers (subchannels), spanning the entire UL transmission, is dedicated to the WirelessMAN-OFDMA operation. The remaining subcarriers, denoted the Advanced Air Interface UL subchannels group and forming the Advanced Air Interface UL AAI subframes, are dedicated to the Advanced Air Interface operation. Figure 479 illustrates an example frame configuration for supporting the WirelessMAN-OFDMA operation when FDM mode is used. In the case of 5, 7, 10, and 20 MHz, all UL AAI subframes are type-1 AAI subframes. In the case of 8.75 MHz with 15 UL OFDM symbols, the first UL AAI subframe is a type-1 AAI subframe and the second UL AAI subframe is a type-4 AAI subframe.

   Data bursts from the WirelessMAN-OFDMA MSs shall not be transmitted in the UL subchannels group for operation of the Advanced Air Interface.

   Bursts for AMS can be scheduled in either group of UL subchannels (group of UL subchannels for Advanced Air Interface or WirelessMAN OFDMA) according to the mode (Advanced Air Interface or WirelessMAN-OFDMA) with which the AMS is connected to the ABS, but not in both groups at the same time.

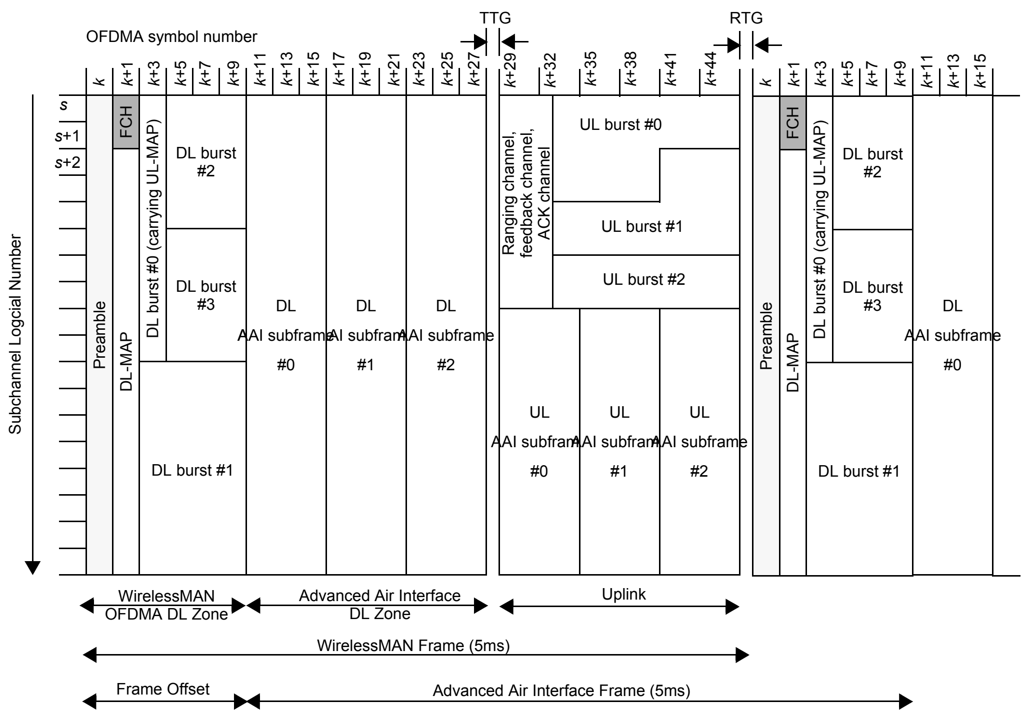


Figure 479—TDD frame configuration to support WirelessMAN-OFDMA UL FDM operation

2) TDM mode: A subset of UL AAI subframes is dedicated to the WirelessMAN-OFDMA operation to enable one or more WirelessMAN-OFDMA UL time zones. The subset includes the 1st Wireless-MAN-OFDMA UL time zone to support the transmission of the ranging channel, feedback channel and ACK channel, which are defined in 8.4. Figure 480 illustrates an example frame configuration for supporting the WirelessMAN-OFDMA operation when TDM mode is used. In the case of 5, 7, 10, 20, and 8.75 MHz, all AAI subframes in the Advanced Air Interface UL Zone are type-1 AAI subframes.

Data bursts from the WirelessMAN-OFDMA MSs shall not be transmitted in the UL AAI subframes for operation of the Advanced Air Interface. Those UL AAI subframes shall be indicated as a UL time zone by transmitting an UL_ZONE_IE(), defined in Table 388, in the UL-MAP message.

Bursts for AMS can be scheduled in either zone (Advanced Air Interface UL Zone or WirelessMAN OFDMA UL Zone) according to the mode (Advanced Air Interface or WirelessMAN-OFDMA) with which the AMS is connected to the ABS, but not in both zones at the same time.

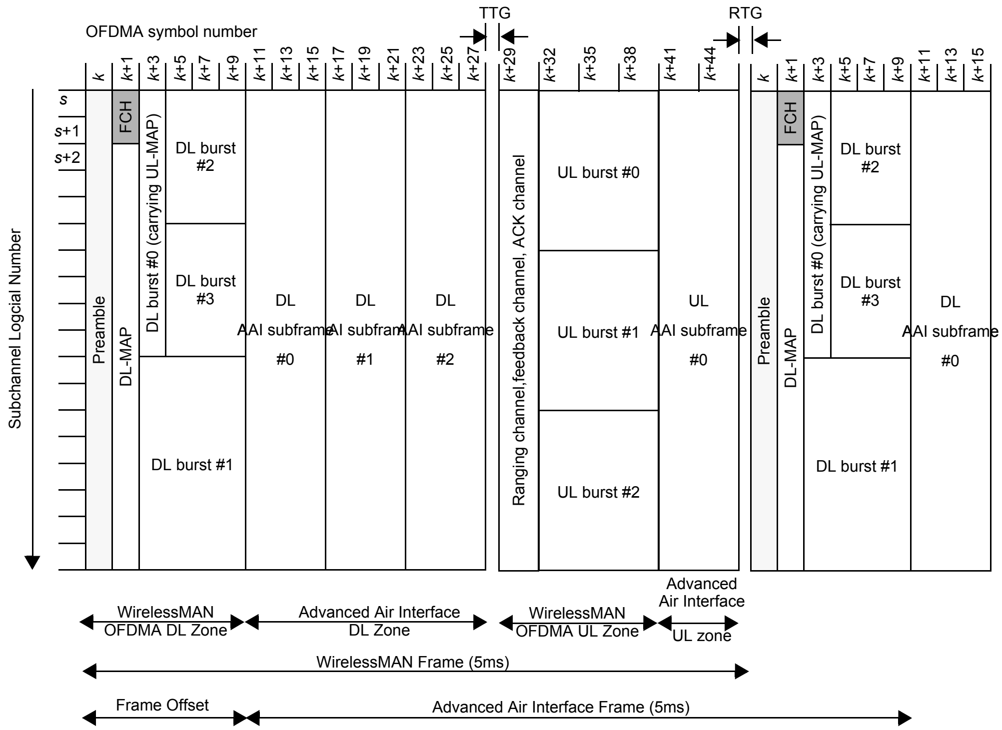


Figure 480—TDD frame configuration to support WirelessMAN-OFDMA UL TDM operation

16.3.3.5.2 FDD frame structure

The WirelessMAN-OFDMA and the Advanced Air Interface frames shall be offset by a fixed number of AAI subframes, FRAME_OFFSET = 1,2, … , K as shown in Figure 481. When the Advanced Air Interface frames support the WirelessMAN-OFDMA for 5, 10, 20MHz channel bandwidths, all AAI subframes in the Advanced Air Interface DL and UL Zones are type-1 AAI subframes. The FDD frame structure is separated into two regions in the DL and UL for supporting the coexistence of the WirelessMAN-OFDMA FDD/H-FDD MSs and AAI FDD MSs in the same frame. An ABS shall be able to simultaneously support FDD and H-FDD AMSs in AAI DL/UL zone. The ABS also supports WirelessMAN-OFDMA FDD and H-FDD MSs in the WirelessMAN-OFDMA DL/UL zone. For WirelessMAN-OFDMA H-FDD MSs, by using the "No. of OFDMA Symbols" field in DL-MAP1 and UL-MAP1 of the WirelessMAN-OFDMA frame, the ABS shall indicate the number of symbols in DL and UL of the WirelessMAN-OFDMA frame for non-overlapped allocation between the WirelessMAN-OFDMA UL zone and the AAI UL zone. In addition, the data bursts for the WirelessMAN-OFDMA FDD/H-FDD MSs shall not be transmitted in the AAI DL zone.

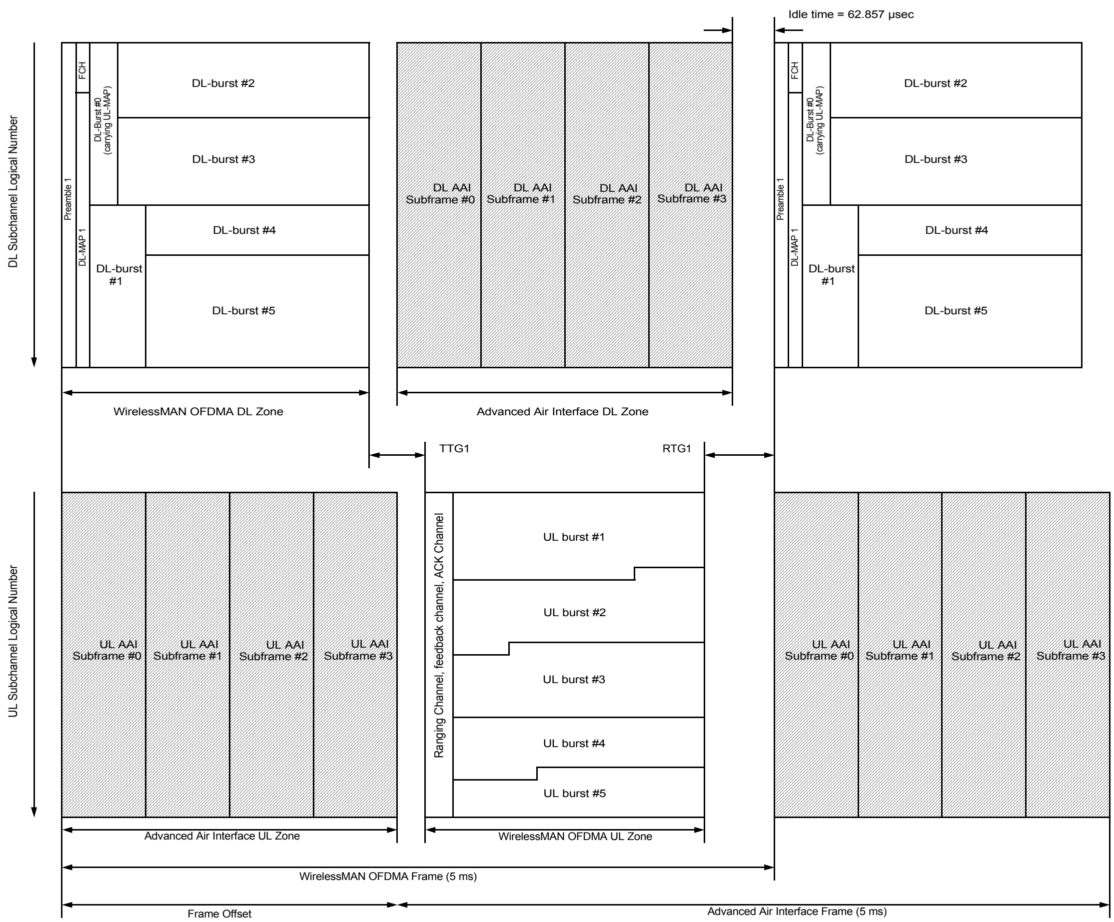


Figure 481—FDD frame configuration to support WirelessMAN-OFDMA FDD/H-FDD operation (e.g. 5, 10, and 20 MHz with 1/8 Tb CP)

16.3.3.6 Frame structure supporting wider bandwidth

The same frame structure (16.3.3.1, 16.3.3.2, 16.3.3.3) is used for each carrier in multicarrier mode operation. Each carrier shall have its own superframe header. Some carriers may have only part of superframe header. Figure 482 illustrates the example of the frame structure to support multicarrier operation. For FDD UL, the preamble and superframe headers are replaced with traffic OFDMA symbols.

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

Each AMS is controlled through an RF carrier which is the primary carrier. When multicarrier feature is supported, the system may define and utilize additional RF carriers to improve the user experience and QoS or provide services through additional RF carriers configured or optimized for specific services. These additional RF carriers are the secondary carriers. The detailed description of the multicarrier operation can be found in 16.2.8.

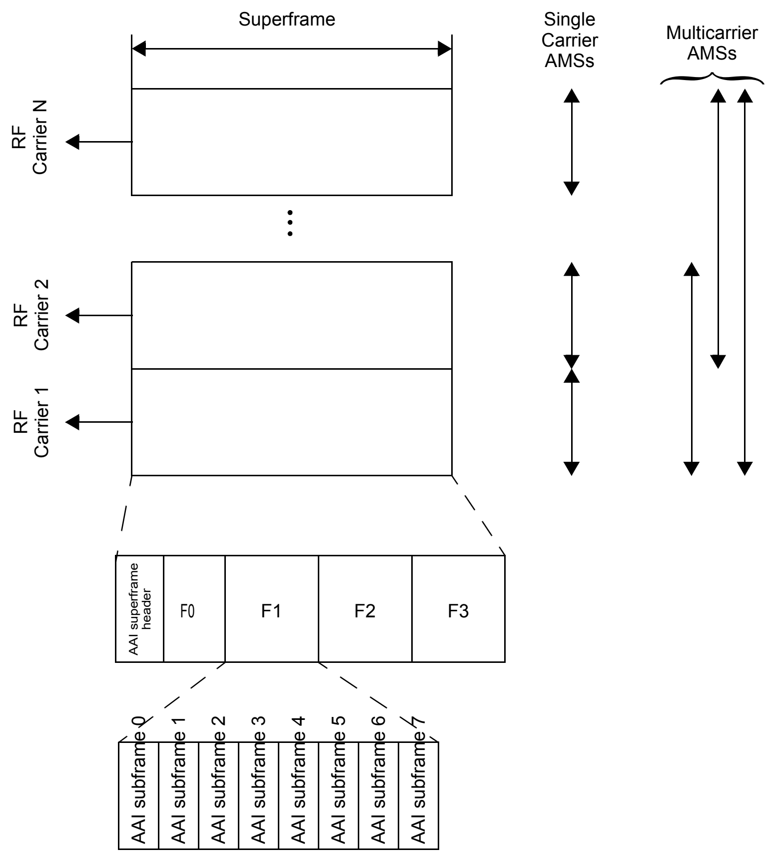


Figure 482—Example of the frame structure to support multicarrier operation

16.3.3.6.1 Frame structure to support WirelessMAN-OFDMA with multicarrier operation

In the multicarrier mode supporting WirelessMAN-OFDMA, each carrier can have either a basic frame structure (16.3.3.1) or a basic frame structure configured to support the WirelessMAN-OFDMA (16.3.3.5). Figure 483 illustrates an example of the frame structure in the multicarrier mode supporting WirelessMAN-OFDMA. In the multicarrier mode, to support WirelessMAN-OFDMA, the uplink can be also configured as TDM as defined in 16.3.3.5.

Multicarrier operation is only performed between Advanced Air Interface AAI subframes. No multicarrier operation is defined between the Advanced Air Interface frames and WirelessMAN-OFDMA frames.

When two adjacent carriers both contain AAI zone and WirelessMAN-OFDMA zone (e.g. RF Carrier 2 in Figure 483), the FRAME_OFFSET and UL support configuration (i.e. TDM or FDM) applied in each of these two carriers shall be the same. The MC_FRAME_OFFSET will be broadcast in AAI_MC-ADV to inform AMS the frame boundary of the AAI zone applied in different carrier groups.

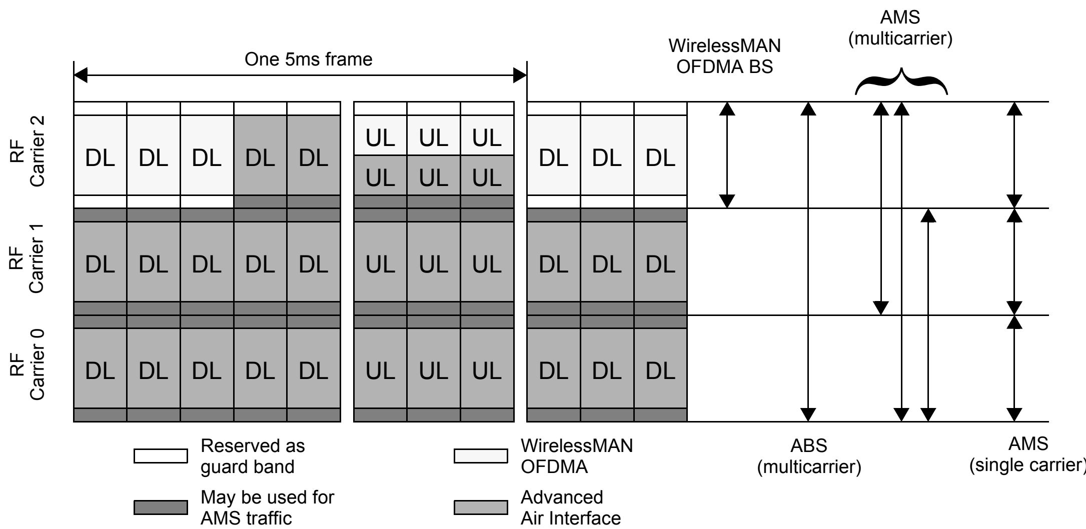


Figure 483—Example of the frame structure to support WirelessMAN-OFDMA with multicarrier operation

16.3.3.6.2 Subcarrier alignment for multicarrier operation

When contiguous carriers only contain AAI zone and involve in multicarrier operation, the overlapped sub-carriers shall be aligned in frequency domain. In order to align the overlapped sub-carriers of the OFDMA signals transmitted over adjacent carriers, a permanent frequency offset ($\Delta f'$) will be applied over the original center frequency. The basic principle is shown by the example in Figure 484.

When one carrier contains both AAI zone and WirelessMAN-OFDMA zone while its adjacent carrier only contain AAI zone, the overlapped sub-carriers shall be aligned. The center frequency of the carriers which contain both AAI zone and WirelessMAN-OFDMA zone will exactly locate on the channel raster grid.

Network operator may choose different multi-carrier configuration according to the available spectrum resources and the restriction due to support of WirelessMAN-OFDMA zone. When two adjacent carriers both contain AAI zone and WirelessMAN-OFDMA zone, the overlapped sub-carriers may not be aligned.

The overlapped sub-carriers of the radio signals transmitted over these two adjacent carriers will not be aligned under this condition. If AMS cannot support carrier aggregation due to hardware restriction under sub-carrier misalignment configuration, the AMS shall inform ABS the carriers it can simultaneously process through AAI_MC-REQ message.

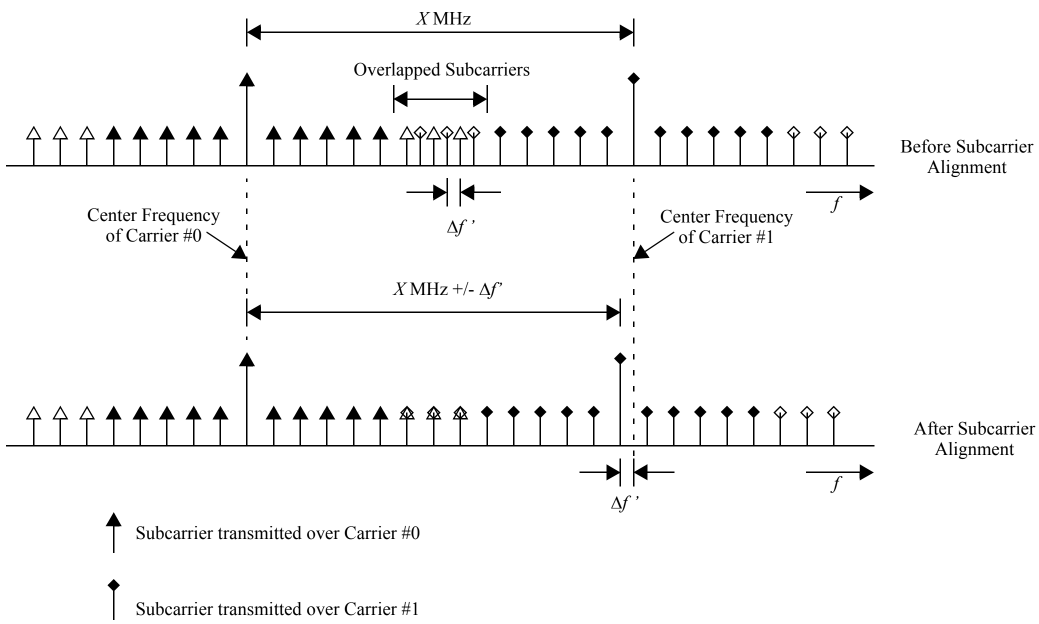


Figure 484—Example of subcarrier alignment of adjacent carriers

During the network entry procedure (defined in 16.2.8.2.3), the ABS will notify the AMS of the frequency offset to be applied over each carrier for sub-carrier alignment through AAI_MC-ADV message. According to the multicarrier configuration index and the Physical Carrier Index of Current Carrier broadcasted by ABS, AMS can derive the center frequency of the available carriers by the associated frequency offset $\Delta f'$ using Table 779. Note that the frequency offset $\Delta f'$ is smaller than the sub-carrier spacing value depicted in Figure 484.

In Table 779, a lookup table is defined to indicate the configurations for a group of contiguous carriers. If the network supports multiple groups of contiguous carriers, AAI_MC-ADV message will separately indicate each group of the contiguous carriers by referring to the index of this table. For example, the multicarrier configuration {5, 10} indicates two contiguous carriers are supported. The first one is a 5MHz carrier and another one is a 10MHz carrier, where the order in this configuration is sorted from lower frequency to higher frequency. In addition, the reference carrier index indicates the index of physical carrier where the AMS received this configuration information.

Based on the center frequency of the reference carrier that AMS received the AAI_MC-ADV message and the bandwidth of each carrier, the center frequency of each carrier before sub-carrier alignment can be derived. Then the AMS can obtain the frequency offset Δf to be applied over each carrier based on the multicarrier configuration index, the reference carrier index and Table 779. So that AMS can obtain the correct center frequency of each carrier including the sub-carrier alignment effect.

When two adjacent carriers both contain AAI zone and WirelessMAN-OFDMA zone, they will be treated as two non-contiguous carriers and be indicated by different carrier group in AAI_MC-ADV message. ABS and AMS shall be capable to encode and decode each multi-carrier configuration depicted in Table 779 and apply the corresponding frequency offset before activating multi-carrier operations.

Table 779—Center frequency offset for sub-carrier alignment and bandwidth of each carrier within a carrie group

Index	Multi-carrier Configuration (MHz)	Frequency Offset Δf (kHz)
1	{5}	{0}
2	{7}	{0}
3	{8.75}	{0}
4	{10}	{0}
5	{20}	{0}
6	{10, 10}	{0, -3.1248}

16.3.3.6.3 Data Transmission over guard subcarriers in multicarrier operation

When contiguous carriers are involved in multicarrier operation, the guard sub-carriers between contiguous frequency channels may be utilized for data transmission. During the secondary carrier assignment procedure defined in 16.2.8.2.3.2, the ABS will notify the information on available guard sub-carriers eligible for data transmission to the AMS.

16.3.3.7 Set of frame configurations

Table 780, Table 781, and Table 782 show sets of the frame configurations and indexing for 5/10/20MHz, 8.75MHz, and 7MHz, respectively. Note that per each combination of bandwidth and CP length, frame configuration information is carried by frame configuration index in S-SFH SP1 IE in Table 811.

The frame structure supporting the WirelessMAN-OFDMA frame defined in 16.3.3.5.1, shall be configured with one of the following configuration numbers (i.e. 'No.' in the tables): 11 to 22 in the Table 780 for 5/10/

20MHz channel bandwidths; 9 to 14 in the Table 781 for 8.75MHz channel bandwidth; 8 to 9 in the Table 782 for 7MHz channel bandwidth. In this case, DL offset and DL length denote Frame_Offset and the number of DL AAI subframes dedicated to Advanced Air Interface operations, respectively. UL length denotes the number of UL AAI subframes dedicated to Advanced Air Interface operations.

When supporting WirelessMAN-OFDMA, for the case when UL length is less than total number of UL AAI subframes in a frame, the UL TDM mode defined in 16.3.3.5.1 is applied. For the case when UL length is the same as the total number of UL AAI subframes in a frame, the UL FDM mode defined in 16.3.3.5.1 is applied.

Table 780—Frame Configuration and Indexing (5/10/20MHz channel bandwidth)

No	BW	CP	Frame configuration index	Duplex	D:U	Subframe provision			AAI subframe Type								TTG/ RTG (μs)
						DL Offset	DL Length	UL Length	#0	#1	#2	#3	#4	#5	#6	#7	
1	5/10/20	1/16	0	TDD	6:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type2	82.853 / 60
2	5/10/20	1/16	1	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type2	82.853 / 60
3	5/10/20	1/16	2	TDD	4:4	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	UL Type2	82.853 / 60
4	5/10/20	1/16	3	TDD	3:5	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	UL Type1	UL Type1	UL Type1	UL Type1	UL Type2	82.853 / 60
5	5/10/20	1/16	4	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type2	N/A
6	5/10/20	1/8	0	TDD	6:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	105.714 / 60
7	5/10/20	1/8	1	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	UL Type1	105.714 / 60
8	5/10/20	1/8	2	TDD	4:4	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	UL Type1	UL Type1	105.714 / 60
9	5/10/20	1/8	3	TDD	3:5	N/A	N/A	N/A	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	UL Type1	UL Type1	UL Type1	105.714 / 60
10	5/10/20	1/8	4	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	N/A
11	5/10/20	1/8	5	TDD	5:3	3	2	3	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	Not used	Not Used	Not Used	105.714 / 60
12	5/10/20	1/8	6	TDD	5:3	3	2	1	DL Type1	DL Type1	Not Used	Not Used	UL Type1	Not used	Not Used	Not Used	105.714 / 60
13	5/10/20	1/8	7	TDD	5:3	2	3	3	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
14	5/10/20	1/8	8	TDD	5:3	2	3	2	DL Type1	DL Type1	DL Type1	Not Used	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
15	5/10/20	1/8	9	TDD	5:3	2	2	3	DL Type1	DL Type1	Not used	UL Type1	UL Type1	UL Type1	Not used	Not Used	105.714 / 60
16	5/10/20	1/8	10	TDD	5:3	2	2	1	DL Type1	DL Type1	Not used	Not used	Not Used	UL Type1	Not Used	Not Used	105.714 / 60
17	5/10/20	1/8	11	TDD	5:3	1	4	3	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	Not Used	105.714 / 60
18	5/10/20	1/8	12	TDD	5:3	1	4	2	DL Type1	DL Type1	DL Type1	DL Type1	Not Used	UL Type1	UL Type1	Not Used	105.714 / 60
19	5/10/20	1/8	13	TDD	5:3	1	3	3	DL Type1	DL Type1	DL Type1	Not used	UL Type1	UL Type1	UL Type1	Not Used	105.714 / 60
20	5/10/20	1/8	14	TDD	5:3	1	3	2	DL Type1	DL Type1	DL Type1	Not used	Not used	UL Type1	UL Type1	Not Used	105.714 / 60
21	5/10/20	1/8	15	TDD	5:3	1	2	3	DL Type1	DL Type1	Not used	Not used	UL Type1	UL Type1	UL Type1	Not Used	105.714 / 60
22	5/10/20	1/8	16	TDD	5:3	1	2	1	DL Type1	DL Type1	Not used	Not used	Not used	Not used	UL Type1	Not Used	105.714 / 60
23	5/10/20	1/8	17	TDD	6:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type3	DL Type3	UL Type1	UL Type1	208.571 / 60
24	5/10/20	1/8	18	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type3	DL Type3	UL Type1	UL Type1	UL Type1	208.571 / 60
25	5/10/20	1/8	19	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type3	DL Type3	DL Type3	UL Type1	UL Type1	UL Type1	311.428 / 60
26	5/10/20	1/4	0	TDD	5:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1		139.988 / 60
27	5/10/20	1/4	1	TDD	4:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1		139.988 / 60
28	5/10/20	1/4	2	TDD	3:4	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	UL Type1		139.988 / 60
29	5/10/20	1/4	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type1		N/A

Table 781—Frame Configuration and Indexing (8.75MHz channel bandwidth)

No	BW	CP	Frame configuration index	Duplex	D:U	Subframe provision			AAI subframe Type								TTG/ RTG (µs)
						DL Offset	DL Length	UL Length	#0	#1	#2	#3	#4	#5	#6	#7	
1	8.75	1/16	0	TDD	5:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	DL Type1	UL Type1	UL Type2		138.4/ 74.4
2	8.75	1/16	1	TDD	4:3	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	UL Type1	UL Type1	UL Type2		138.4/ 74.4
3	8.75	1/16	2	TDD	3:4	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	UL Type1	UL Type1	UL Type1	UL Type2		138.4/ 74.4
4	8.75	1/16	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type2	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type2		N/A
5	8.75	1/8	0	TDD	5:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1		87.2/ 74.4
6	8.75	1/8	1	TDD	4:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1		87.2/ 74.4
7	8.75	1/8	2	TDD	3:4	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	UL Type1		87.2/ 74.4
8	8.75	1/8	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type1		N/A
9	8.75	1/8	4	TDD	5:2	3	2	2	DL Type1	DL Type1	UL Type1	UL Type4	Not Used	Not Used	Not Used		87.2/ 74.4
10	8.75	1/8	5	TDD	5:2	3	2	1	DL Type1	DL Type1	Not Used	UL Type1	Not Used	Not Used	Not Used		87.2/ 74.4
11	8.75	1/8	6	TDD	5:2	2	3	2	DL Type1	DL Type1	DL Type1	UL Type1	UL Type4	Not Used	Not Used		87.2/ 74.4
12	8.75	1/8	7	TDD	5:2	2	3	1	DL Type1	DL Type1	DL Type1	Not Used	UL Type1	Not Used	Not Used		87.2/ 74.4
13	8.75	1/8	8	TDD	5:2	2	2	2	DL Type1	DL Type1	Not Used	UL Type1	UL Type1	Not Used	Not Used		87.2/ 74.4
14	8.75	1/8	9	TDD	5:2	2	2	1	DL Type1	DL Type1	Not Used	Not Used	UL Type1	Not Used	Not Used		87.2/ 74.4
15	8.75	1/4	0	TDD	4:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	UL Type1	UL Type1			189.6/ 74.4
16	8.75	1/4	1	TDD	3:3	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	UL Type1	UL Type1	UL Type1			189.6/ 74.4
17	8.75	1/4	2	TDD	2:4	N/A	N/A	N/A	DL Type1	DL Type2	UL Type1	UL Type1	UL Type1	UL Type1			189.6/ 74.4
18	8.75	14	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type2	D/U Type1	D/U Type2	D/U Type1	D/U Type2			N/A

Table 782—Frame Configuration and Indexing (7MHz channel bandwidth)

No	BW	CP	Frame configuration index	Duplex	D:U	Subframe provision			AAI subframe Type								TTG/ RTG (μs)
						DL Offset	DL Length	UL Length	#0	#1	#2	#3	#4	#5	#6	#7	
1	7	1/16	0	TDD	4:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1			180/ 60
2	7	1/16	1	TDD	3:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	UL Type1			180/ 60
3	7	1/16	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1			N/A
4	7	1/8	0	TDD	3:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type2	UL Type1	UL Type2				188/ 60
5	7	1/8	1	TDD	2:3	N/A	N/A	N/A	DL Type1	DL Type2	UL Type1	UL Type2	UL Type2				188/ 60
6	7	1/8	2	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type2	D/U Type2	D/U Type2	D/U Type2				N/A
7	7	1/8	3	TDD	3:2	1	2	2	DL Type1	DL Type1	UL Type1	UL Type1	Not Used				188/ 60
8	7	1/8	4	TDD	3:2	1	2	1	DL Type1	DL Type1	Not Used	UL Type1	Not Used				188/ 60
9	7	1/4	0	TDD	3:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1				140/ 60
10	7	1/4	1	TDD	2:3	N/A	N/A	N/A	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1				140/ 60
11	7	1/4	2	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type2	D/U Type1	D/U Type1				N/A

16.3.4 Reserved

16.3.5 Downlink physical structure

Each downlink AAI subframe is divided into 4 or fewer frequency partitions; each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the AAI subframe. Each frequency partition can include contiguous (localized) and/or non-contiguous (distributed) physical resource units. Each frequency partition can be used for different purposes such as fractional frequency reuse (FFR). Figure 485 illustrates the downlink physical structure in the example of two frequency partitions with frequency partition 2 including both contiguous and distributed resource allocations, where Sc stands for sub-carrier.

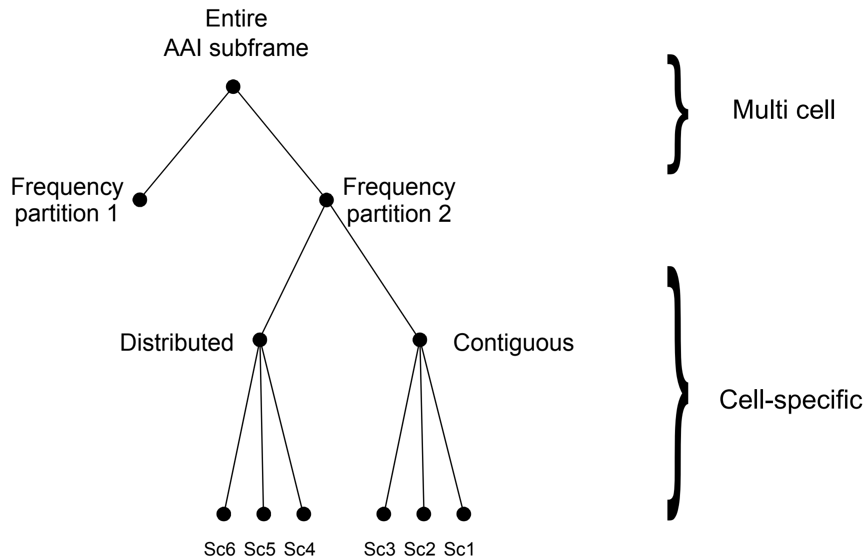


Figure 485—Example of downlink physical structure

16.3.5.1 Physical and logical resource unit

A physical resource unit (PRU) is the basic physical unit for resource allocation that comprises P_{sc} consecutive subcarriers by N_{sym} consecutive OFDMA symbols. P_{sc} is 18 subcarriers and N_{sym} is 6, 7, and 5 OFDMA symbols for type-1, type-2, and type-3 AAI subframes, respectively. A logical resource unit (LRU) is the basic logical unit for distributed and localized resource allocations. An LRU is $P_{sc} \cdot N_{sym}$ subcarriers for type-1 AAI subframes, type-2 AAI subframes, and type-3 AAI subframes. The effective number of subcarriers in an LRU depends on the number of allocated pilots.

16.3.5.1.1 Distributed logical resource unit

The distributed logical resource unit (DLRU) contains a group of subcarriers that are spread across the distributed resource allocations within a frequency partition. The size of the DLRU equals the size of PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The minimum unit for forming the DLRU is equal to a pair of subcarriers, called tone-pair, as defined in 16.3.5.3.2. The DLRUs are obtained by subcarrier permuting the distributed resource units (DRUs).

16.3.5.1.2 Contiguous logical resource unit

The localized logical resource unit, also known as contiguous logical resource unit (CLRU) contains a group of subcarriers that are contiguous across the localized resource allocations. The size of the CLRU equals the size of the PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The CLRUs are obtained from direct mapping of contiguous resource units (CRUs). Two types of CLRUs, subband LRU (SLRU) and miniband LRU

(NLRU), are supported according to the two types of CRUs, subband and miniband based CRUs, respectively.

16.3.5.2 Multi-cell resource mapping

16.3.5.2.1 Subband partitioning

The PRUs are first subdivided into subbands and minibands where a subband comprises of N_1 adjacent PRUs and a miniband comprises of N_2 adjacent PRUs, where $N_1 = 4$ and $N_2 = 1$. Subbands are suitable for frequency selective allocations as they provide a contiguous allocation of PRUs in frequency. Minibands are suitable for frequency diverse allocation and are permuted in frequency.

The number of subbands is denoted by K_{SB}. The number of PRUs allocated to subbands is denoted by L_{SB}, where $L_{SB} = N_1 \cdot K_{SB}$. A 5, 4 or 3-bit field called Downlink Subband Allocation Count (*DSAC*) determines the value of K_{SB} depending on FFT size. The *DSAC* is transmitted in the SFH. The remaining PRUs are allocated to minibands. The number of minibands in an allocation is denoted by K_{MB}. The number of PRUs allocated to minibands is denoted by L_{MB}, where $L_{MB} = N_2 \cdot K_{MB}$. The total number of PRUs is denoted as N_{PRU} where $N_{PRU} = L_{SB} + L_{MB}$. The maximum number of subbands that can be formed is denoted as N_{sub} where $N_{sub} = \lfloor N_{PRU}/N_1 \rfloor$.

Table 783 through Table 785 show the mapping between *DSAC* and K_{SB} for FFT sizes of 2048, 1024, and 512, respectively.

For those system bandwidths in range of (10, 20], the relation between the system bandwidth and supported number of N_{PRU} is listed in Table 777. The mapping between *DSAC* and K_{SB} is based on Table 783, the maximum valid value of K_{SB} is $N_{PRU}/4-3$.

For those system bandwidths in range of [5, 10], the relation between the system bandwidth and supported number of N_{PRU} is listed in Table 778. The mapping between *DSAC* and K_{SB} is based on Table 784, the maximum valid value of K_{SB} is $N_{PRU}/4-2$.

Table 783—Mapping between *DSAC* and K_{SB} for 2048 FFT size

DSAC	Number of subbands allocated (K_{SB})	*DSAC*	Number of subbands allocated (K_{SB})
0	0	16	16
1	1	17	17
2	2	18	18
3	3	19	19
4	4	20	20
5	5	21	21
6	6	22	NA.
7	7	23	NA.
8	8	24	NA.
9	9	25	NA.
10	10	26	NA.
11	11	27	NA.
12	12	28	NA.
13	13	29	NA.
14	14	30	NA.
15	15	31	NA.

Table 784—Mapping between *DSAC* and K_{SB} for 1024 FFT size

DSAC	Number of subbands allocated (K_{SB})	*DSAC*	Number of subbands allocated (K_{SB})
0	0	8	8
1	1	9	9
2	2	10	10
3	3	11	NA.
4	4	12	NA.
5	5	13	NA.
6	6	14	NA.
7	7	15	NA.

Table 785—Mapping between *DSAC* and K_{SB} for 512 FFT size

DSAC	Number of subbands allocated (K_{SB})	*DSAC*	Number of subbands allocated (K_{SB})
0	0	4	4
1	1	5	NA.
2	2	6	NA.
3	3	7	N.A

PRUs are partitioned and reordered into two groups: subband PRUs and miniband PRUs, denoted by PRU_{SB} and PRU_{MB}, respectively. The set of PRU_{SB} is numbered from 0 to (L_{SB} - 1). The set of PRU_{MB} are numbered from 0 to (L_{MB} - 1). Equation (176) defines the mapping of PRUs to PRU_{SB}s. Equation (177) defines the mapping of PRUs to PRU_{MB}s. Figure 486 illustrates the mapping from PRU to PRU_{SB} and PRU_{MB} for a 10 MHz bandwidth with K_{SB} equal to 7.

$$PRU_{SB}[j] = PRU[i]; \quad j = 0, 1, \ldots, L_{SB} - 1 \tag{176}$$

where

$$i = N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{j + L_{MB}}{N_1} \right\rfloor + \left\lfloor \left\lfloor \frac{j + L_{MB}}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\rfloor \right\} \mathrm{mod}\{N_{sub}\} + \{j + L_{MB}\} \mathrm{mod}\{N_1\}$$

where $\{x\}$ mod $\{y\}$ is modulus when dividing x by y, and GCD(x, y) is the greatest common divisor of x and y.

$$PRU_{MB}[k] = PRU[i]; k = 0, 1, \ldots, L_{MB} - 1 \tag{177}$$

where

$$i = \begin{cases} N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{k}{N_1} \right\rfloor + \left\lfloor \left\lfloor \frac{k}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\rfloor \right\} \mathrm{mod}\{N_{sub}\} + \{k\} \cdot \mathrm{mod}\{N_1\} & K_{SB} > 0 \\ k & K_{SB} = 0 \end{cases}$$

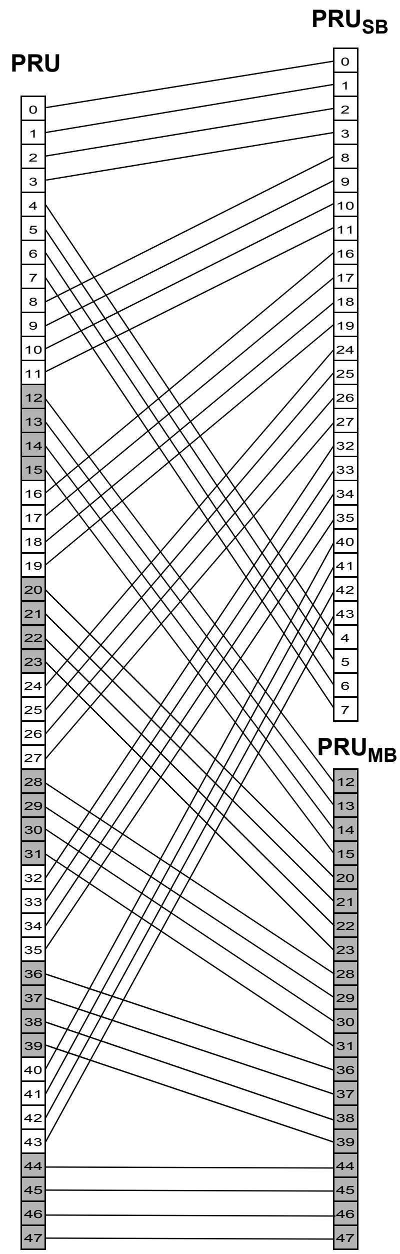


Figure 486—PRU to PRU_{SB} and PRU_{MB} mapping for *BW*=10 MHz, K_{SB}=7

16.3.5.2.2 Miniband permutation

The miniband permutation maps the PRU_{MB}s to Permuted PRU_{MB}s ($PPRU_{MB}$s) to ensure frequency diverse PRUs are allocated to each frequency partition. Equation (178) describes the mapping from PRU_{MB} to $PPRU_{MB}$s:

$$PPRU_{MB}[j] = PRU_{MB}[i]; j = 0, 1, \ldots, L_{MB} - 1 \tag{178}$$

where:

$$i = (q(j) mod(D)) \cdot P + \left\lfloor \frac{q(j)}{D} \right\rfloor \tag{179}$$

$$P = min(K_{MB}, N_1 / N_2) \tag{180}$$

$$r(j) = max(j - (K_{MB} mod(P) \cdot D), 0) \tag{181}$$

$$q(j) = j + \left\lfloor \frac{r(j)}{D-1} \right\rfloor \tag{182}$$

$$D = \left\lfloor \frac{K_{MB}}{P} + 1 \right\rfloor \tag{183}$$

Figure 487 depicts the mapping from PRUs to PRU_{SB} and $PPRU_{MB}$.

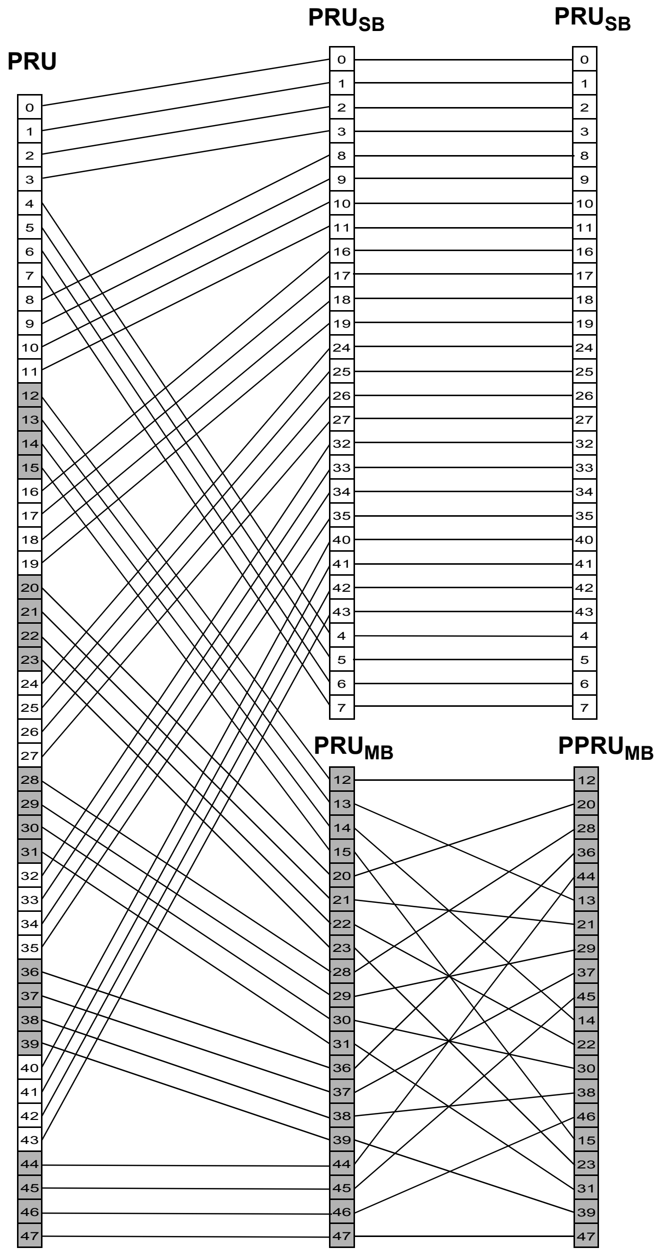


Figure 487—Mapping from PRUs to PRU_{SB} and $PPRU_{MB}$ mapping for BW=10 MHz, K_{SB}=7

16.3.5.2.3 Frequency partitioning

The PRU_{SB}s and $PPRU_{MB}$s are allocated to one or more frequency partitions. By default, only one partition is present. The maximum number of frequency partitions is 4. The frequency partition configuration is transmitted in the SFH in a 4 or 3-bit field called the Downlink Frequency Partition Configuration (*DFPC*) depending on FFT size. The Frequency Partition Count (*FPCT*) defines the number of frequency partitions. The Frequency Partition Size (FPS_i) defines the number of PRUs allocated to the *i*-th frequency partition, FP_i. *FPCT* and FPS_i are determined from *DFPC* as shown in Table 775 through Table 788. A 3, 2, or 1-bit field called the Downlink Frequency Partition Subband Count (*DFPSC*) defines the number of subbands allocated to FP_i, $i > 0$.

Table 786—Mapping between *DFPC* and frequency partitioning for 2048 FFT size

DFPC	Freq. Partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i (i>0)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$FPS_1 = N_{PRU} - 2*\text{floor}(N_{PRU}/3)$ $FPS_2 = \text{floor}(N_{PRU}/3)$ $FPS_3 = \text{floor}(N_{PRU}/3)$
2	1 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/4)	floor(N_{PRU}/4)
3	3 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/6)	floor(N_{PRU}/6)
4	5 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/8)	floor(N_{PRU}/8)
5	9 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/12)	floor(N_{PRU}/12)
6	9 : 5 : 5 : 5	4	N_{PRU}-3*floor(N_{PRU}*5/24)	floor(N_{PRU}*5/24)
7	0 : 1 : 1 : 0	2	0	N_{PRU}/2 for i=1, 2 0 for i =3
8	1 : 1 : 1 : 0	3	N_{PRU}-2*floor(N_{PRU}/3)	floor(N_{PRU}/3) for i=1, 2 0 for i =3
9-15	Reserved			

Table 787—Mapping between *DFPC* and frequency partitioning for 1024 FFT size

DFPC	Freq. Partitioning ($FP_0:FP_1:FP_2:FP_3$)	*FPCT*	FPS_0	FPS_i (i>0)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$FPS_1 = N_{PRU} - 2*\text{floor}(N_{PRU}/3)$ $FPS_2 = \text{floor}(N_{PRU}/3)$ $FPS_3 = \text{floor}(N_{PRU}/3)$
2	1 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/4)	floor(N_{PRU}/4)
3	3 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/6)	floor(N_{PRU}/6)
4	5 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/8)	floor(N_{PRU}/8)
5	9 : 5 : 5 : 5	4	N_{PRU}-3*floor(N_{PRU}*5/24)	floor(N_{PRU}*5/24)
6	0 : 1 : 1 : 0	2	0	N_{PRU}/2 for i=1, 2 0 for i =3
7	1 : 1 : 1 : 0	3	N_{PRU}-2*floor(N_{PRU}/3)	floor(N_{PRU}/3) for i=1, 2 0 for i =3

Table 788—Mapping between *DFPC* and frequency partitioning for 512 FFT size

DFPC	Freq. Partitioning ($FP_0:FP_1:FP_2:FP_3$)	*FPCT*	FPS_0	FPS_i (i>0)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	N_{PRU} /3
2	1 : 1 : 1 : 1	4	N_{PRU} /4	N_{PRU} /4
3	3 : 1 : 1 : 1	4	N_{PRU} /2	N_{PRU} /6
4	9 : 5 : 5 : 5	4	N_{PRU} * 3/8	N_{PRU} * 5/24
5	0 : 1 : 1 : 0	2	0	N_{PRU}/2 for i=1, 2 0 for i =3
6	1 : 1 : 1 : 0	3	N_{PRU}/3	N_{PRU}/3 for i=1, 2 0 for i =3
7	Reserved			

The number of subbands in i^{th} frequency partition is denoted by $K_{SB,FPi}$. The number of minibands is denoted by $K_{MB,FPi}$, which is determined by the FPS_i and *DFPSC* fields. When *DFPC* = 0, *DFPSC* must be equal to 0. The number of subband PRUs in each frequency partition is denoted by $L_{SB,FPi}$, which is given by $L_{SB,FPi} = N_1 \cdot K_{SB,FPi}$. The number of miniband PRUs in each frequency partition is denoted by $L_{MB,FPi}$, which is given by $L_{MB,FPi} = N_2 \cdot K_{MB,FPi}$. The number of subbands for each frequency partition is given by Equation (184).

$$K_{SB,FP_i} = \begin{cases} K_{SB} - (FPCT-1)\cdot DFPSC & i=0,\ FPCT=4 \\ DFPSC & i>0,\ FPCT=4 \\ DFPSC & i>0,\ FPCT=3,\ DFPC=1 \\ K_{SB} - (FPCT-1)\cdot DFPSC & i=0,\ FPCT=3,\ DFPC\neq 1 \\ DFPSC & i=1,2,\ FPCT=3,\ DFPC\neq 1 \\ DFPSC & i=1,2,\ FPCT=2 \\ K_{SB} & i=0,\ FPCT=1 \end{cases} \quad (184)$$

When $FPCT = 2$, $DFPSC$ shall be $K_{SB}/2$. (185)

The number of minibands for each frequency partition is given by Equation (186).

$$K_{MB,FP_i} = (FPS_i - K_{SB,FPi}\cdot N_1)/N_2 \qquad 0 \le i < FPCT \quad (186)$$

The mapping of subband PRUs and miniband PRUs to the frequency partition i is given by Equation (187):

$$PRU_{FP_i}(j) = \begin{cases} PRU_{SB}(k_1) & \text{for } 0 \le j < L_{SB,FP_i} \\ PPRU_{MB}(k_2) & \text{for } L_{SB,FP_i} \le j < (L_{SB,FP_i} + L_{MB,FP_i}) \end{cases} \quad (187)$$

where $k_1 = \sum_{m=0}^{i-1} L_{SB,FP_m} + j$ and $k_2 = \sum_{m=0}^{i-1} L_{MB,FP_m} + j - L_{SB,FP_i}$

Figure 488 depicts the frequency partitioning for BW = 10 MHz, K_{SB} = 7, $FPCT$ = 4, $FPS_0 = FPS_i$ = 12, and $DFPSC$ = 2.

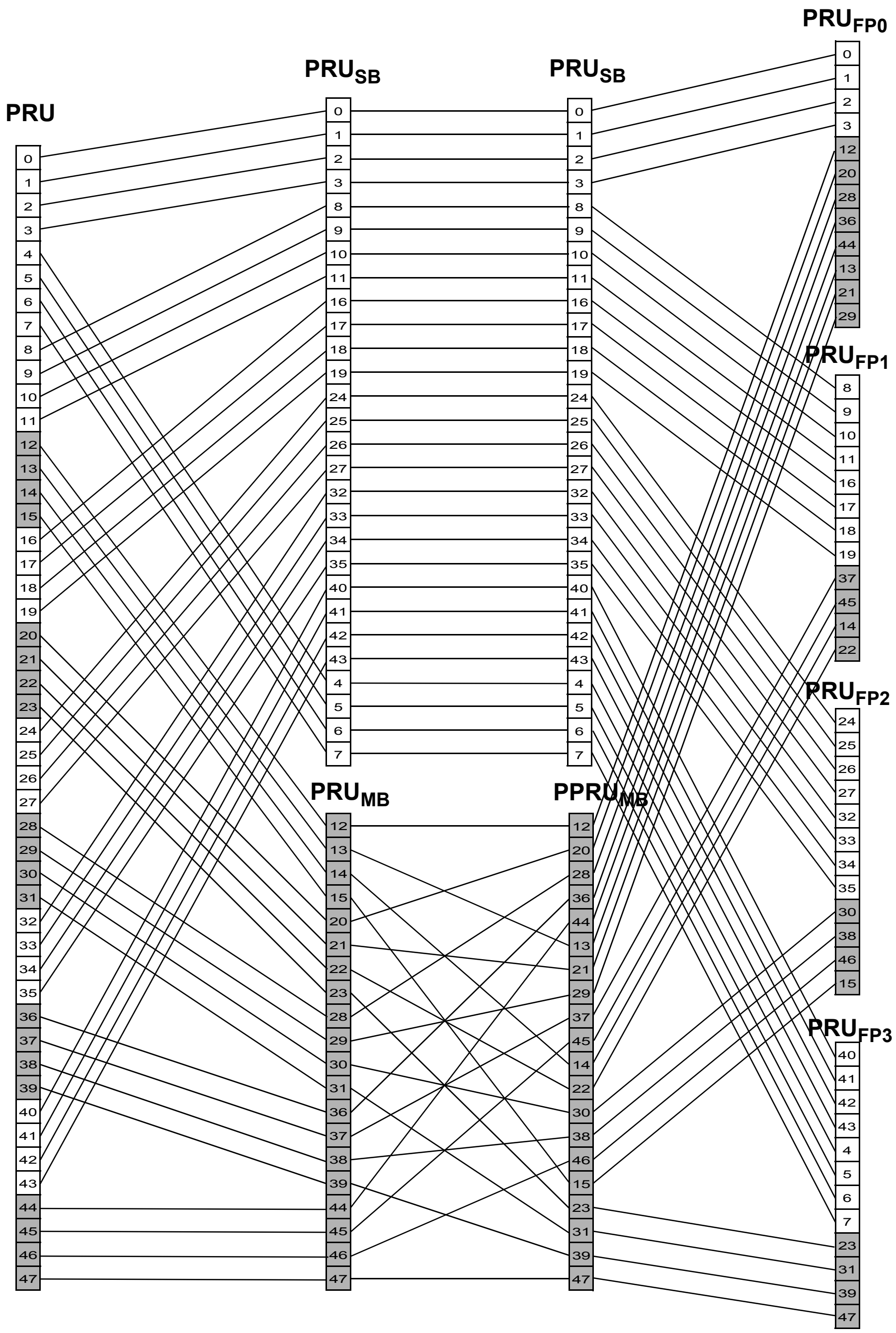


Figure 488—Frequency partition for *BW*=10 MHz, K_{SB}=7, *FPCT*=4, FPS_0=FPS_i=12, *DFPSC*=2

16.3.5.3 Cell-specific resource mapping

PRU_{FPi}s are mapped to LRUs. All further PRU and subcarrier permutation are constrained to the PRUs of a frequency partition.

16.3.5.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector specific basis. Let $L_{SB\text{-}CRU,\ FPi}$ and $L_{MB\text{-}CRU,\ FPi}$ denote the number of allocated subband CRUs and miniband CRUs for FP_i ($i \geq 0$). The number of total allocated subband and miniband CRUs, in units of a subband (i.e. N_1 PRUs), for FP_i ($i \geq 0$) is given by the downlink CRU allocation size, $DCAS_i$. The numbers of subband-based and miniband-based CRUs in FP_0 are given by $DCAS_{SB,0}$ and $DCAS_{MB,0}$, in units of a subband and miniband, respectively. When $DFPC = 0$, $DCAS_i$ must be equal to 0.

For FP_0, the value of $DCAS_{SB,0}$ is explicitly signaled in the SFH as a 5, 4 or 3-bit field to indicate the number of subbands in unsigned-binary format. $DCAS_{SB,0} \leq K_{SB,\ FPi}$. A 5, 4 or 3-bit Downlink miniband-based CRU allocation size ($DCAS_{MB,0}$) is sent in the SFH only for partition FP_0, depending on FFT size. The number of subband-based CRUs for FP_0 is given by the Equation (188).

$$L_{SB-CRU,FP_0} = N_1 \cdot DCAS_{SB,0} \tag{188}$$

The mapping between $DCAS_{MB,0}$ and the number of miniband-based CRUs for FP_0 is shown in the Table 789 through Table 791 for FFT sizes of 2048, 1024 and 512, respectively.

For those system bandwidths in range of (10, 20], the mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 is based on Table 789, the maximum valid value of $L_{MB\text{-}CRU,\ FP0}$ is less than floor(88*N_{PRU}/96).

For those system bandwidths in range of [5, 10], the mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 is based on Table 790, the maximum valid value of $L_{MB\text{-}CRU,\ FP0}$ is less than floor(42*N_{PRU}/48).

Table 789—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 2048 FFT size

$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e. $L_{MB\text{-}CRU,\ FP0}$)	$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e. $L_{MB\text{-}CRU,\ FP0}$)
0	0	16	28
1	2	17	32
2	4	18	36
3	6	19	40
4	8	20	44
5	10	21	48
6	12	22	52
7	14	23	56
8	16	24	60
9	18	25	64
10	19	26	68
11	20	27	72
12	21	28	76
13	22	29	80
14	23	30	84
15	24	31	88

Table 790—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 1024 FFT size

$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e. $L_{MB\text{-}CRU,\ FP0}$)	$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e. $L_{MB\text{-}CRU,\ FP0}$)
0	0	8	16
1	2	9	18
2	4	10	20
3	6	11	22
4	8	12	24
5	10	13	38
6	12	14	40
7	14	15	42

Table 791—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 512 FFT size

$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e. $L_{MB\text{-}CRU,\ FP0}$)	$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e. $L_{MB\text{-}CRU,\ FP0}$)
0	0	4	8
1	2	5	10
2	4	6	18
3	6	7	20

For $FP_i(i > 0, FPCT \neq 2)$ only one value for $DCAS_i$ is explicitly signaled for all $i > 0$, in the SFH as a 3, 2 or 1-bit field to signal the same numbers of allocated CRUs for $FP_i(i > 0, FPCT \neq 2)$.

For $FP_i(i > 0, FPCT \neq 2)$, the number of subband CRUs ($L_{SB\text{-}CRU,FPi}$) and miniband CRUs ($L_{MB\text{-}CRU,FPi}$) are derived using Equation (189) and Equation (190) respectively.

$$L_{SB-CRU,FPi} = N_1 \cdot min\{DCAS_i, K_{SB,FPi}\} \tag{189}$$

$$L_{MB-CRU,FPi} = \begin{cases} 0, & DCAS_i \le K_{SB,FPi} \\ (DCAS_i - K_{SB,FPi}) \cdot N_1 & DCAS_i > K_{SB,FPi} \end{cases} \tag{190}$$

When $FPCT = 2$, $DCAS_{SB,i}$ and $DCAS_{MB,i}$ for i = 1 and 2 are signaled using the $DCAS_{SB,0}$ and $DCAS_{MB,0}$ fields in the SFH. Since FP_0 and FP_3 are empty, $L_{SB\text{-}CRU,FP0} = L_{MB\text{-}CRU,FP0} = L_{DRU,FP0} = 0$ and $L_{SB\text{-}CRU,FP3} = L_{MB\text{-}CRU,FP3} = L_{DRU,FP3} = 0$. For i = 1 and 2, $L_{SB\text{-}CRU,FPi} = N_1 * DCAS_{SB,0}$ and $L_{MB\text{-}CRU,FPi}$ is obtained from $DCAS_{MB,0}$ using the mapping in Table 789 through Table 791 for FFT sizes of 2048, 1024 and 512, respectively.

The total number of CRUs in frequency partition FP_i, for $0 \le i < FPCT$, is denoted by $L_{CRU,FPi}$, where

$$L_{CRU,FPi} = L_{SB-CRU,FPi} + L_{MB-CRU,FPi} \tag{191}$$

The number of DRUs in each frequency partition is denoted by $L_{DRU,FPi}$, where

$$L_{DRU,FPi} = FPS_i - L_{CRU,FPi} \quad \text{for } 0 \le i < FPCT \tag{192}$$

and FPS_i is the number of PRUs allocated to FP_i.

The mapping from PRU_{FPi} to CRU_{FPi} (for $0 \le i < FPCT$) is given by:

$$CRU_{FPi}[j] = \begin{cases} PRU_{FPi}[j], & 0 \le j < L_{SB-CRU,FPi} \\ PRU_{FPi}[k + L_{SB-CRU,FPi}], & L_{SB-CRU,FPi} \le j < L_{CRU,FPi} \end{cases} \quad (193)$$

where $k = s[j - L_{SB-CRU,FPi}]$.

$s[]$ is the CRU/DRU allocation sequence defined in Equation (194) and $0 \le s[j] < FPS_i - L_{SB-CRU,FPi}$.

$$s[j] = \{\text{PermSeq}(j) + \text{DL\_PermBase}\} \bmod (FPS_i - L_{SB-CRU,FPi}) \quad (194)$$

In Equation (194), PermSeq() is the permutation sequence of length (FPS_i-$L_{SB-CRU,FPi}$) and is determined by $SEED = \{IDcell*343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in 16.3.5.3.3. DL_PermBase is set to preamble *IDcell*.

The mapping of PRU_{FPi} to DRU_{FPi} is given by:

$$DRU_{FPi}[j] = PRU_{FPi}[k + L_{SB-CRU,FPi}], \quad 0 \le j < L_{DRU,FPi} \quad (195)$$

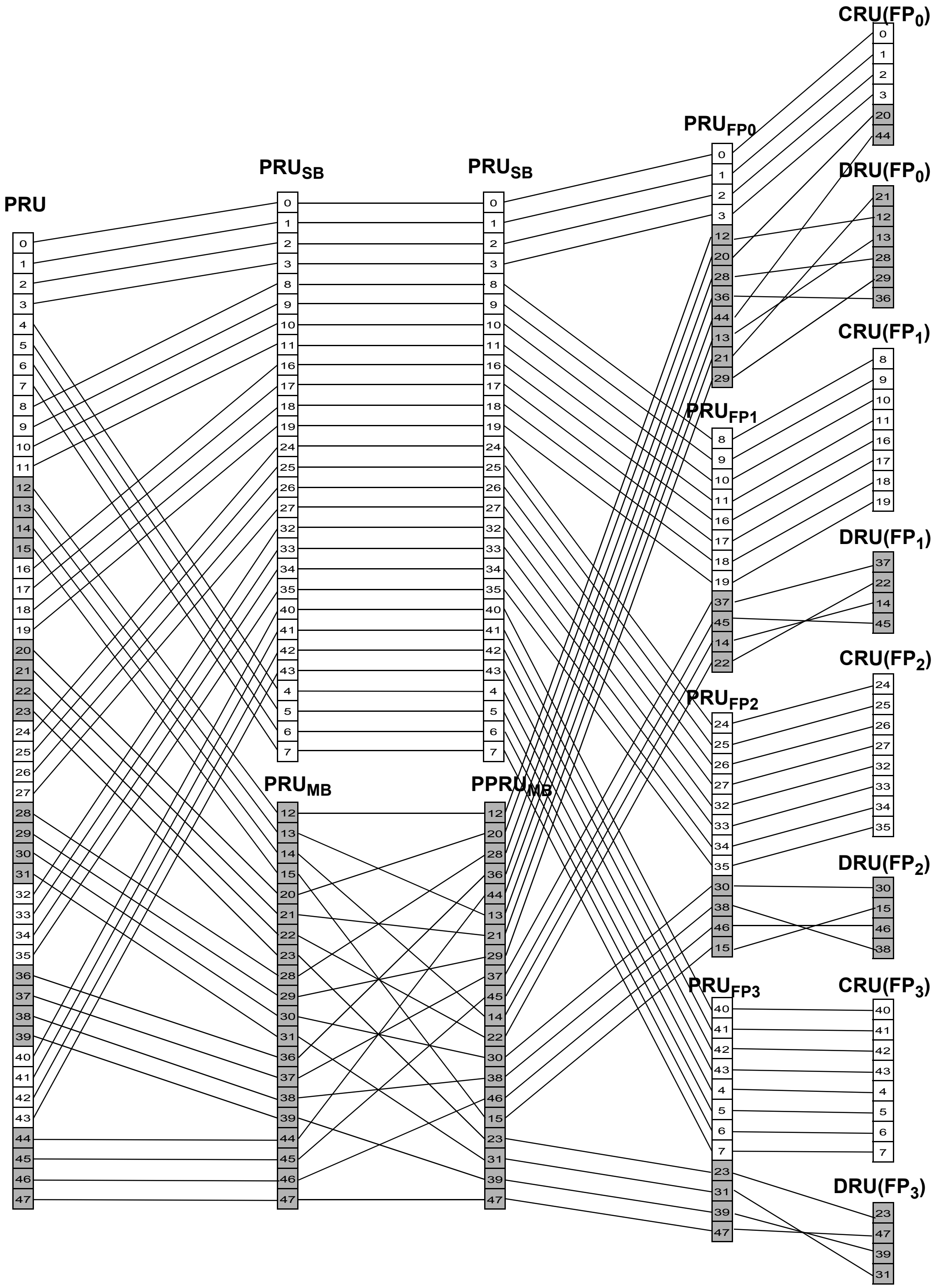
where $k = s[j + L_{CRU,FPi} - L_{SB-CRU,FPi}]$.

Figure 489 presents an example to illustrate the various steps of subband partitioning, miniband permutation, frequency partitioning, and CRU/DRU allocation for the case of 10 MHz system bandwidth. For this example, $K_{SB} = DSAC = 7$, $FPCT = 4$, $FPS_i = 12$ (for $i \ge 0$), $DFPSC = 2$, $DCAS_{SB,0} = 1$, $DCAS_{MB,0} = 1$, and $DCAS_i = 2$.

Table 792 presents a summary of the parameters used to configure the DL PHY structure.

Table 792—DL PHY Structure - Summary of parameters

	Operation Procedure	Related Signaling Field (BW20/10/5MHz)	Channel for Signaling	Parameters Calculated from Signaled Fields	Definition	Units
Sector Common	Sub-band partitioning Mini-band partitioning	$DSAC$ (5/4/3) bits	SFH - SP2	K_{SB}	Number of subbands	Subbands
				$L_{SB} = N_1 * K_{SB}$	Number of PRUs assigned to subbands	PRUs
				L_{MB}	Number of PRUs assigned to minibands	PRUs
	Frequency partitioning	$DFPC$ (4/3/3 bit)		$FPCT$	Number of frequency partitions	Frequency partitions
				FPS_i	Number of PRUs in FP_i	PRUs
		$DFPSC$ (3/2/1 bit)		$K_{SB, FPi}$	Number of subbands assigned to FP_i	Subbands
				$K_{MB, FPi}$	Number of minibands assigned to FP_i	Subbands (Groups of N_1 PRUs)
				$L_{SB, FPi} = N_1 * K_{SB, FPi}$	Number of PRUs assigned to be subbands in FP_i	PRUs
				$L_{MB, FPi} = N_2 * K_{MB, FP}$	Number of PRUs assigned to be minibands in FP_i	PRUs
Sector Specific	CRU/DRU allocation	$DCAS_{SB,0}$ (5/4/3 bit)	SFH - SP1	$L_{SB\text{-}CRU, FPi}$	Number of subband-based CRUs in FP_i	CRUs
		$DCAS_{MB,0}$ (5/4/3 bit)		$L_{MB\text{-}CRU, FPi}$	Number of miniband-based CRUs in FP_i	CRUs
				$L_{CRU,FPi} = L_{SB\text{-}CRU, FPi} + L_{MB\text{-}CRU, FPi}$	Number of CRUs in FP_i	CRUs
		$DCAS_i$ (3/2/1) bit		$L_{DRU,FPi} = FPS_i - L_{CRU,FPi}$	Number of DRUs in FP_i	DRUs
	Tone permutation		Obtained from SA-Preamble			



K_{SB}=7, $FPCT$=4, FPS_0=FPS_i=12, $DFPSC$=2,
$DCAS_{SB,0}$ = 1, $DCAS_{MB,0}$ = 1, $DCAS_i$=2, and $IDcell$=2.

Figure 489—Frequency partition for *BW*=10 MHz

16.3.5.3.2 Subcarrier permutation

The downlink DRUs are used to form two-stream DLRUs by subcarrier permutation. The subcarrier permutation defined for the DL distributed resource allocations within a frequency partition spreads the subcarriers of the DRU across the whole distributed resource allocations. The granularity of the subcarrier permutation is equal to a pair of subcarriers.

After mapping all pilots, the remaining used subcarriers are used to define the distributed LRUs. To allocate the LRUs, the remaining subcarriers are paired into contiguous tone-pairs. Each LRU consists of a group of tone-pairs.

Let $L_{SC,l}$ denote the number of data subcarriers in l^{th} OFDMA symbol within a PRU, i.e., $L_{SC,l} = P_{sc} - n_l$, where n_l denotes the number of pilot subcarriers in the l^{th} OFDMA symbol within a PRU. Let $L_{SP,l}$ denote the number of data subcarrier-pairs in the l^{th} OFDMA symbol within a PRU and is equal to $L_{SC,l}$ / 2. The permutation sequence PermSeq() is defined in 16.3.5.3.3. The DL subcarrier permutation is performed as follows:

For each l^{th} OFDMA symbol in the AAI subframe:

1) Allocate the n_l pilots within each DRU as described in 16.3.5.4. Denote the data subcarriers of $DRU_{FPi}[j]$ in the l^{th} OFDMA symbol as $SC_{DRUj,l}^{FPi}[k]$ for $0 \le j < L_{DRU,FPi}$ and $0 \le k < L_{SC,l}$.

2) Renumber the $L_{DRU,FPi} \cdot L_{SC,l}$ data subcarriers of the DRUs in order, from 0 to $L_{DRU,FPi} \cdot L_{SC,l} - 1$. Group these contiguous and logically renumbered subcarriers into $L_{DRU,FPi} \cdot L_{SP,l}$ pairs and renumber them from 0 to $L_{DRU,FPi} \cdot L_{SP,l} - 1$. The renumbered subcarrier pairs in the l^{th} OFDMA symbol are denoted by $RSP_{FPi,l}$.

$$RSP_{FPi,l}[u] = \{ SC_{DRUj,l}^{FPi}[2v], \quad SC_{DRUj,l}^{FPi}[2v+1] \}, \qquad 0 \le u < L_{DRU,FPi} L_{SP,l}$$

where $j = \lfloor u / L_{SP,l} \rfloor$ and $v = \{u\} mod(L_{SP,l})$.

3) Apply the subcarrier permutation formula as Equation (196) to map $RSP_{FPi,l}$ into the s^{th} distributed LRU, s = 0,1,..., $L_{DRU,FPi}$ - 1. The subcarrier permutation formula is given by

$$SP_{LRU_{s,l}}^{FP_i}[m] = RSP_{FPi,l}[k] \qquad 0 \le m < L_{SP,l} \tag{196}$$

where

$$k = L_{DRU,FPi} \cdot f(m,s,l) + g(PermSeq(), s, m, l)$$

- $SP^{FPi}_{LRUs,l}[m]$ is the m^{th} subcarrier pair in the l^{th} OFDMA symbol in the s^{th} distributed LRU of the t^{th} AAI subframe.
- m is the subcarrier pair index, 0 to $L_{SP,l}$-1.
- l is the OFDMA symbol index, 0 to N_{sym}-1.
- s is the distributed LRU index, 0 to $L_{DRU,FPi}$-1.
- *PermSeq*() is the permutation sequence of length $L_{DRU,FPi}$ and is determined by *SEED*={*IDcell**343} mod 2^{10}. The permutation sequence is generated by the random sequence generation algorithm specified in 16.3.5.3.3.
- $g(PermSeq(),s,m,l)$ is a function with value from the set [0, $L_{DRU,FPi}$-1], which is defined according to Equation (197), where DL_PermBase is set to preamble *IDcell*.
- $f(m,s,l) = (m + 13*(s+l)) \bmod L_{SP,l}$

$$g(PermSeq(), s, m, l) = \{PermSeq[\{f(m, s, l) + s + l\} mod L_{DRU, FPi}] + DL\_PermBase\} mod L_{DRU, FPi} \quad (197)$$

16.3.5.3.3 Random sequence generation

The permutation sequence generation algorithm with 10-bit *SEED* (*Sn*-10, *Sn*-9, …, *Sn*-1) generates a permutation sequence of size *M* as described below:

1) Initialization
   a) Initialize the variables of the first order polynomial equation with the 10-bit seed, *SEED*. Set d_1 = floor($SEED/2^5$) + 619 and d_2 = *SEED* mod 2^5.
   b) Initialize an array *A* with size *M* with the numbers 0, 1, … , *M* - 1 (i.e. *A*[*0*]=*0*, *A*[*1*]=*1*, … , *A*[*M*-1]=*M*-1).
   c) Initialize the counter *i* to *M*-1.
   d) Initialize *x* to -1.
2) Repeat the following steps if $i > 0$
   a) Increment *x* by *i*.
   b) Calculate the output variable of $y = \{(d_1 * x + d_2) \bmod 1031\} \bmod M$.
   c) If $y \geq i$, set $y = y \bmod (i + 1)$.
   d) Swap *A*[*i*] and *A*[*y*].
   e) Decrement *i* by 1.
3) PermSeq[*i*] = *A*[*i*], where $0 \leq i < M$.

16.3.5.3.4 Formation of MLRU

To form MLRUs for the assignment A-MAP,

1) Renumber all tone pairs in the distributed LRUs in the A-MAP region in a time first manner. Assuming that each LRU has L_{SP} tone-pairs per symbol, the renumbered A-MAP tone-pairs are denoted by RMP[*u*], where *u* ranges from 0 to $L_{AMAP} \cdot N_{sym} \cdot L_{SP}$ - 1, and L_{AMAP} is the number of LRU allocated to the A-MAP.

2) A distributed tone-pair, $SP^{FPi}_{LRUs,l}[m]$, is mapped to RMP[*u*], where $u = s \cdot N_{sym} \cdot L_{SP} + m \cdot N_{sym} + l$. $u = s \cdot N_{sym} \cdot L_{SP} + m \cdot N_{sym} + l$. $SP^{FPi}_{LRUs,l}[m]$ is the tone-pair index of the m^{th} tone-pair in the l^{th} OFDMA symbol in the s^{th} distributed LRU of frequency partition *i* as defined in 16.3.5.3.2.

3) Suppose RMP[v] is the first tone-pair for Assignment A-MAP. The k^{th} MLRU is formed by tone-pairs from RMP[$v + k \cdot N_{MLRU} / 2$] to RMP[$v + (k+1) \cdot N_{MLRU} / 2 - 1$], where N_{MLRU} is the size of an MLRU.

16.3.5.3.5 Logical Resource Unit Mapping

Both contiguous and distributed LRUs are supported in the downlink. The CRUs are directly mapped into contiguous LRUs, including subband LRUs and miniband LRUs. The mapping between CRU_{FPi} and $SLRU_{FPi}$ or $NLRU_{FPi}$ is defined as

$$SLRU_{FPi}[j] = CRU_{FPi}[j] \quad \text{for} \quad 0 \le j < L_{SB-(CRU,\,FPi)}[j]\ ,\ \ 0 \le i \le 3$$

$$NLRU_{FPi}[j] = CRU_{FPi}[j + L_{SB-CRU,\,FPi}] \quad \text{for} \ \ 0 \le j < L_{MB-CRU,FPi}[j]\ ,\ \ 0 \le i \le 3$$

The DRUs are permuted as described in 16.3.5.3.2 to form distributed LRUs. For FP_i , $0 \le i \le 3$, $DLRU_{FPi}[j]$ is composed of $L_{SP,l} \cdot N_{sym}$ subcarrier pairs, e.g., $SP^{FPi}_{LRUj,\,l}[m]$ for $0 \le m < L_{SP,l}[j]$ and $0 \le l < N_{sym}$

16.3.5.4 Pilot structure

The transmission of pilot subcarriers in the downlink is necessary for enabling channel estimation, measurements of channel quality indicators such as the SINR, frequency offset estimation, etc. To optimize the system performance in different propagation environments and applications, AAI supports both common and dedicated pilot structures. The categorization in common and dedicated pilots is done with respect to their usage. The common pilots can be used by all MSs and the pilots are precoded in the same way as the data subcarriers within the same PRU. Dedicated pilots can be used with both localized and distributed allocations. The dedicated pilots are associated with a specific resource allocation, are intended to be used by the MSs allocated to said specific resource allocation, and therefore shall be precoded or beamformed in the same way as the data subcarriers of the resource allocation. The pilot structure is defined for up to eight transmission (Tx) streams and there is a unified pilot pattern design for common and dedicated pilots. There is equal pilot density per Tx stream, while there is not necessarily equal pilot density per OFDMA symbol of the downlink AAI subframe. Further, within the same AAI subframe there is equal number of pilots for each PRU of a data burst assigned to one MS.

16.3.5.4.1 Pilot patterns

Pilot patterns are specified within a PRU.

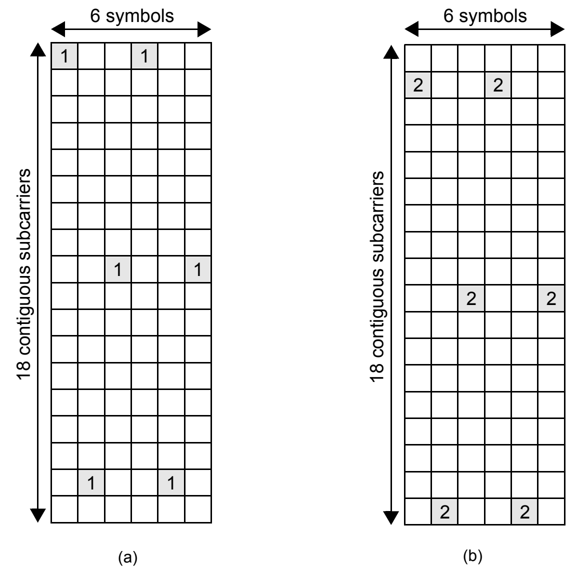


Figure 490—Pilot patterns used for 1 DL data stream outside the open-loop region

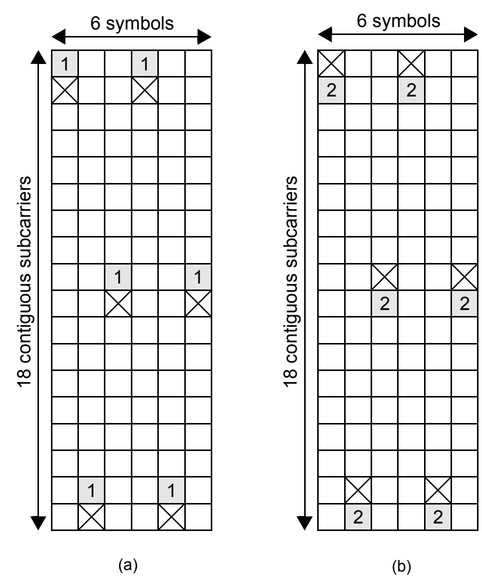


Figure 491—Pilot patterns used for 2 DL data streams

Base pilot patterns used for DL data transmission with one data stream in dedicated and common pilot scenarios are shown in Figure 490, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) and Subfigure (b) in Figure 490 show the pilot locations for pilot stream 1 and pilot stream 2, respectively.

Type-1 OL MIMO region shall use Collision Free Interlaced Pilot (CoFIP) pattern. Figure 492 shows the CoFIP pattern for AAI subframes consisting of 6 OFDM symbols. The index of the pilot pattern set used by a particular BS with *IDcell* = *k* is denoted by p_k. The index of the pilot pattern set is determined by the *IDcell* according to the following equation:

$$p_k = \mathrm{mod}(k, 3)$$

For AAI subframes consisting of 7 OFDM symbols, the first OFDM symbol which contains pilot tones and null tones in each pilot pattern set shown in Figure 492 is added as the 7th symbol. Figure 493 shows the pilot pattern set for AAI subframes consisting of 5 OFDM symbols

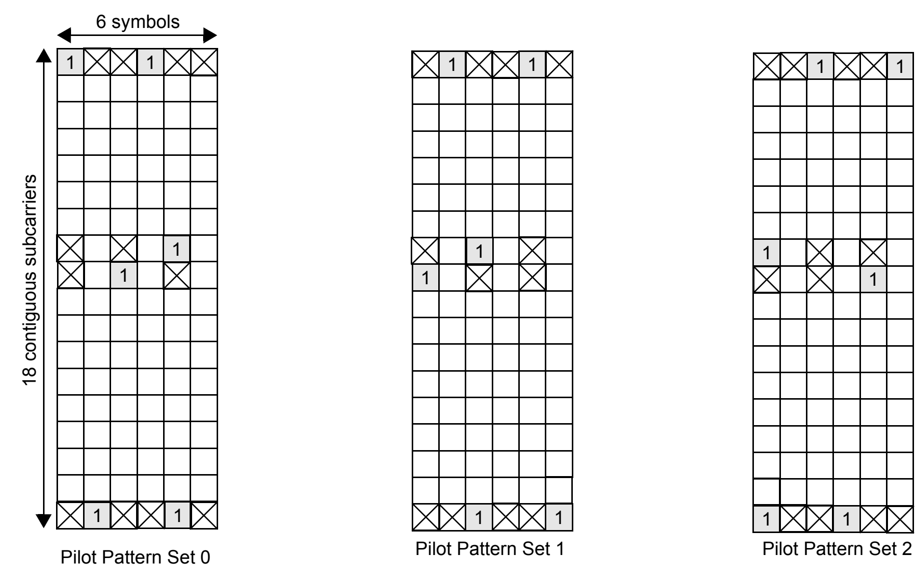


Figure 492—The CoFIP Pattern for AAI sub frames with 6 OFDM symbols

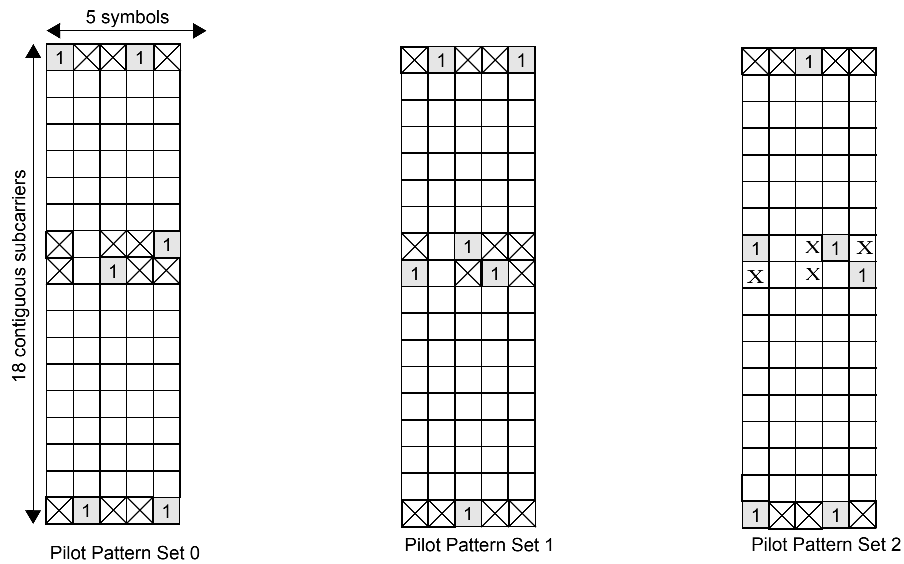


Figure 493—The CoFIP Pattern for AAI sub frames with 5 OFDM symbols

The base pilot patterns used for two DL data streams in dedicated and common pilot scenarios are shown in Figure 491, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) and Subfigure (b) in Figure 491 shows the pilot location for pilot stream 1 and pilot stream 2 in a PRU, respectively. The number on a pilot subcarrier indicates the pilot stream the pilot subcarrier corresponds to. The subcarriers marked as 'X' are null sub-carriers, on which no pilot or data is transmitted.

The interlaced pilot patterns are generated by cyclic shifting the base pilot patterns. The interlaced pilot patterns are used by different BSs for one and two streams. Interlaced pilot patterns for one stream is shown in Figure 494 and interlaced pilot patterns on stream 1 and stream 2 for two streams are shown in Figure 495 and Figure 496, respectively. Each BS chooses one of the three pilot pattern sets (pilot pattern set 0, 1, and 2) as shown in Figure 494, Figure 495 and Figure 496. The index of the pilot pattern set used by a particular BS with $IDcell = k$ is denoted by p_k. The index of the pilot pattern set is determined by the *IDcell* according to the following equation:

$$p_k = \text{floor}(k/256)$$

For one stream, each ABS additionally chooses one of the two stream sets (stream set 0 and 1) within each pilot pattern set. The index of the stream, denoted by s_k, shall be determined according to the following equation:

$$s_k = \mathrm{mod}(k, 2)$$

For the AAI subframe consisting of 5 symbols, the last OFDM symbol in each pilot pattern set shown in Figure 491 is deleted. For the AAI subframe consisting of 7 symbols, the first OFDM symbol in each pilot pattern set shown in Figure 491 is added as 7^{th} symbol.

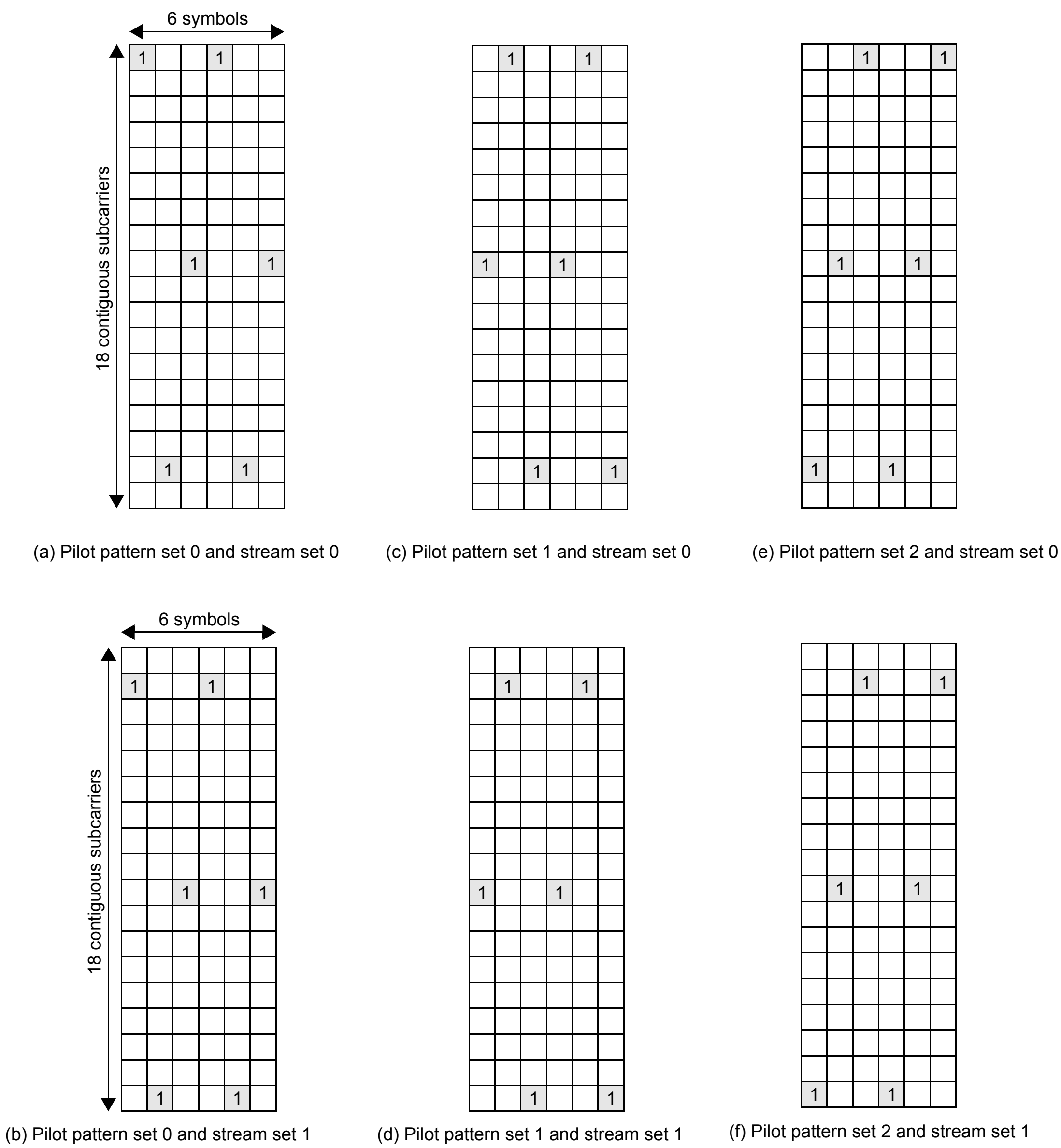


Figure 494—Interlaced pilot patterns for 1 data stream outside the open-loop region

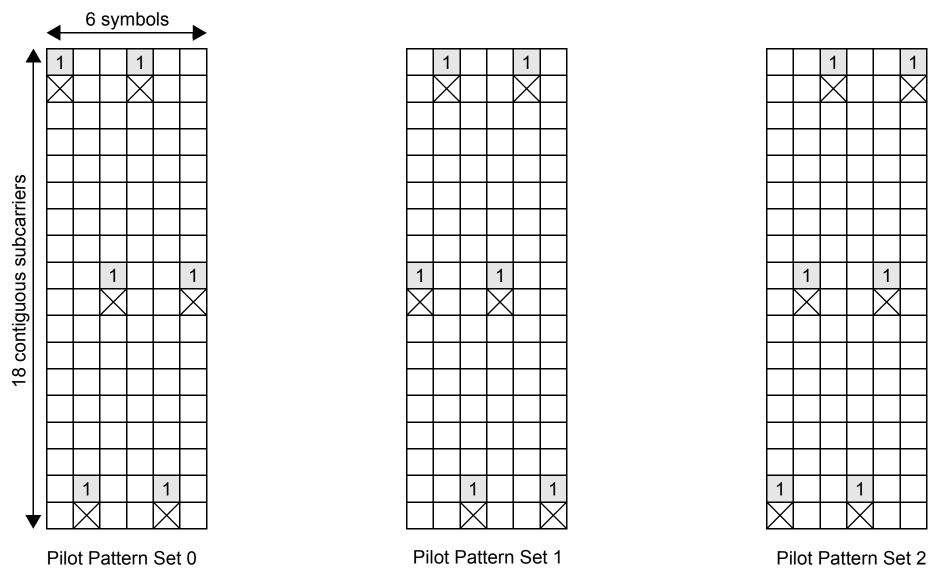


Figure 495—Interlaced pilot patterns on stream 0 for 2 data streams

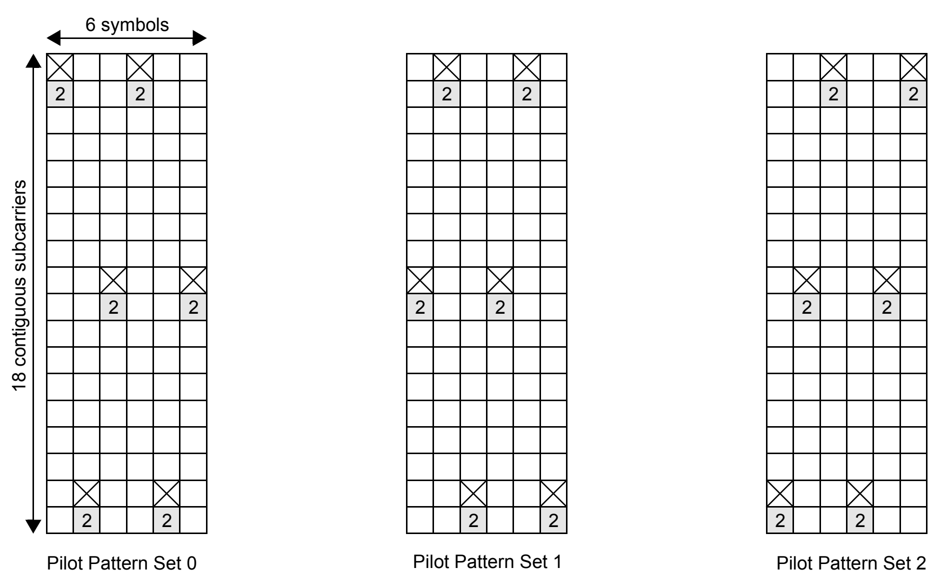


Figure 496—Interlaced pilot patterns on stream 1 for 2 data streams

The pilot patterns on stream 0 - stream 3 for four pilot streams are shown in Figure 497 through Figure 500 respectively, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) in Figure 497 through Figure 500 show the pilot pattern for four pilot streams in AAI subframe with six OFDM symbols; Subfigure (b) in Figure 497 through Figure 500 show the pilot pattern for four pilot streams in AAI subframe with five OFDM symbols; Subfigure (c) in Figure 497 through Figure 500 show the pilot pattern for four pilot streams in AAI subframe with seven OFDM symbols.

For 3 streams MIMO transmissions, the first three of the four pilot streams will be used and the unused pilot stream is allocated for data transmission.

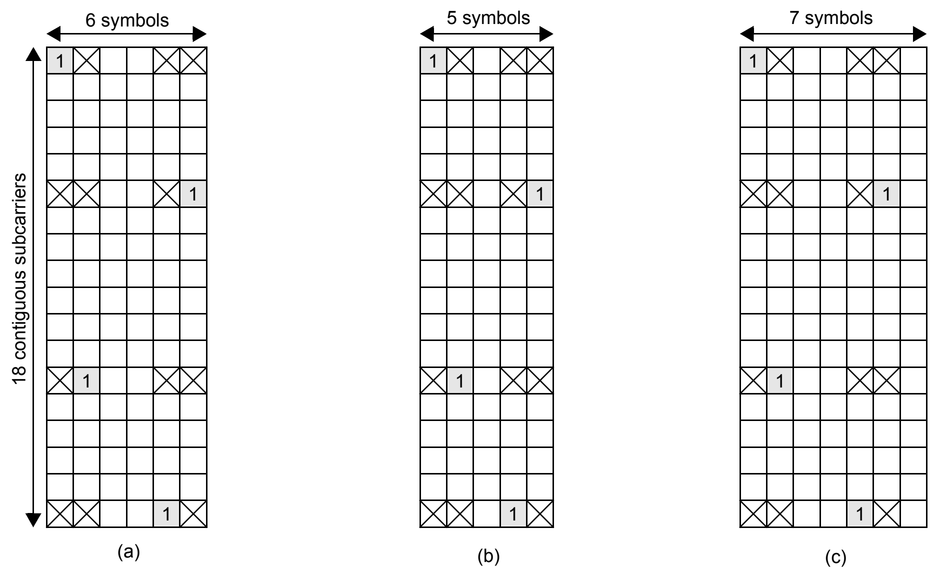


Figure 497—Pilot patterns on stream 0 for 4 data streams

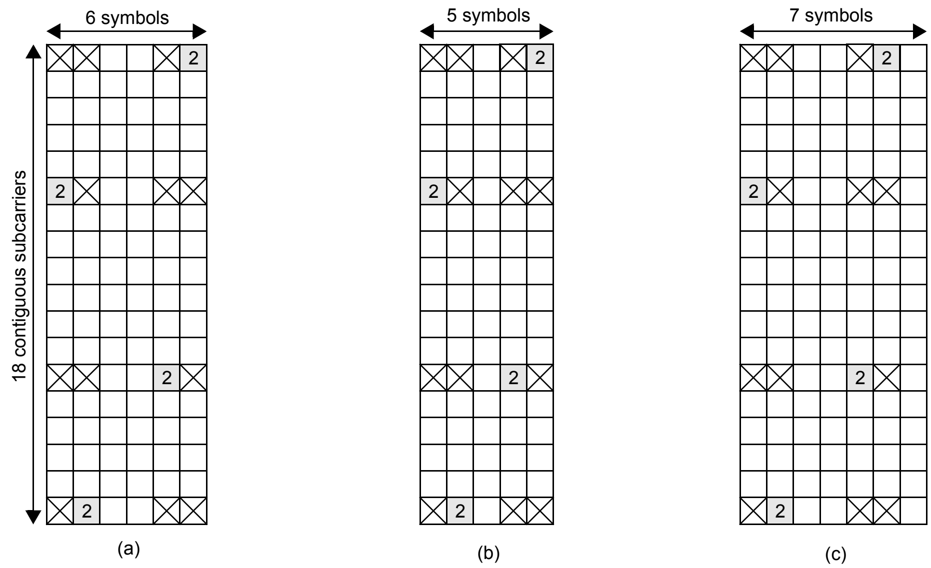


Figure 498—Pilot patterns on stream 1 for 4 data streams

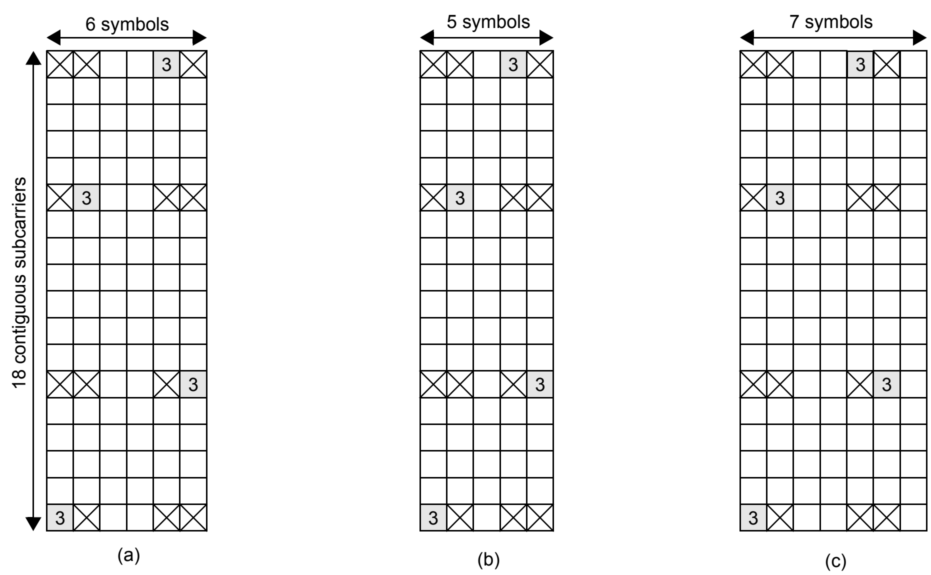


Figure 499—Pilot patterns on stream 2 for 4 data streams

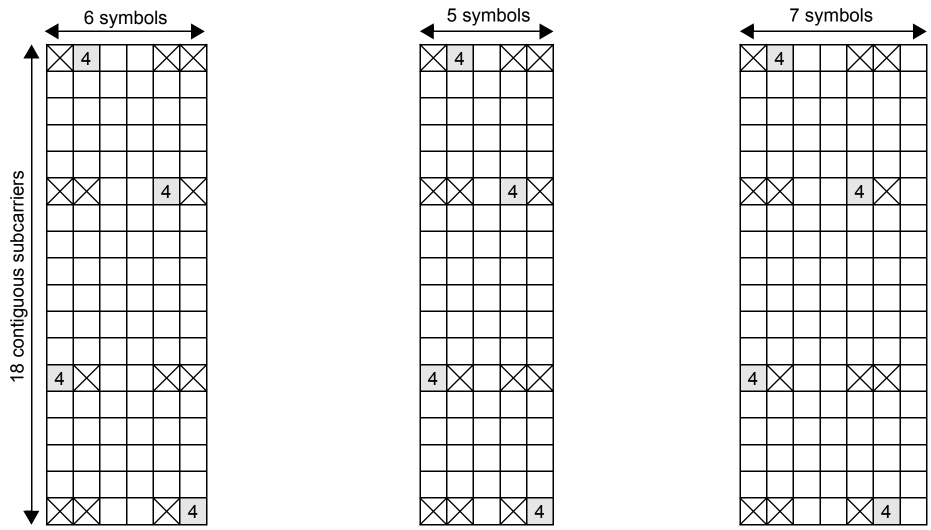


Figure 500—Pilot patterns on stream 3 for 4 data streams

The pilot patterns for eight pilot streams are shown in Figure 501 with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) in Figure 501 shows the pilot pattern for eight pilot streams in AAI subframewith six OFDM symbols; Subfigure (b) in Figure 501 shows the pilot pattern for eight pilot streams in AAI subframe with five OFDM symbols; Subfigure (c) in Figure 501 shows the pilot pattern for eight pilot streams in AAI subframe with seven OFDM symbols.

For 5, 6 and 7 streams MIMO transmissions, the first five, six and seven of the eight pilot streams will be used, respectively. The unused pilot stream is allocated for data transmission.

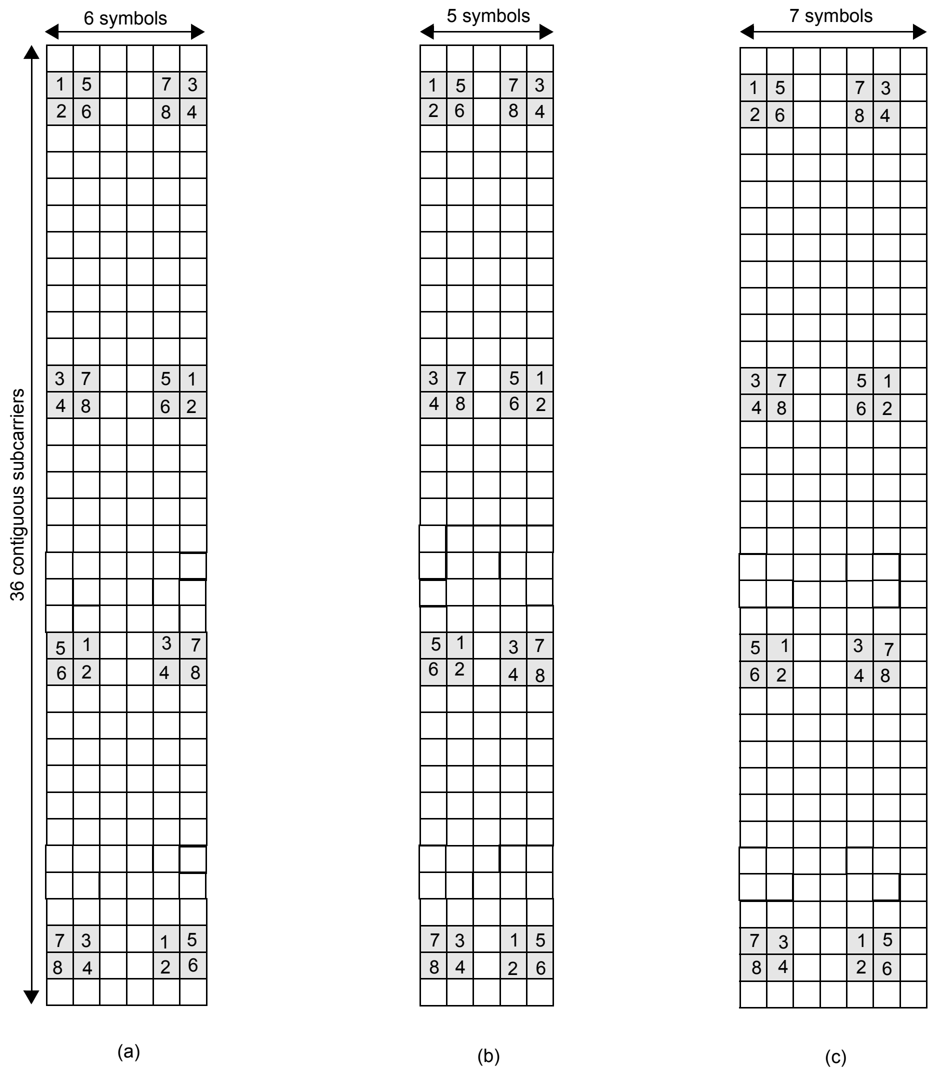


Figure 501—Pilot patterns for 8 data streams

16.3.5.4.2 MIMO midamble

MIMO midamble is used for PMI selection in closed loop MIMO. For OL MIMO, midamble can be used to calculate CQI. MIMO midamble shall be transmitted every frame on the second DL AAI subframe. The midamble signal occupies the first OFDMA symbol in a DL type-1 or type-2 AAI subframe. For the type-1 AAI subframe case, the remaining 5 consecutive symbols form a type-3 AAI subframe. For the type-2 AAI subframe case, the remaining 6 consecutive symbols form a type-1 AAI subframe.

The MIMO midamble signal transmitted by the ABS antenna is defined by Equation (198):

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{\substack{k=0 \\ k \neq \frac{N_{used}-1}{2}}}^{k=N_{used}-1} b_k \cdot e^{j2\pi\left(k - \frac{N_{used}-1}{2}\right)\Delta f (t - T_g)} \right\} \tag{198}$$

where b_k is a coefficients modulating subcarriers in the midamble symbol defined by Equation (199):

$$b_k = \begin{cases} 2.18 \cdot \{1 - (2G([k + u + offset(fft)] \bmod fft))\}, k \neq \frac{N_{used}-1}{2}, (k-s) \bmod (3 \times N_t) = 3g + \left(\left\lfloor \frac{IDCell}{256} \right\rfloor + \left\lfloor \frac{k-s}{N_1 \times N_{SC}} \right\rfloor\right) \bmod 3 \\ 0, otherwise \end{cases} \tag{199}$$

where k is the subcarrier index $(0 \le k \le N_{used} - 1)$, N_{used} is the number of used subcarriers, *G(x)* is the Golay sequence defined in Table 793 $(0 \le x \le 2047)$, *fft* is the FFT size used, *u* is a shift value, where the actual value of *u* is derived from *u* = mod (*IDcell*, 256), *offset(fft)* is an FFT size specific offset as defined in Table 794, *g* is an ABS transmit antenna index (in range of 0 to N_t-1), N_t is number of ABS transmit antennas, parameter *s* = 0, for $k \le (N_{used} - 1)/2$ and *s* = 1, for $k > (N_{used} - 1)/2$. *IDcell* shall correspond to SA-Preamble.

Example of physical structure of MIMO midamble is shown in Figure 502 for 4TX antenna and *IDcell* = 0.

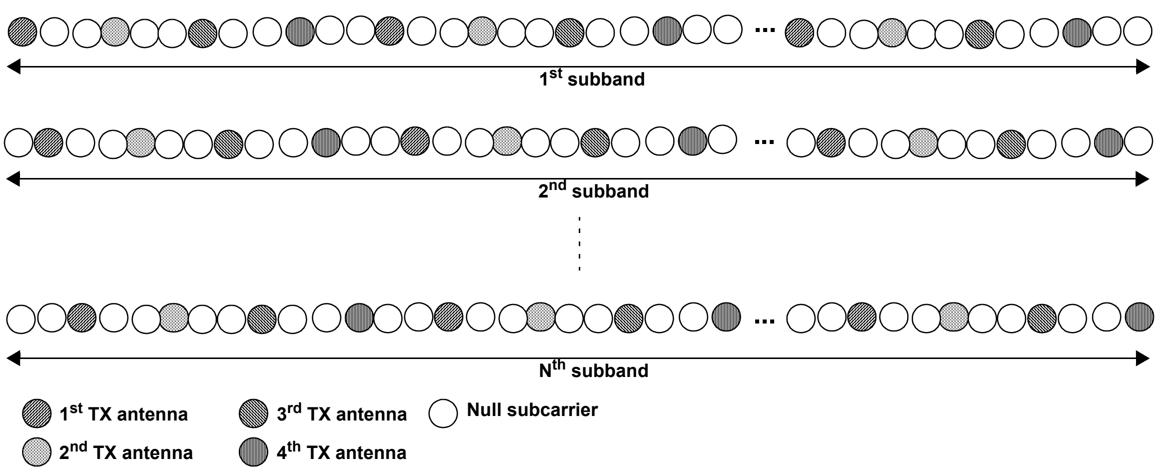


Figure 502—MIMO midamble physical structure for 4TX antennas and *IDcell*=0

Table 793—Golay sequence of length 2048 bits

0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2

Table 793—Golay sequence of length 2048 bits

0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D
0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2
0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2	0x121D	0x12E2	0xEDE2	0x12E2
0x121D	0x12E2	0x121D	0xED1D	0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2
0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D
0xEDE2	0xED1D	0xEDE2	0x12E2	0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2
0xEDE2	0xED1D	0x121D	0xED1D	0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D
0x121D	0x12E2	0x121D	0xED1D	0x121D	0x12E2	0xEDE2	0x12E2	0x121D	0x12E2	0x121D	0xED1D
0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D
0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D				

Table 794—Offsets in the Golay sequence

FFT Size	Offset
2048	30
1024	60
512	40

In Table 793, hexadecimal series should be read as a sequence of bits where each 16 bit word is started at the MSB and ends at the LSB where the second word MSB follows. The first bit of the sequence is referenced as offset 0.

16.3.5.4.3 Usage of Downlink Pilots

The demodulation pilots in a given PRU on a given pilot stream shall be precoded the same way as the data transmitted on the same stream in that PRU. In DLRU the data transmitted in a given PRU on a given stream may be sent to several AMSs but in different tones using the same precoder.

Two pilot streams shall always be transmitted in the DLRUs, whether inside or outside the open-loop region type 0, and whether or not data is being transmitted by the ABS in all DLRUs.

If no data is transmitted by the ABS on all or some CLRUs in the open-loop region type 1 or type 2, the $MaxM_t$ pilots shall still be transmitted across all CLRUs in that open-loop region. If no data is transmitted by the ABS on all or some CLRUs outside any open-loop region, the pilots shall not be transmitted on the CLRUs where no data is sent.

The precoder may be adaptive (user-specific) or non-adaptive (non user-specific) depending on the DL MIMO mode. Non-adaptive precoders are determined according to the DL MIMO mode, the number of streams, the type of LRU, operation inside or outside the open-loop region, and the physical index of the subband or miniband where the precoder is applied.

In MU-MIMO transmissions in CLRU each pilot stream is dedicated to one AMS. The AMS shall use its dedicated pilot stream for channel estimation within the allocation. Other pilot streams may be used for inter-stream interference estimation. The total number of streams in the transmission and the index of the dedicated pilot stream are indicated in the DL Basic Assignment A-MAP IE, DL Persistent Allocation A-MAP IE or DL Subband Assignment A-MAP IE.

Channel estimation for demodulation of data burst at AMS should be performed as follows:

- In DLRU: the 2-streams non-adaptively precoded common pilots across the DLRU should be used for channel estimation by all AMSs allocated a burst in the DLRU. Within each frequency partition, all pilots are shared by all AMSs for demodulation in DLRU. Only the pilots located within a physical subband should be used for channel estimation within that subband.
- In CLRU: The AMS should use its dedicated pilot streams for channel estimation in the allocation. Pilots are not shared by AMSs for demodulation in CLRU, whether they are non-adaptively or adaptively precoded.

MIMO feedback measurements at the AMS should be performed as follows:

- For MIMO feedback reports requested with a MIMO feedback mode for operation in an open-loop region, measurements should be taken on the $MaxM_t$ streams non-adaptively precoded pilots in that open-loop region. All pilots are shared by all AMSs for MIMO feedback measurements in each open-loop region.
  - Wideband CQI reports inside OL region should be averaged over OL region pilots of the PRUs in the frequency partition 0.
- For MIMO feedback reports requested with a MIMO feedback mode for operation outside the open-loop region, measurements should be taken on the downlink MIMO midamble.
  - Wideband CQI reports outside OL region (measured on MIMO midamble) should be averaged over the frequency partition indicated by Frequency Partition Indicator (PFI) in Feedback Allocation A-MAP IE or according to PFCT for feedback allocated by Feedback Polling A-MAP IE.
  - For reports requested with a MIMO feedback mode for open-loop MIMO operation, the AMS should adjust the non-precoded MIMO channel estimated from the midamble by applying it with the non-adaptive precoder according to the MFM, the subband index and assumption on STC rate.
  - For reports requested with a MIMO feedback mode for closed-loop MIMO operation, the AMS should adjust the non-precoded MIMO channel estimated from the midamble with an estimated adaptive precoder.
  - Subband CQI reports (inside and outside OL region) should be reported for subbands in SLRUs indicated by SFH.

16.3.5.4.4 E-MBS Zone Specific pilot Patterns

E-MBS zone specific pilots are transmitted for multi-cell multicast broadcast single frequency network (MBSFN) transmissions. An E-MBS zone is a group of ABSs involved in an SFN transmission. The E-MBS zone specific pilots are common inside one E-MBS zone. Synchronous transmission of the same pilots from multiple ABSs helps an AMS to estimate the composite channel response within an E-MBS zone.

The E-MBS pilot pattern is robust for various cell size MBSFN deployments and supports channel estimation of up to two transmit streams within an E-MBS zone. The structures of the E-MBS zone specific pilot pattern for Type-1 subframes are shown in Figure 503.

The E-MBS zone specific pilot pattern for Type-2 subframes is derived from the E-MBS zone specific pilot pattern for Type-1 sunframes by duplicating the second symbol and appending to the end of the last symbol.

The E-MBS zone specific pilot pattern for Type-3 subframes is derived from the E-MBS zone specific pilot pattern for Type-1 sunframes by removing the fourth symbol.

Figure 504 and Figure 505 show the E-MBS zone specific pilot patterns for Type-2 and Type-3 subframes, respectively.

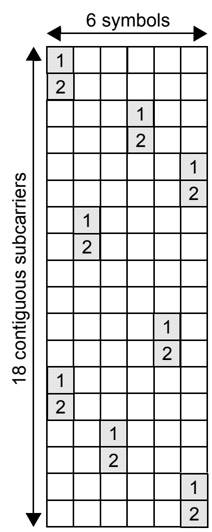


Figure 503—-E-MBS zone specific pilot patterns for 1 and 2 stream transmission in Type-1 subframe

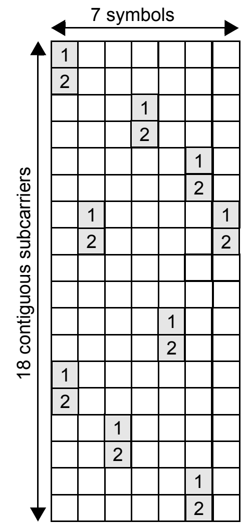


Figure 504—-E-MBS zone specific pilot patterns for 1 and 2 stream transmission in Type-2 subframe

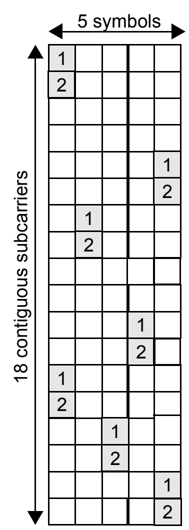


Figure 505—-E-MBS zone specific pilot patterns for 1 and 2 stream transmission in Type-3 subframe

16.3.5.5 Downlink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRU is the same as the structure defined in 16.3.5.1 and 16.3.5.4. The guard PRUs are used as miniband CRUs at partition

FP0 for data transmission only. The number of useable guard subcarriers is predefined and should be known to both AMS and ABS based on carrier bandwidth. The number of guard PRUs in left and right edge of each carrier are shown in Table 795. Denote the number of guard PRUs in the left (right) edge of carrier by N_{LGPRU} (N_{RGPRU}). The total number of guard PRUs are $N_{GPRU} = N_{LGPRU} + N_{RGPRU}$.

Table 795—Number of guard PRUs

BW	**Number of guard PRUs in the left edge of carrier[1)]**	**Number of guard PRUs in the right edge of carrier[2)]**
5 MHz	0	0
10 MHz	1	1
20 MHz	2	2
7 MHz	0	0
8.75 MHz	0	0

1) When a carrier occupies the left most spectrum among multiple contiguous carriers the number of guard PRUs in the left edge of carrier is zero.

2) When a carrier occupies the right most spectrum among multiple contiguous carriers the number of guard PRUs in the right edge of carrier is zero.

Denote left guard PRUs and right guard PRUs by $GPRU_L[0]$,…. $GPRU_L[N_{LGPRU}-1]$ and $GPRU_R[0]$,…. $GPRU_R[N_{RGPRU}-1]$ from the lowest frequency. Then, guard PRUs are indexed by interleaving $GPRU_L$ and $GPRU_R$ one by one. That is, $GPRU[i] = GPRU_L[i/2]$, for i is an even number and $GPRU[i] = GPRU_R[(i-1)/2]$, for i is an odd number, If $N_{LGPRU} = 0$, then $GPRU[i]= GPRU_R[i]$. If $N_{RGPRU} = 0$, then $GPRU[i]= GPRU_L[i]$.

The N_{GPRU} guard PRUs are used as mini-band LRUs, i.e., NLRUs at frequency partition FP0 without any permutation for data transmission only. In detail, i-th guard NLRU, i.e., GNLRU[i] is always allocated along with the i-th last NLRU at partition FP_0. In other words, when an allocation including the i-th last NLRU at partition FP_0 is made to an AMS for multicarrier support, the i-th guard NLRU, i.e., GNLRU[i] is allocated together. The mapping to the GNLRU[i] is made after mapping to the i-th NLRU at partition FP_0.

When adjacent carrier is not an active carrier of the AMS, the guard sub-carriers in between active and non-active carriers shall not be utilized for data transmission for that AMS.

When the overlapped guard sub-carriers are not aligned in the frequency domain, they shall not be used for data transmission.

16.3.5.6 Downlink physical structure for E-MBS support

In a carrier that is not dedicated to E-MBS traffic, it may be required to multiplex E-MBS and unicast traffic. When multiplexed with unicast data, the E-MBS traffic is FDMed with the unicast traffic in the downlink subframes. More specifically, the E-MBS traffic is transmitted using subbands assigned in frequency partition FP_0. The number of subbands used for E-MBS data, denoted by $K_{SB,E\text{-}MBS}$, is indicated in the E-MBS_SUBBAND_INDICATOR in AAI-E-MBS_CFG message. This set of sub-bands form the E-MBS region in the downlink subframes. The E-MBS_SUBFRAME_INDICATOR indicates which sub-frames in a frame carry E-MBS traffic of all E-MBS Zones on that carrier. The E-MBS_SUBBAND_INDICATOR and E-MBS_SUBFRAME_INDICATOR are valid for the set of super-frames over which the AAI-E-MBS_CFG indicators are valid. For MBSFN support, $K_{SB,E\text{-}MBS}$ subbands are assigned from the lowest SLRU in frequency partition FP_0. If the $K_{SB,E\text{-}MBS}$ is larger than the number of subbands in FP_0, i.e., $K_{SB,E\text{-}MBS} > K_{SB,FP0}$, then, the remaining ($K_{SB,E\text{-}MBS}$ - $K_{SB,FP0}$) subbands are assigned equitably to the three partitions FP_i ($i > 0$) one by one starting from the lowest SLRU of the each FP. When FPCT = 3, $K_{SB,E\text{-}MBS}$ subbands are assigned equitably from FP_i ($i > 0$) one by one starting from the lowest SLRU of the lowest FP.

16.3.6 Downlink control structure

16.3.6.1 Advanced Preamble

There are two types of Advanced Preamble (A-Preamble): primary advanced preamble (PA-Preamble) and secondary advanced preamble (SA-Preamble). One PA-Preamble symbol and three SA-Preamble symbols exist within the superframe. The location of the A-Preamble symbol is specified as the first symbol of frame. PA-Preamble is located at the first symbol of second frame in a superframe while SA-Preamble is located at the first symbol of remaining three frames. Figure 506 depicts the location of A-Preamble symbols.

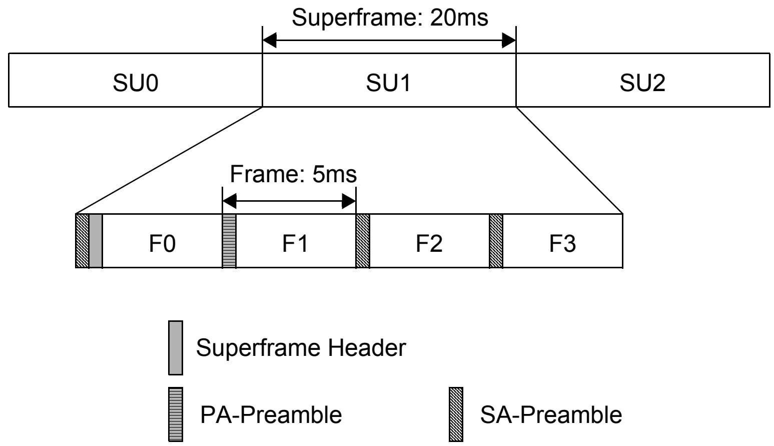


Figure 506—Location of the A-Preamble

16.3.6.1.1 Primary advanced preamble (PA-Preamble)

The length of sequence for PA-Preamble is 216 regardless of the FFT size. PA-Preamble carries the information of system bandwidth and carrier configuration. When the subcarrier index 256 is reserved for DC, the allocation of subcarriers is accomplished by Equation (200):

$$PAPreambleCarrierSet = 2 \cdot k + 41 \tag{200}$$

where

PAPreambleCarrierSet specifies all subcarriers allocated to the PA-Preamble, and
k is a running index 0 to 215.

Figure 507 depicts the symbol structure of the PA-Preamble in the frequency domain.

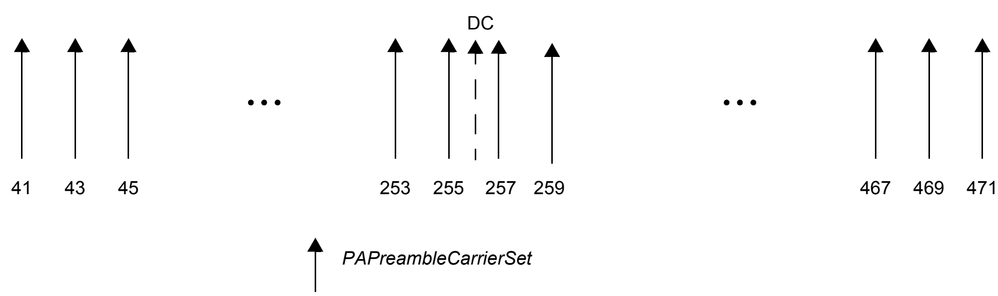


Figure 507—PA-Preamble symbol structure

In Table 796 the sequence of the PA-Preamble is defined in a hexadecimal format. The defined series is mapped onto subcarriers in ascending order. The value of the series is obtained by converting the series to a binary series and starting the series from the MSB up to 216 bits (0 mapped to +1 and 1 mapped to -1).

Table 796—PA-Preamble series

Index	Carrier	BW	Series to modulate
0	Fully configured	5 MHz	6DB4F3B16BCE59166C9CEF7C3C8CA5EDFC16 A9D1DC01F2AE6AA08F
1		7, 8.75 and 10 MHz	1799628F3B9F8F3B22C1BA19EAF94FEC4D37D EE97E027750D298AC
2		20 MHz	92161C7C19BB2FC0ADE5CEF3543AC1B6CE6B E1C8DCABDDD319EAF7
3		*Reserved*	6DE116E665C395ADC70A89716908620868A603 40BF35ED547F8281
4		*Reserved*	BCFDF60DFAD6B027E4C39DB20D783C9F4671 55179CBA31115E2D04
5		*Reserved*	7EF1379553F9641EE6ECDBF5F144287E329606 C616292A3C77F928
6		*Reserved*	8A9CA262B8B3D37E3158A3B17BFA4C9FCFF4 D396D2A93DE65A0E7C
7		*Reserved*	DA8CE648727E4282780384AB53CEEBD1CBF79 E0C5DA7BA85DD3749
8		*Reserved*	3A65D1E6042E8B8AADC701E210B5B4B650B6 AB31F7A918893FB04A
9		*Reserved*	D46CF86FE51B56B2CAA84F26F6F204428C1BD 23F3D888737A0851C
10	Partially configured	N/A	640267A0C0DF11E475066F1610954B5AE55E189 EA7E72EFD57240F

The sequences of indexes from 3 to 9 in Table 796 are reserved for the irregular nominal channel bandwidth to support tone dropping.

The magnitude boosting levels in single carrier mode for different FFT size are shown in Table 797.

Table 797—PA-Preamble boosting levels

512	1k	2k
2.3999	3.4143	5.1320

For 512-FFT, the boosted PA-Preamble at k^{th} subcarrier can be written as

$$c_k = 2.3999 \cdot b_k$$

where b_k represents the PA-Preamble before boosting (+1 or - 1).

In the case where advanced air interface supports the WirelessMAN-OFDMA MSs in mixed mode, the PA-Preamble symbol with a different time domain waveform from the WirelessMAN-OFDMA preamble should be transmitted by offset of an integer number of symbols, as specified by T_{OFFSET} and shown in Figure 508

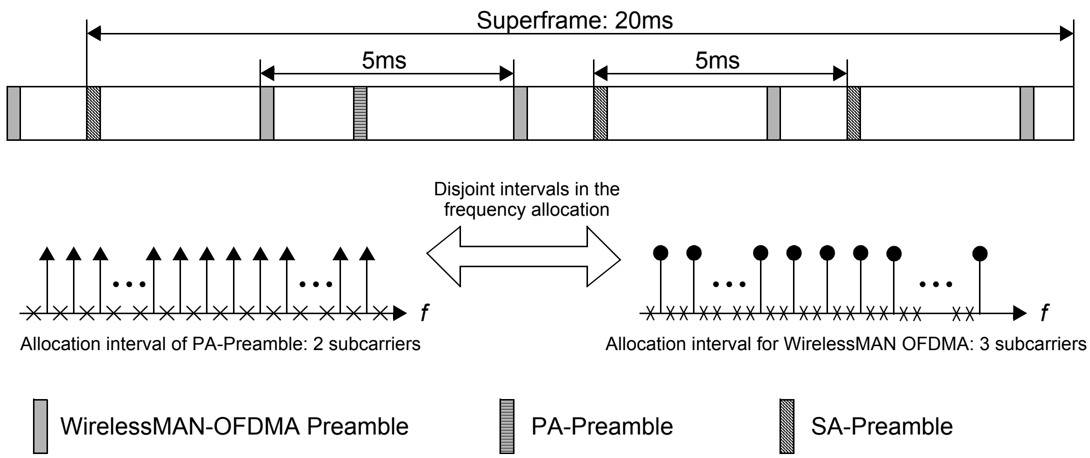


Figure 508—A-Preamble transmission structure supporting WirelessMAN-OFDMA

16.3.6.1.2 Secondary advanced preamble (SA-Preamble)

The N_{SAP}, the number of subcarriers allocated for SA-Preamble are 144, 288, and 576 for 512-FFT, 1024-FFT, and 2048-FFT, respectively. The allocation of subcarriers is accomplished by Equation (201), when the subcarrier indexes 256, 512, and 1024 are reserved for DC for 512-FFT, 1024-FFT, and 2048-FFT, respectively.

$$SAPreambleCarrierSet_n = n + 3 \cdot k + 40 \cdot \frac{N_{SAP}}{144} + \left\lfloor \frac{2 \cdot k}{N_{SAP}} \right\rfloor \quad (201)$$

where

$SAPreambleCarrierSet_n$ specifies all subcarriers allocated to the specific SA-Preamble,

n is the index of the SA-Preamble carrier-set 0, 1 and 2 representing segment ID,
k is a running index 0 to N_{SAP} - 1 for each FFT sizes.

No circular shift is assumed in Equation (201).

Each segment uses an SA-Preamble composed of a carrier-set out of the three available carrier-sets in the following manner:

Segment 0 uses SA-Preamble carrier-set 0.
Segment 1 uses SA-Preamble carrier-set 1.
Segment 2 uses SA-Preamble carrier-set 2.

Each cell ID has an integer value *IDcell* from 0 to 767. The *IDcell* is defined by segment index and an index per segment as follows:

$$IDcell = 256n + Idx$$

where

n is the index of the SA-Preamble carrier-set 0, 1 and 2 representing segment ID,
$Idx = 2mod(q, 128) + \lfloor q/128 \rfloor$, *q* is a running index 0 to 255.

SA-Preamble sequences are partitioned and each partition is dedicated to specific base station type like macrocell ABS, Macro Hotzone ABS, Femto ABS. The base station types are categorized into macro ABS and non-macro ABS cells by hard partition with 258 sequences (86 sequences per segment * 3 segments) dedicated for macro ABS. The non-macro ABS information is broadcasted in a hierarchical structure, which composes of S-SFH SP3 and AAI_SCD message. In S-SFH SP3, non-macro ABS cell type is partitioned as public and CSG femto base stations. Total 16 cases of *IDcell* partition for public and CSG-femto ABS are shown in Table 798, which is composed of *IDcell* partitions based on 30 sequence (10 sequences per segmentation) granularity.

For the support of femtocell deployment, a Femto ABS should self-configure the segment or subcarrier set for SA-Preamble transmission based on the segment information of the overlay macrocell ABS for minimized interference to macrocell if the Femto ABS is synchronized to macrocell ABSs. The segment information of the overlay macrocell ABS may be obtained by communications with macrocell ABS through backbone network or active scanning of SA-Preamble transmitted by macrocell ABS.

For the support of macro, public and CSG femto deployment, if 0<= *Idx*<= 85, it is reserved for macro ABS, if 86<= *Idx*<= *z*, it belongs to public ABS, and if *z* + 1 <= *Idx*<= 255, it belongs to CSG femto ABS, where *z*

Table 798—*IDcell* partitioning for public ABS and CSG-femto ABS

Value indicated in 4bit-SFH SP3	*IDcell* partition for public ABS (Number of sequence per each segmentation)	*IDcell* partition for CSG-femto ABS (Number of sequence per each segmentation)
0000	86+256*n ~ 95+256*n (10)	96+256*n ~ 255+256*n (160)
0001	86+256*n ~ 105+256*n (20)	106+256*n ~ 255+256*n (150)
0010	86+256*n ~ 115+256*n (30)	116+256*n ~ 255+256*n (140)
0011	86+256*n ~ 125+256*n (40)	126+256*n ~ 255+256*n (130)
0100	86+256*n ~ 135+256*n (50)	136+256*n ~ 255+256*n (120)
0101	86+256*n ~ 145+256*n (60)	146+256*n ~ 255+256*n (110)
0110	86+256*n ~ 155+256*n (70)	156+256*n ~ 255+256*n (100)
0111	86+256*n ~ 165+256*n (80)	166+256*n ~ 255+256*n (90)
1000	86+256*n ~ 175+256*n (90)	176+256*n ~ 255+256*n (80)
1001	86+256*n ~ 185+256*n (100)	186+256*n ~ 255+256*n (70)
1010	86+256*n ~ 195+256*n (110)	196+256*n ~ 255+256*n (60)
1011	86+256*n ~ 205+256*n (120)	206+256*n ~ 255+256*n (50)
1100	86+256*n ~ 215+256*n (130)	216+256*n ~ 255+256*n (40)
1101	86+256*n ~ 225+256*n (140)	226+256*n ~ 255+256*n (30)
1110	86+256*n ~ 235+256*n (150)	236+256*n ~ 255+256*n (20)
1111	86+256*n ~ 245+256*n (160)	246+256*n ~ 255+256*n (10)

is calculated from SA-Preamble sequence soft partitioning information in S-SFH SP3 IE. The public ABS and CSG femto ABS will use different segments to the co-located macro ABS. CSG femto ABS can be further restrict to one segment to reduce interference to public ABS. Public ABS can choose different segment to CSG femto ABS. For example: the public ABS can choose the segment as i = mod((n+1), 3), and CSG femto can choose the segment as j = mod((n-1), 3) if the co-located macro ABS uses segment n. The *IDcell* of public ABS can be 256i + Idx, 86 <= Idx<= z, and that of CSG femto ABS can be 256j + Idx, z + 1 <= Idx <= 255. The public ABS also can choose the segment as j = mod((n-1), 3) to reduce interference between public ABSs.

For 512-FFT size, the 288-bit SA-Preamble sequence is divided into 8 main sub-blocks, namely, A, B, C, D, E, F, G, and H. The length of each sub-block is 36 bits. Each segment ID has different sequence sub-blocks. Table 803 to Table 805 depict the 8 sub-blocks of each segment ID where the sequence {+1, +j, -1, -j} for each sub-block for each segment is represented by QPSK manner. Table 803, Table 804, and Table 805 include 128 sequences indexed by q from 0 to 127 in a hexadecimal format for segment 0, segment 1, and segment 2, respectively. The modulation sequence is obtained by converting a hexadecimal $X_i^{(q)}$ of a subblock into two QPSK symbols $v^{(q)}_{2i}$ and $v^{(q)}_{2i+1}$, where i = 0, 1, …,7, 8. The converting equations are as follows:

$$v_{2i}^{(q)} = \exp\left(j\frac{\pi}{2}(2 \cdot b_{i,0}^{(q)} + b_{i,1}^{(q)})\right)$$

$$v_{2i+1}^{(q)} = \exp\left(j\frac{\pi}{2}(2 \cdot b_{i,2}^{(q)} + b_{i,3}^{(q)})\right)$$

where

$$X_i^{(q)} = 2^3 \cdot b_{i,0}^{(q)} + 2^2 \cdot b_{i,1}^{(q)} + 2^1 \cdot b_{i,2}^{(q)} + 2^0 \cdot b_{i,3}^{(q)}$$

The other 128 sequences indexed by q from 128 to 255 can be obtained by the following equations: $v_k^{(q)} = (v_k^{(q-128)})^*$, where $q = 128, 129, \ldots, 254, 255$

For 512-FFT size, A, B, C, D, E, F, G, and H are modulated and mapped sequentially in ascending order onto the circular-shifted SA-Preamble subcarrier-set corresponding to segment ID, as shown in Figure 509. For higher FFT sizes, the basic sub-blocks (A, B, C, D, E, F, G, H) are repeated in the same order. For instance in 1024-FFT size, E, F, G, H, A, B, C, D, E, F, G, H, A, B, C, D are modulated and mapped sequentially in ascending order onto the circular-shifted SA-Preamble subcarrier-set corresponding to segment ID.

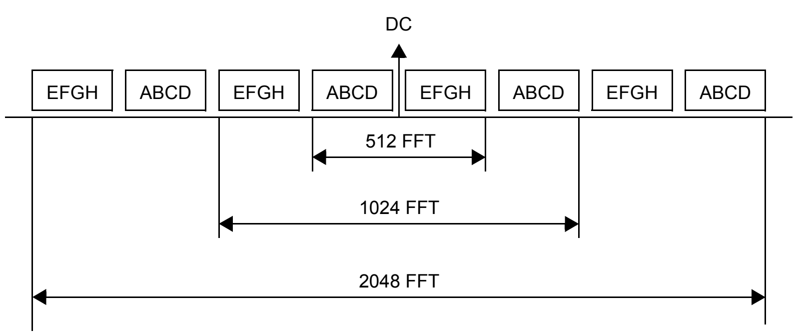


Figure 509—Allocation of sequence sub-blocks for each FFT

A circular shift is applied to over 3 consecutive sub-carriers after applying subcarrier mapping based on Equation (201). Each subblock has common offset. The circular shift pattern for each subblock is:

[2,1,0…,2,1,0,…,2,1,0,2,1,0, DC, 1,0,2,1,0,2,…,1,0,2,…,1,0,2],

where the shift is circularly right shift.

For 512-FFT size, the sub-blocks (A, B, C, D, E, F, G, H) experience the following right circular shift (0, 2, 1, 0, 1, 0, 2, 1) respectively. Figure 510 depicts the symbol structure of SA-Preamble in the frequency domain for 512-FFT.

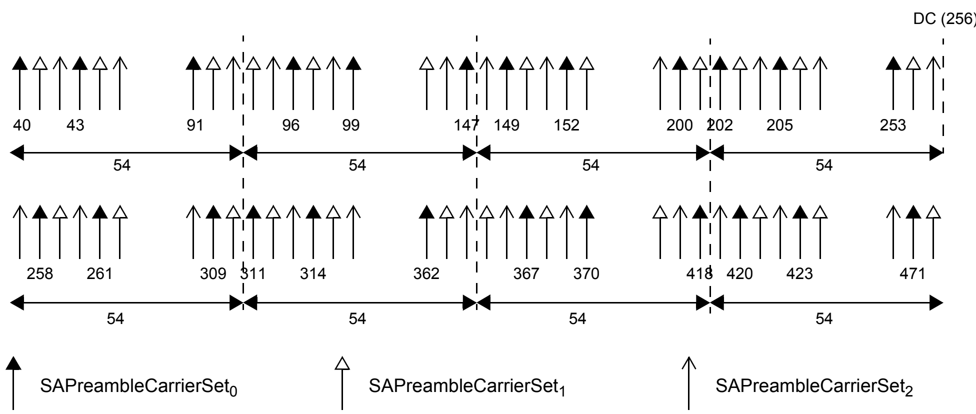


Figure 510—SA-Preamble symbol structure for 512-FFT

For multiple antenna systems, the SA-Preamble blocks or sub-blocks are interleaved on the number of antennas as follows. For 512-FFT size, Figure 511 depicts the SA-Preamble allocation for 1, 2, 4 and 8 antennas.

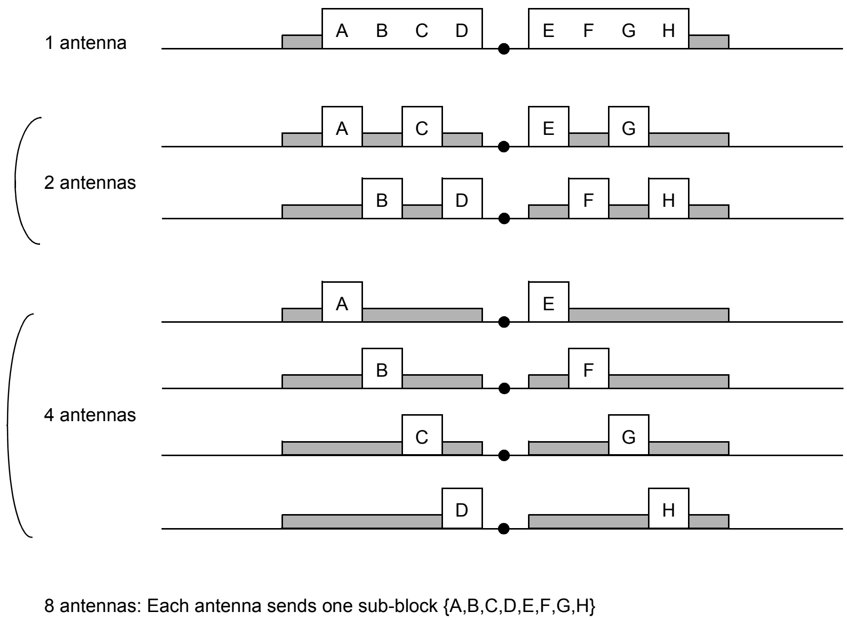


Figure 511—Multi antenna example for 512-FFT

For 1024-FFT size, Figure 512 depicts the SA-Preamble allocation for 1, 2, 4, and 8 antennas.

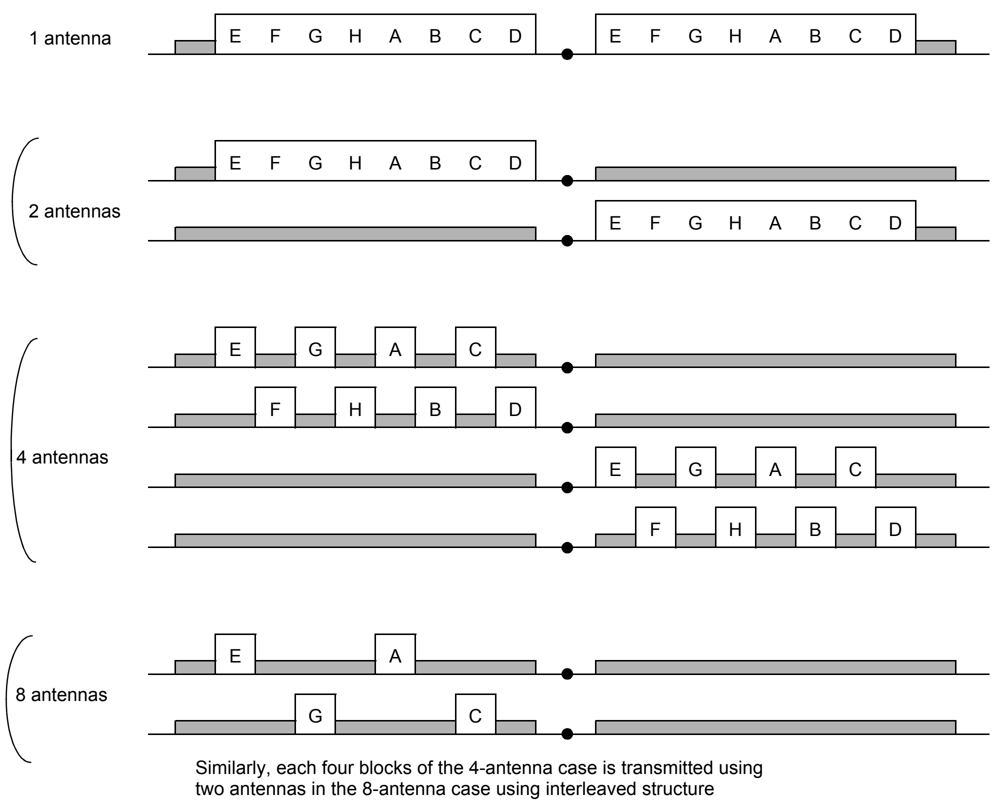
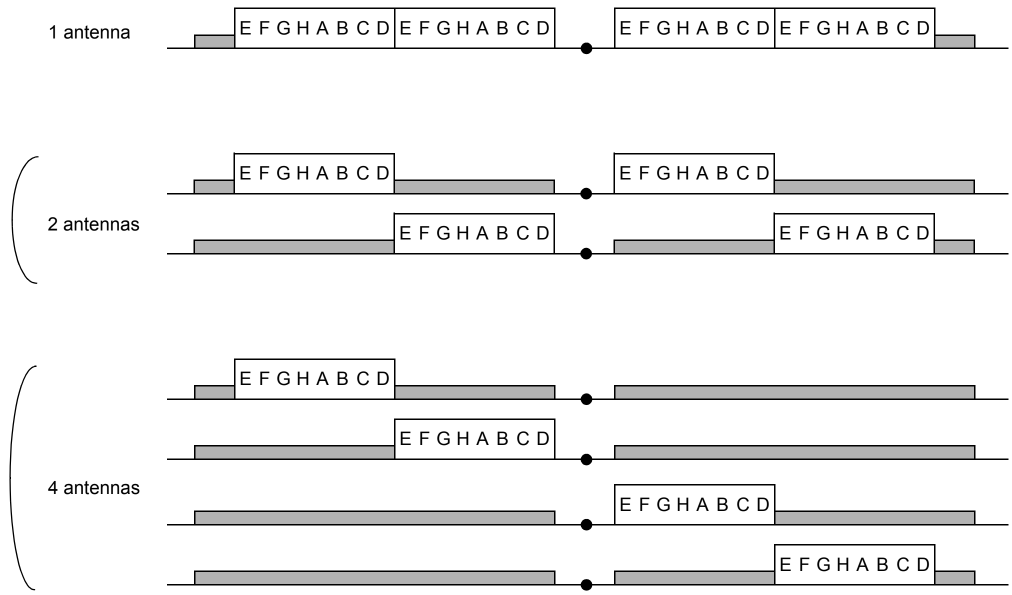


Figure 512—Multi-antenna example for 1024-FFT

For the 2048-FFT, Figure 513 depicts the SA-Preamble allocation for 1, 2, 4 and 8 antennas.



8 antennas: Each block {E,F,G,H,A,B,C,D} in the above 4-antenna scenario is interleaved across two antennas where [E,0,G,0,A,0,C,0] is transmitted via the first antenna and [0,F,0,H,0,B,0,D] is transmitted via the second antenNA.

Figure 513—Multi-antenna example for 2048-FFT

Let "block" denote 8 consecutive sub-blocks {E, F, G, H, A, B, C, D}. The algorithm to assign the preamble blocks to multiple transmit antennas where the tone dropping is not applied and the number of antennas is power of 2 can be described as follows. Let:

N_t: number of transmit antennas,

N_b: total number of blocks,

N_s: total number of sub-blocks; $N_s = 8*N_b$,

N_{bt}: number of blocks per antenna; $N_{bt} = N_b/N_t$, and

N_{st}: number of sub-blocks per antenna; $N_{st} = N_s/N_t$

If (N_{bt} >= 1)

Distribute consecutive blocks across the N_t antennas

For a given antenna, a block is repeated with period N_t

Block position of the antenna t is $t + p * N_t$, where t = 0, 1, …, N_t-1 , p = 0, 1, …, N_{bt}-1

Else

If (N_{st} = 4)

Interleave the 8 sub-blocks {E,F,G,H,A,B,C,D} across each 2 consecutive antennas

Block [E,0,G,0,A,0,C,0] is sent from antenna i at block position: floor(i/2)

Block [0,F,0,H,0,B,0,D] is sent from antenna i+1 at block position: floor((i+1)/2), where i = 0 for 512-FFT. i = 0,2 for 1024-FFT, and i = 0,2,4,6 for 2048-FFT

Else If (N_{st} = 2)

Interleave the 8 sub-blocks {E,F,G,H,A,B,C,D} across each 4 consecutive antennas

Block [E,0,0,0,A,0,0,0] is sent from antenna i at block position: floor(i/4)

Block [0,0,G,0,0,0,C,0] is sent from antenna i+1 at block position: floor((i+1)/4)

Block [0,F,0,0,0,B,0,0] is sent from antenna i+2 at block position: floor((i+2)/4)

Block [0,0,0,H,0,0,0,D] is sent from antenna i+3 at block position: floor((i+3)/4), where i = 0 for 512-FFT and i = 0,2 for 1024-FFT

Else If (N_{st} = 1)

Interleave the 8 sub-blocks {E,F,G,H,A,B,C,D} across each 8 consecutive antennas, i.e., send 1 sub-block per antenna

Block [E,0,0,0,0,0,0,0] is sent from antenna i at block position: floor(i/8)

Block [0,F,0,0,0,0,0,0] is sent from antenna i+1 at block position: floor((i+1)/8)

Block [0,0,G,0,0,0,0,0] is sent from antenna i+2 at block position: floor((i+2)/8)

Block [0,0,0,H,0,0,0,0] is sent from antenna i+3 at block position: floor((i+3)/8)

Block [0,0,0,0,A,0,0,0] is sent from antenna i+4 at block position: floor((i+4)/8)

Block [0,0,0,0,0,B,0,0] is sent from antenna i+5 at block position: floor((i+5)/8)

Block [0,0,0,0,0,0,C,0] is sent from antenna i+6 at block position: floor((i+6)/8)

Block [0,0,0,0,0,0,0,D] is sent from antenna i+7 at block position: floor((i+7)/8), where i = 0 for 512-FFT.

At each time frame containing SA-Preamble, the transmitted structures are rotated across the transmit antennas. For example, we consider the 512-FFT system with 4 transmit antennas. At the f^{th} frame, the SA-Preamble structure [A,0,0,0,E,0,0,0] is sent via the first antenna, and structure [0,0,0,D,0,0,0,H] is sent via the fourth antenNA. Hence, if the $(f+1)^{th}$ frame contains SA-Preamble, structure [0,0,0,D,0,0,0,H] is sent via the first antenna, while structure [A,0,0,0,E,0,0,0] is sent via the second antenNA.

The magnitude boosting levels in single carrier mode for different FFT size and number of antennas are shown in Table 799.

Table 799—SA-Preamble boosting levels

Ant\FFT	512	1k	2k
1	1.87	1.75	1.73
2	2.51	2.33	2.43
4	4.38	3.56	3.98
8	8.67	6.25	5.13

For single-antenna case, the SA-Preamble is transmitted with a magnitude boost of 1.87. The boosted SA-Preamble at $k^{\text{-th}}$ subcarrier can be written as:

$$c_k = 1.87 \cdot b_k$$

where b_k represents SA-Preamble before the boosting (+1, -1, +j or -j). The block cover sequence shall be applied to each sub-block. Each bit {0, 1} of block cover sequence shown in Table 800 as a hexadecimal format is mapped to real number {+1, -1}, and then multiplied to all the sub-carriers in the corresponding sub-block in the structure depicted in Figure 509.

Table 800—SA-Preamble block cover sequence

(FFT,number of antennas)\Segment ID	0	1	2
(512,1)	00	00	00
(512,2)	22	22	37
(512,4)	09	01	07
(512,8)	00	00	00
(1024,1)	0FFF	555A	000F
(1024,2)	7373	3030	0000
(1024,4)	3333	2D2D	2727
(1024,8)	0F0F	0404	0606
(2048,1)	08691485	1E862658	4D901481
(2048,2)	7F55AA42	4216CC47	3A5A26D9
(2048,4)	6F73730E	1F30305A	77000013
(2048,8)	2F333319	0B2D2D03	0127271F

SA-Preamble sequences for tone dropping support are obtained by dropping the farthest sub-blocks of the reference bandwidth from DC subcarrier on both sides.

For support of irregular nominal channel bandwidth by tone dropping, the dropping unit of SA-Preamble is two sub-blocks. The granularity of nominal channel bandwidth is 1.25MHz. Table 801 shows the allocation of sequence sub-blocks for SA-Preamble according to the different range of available nominal channel bandwidth where N_{si} is the total number of sub-blocks in irregular nominal channel bandwidth.

In case of $5 < x < 6.25$, the antenna configuration of 512-FFT size for the regular channel bandwidth 5MHz is used. In case of $10 < x < 11.25$, the antenna configuration of 1024-FFT size for the regular channel bandwidth 10MHz is used. Except for these two cases, the algorithm to assign the SA-Preamble sub-blocks to

Table 801—Allocation of sequence sub-blocks for tone dropping support

Irregular Nominal Channel Bandwidth Range, x (MHz)	N_{si}	Allocation of sequence sub-blocks
5 < x < 6.25	8	ABCD EFGH
6.25 <= x < 7.5	10	H ABCD EFGH A
7.5 <= x < 8.75	12	GH ABCD EFGH AB
8.75 <= x < 10	14	FGH ABCD EFGH ABC
10 < x < 11.25	16	EFGH ABCD EFGH ABCD
11.25 <= x < 12.5	18	D EFGH ABCD EFGH ABCD E
12.5 <=x < 13.75	20	CD EFGH ABCD EFGH ABCD EF
13.75 <= x < 15	22	BCD EFGH ABCD EFGH ABCD EFG
15 <= x < 16.25	24	ABCD EFGH ABCD EFGH ABCD EFGH
16.25 <= x < 17.5	26	H ABCD EFGH ABCD EFGH ABCD EFGH A
17.5 <= x < 18.75	28	GH ABCD EFGH ABCD EFGH ABCD EFGH AB
18.75<= x < 20	30	FGH ABCD EFGH ABCD EFGH ABCD EFGH ABC

multiple transmit antennas in the irregular system bandwidth is described as follows. Let $N_{st,k}$ be the number of sub-blocks for kth antenna, where k = 0, 1, ..., N_t -1. Then $N_{st,k}$ is defined by Equation (202):

$$N_{st,k} = \left\lfloor \frac{N_{si} + N_t - 1 - \mathrm{mod}(k - p, N_t)}{N_t} \right\rfloor \quad , \tag{202}$$

where $p = \left\lfloor \frac{N_t - \mathrm{mod}(N_{si}, N_t)}{2} \right\rfloor$.

The sub-block position for the k^{th} antenna is $t + \sum_{i=0}^{k-1} N_{st,i}$, where t = 0, 1, ..., $N_{st,k} - 1$ and $N_{st,-1} = 0$.

Figure 514 shows the proposed SA-Preamble allocation at $11.25 \le x < 12.5$ as an example.

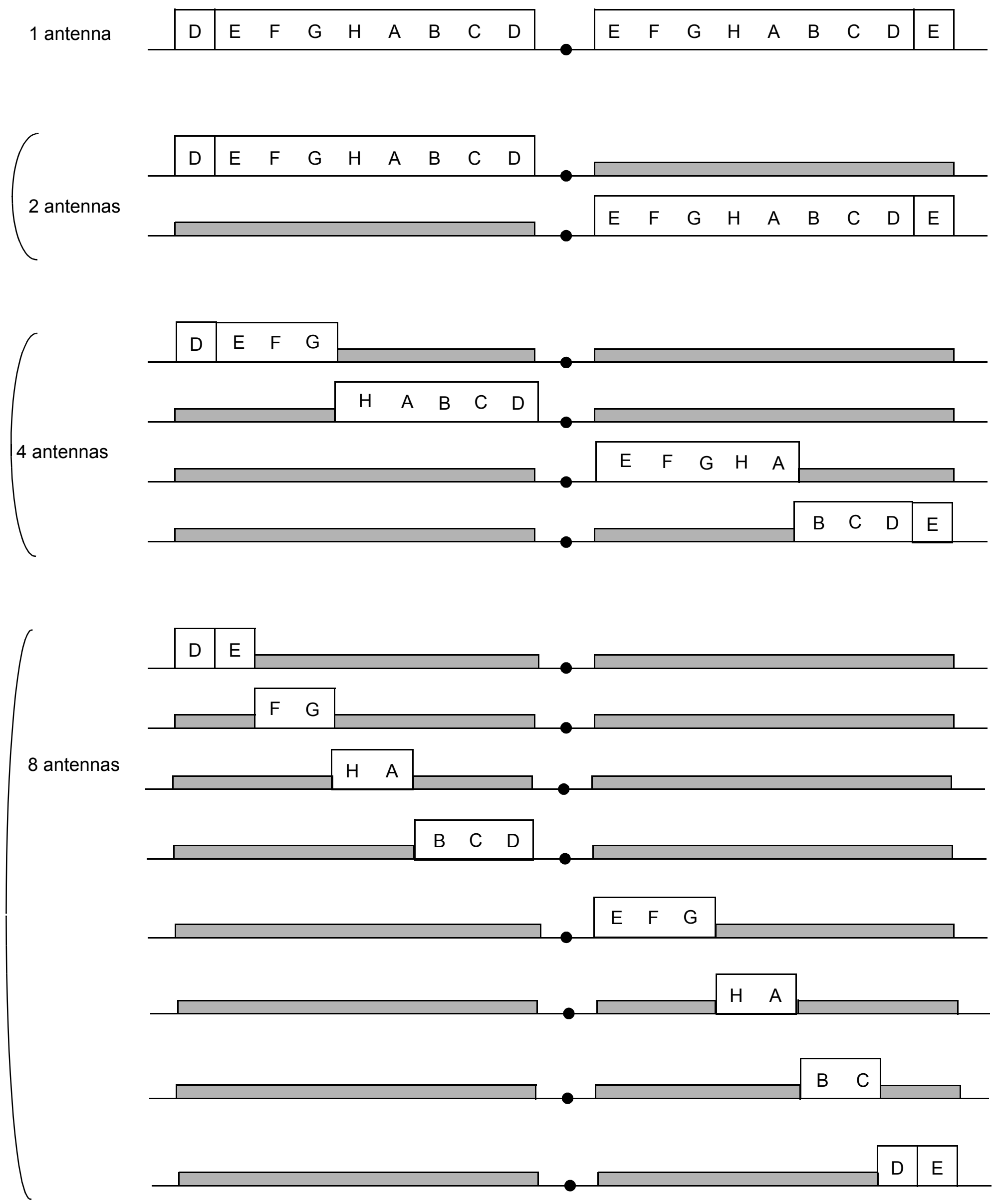


Figure 514—Proposed allocation of SA-Preamble at $11.25 \leq x < 12.5$

At each time frame containing SA-Preamble, the transmit structure are rotated across the transmit antennas. The rotating direction is same as the reference channel bandwidth.

The block cover sequence shall be applied to each sub-block. Each bit {0, 1} of block cover sequence shown in Table 802 as a hexadecimal format is mapped to real number {+1, -1}, and then multiplied to all the sub-carriers in the sub-block structure corresponding to the tone dropping design. In Table 802, BW_{min} denotes the minimum value (MHz) of Irregular Nominal Channel Bandwidth Range as shown in Table 793. BCS for the range 5 < x < 6.25 is same as BCS of 512-FFT size for the regular channel bandwidth 5MHz, and BCS for the range 10 < x < 11.25 is same as BCS of 1024-FFT size for the regular channel bandwidth 10MHz as shown in Table 800.

Table 802—SA-Preamble block cover sequence based on sub-block dropping

(BW_{min}, number of antennas)\ Segment ID	0	1	2
(6.25,1)	0AA0	0FF8	0008
(6.25,2)	0f68	0650	0458
(6.25,4)	0300	0300	0908
(6.25,8)	0140	0000	0100
(7.5,1)	000C	1008	0990
(7.5,2)	0C24	1558	0F58
(7.5,4)	1B08	030C	1904
(7.5,8)	0140	0400	0510
(8.75,1)	0C10	229A	2554
(8.75,2)	335A	146C	3C10
(8.75,4)	1320	0252	2406
(8.75,8)	0140	0404	1514
(11.25,1)	F7FDCEF3	29D51936	6B59CC03
(11.25,2)	005A0F80	00000000	00000000
(11.25,4)	00AF6A80	00E65280	00A45900
(11.25,8)	00230000	00A30200	00090800
(12.5, 1)	AC1AD967	602F7D20	96771160
(12.5, 2)	000F7000	01FF0000	00000040
(12.5, 4)	00AF6A80	00E65040	00C45900
(12.5, 8)	015B0940	00030C40	01190540
(13.75, 1)	4F56FD74	C0F7EEAD	55459EDB
(13.75, 2)	012C1BA0	030177A0	02266200
(13.75, 4)	024C2400	03155920	01CF59A0
(13.75, 8)	009B0800	02830D20	02190420
(15, 1)	DAD99B4F	96771160	CCF40660

Table 802—SA-Preamble block cover sequence based on sub-block dropping

(BW_{min}, number of antennas)\ Segment ID	0	1	2
(15, 2)	00CC5AB0	015411D0	020E0050
(15, 4)	038C2470	02D559C0	048F58D0
(15, 8)	009B0820	02830D10	06190420
(16.25, 1)	492F4A63	3785F431	AFCB95FD
(16.25, 2)	065A5AD0	06543808	080F4C50
(16.25, 4)	0D335A70	01146C70	053C10D8
(16.25, 8)	09932018	0D025248	00240640
(17.5, 1)	DD37B03D	81418C78	A47BAAA9
(17.5, 2)	10C36614	1B553644	0F9A5524
(17.5, 4)	19B35A4C	13146C44	03BC1030
(17.5, 8)	1223234C	09525248	1B04042C
(18.75, 1)	56849127	7EBE7387	4B958D3A
(18.75, 2)	2BA55AD4	029C6D58	13590072
(18.75, 4)	3D73734C	0F30306C	2B00000E
(18.75, 8)	05232312	21525272	04040414

Table 803—SA Preamble for *n* = 0 (Segment 0)

q\blk	A	B	C	D	E	F	G	H
0	314C8648F	18BC23543	06361E654	27C552A2D	3A7C69A77	011B29374	277D31A46	14B032757
1	281E84559	1A0CDDF7E	2473A5D5B	2C6439AB8	1CA9304C1	0AC3BECD0	34122C7F5	25362F596
2	00538AC77	38F9CBBC6	04DBCCB40	33CDC6E42	181114BE4	0766079FA	2DD2F5450	13E0508B2
3	3BE4056D1	2C7953467	0E5F0DE66	03C9B2E7D	1857FD2E3	15A276D4F	210F282AF	27CE61310
4	3DBAAE31E	254AE8A85	168B63A64	05FDF74FB	3948B6856	33656C528	1799C9BA1	004E0B673
5	177CE8FBC	21CEE7F09	397CD6551	01D4A1A10	1730F9049	067D89EA9	3AC141077	3D7AD6888
6	3B78215A1	17F921D66	385006FDC	011432C9D	24ED16EA6	0A54922F1	02067E65D	0FEC2128D
7	01FF4E172	2A704C742	3A58705E1	3F3F66CD2	07CA4C462	1854C8AA3	03F576092	06A989824
8	1A5B7278E	1630D0D82	3001EF613	34CCF51A1	2120C250A	06893FA2D	156073692	07178CFA7
9	032E31906	2DD318EAA	1DE55B14D	0EF4B6FB3	27DED0610	1BC8440D3	0ED86BF8D	14FAFDE2C
10	174725FFD	0D2FB1732	124470F56	292D9912B	1571408A7	227197AE9	2430BC576	0B67304E0
11	1F1DCD669	293DD1701	0C34F1B84	28496EE51	3DC41327F	071C06523	28E1657B6	02588EFDA
12	22E4AA041	3810362F1	1955F1DE7	0D6D2F8BE	11F31358E	3EB27BB12	1F4E60111	119BDA927

Table 803—SA Preamble for *n* = 0 (Segment 0)

13	14300B522	152E6D482	168DF6E43	0740B7AE0	14FE7DCDD	0FA092626	23697615A	1F1331EB8
14	12C65ED00	317643CD7	2C637A415	15E3E5185	0F5CBB9E0	23290B156	26F37EFE8	1AA174793
15	1DD6453F0	032C4BD39	082659BD5	320C5E691	224E555B2	3A9615A8D	1BED03424	28E6A9CED
16	068AE7EE9	16F724910	3803DD9BD	2A31A2FFB	010BF5237	33CB067E6	0280C28B7	184417B94
17	1D651280A	2C7BCF443	17324EFB0	236E5C411	381215183	2F076E64E	0A6F2EE74	3DA4196B7
18	27341650F	1B520099C	09AC91114	000A5F48B	30AB4B9B6	2D0DB0DE6	1CF57978A	2D424406B
19	3A01E2FB2	0DF5B257B	019D1C63A	0EA7DCDDB	242D96605	2DA675F15	1DEC54193	3B6341C16
20	2DDFAEB05	21D0A1700	0FA09BB78	17DA7F8BB	06E883B3F	02E6B929B	2C1C413B4	030E46DD1
21	1B625E3F9	0F708F756	00CD97B18	3F036B4DF	2CF08C3E5	213A5A681	14A298D91	3D2ED63BC
22	2DA48D5A9	0C085BD17	01903428A	3DF2A30D9	29061309A	16F7DC40E	2AF88A583	27C1DA5E9
23	30DBAC784	20C3B4C56	0F1538CB7	0DDE7E1BE	2C312903B	0FF21E6C2	032C15DE3	26C9A6BA4
24	3188E8100	385FEFE2D	3967B56C7	3F62D246B	1826A755E	2CDA895EA	2FAB77825	1B525FF88
25	339467175	2DE49506B	27B7282A9	0254470A3	3374310AF	2DF20FD64	3848A6806	11C183E49
26	02AFA38DC	0F2AFDDF4	1A05650E2	061439F88	11C275BE0	30C41DEC9	119E070E9	1E76542C1
27	1B364E155	086FF808C	29F1BA9DC	0A830C788	2E70D0B3A	34EA776B1	3D13615C0	15FC708D4
28	38ECFC198	07034E9B3	2340F86B3	07562464C	22823E455	1F68D29E9	257BB66C6	1083992F1
29	375C4F5AB	3C0F5A212	0EA21BC30	13E8A26F2	17C039773	283AD6662	1F63AB833	2DE933CAF
30	2B773E3C5	3849BBE6C	1CAD2E5AB	0405FA1DE	1B27B4269	3B3BF258F	300E77286	39599C4B1
31	1E878F0BE	0AE5267EC	376F42154	1CD517CC2	302781C47	123FEC7E0	16664D3D8	24B871A55
32	20E200C0A	1C94D2FF1	213F8F01B	369A536E0	161588399	29389C7FC	259855CAC	06025DCE2
33	28D2E001C	3C51C3727	106F37D0E	1FB0EFDD1	2CD9D33C3	1EA190527	0BB5A6F9E	074867D50
34	08EFC44B5	1B484EABE	05FEB2DE2	211AF91B5	0CF52B1E1	002B5C978	11D6E5138	0D402BDD2
35	337C618F4	0A4C31DDA	1D93003D6	006D7D088	348043A6D	325E05758	2C53EEEB8	15ED8E614
36	38375C2FF	18C78FD02	30C11EF53	3916581DD	1B75263FF	2D8DFD6A9	00C4E8482	1D201F96A
37	2E10B0D05	2EF203893	2491D95F1	34D995B51	32214BDF5	3E45674B1	3E74AC66E	1B813A999
38	153E7269D	2391C7BFC	1ADD3A595	0EFD3086E	00AD88A8E	0D8B007CA	0F22C5F9D	010E86385
39	3B58C7BFF	0BA76496E	3AD0B7BBF	1D6D10FB3	3A607BEFC	28F122A95	057950727	179449CB7
40	37AC5194A	390BD9C00	3A48C0461	12FBCE4C6	2A8DD4171	10E9F1E34	251F5D167	1124E96B1
41	0FEF20C67	31EC9EA3F	275B31143	22DA4F02B	352C0F648	21FF5B9F3	3E5BC2372	0A1AE08FE
42	080EDC49B	17AD7F7BA	390775B3C	1380B00DA	2477FF17C	2E6D9E5AF	05381F2DD	26143CC17
43	2DB485795	1B3252799	39AD0211C	3AAE31B76	30532A187	1C8EA5F5A	2EA6E4D6B	30570A2E4
44	11BB4F78A	12CCE1428	2C67EEF99	20E3F841A	20CFCD5F2	1618A7B94	111FF6092	2ED034E06
45	1C66335E5	0CA9B9BD2	3213028AE	15542DD28	290F7DAE2	2137F02D5	17DF9445D	24F162FFB
46	360FB966B	17D878955	1C1D67093	065B84F3A	1A1D955E3	24C73C11E	270EA9EB2	114DCA02C
47	002CE84DD	0616DD253	3EB188345	1FF852926	37E160F00	040DF51EC	1857A33BA	230FD8A0D
48	233C0A71F	22E428104	0325F8170	39566B188	32DA16A4A	039FDF1DC	27A3E946C	0D69F26D9
49	0583F9F73	378380CB6	059D8A960	3E3442C7F	026138ADB	25F370F1E	09D3EB2CC	2D37D50C0
50	08DF9CC66	2C2E7AA8F	3CB241ED2	03216B4D2	39736B451	25F6F113F	08FD2AC3C	1974574FD
51	3D1FF6041	2CE2AB97F	01A734F3B	1DCF9F3C5	268D595CA	1FBD2A8B8	0F1449F86	370C352FD

Table 803—SA Preamble for *n* = 0 (Segment 0)

52	123218E40	3AA057589	20F73A16F	26E3BCA5F	3A7330DC6	12C659384	39D99FF1B	276DFC540
53	185AEDEA4	0418B3643	382F7700A	3FC35ED60	07BA2F838	1BC840C93	2469A41EC	0CE7B4CB0
54	2E194E2BF	3302A0B28	1836001EE	154A4738A	36A3BBD72	23CCD0EB1	044B3A13B	2B50C8057
55	0B76405D3	231AAA728	0EE05E9B6	0093A21F2	2065A01D0	1F2B810D4	1082F3A73	1DAFEA492
56	07AD23A3A	2091957F1	3B9D8CBF0	21E4160BE	1BFB25224	3D9085D16	03076DD39	1DBCF8D03
57	226D70EBF	3ED15246C	364130C46	22F6D4AA3	3FCC9A71B	3B9283111	0484F0E58	14574BD47
58	3F49B0987	305231FA6	0CF4F6788	3B9296AED	2346190C5	3365711F4	078900D4A	352686E95
59	1D62AC9A4	104EDD1F5	1B0E77300	1CED8E7F0	388E8002C	1FE6199F4	02239CB15	1FE5D49A2
60	21314C269	28600D12A	22E4F1BAA	044E211B1	0DECFE1B4	3E5B208CC	1CFC91293	21E7A906B
61	02C029E33	1BA88BE4D	3742AE82F	21EF0810F	17D23F465	240446FB5	17CCE51D9	2C0B0E252
62	16F9D2976	10185ECE6	2821673FD	02674271C	3A8A75B7C	226D4BF0F	2216004E5	0E8605674
63	06E4CB337	32A31755D	062BE7F99	1417A922D	2271C07E5	24D6111FA	3F2639C75	0CE2BB3A0
64	18D139446	2426B2EA8	352F18410	1133C535E	10CC1A28F	1A8B54749	22A54A6F4	2F1920F40
65	22443017D	2265A18F5	14E1DAE70	11AC6EA79	31A740502	3B14311E7	3AA31686D	26A3A961C
66	2018F4CA9	3A0129A26	39BDA332E	1941B7B49	03BBCE0D8	20E65BD62	2E4A6EE6C	3B095CCB3
67	0CC97E07D	11371E5FF	31DFF2F50	17D46E889	352B75BEA	1F1529893	21E6F4950	1BD034D98
68	275B00B72	125F0FE20	0FB6DE016	0C2E8C780	3026E5719	119910F5F	3B647515B	1D49FED6F
69	250616E04	0882F53BF	11518A028	3E9C4149D	09F72A7FB	0CC6F4F74	2838C3FD1	08E87689B
70	212957CC2	03DD3475B	044836A0B	2463B52C0	0342FB4B0	34AD95E9B	2936E2045	3B0592D99
71	2922BD856	22E06C30C	390070AED	09D6DC54F	3485FA515	064D60376	07E8288B3	3DD3141BF
72	29CB07995	007EE4B8B	16E787603	07C219E93	1031B93DD	23DEFF60B	30F1D7F67	0EFE02882
73	11F3A0A2F	38C598A57	3FE72D35B	1F655E0D1	0B3AC0D92	3430DDB1A	3BAADBF42	02D6124C0
74	05FC8085D	345A5C470	07DAAE1E9	0D7150B88	25D2A5B10	16F8E5021	3240EFC71	0F0F5922D
75	399F32F6E	2EEB17A8E	0D61665D0	2138EE96F	3F8119063	01B5048F7	27075153D	265DF8280
76	3962CC581	2337D2983	286FD7BBA	185126E0E	1F95AD927	0F7EBC374	1E3A4B6FF	20CA9B9BD
77	1C85C13AF	290C37167	1FDD26E8F	0C38736B8	0174DB972	0A921E3CC	097557C9D	09452C1E6
78	2D48D6C00	2D9BC8DFE	10FF1E128	25C96BA85	0FB071B8E	0F09B3C9C	1A3E11441	38EDDA03D
79	396B88B2F	0029F4BDB	30D098CAD	0D54D12CB	1D0823F55	2DC53B9AA	11BCF7438	33F6EC091
80	21E03CD65	1A2FE5B92	2851F8445	0251E386C	1468950D8	1A8B39748	001B42236	26CD82DA5
81	2CEA1E6BB	006C97E74	00C2B887D	23461AF95	0E9CB2BD2	0B0EA3022	1FB56A7A3	25A7FA625
82	208FC2A1F	381C5733A	03F11D7E3	07ED6A7B7	1FEC85E09	3D61E0440	356F4B1C3	3756E5042
83	2061E47F0	22EAA0AD3	24796BB65	03C59B4D8	32A75E105	22155381B	23E5F041C	155D2D7F9
84	381AFFB73	212B5E400	1F1FE108E	04BF2C90D	3C1A949D9	2854A9B45	001B09322	3A9372CC1
85	058B23433	0904C6684	158CADB9E	11BA4B978	1854368F4	1919ECEA7	147F1FD34	2E228AA3C
86	34857F3DB	2CB44F7BF	111A065D3	1BEAB392E	27F081ED8	3E67D1186	0F6265AC5	27716FAF9
87	38EBB8BF1	32ED6E78F	2B0BA4966	2188282AA	00D49B758	1765BA752	2B50AFDCC	068C82450
88	234F0B406	02FB239CD	15AD61139	2250A5A05	1CD8117E0	0D849163F	268C7A5A6	22A802020
89	2D0FE8D16	0C14E3771	07DE5320C	0640C2762	1CBD9FF4E	37A91986D	2024DA401	164D4A84C
90	3225B4D60	3013B75F2	2A77AE5C5	2C25377EE	03C8DF835	346E80FCB	116B79FA5	356D2B604

Table 803—SA Preamble for *n* = 0 (Segment 0)

91	0D55231FD	247907F31	0CFA0B049	36D069A95	10D4CDE71	1A32544D7	38336885F	173ECC08D
92	207420EAC	26FCFE182	3FE7B31C6	15B320E13	187AA34A8	1B52253BF	1FA16669D	3725A81A5
93	3C9C7404A	092B77FEB	3B9865B46	349456F61	39B7C6A66	3075EC990	01BE637DF	330897B17
94	1CA4C048D	2B4D50621	2BF917627	3EA2CC5E1	33EC0A1E3	05FE0F747	349553D72	396077301
95	04CEC1C82	1F828DD00	30122C790	1AD8A7895	1CE0912C0	298382F37	2D4D33F06	001364B36
96	37F8BB035	2F0897994	333F5F096	0F28AB363	20036829F	338017E2D	3A5A05D76	0CC02E5E0
97	02FD351E6	03E316288	2FCAEB4F8	1C5A80CE3	3D3AC3FDD	3E456746D	119A5381F	1581C894E
98	1623B3D0F	103224DB0	0FB936BC8	2EED7F082	26C91513A	2F12E4C31	290F3AEF2	392CBFF67
99	02F75DE8F	2E61A834D	02A692866	1F21044A3	2D7881A95	18651EE05	11FE3D308	39EED56DA
100	3A858659E	2F7A87BE0	135FD561D	27B3B651A	05E131CB9	0D5865123	2CD6991E5	3EE6DF705
101	3F3B247E1	32D02B245	16B98A593	1E4CCFF18	0C4A9D285	06D519FE2	023A336CD	1B20E999E
102	3A9E8B49B	239656AD1	3396D1C51	06F4DCF40	15D819D3F	2A3061144	20BD2A33E	2FFB139CD
103	38622F3AF	24BF9BB7F	1D2729010	15877B93A	00376B0E7	0FF064887	3505CFD9B	354C366B6
104	2A0AB7033	1AFA65DE1	1198D0AD6	38E80C86A	27693D541	3BB26F3D4	39154881C	0E7DD6B6B
105	1B0DE4333	27FE0F6D1	0F00B2888	0BDA322FF	2759B5A4F	0543A2D27	0C36DD1E5	04E9A262D
106	1C7E636BF	000E9C271	2B44F4F30	28255BF77	1CC4D69CE	03F4C57B2	3E926D59B	00AA39BDB
107	1FDE98AE0	0CD076B07	171124FB5	33F098288	1E0B3043E	39731D117	3E7ABC2C8	19CC50279
108	28EE855ED	2A704C371	03288F4B0	3C83E26C2	0A905148B	18C66BB94	1BCC32537	10D71AB44
109	26238A065	0FBD7BCDD	02507CF76	059F69484	3FE0D6F77	2466A50DB	3C07A75B2	2DC0F099E
110	3CDCD6CBE	1446783DA	1626C83F9	2FD4C4DF3	13A59A2D1	2C903D2A3	0FD37F076	0B1039EDD
111	043B07DD7	28D9C2155	2CCEF57A8	34254C1B7	09B933B2F	1FA410127	10BD5E9E6	010EC6389
112	345E8FCAC	226BD7EFA	27341A51C	23854F031	04C297212	044DED8E8	319B3BFB8	37DBBBF57
113	16FBEFA72	1B5EF9484	2DEE7A5BF	097695C12	08AEAD5E8	3DA7C1327	2B81F3E2D	31AFBED32
114	3484086B1	2DFA56B9E	226E8AFE5	285F45484	3E69AC8E1	1CB33645F	2DE53BC30	2F6ED567E
115	1117B5E7D	122A4D471	1AC936544	267010D71	10428CA47	24B72A000	2E27FE185	1E62C1403
116	0B3161E37	038C3DC98	100793647	1A95D8D36	399668787	06C0D4922	25F48AA58	2DFFF1789
117	04FEF7231	381910B63	298783078	30CE5EC1C	29F6F299D	3C34CA770	37BAAB139	3D2069B65
118	18F644052	2051880EC	23ADBF949	04237280A	18304E663	287364EFF	314698D78	149A21E51
119	39E14BBCB	1DBDA9EF4	3ECCAD8D3	1BA3EF99D	26D85CEBF	270547292	0FB3C7826	0131E73D6
120	2DD6F3F93	0FC282088	14A143DDD	0AB840813	0B973037C	29535C9AB	0DF8DA2AC	271CBC095
121	1C1D063F9	3F4EF6DCC	00128D932	145E31F97	0B21590D1	38F1602D8	3AC2EBB74	2320957C5
122	3383C846F	12128F29B	19985CE7D	2834CBBF2	1E1513B3D	364DB5800	33EE3F46C	01A865277
123	0129D260B	238A85BA0	2D81AA924	3917048B6	36F857692	1D2F813C3	0505FB48B	3DC438BC5
124	05E0F8BDC	3D978C1F1	266F83FCA	0E89D715A	01821DEA4	12D9AE517	22F8EAC2C	3C098DA58
125	1575D1CE9	26F291851	3A7BB6D2C	12CC21A3A	2975589B0	39CF607FF	388ABF183	3D3BAAB0B
126	101E5EC7A	0B75BCF3B	13ED25A86	35FC032B6	2F6209FF0	13C7B2041	1F2791466	3A759A6C2
127	1EF89091A	11A653D2C	223FC1F42	2F7B97B31	2CA4EE011	00F68767D	10FE34682	018339212

Table 804—SA Preamble for *n* = 1 (Segment 1)

q\blk	A	B	C	D	E	F	G	H
0	20A601017	10D0A84DE	0A8C74995	07B9C4C42	23DB99BF9	12114A3F5	25341EDB0	362D37C00
1	1364F32EC	0C4648173	08C12DA0C	19BD8D33A	3F5F0DDA6	24F99C596	026976120	3B40418C7
2	1C6548078	0A0D98F3C	0AC496588	38CBF2572	22D7DA300	1CCEAF135	356CA0CCF	093983370
3	03A8E3621	2D2042AF5	2AB5CC93B	05A0B2E2E	0B603C09E	117AC5C94	2D9DEA5A0	0BDFF0D89
4	07C4F8A63	3E6F78118	32CCD25F2	1792A7B61	0A8659788	1F9708C04	086AF6E64	040B9CD78
5	2D7EE485A	2C3347A25	3B98E86AF	242706DC3	1CEF639AF	2E1B0D6A9	3E9F78BC1	0FB31275F
6	0307936D0	21CE15F03	392655B2D	17BE2DE53	3718F9AB8	01A986D24	077BDA4EB	1D670A3A6
7	05A10F7B7	31900ACE0	28DCA8010	2D927ABE5	370B33E05	31E57BCBE	030DC5FE1	093FDB77B
8	092C4FED1	268BF6E42	24576811F	09F2DAA7F	24EFFC8B1	21C205A90	1E7A58A84	048C453EB
9	29F162A99	1F739A8BF	09F684599	1BEC37264	38ED51986	286325300	344FC460A	3907B1161
10	0E4616304	0FABDCD08	0F6D6BE23	1B0E7FEDD	0047DE6C2	36742C0C6	2D7ABB967	10D5481DF
11	32DD51790	237D6ACFA	2F691197A	16724EA58	149143636	3810C6EE1	3A78B3FC6	1B1259333
12	1BB0FD4D3	235F10A55	1C7302A27	1148B18E5	04F25FBC8	2A0A8830C	3646DBE59	2F25F8C30
13	0FB38C45B	069DF29E9	00F93771B	3AA35746D	2CAF48FD0	0A42CDD55	19A23CE8F	26318A30F
14	365FBEDAC	27710945F	2AA367D61	05A484318	2563F27D9	2D37D5C00	287D18FBB	3ADB44805
15	3038BC77D	2A45D29EC	156173792	03EC7679E	07577E1A4	1B6A94A74	1D26E5A94	0FD878D5A
16	1F22158E4	3F02A1D37	2767EC03F	1C8CD535A	23DA2E5AB	2D5F25A59	0971AA889	3E78C1846
17	16521E709	12C2DB8FE	3A596C221	1562D5C27	1D9E1F39A	345B96872	301C7894E	2797F032D
18	2EC951A24	1ED768F3F	11217930A	39DB44855	36E41B3FC	0F6E48C44	36254C517	14493C673
19	3EA159E72	24ADE96FE	3458C73A6	30674E1FB	242109AF2	24DAF32B6	24B1EDFFE	291CB9D15
20	2AD0E6696	04F4077D9	1BB279A53	38957605B	379B7A6A0	0BAD35616	1285EAE51	37425C7FF
21	083637980	34F2ED66F	282846A88	19D5E40A6	21205942C	27AC551E9	0F3F4C262	0505FB522
22	3E7D64856	1DB0E599E	159120A4B	1FC788139	235C454FB	3CE5B67C8	339EADB32	0F9F7DDC1
23	3956371B8	1D67BE6E5	1EFCF7D53	041A5C363	2E281EB3F	00AF8A1ED	2DE24A56F	1332C0793
24	0818C47A9	1F945634B	1C5ED3403	1043B5BF4	149702D22	024CBB687	34B01FA8B	1E9F5992F
25	3A6618167	3A0007886	3EDB5756B	2F2FA6FCD	21A5252B8	396FFAD9D	05347B60C	2E0ECA200
26	0D45F89A1	3F9C2C26E	1CBCF809E	3CBE5FCD0	3D2DCF245	14F351A1E	224F5B3FF	2AA6ED34B
27	3BA85ADF8	282005732	3AD7C0223	2E73D1800	23DEA3F46	2275280F6	1586270F9	0CEF4287B
28	07DFE662E	314B74F2F	397BDDC4C	223A8071F	1F5BE3BB4	093BB1F33	0FCA2D129	21B3526A9
29	39FEADC12	0ECE1CD67	206228FAA	38FCCA606	0C5EEE08F	1C1BBDD4E	1459E42ED	11FD64ADF
30	2735FFB20	2AE9B244A	1A5AED974	38FCFD5CB	20310DB81	1C5FC3E24	19FB3BA17	3785BE865
31	24FF6B7EC	01C682673	19CB14113	2C8CD3C2A	066725853	02CD0A23B	279B54315	0CD571063
32	015E28584	30B497250	127E9B2E1	2C675E959	05F442DEE	394AEF6E2	079E5C840	12703D619
33	3CE4B1266	35270B10F	03549C4B3	3B3E6C375	1DBEF270E	0042C9737	049522EC6	24961653E
34	34176CD90	2B5E9EAE1	1C95E3C2B	1EF541D4D	26D1450E6	3B9D895AB	1B0C84349	104B6B428
35	07A813421	2B39EAADC	33553571C	0F8046CDF	2CF6A7F23	0AE3BE8C8	308BFF531	2DBC0F9E3

Table 804—SA Preamble for *n* = 1 (Segment 1)

36	168276972	2CF41744F	3CF2512E0	0F8B68ABC	2E609F6AF	04E03AC8C	0F9B66F49	3AFE28736
37	03456021F	1982574F3	0BB2B3F49	15A4A1CDE	15487D58E	2907C9ABB	15C0D2D73	28D8CFEC3
38	3D3FD677C	33AF2628F	3D217FDCF	30027E85F	0A463F23B	2F2AE8324	1D1E945E0	2EB355D28
39	3BCAF9076	3A7D2FF70	3C541F38B	249BD8A94	287BC4833	141391EB7	05B6443D0	2FEACC5E7
40	275F118FA	3A96B346D	0C713CDE5	02F394A28	3EBB1D18D	1BE7A9FDD	223C53CA1	2BF040F77
41	1161DE4F5	0544F9DB7	230847E45	322AF4E17	26944A0B4	3299F1420	1C9405B8E	2DBABD4CE
42	33165C531	268FE9B9B	081A914B4	39100772B	27DBF03E9	3E3A18AB0	13F2D2B83	2CEEE5FF4
43	275F97006	0A578F2EF	16CEE7EC8	38A5B0084	00DC9A1F5	1B88CFA3D	0D8B0B8EF	29FC4CCF2
44	04BBE4F2C	1546C3988	237105A43	339042B36	3A5DEBE2B	1BD09449D	38EFF588B	1CDD3A6C0
45	002E32D38	1E85D3125	3F51120D7	00420ED63	3384713AF	1D941BD34	2B39EA9CF	05B6D9E94
46	2B3100F7B	335EDB2E6	1AC8C8EE4	337FF7139	0672D7995	38A54856E	0124753F2	3A3560851
47	046207CE9	0FE1BC312	09BA5B289	39376EF2B	33F826C2C	2F6531496	3933B8616	23125B50F
48	3E5849C45	01EEDB390	141D9A024	2DE07E565	1813D12BB	36DB8D404	0E8A272AB	3A66B71AD
49	1A2A88A4C	3F0C9B4DB	266CFBDF9	163420CA5	281ABBE99	34771C295	3AC051848	3C53CB875
50	16F795184	3466F1FFA	1F433B456	1DDF13810	25F58CF69	1DD6CFE4E	10A236FDF	12AE697ED
51	1C8D17F4F	07C43B7D1	1C8DAD395	28F6C112E	3A336ADB3	0EB6889AB	2783A6A1F	2CDA40458
52	16044624E	252AA04B2	11484E85C	07F5024B7	286E3A67F	2EE6BACE4	277F1F864	22F3CF57D
53	2D1A3F4CF	0EEB6DEC1	30CD76F42	20403D1AC	3A72EF9D6	1DAAF2A39	03AB76CE0	0A2856267
54	0FA2A786B	38273EDF2	228A45016	0309DF52D	093BDAEDC	1B11E9300	1DA9C5324	03365EB1E
55	24DCFDC06	11CF909D6	2FF693F4C	366338F1F	22E641569	0ACA60D55	32D1B009E	035472E09
56	17F5D6662	062FCF913	35B211035	21ACE73FB	3B4148706	2D0CD106F	2CAB457A4	103E1E49B
57	21859E8DA	2F1E3B3D9	1F1014BE2	062A3DEB5	354C0C786	05A8982D4	35A758943	346EBA72A
58	00CB49E5F	211B1034A	3A5D2DAF1	21D3F3EB0	24B2D1150	1097C3685	2AA3671CE	0E5DC1308
59	24C8401BE	217B1F994	1FB9664A8	3D5057708	05A506088	1314842B9	3C8657064	14B1FA77F
60	2AD698E2E	3C129D1F6	2C744FF4E	1C1C052F8	18C38A9FE	252168A10	2EB68D098	3A001CBD2
61	2AF71324C	2BF41D408	0FC498E18	149A1A407	0FDC2C4A3	19D00C4A1	0F6B0DD29	268CF8E86
62	19F4D82A5	342C73FD5	0F5AEEDE7	21A2A8953	15ADB7A94	11DBE038D	0A5B6634A	0FA382B77
63	0A5985778	35AC3032D	35691C85D	2829D55EE	04A3FBD8C	2C85BFA8E	0F459B864	3E878F0BC
64	10C785EB0	054D4CE18	1BF657A8E	101DC64EF	0B4E3032A	24ECFD9C2	00C98BE0A	2A1F82444
65	300E8B09C	31A079FB3	0C41DEC5F	216CCFE4D	226C5A693	3C31A41DD	3A019974C	23B64EAFC
66	249BDC80F	0316ED79E	1E42B5567	0CFF04A4B	310678543	34D986980	1E3195429	280966E65
67	359A72B64	186A3999D	065825DDF	2D28E6000	10964C1E1	1468C970E	34C8B606A	33CC94DB1
68	370B29C05	12841A9E8	2147E7160	1835345EE	06DB43F37	33854A725	065E6614C	151E2D7B1
69	0EAADDB27	004EC6DDD	30AA39B8B	2AEB34AD4	2A13D6649	00EC67B83	1176417CE	0E3683151
70	0832BA87B	3B67515B9	0FD34BC87	1688F83CB	370B52AD5	3A2CD6F3F	3343BF461	37BD48546
71	16EA2751C	1799D9C42	24055CEC9	226A907D4	133C68F80	22CA03BF0	05F723395	2D35008AF
72	122A5C67D	3E46230BC	09F475BA9	15B4B6754	11DE75C50	28C17544F	1D85FAB8D	0D5AD9537
73	1C5497CD9	3D405F487	05535D737	06952087B	1C4744AF4	3E0EF881C	3CED3D1BB	1D91157CE
74	1D276153D	14604EA77	1661FB979	3BAC5E9FB	089F41406	283154122	2AFDCE892	1FD5E0810

Table 804—SA Preamble for *n* = 1 (Segment 1)

75	2A620F4C2	0DE484180	2D05E6458	3E6D15A27	0A92FF0B7	2CBF7BF53	25A2F28FA	19A10CE02
76	3A77B1FBE	2B262F810	2BEEA0F46	39706BBA2	09257163F	1026D5D74	2E2483EBF	1D6527C1E
77	0DC1EBA02	383C59C77	28C7ED115	06FED31D4	16F610DC3	000890B82	2FAD16A3A	35C9AD95F
78	3E5C1EBE2	3C65A7691	2394005B6	251B1BB49	1F42BFA23	0E8608C07	24666F55C	11A5214DF
79	323E882C5	2DBFF5E13	3638BC43F	38CC5CBB5	1DBF783FB	0499418C7	2285E5A40	1A61D17E7
80	1E508F19D	0CF345F97	0E5648601	0A0951DF3	1194EE717	0A6C0B374	03C4E19EC	06F725799
81	0B54F4AEF	186A12343	04C4A60C6	27C2CC0E9	3973075A1	392C5EEB7	3933C99B1	005F98CB2
82	021B6635A	3764D0696	20942B266	0155C4EDD	3FDBF7497	37356D442	374F3DB06	2718357FE
83	120DF6F80	0E41F376A	03544C7B2	2D6795EFD	29E8811F1	1B3EFD388	01CA4C48D	2067E8033
84	07703D649	35221AB50	22141A0D7	268061A59	2D9192B05	3834711FF	3A07258C0	36253B5AA
85	1C4A564C1	26804247A	16A4DB29D	0BEF93C88	37A3EAB6C	25547B136	3FC935878	250E3BF1C
86	17049BB43	0D6426761	2BF3A471E	1665820E9	14412A13D	30D5744B0	2ECE5CAE6	01395189C
87	29615B890	0A2C5A664	216DA64F4	3D4AA9D2C	07B98342C	2603F0D76	0574BDFA8	3F9B35D5D
88	3A0414B22	0A8BE885E	155C220E4	2D3B17AA6	3017E1B48	26508C6C8	3FF25EC63	240EFF072
89	2ACD81CE3	0468D7943	2A4108121	1F2E8E67F	3AB446179	33325CA24	3006DD3A5	1A33F3A2C
90	2B038BAF7	070660C4E	30953C7B7	3E7375D04	1D6A39944	001BE5C8D	199A89253	0A82087BB
91	03BF7C836	2CBF9FC48	38EAB1C98	11C303993	3D748807F	1EBD41D17	351085EF2	1C55B94D3
92	116E0BE61	17BC8C403	31BD1EAA2	1CF87C049	2A41CC04D	3883EFEC1	3971BBBE2	190CAE3B7
93	172799BB5	3301DB193	2480B569B	34DBEFE9C	003287827	38DAEA1CB	0B0E25BB4	1972B37E3
94	3EF1F9EF4	189D8C3E0	1941998D3	259838BC9	28E545988	33BFC60D8	3572B10F3	197913B6B
95	24CF96D66	285347801	22BC70E5E	394231BCC	077583F4E	0364420AF	278FBF5CB	3850AFC8B
96	1B38C4A50	04439E0B5	3A7BEB18B	3003A36CD	329D5A2B6	1BB123AFA	049C2CC94	0F604D1DC
97	28D47EF33	24CF66B6B	24B716FA9	34ED7F6BB	186AE44B4	1380D0726	1CC51324E	16BA74F62
98	04422E60A	3424BA16C	3FF1B39DD	1A1E658F7	33457317D	14E822151	3EC02F279	28593D11D
99	0F2DF0912	21BBFA838	32D634EBF	2061148FD	09A565B74	2BCE430B7	34DAAD9FA	228ADAFE5
100	2D7EE0544	25D57B7CA	0FADAF20D	19B4F6444	3A75DF1C1	0AD3EDD56	0A4D61EEA	28C1262A5
101	1B6AEE253	0BFE02772	24AB19547	186A377A5	03089B4E8	128955F60	3A8DA9AC8	2931648B3
102	21BE0200F	00F34B4F5	34FF3261B	1A0E27AED	0A821AEFB	21B0BA404	1C6A644A4	1734EBB33
103	201FBFD73	0592E9D86	053D87C9D	3CAFC7479	22F1BA3FA	3DB25DD15	31D468990	22FF2B539
104	06C77404E	18AE64252	3963D899A	37179C03C	0FD2E3D04	191E64DBB	380B841FB	368E1DEAA
105	3A561759B	156243DE8	04325D217	33993D0B0	0CEAC2109	002242D1B	33C1D9F5E	1EC4195D3
106	17D7A9B74	1F44ABA75	17B572FE3	096008B9B	1F1E00AAE	05489F7A1	17A4C131D	1C018E923
107	0A4ACCEC8	1F294A30D	19CAEE64E	002787A1B	03EB3238D	27C10F626	1C9E656A0	3F73609F0
108	1E0E3C802	1B52D12AA	2F4E003B7	23BA7A6F1	3CAA0998A	32E96C916	168EFA1EE	28147EE33
109	1CEC9799E	215D9302B	176BB6639	003D5E371	12FE4ADB3	3106B64E2	001D9C28E	0F39059DC
110	31570792D	2260D7FEF	1AC830374	118FE7C78	08F982159	23BB2B13A	2C7944305	376396F3C
111	2D340540B	272E94D06	097C70995	0E70DDADA	1DBD644E5	341A72A58	01CBF5334	2C7999AF9
112	3FF17764D	0701DFAD3	146BDBB97	229D2D7F0	03C5DA21D	3A5916EC7	2390AC01D	197D64233
113	3E9759D5A	00B237425	0B7E646B9	190CB4D16	2646AA1D4	1A373103D	337E5EFB1	0199DE4A1

Table 804—SA Preamble for *n* = 1 (Segment 1)

114	3FD5ADE8A	26B843860	0A2D0AA7B	3C351E07F	1B25376AE	05C553CDD	1DBC3F38D	019823A2A
115	30FF187B4	112F9D7A1	1AE977517	3760AF555	004F86368	3700975C2	0518029DE	032427D9B
116	3A86D49BB	057E649D8	2FDE33D7E	31254217C	30E05CE12	10BCC1CD7	1889C5139	38A163ECF
117	2610F5174	02A7ACB27	208B84FF0	14609CA80	0F3526318	38EBC7384	287C57BAA	279661A9C
118	014F6D77B	1036B3D2C	294F1999A	33A059187	26CCE0507	180DF3129	00A6CAE22	2AC0F23A2
119	347C62997	1912A710D	2260C531F	2F54BBEBB	0A2D90305	1BBEE20E4	0AF79997E	2376F3D0F
120	04484EB82	181977944	1C1CC2693	227ECAB0F	23F32982B	19E2F290C	1BA2300F8	0EFB06247
121	0EC048AD8	3B2168495	34FC02DA1	2C0CDEF52	0553CA222	25DFA4581	29CF66B6B	0AB9C21CD
122	2AF502148	3B00632F9	387CDC4BF	3F8B9F716	19084CD65	0354918C7	39D1FD9AA	0F5ABDB77
123	2C6E2557A	3E8A19D6B	3E6756A28	237E6E5BF	24CA57004	1D52401AD	0237F1D80	0FB2B335D
124	228F4B540	07532BF5D	101F67F52	29D8598EE	0421A0E23	2D89C2AFF	0963D2F3B	24C472A63
125	0CF3598E8	196A40BD2	00E63B26D	088A0BFCA	1C78E9016	03835236C	33071A836	3949DC586
126	3E815D747	1588D4E96	073C8D44A	303281AE4	095D31EC8	1F10F69DC	200F057D8	1F270128F
127	34F9ACB6B	384870FF1	257A863DE	34B36BA0F	3FA3D216B	27425041B	0E0DD0BAD	2E95AD35D

Table 805—SA Preamble for *n* = 2 (Segment 2)

q\blk	A	B	C	D	E	F	G	H
0	13F99E8EC	3CF776C2A	3300A482C	0B2BF4791	17BECDFE8	35998C6D4	05F8CB75C	259B90F0B
1	116913829	05188F2A4	2DB0A8D00	2F770FE4A	185BE5E33	0F039A076	212F3F82C	116635F29
2	004EE1EC6	18EF4FDD9	26C80900E	1A63FB8A7	1DAA917D4	0E6716114	02690646D	0CC94AD36
3	06D4FF377	2716E8A54	16A1720C8	08750246F	393045CCB	1DBCCDE43	114A0CAD6	181690377
4	3DC4EF347	1F53452FC	01584B5D3	11D96034F	1FA62568E	11974FACA	191BE154D	397C9D440
5	05A1B6650	29835ADAD	2F6DDABE4	0976A607B	11BA92926	2456B1943	3E3FD608B	095E7584B
6	00CC66282	0560BE767	21EBAA7C6	2D8E9ACE3	198A9E285	05F3E73DD	13DA751A2	176B75E43
7	03D08ADC1	2254606FC	3C695D892	1DA9E0280	2CD4FF589	19B78A5A4	0CE67A7C6	12535A61C
8	0984647CF	0822BA46B	3EB2BC076	212596F54	11CC2E64E	120BADF9F	0DA72CEDE	30D0E106F
9	083CE5726	1F05DA925	169D93EF6	1FCADF3D3	08A5CF0BC	317C8508F	19BDCCFE7	0FACE3631
10	27583A466	1CB1634D5	03C7849F7	38C6CED00	1161C173A	15A645D3E	281A7ED92	076ADA797
11	33BA1AE8F	187F578EE	32473D69A	2458B703B	267E59071	0F317883B	3E7DEDBF1	3B9859BA7
12	0322609A3	20C4C957C	3FD638746	3FB716D79	36BD0CF1C	333B11B8F	0027ED1F2	3E7471BF3
13	3529922B1	0ECECBE04	1980B9B9E	38D60363F	18904BCED	108E3E5F1	34B95C446	338F51DAC
14	21FD50527	0EA2F7A31	1E294A159	114734A02	120B90BF3	3F3617C92	0129071E2	106640936
15	2B59354BB	275BF9761	39C6FF332	2004B3902	053F9DCB0	19D79A902	2B3125038	20649B43E
16	03A8A7A2B	091AE6721	18651FD9E	1F5415ECD	1B38EA62E	07FB0F422	3EB58896B	077FE4C7C
17	06A13CB38	340099B18	2AE6D6385	1669631F9	28E51A676	19A023391	261855F39	3E518F0BC
18	2A88F831B	09D295831	294C468DF	1477F0A13	37725C6EB	00E7DB222	27D610157	349A8FAB6

Table 805—SA Preamble for *n* = 2 (Segment 2)

19	163E1C44D	3F98B6F4A	1805538DD	01EE3DB4A	22AA1797E	27568753E	16090F219	2C9838C01
20	34B0543DC	121B8EA82	00873B4A0	220FE7C05	2EDBEAE34	1104BDB93	0711E8C0E	0E1C107BD
21	226183AFF	15643DE71	04A4CDECB	2E67FDF8A	26D2A6D40	25E7695F1	1A99778F5	20FE0C1A3
22	0F7EAC09D	12BB72B2A	182E44301	2962EB85A	3477C1B69	3E3CF56F7	29C9D00C6	39788600C
23	31084BEB5	1DC90E345	391736CC1	3C8292AE1	38A0D515C	3977012F6	25D1F6055	36A7D3F8B
24	229D3ABAC	1044BA05F	0C391B88A	0636A90A6	0B14322AB	21ADC33E4	2DC1A3BFE	0D7FF6D1F
25	33C85B393	37BFA31B6	134F872F0	0C5EA36E1	286956ED1	1632092FA	382B4BB10	23DC3EF14
26	38E8B9BF6	0A0CE666B	207D98054	23FF360AD	121BFDA4E	347D442FD	242922C07	23C6E4115
27	263EA8516	36138BD6A	0ED9C55E7	3F0937876	03232BC24	18E5FFF26	3530CF206	3981B7414
28	1D9AC2E79	051B220E9	3F3B09EC8	0D3F6C366	0201A7CB9	3D5477092	22185FF9F	1C5AA5348
29	208D85694	22104E7C5	14BCFD3DD	3592DF665	1F4EC3265	24358076A	2D20A8000	017F2D489
30	36B3A9A2C	3F8E0F162	13ACDCCF2	16951F727	271E73555	1B3EDCDE7	162B45352	1CAFA635A
31	2D30FE705	3EC9BFC8D	1B10F8349	34F973F31	1CA96A349	1A28B4543	1C5367CE6	2DFAB0AE7
32	21D93EB5A	0E49D6211	3C6FCF774	09F44CACF	2D8CD2BEA	037DDAD3D	3BBD06D1D	39CBB996F
33	159B1F948	0183E8DCD	3A484866C	21F8DF1A5	219A58193	2D1B3C399	2275F19BA	0EFF4C612
34	22EB93A82	15047E272	15428D77B	38FFC612E	20609BE54	3226C8254	3E5568DB2	159284EED
35	34529707C	2E84585F4	20DFFB4C5	28288AA00	10EFC1E07	3C4D211FC	379087C3F	25716A7DD
36	20106354F	22AEB9FD7	3A6BAC67D	3126294C6	0FBC874AC	2DFE5675A	391B1DDAA	06BAA74D8
37	348F831C5	2E44BF3C2	3D9F6F454	20746A30E	08D183029	35C6BFEA7	2729B552B	263BB2EBD
38	202D7F08F	0DBE1C144	132F4EC09	184CD9B93	2596F5884	2A55B8217	2BEAE02D8	235A19A43
39	2DDE3FF5F	23932555C	001ED92D7	22FCD3D60	2C0737593	0B27E62FF	0693CFBDC	284D5B33F
40	1DB9AB8E9	2995EE0A1	1ACFE9892	0D41BCB9D	2E3806507	25CCD5D60	3536DF04C	0BB0A5E3B
41	3FFD4DD82	3E69CC1C1	2BC30FB74	3462F70FC	164FAE762	09B83F8AD	1DF593F3C	2DB478034
42	16E24E9B6	0A9FCFBD2	3A018544C	1ED8E2855	0037681E4	05950E1F8	1107DA097	377A25C65
43	03C9318B8	0C70A7749	0D58708C2	0CA2808C4	219E02554	39315B2F2	2E089B00F	302E135C7
44	04DC211E8	1DD20A505	21A50649F	2CA438C04	39CAD66AE	2E1BD969F	002748760	069924211
45	2E84BCF09	226F5D43C	37BE7EB10	07CDC854A	06FB50D48	08966435B	01BA5E5D2	1D34057FA
46	2D8DFD565	0A30D633F	33F93B7C6	0B330E9D2	0E659B262	130669024	19A9D5F64	38059132D
47	17E4777AE	1308F9046	2F7C0483E	1859E0943	0982C9101	05453D92C	001F53877	388A571AB
48	00D29CC63	0A6D3BDED	1CA44D2AF	388C002CA	2A3D70EF7	2DD3F5A6F	39FEAF0B6	11DFE385F
49	3E3A6CEC4	122F5E8BE	360B96301	0632CF244	2E8985A9F	0FD256C87	0449C29D4	26B713C90
50	238150687	3D96F7F7B	0091E6D18	21802352A	02F7A466E	0A5BB6648	350DA85DB	1C97F4544
51	306BA76DE	379A88697	3F0DA31E1	0EBF48C71	27F8A46EB	3F75A19F6	277002F97	275B43715
52	24D946CC1	38DF102DC	3EFE1F5B3	3C316E148	2735B20CF	0688E430F	0316DC923	24919BEA1
53	0EEAF72D2	3C7248573	1087A7BD6	08EDA9BF6	2B5D97BF4	26733DC60	1190D275B	2EC7ABD30
54	37C6AB63E	2FFC9C790	02CAA37A7	1B34A3F84	0022CD5F6	3ECF891BF	193D545E2	0172C674E
55	0848A41C3	1D8150EE7	3D8A8549A	2595F707B	00640B276	2D44EBDAE	1CAF37453	377EF590A
56	16B7A5F7D	1F5AA7998	382300A8B	218916E53	19D00E728	1EDA11790	0BBDEF9C4	1DEB15796
57	3EFB3368D	392AA88AD	29CF3CACD	03F59ED8A	1042098CA	1721B8F3A	2B5DE9312	0CB5E6F23

Table 805—SA Preamble for *n* = 2 (Segment 2)

58	1A8B0FB9E	3FBC09C8B	3D7F3E248	034C9BCB5	1BDD89300	3392476C0	0C10AED4B	23BECA42A
59	0EBC749B6	33453C7F6	304735F5C	334628143	1DAF6E7A9	11BB9C393	226C5E4FF	170372039
60	3F9262CBC	0693308C8	21B563415	09BDCC403	0112C79D4	2DA9F1134	36AA1CD7D	3A1608BFC
61	218AC590E	0FACC734D	02132C9A3	27087557E	076B3ECE7	2EA16BA3D	0E1D452F1	3F70B027A
62	004F9DC68	25BE3AD9C	2CBD3C07B	3F9DECD71	3E771E15A	11FF2F24D	2AEA5DF67	1E838955D
63	3A04BC376	1D19254F1	00F92DD2B	3C57484F3	181D0973E	319F9CEEA	053ADEEDB	1A3C22150
64	0F78BA6BC	2DFE0E681	3035BD77D	0A0FFD148	275F50C66	2246E9053	27B2BF3E9	1741894F8
65	1ACCD0F79	22F0AEA4F	32796ADB5	134A4A876	183D989E3	204C4BF97	22300E86F	3F18744A3
66	3EB6E19EF	1B24EAB88	2E318F810	3F07B618E	26B4C0C87	31CC10EA8	169E1B650	017DF88ED
67	2BD9E8FED	0AB104122	30C9D81A0	09EA73C7F	141357B1D	000A7DB48	1DD06FD41	0AFA8EF72
68	19CA5678F	28A89AA43	1DB945917	262AF69C3	3145A4473	3742CBFF5	1BCD965E9	1B0E7FC84
69	077838B25	2BF7032F8	23DC2E014	028544277	37B411B5F	392FF6CDC	1D66F2BE9	011372DA0
70	39596216C	05A651F63	183A6AE26	0D1FCA203	0FF6F0D22	2FEB8364B	05A438ED8	32D045F13
71	3711AD513	290B237FF	20E2A9B26	0C72A0234	2F1ABBE93	19B505378	354ED915D	0C359F272
72	1D7786BA4	1CCDF053A	36828B333	0ED27AFB6	241326FC4	1A9C37F8B	0A9C3C372	05937E898
73	1053B9CDB	040B97B1D	0D4FF481D	23AD465A8	2906EBDE2	0C4F6C09D	2189C5FEA	2D90D305A
74	39073122B	35FEAA236	1B38B7A90	2E02AB9F7	219FEEA0A	36B3B2EF8	39A3F4C8B	15A42C9DD
75	2C6326A9E	33F7536C1	2A120C75F	37030CAA0	3A011882C	098C8504E	3B92D756B	175811CF9
76	38A0F736B	2BD9E9C32	3B989715A	2A646ADF4	2D02FE38C	11AC7E9E6	3F5464862	0F382B0D8
77	26897D80C	145B21D3E	143F5E320	30549707E	28126710C	122CA92BE	3AF47270C	0B544128F
78	00E931208	2E1E75EAA	374C36E5F	21724DFC5	1DFCD2028	1B3FF774E	3A826A68B	1781CDCA4
79	0C3D7268D	0B7A26BF9	1587CE5CD	1D04E1E60	36240C07D	1AC403449	0417F9622	02B9F8BED
80	1B569F488	08A3F3A46	377F03A18	2DE416045	1ED96E381	33F4F16DC	2C8DAAE4F	33E384AC7
81	13F709786	02A4E32CB	14C7F849E	09EA16987	06C849EA4	219E4B995	243CB7F07	253513BC6
82	09B83FDF2	119D60439	278290BFF	2483E6F2C	0EDEC175D	242A669C1	3EB639EF0	31EBB4CA0
83	22CAEF0E4	0B2FCDED0	19BA79607	343F81C7B	289AA213E	358AC9FFA	23956ADA1	00BC725E7
84	1186F95E3	2F95F4048	3CFBF41E2	1D1E4BE96	26B38BA65	2F715E590	2235C0029	2C89AF93F
85	33437ED6C	12F14DB69	2E70F5611	183752704	142BC8B34	3B90ECD86	1C11EB493	1022D4782
86	248457F60	05B9A28A5	0A2A5DD56	16002D9E7	34C87FB16	2E32BAE0C	21065BD64	1CCE92BB0
87	1DCE3941A	1D940ACE3	30D331B98	3D5A3BAB6	119791607	10FB0D788	2C78E9015	100B598E4
88	39C0BC811	1B886594E	27AF50C73	2DCEA05E6	0805EDCA9	3A5989B08	18AD24255	1683B7CF2
89	186A3D233	09E8B95DA	1ED9F3DBE	1B19A74F8	356CA7443	316C9FBE9	3F8A3162A	3A0BC11CC
90	02F039B63	2F02D3E75	0F5B5E89E	3D062255C	222C6AA4E	25DEA06FB	39488C071	139318BFB
91	27B5B6EE8	22154E0BD	3FF7729F1	1052B1947	3D477BF2B	3EDB6745A	1B30CF849	030F84AF4
92	27B2D40BC	01EE5E9B6	24B0ACF84	3370F65E0	067D8DFA9	1C01B9327	26FF8FDB5	3809C0CA6
93	11F581193	07B9B7A7D	1CA56B4A3	3D088CC6C	11D52C38A	344760F0A	3D3AA336D	0118CBD93
94	096990784	2960D1672	3BFD7D847	2BC297EEE	32168CF28	3912FFF6C	08ED9BAB1	34452C6E5
95	02CD48DC2	186403849	24C6EE1EA	12ED5268A	2718C00E9	27E8F18CF	145913E2D	0B09009BB
96	06B97DD08	2880C9B96	37EB87E03	14C4ED01D	17041E5DC	347A412CB	088CE591B	0BE926B22

Table 805—SA Preamble for *n* = 2 (Segment 2)

97	116250DF7	1745B4329	1102B7093	1CA549C5A	25244AB6C	374E0F19B	274F76015	0FB738F16
98	12841B9E9	1F9C4AEEB	1445F0C98	39FFB6307	02AB688E7	0FD8B499E	28D533072	138F162EA
99	22BD9525E	2030E58C6	25F2CD033	157D93437	1442E92D2	3D6EE9DF3	3CA5B469D	0588A0FAE
100	0FDEC177D	2606157BE	2224E556C	0C6F33897	0F830DE1B	3C3F9C1D8	2AF576923	0D4173E27
101	376EF82C2	30E3C582E	0A82DE29A	1B8D454D9	079ACE6D9	2579984C6	392F28400	24CEAEDF1
102	1CD4AA9D2	1DD6F4DA5	3485B7150	105DE02F9	22168E0FA	24F48AA6C	003771A39	306890843
103	1F8303786	2C981AAE4	0819F22E9	0A1D88D55	3B4C012FD	0214CDF52	19DF3BE8F	02364E19A
104	1364A15C0	16E9F9961	17E598810	2654E5A2C	09B43C7C8	3A5E2AF45	14FC71E26	2B4BA69F4
105	12E128BEF	19166342E	04A1404B7	283D17B66	014836F64	13BE0B4B5	2F8583C08	2B19A7FB4
106	19F83FDE2	361D25170	36354011B	3FF4EC74B	1B2128FF9	0C849EB1B	096B991D8	1CA7A74AA
107	32E0BEF35	11A61714D	34C56D40B	0742C52FE	00ED2F1C4	3997FC7B7	06E414374	180DCD64F
108	18399ED59	224E6C2FF	3450F1BB7	27A1CA959	21B5E00F8	13B67DAE8	0B14C022E	0E41BBEE2
109	318D94D05	2EBB53B17	331C3E6F4	0FBCD71ED	380FF18B8	3E3C75B26	0E0088A18	17553D2A2
110	37AC7E5D5	27C9EADFA	3FC47B5E4	38699BB57	1564F8B27	3579C7FEB	13401BD88	0DB519DE0
111	0FF4D6F22	3C84242F3	2DEAE40AD	305F320A5	244CB97B0	0892DA905	3F09D5CB5	332E7DB02
112	31479E580	1B6AD13E0	16A1CF9E2	33A0A119A	1AC8388E9	3D4105F37	226501835	27AF1310F
113	1CBDAFE39	3E5A30C1C	236E9A029	063430D97	0CD91A825	02F335D7E	1989FE0BE	13C4E2A20
114	10B393370	33CB79316	2CEB44FC0	236019420	248F95ACB	35034B6F0	365691771	34A8FBCB6
115	25463FC5F	082FC0ED2	038ACE1CC	3E959B49D	21B8C04F5	08633F3A0	3A5D18159	12B3EC4C7
116	167B32C3E	06FF88387	34C3F468B	3239005B2	121C913AF	21C90CE16	28B54D557	3811CB0A9
117	221BD0503	0AF619499	21F8D40C1	1B3DA7AEE	3FA2E3B05	348466C50	10F12A28D	0E70B26AB
118	1D79A57C5	315D2460F	1402B8222	28DC66FEA	1BCF748F9	2AD5D4227	0094D2CAD	25EA22A58
119	062B39CFB	310E8818D	0F2D0A235	3F6468866	33F86F342	39CAB5BBC	2E7D6A8BF	3E9218162
120	2FCDEA0E0	1BDD766A4	2827B99BB	0B5F04CC9	1C9E02A9A	1A6675ED4	033497A06	07D4ADD44
121	3CD46CD9D	311A64A85	24DDFE6FF	3411C6FE5	0D0613CDA	0E9276056	178ACC4F8	23DEA3CB0
122	2762D6A40	306FE3843	1402589C8	382B07654	160BA3DEA	3815B54C8	273960105	2076A15E5
123	1C593A744	1562487F6	0C38617B4	2CA68266A	071C4BF93	2593F0BDC	1562436E5	199BEEA49
124	35B8C7503	278F57EAA	34A804061	19C657A74	385734710	3FAC27628	0707BED4E	32F20F45E
125	34994C46C	1C6B99499	1AF24D850	11AD795D3	19288BFE9	1360C1B96	3B5D8DBC0	2554E72D6
126	22D7095A4	34B70502A	3F0CB27D2	04FC214E6	24C0B80C5	03D6F4DC8	1432A099E	26300D70E
127	21C33416F	18B894695	3AC062614	3537CF601	00A20A8B8	1CD10BAF5	394DF1DC0	0925851ED

16.3.6.2 DL Control Channels

DL control channels convey information essential for system operation. Information on DL control channels is transmitted hierarchically over different time scales from the superframe level to the AAI subframe level.

In mixed mode operation (WirelessMAN-OFDMA/Advanced Air Interface), an AMS can access the system without decoding WirelessMAN-OFDMA FCH and MAP messages.

16.3.6.2.1 Superframe Header

The Superframe Header (SFH) carries essential system parameters and system configuration information. The SFH is located in the first AAI subframe within a superframe. The SFH uses the last 5 OFDM symbols within the first AAI subframe.

All PRUs in the first AAI subframe of a superframe have 5 OFDM symbols with the 2 stream pilot pattern defined in 16.3.5. The resource mapping process in the SFH AAI subframe is predefined as follow.

The AAI subframe where SFH is located always has one frequency partition FP_0. All N_{PRU} PRUs in the AAI subframe where SFH is located are permuted to generate the distributed LRUs. The permutation and frequency partition of the SFH AAI subframe can be described by *DSAC* = 0 (all mini¬bands without sub-band), *DFPC* = 0 (reuse 1 only), $DCAS_{SB0}$ = 0 (no subband CRU allocated), and $DCAS_{MB0}$ = 0 (no mini-band CRU allocated). Definitions of these parameters are given in 16.3.5.

The SFH occupies the first N_{SFH} distributed LRUs in the first AAI subframe of a superframe where N_{SFH} is no more than 24. The remaining distributed LRUs in the first AAI subframe of a superframe are used for other control and data transmission

The SFH is divided into two parts: Primary Superframe Header (P-SFH) and Secondary Superframe Header (S-SFH).

Table 806 includes the parameters and values for resource allocation of the SFH.

Table 806—Parameters and values for resource allocation of SFH

Parameters	Description	Value
N_{SFH}	The number of distributed LRUs which are occupied by SFH. Note that $N_{SFH} = N_{P\text{-}SFH} + N_{S\text{-}SFH}$	$N_{P\text{-}SFH} + N_{S\text{-}SFH}$
$N_{P\text{-}SFH}$	The number of distributed LRUs which are occupied by P-SFH	Fixed (value is TBD)
$N_{S\text{-}SFH}$	The number of distributed LRUs which are occupied by S-SFH	Variable according to the type of S-SFH SP

16.3.6.2.1.1 Primary Superframe Header

The Primary Superframe Header (P-SFH) shall be transmitted in every superframe.

The first $N_{P\text{-}SFH}$ distributed LRUs of the first AAI subframe are allocated for P-SFH transmission. $N_{P\text{-}SFH}$ is a fixed value.

16.3.6.2.1.2 Secondary Superframe Header

The Secondary Superframe Header (S-SFH) may be transmitted in every superframe

If the S-SFH is present, the S-SFH shall be mapped to the $N_{S\text{-}SFH}$ distributed LRUs following the $N_{P\text{-}SFH}$ distributed LRUs. The value of $N_{S\text{-}SFH}$ is indicated in P-SFH IE.

The S-SFH can be repeated over two consecutive superframes.

The information transmitted in S-SFH is divided into three sub-packets.

The sub-packets of S-SFH are transmitted periodically where each sub-packet has a different transmission periodicity as illustrated in Figure 515.

The “SP scheduling periodicity information" field of S-SFH SP3 is used to indicate the transmission periodicity of the S-SFH SPs (1, 2, 3). Table 807 shows the transmission periodicity of different S-SFH SPs for different values of "SP scheduling periodicity information" field.

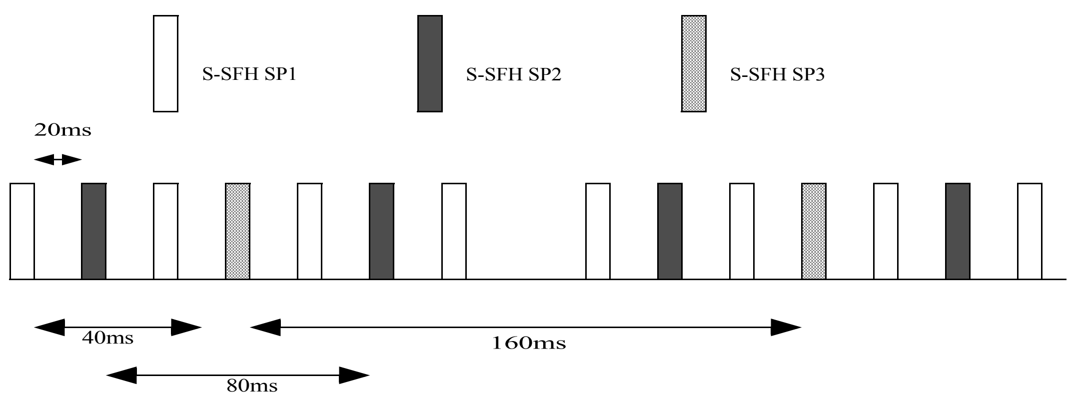


Figure 515—Illustration of periodic transmission of S-SFH SPs with example transmission periodicity of 40 ms, 80 ms and 160 ms for SP1, SP2 and SP3, respectively

When there is no S-SFH SP in the SFH, the SFH resources are used for transmitting other control information or A-MAP.

16.3.6.2.2 Advanced MAP (A-MAP)

The Advanced MAP (A-MAP) carries unicast service control information. Unicast service control information consists of user-specific control information and non-user-specific control information. User-specific

Table 807—Transmission Periodicity of S-SFH SPs

SP scheduling periodicity information	Transmission periodicity of S-SFH SP1	Transmission periodicity of S-SFH SP2	Transmission periodicity of S-SFH SP3
0000	40 ms	80 ms	160 ms
0001	40 ms	80 ms	320 ms
0010-1111: reserved			

control information is further divided into assignment information, HARQ feedback information, and power control information, and they are transmitted in the assignment A-MAP, HARQ feedback A-MAP, and power control A-MAP, respectively. All the A-MAPs share a region of physical resources called A-MAP region.

A-MAP regions shall be present in all DL unicast AAI subframes. When default TTI is used, DL data allocations corresponding to an A-MAP region occupy resources in the AAI subframe where the A-MAP region is located

Figure 516 illustrates the location of A-MAP region in the TDD mode.

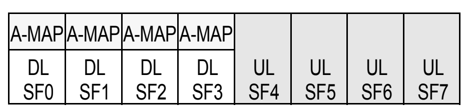


Figure 516—Example of locations of A-MAP regions in a TDD system with a 4:4 DL:UL ratio

If FFR is used in a DL AAI subframe, both the reuse 1 partition and the power-boosted reuse 3 partition may contain an A-MAP region. In a DL AAI subframe, non-user specific, HARQ feedback, and power control A-MAPs are located in a frequency partition called the primary frequency partition. The primary frequency partition can be either the reuse 1 partition or the power-boosted reuse 3 partition, which is indicated by ABS through S-SFH SP1 IE. Assignment A-MAP can be in the reuse 1 partition or the power-boosted reuse 3 partition or both. The number of assignment A-MAPs in each frequency partition is signaled through non-user specific A-MAP.

The structure of an A-MAP region is illustrated in the example in Figure 517. The resource occupied by each A-MAP may vary depending on the system configuration and scheduler operation.

In DL AAI subframes other than the first AAI subframe of a superframe, an A-MAP region consists of the first $N_{\text{A-MAP}}$ distributed LRUs in a frequency partition and the LRUs are formed from PRUs with N_{sym} symbols. In the first DL AAI subframe of a superframe, the A-MAP region consists of the first $N_{\text{A-MAP}}$ distributed LRUs after N_{SFH} distributed LRUs occupied by SFH.

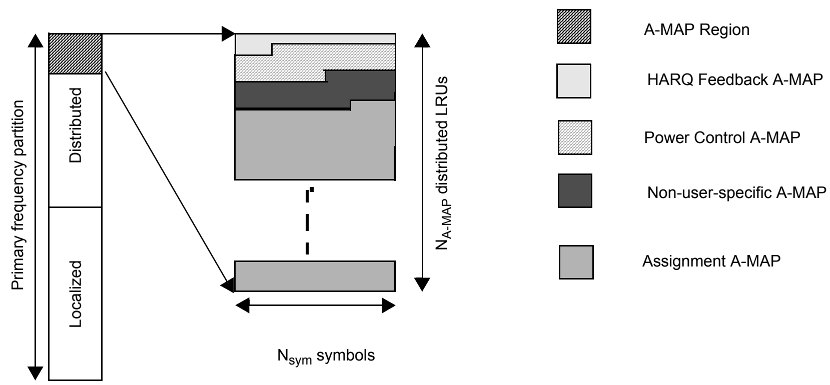


Figure 517—Structure of an A-MAP region

16.3.6.2.2.1 Non-user Specific A-MAP

Non-user-specific A-MAP consists of information that is not dedicated to a specific user or a specific group of users. The AMS should firstly decode the non-user-specific A-MAP in the primary frequency partition to obtain the information needed for decoding assignment A-MAPs and HF A-MAPs.

The resource occupied by non-user specific information is of fixed size.

16.3.6.2.2.2 HARQ Feedback A-MAP

HARQ feedback A-MAP carries HARQ ACK/NACK information for uplink data transmission.

16.3.6.2.2.3 Power Control A-MAP

Power Control A-MAP carries fast power control command to AMS.

16.3.6.2.2.4 Assignment A-MAP

Assignment A-MAP contains resource assignment information which is categorized into multiple types of assignment A-MAP IEs. Each assignment A-MAP IE is coded separately and carries information for one or a group of AMSs.

The minimum logical resource unit in the assignment A-MAP is called MLRU, consisting of N_{MLRU} = 56 data tones.

The assignment A-MAP IE shall be transmitted with one MLRU or multiple concatenated MLRUs in the A-MAP region. The number of logically contiguous MLRUs is determined based on the assignment A-MAP IE size and channel coding rate, where channel coding rate is selected based on AMS' link condition.

Assignment A-MAP IEs are grouped together based on channel coding rate. Assignment A-MAP IEs in the same group are transmitted in the same frequency partition with the same channel coding rate. Each assignment A-MAP group contains several logically contiguous MLRUs. The number of assignment A-MAP IEs in each assignment A-MAP group is signaled through non-user specific A-MAP in the same AAI subframe.

If two assignment A-MAP groups using two channel coding rates are present in an A-MAP region, assignment A-MAP group using lower channel coding rate is allocated first, followed by assignment A-MAP group using higher channel coding rate.

If a broadcast assignment A-MAP IE, i.e., the assignment A-MAP IE intended for all the AMSs, exists in a DL AAI subframe, it shall be present at the beginning of either assignment A-MAP group 1 or assignment A-MAP group 3.

All the multicast assignment A-MAP IEs, i.e., all the assignment A-MAP IEs intended for a specific group of AMSs, present in any assignment A-MAP group, shall occupy a contiguous set of MLRUs starting from the beginning of the assignment A-MAP group. If the broadcast assignment A-MAP IE is present in the assignment A-MAP group, the multicast assignment A-MAP IEs are located right after the broadcast assignment A-MAP IE. The Group Resource Allocation A-MAP IE is an example of multicast assignment A-MAP IEs.

All the unicast assignment A-MAP IEs intended for a particular AMS shall be transmitted in the same assignment A-MAP group. The DL/UL Basic Assignment A-MAP IEs are an example of unicast assignment A-MAP IEs.

The maximum number of assignment A-MAP IEs in one AAI subframe that the ABS may allocate to an AMS is 8. This number includes all of the assignment A-MAP IEs that are required to be considered by the AMS (its STID, group ID of GRA, Broadcast ID). For a segmentable assignment A-MAP IE (assignment A-MAP IE that occupies more than 1 MLRU in QPSK ½), each segment is counted as 1 assignment A-MAP IE.

16.3.6.2.3 Enhanced Multicast Broadcast Service MAP (E-MBS MAP)

The E-MBS MAP carries configuration information for enhanced multicast broadcast service for one E-MBS Zone. The E-MBS MAP is transmitted in the first several RUs of the E-MBS region in the beginning of the MSI. The parameters of the E-MBS region and the burst size of the E-MBS MAP is transmitted in the AAI_E-MBS-CFG MAC control message described in 16.9.3.1. AAI_E-MBS-CFG Change Indication indicates any change in the parameters of AAI_E-MBS-CFG MAC Control Message at its next transmission instance.

Table 808—E-MBS MAP Structure

Syntax	Size (bits)	Notes
E-MBS-MAP () {		
AAI_E-MBS-CFG Change Indication	1	AAI_E-MBS-CFG Change Indication indicates any change in the parameters of AAI_E-MBS-CFG MAC Control Message at its next transmission instance. If it is set (AAI_E-MBS-CFG Change Indication = 1), parameters in the AAI_E-MBS-CFG message will change and AMS shall decode the next AAI_E-MBS-CFG message. Otherwise, the AAI_E-MBS-CFG message does not change and the AMS resets the Allocation Lifetime as defined in the previous AAI_E-MBS-CFG message and may not decode the next transmission.
S-SFH SP2 update indicator	1	Indicates whether the changed S-SFH SP2 will be transmitted in this MSI. If this field is set to 1, the time offset which the changed S-SFH SP2 is transmitted will be included in this E-MBS MAP.
If (S-SFH SP2 update indicator ==1) {		AMS shall wake up every S-SFH SP2 transmission period until the AMS receives the changed S-SFH SP2.
S-SFH SP2 transmission time offset	Variable	Indicates the superframe offset which the changed S-SFH SP2 is changed. The size of this field depends on MSI MSI == 0b00: 1 bits MSI == 0b01: 2 bits MSI == 0b10: 3 bits MSI == 0b11: 4 bits
}		
E-MBS_DATA_IE()	-	-
Padding	variable	Padding to reach byte boundary
}		

16.3.6.3 Resource Mapping of DL Control Channels

16.3.6.3.1 Superframe Header

16.3.6.3.1.1 Primary Superframe Header

Figure 518 shows the physical processing block diagram for the P-SFH.

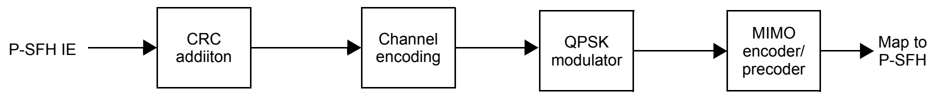


Figure 518—Physical processing block diagram for the P-SFH

The P-SFH IE shall be appended with *5* bits CRC. The generating polynomial is $G(x) = x^5 + x^4 + x^2 + 1$.

The resulting sequence of bits shall be encoded by the TBCC described in 16.3.11.2 with parameter $M = N_{Rep,\,P-SFH} K_{bufsize}$ and $K_{bufsize} = 4L$, where L is the number of information bits and $N_{Rep,\,P-SFH}$ is the number of repetition for effective code rate of [1/16] or 1/24.

The encoded bit sequences shall be modulated using QPSK.

The modulated symbols shall be mapped to two transmission streams using SFBC. The two streams using SFBC shall be precoded and mapped to the transmit antennas described in 16.3.7.1.1.

Antenna specific symbols at the output of the MIMO encoder/precoder shall be mapped to the resource elements described in 16.3.6.2.1.1.

16.3.6.3.1.2 Secondary Superframe Header

Figure 519 shows the physical processing block diagram for the S-SFH.

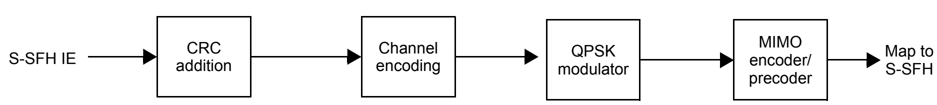


Figure 519—Physical processing block diagram for the S-SFH

The S-SFH IE shall be appended with a 16-bit CRC.

The resulting sequence of bits shall be encoded by the TBCC described in 16.3.11.2 with parameter $M = N_{Rep,S-SFH}K_{bufsize}$ and $K_{bufsize} = 4L$, where L is the number of information bits.

The value of $N_{Rep,S\text{-}SFH}$ is indicated in P-SFH.

The encoded bit sequences shall be modulated using QPSK.

The modulated symbols shall be mapped to two transmission streams using SFBC. The two streams using SFBC shall be precoded and mapped to the transmit antennas.

Antenna specific symbols at the output of the MIMO encoder/precoder shall be mapped to the resource elements described in 16.3.6.2.1.

16.3.6.3.2 Advanced MAP (A-MAP)

SFBC with precoding shall be used for the A-MAP region.

16.3.6.3.2.1 Non-user Specific A-MAP

The coding chain for non-user-specific A-MAP IE to non-user-specific A-MAP symbols is shown in Figure 520.

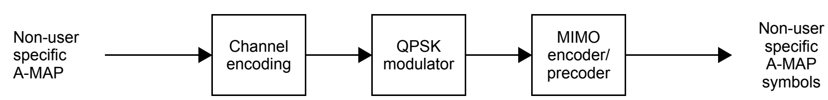


Figure 520—Chain of non-user specific A-MAP IE to non-user specific A-MAP symbols

The non-user specific A-MAP IE is encoded by TBCC described in 16.3.11.2 with parameter $M = 3K_{bufsize}$ and $K_{bufsize} = 4L$ for 1/12 code, where L is the number of information bits. In FFR configurations, the non-user specific A-MAP is also encoded with a code rate of 1/12 when it is in the frequency reuse 1 partition. When the non-user specific A-MAP is in the power-boosted frequency reuse 3 partition, it should be encoded with parameter $M = K_{bufsize} = 4L$ for 1/4 code rate. The encoded sequence is modulated using QPSK.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{NUS}[0]$ to $S_{NUS}[L_{NUS}$-1], are mapped to tone-pairs from RMP[$(L_{HF} + L_{PC})/2$] to RMP[$(L_{HF} + L_{PC} + L_{NUS})/2$ -1], where RMP refers to the renumbered A-MAP tone-pairs described in 16.3.5.3.4 and L_{HF} is the number of tones required to transmit the entire HARQ feedback A-MAP; L_{PC} is the number of tones required to transmit the entire power control A-MAP; L_{NUS} is the number of tones required to transmit the non-user specific-A-MAP.

16.3.6.3.2.2 HARQ Feedback A-MAP

HARQ feedback A-MAP (HF-A-MAP) contains HARQ-feedback-IEs for ACK/NACK feedback information to uplink data transmission.

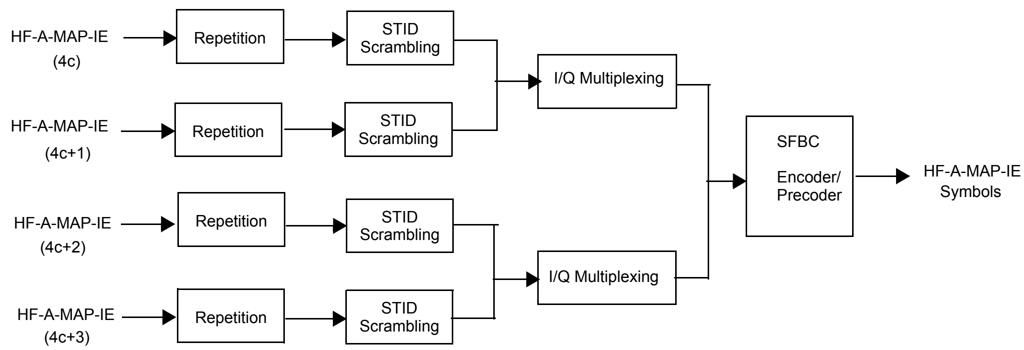


Figure 521—Chain of HF-A-MAP IE to HF-A-MAP symbols

Figure 521 shows the construction procedure of HF-A-MAP symbols from HF-A-MAP-IE.

Each HF-A-MAP IE carries 1 bit information. Firstly, it is repeated $N_{Rep,\ HF\text{-}A\text{-}MAP}$ times, where $N_{Rep,\ HF\text{-}A\text{-}MAP}$ is 8. Then, Repeated HF-A-MAP IE bits are scrambled by the $N_{Rep,\ HF\text{-}A\text{-}MAP}$LSBs of the STID of the associated AMS. Depending on the channel conditions, power scaling can be applied to each scrambled sequence. Before MIMO encoding, each scrambled sequence is mapped to either real part or imaginary part in the signal constellation and multiplexed with other scrambled sequence, if exist.

Figure 521 shows a cluster of HF-A-MAP channels, which consists of 4 HF-A-MAP channels numbered as 4c, 4c+1, 4c+2, 4c+3 where c is the HF-A-MAP cluster index in a HF-A-MAP region. Channel 4c in the cluster occupies the real part of the first symbol in each tone pair before the SFBC encoder. Channel 4c+1 in the cluster occupies the imaginary part of the first symbol in each tone pair before the SFBC encoder. Channel 4c+2 in the cluster occupies the real part of the second symbol in each tone pair before the SFBC encoder. Channel 4c+3 in the cluster occupies the imaginary part of the second symbol in each tone pair before the SFBC encoder.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{HF}[0]$ to $S_{HF}[L_{HF}-1]$, are mapped to tone-pairs from RMP[0] to RMP[L_{HF}/2 -1], where RMP refers to the renumbered A-MAP tone-pairs described in 16.3.5.3.4 and L_{HF} is the number of tones required to transmit the entire HARQ feedback A-MAP. Clusters of the HF-A-MAP are indexed sequentially from index 0 within an HF-A-MAP region in the mapping process.

There is one HF-A-MAP region in each DL AAI subframe. Within each HF-A-MAP region, the index for HF-A-MAP channel is calculated as follows.

For the deallocation of a persistent allocation, the HF-A-MAP resource index is specified in the HFA the of UL Persistent Allocation A-MAP IE.

For group resource allocation, the HF-A-MAP resource index for the l^{th} AMS in the GRA allocation is $(i_{start} + \lfloor l \cdot N_{HF-A-MAP}/N_{GRA} \rfloor) \bmod N_{HF-A-MAP}$, where i_{start} is the ACK Channel Offset in the UL group resource allocation A-MAP IE, $N_{HF\text{-}A\text{-}MAP}$ is the total number of HF-A-MAP configured per HF-A-MAP region, and N_{GRA} is the User Bit Map Size in the UL group resource allocation A-MAP IE.

For the BR-ACK A-MAP IE, the HF-A-MAP resource index for the l^{th} AMS grant in the BR-ACK bitmap is $(i_{start} + \lfloor l \cdot N_{HF-A-MAP}/N_{BR\text{-}ACK} \rfloor) \bmod N_{HF-A-MAP}$, where i_{start} is the HFA start offset in the BR-ACK A-MAP IE, $N_{HF\text{-}A\text{-}MAP}$ is the total number of HF-A-MAP channels configured per HF-A-MAP region, and $N_{BR\text{-}ACK}$ is the number of AMSs with grants in the BR-ACK A-MAP IE.

For resource allocation using the UL Basic Assignment A-MAP IE, UL Subband Assignment A-MAP IE, CDMA Allocation A-MAP IE and the UL Persistent Allocation A-MAP IE, the HF-A-MAP resource index is $(M(j) + n) \bmod N_{HF-A-MAP}$, where j is HF-A-MAP Index Parameter in the Non-user specific A-MAP IE, n is a 3 bit HFA value in each assignment A-MAP IE, $N_{HF\text{-}A\text{-}MAP}$ is the total number of HF-A-MAP channels configured per HF-A-MAP region. *M(j)* is STID for the UL Basic Assignment A-MAP IE and UL Subband Assignment A-MAP IE and RA-ID for CDMA Allocation A-MAP IE when $j=0$ and *M(j)* is the lowest LRU index of the corresponding UL transmission when $j=1$. For the UL persistent allocation A-MAP IE, *M(j)* is always STID regardless of value j.

16.3.6.3.2.3 Power Control A-MAP

Power Control A-MAP (PC-A-MAP) contains PC-A-MAP-IEs for closed-loop power control of the uplink transmission. The ABS shall transmit PC-A-MAP-IE to every AMS which operates in closed-loop power control mode.

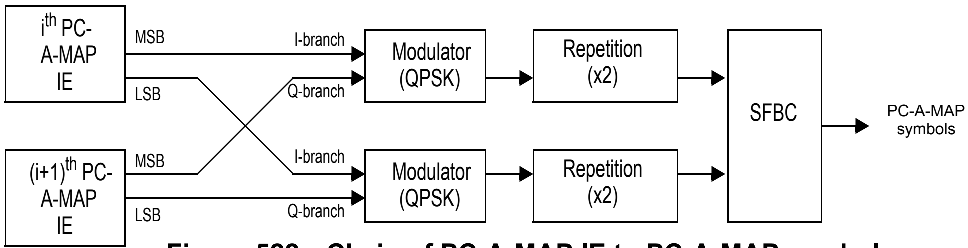


Figure 522—Chain of PC-A-MAP IE to PC-A-MAP symbols

Figure 522 shows the construction procedure of PC-A-MAP symbols from PC-A-MAP-IE.

The i^{th} PC-A-MAP-IE shall have the size of 2 bits according to power correction value.

The i^{th} and $(i+1)^{th}$ PC-A-MAP IEs shall be mapped to two QPSK symbols as depicted in Figure 522. Only the i^{th} PC-A-MAP may also be mapped to two QPSK symbols for transmitting to the corresponding MS with poor channel quality.

Power scaling by sqrt(Pi) $(0 \le i < N_{\text{PC-A-MAP-IE}})$ shall be applied to the i^{th} PC-A-MAP-IE where $N_{PC\text{-}A\text{-}MAP\text{-}IE}$ is the number of PC-A-MAP-IEs and sqrt(Pi) is the value determined by the management entity to satisfy the link performance.

The QPSK symbols are repeated $N_{rep,PC\text{-}A\text{-}MAP\text{-}IE}$ times, where $N_{rep,PC\text{-}A\text{-}MAP\text{-}IE}$ equals two.

Figure 522 shows a cluster of PC-A-MAP channels, which consists of 2 PC-A-MAP channels numbered as 2c and 2c+1 where c is the PC-A-MAP cluster index in the A-MAP region. Channel 2c in the cluster occupies the real part of both symbols in each tone pair before the SFBC encoder. Channel 2c+1 occupies the imaginary part of both symbols in each tone pair before the SFBC encoder.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{PC}[0]$ to $S_{PC}[L_{PC}\text{-}1]$, are mapped to tone-pairs from RMP[$(L_{HF}/2$] to RMP[$(L_{HF} + L_{PC})/2$ -1], where RMP refers to the renumbered A-MAP tone-pairs described in 16.3.5.3.4 and L_{HF} is the number of tones required to transmit the entire HARQ feedback A-MAP; L_{PC} is the number of tones required to transmit the entire power control A-MAP. Clusters of the PC-A-MAP are indexed sequentially in the mapping process.

16.3.6.3.2.4 Assignment A-MAP

The Assignment A-MAP (A-A-MAP) shall include one or multiple A-A-MAP IEs and each A-A-MAP IE is encoded separately. Figure 523 describes the procedure for constructing A-A-MAP symbols.

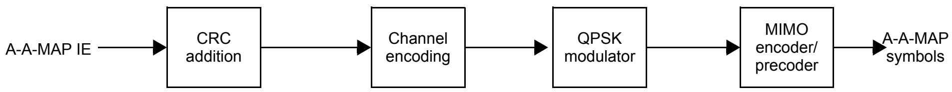


Figure 523—Chain of A-A-MAP IE to A-A-MAP symbols

A 16-bit CRC is generated based on the contents of the assignment A-MAP IE. Denote the assignment A-MAP IE by $m(x) = b_{N-1}x^{N-1} + b_{N-2}x^{N-2} + \ldots + b_1x + b_0$, where b_{N-1} is the MSB of the assignment A-MAP IE and b_0 is the LSB of the assignment A-MAP IE. The 16-bit CRC is calculated as the remainder of dividing $m(x)x^{16}$ by the 16-bit CRC generator polynomial $g(x) = x^{16} + x^{12} + x^5 + 1$. The resulted CRC is denoted by $p(x) = p_{15}x^{15} + p_{14}x^{14} + \ldots + p_1x + p_0$ where p_{15} is the MSB of the CRC and p_0 is the LSB of the CRC.

The 16-bit CRC mask, denoted by $q(x)$, is generated according to 16.3.6.5.2.4. The 16-bit CRC mask is then applied to the 16-bit CRC by bitwise XOR operation.

The masked CRC is then appended to the assignment A-MAP IE, resulting in a bit sequence of $m(x)*x^{16} + p(x) \oplus q(x)$. The resulting sequence of bits shall be encoded by the TBCC described in 16.3.11.2.

Coded bits can be repeated to improve the robustness of an A-A-MAP channel based on the link condition of a particular AMS.

For a given system configuration, assignment A-MAP IEs can be encoded with two different effective code rates. The set of code rates is (1/2, 1/4) or (1/2, 1/8) and is explicitly signaled in the S-SFH.

In case of FFR, two code rates, either (1/2, 1/4) or (1/2, 1/8), can be used in the reuse 1 partition. 1/2 or 1/4 code rate is used in the power-boosted reuse 3 partition and signaled in the S-SFH.

The parameters for TBCC are $M = K_{bufsize} = 2L$ for 1/2 code rate, $M = K_{bufsize} = 4L$ for 1/4 code rate, and and $M = 2K_{bufsize}$ and $K_{bufsize} = 4L$ for 1/8 code rate where L is the number of information bits. The encoded bit sequences shall be modulated using QPSK.

16.3.6.3.3 Enhanced- Multicast Broadcast Services MAP (E-MBS MAP)

A 16-bit CRC is generated based on the contents of the E-MBS MAP. Following randomization, the resulting sequence of bits shall be encoded by the CTC described in 16.3.11.1.

16.3.6.4 Downlink power control

The ABS should be capable of controlling the transmit power per AAI subframe and per user.

An ABS can exchange necessary information with neighbor ABS through backbone network to support downlink power control.

16.3.6.4.1 Power Control for A-MAP

Downlink transmit power density of A-MAP transmission for an AMS may be set in order to satisfy target error rate for the given MCS level which is used for the A-MAP transmission. Detail algorithm is left to vendor-specific implementations.

16.3.6.5 DL Control Information Elements

16.3.6.5.1 Broadcast Control Information Elements

16.3.6.5.1.1 P-SFH IE

The P-SFH IE contains essential system information and it is mapped to the P-SFH. The format of the P-SFH IE is shown in Table 809.

Table 809—P-SFH IE format

Syntax	Size (bit)	Notes
P-SFH IE format () {		
LSB of superframe number	4	Part of superframe number
S-SFH change count	4	Indicates the value of S-SFH change count associated with the S-SFH SPx IE(s) transmitted in this superframe
S-SFH size	4	The units of LRU
S-SFH number of repetitions	2	Indicate the transmission format (repetition) used for S-SFH.
S-SFH scheduling information bitmat	3	0b000: no S-SFH If 1st bit (LSB)= 1, S-SFH includes SP1 IE. Otherwise no SP1 IE If 2nd bit = 1, S-SFH includes SP2 IE. Otherwise no SP2 IE If 3rd bit = 1, S-SFH includes SP3 IE. Otherwise no SP3 IE
S-SFH SP change bitmap	3	Indicates the change of S-SFH SPx IE(s) associated with the S-SFH change count. If in S-SFH SP1 IE is changed, then bit#0 (LSB) is toggled. Otherwise no change in SP1. If in S-SFH SP2 IE is changed, then bit#1 is toggled. Otherwise no change in SP2. If in S-SFH SP3 IE is changed, then bit#2 (MSB) is toggled. Otherwise no change in SP3.
Start super-frame offset where new S-SFH information is used	2	
Reserved	3	The reserved bits are for future extension.
}		

S-SFH change count

Incremented by one (modulo 16) by the ABS whenever any of the values (except MSB of superframe number in S-SFH SP1 IE) of the S-SFH IEs changes. If the value of this count in a subsequent P-SFH IE remains the same, the AMS may assume that the S-SFH IEs have not changed and decide to disregard the following S-SFH IEs in this superframe

S-SFH SP change bitmap

A bitmap indicating the S-SFH SPx IE changed in association with the current S-SFH change count. If any field of S-SFH SPx IE is changed (except MSB of Superframe Number in S-SFH SP1), the bit corresponding to the S-SFH SPx IE is toggled.

16.3.6.5.1.2 S-SFH IE

The S-SFH IE is mapped to the S-SFH. Essential system parameters and system configuration information belonging to the S-SFH are categorized into three S-SFH subpacket IEs such as SP1, SP2 and SP3. These SPs are transmitted in different timing and periodicity. The periodicity of SP (T_{SP}) is determined with $T_{SP1} < T_{SP2} < T_{SP3}$.The S-SFH IE format are shown in Table 810.

Each S-SFH subpacket IE is of a fixed size.

Table 810—S-SFH IE format

Syntax	Size (bit)	Notes
S-SFH IE format () {		
If (1st bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP1 IE ()		
}		
if (2nd bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP2 IE ()		
}		
if (3rd bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP3 IE ()		
}		
}		

S-SFH SP1 IE contains information for network re-entry, see Table 811.

Table 811—S-SFH SP1 IE format

Syntax	Size (bit)	Notes
S-SFH SP1 IE format () {		
MSB of superframe number	8	Remaining bit of SFN except LSB of SFN in P-SFH
LSBs of 48 bit ABS MAC ID	12	Specifies the 12 least significant bits of ABS ID
Number of UL ACK/NACK channels per HARQ feedback region	2	Describes L_{HFB} in 16.3.8.3.3.2. Channel numbers represented by the two bits (0, 1,2, 3) are as follows. For 5 MHz band, 6, 12, 18, 24 For 10 MHz band, 6, 12, 24, 30 For 20 MHz band, 12, 24, 48, 60
Number of DL ACK/NACK channels per HF-A-MAP region	2	Channel numbers represented by the two bits (0, 1,2, 3) are as follows. For 5 MHz band, 4, 8, 12, 16 For 10 MHz band, 8, 16, 24, 32 For 20 MHz band, 16, 32, 48, 64
Power control channel resource size indicator	2	
Primary frequency partition location	1	0b0: Reuse 1 partition 0b1: Power-boosted reuse 3 partition
A-A-MAP MCS selection	1	0b0: QPSK 1/2 and QPSK 1/4 can be used for assignment A-MAP in reuse-1 partition. QPSK 1/2 is used for assignment A-MAP in the power-boosted reuse 3 partition of FFR. 0b1: QPSK 1/2 and QPSK 1/8 can be used for assignment A-MAP in reuse-1 partition. QPSK 1/4 is used for assignment A-MAP in the power-boosted reuse 3 partition of FFR.
$DCAS_{SB0}$	5/4/3	See 16.3.5.3.1 DL CRU/DRU allocation For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
$DCAS_{MB0}$	5/4/3	See 16.3.5.3.1DL CRU/DRU allocation For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
$DCAS_i$	3/2/1	See 16.3.5.3.1 DL CRU/DRU allocation For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bit
Frame configuration index	6	The mapping between value of this index and frame configuration is listed in Table Table 780, Table 781,and Table 782
WirelessMAN-OFDMA support	1	Indicates whether frame configuration supports WirelessMAN-OFDMA systems or not 0b0 : No support of WirelessMAN-OFDMA 0b1 : Support of WirelessMAN-OFDMA
If (WirelessMAN-OFDMA support = 0b1){		
Allocation periodicity of ranging channel	2	Indicates the periodicity of ranging channel allocation according to the Table 898.

Table 811—S-SFH SP1 IE format

Syntax	Size (bit)	Notes
Subframe offset of ranging channel	2	Indicates the subframe offset (O_{SF}) of ranging channel allocation related to the Table 901. The range of values is $0 \le O_{SF} \le 3$
Start code information of ranging channel	4	Indicates the kns which is the parameter for start of code group (S). $S = 16 \times k_{ns} + 1$ The range of values is $0 \le k_{ns} \le 15$.
Ranging preamble code partition information	4	Indicates the number of initial, handover and periodic codes (N, O and M) according to the Table 902.
UL_Permbase	7	Indicate UL_Permbase used in WirelessMAN-OFDMA system
Reserved	3	
} else if (WirelessMAN-OFDMA support = 0b0) {		
if(Femtocell) {		for 16m Femtocell
Allocation periodicity of ranging channel for synchronized AMSs	2	Indicates the periodicity of ranging channel allocation according to the Table 900.
Subframe offset of ranging channel	2	Indicates the subframe offset (O_{SF}) of ranging channel allocation related to the Table 900. The range of values is $0 \le O_{SF} \le 3$
Start code information of ranging channel for synchronized AMSs	4	Indicates the k_s which is the parameter controlling the start root index of ranging preamble codes (r_{s0}). $r_{s0} = 6 \times k_s + 1$ The range of values is $0 \le k_s \le 15$
Ranging preamble code partition information	4	Indicates the number of initial, handover and periodic codes (N, O and M) according to the Table 900.
Reserved	3	
} else {		
Allocation periodicity of ranging channel for non-synchronized AMSs	2	Indicates the periodicity of ranging channel allocation according to the Table 897.
Subframe offset of ranging channel	2	Indicates the subframe offset (O_{SF}) of ranging channel allocation related to the Table 901. The range of values is $0 \le O_{SF} \le 3$
Start code information of ranging channel for non-synchronized AMSs	4	Indicates the kns which is the parameter controlling the start root index of ranging preamble codes (r_{ns0}). $r_{ns0}(k_{ns}) = 4 \times k_{ns} + 1$ for ranging channel format 0. $r_{ns0}(k_{ns}) = 16 \times k_{ns} + 1$ for ranging channel format 1. The range of values is $0 \le k_{ns} \le 15$
Ranging preamble code partition information for non-synchronized AMSs	4	Indicates the number of initial and handover ranging preamble codes (N_{IN} and N_{HO}) according to the Table 899.
Number of cyclic shifted ranging preamble codes per root index for non-synchronized AMSs	2	Indicates the number of cyclic shifted codes per root index (M_{ns}) for ranging preamble codes according to the Table 896.

Table 811—S-SFH SP1 IE format

Syntax	Size (bit)	Notes
Ranging channel formats for non-synchronized AMSs	1	Indicates the ranging channel formats number of Table 891
}		
$UCAS_{SB0}$	5/4/3	See 16.3.8.3.1UL CRU/DRU allocation For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
$UCAS_{MB0}$	5/4/3	See 16.3.8.3.1 UL CRU/DRU allocation For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
$UCAS_i$	3/2/1	See 16.3.8.3.1 UL CRU/DRU allocation For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bits
}		
Uplink AAI subframes for sounding	3	This value represents the number of uplink AAI subframes with sounding symbols. 0b000 – no sounding symbols 0b001 – 1 AAI subframe 0b010 – 2 AAI subframes 0b011 – 3 AAI subframes 0b100 – 4 AAI subframes 0b101-111 – reserved The sounding symbols shall be placed in AAI subframes in accordance to their type. First, sounding symbols shall be allocated in uplink AAI subframes of type 2 starting from the first in time AAI subframe of type 2. If the number of uplink AAI subframe of type 2 is less than the number of AAI subframes for sounding, sounding symbols shall be allocated in the AAI subframes of other types in the following order: type 1. For these types of uplink AAI subframes sounding symbols shall be allocated in the similar way as for type 2. Type 3 uplink AAI subframes are not used for sounding.
ABS EIRP	7	Signed in units of 1 dBm
Cell bar information	1	If Cell Bar bit = 1, this cell is not allowed for network entry or re-entry
UL_N_MAX_ReTx	1	Specifies the maximum retransmission number for UL HARQ 0b0: 4 0b1: 8
DL_N_MAX_ReTx	1	Specifies the maximum retransmission number for DL HARQ 0b0: 4 0b1: 8
$T_{UL\_Rx\_Processing}$	1	Specifies the ABS's Rx processing time for UL HARQ for F= 8 in FDD or D + U = 8 in TDD 0b0: 3 AAI subframes 0b1: 4 AAI subframes
Reserved	TBD	
}		

S-SFH SP2 IE contains information for initial network entry and network discovery, see Table 812.

Table 812—S-SFH SP2 IE format

Syntax	Size (bit)	Notes
S-SFH SP2 IE format () {		
If (Duplexing mode == FDD) {		The duplexing mode is obtained from the frame configuration index set in S-SFH SP1 IE
UL carrier frequency	6	
UL bandwidth	3	The frequency spacing for UL channel is same with DL channel. 0b000: 512 FFT 0b001: 1024 FFT 0b010: 2048 FFT 0b011 to 0b111: reserved
}		
MSB bytes of 48 bit ABS MAC ID	36	Specifies 36 MSB of BS ID
MAC protocol revision	4	Version number of AAI supported on this channel

Table 812—S-SFH SP2 IE format

Syntax	Size (bit)	Notes
DSAC	5/4/3	See 16.3.5.2.3 DL Frequency partitioning For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
DFPC	4/3/3	See 16.3.5.2.3 DL Frequency partitioning For 2048 FFT size, 4 bits For 1024 FFT size, 3 bits For 512 FFT size, 3 bits
DFPSC	3/2/1	See 16.3.5.2.3 DL Frequency partitioning For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bit
USAC	5/4/3	See 16.3.8.2.3 UL Frequency partitioning For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
UFPC	4/3/3	See 16.3.8.2.3 UL Frequency partitioning For 2048 FFT size, 4 bits For 1024 FFT size, 3 bits For 512 FFT size, 3 bits
UFPSC	3/2/1	See 16.3.8.2.3 UL Frequency partitioning For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bits
AMS Transmit Power Limitation Level	5	Unsigned 5-bit integer. Specifies the maximum allowed AMS transmit power. Values indicate power levels in 1 dB steps starting from 0 dBm
$EIRxP_{IR,min}$	5	
reserved		
}		

S-SFH SP3 IE contains remaining essential system information, see Table 813.

Table 813—S-SFH SP3 IE format

Syntax	Size (bit)	Notes
S-SFH SP3 IE format () {		
Rate of change of S-SFH info	4	Minimum duration over which the contents of the S-SFH does not change 0b0000: 16 0b0001: 32 0b0010: 64 0b0001 ~ 0b1111: reserved
SA-Preamble sequence soft partitioning information	4	Specifies the partition information of SA-Preamble sequence for non-macro ABS as public and CSG femto BS
FFR partition resource metrics	0 or 4 or 8	0 bit: if FPCT=1. 4 bits or 8 bits: as defined in Table 772
IoT correction value for UL power control	10	The 10-bits IoT correct value is used to support the correction of 5 IoT values (IOT_Sounding, IOT_FP0, IOT_FP1, IOT_FP2, IOT_FP3) defined in AAI_UL_NI message, each 2 bits are expressed as the correction value: 0b00: +1dB 0b01: +0.5dB 0b10: 0 dB 0b11: -0.5dB The correction value is accumulated on IoT values from the latest AAI_ULPC_NI message until the new AAI_ULPC_NI message received and applied.
Number of Distributed LRUs for UL feedback channel per a UL AAI subframe	4	The number of UL feedback channels according to UL_FEEDBACK_SIZE is specified in 16.3.8.3.3.2
# Tx antenna	2	0b00: 2 antennas 0b01: 4 antennas 0b10: 8 antennas 0b11: reserved
SP scheduling periodicity information	TBD	

Table 813—S-SFH SP3 IE format

Syntax	Size (bit)	Notes
HO Ranging backoff start	4	Initial backoff window size for MS performing initial ranging during HO process, expressed as a power of 2. Values of n range 0-15 (the highest order bits shall be unused and set to 0)
HO Ranging backoff end	4	Final backoff window size for MS performing initial ranging during HO process, expressed as a power of 2. Values of n range 0-15
Initial ranging backoff start	4	Initial backoff window size for initial ranging contention, expressed as a power of 2. Values of n range 0-15
Initial ranging backoff end	4	Final backoff window size for initial ranging contention, expressed as a power of 2. Values of n range 0-15
UL BW REQ channel information	3	0b000: First UL AAI subframe in every superframe 0b001: First UL AAI subframe in every frame 0b010: Every UL AAI subframes in every frame 0b011-0b111: reserved
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)
Bandwidth request backoff end	4	Final backoff window size for contention BRs, expressed as a power of 2. Values of n range 0-15
fpPowerConfig	4	The power boosting/de-boosting values are listed in Table 814
Reserved	TBD	
}		

Table 814—Power boosting/de-boosting values

fpPower Config	***FPCT*=3 or 4 and $FPS_i > 0$ for $1 \le i \le 3$**			**FPCT=2 or 3 and $FPS_3 = 0$**	
	FP_1 power (dB)	FP_2 power (dB)	FP_3 power (dB)	FP_1 power (dB)	FP_2 power (dB)
0b000	0.0	0.0	0.0	0.0	0.0
0b001	1.0	-0.5	-0.5	0.5	0.5
0b010	2.0	-1.5	-1.5	1.0	1.0
0b011	2.5	-2.0	-2.0	1.5	1.5
0b100	3.0	-3.0	-3.0	2.0	2.0

Table 814—Power boosting/de-boosting values

fpPower Config	***FPCT*=3 or 4 and $FPS_i > 0$ for $1 \le i \le 3$**			**FPCT=2 or 3 and $FPS_3 = 0$**	
	FP_1 power (dB)	FP_2 power (dB)	FP_3 power (dB)	FP_1 power (dB)	FP_2 power (dB)
0b101	3.5	-4.5	-4.5	2.5	2.5
0b110	4.0	-6.0	-6.0	3.0	3.0
0b111	4.75	-Inf	-Inf	reserved	reserved

The power loading values of the power de-boosted partition will be overwritten by fp2Power and fp3Power in AAI_DL_IM message.

16.3.6.5.2 Unicast Control Information Elements

A-MAP IE is defined as the basic element of unicast service control.

16.3.6.5.2.1 Non-user-specific A-MAP IE

Non-user-specific A-MAP IE consists of information that is not dedicated to a specific user or a specific group of users. It includes information required to decode assignment A-MAP IE. The number of assignment A-MAPs in each assignment A-MAP group is indicated in the Non-user-specific A-MAP IE. A-MAP IE also includes HF-A-MAP Index Parameter and HFBCH Index Parameter, which are used to indicate which transmission parameter is used to calculate HF-A-MAP index and HFBCH index respectively. The non-user specific A-MAP IE is shown in Table 815. Non-user specific A-MAP IE has [12] bits in total.

The number of assignment A-MAPs in each assignment A-MAP group can be derived from the Assignment A-MAP size in the non-user-specific A-MAP IE through table lookup. The actual number of assignment A-MAP IEs in each assignment A-MAP group can be equal to or less than the number indicated by the lookup tables. The lookup tables, each with 256 entries, can be generated by the following equations for a particular assignment A-MAP MCS set and FFR configuration.

For non-FFR configuration with Group 1 using QPSK 1/4 and Group 2 using QPSK 1/2, the lookup table can be generated using Equation (203) to Equation (206) and looping through all values of N_{total} and k

Table 815—Non-user specific A-MAP IE

Syntax	Size [bits]	Notes
Assignment A-MAP size	8	Indicate the number of assignment A-MAPs in each assignment A-MAP group as shown in Table 806 to Table 806
HF-A-MAP Index Parameter	1	Indicate which transmission parameter is used to calculate HF-A-MAP index.
HFBCH Index Parameter	1	Indicate which transmission parameter is used to calculate HFBCH index.
Non-user specific A-MAP extension flag	1	If non-user specific A-MAP extension flag is set, it indicates that non-user specific A-MAP is extended. The extended non-user specific part uses the same PHY structure as the non-user specific A-MAP
Reserved	TBD	Reserved bits

$$G_1(I) = \begin{cases} k & k = 0, 1, ..., \lfloor N_{total}/2 \rfloor & 0 \le N_{total} \le 24 \\ N_{total} - 24 + 3 \times k, & k = 0, 1, 2, 3, & 25 \le N_{total} \le 29 \\ N_{total} - 29 + 4 \times k, & k = 0, 1, 2, 3, & 30 \le N_{total} \le 32 \\ N_{total} - 30 + 4 \times k, & k = 0, 1, 2, 3, & 33 \le N_{total} \le 34 \\ N_{total} - 32 + 3 \times k, & k = 0, 1, 2, 3, & 35 \le N_{total} \le 39 \\ N_{total} - 32 + 4 \times k, & k = 0, 1, 2, & 40 \le N_{total} \le 42 \\ N_{total} - 32 + 3 \times k, & k = 0, 1, 2, & 43 \le N_{total} \le 48 \end{cases} \quad (203)$$

$$G_2(I) = N_{total} - 2 \times G_1(I) \quad (204)$$

$$I = I_b(N_{total}) + k \quad (205)$$

$$I_b(N_{total}) = \begin{cases} 0, & N_{total} = 0 \\ I_b(N_{total} - 1) + \lfloor (N_{total} - 1)/2 \rfloor + 1, & 1 \le N_{total} \le 25 \\ I_b(N_{total} - 1) + 4, & 26 \le N_{total} \le 40 \\ I_b(N_{total} - 1) + 3, & 41 \le N_{total} \le 48 \\ 0, & otherwise \end{cases} \quad (206)$$

where I is the 8-bit index for Assignment A-MAP size in non-user-specific A-MAP IE; $G_i(I)$ is the number of assignment A-MAPs in group i for a given I; N_{total} ($0 \le N_{total} \le 48$) is the total number of MLRUs for all A-A-MAP in an AAI subframe; $I_b(N_{total})$ is the base index for a given N_{total} value.

For non-FFR configuration with Group 1 using QPSK 1/8 and Group 2 using QPSK 1/2, the lookup table can be generated using Equation (207) to Equation (210) and looping through all values of N_{total} and k

$$G_1(I) = \begin{cases} k & k = 0, 1, ..., \lfloor N_{total}/4 \rfloor & 0 \le N_{total} \le 24 \\ k+1 & k = 0, 1, 2, 3, 4, 5, & 25 \le N_{total} \le 27 \\ k+1 & k = 0, 1, 2, 3, 4, 5, 6, & 28 \le N_{total} \le 32 \\ k + \lfloor N_{total}/3 \rfloor - 10 & k = 0, 1, 2, 3, 4, 5, 6, & 33 \le N_{total} \le 48 \end{cases} \quad (207)$$

$$G_2(I) = N_{total} - 4 \times G_1(I) \quad (208)$$

$$I = I_b(N_{total}) + k \quad (209)$$

$$I_b(N_{total}) = \begin{cases} 0, & N_{total} = 0 \\ I_b(N_{total}-1) + \lfloor (N_{total}-1)/4 \rfloor + 1, & 1 \le N_{total} \le 25 \\ I_b(N_{total}-1) + 6, & 26 \le N_{total} \le 28 \\ I_b(N_{total}-1) + 7, & 29 \le N_{total} \le 48 \\ 0, & otherwise \end{cases} \quad (210)$$

For FFR configuration with Group 1 using QPSK 1/8, Group 2 using QPSK 1/2, and Group 3 using QPSK 1/2, the lookup table can be generated using Equation (211) to Equation (215) and looping through all values of N_{total} and k.

$$G_1(I) = \begin{cases} k & k = 0, 1, ..., \lfloor N_{total}/4 \rfloor & 0 \le N_{total} \le 24 \\ k+1 & k = 0, 1, 2, 3, 4, 5, & 25 \le N_{total} \le 27 \\ k+1 & k = 0, 1, 2, 3, 4, 5, 6, & 28 \le N_{total} \le 32 \\ k + \lfloor N_{total}/3 \rfloor - 10 & k = 0, 1, 2, 3, 4, 5, 6, & 33 \le N_{total} \le 48 \end{cases} \quad (211)$$

$$G_2(I) = \left\lfloor \frac{N_{total} - G_1(I)}{2} \right\rfloor \quad (212)$$

$$G_3(I) = N_{total} - 4 \times G_1(I) - G_2(I) \quad (213)$$

$$I = I_b(N_{total}) + k \quad (214)$$

$$I_b(N_{total}) = \begin{cases} 0, & N_{total} = 0 \\ I_b(N_{total}-1) + \lfloor (N_{total}-1)/4 \rfloor + 1, & 1 \le N_{total} \le 25 \\ I_b(N_{total}-1) + 6, & 26 \le N_{total} \le 28 \\ I_b(N_{total}-1) + 7, & 29 \le N_{total} \le 48 \\ 0, & otherwise \end{cases} \quad (215)$$

For FFR configuration with Group 1 using QPSK 1/4, Group 2 using QPSK 1/2, and Group 3 using QPSK 1/2, the lookup table can be generated using Equation (216) to Equation (220) and looping through all values of N_{total} and k.

$$G_1(I) = \begin{cases} k & k = 0, 1, ..., \lfloor N_{total}/2 \rfloor & 0 \le N_{total} \le 3 \\ k+1 & k = 0, 1, ..., \lfloor N_{total}/2 \rfloor - 2 & 4 \le N_{total} \le 24 \\ \lfloor (N_{total}-23)/2 \rfloor + 2 \times k, & k = 0, 1, 2, 3, 4, & 25 \le N_{total} \le 31 \\ \lfloor (N_{total}-28)/2 \rfloor + 3 \times k, & k = 0, 1, 2, 3, 4, & 32 \le N_{total} \le 33 \\ N_{total} - 32 + 2 \times k, & k = 0, 1, 2, 3, 4, 5, & 34 \le N_{total} \le 40 \\ N_{total} - 32 + k, & k = 0, 1, 2, 3, 4, 5, & 41 \le N_{total} \le 42 \\ N_{total} - 32 + 2 \times k, & k = 0, 1, 2, 3, 4, & 43 \le N_{total} \le 44 \\ N_{total} - 32 + k, & k = 0, 1, 2, 3, 4, & 45 \le N_{total} \le 48 \end{cases} \quad (216)$$

$$G_2(I) = \left\lfloor \frac{N_{total} - 2 \times G_1(I)}{2} \right\rfloor \quad (217)$$

$$G_3(I) = N_{total} - 2 \times G_1(I) - G_2(I) \quad (218)$$

$$I = I_b(N_{total}) + k \quad (219)$$

$$I_b(N_{total}) = \begin{cases} 0, & N_{total} = 0 \\ I_b(N_{total}-1) + \lfloor (N_{total}-1)/2 \rfloor + 1, & 1 \le N_{total} \le 4 \\ I_b(N_{total}-1) + \lfloor (N_{total}-1)/2 \rfloor - 1, & 5 \le N_{total} \le 25 \\ I_b(N_{total}-1) + 5, & 26 \le N_{total} \le 34 \\ I_b(N_{total}-1) + 6, & 35 \le N_{total} \le 43 \\ I_b(N_{total}-1) + 5, & 44 \le N_{total} \le 48 \\ 0 & otherwise \end{cases} \quad (220)$$

If the non-user specific A-MAP extension flag in the non-user specific A-MAP is set, the non-user specific A-MAP extension may be used to specify the information used to decode the PGID Info, AAI-TRF-IND, AAI-PAG-ADV, and other broadcast messages. The PHY structure for this extension is the same as the non-user specific A-MAP.

16.3.6.5.2.2 HARQ Feedback A-MAP IE

The HARQ Feedback A-MAP IE includes one bit and corresponding value for HARQ ACK/NACK information is shown in Table 816. If HF-A-MAP IE has the 0b0 or 0b1, it shall be interpreted as ACK information or NACK information, respectively.

Table 816—HF-A-MAP-IE

Syntax	Size (bit)	Notes
HF-A-MAP IE format {		
HF-A-MAP IE value	1	0b0 : ACK feedback info. 0b1 : NACK feedback info.
}		

16.3.6.5.2.3 Power Control A-MAP IE

The PC-A-MAP IE includes two bits and corresponding values for power correction is shown in Table 817, e.g., if the power correction value is 0b00, it shall be interpreted as tone power (power density) should be reduced by 0.5dB

16.3.6.5.2.4 Assignment A-MAP IE

Table 818 describes Assignment A-MAP IE Types.

Table 817—PC-A-MAP IE format

Syntax	Size (bit)	Notes
PC-A-MAP IE format {		
Power correction value	2	0b00 = -0.5 dB 0b01 = 0.0 dB 0b10 = 0.5 dB 0b11 = 1.0 dB
}		

Table 818—Assignment IE Types

A-MAP IE Type	Usage
0b0000	DL Basic Assignment A-MAP IE
0b0001	UL Basic Assignment A-MAP IE
0b0010	DL Subband Assignment A-MAP IE
0b0011	UL Subband Assignment A-MAP IE
0b0100	Feedback Allocation A-MAP IE
0b0101	UL Sounding Command A-MAP IE
0b0110	CDMA Allocation A-MAP IE
0b0111	DL Persistent Allocation A-MAP IE
0b1000	UL Persistent Allocation A-MAP IE
0b1001	Group Resource Allocation A-MAP IE
0b1010	Feedback Polling A-MAP IE
0b1011	BR-ACK A-MAP IE
0b1100	Broadcast Assignment A-MAP IE
0b1101	UL CSM Beamforming A-MAP IE
0b1110	Reserved
0b1111	Extended Assignment A-MAP IE

CRC Mask

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

Table 819—Description of CRC Mask

Masking Prefix	Description
0b0	CRC is masked by 1 bit masking prefix, 3 bit message type indicator, and 12 bit Masking Code The 3-bit type indicator shall be set/interpreted as follows. 000: 12 bit Masking Code refers to an STID (i.e. CRC mask = 0000| Masking Code) 001: 12 bit Masking Code used to mask Broadcast Assignment A-MAP IE, BR-ACK A-MAP IE, and Group Resource Allocation A-MAP IE, which is described in Table 820 (i.e. CRC mask = 0001| Masking Code).
0b1	CRC is masked by 1 bit masking prefix, and 15 bit RAID (i.e. CRC mask = 1|RAID)

Table 820—Description of the Masking Code for type indicator 001

Decimal Value	Description
0	Used to mask Broadcast Assignment A-MAP IE
1	Used to mask BR-ACK A-MAP IE
2-64	Used to mask Group Resource Allocation A-MAP IE (group ID)

16.3.6.5.2.4.1 DL basic assignment A-MAP IE

Table 821 describes the fields in a DL Basic Assignment A-MAP IE used for resource assignment in the DL..

A-MAP IE Type: Defines the structure of the assignment A-MAP IE for the bits in the assignment A-MAP IE following the A-MAP IE type field. A-MAP IE Type distinguishes between assignment A-MAP IEs used for the UL/DL, and assignment A-MAP IEs used for resource allocation and control signaling. Additional A-MAP IE types are reserved for future use.

M_t **:** Number of streams in transmission. The DL pilot pattern with M_t streams shall be used in the allocated resource.

Si: Index used 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. For Co-MIMO transmission to two users, the ABS shall indicate to one AMS a total number of

Table 821—DL Basic Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
DL_Basic_Assignment_A-MAP_IE() {		
A-MAP IE Type	4	DL Basic Assignment A-MAP IE
$I_{SizeOffset}$	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){		Parameters for vertical encoding
M_t	3	Number of streams in transmission $M_t \le N_t$ N_t : Number of transmit antennas at the ABS 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
Reserved	2	Reserved bit
} else if(MEF == 0b10) {		Parameters for multi-layer encoding

Table 821—DL Basic Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
Si	5	Index used to identify the combination of the number of streams and the allocated pilot stream index (PSI) in a transmission with MU-MIMO , and the modulation constellation of paired user in the case of 2 stream transmission 0b00000: 2 streams with PSI=stream0 and other modulation =QPSK 0b00001: 2 streams with PSI=stream0 and other modulation =16QAM 0b00010: 2 streams with PSI=stream0 and other modulation =64QAM 0b00011: 2 streams with PSI=stream0 and other modulation information not available 0b00100: 2 streams with PSI=stream1 and other modulation =QPSK 0b00101: 2 streams with PSI=stream1 and other modulation =16QAM 0b00110: 2 streams with PSI=stream1 and other modulation =64QAM 0b00111: 2 streams with PSI=stream1 and other modulation information not available 0b01000: 3 streams with PSI=stream0 0b01001: 3 streams with PSI=stream1 0b01010: 3 streams with PSI=stream2 0b01011: 4 streams with PSI=stream0 0b01100: 4 streams with PSI=stream1 0b01101: 4 streams with PSI=stream2 0b01110: 4 streams with PSI=stream3 0b01111: 3 streams with PSI=stream0 and stream1 0b10000: 4 streams with PSI=stream0 and stream1 0b10001: 4 streams with PSI=stream2 and stream3 0b10010~0b11111: n/a
}else{		
Reserved	5	Reserved bits

Table 821—DL Basic Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
}		
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 of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 DL AAI subframes for FDD or all DL AAI subframes for TDD
HFA	3	HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
ACID	4	HARQ channel identifier
SPID	2	HARQ subpacket identifier for HARQ IR 0b00: 0 0b01: 1 0b10: 2 0b11: 3
CRV	1	Constellation Rearrangement Version 0b0: 0 0b1: 1
Reserved	1	Reserved bits
}		

*A 16 bit CRC is generated based on the contents of the DL Basic Assignment A-MAP IE. The CRC is masked by the Station ID.

streams equal to 3 using one of the values 0b1000, 0b1001 or 0b1010, in order to ensure that the AMS will perform channel estimation using one stream of the non-interlaced pilot pattern with 3 streams.

Resource Index: Resource Index with starting LRU index and size of a single allocation spanning contiguous LRUs.

Resource Indexing in the DL Basic Assignment A-MAP IE

The Resource Index in the DL/UL Basic Assignment A-MAP IE identifies a single allocation of a resource comprising a set of contiguous LRUs in a DL/UL AAI subframe. The index determines the size (S) of the allocated resource in number of contiguous LRUs in frequency within the subframe and the index (L) of the LRU from where the scheduled allocation begins. The contiguous LRUs can be constructed from DLRUs or

NLRUs or SLRUs. Multiple non-contiguous subbands are indexed using the DL/UL Subband Assignment A-MAP IEs.

For a given system bandwidth with N_{max} LRUs, the size of allocations comprising contiguous LRUs can be chosen from *1* to N_{max}. For each allocation size, resources can be allocated starting from different LRUs in the AAI subframe. Every possible allocation size *S*, from *1* to N_{max} can be assigned in any location starting at LRU *L*, provided $(S + L) \le 24$ and $(S + L) \le 48$ for 5 and 10 MHz system bandwidths respectively.

For a 20 MHz system bandwidth, the number of assignable resource sizes is reduced, but there is no constraint on where these allocations may be made in the AAI subframe, as long as $(S + L) \le 96$. The assignable resource sizes are specified as follows:

- All resource sizes in increments of 1 LRU are assignable in the range of 1 to 12 LRUs.
- Only even resource sizes are assignable in increments of 2 LRUs in the range of 12 to 24 LRUs.
- Resource sizes are assignable in increments of 4 LRUs in the range of 24 to 48 LRUs .
- Resource sizes are assignable in increments of 8 LRUs in the range of 48 to 88 LRUs.
- All resource sizes in increments of 1 LRU are assignable in the range of 92 to 96 LRUs.

Derivation of the mapping between LRU index and physical PRU index:

For each frequency partition *i*, $TC_{LRU,i}$, the total number of CLRUs & DLRUs up-to and including that partition is calculated as

$$TC_{LRU,i} = \sum_{m=0}^{i} FPS_m,\ 0 \le i \le 3 \qquad (221)$$

$$LRU[k] = \begin{cases} DLRU_{FPi}[k - TC_{LRU,\,i-1}], \\ \text{for } TC_{LRU,\,i-1} \le k < (LRU_{DRU,\,FPi} + TC_{LRU,\,i-1}) \\ NLRU_{FPi}[k - (LRU_{DRU,\,FPi} + TC_{LRU,\,i-1})], \\ \text{for } ((LRU_{DRU,\,FPi} + TC_{LRU,\,i-1}) \le k < (LRU_{DRU,\,FPi} + LRU_{MB\text{-}CRU,\,FPi} + TC_{LRU,\,i-1})) \\ SLRU_{FPi}[k - (LRU_{DRU,\,FPi} + LRU_{MB\text{-}CRU,\,FPi} + TC_{LRU,\,i-1})], \\ \text{for } ((LRU_{DRU,\,FPi} + LRU_{MB\text{-}CRU,\,FPi} + TC_{LRU,\,i-1}) \le k < TC_{LRU,\,i}) \end{cases} \qquad (222)$$

with $0 \le i \le 3$, $0 \le k < \sum_{m=0}^{3} FPS_m$ and $TC_{LRU,\,-1} = 0$.

The mapping from $DLRU_{FP_i}$, $NLRU_{FP_i}$ and $SLRU_{FP_i}$ to the PRU indices (and vice-versa) is as specified in 16.3.5.3.5.

Determining the Resource Index for the Scheduled Resource at the ABS

For a given system bandwidth with N_{max} LRUs across all frequency partitions, the ABS maintains a vector I_a of length N_{max} in which the non-zero entries contain the starting index for each of the assignable resource sizes.

The S^{th} element of I_a, $1 \le S \le 96$ for 11 bit resource indexing in a DL/UL AAI subframe for a 20 MHz system bandwidth is defined as in equation:

$$I_a(S) = \begin{cases} 0 & S = 1 \\ I_a(S-1) + (96 - (S-1) + 1) & 2 \le S \le 12 \\ I_a(S-2) + (96 - (S-2) + 1) & S = 2k, 7 \le k \le 12 \\ I_a(S-4) + (96 - (S-4) + 1) & S = 4k, 7 \le k \le 12 \\ I_a(S-8) + (96 - (S-8) + 1) & S = 8k, 7 \le k \le 11 \\ 2048 - \sum_{k=S}^{96} (96 - k + 1) & 92 \le S \le 96 \\ 0 & \text{otherwise} \end{cases} \quad (223)$$

The resource index RI for an allocation of size S LRUs beginning at LRU L is computed as

$$RI = \begin{cases} I_a(S) + L & \text{if } I_a(S) > 0 \text{ or } S = 1 \\ \text{not assignable} & \text{if } I_a(S) = 0 \text{ and } S > 1 \end{cases}$$

where $1 \le S \le 96$, $0 \le L \le 95$ and $(S + L) \le 96$.

The ABS first determines if the required resource size is assignable by checking if the S^{th} element in I_a has a non-zero value or $S = 1$. If the size S is assignable, then the 11 bit resource index is then determined by simply adding L to the value of the S^{th} element in I_a. If the required resource is not assignable, the next higher or lower non-zero element in I_a is selected based on the link adaptation scheme employed.

The S^{th} element of I_a, for 11 bit resource indexing in a DL/UL AAI subframe for a 10 MHz system bandwidth is defined as:

$$I_a(S) = \begin{cases} 0 & S = 1 \\ I_a(S-1) + (48 - (S-1) + 1) & 2 \le S \le 48 \end{cases}$$

The resource index RI for an allocation of size S LRUs beginning at LRU L is computed as

$$RI = I_a(S) + L, 1 \le S \le 48, 0 \le L \le 47 \text{ and } (S + L) \le 48$$

The S^{th} element of I_a, $1 \le S \le 24$ for 9 bit resource indexing in a DL/UL AAI subframe for a 5 MHz system bandwidth is defined as:

$$I_a(S) = \begin{cases} 0 & S = 1 \\ I_a(S-1) + (24 - (S-1) + 1) & 2 \le S \le 24 \end{cases}$$

The resource index *RI* for an allocation of size *S* LRUs beginning at LRU *L* is computed as

$$RI = I_a(S) + L,\ 1 \le S \le 24,\ 0 \le L \le 23 \text{ and } S + L \le 24$$

Determining the Scheduled Resource from the Resource Index at the Receiver

At the receiver, the 11 bit resource index, *RI*, in the DL/UL Basic Assignment A-MAP IE is used to determine the assigned resource size *S* as described by Equation (224). The element in the vector I_a with the maximum possible value, $I_a(S)$, is found such that $I_a(S) \le RI$; then the value *S* is the assigned resource size.

$$S = \max_{s \in \{1, 2, \ldots, N_{max}\}} \{I_a(s) | I_a(s) \le RI\} \quad (224)$$

The starting LRU for the allocation is determined by subtracting the value of I_a corresponding to the assigned resource size *S* from the index *RI* in the DL/UL Basic Assignment A-MAP IE, i.e.,

$$L = RI - I_a(S)$$

16.3.6.5.2.4.2 UL basic assignment A-MAP IE

Table 822 describes the fields in a UL Basic Assignment A-MAP IE used for resource assignment in the UL.

In the UL, the amount of LRUs that the ABS allocates to a specific AMS, starting in a specific AAI subrame, shall not be larger than the amount of LRUs in that AAI subframe over all used carriers. This limitation considers both bursts that are long TTI and bursts that are not.

TNS: Total number of streams in the LRU for CSM

SI: First pilot index for CSM.

PF: Precoding flag to indicate adaptive or non-adsptive precoding.

PMI: Precoding matrix index .

SU-PMI Indicator: Flag to indicate if both SU-MIMO and PMI are signaled

CSM: Flag to indicate if CSM is signaled

Table 822—UL Basic Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
UL_Basic_Assignment_A-MAP_IE() {		
A-MAP IE Type	4	UL Basic Assignment A-MAP IE
$I_{SizeOffset}$	5	Offset used to compute burst size index
M_t	2	Number of streams in transmission $M_t \leq N_t$, up to 4 streams per AMS supported N_t : Number of transmit antennas at the AMS 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
SU-PMI Indicator	1	Flag to indicate if both SU-MIMO and PMI are signaled 0b0: SU MIMO without PMI indication, or CSM without PMI indication 0b1: SU MIMO with PMI indication
if(SU-PMI Indicator == 0b0){		
CSM	1	Flag to indicate CSM 0b0: SU-MIMO 0b1: CSM
if(CSM == 0b0){		
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding Non-adaptive precoding shall be used at the AMS with SFBC. M_t shall be ignored with SFBC
if(MEF == 0b0){		
Reserved	4	Reserved bits
}else if(MEF == 0b1){		
PF	1	Precoding flag for SU-MIMO when PMI is not signaled 0b0: Non-adaptive precoding 0b1: Adaptive precoding using the precoder of rank M_t of the AMS's choice
Reserved	3	Reserved bits
}		
}else if(CSM == 0b1){		Parameters for CSM
PF	1	Precoding flag for CSM when PMI is not signaled 0b0: Non-adaptive precoding 0b1: Adaptive precoding using the precoder of rank M_t of the AMS's choice

Table 822—UL Basic Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
TNS	2	Total number of streams in the LRU for CSM 0b00: reserved 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
SI	2	First pilot index for CSM For TNS=2 0b00: SI=1 0b01: SI=2 0b10: N/A 0b11: N/A For TNS=3 0b00: SI=1 0b01: SI=2 0b10: SI=3 0b11: N/A For TNS=4 0b00: SI=1 0b01: SI=2 0b10: SI=3 0b11: SI=4
}		

Table 822—UL Basic Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
}else if (SU-PMI Indicator == 0b1){		Parameters for SU-MIMO with PMI (adaptive precoding)
PMI	6	4 bits PMI for $N_t = 2$, first 2 MSB set to 0 6 bits PMI for $N_t = 4$
}		
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 If all bits are set to 1, the AMS shall not transmit the corresponding HARQ subpacket for the ACID in this IE. The retransmission number is incremented by one for the skipped retransmission.
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL AAI subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator= 0b1
HFA	3	HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
ACID	4	HARQ channel identifier
Reserved	2	Reserved bits
}		

*A 16 bit CRC is generated based on the contents of the UL Basic Assignment A-MAP IE. The CRC is masked by the Station ID

The Resource Index field in the UL Basic Assignment A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE, with 'DL' specific terminology replaced by 'UL' equivalents.

16.3.6.5.2.4.3 DL Subband Assignment A-MAP IE

The DL Sub-band Assignment A-MAP IE shall have an identical structure to the DL Basic Assignment A-MAP IE. With the exception of the “IE Type” and the “Resource Allocation” field, all of the other fields shall be interpreted in the same manner as defined for the DL Basic Assignment A-MAP IE.

The “A-MAP IE Type” field shall be set to the value 0b0010.

For all bandwidths, the “Resource Allocation” field shall be 11 bits long

The structure and interpretation of the RA field for the DL Subband Assignment A-MAP IE shall be as defined below, for the cases of 5, 10 & 20 MHz.

In all cases, the ABS/AMS shall perform the following pre-processing steps to define some terms that are used in the indexing and in the interpretation of the RA field. The notation and terms in these steps, related to sub-channelization, are defined in 16.3.5.

Pre-Processing

Derivation of the mapping between the sub-band logical resource unit (SLRU) index and the PRU index shall be done as follows. The total number of sub-bands over all partitions may be calculated as

$$Y_{SB} = \sum_{m=0}^{3} \frac{L_{SB-CRU,FP_m}}{N_1} \quad (225)$$

For each frequency partition *i*, the total number of sub-band-CRUs up-to and including that partition may be calculated as

$$X_i = \sum_{m=0}^{i} L_{SB-CRU,FP_m},\ 0 \le i \le 3 \quad (226)$$

Then, the SLRUs are indexed as

$$\mathrm{SLRU}[k] = \mathrm{SLRU}_{\mathrm{FP}_i}[k - X_{i-1}], \mathrm{for} X_{i-1} \le k < X_i \text{ with } 0 \le i < 3, \text{ with } 0 \le k < N_1 Y_{SB}, X_1 = 0 \quad (227)$$

The sub-bands are indexed as

$$\mathrm{SB}[m] = \left\{ \text{All SLRU[k]with indices k such that } \left\lfloor \frac{k}{N_1} \right\rfloor = m \right\}, \text{with } 0 \le m < Y_{SB} \quad (228)$$

The mapping from the SLRU_{FPi} to the PRU indices (and vice-versa) is as specified in 16.3.5.3.5.

Nominal Channel Bandwidth = 5 MHz

For a 5 MHz system:

1) A single instance of a resource allocation shall be made using a single IE.
2) It may be noted that Y_{SB} <= 4 for a 5 MHz system. The AMS shall interpret the RA field as defined below

a)Each of the *j* bit positions in the RA field, 0 <= *j* < 11, indicates the allocation or non-allocation of 2 SLRUs within a particular subband.

b)Position *j* in the RA field corresponds to the 2 SLRUs with inidices *k* such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = j$.

c)Denoting RA[*j*] as the *j*th position in the RA field, *0* <= *j* < 11, with *j* = *0* being the LSB

RA[*j*] = 1 => The2 SLRUs with indices *k* such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = j$ have been allocated.

RA[*j*] = *0* => The 2 SLRUs with indices *k* such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = j$ have not been alloctaed.

Figure 524 pictorially illustrates the above description of the interpretation of the RA field in a 5 MHz system.

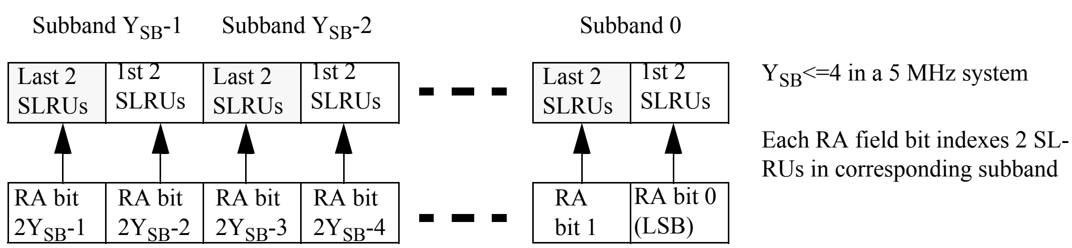


Figure 524—Interpretation of the RA field in a 5 MHz system

Nominal Channel Bandwidth = 10 MHz

For a 10 MHz system a single instance of a resource allocation shall be made using a single IE. It may be noted that Y_{SB} <= 10 for a 10 MHz system. For a particular value of Y_{SB}, the AMS shall interpret the bits in the Resource Allocation field as indicated by the row corresponding to that value of Y_{SB} in Table 823.

Table 823—Interpretation of the RA Field in a 10 MHz or a 20 MHz system, when Y_{SB} <= 11 (Y_{SB} is the total number of sub-bands over all frequency partition)

<table>
<tr><th>Total # of sub-bands over all frequency partitions, Y_{SB}</th><th colspan="2">RA Field Interpretation</th></tr>
<tr><td>Y_{SB} = 10 or 11</td><td colspan="2">Each of the j bit-positions in the RA field, 0 <= j < 11, indicates the allocation or non-allocation of all N_1 (= 4) CRUs within a particular sub-band.
Denote $RA[j]$ as the j^{th} bit position in the RA Field, 0 <= j < 11, with $j = 0$ being the LSB.
RA[j] corresponds to the subband, i.e., the the 4 CRUs with indices k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$
Depending on the value of Y_{SB}, not all j may be relevant.
RA[j]= 1: The 4 CRUs with index k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have been allocated.
RA[j]= 0: The 4 CRUs with index k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have not been allocated.</td></tr>
<tr><td rowspan="4">Y_{SB} = 7, 8 or 9</td><td colspan="2">The 2 MSB bits of the RA field are denoted as the “Indication Type field” (ITF).
The Y_{SB} LSB bits of the RA field are denoted as the “Resource Indexing Field” (RIF).
Denote RIF[j] as the j^{th} bit position in the RIF, 0 <= j < Y_{SB}, with $j = 0$ being the LSB.</td></tr>
<tr><td>ITF == 00</td><td>Each of the RIF[j], 0 <= j < Y_{SB}, indicates the allocation or non-allocation of all N_1 (= 4) CRUs within a particular sub-band (out of the Y_{SB} sub-bands).
RIF[j]= 1: The 4 CRUs with index k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have been allocated.
RIF[j]= 0: The 4 CRUs with index k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have not been allocated.</td></tr>
<tr><td>ITF == 01</td><td>Each of the RIF[j], 0 <= j < Y_{SB}, indicates the allocation or non-allocation of the 1st 2 CRUs within a particular sub-band.
RIF[j]= 1: The 2 CRUs with index k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1/2} \right\rfloor = 2j$ have been allocated.
RIF[j]= 0: The 2 CRUs with index k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1/2} \right\rfloor = 2j$ have not been allocated.</td></tr>
<tr><td>ITF == 10</td><td>Each of the RIF[j], 0 <= j < Y_{SB}, indicates the allocation or non-allocation of the last 2 CRUs within a particular sub-band.
RIF[j]= 1: The 2 CRUs with index k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1/2} \right\rfloor = 2j+1$ have been allocated.
RIF[j]= 0: The 2 CRUs with index k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1/2} \right\rfloor = 2j+1$ have not been allocated.</td></tr>
</table>

Table 823—Interpretation of the RA Field in a 10 MHz or a 20 MHz system, when Y_{SB} <= 11 (Y_{SB} is the total number of sub-bands over all frequency partition)

$Y_{SB} = 6$	The 2 MSB bits of the RA field are denoted as the “Indication Type field” (ITF). The 9 LSB bits of the RA field are denoted as the “Resource Indexing Field” (RIF). Denote RIF[j] as the j^{th} bit position in the RIF, 0 <= j < 9, with $j = 0$ being the LSB.	
	ITF == 00	Each of the RIF[j], 0 <= j < 6, indicates the allocation or non-allocation of all N_1 (= 4) CRUs within a particular sub-band. RIF[j]= 1: The 4 CRUs with index k such that $\left\lfloor \frac{SLRU[k]}{N_1} \right\rfloor = j$ have been allocated. RIF[j]= 0: The 4 CRUs with index k such that $\left\lfloor \frac{SLRU[k]}{N_1} \right\rfloor = j$ have not been allocated.
	ITF == 01	The 9 bits in the RIF index into the 9 half sub-bands (out of 12) with the higher indices. Each of the RIF[j], 0 <= j < 9, indicates the allocation or non-allocation of the 1st or last 2 CRUs within a particular sub-band. RIF[j]= 1: The 2 CRUs with index k such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = 2j+3$ have been allocated. RIF[j]= 0: The 2 CRUs with index k such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = 2j+3$ have not been allocated.
	ITF == 10	The 9 bits in the RIF index into the 9 half sub-bands (out of 12) with the lower indices. Each of the RIF[j], 0 <= j < 9, indicates the allocation or non-allocation of the 1st or last 2 CRUs within a particular sub-band RIF[j]= 1: The 2 CRUs with index k such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = j$ have been allocated. RIF[j]= 0: The 2 CRUs with index k such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = j$ have not been allocated.
Y_{SB} <= 5	Each of the j bit-positions in the RA field, 0 <= j < 11, indicates the allocation or non-allocation of 2 CRUs within a particular sub-band. Denote RA[j] as the j^{th} bit position in the RA Field, 0 <= j < 11, with $j = 0$ being the LSB. RA[j] corresponds to the 2 CRUs with indices k such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = j$ Depending on the value of Y_{SB}, not all j may be relevant. RA[j]= 1: The 2 CRUs with index k such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = j$ have been allocated. RA[j]= 0: The 2 CRUs with index k such that $\left\lfloor \frac{SLRU[k]}{N_1/2} \right\rfloor = j$ have not been allocated.	

Figure 525, Table 526, Table 527 and Table 528 pictorially illustrate the description, in Table 823, of the interpretation of the RA field for the various cases.

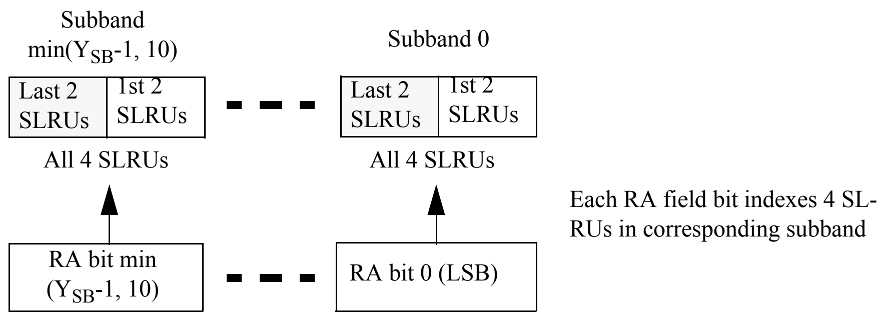


Figure 525—Interpretation of the RA field in Table 823, when Y_{SB} = 10 or 11

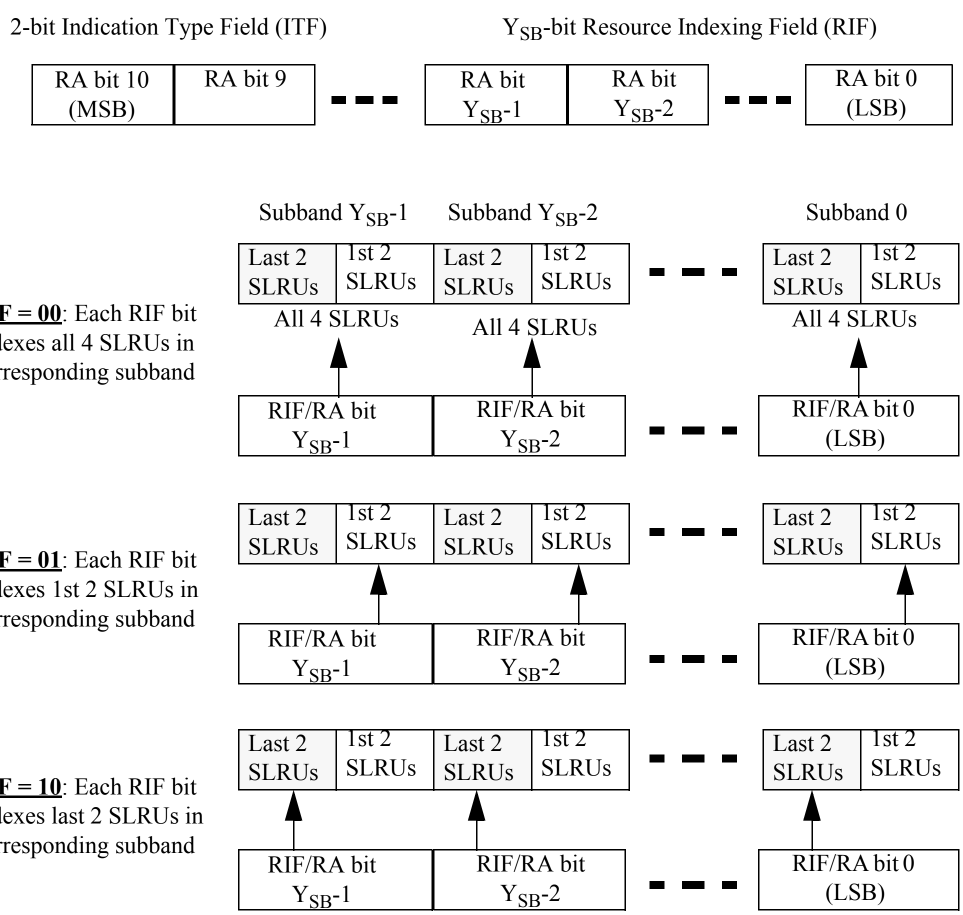


Figure 526—Interpretation of the RA field in Table 823, when Y_{SB} = 7, 8 or 9

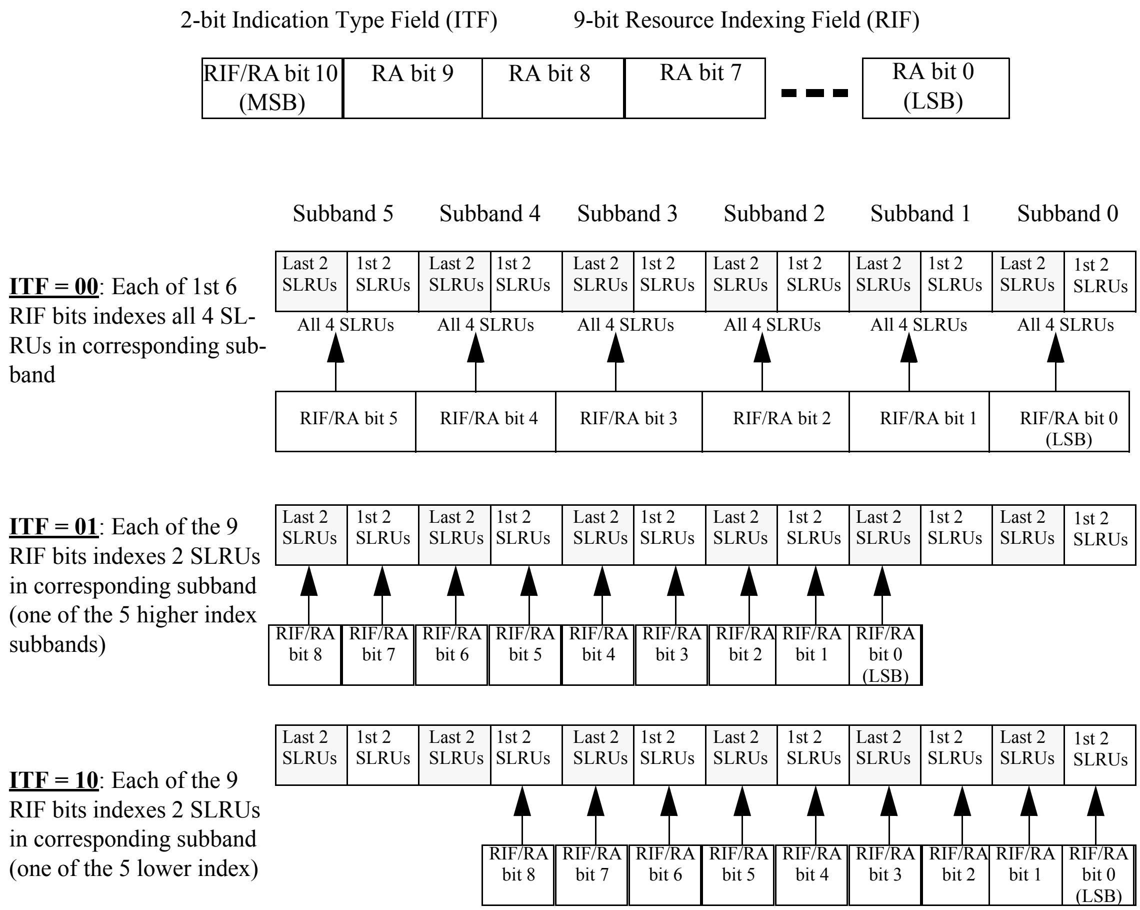


Figure 527—Interpretation of the RA field in Table 823, when Y_{SB} = 6

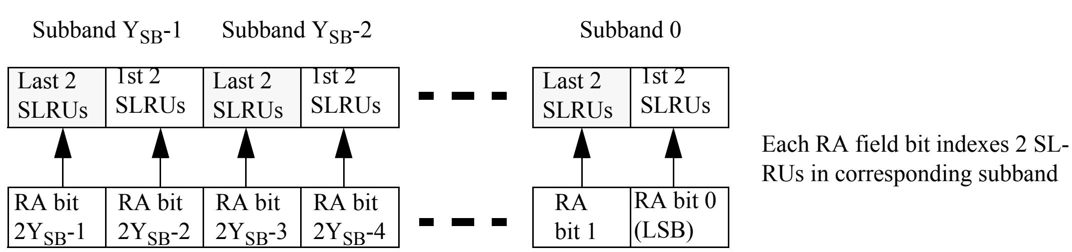


Figure 528—Interpretation of the RA field in Table 823, when Y_{SB} <= 5

Nominal Channel Bandwidth = 20 MHz

For a 20 MHz system the following procedure shall be followed:

1) It may be noted that Y_{SB} <= 21 for a 20 MHz system. When Y_{SB} (total number of sub-bands over all frequency partitions) <= 11, a single instance of a resource allocation shall be made using a single IE. In this case, the AMS shall interpret the bits in the Resource Allocation field as indicated by Table 824 (the row corresponding to the particular value of Y_{SB} in that table).

a) When Y_{SB} (total number of sub-bands over all frequency partitions) > 11, a single instance of a resource allocation may be made using a single or two IEs.

a) When an allocation is made using 2 IEs, the RA fields of the two IEs shall be concatenated to form a 22-bit field, referred to as the Concatenated-RA field (C-RA field). The LSB of the RA field of the IE occurring last in the A-AMAP region shall be interpreted as the LSB of the C-RA field. The AMS shall interpret the bits in the C-RA field as indicated by Table 824 (the row corresponding to the particular value of Y_{SB} in that table). The AMS may infer that two IEs refer to the same instance of a resource allocation from the values of the ACID and SPID fields.

b) When an allocation is made using a single IE, the RA field shall be interpreted as in 16.3.6.5.2.4.1. This section defines the mapping of the RA field to all possible non-contiguous combination of indices of 2 or 3 subband

The overall interpretation procedure for 20 MHz as described above is pictorially illustrated in Figure 529.

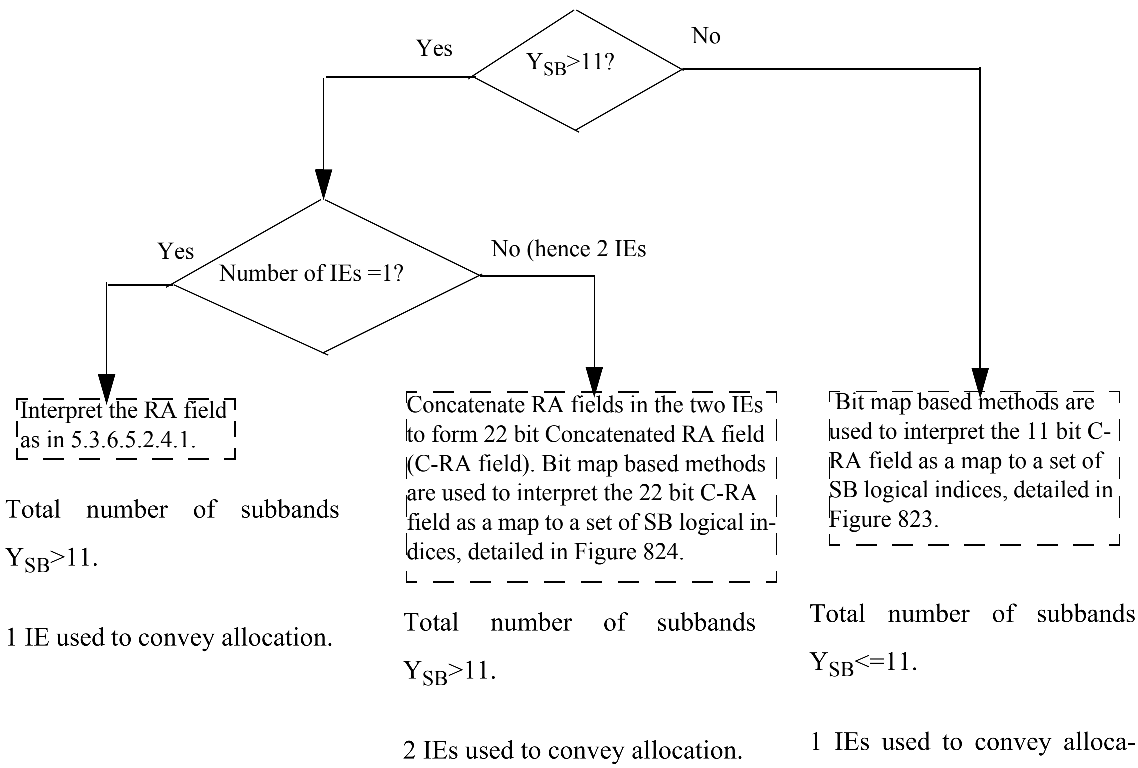


Figure 529—Overall RA field interpretation cases and corresponding procedures in a 20 MHz system

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Table 824— Interpretation of the C-RA Field in a 20 MHz system

Total # of subbands over all frequency partitions, Y	C-RA Field Interpretation

Table 824— Interpretation of the C-RA Field in a 20 MHz system

Y_{SB} = 21	Each of the *j* bit-positions in the C-RA field, 0 <= j < 22, indicates the allocation or non-allocation of all N_1 (= 4) CRUs within a particular sub-band. Denote RA[*j*] as the *j*th bit position in the C-RA Field, 0 <= *j* < 22, with $j = 0$ being the LSB. RA[*j*] corresponds to the sub-band, i.e., the the 4 CRUs with indices *k* such that $\left\lfloor \frac{\mathrm{SBCRU}[k]}{N_1} \right\rfloor = j$ Depending on the value of Y, not all *j* may be relevant. RA[*j*]= 1: The 4 CRUs with index *k* such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have been allocated. RA[*j*]= 0: The 4 CRUs with index *k* such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have not been allocated.	
12 <= Y_{SB} <= 20	The 2 MSB bits of the C-RA field are denoted as the “Indication Type field” (ITF). The Y_{SB} LSB bits of the C-RA field are denoted as the “Resource Indexing Field” (RIF). Denote RIF[*j*] as the *j*th bit position in the RIF, 0 <= *j* < Y_{SB}, with $j = 0$ being the LSB.	
	ITF == 00	Each of the RIF[*j*], 0 <= *j* < Y_{SB}, indicates the allocation or non-allocation of all N_1 (= 4) CRUs within a particular sub-band (out of the Y_{SB} sub-bands). RIF[*j*]= 1: The 4 CRUs with index *k* such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have been allocated. RIF[*j*]= 0: The 4 CRUs with index *k* such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have not been allocated.
	ITF == 01	Each of the RIF[*j*], 0 <= *j* < Y_{SB}, indicates the allocation or non-allocation of the 1st 2 CRUs within a particular sub-band. RIF[*j*]= 1: The 2 CRUs with index *k* such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = 2j$ have been allocated. RIF[*j*]= 0: The 2 CRUs with index *k* such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = 2j$ have not been allocated.
	ITF == 10	Each of the RIF[*j*], 0 <= *j* < Y_{SB}, indicates the allocation or non-allocation of the last 2 CRUs within a particular sub-band. RIF[*j*]= 1: The 2 CRUs with index *k* such that $\frac{\mathrm{SLRU}[k]}{N_1} \rfloor = 2j+1$ have been allocated. RIF[*j*]= 0: The 2 CRUs with index *k* such that $\frac{\mathrm{SLRU}[k]}{N_1} \rfloor = 2j+1$ have not been allocated.

Figure 530 pictorially illustrates the interpretation of the C-RA field as detailed in Table 824.

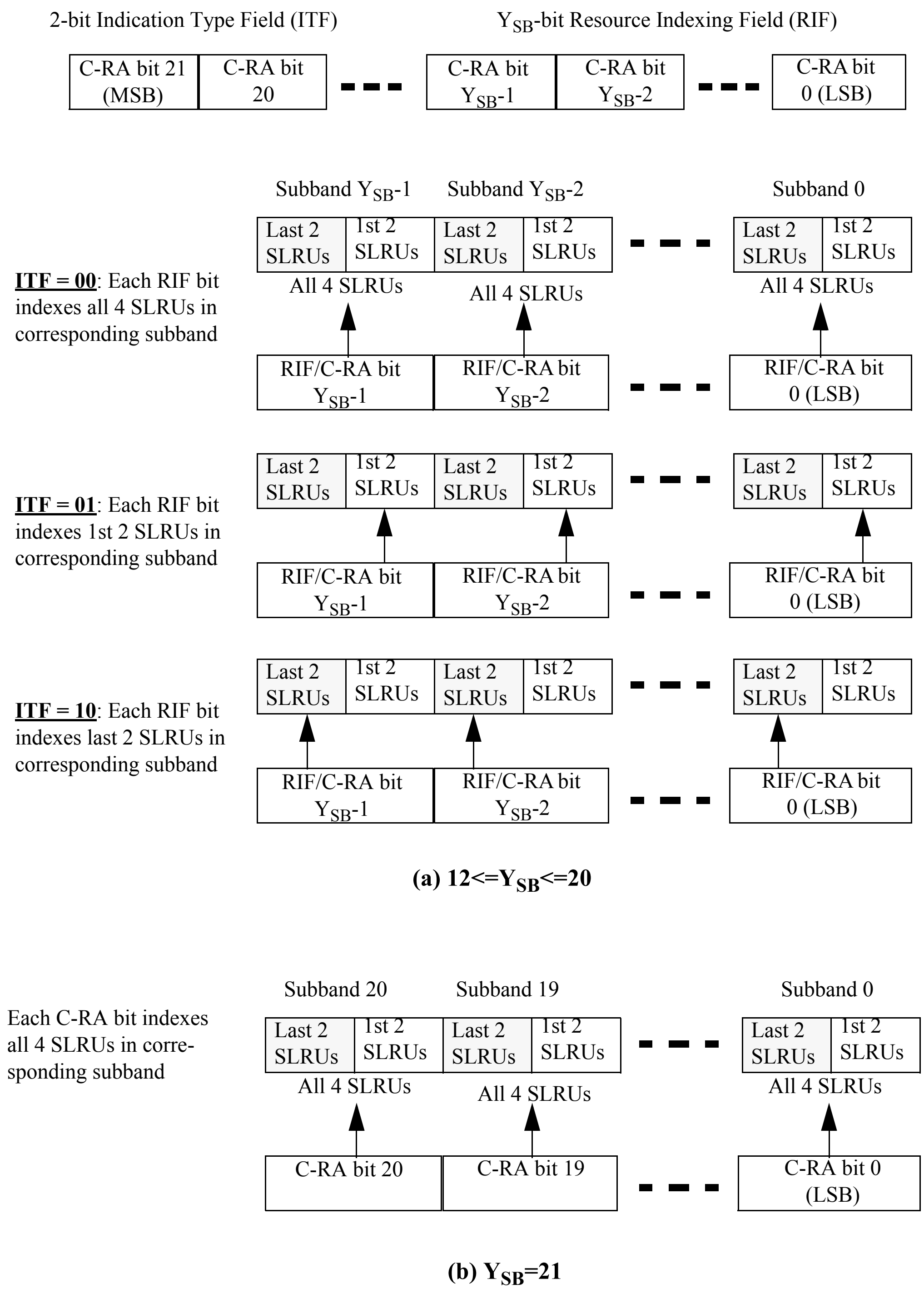


Figure 530—IInterpretation of the C-RA field in a 20 MHz system, in the case that Y_{SB} > 11 and 2 IEs are used to make an allocation, as detailed in Table 824

Nominal Channel Bandwidth = 20 MHz, Y_{SB}>11, Allocation Using a Single IE

When Y (total number of sub-bands over all frequency partitions) > 11, a single IE may be used to make allocations of 2 or 3 sub-bands with arbitrary non-contiguous logical indices. This section defines the interpretation of the RA field in this case, allowing for the indication of all possible combinations of 2 or 3 sub-bands with non-contiguous logical indices.

The following definitions and associated terminology are used to make interpretations.

1) A "Sub-band Pair" (SBP) contains a pair of sub-bands with contiguous indices. The indices of a sub-band pair and the corresponding sub-bands are related as follows: $SBP[j] \leftrightarrow \{SB[2j], SB[2j+1]\}$.

   a)There are a maximum of 21 sub-bands in a 20 MHz system. The corresponding 11 sub-band pairs are indexed as: $SBP[0] \leftrightarrow \{SB[0], SB[1]\}$, $SBP[1] \leftrightarrow \{SB[2], SB[3]\}$,..., $SBP[9] \leftrightarrow \{SB[18], SB[19]\}$,while $SBP[10] \leftrightarrow \{SB[20]\}$.

a) The set of 11 sub-band pairs are partitioned into 2 "Pair-Groups" (PG). The pair-group with index 0 contains 5 SBPs, while the pair-group with index 1 contains 6 SBPs. The pair-group and sub-band pair indices are related as follows: $PG[0] \leftrightarrow \{SBP[0], SBP[1], \ldots, SBP[4]\}$, $PG[1] \leftrightarrow \{SBP[5], SBP[6], \ldots SBP[10]\}$.

a) The first 7 (MSB) bits of the RA field are referred to as the "Resource Indexing Field" (RIF), while the last 4 (LSB) bits are referred to as the "Indication Type Field" (ITF).

The mapping between the RA field and the allocated sub-band indices proceeds as follows - The Resource Indexing Field indicates the sub-band pair(s) being allocated, while the Indication Type Field further indicates the particular sub-bands within the sub-band pair that are being allocated.

Figure 531 pictorially depicts the definitions of sub-band pairs and pair groups, while Figure 532 depicts the partitioning and usage of the RA field.

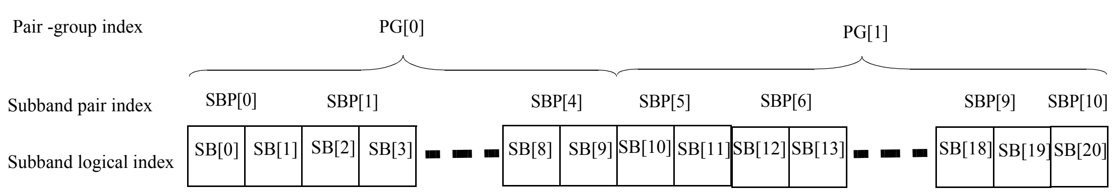
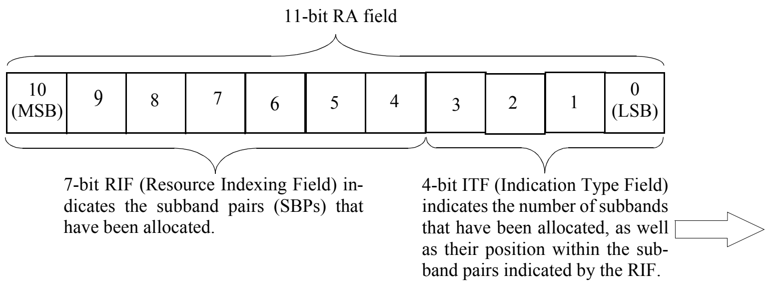


Figure 531—Definitions of sub-band pairs and pair groups in the 20 MHz, Y_{SB} > 11, single IE case



ITF values	Number of subbands indicated
0000 to 0011	2
0100 to 1111	3

Figure 532—Partitioning and usage of the RA field in the 20 MHz, Y_{SB} > 11, single IE case

The interpretations of the RIF & the ITF for the 2- and 3 sub-band allocation cases are described as follow.

Allocation of 2 sub-bands

The values of the Indication Type Field (4 LSB bits of the RA field) from 0000 through 0011 indicate the assignment of 2 sub-bands. Denoting the assigned sub-bands as SB[x] and SB[y], and further denoting SB[x]<-->SBP[u] and SB[y]<-->SBP[v], the values of the ITF from 0000 through 0011 shall be interpreted as follows.

1) ITF = 0000 => Both SB[x] and SB[y] are the lower SB indices in SBP[u] and SBP[v], respectively.

a) ITF = 0001 => SB[x] and SB[y] are the higher SB indices in SBP[u] and SBP[v], respectively.

a) ITF = 0010 => SB[x] is the lower SB index in SBP[u], SB[y] is the higher SB index in SBP[v].

a) ITF = 0011 => SB[x] is the higher SB index in SBP[u], SB[y] is the lower SB index in SBP[v].

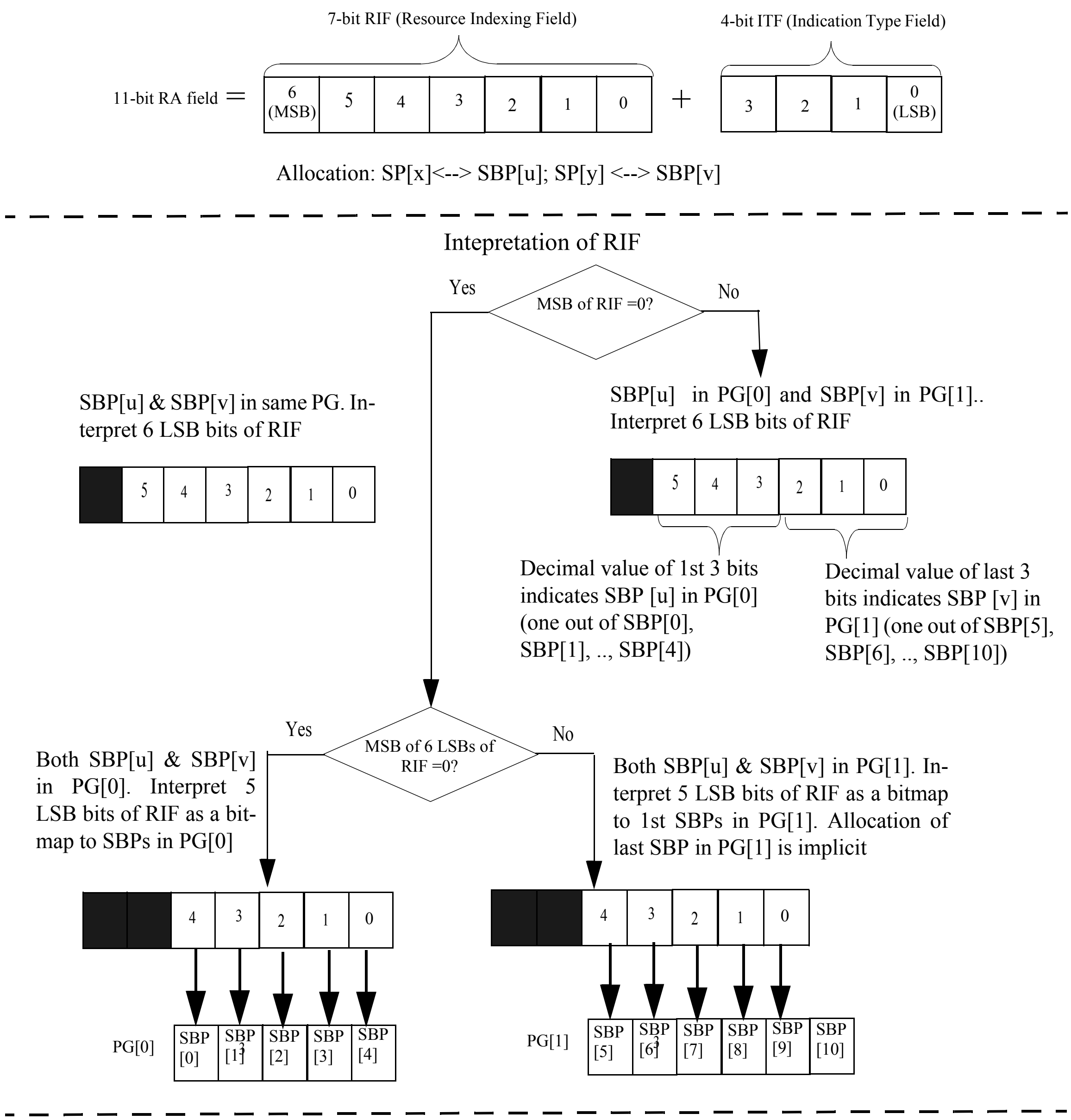
The Resource Indexing Field (7 MSB bits of the RA field) are then interpreted as in Table 825—to indicate the SBPs allocated. As indicated in the table, the MSB and 6 LSB bits of the RIF are interpreted separately. Knowledge of the SBPs allocated, along with the information about the allocated sub-bands within the SBPs as indicated by the ITF, completes the allocation details for this case.

As an example, consider the case where RA = 11000100001, i.e., RIF = 1100010 and ITF = 0001. From the ITF, this is a 2 sub-band allocation. As above, let the two allocated sub-bands be denoted as SB[x] and SB[y], with SB[x]<-->SBP[u] and SB[y]<-->SBP[v]. From Table 1, since the MSB of the RIF is 1, this implies that the two allocated sub-band pairs are in different pair groups. The 1st 3 bits of the 6 LSB bits of the RIF (= 100) indicate SBP[u] relative to PG[0]; hence, SBP[u] = 4. The last 3 bits of the 6 LSB bits of the RIF (= 010) indicate SBP[v] relative to PG[1]; hence, SBP[v] = 7. Hence, the allocation is in SBP[4] = {SB[8], SB[9]} and SBP[7] = {SB[14], SB[15]}. The ITF (= 0001) indicates that the allocated SBs occupy the higher indices in the indicated SBPs. Hence, the allocation is {SB[9], SB[15]}.

Table 825—Interpretation of the Resource Indexing Field (7MSB bits of RA field) in the 2 sub-band allocation case

MSB of RIF = 0 =>SBP[u] & SBP[v] in same PG.	MSB of 6-bit LSB of RIF = 0 => SBP[u] & SBP[v] in PG[0].	Remaining 5 bits in 6-bit LSB of RIF used as a bit-map to indicate allocated SBPs over the 5 SBPs in PG[0] (SBP[0], SBP[1], SBP[2], SBP[3], SBP[4]), with the LSB of the 5 bit field corresponding to SBP[4]. A "1"/"0" in a particular position in the 5-bit field indicates the allocation/ non-allocation of a sub-band in the corresponding SBP.
	MSB of 6-bit LSB of RIF = 1 => SBP[u] & SBP[v] in PG[1].	Remaining 5 bits in 6-bit LSB of RIF used as a bit-map to indicate allocated SBPs over the 1st 5 of the 6 SBPs in PG[1] (SBP[5], SBP[6], SBP[7], SBP[8], SBP[9]), with the LSB of the 5-bit field corresponding to SBP[9]. A "1"/"0" in a particular position in the 5-bit field indicates the allocation/ non-allocation of a sub-band in the corresponding SBP. Allocation of the 6th SBP in PG[1] (SBP[10]) is implied in the case that there is only a single "1" in the bit-map.
MSB of RIF = 1 => SBP[u] & SBP[v] in different PGs.	The decimal value of the 1st 3 bits of the 6-bit LSB of the RIF indicate index SBP[u], relative to PG[0]. Hence, "000" indicates SBP[0], "001" indicates SBP[1], ..., "100" indicates SBP[4]. The decimal value of the last 3 bits of 6-bit LSB of the RIF indicate index SBP[v], relative to PG[1]. Hence, "000" indicates SBP[5], "001" indicates SBP[6], ..., "101" indicates SBP[10].	

Figure 533 pictorially illustrates the usage of the RA field to make 2-sub-band assignments as detailed in Table 825.



Intepretation of ITF

ITF values	Position of SB[x] in SBP[u]	Position of SB[y] in SBP[v]
0000	Lower	Lower
0001	Higher	Higher
0010	Lower	Higher
0011	Higher	Lower

Figure 533—RA field usage to make an allocation of 2 sub-bands with non-contiguous indices, using a single IE, in a 20 MHz system with Y_{SB} > 11

Allocation of 3 sub-bands

The values of the Indication Type Field (4 LSB bits of the RA field) from 0100 through 1111 indicate the assignment of 3 sub-bands. Denoting the assigned sub-bands as SB[x], SB[y] and SB[z], and further denoting SB[x]<-->SBP[u], SB[y]<-->SBP[v] and SB[z]<-->SBP[w], three sub-cases, and the interpretations of the ITF and RIF in each sub-case, are as follows.

Allocation of 3 sub-bands, with 2 of them in the same Sub-band Pair

In this sub-case of a 3 sub-band allocation, we have SB[x] and SB[y] belonging to the same SBP, i.e., SBP[u] = SBP[v]. The ITF values 0100 and 0101 indicate these cases, and shall be interpreted as follows.

1) ITF = 0100 => SB[z] is the lower SB index in SBP[w].

a) ITF = 0101 => SB[z] is the higher SB index in SBP[w].

The 7 bits of the Resource Indication Field shall be interpreted as in Table 826—to indicate the three sub-band pairs SBP[u], SPB[v], SBP[w] that have been allocated. Since SBP[u] = SBP[v], the table indicates SBP[u] & SBP[w].

Table 826—Mapping of 7 RIF bits to assignment of sub-band pairs SBP[u] (= SBP[v]) and SBP[w]

SBP[w] SBP[u] (= SBP[v])	0	1	2	3	4	5	6	7	8	9	10
0		0							7		9
1	10										19
2	20										29
3	30										39
4	40										49
5	50										59
6	60										69
7	70										79
8	80										89
9	90										99
10	100	101	102	103	104	105	106	107	108	109	

In the table, the decimal values of the 7 bits of the RIF increase from left to right and from top to bottom (the first and last values in each row of the table are shown). The shaded cells are not used to make interpretations. Each particular cell in the table, corresponding to a particular decimal value of the RIF, indicates the values of the SBPs SBP[u] (= SBP[v]) and SBP[w] that have been allocated.

Knowledge of the SBPs allocated from Table 826—, along with the information about the allocated sub-bands within the SBPs as indicated by the ITF, completes the allocation details for this sub-case.

For example, consider the case where the RA field = 00001110100, i.e., the decimal value of the RIF is 7 (= 0000111) and ITF = 0100. From the table above, the RIF maps to the 3 sub-band pairs SBP[u] = SBP[v] = 0 and SBP[w] = 8. SBP[0]<-->{SB[0], SB[1]}, while SBP[8] <-->{SB[16], SB[17]}. The ITF indicates that the lower SB index in SBP[8] is being allocated. Hence, the allocation is {SB[0], SB[1], SB[16]}.

This case is pictorially illustrated in Figure 534.

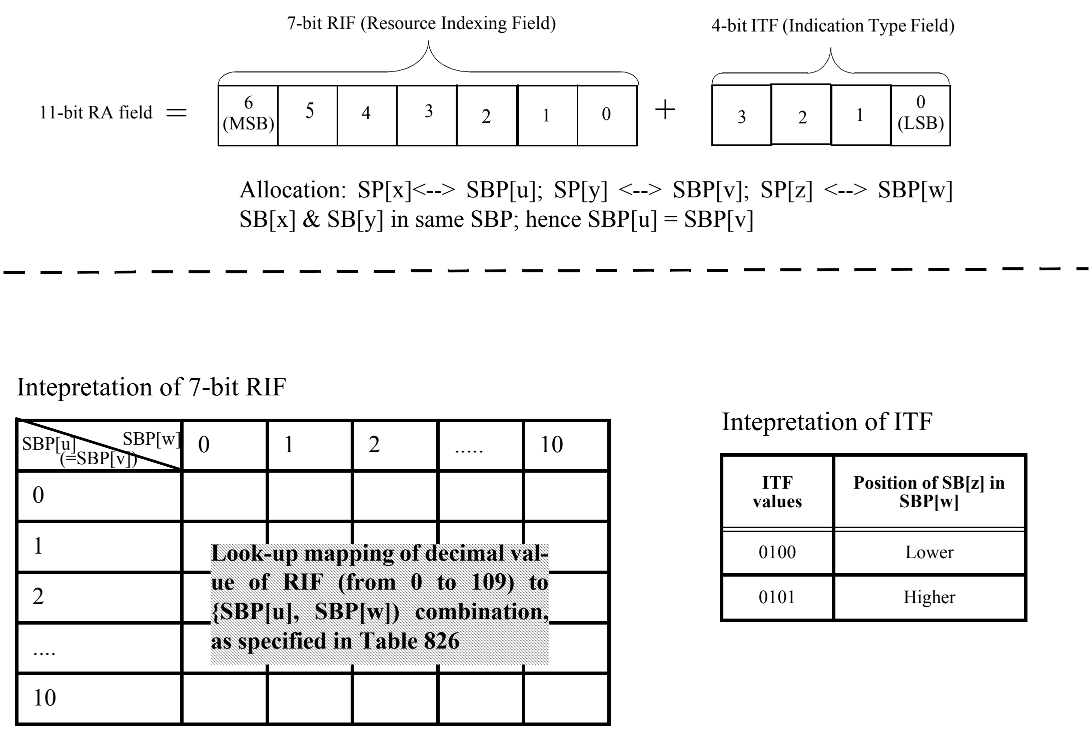


Figure 534—Allocation of 3 sub-bands, with 2 of them in the same sub-band pair, using a single IE, in a 20 MHz system with Y_{SB} > 11

Allocation of 3 sub-bands, with all 3 in different Sub-band Pairs, not including SBP[10]

In this sub-case of a 3 sub-band allocation, we have $SBP[u] \neq SBP[v] \neq SBP[w]$, and none of SBP[u], SBP[v] or SBP[w] equaling SBP[10].

The 8 ITF values from 0110 through 1101 shall indicate this sub-case, and these ITF values shall be interpreted as follows. They allow indication of all possible arrangements of the indicated 3 sub-bands SB[x], SB[y] and SB[z] within the 3 indicated sub-band pairs SBP[u], SBP[v] and SBP[w], and shall be interpreted as in Table 827—.

Table 827—Interpretation of the ITF from 0110 through 1101 (decimal 6 through 13)

ITF value	Position of SB[x] in SBP[u](Higher index/ Lower index)	Position of SB[y] in SBP[v](Higher index/ Lower index)	Position of SB[z] in SBP[w](Higher index/ Lower index)
0110	Higher	Higher	Higher
0111	Higher	Higher	Lower
1000	Higher	Lower	Higher
1001	Higher	Lower	Lower
1010	Lower	Higher	Higher
1011	Lower	Higher	Lower
1100	Lower	Lower	Higher
1101	Lower	Lower	Lower

The 7 bits of the Resource Indication Field shall be interpreted as in Table 828—to indicate the three sub-band pairs SBP[u], SPB[v], SBP[w] that have been allocated.

Table 828—Mapping of 7 RIF bits to assignment of 3 sub-band pairs SBP[u], SBP[v] and SBP[w]

SBP[w] / SBP[u], SBP[v]	2	3	4	5	6	7	8	9
0, 1	0				4			7
0, 2		8						14
0, 3			15					20

Table 828—Mapping of 7 RIF bits to assignment of 3 sub-band pairs SBP[u], SBP[v] and SBP[w]

SBP[w] / SBP[u], SBP[v]	2	3	4	5	6	7	8	9
0, 4				21				25
0, 5					26			29
0, 6						30		32
0, 7							33	34
0, 8								35
1, 2		36						42
1, 3			43					48
1, 4				49				53
1, 5					54			57
1, 6						58		60
1, 7							61	62
1, 8								63
2, 3			64					69
2, 4				70				74
2, 5					75			78
2, 6						79		81
2, 7							82	83
2, 8								84
3, 4				85				89
3, 5					90			93
3, 6						94		96
3, 7							97	98
3, 8								99
4, 5					100			103
4, 6						104		106
4, 7							107	108
4, 8								109
5, 6						110		112
5, 7							113	114

Table 828—Mapping of 7 RIF bits to assignment of 3 sub-band pairs SBP[u], SBP[v] and SBP[w]

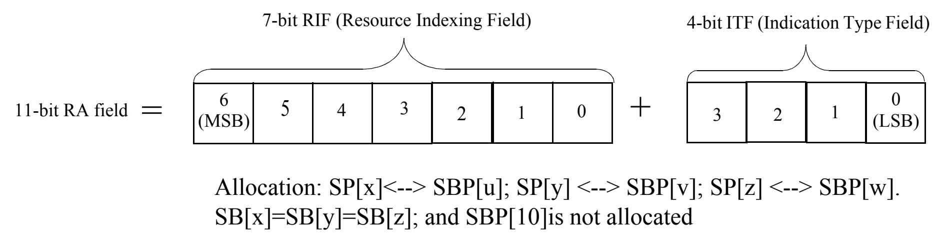
SBP[w] SBP[u], SBP[v]	2	3	4	5	6	7	8	9
5, 8								115
6, 7							116	117
6, 8								118
7, 8								119

In the table, the decimal values of the 7 bits of the RIF increase from left to right and from top to bottom (the first and last values in each row of the table are shown). The shaded values are not used to make interpretations. Each particular cell in the table, corresponding to a particular decimal value of the RIF, indicates the values of the SBPs SBP[u], SBP[v] and SBP[w] that have been allocated.

Knowledge of the SBPs allocated from Table 828—, along with the information about the allocated sub-bands within the SBPs as indicated by the ITF, completes the allocation details for this sub-case.

As an example. consider the case where the RA field = 00001000110, i.e., the decimal value of the RIF is 4 (= 0000100) and ITF = 0110. From the table above, the RIF maps to the 3 sub-band pairs SBP[u] = 0, SBP[v] = 1 and SBP[w] = 6. SBP[0]<-->{SB[0], SB[1]}, SBP[1]<-->{SB[2, SB[3]} and SBP[6]<--> {SB[12], SB[13]}. From Table 827—, ITF = 0110 implies that the allocated sub-bands are the ones with the higher indices in SPB[u], SPB[v] and SPB[w]. Hence, the allocation is {SB[1], SB[3], SB[13]}.

This case is pictorially illustrated in Figure 535.



Intepretation of 7-bit RIF

SBP[u], SBP[v] \ SBP[w]	2	3	4	.....	9
0,1					
...					
0,8					
1,2.					
...					
1,8					
2,3					
...					
2,8					
...					
7,8					

Look-up mapping of decimal value of RIF (from 0 to 109) to {SBP[u], SBP[v], SBP[w]) combination, as specified in combination, as specified in Table 828

Intepretation of ITF

ITF values	Position of SB[x] in SBP[u]	Position of SB[y] in SBP[v]	Position of SB[z] in SBP[w]
0110	higher	higher	higher
0111	higher	higher	lower
1000	higher	lower	higher
1001	higher	lower	lower
1010	lower	higher	higher
1011	lower	higher	lower
1100	lower	lower	higher
1101	lower	lower	lower

Figure 535—Allocation of 3 sub-bands, all in different sub-band pairs (except SBP[10]), using a single IE, in a 20 MHz system with Y_{SB} > 11

Allocation of 3 sub-bands, with all 3 in different Sub-band Pairs, including SBP[10]

In this sub-case of a 3 sub-band allocation, we have $SBP[u] \neq SBP[v] \neq SBP[w]$, with SBP[w] = SBP[10]. Hence, in this sub-case, we have one of the allocated sub-bands, SB[z] = SB[20].

The 2 ITF values 1110 and 1111 shall indicate this sub-case, and these ITF values shall be interpreted as follows.

1) ITF = 1110 => SB[x] and SB[y] are both the higher SB indices in SBP[u] and SBP[v] or both the lower indices in SBP[u] and SBP[v], respectively.

a) ITF = 1111 => Either SB[x] is the higher SB index in SBP[u] and SB[y] is the lower SB index in SBP[v], or SB[x] is the lower SB index in SBP[u] and SB[y] is the higher SB index in SBP[v].

The MSB bit of the RIF provides further indication about SB[x] and SB[y] as follows.

1) MSB bit of RIF = 0 => SB[x] is the higher SB index in SBP[u].

a) MSB bit of RIF = 1 => SB[x] is the lower SB index in SBP[u].

The values of the ITF and the MSB bit of the RIF, taken together, complete the information about SB[x] and SB[y].

The 6 LSB bits of the Resource Indication Field shall be interpreted as in Table 829—to indicate the sub-band pairs SBP[u] and SPB[v] that have been allocated.

Table 829—Mapping of 6 LSB bits of the 7-bit RIF bits to assignment of sub-band pairs SBP[u] and SBP[v]

SBP[v] / **SBP[u]**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	0					5			8
1		9							16
2			17						23
3				24					29
4					30				34
5						35			38
6							39		41
7								42	43
8									44

In the table, the decimal values of the 6 LSB bits of the RIF increase from left to right and from top to bottom (the first and last values in each row of the table are shown). The shaded values are not used to make interpretations. Each particular cell in the table, corresponding to a particular decimal value of the RIF, indicates the values of the SBPs SBP[u] and SBP[v] that have been allocated.

Knowledge of the SBPs allocated from Table 829—, along with the information about the allocated sub-bands within the SBPs as indicated by the ITF and the MSB bit of the RIF, completes the allocation details for this sub-case.

For example, consider RA field = 00001011110, with RIF = 0000101, and ITF = 1110. The 6 LSB bits of the RIF are 000101 (decimal value 5), which, from Table 829, map to SBP[u] = 0, SBP[v] = 6. Hence, the allocated sub-bands are in SBP[0] = {SB[0], SB[1]}, SBP[6] = {SB[12], SB[13]} and SBP[10] = {SB[20]}. The value of the ITF and the MSB of the RIF indicate that allocated sub-bands are the ones with the higher indices in SBP[0] and SBP[6]. Hence, the allocation is {SB[1], SB[13], SB[20]}.

This case is pictorially illustrated in Figure 536

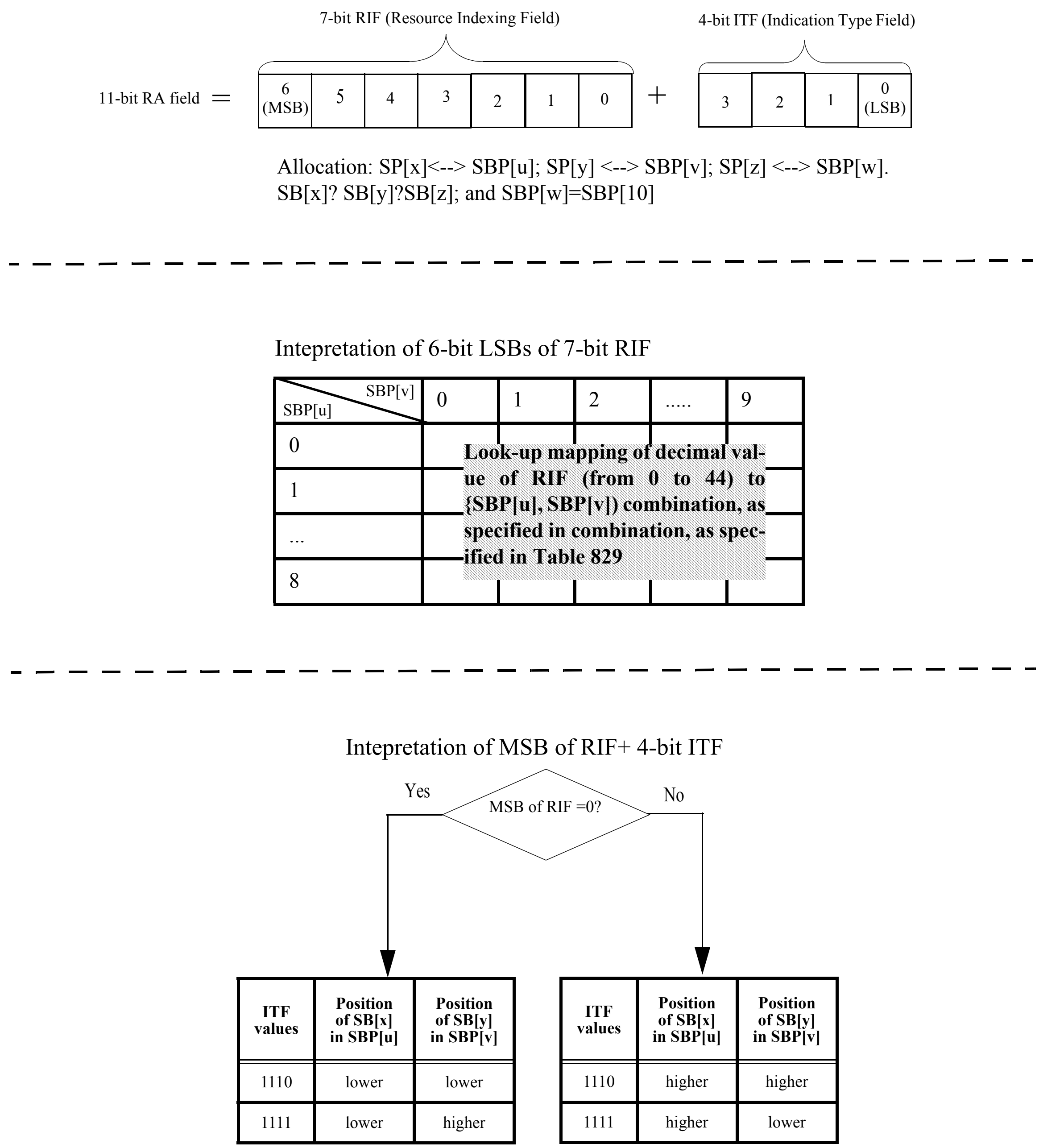


Figure 536—Allocation of 3 sub-bands, all in different sub-band pairs, including SBP[10], using a single IE, in a 20 MHz system with Y_{SB} > 11

16.3.6.5.2.4.4 UL Subband Assignment A-MAP IE

The UL Sub-band Assignment A-MAP IE shall have an identical structure to the UL Basic Assignment A-MAP IE. With the exception of the “IE Type” and the “Resource Allocation” field, all of the other fields shall be interpreted in the same manner as defined for the DL Basic Assignment A-MAP IE.

The “IE Type” field shall be set to the value 0b0010.

For all bandwidths, the “Resource Allocation” field shall be 11 bits long.

The structure and interpretation of the RA field for the UL Sub-band Assignment A-MAP IE shall be the same as that for the RA field for the DL Sub-band Assignment A-MAP IE, with all DL parameters/terms replaced by their UL equivalents.

16.3.6.5.2.4.5 Feedback Allocation A-MAP IE

Table 830 describes the fields in a Feedback Allocation A-MAP IE used for dynamically allocating or de-allocating UL fast feedback control channels (including both PFBCH and SFBCH) to an AMS. If an AMS has an existing fast feedback control channel for an active DL carrier and receives a new feedback channel allocation for the same active DL carrier, the original fast feedback channel is de-allocated automatically..

Definitions of the fields in the Feedback Allocation A-MAP IE are listed below in Table 830.

Channel Index: Uniquely identifies a fast feedback channel on which an AMS can transmit fast feedback information. With this allocation, a one-to-one relationship is established between channel index and the AMS.

ACK Allocation Flag: The ABS may set ACK Allocation Flag to 0b1 if Allocation Duration equals 0b000. ABS may set ACK Allocation Flag to 0b1 if Allocation Duration is not equal to 0b000 and the channel index of the newly allocated FBCH is the same as the channel index of the deallocated FBCH.

Short-term Feedback Period (*p*): Short-term feedback is transmitted on the FBCH every 2^p frames

Long-term Feedback Period (*q*): Long-term feedback is transmitted on the FBCH every 2^q short-term feedback reports are transmitted. If q = 0b00, long-term feedback is not used.

Allocation duration (*d*): A FBCH is transmitted on the FBCH channels indexed by Channel Index for 8×2^d frames. If d = 0b000, the FBCH is deallocated. If d = 0b111, the AMS shall report until the ABS command for the AMS to stop.

MFM: MIMO feedback mode, defined in Table 849.

Feedback Format: This field specifies the feedback format index when reporting fast feedback information in the FBCH. Feedback format definitions for different MIMO feedback modes are described in 16.3.9.3.1.4.

Table 830—Feedback Allocation A-MAP IE*

Syntax	Size (bit)	Notes
Feedback_Allocation_A-MAP_IE() {	-	-
A-MAP IE Type	4	Feedback Allocation A-MAP IE
Channel Index	6	Feedback channel index within the UL fast feedback control resource region (Dependent on $L_{FB,FPi}$ defined in 16.3.8.3.3.2)
Short-term feedback period (*p*)	3	Feedback is transmitted on the FBCH every 2^p frames
Long-term feedback Period (*q*)	2	Long-term feedback is transmitted on the FBCH every 2^q short-term feedback opportunities. If q = 0b00, either the short-term or the long-term feedback shall be reported by the AMS, depending on the feedback formats defined in 16.3.9.3.1.5
Frame_number	2	The AMS starts reporting at the frame which number in the superframe is equal to Frame_number. If the current frame is specified, the AMS starts reporting in four frames. Frames are numbered from 0 to 3 in the superframe. MIMO feedback reported by an AMS in frame *N* pertains to measurements performed at least up to frame *N*–1. The first MIMO feedback report following the Feedback Allocation A-MAP IE as per the “Frame_number” may contain invalid MIMO feedback information if the MIMO feedback is sent in the frame immediately following the frame in which the Feedback Allocation A-MAP IE was received.
Subframe index	3	Indicates the UL AAI subframe index in the UL portion of the frame
Allocation Duration(*d*)	3	An FBCH is transmitted on the FBCH channels indexed by Channel Index for 8×2^d frames. If d = 0b000, the FBCH is deallocated. If d = 0b111, the AM reports until the ABS command for the AMS to stop.
ACK allocation flag	1	Indicates if one ACK channel is allocated to acknowledge the successful detection of this IE.
if (ACK allocation flag == 0b1) {		

Table 830—Feedback Allocation A-MAP IE*

Syntax	Size (bit)	Notes
HFA	6	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
}		
MFM	3	MIMO Feedback Mode as defined in Table 849
if (MFM ≠ 1) {		
$MaxM_t$	*Variable* 1 or 2	Variable number of bits - depends on number of transmit antennas N_t If N_t =2: (Any MFM) 0b0: 1 0b1: 2 If N_t =4: (Any MFM) 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If N_t =8 (SU-MIMO, MFM 0,1,2,3,4) 0b00: 1 0b01: 2 0b10: 4 0b11: 8 If N_t =8: (MU-MIMO, MFM 5,6,7) 0b00: 1 0b01: 2 0b10: 3 0b11: 4
}		
if (MFM == 2,3,5,6) {		
Feedback Format	2	
}		
if (MFM == 0,4,7 & FPCT >1) {		Diversity Permutation and FFR is enabled
if (FPCT == 2){		

Table 830—Feedback Allocation A-MAP IE*

Syntax	Size (bit)	Notes
FPI	1	Frequency partition indication: ABS indicate AMS to send wideband CQI and STC rate of the frequency partition and reuse factor in the future: 0b0: Frequency partition index 1 0b1: Frequency partition index 2 ABS should set FPI to a value such that FPS_{FPI}>0
}		
else {		
FPI	2	Frequency partition indication: ABS indicate AMS to send wideband CQI and STC rate of the frequency partition and reuse factor in the future: 0b00: Frequency partition index 0 0b01: Frequency partition index 1 0b10: Frequency partition index 2 0b11: Frequency partition index 3 ABS should set FPI to a value such that FPS_{FPI}>0
}		
}		
if (MFM == 0 & *q*!= 0b00 & FPCT >1){		
if (FPCT == 2){		When FPCT=2, Long term FPI is implicitly signaled by FPI. ABS indicates to the AMS to send wideband CQI and STC rate for the second frequency partition using long term feedback.

Table 830—Feedback Allocation A-MAP IE*

Syntax	Size (bit)	Notes
Long-Short FPI Switch Flag		Used to inform the AMS to switch Short and Long term reporting based on the FPI of the latest data allocation. 0b0: FPI for Long & Short Term Period report remains constant for the Allocation Duration (d) 0b1: FPI for Long & Short Term Period interchange after every update of FPI of latest data allocation at the subsequent Long Term Feedback Opportunity.
} else {		
Long term FPI	2	Frequency partition indication: ABS indicate to the AMS to send wideband CQI and STC rate for the second frequency partition using long term feedback: 0b00: Frequency partition index 0 0b01: Frequency partition index 1 0b10: Frequency partition index 2 0b11: Frequency partition index 3 ABS should set Long term FPI to a different value than FPI and $FPS_{Long\ term\ FPI}$>0.
}		
}		
if (MFM == 3) {		SCL SU MIMO
Codebook_mode	2	Codebook Feedback Mode and Codebook Coordination 0b00: base mode with codebook coordination disabled 0b01: transformation mode with codebook coordination disabled 0b10: differential mode with codebook coordination disabled 0b11: base mode with codebook coordination enabled
if (N_t ==4) {		

Table 830—Feedback Allocation A-MAP IE*

Syntax	Size (bit)	Notes
Codebook_subset		0b0: report PMI from the base codebook or transformed base codebook 0b1: report PMI from the codebook subset or transformed codebook subset
}		
}		
if (MFM == 6) {		CL MU MIMO
Codebook_mode	2	Codebook Feedback Mode and Codebook Coordination Enable 0b00: reserved 0b01: transformation mode with codebook coordination disabled 0b10: differential mode with codebook coordination disabled 0b11: base mode with codebook coordination enabled
if (N_t ==4) {		
Codebook_subset	1	0b0: report PMI from the base codebook or transformed base codebook 0b1: report PMI from the codebook subset or transformed codebook subset
}		
}		
if (MFM == 4,7) {		CL SU and MU MIMO

Table 830—Feedback Allocation A-MAP IE*

Syntax	Size (bit)	Notes
Codebook_coordination	1	Codebook Feedback Mode and Codebook Coordination 0b0: base mode with codebook coordination disabled 0b1: base mode with codebook coordination enabled
if (N_t ==4) {		
Codebook_subset	1	0b0: report PMI from the base codebook 0b1: report PMI from the codebook subset
}		
}		
if(MFM==0,1,2,5) {		
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
Padding	*Variable*	Padding to reach byte boundary
}	-	-

*A 16 bit CRC is generated based on the contents of the Feedback Allocation A-MAP IE. The CRC is masked by the Station ID.

FPI: The frequency partition over which the short term period report shall be measured by the AMS.This field doesn't exist when FPCT=1.

Long term FPI: The frequency partition over which the long term period report shall be measured by the AMS. This field doesn't exist when FPCT=1 and is implicitly signaled using FPI when FPCT=2.

Long-Short FPI Switch Flag: This field indicates whether AMS switches Short and Long term reporting based on the FPI of the latest data allocation. If set to 0, the Long & Short term feedback reports do not change during fast feedback allocation duration. If set to 1, FPI for Long & Short Term Period interchange after every update of FPI of data allocation. The Long-Short interchange takes effect in the immediate "Long-term" FFB opportunity after sending the HARQ response to the data allocation.

$MaxM_t$: This field specifies the maximum rank to be fed back by the AMS if MFM=0,1,2,3,4 (which indicates a SU MIMO feedback mode for SM), or it specifies the maximum number of users scheduled on each RU at the ABS if MFM=5,6,7 (which indicates a MU MIMO feedback mode)

Codebook_coordination: When codebook coordination is enabled, if the AMS reports STC rate equal to 1, then the AMS shall find the rate-1 PMI from the codebook entries broadcasted in BC_SI in AAI_DL_IM Message.

Codebook_mode: This field specifies thecodebook feedback mode.If codebook coordination is enabled by setting Codebook_mode to 0b11 and if the AMS reports STC rate equal to 1, then the AMS shall find the rate-1 PMI from the codebook entries broadcasted in BC_SI in AAI_DL_IM Message.

Measurement Method Indication: This field indicates the use of midamble or pilots for CQI measurement.

For SU MIMO feedback modes, the he ABS should choose $MaxM_t \le min(N_t, N_r)$ .The AMS should apply an additional constraint in the choice of its STC rate feedback: $M_t \le MaxM_t$, where N_t is the number of transmit antennas at the ABS, N_r is the number of receive antennas at the AMS, and $MaxM_t$ is indicated in the Feedback Allocation A-MAP IE.

The DL Basic Assignment A-MAP IE sent by the ABS can indicate any value of M_t as long as it complies with $M_t \le min(N_t, N_r)$. There is no constraint on the assigned M_t relative to $MaxM_t$ for an allocation outside the open-loop region. M_t shall be equal to $MaxM_t$ for an allocation in the open-loop region with $MaxM_t$ streams.

$MaxM_t$ should be interpreted as a function of Measurement Method Indication and the MIMO Feedback Mode.

If Measurement Method Indication == 0b0:

- With an MFM supporting MU MIMO operation, $MaxM_t$ indicates the maximum number of users the AMS should assume will be scheduled in future MU MIMO allocations. Based on this information, the AMS may make a better estimation of the multiuser interference in the CQI. If $MaxM_t$ is set to one, then the AMS shall assume it will be paired with no other AMSs when it calculates CQI. If MFM 5 is indicated in the Feedback Allocation A-MAP IE, $MaxM_t$ indicates the unitary matrix from which the AMS should feedback its preferred stream index on a given physical subband.
- With an MFM supporting SU MIMO operation, MaxMt indicates the maximum STC rate allowed in the feedback report of the AMS. The ABS also uses $MaxM_t$ to make sure that the STC rate feedback is in accordance to STC rate $\le min(N_t, N_r)$ for the AMS. For an MFM requesting OL MIMO feedback for operation with a diversity allocation, setting $MaxM_t = 2$ enforces feedback for DLRU, otherwise the AMS may feedback STC rate up to 4.With MFM 0, $MaxM_t = 1$, indicates that the AMS shall feedback the wideband CQI for SFBC

If Measurement Method Indication == 0b1:

- *MaxM*$_t$ indicates the rank of the open-loop region for which the feedback shall be provided. The open-loop region type can be deduced from *MaxM*$_t$ and MFM. *MaxM*$_t$ indicates the pilot pattern used in the OL region in which CQI measurements should be taken by the AMS.

16.3.6.5.2.4.6 UL Sounding Command A-MAP IE

Table 831 specifies the fields of UL Sounding Command A-MAP IE used by the ABS to request sounding transmission by the AMS.

The number of UL sounding transmissions per frame that the ABS allocates to an AMS shall be less than or equal to one.

Table 831—UL Sounding Command A-MAP IE*

Syntax	Size (bit)	Notes
UL_Sounding_Command_A-MAP_IE() {	-	-
A-MAP IE type	4	UL Sounding Command A-MAP IE
Sounding AAI subframe	2	Indicates the sounding AAI subframe. AAI subframes with sounding symbol are renumbered in time starting from 0.
Sounding subband bitmap	variable max. 24	FFT size dependant
If (Multiplexing type == 0) {		
Decimation offset d	5	Unique decimation offset
} else {		
Cyclic time shift m	5	Unique cyclic shift
}		
Periodicity (p)	3	0b000 = Single command, not periodic, or terminate the periodicity. Otherwise, repeat sounding once per $2^{(p-1)}$ frames, where p is decimal value of the periodicity field
Antenna switching	1	0b0: Antenna switching 0b1: No antenna switching
Padding	variable	Padding
}		

d: Sounding channel index indicates unique decimation offset

n: Sounding channel index indicates unique cyclic time shift.

*A 16-bit CRC is generated based on the contents of the UL Sounding Command A-MAP IE. The CRC is masked by the Station ID.

Table 831 specifies the fields of UL Sounding Command A-MAP IE used by the ABS to request sounding transmission by the AMS. Decimal equivalent of the sounding AAI subframe indicates the AAI subframe number with sounding symbol (the first AAI subframe in frame is indexed 0). The sounding subband bitmap field is used to indicate the sounding subbands used in the sounding allocation. For that purpose, the N_{used} contiguous subcarriers are divided into sounding subbands, where each sounding subband compromises $N_1 * N_{sc}$ adjacent subcarriers with N_1= 4 and N_{sc} = 18 for N_{FFT} = 512, 1024 and 2048. The MSB of the Sounding subband bitmap field corresponds to the sounding subband with lowest subcarrier indexes. The three periodicity bits are used to indicate the AMS to periodically repeat the sounding transmission. Setting periodicity bits to 0b000 indicates a single sounding command or terminates the sounding if periodic sounding command is being performed.

If the antenna switching flag equals 0, the AMS sounds with antenna switching, while if the antenna switching flag equals 1, the AMS sounds all transmit antennas. If the antenna switching field equals 1 then the i^{th} antenna of the AMS corresponds to the actual decimation offset $g = d + i - 1$ for multiplexing type 0 or to the actual cyclic shift index $n = m + i - 1$ for multiplexing type 1. The AMS transmit antennas are indexed starting from one.

16.3.6.5.2.4.7 CDMA Allocation A-MAP IE

Table 832—CDMA Allocation A-MAP IE*

Syntax	Size (bits)	Notes
CDMA_Allocation_A-MAP IE() {	-	-
A-MAP IE Type	4	CDMA Allocation A-MAP IE
CDMA allocation indication	1	0b0: Bandwidth allocation for bandwidth request. 0b1: Bandwidth allocation for ranging
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.

Table 832—CDMA Allocation A-MAP IE*

Syntax	Size (bits)	Notes
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 DL AAI subframes for FDD or all DL AAI subframes for TDD
$I_{SizeOffset}$	5	Offset used to compute burst size index
HFA	3	HARQ Feedback Allocation
Reserved	15	Reserved bits
}	-	-

*A 16 bit CRC is generated based on the contents of the CDMA Allocation A-MAP IE. The CRC is masked by the RAID.

16.3.6.5.2.4.8 DL PA A-MAP IE

The DL persistent allocation A-MAP IE is specified in Table 833.

Table 833—DL Persistent Allocation A-MAP IE*

Syntax	Size (bit)	Description/Notes
DL Persistent Allocation A-MAP_IE() {	-	-
A-MAP IE Type	4	DL Persistent Allocation A-MAP IE
Allocation Period	2	Period of persistent allocation. If (Allocation Period==0b00), it indicates the deallocation of a persistently allocated resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 8 frames
if (Allocation Period==0b00){		
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 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 of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 DL AAI subframes for FDD or all DL AAI subframes for TDD

Table 833—DL Persistent Allocation A-MAP IE*

Syntax	Size (bit)	Description/Notes
HFA	6	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
Reserved	16	Reserved bits
} else if (Allocation Period != 0b00){		
$I_{SizeOffset}$	5	Offset used to compute burst size index
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Horizontal encoding 0b11: CDR
if (MEF == 0b01){		Parameters for vertical encoding
M_t	3	Number of streams in transmission $M_t \leq N_t$ N_t : Number of transmit antennas at the ABS 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
Reserved	1	
} else if(MEF == 0b10){		Parameters for horizontal encoding

Table 833—DL Persistent Allocation A-MAP IE*

Syntax	Size (bit)	Description/Notes
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 stream 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 of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 DL AAI subframes for FDD or all DL AAI subframes for TDD
HFA	3	HARQ Feedback Allocation
N_ACID	2	Number of ACIDs for implicit cycling of HARQ channel identifier. 0b00: 2 0b01: 3 0b10: 4 0b11: 8
Initial_ACID	4	Initial value of HARQ channel identifier for implicit cycling of HARQ channel identifiers.
Reserved	2	Reserved bits

Table 833—DL Persistent Allocation A-MAP IE*

Syntax	Size (bit)	Description/Notes
}		
}	-	-

*A 16 bit CRC is generated based on the contents of the DL Persistent Allocation A-MAP IE. The CRC is masked by the Station ID

The Resource Index field in the DL Persistent Allocation A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE

16.3.6.5.2.4.9 UL PA A-MAP IE

The UL persistent allocation A-MAP IE is specified in Table 834.

Table 834—UL Persistent Allocation A-MAP IE*

Syntax	Size (bit)	Description/Notes
UL Persistent A-MAP_IE() {	-	-
A-MAP IE Type	4	UL Persistent Allocation A-MAP IE
Allocation Period	2	Period of persistent allocation If (Allocation Period==0b00), it indicates the deallocation of persistent resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 8 frames
If (Allocation Period==0b00){		
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 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 of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 DL AAI subframes for FDD or all DL AAI subframes for TDD
HFA	6	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
Reserved	16	Reserved bits

Table 834—UL Persistent Allocation A-MAP IE[*]

Syntax	Size (bit)	Description/Notes
} else if (Allocation Period != 0b00){		
$I_{SizeOffset}$	5	Offset used to compute burst size index
M_t	1	Number of streams in transmission $M_t \le N_t$ up to 2 streams per AMS supported N_t : Number of transmit antennas at the AMS 0b0: 1 stream 0b1: 2 streams
TNS	2	Total number of streams in the LRU for CSM 0b00: reserved 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
if(TNS >M_t){		
SI	2	First pilot index for CSM with TNS = 2 streams: 0b00, 0b01 First pilot index for CSM with TNS = 3,4 streams: 0b00, 0b01, 0b10, 0b11
}		
else if (TNS == Mt) {		
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding
Reserved	1	Reserved bits
}		
PF	1	Precoding Flag 0b0: non adaptive precoding 0b1: adaptive precoding using the precoder of rank M_t of the AMS's choice
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 of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL AAI subframes for TDD If number of DL AAI subframes, D is less than number of UL AAI subframes, U, Long TTI Indicator= 0b1

Table 834—UL Persistent Allocation A-MAP IE*

Syntax	Size (bit)	Description/Notes
HFA	3	HARQ Feedback Allocation
N_ACID	2	Number of ACIDs for implicit cycling of HARQ channel identifier. 0b00: 2 0b01: 3 0b10: 4 0b11: 8
Initial_ACID	4	Initial value of HARQ channel identifier for implicit cycling of HARQ channel identifiers.
Reserved	2	Reserved bits
}	-	-
}	-	-

*A 16 bit CRC is generated based on the contents of the UL Persistent Allocation A-MAP IE. The CRC is masked by the Station ID

The Resource Index field in the UL Persistent Allocation A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IEwith 'DL' specific terminology replaced by 'UL' equivalents.

16.3.6.5.2.4.10 Group resource allocation A-MAP IE

Group control information is used to allocate resources to one or multiple AMSs within a user group. The Group Resource Allocation A-MAP IE is used for signaling group resource allocation in the DL or UL. The Group Resource Allocation A-MAP IE is shown in Table 835 .

Group scheduling requires two operations

1) Assignment of an AMS to a group. In order to add a AMS to a group in the DL or UL, the ABS shall transmit a Group Configuration MAC control message.

2) Allocation of resources to AMSs within a group. In order to assign resources to one or more AMSs in a group, the ABS shall transmit the Group Resource Allocation A-MAP IE. The Group Resource Allocation A-MAP IE is included in user-specific resource assignment in an A-MAP region. The GRA A-MAP IE contains bitmaps to indicate scheduled AMSs and signal MIMO mode HARQ burst size and resource size.

Table 835—Group Resource Allocation A-MAP IE*

Syntax	Size (bit)	Description/Notes
Group_Resource_Allocation_A-MAP_IE() {	-	-
A-MAP IE Type	4	Group Resource Allocation A-MAP IE

Table 835—Group Resource Allocation A-MAP IE[*]

Syntax	Size (bit)	Description/Notes
User Bitmap	*Variable*	Bitmap to indicate scheduled AMSs in a group. The size of the bitmap is equal to the User Bitmap Size signaled to each AMS in the Group configuration MAC control message. 0b0: AMS not allocated in this AAI subframe 0b1: AMS allocated in this AAI subframe
Resource Offset	7	Indicates starting LRU for resource assignment to this group
HFA Offset	6	Indicates the start of the HARQ feedback channel index used for scheduled allocations.
if(Group MIMO mode set ==0b01){		
MIMO Bitmap	*Variable*	Bitmap to indicate MIMO mode for the scheduled AMSs. 0b0: Mode 0 0b1: Mode 1
}		
Resource Assignment Bitmap	*Variable*	Bitmap to indicate burst size/resource size for each scheduled AMS
}	-	-

[*]Depending upon its size, the Group Resource Allocation A-MAP IE may have one segment or may be broken into multiple segments, each of which is coded separately. A 16-bit CRC shall be generated based on the contents of each segment. The CRC is masked with the 12 bit Group ID of the corresponding group. Knowledge of the "User Bitmap" field, which always appears in the first segment, is used to infer the sizes of the other variable length fields. Hence, the total size of the GRA A-MAP IE, as well as the number of segments it is partitioned into, can be inferred from the first segment.

Resource Offset: Signals the offset of the LRU where the allocation for the group starts. The offset is with respect to the start of the AAI subframe.

HFA Offset: Signals the starting HARQ feedback channel index for scheduled AMSs of the group (as identified by 1's in the User bitmap). The exact HARQ feedback allocation for a given AMS is determined by using the mechanism described in 16.3.8.3.3.2 for DL GRA allocations and 16.3.6.3.2.2 for UL GRA allocations

User Bitmap: A bitmap that uses 1 bit per AMS of the group to signal whether the AMS has an allocation in that AAI subframe. The size of the bitmap is determined by BS and can be 8, 16 or 32 bits. This size is signaled to each AMS in the Group configuration MAC control message when the user is added to the group. The AMSs for which the corresponding bit is set to 1 are referred to as scheduled AMSs in that subframe.

MIMO Bitmap: This bitmap is included in the group only when the group MIMO mode set is 0b01. The MIMO mode set is signaled to AMS in the Group configuration MAC control message when the user is added to the group. The size of this bitmap is equal to the number of scheduled AMSs in the group in that subframe. For each scheduled AMS, the value of corresponding bit in this bitmap signals the MIMO mode (mode 0 or mode 1).

Resource Allocation Bitmap: The resource allocation bitmap uses 5 bits per AMS to signal the HARQ burst size and the resource size for the AMS's allocation in that subframe. The first 2 bits signal the HARQ burst size and the next 3 bits signal the resource size. The 2-bit and 3-bit codes for burst sizes and resource sizes respectively for the group are determined by each AMS based on the information in the Group Configuration MAC control message

16.3.6.5.2.4.11 Feedback Polling A-MAP IE

The information element shown in Table 836 is used by the ABS to schedule MMO feedback transmission by the AMS. The AMS sends the MIMO feedback using a MAC control message or an extended header, depending on the requested feedback content.

When the Polling_sub_type bit is set to 0b0, a dedicated UL allocation is included in this IE. The dedicated UL allocation shall be used by the AMS to transmit feedback at the designated feedback transmission frame defined by this IE. When the Polling_sub_type bit is set to 0b1, no dedicated UL allocation is included. Instead, at the designated transmission frame defined by this IE, the AMS shall compose the feedback and the ABS shall either include a UL allocation for the transmission using UL Basic Assignment A-MAP IE or UL Subband Assignment A-MAP IE, or the AMS shall transmit in a dedicated UL allocation assigned by a previous Feedback Polling A-MAP IE with feedback periods designating the same transmission frames..

The AMS shall send the feedback in an extended header when the following feedback information is requested:

- wideband information for MIMO feedback modes 0, 1, 4 and 7
- subband information for 1 subband for MIMO feedback modes 2, 3, 5 and 6

The AMS shall send the feedback in a MAC control message when the following feedback information is requested:

- subband information for more than one subband for MIMO feedback modes 2, 3, 5 and 6
- multi-BS feedback

The coefficients of the quantized transmit correlation matrix should be feedback in Correlation Matrix Feedback Extended Header (CMFEH) when no AAI_SingleBS_MIMO_FBK message is sent in the same packet if the ABS is equipped with 2 or 4 transmit antennas. Otherwise, the coefficients of the quantized transmit correlation matrix should be feedback in AAI_SingleBS_MIMO_FBK message. The coefficients of the quantized transmit correlation matrix shall be feedback in AAI_SingleBS_MIMO_FBK message if the ABS is equipped with 8 transmit antennas.

In case of feedback for MIMO feedback mode 0 with Measurement Method Indication = 0b0, and MIMO feedback modes 4 or 7, the AMS shall feedback the CQI for FP_0 if $FPS_0 > 0$, or for FP_k if $FPS_0 > 0$, where FP_k is determined by k = floor($IDcell$/256) +1 for FPCT=3 or k = floor($IDcell$/384)+1 for FPCT=2.

MIMO feedback reported by an AMS in frame *N* pertains to measurements performed at least up to frame *N*-1. The first MIMO feedback report following the Feedback Polling A-MAP IE may contain invalid MIMO feedback information if the MIMO feedback is sent in the frame immediately following the frame in which the Feedback Polling A-MAP IE was received.

Table 836—Feedback Polling A-MAP IE*

Syntax	Size (bits)	Notes
Feedback_Polling_A-MAP_IE(){		
A-MAP IE Type	4	Feedback Polling A-MAP IE
Polling_sub_type	1	0b0: uplink resource allocation or de-allocation. 0b1: feedback mode allocation or de-allocation.
if (Polling_sub_type == 0b0){		
Allocation Duration (d)	3	The allocation is valid for $2^{(d-1)}$ superframes starting from the superframe defined by allocation relevance. If d == 0b000, the pre-scheduled feedback transmission is released. If d == 0b111, the pre-scheduled feedback transmission shall be valid until the ABS commands to release it.
if (d ==0b000){		Feedback de-allocation
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 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
Polling_deallocation_bitmap	3	
HFA	3	HARQ feedback channel allocation for Feedback Channel De-allocation confirmation
} else if (d !=0b000){		Feedback allocation
$I_{SizeOffset}$	5	Offset used to compute burst size index

Table 836—Feedback Polling A-MAP IE[*]

Syntax	Size (bits)	Notes
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 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
MEF	2	MIMO encoder format for uplink feedback transmission Non-adaptive precoding shall be used at the AMS. 0b00: SFBC 0b01: Vertical encoding with M_t = 2, or M_t =1 if AMS has 1 tranmsit antenna 0b10: CSM with TNS = 2, M_t =1, SI =1 0b11: CSM with TNS = 2, M_t =1, SI =2
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL AAI subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator = 0b1
HFA	3	HARQ feedback channel allocation for Feedback Channel De-allocation confirmation
ACID	4	HARQ channel identifier
MFM_allocation_index	2	0b00: MFM 0 with Measurement Method Indication = 0 0b01: MFM 3 with all subbands 0b10: MFM 6 with all subbands 0b11: MFM is defined in Feedback Polling A-MAP IE with Polling_sub-type = 0b1
$MaxM_t$	1~2	

Table 836—Feedback Polling A-MAP IE*

Syntax	Size (bits)	Notes
Period	4	Resource is allocated at frames designated by every short and long period. The short feedback period is *p* frames. The long feedback period is *q* superframes. The first allocation shall start two frames later. The AAI subframe index is defined as in 16.2.14.2.2 and the AAI frame index is given by *i+2*, where i is the index of the frame where the Feedback Polling A-MAP IE is transmitted. The feedback of MIMO feedback modes in MFM_allocation_index is allocated on the short period. The feedback of the transmit correlation matrix is allocated on the long period if $q > 0$. Short and long period reports shall start at the first allocation. When short and long period feedback reports coincide in the same frame, both short period feedback content and long period feedback content shall be sent in the same burst. 0b0000: $p = 1$, $q = 0$ 0b0001: $p = 2$, $q = 0$ 0b0010: $p = 4$, $q = 0$ 0b0011: $p = 8$, $q = 0$ 0b0100: $p = 16$, $q = 0$ 0b0101: $p = 1$, $q = 1$ 0b0110: $p = 2$, $q = 1$ 0b0111: $p = 1$, $q = 2$ 0b1000: $p = 2$, $q = 2$ 0b1001: $p = 4$, $q = 2$ 0b1010: $p = 1$, $q = 4$ 0b1011: $p = 2$, $q = 4$ 0b1100: $p = 4$, $q = 4$ 0b1101: $p = 0$, $q = 1$ 0b1110: $p = 0$, $q = 2$ 0b1111: $p = 0$, $q = 4$
}		
}else{		Polling_sub_type == 0b1
ACK Allocation Flag	1	
if (ACK Allocation Flag == 0b1)		
HFA	6	HARQ feedback channel allocation to acknowledge the successful detection of this IE.
}		

Table 836—Feedback Polling A-MAP IE*

Syntax	Size (bits)	Notes
Allocation Duration (d)	3	The allocation is valid for $2^{(d-1)}$ superframes starting from the superframe defined by allocation relevance. If d == 0b000, the pre-scheduled feedback transmission is released. If d == 0b111, the pre-scheduled feedback transmission shall be valid until the ABS commands to release it.
if (d ==0b000){		Feedback de-allocation
Polling_deallocation_bitmap	3	
} else {		Feedback allocation
MIMO_feedback_IE_type	1	
if (MIMO_feedback_IE_type == 0b0){		0b0: feedback allocation for single-BS MIMO operation 0b1: feedback allocation for multi-BS MIMO operation
MFM_bitmap	8	If a currently allocated MFM is indicated in the MFM_bitmap, it indicates a deallocation and reallocation of this MFM. ACK Allocation Flag shall be set to 0b1 in this case.

Table 836—Feedback Polling A-MAP IE*

Syntax	Size (bits)	Notes
Period	4	Resource is allocated at frames designated by every short and long period. The short feedback period is *p* frames. The long feedback period is *q* superframes. The first allocation shall start two frames later. The AAI subframe index is defined as in 16.2.14.2.2 and the AAI frame index is given by *i+2*, where i is the index of the frame where the Feedback Polling A-MAP IE is transmitted. The feedback of MIMO feedback modes in MFM_allocation_index is allocated on the short period. The feedback of the transmit correlation matrix is allocated on the long period if $q > 0$. Short and long period reports shall start at the first allocation. When short and long period feedback reports coincide in the same frame, both short period feedback content and long period feedback content shall be sent in the same burst. 0b0000: $p = 1$, $q = 0$ 0b0001: $p = 2$, $q = 0$ 0b0010: $p = 4$, $q = 0$ 0b0011: $p = 8$, $q = 0$ 0b0100: $p = 16$, $q = 0$ 0b0101: $p = 1$, $q = 1$ 0b0110: $p = 2$, $q = 1$ 0b0111: $p = 1$, $q = 2$ 0b1000: $p = 2$, $q = 2$ 0b1001: $p = 4$, $q = 2$ 0b1010: $p = 1$, $q = 4$ 0b1011: $p = 2$, $q = 4$ 0b1100: $p = 4$, $q = 4$ 0b1101: $p = 0$, $q = 1$ 0b1110: $p = 0$, $q = 2$ 0b1111: $p = 0$, $q = 4$
if (LSB #0 in MFM_bitmap == 1){		MFM 0
$MaxM_t$	1~2	
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
if (LSB #1 in MFM_bitmap == 1){		MFM 1
$MaxM_t$	2	

Table 836—Feedback Polling A-MAP IE*

Syntax	Size (bits)	Notes
Measurement Method Indication	1	0b0: Reserved 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
if (LSB #2 in MFM_bitmap == 1){		MFM 2
$MaxM_t$	1~2	
Num_best_subbands	2	0b00: report all subbands 0b01: 1 best subband 0b10: min{6, Y_{SB}} best subbands 0b11: min{12, Y_{SB}} best subbands $1 \leq$ Num_best_subbands $\leq Y_{SB}$
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
if (LSB #3 in MFM_bitmap == 1){		MFM 3
$MaxM_t$	1~2	
Num_best_subbands	2	0b00: report all subbands 0b01: 1 best subband 0b10: min{6, Y_{SB}} best subbands 0b11: min{12, Y_{SB}} best subbands $1 \leq$ Num_best_subbands $\leq Y_{SB}$
if (q == 0){		
Codebook_coordination	1	0b0: base mode with codebook coordination disabled 0b1: base mode with codebook coordination enabled
}		
if (N_t == 4){		
Codebook_subset		0b0: report PMI from the base codebook or transformed base codebook 0b1: report PMI from codebook subset or transformed codebook subset
}		
}		
if (LSB #4 in MFM_bitmap == 1){		MFM 4

Table 836—Feedback Polling A-MAP IE*

Syntax	Size (bits)	Notes
$MaxM_t$	1~2	
if (q == 0){		
Codebook_coordination	1	0b0: base mode with codebook coordination disabled 0b1: base mode with codebook coordination enabled
}		
if (N_t == 4){		
Codebook_subset		0b0: report PMI from the base codebook 0b1: report PMI from codebook subset
}		
}		
if (LSB #5 in MFM_bitmap == 1){		MFM 5
$MaxM_t$	1~2	
Num_best_subbands	2	0b00: report all subbands 0b01: 1 best subband 0b10: min{6, Y_{SB}} best subbands 0b11: min{12, Y_{SB}} best subbands $1 \leq$ Num_best_subbands $\leq Y_{SB}$
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
if (LSB #6 in MFM_bitmap == 1){		MFM 6
$MaxM_t$	1~2	
Num_best_subbands	2	0b00: report all subbands 0b01: 1 best subband 0b10: min{6, Y_{SB}} best subbands 0b11: min{12, Y_{SB}} best subbands $1 \leq$ Num_best_subbands $\leq Y_{SB}$
if (q == 0){		
Codebook_coordination	1	0b0: base mode with codebook coordination disabled 0b1: base mode with codebook coordination enabled
}		

Table 836—Feedback Polling A-MAP IE*

Syntax	Size (bits)	Notes
if (N_t == 4){		
Codebook_subset	1	0b0: report PMI from the base codebook 0b1: report PMI from codebook subset
}		
} else{		Multi-BS MIMO feedback request
Period (*p*)	3	
TRU	2	Target RU indicating which RUs or which type of RU to work on for feedback 0b00: Latest best subbands reported for single BS MIMO 0b01: Whole bandwidth 0b10: FFR partition 0 0b11: boosted FFR partition
ICT	2	0b00: PMI restriction for single-BS precoding; 0b01: PMI recommendation for single-BS precoding; 0b10: CL-MD for multi-BS precoding; 0b11: Co-MIMO for multi-BS precoding;
if (N_t == 4){		
Codebook_subset	1	0b0: report PMI from the base codebook 0b1: report PMI from codebook subset
}		
N_multiBS_reports	3	Indicates the number of reports
if (ICT== 0b11){		
MaxUser	2	Maximum number of users supported in Co-MIMO in the same resource. 0b00: 2 users 0b01: 3 users 0b10: 4 users 0b11: reserved
}		
}		
}		
}		
Padding	*Variable*	Padding to reach byte boundary
}		

*A 16 bit CRC is generated based on the contents of the Feedback Polling A-MAP IE. The CRC is masked by the Station ID

Parameters in the Feedback Polling A-MAP IE should be interpreted as for the Feedback Allocation A-MAP IE.

$MaxM_t$: The possible values of MaxMt follow the rules of the Feedback Allocation A-MAP IE.

ACID: HARQ channel identifier. If q=0 or p=0, a single ACID is reserved. Otherwise, two ACIDs are reserved. The second ACID is obtained as ACID+1 modulo 15. When two feedback periods are allocated, the AMS shall send packets at the long period feedback reports with the first ACID, and the AMS shall send packets at the short period feedback reports with the second ACID.

For uplink retransmissions of MIMO feedback, the ABS shall allocate an uplink resource with the UL Basic Assignment A-MAP IE and the ACID corresponding to the packet to retransmit. Retransmissions shall obey the following rules:

- If the retransmission process for the previous HARQ burst is not finished before a new HARQ burst with the same ACID is transmitted, the retransmission process for the previous HARQ burst is terminated and the new HARQ burst overrides it.
- If the retransmission process for the previous HARQ burst reporting short-period feedback is not finished before a new HARQ burst reporting long-period feedback is transmitted, the retransmission process for the previous HARQ burst reporting short-period feedback is terminated and the new HARQ burst overrides it.
- If the retransmission process for the previous HARQ burst reporting long-period feedback is not finished before a new HARQ burst reporting short-period feedback is transmitted, the retransmission process for the previous HARQ burst reporting short-period feedback is carried on, but the short-period feedback content of the retransmitted packet shall be discarded by the ABS and the new HARQ burst reporting short-period feedback overrides it.

Polling_deallocation_bitmap: An AMS supports a maximum of 3 distinct concurrent feedback allocations, including one or several MFMs, the transmit correlation matrix, and multiBS MIMO feedback. Ordering of concurrent allocations in the Polling_deallocation_bitmap shall follow the order MFM i, MFM j $(j>i)$, k $(k>j)$, transmit correlation matrix, multiBS MIMO feedback, as shown in Table 837.

Table 837—Polling Deallocation Bitmap

Polling_deallocation_bitmap bit #2 (MSB)	Polling_deallocation_bitmap bit #1	Polling_deallocation_bitmap bit #0 (LSB)
MFM i	MFM j (j>i)	MFM $k(k>j)$
MFM i	MFM j (j>i)	Transmit correlation matrix
MFM i	MFM j (j>i)	MultiBS MIMO feedback

Table 837—Polling Deallocation Bitmap

Polling_deallocation_bitmap bit #2 (MSB)	Polling_deallocation_bitmap bit #1	Polling_deallocation_bitmap bit #0 (LSB)
MFM *i*	Transmit correlation matrix	MultiBS MIMO feedback
MFM *i*	MFM *j (j>i)*	N.A.
MFM *i*	Transmit correlation matrix	N.A.
MFM *i*	MultiBS MIMO feedback	N.A.
Transmit correlation matrix	MultiBS MIMO feedback	N.A.
MFM *i*	N.A.	N.A.
Transmit correlation matrix	N.A.	N.A.
MultiBS MIMO feedback	N.A.	N.A.

Period: The setting of short and long periods p and q when Polling_sub_type = 0b0 and MIMO_feedback_IE_type = 0b0 shall obey the rules below.

For MFM 0 or 1: When $p > 0$, $q = 0$, the wideband CQI and wideband STC rate shall be transmitted using short feedback period. $p > 0$ and $q > 0$ shall not be set at the same time with MFM 0 or 1.

For MFM 2 or 5: When $p > 0$, $q = 0$, the Best_subbands_index, subband CQI and Stream index shall be transmitted using short feedback period. $p > 0$ and $q > 0$ shall not be set at the same time with MFM 2 or 5.

For MFM 3: when $p > 0$, $q = 0$, the Best_subbands_index, STC_Rate, subband CQI and subband PMI from the base codebook shall be transmitted using short period. When $p > 0$, $q = 0$, only the correlation matrix shall be transmitted using long feedback period. When $p > 0$, $q > 0$, the Best_subbands_index, STC_Rate, subband CQI and subband PMI from the transformed codebook shall be transmitted using short period, while the correlation matrix shall be transmitted using long period.

For MFM 6: When $p > 0$, $q > 0$, the Best_subbands_index, STC_Rate, subband CQI and subband PMI from the transformed codebook shall be transmitted using short period, while the correlation matrix shall be transmitted using long period. When $p = 0$ and $q > 0$, only the correlation matrix shall be transmitted using long feedback period. The ABS shall not set $p > 0$ and $q = 0$ simultaneously unless it has previously allocated feedback for the correlation matrix, in which case the Best_subbands_index, STC_Rate, subband CQI and subband PMI from the transformed codebook shall be transmitted using short period.

For MFM 4: when $p > 0$ and $q = 0$, the wideband CQI, STC rate and PMI from the base codebook shall be transmitted using short feedback period. When $p > 0$ and $q > 0$, the wideband CQI and STC rate shall be transmitted using short feedback period, and the correlation matrix shall be transmitted using long feedback period. When $p = 0$ and $q > 0$, only the correlation matrix shall be transmitted using long feedback period.

For MFM 7: when $p > 0$ and $q = 0$, the wideband CQI and PMI from the base codebook shall be transmitted using short feedback period. When $p > 0$ and $q > 0$, the wideband CQI shall be transmitted using short feedback period, and the correlation matrix shall be transmitted using long feedback period. When $p = 0$ and $q > 0$, only the correlation matrix shall be transmitted using long feedback period.

16.3.6.5.2.4.12 BR ACK A-MAP IE

The BR Acknowledgement A-MAP IE indicates the decoding status of the BR opportunities in the previous UL frame. All the successfully received preamble sequences, if present, shall be included in an ascending order. BR opportunities are encoded in ascending order based on the number of the uplink subframe in which they are contained. In addition, the BR-ACK A-MAP IE also includes the allocation information for the fixed sized BR header. The UL resource and HFA shall be allocated to the preamble sequences whose grant indicator is ‘1’. The allocations shall be ordered based on the index of preamble sequences arranged in an ascending order. The maximum number of the HARQ retransmissions is set to the default value defined in 16.2.14.2.

The ABS shall not transmit in one sub-frame more than 1 BR ACK A-MAP IE.

Table 838—BR-ACK A-MAP IE*

Syntax	Size (bits)	Notes
BR-ACK_A-MAP_ IE() {	—	—
A-MAP IE Type	4	BR-ACK A-MAP IE
BR-ACK Bitmap	N_BR_Opportunities	Each bit indicates the decoding status of BR preamble sequence in the corresponding BR opportunity. 0b0: No BR preamble sequence is detected, 0b1: At least one preamble sequence is detected
MSB of resource start offset	2	0b00, 0b01, 0b10: 2bit-MSB of the start offset of the resource allocation (LRU) 0b11: No grant exist in this BR ACK A-MAP IE.
if (MSB of resource start offset != 0b11) {	—	—
LSB of resource start offset	5	This field is the LSB of the start offset of the Resource allocation (LRU) for BR Header
HFA start offset	6	This field is start offset of HARQ Feedback Allocation.

Table 838—BR-ACK A-MAP IE*

Syntax	Size (bits)	Notes
Allocation size	1	Resource size in an AAI subframe which is allocated to a BR preamble sequence index 0b0: 1 LRU, 0b1: 2 LRUs
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator= 0b1
}	—	—
for (i = 0; i < N_BR_Opportunities ; i++) {	—	—
if (BR-ACK Bitmap[i] == 1) {	—	—
Number of received preamble sequences (L)	6	The number of BR preamble sequence indices included in this ACK A-MAP IE.
for (j = 0; j < L; j++) {	—	—
Preamble sequence index	5	Preamble sequence index received in the BR opportunity
MSG decoding indicator	1	To indicate the decoding status of quick access message
If (MSB of resource start offset != 0b11) {	—	—
Grant indicator	1	To indicate whether grant of BR Header for the preamble sequence index is included or not If this bit is set, the UL resource is allocated with fixed size and MCS.
}	—	—
}	—	—
}	—	—
}	—	—
Reserved	*variable*	For byte alignment
}	—	—

*A 16 bit CRC is generated based on the contents of the BR-ACK A-MAP IE. The CRC is masked by the reserved Station ID for BR-ACK A-MAP

16.3.6.5.2.4.13 Broadcast Assignment A-MAP IE

Broadcast assignment A-MAP allocates resource for a broadcast burst. All broadcast MAC control messages to be transmitted in a AAI subframe shall be included in a broadcast burst.Table 839 describes the fields in a broadcast assignment A-MAP IE.

Table 839—Broadcast Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
Broadcast_Assignment_A-MAP_IE() {		
A-MAP IE Type	4	Broadcast Assignment A-MAP IE
Function Index	1	0: This IE carries broadcast assignment information 1: This IE carriers ranging channel allocation information
If(Function Index == 0){		
Burst Size	6	Burst size as indicated in the first 64 entries in Table 931
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 of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator= 0b1
BCID	2	Broadcast Channel ID
Repetition	2	0b00: no more repetition of the same burst 0b01: the same burst will be transmitted one more time 0b10: the same burst will be transmitted two more times 0b11: the same burst will be transmitted three more times
Periodicity of Repetition	2	0b00: 1 frame periodicity 0b01: 2 frame periodicity 0b10: 3 frame periodicity 0b11: 4 frame periodicity
Reserved	TBD	Reserved bits
} else if (Function Index == 1){		
Number of Ranging Opportunities (N)	2	TBD
for(i=0; i<N; i++) {		
Subframe Index	3	

Table 839—Broadcast Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
}		
Reserved	TBD	Reserved bits
}		
}		

*A 16 bit CRC is generated based on the contents of the Broadcast Assignment A-MAP IE.

The broadcast message signaled by the Broadcast Assignment A-MAP IE is always transmitted using SFBC as the MIMO encoder format.

16.3.6.5.2.4.14 UL CSM beamformingA-MAP IE

Table 840 describes the fields in a UL CSM Beamforming A-MAP IE.

Table 840—UL CSM Beamforming A-MAP IE*

Syntax	Size (bit)	Description/Notes
UL_CSM_Beamforming_A-MAP_IE() {		
A-MAP IE Type	4	UL CSM Beamforming A-MAP IE
$I_{SizeOffset}$	5	Offset used to compute burst size index
CSM Format	4	For CSM modes the following combinations apply for upto 4 streams 0b0000: TNS = 2, M_t=1, SI =1 0b0001: TNS = 2, M_t =1, SI =2 0b0010: TNS = 3, M_t =1, SI =1 0b0011: TNS = 3, M_t =1, SI =2 0b0100: TNS = 3, M_t =1, SI =3 0b0101: TNS = 3, M_t =2, SI =1 0b0110: TNS = 3, M_t =2, SI =2 0b0111: TNS = 4, M_t =1, SI =1 0b1000: TNS = 4, M_t =1, SI =2 0b1001: TNS = 4, M_t =1, SI =3 0b1010: TNS = 4, M_t =1, SI =4 0b1011: TNS = 4, M_t =2, SI =1 0b1100: TNS = 4, M_t =2, SI =2 0b1101: TNS = 4, M_t =2, SI =3 0b1110: TNS = 4, M_t =3, SI =1 0b1111: TNS = 4, M_t =3, SI =2
PMI	6	4 bits PMI for N_t = 2, first 2 MSB set to 0 6 bits PMI for N_t = 4

Table 840—UL CSM Beamforming A-MAP IE*

Syntax	Size (bit)	Description/Notes
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 If all bits are set to 1, the AMS shall not transmit the corresponding HARQ subpacket for the ACID in this IE. The retransmission number is incremented by one for the skipped retransmission.
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL AAI subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator= 0b1
HFA	3	HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
ACID	4	HARQ channel identifier
Reserved	1	Reserved bit
}		

*A 16 bit CRC is generated based on the contents of the UL CSM Beamforming A-MAP IE. The CRC is masked by the Station ID

The Resource Index field in the UL CSM Beamforming A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE, with 'DL' specific terminology replaced by 'UL' equivalents.

16.3.6.5.3 E-MBS Control Information Elements

The resource mapping for E-MBS allows are defined in E-MBS-DATA_IEs as defined in Table 841.

Table 841—E-MBS DATA Information Elements

Syntax	Size (bit)	Description/Notes
E-MBS-DATA_IE () {	-	-
No. of Multicast STIDs+FIDs	8	Total number of E-MBS streams in the IE
for (i=0; i< No. of Multicast STID +FID's, i++){	-	
MSTID+FID	16	Multicast STID + Flow ID of an E-MBS stream
$I_{SizeOffset}$	5	Depends on supported modes, 32modes assumed as baseline
MEF	1	E-MBS MIMO Encoding Format 0b0: SFBC 0b1: Vertical Encoding
if (MEF=0b1){	-	-
M_t		Number of streams for transmission for N_t =2, N_t =4, and N_t =8 (M_t <= N_t) 0b0: 1 stream 0b1: 2 streams
}	-	-
if(i<No. of Multicast STIDs+FIDs - 1){	-	-
E-MBS AAI subframe offset	*Variable*	Includes the location of the AAI subframe where the E-MBS data burst begins MSI == 0b00: 6 bits MSI == 0b01: 7 bits MSI == 0b10: 8 bits MSI == 0b11: 9 bits
E-MBS Resource Indexing	7	Includes the location of the SLRU index where the E-MBS data burst ends
Allocation Period	[TBD]	Inter-arrival intervals of E-MBS data bursts for an E-MBS stream (in number of frames)
}	-	-
}	-	-
}	-	-

16.3.7 Downlink MIMO

16.3.7.1 Downlink MIMO architecture and data processing

The architecture of downlink MIMO at the transmitter side is shown in Figure 537.

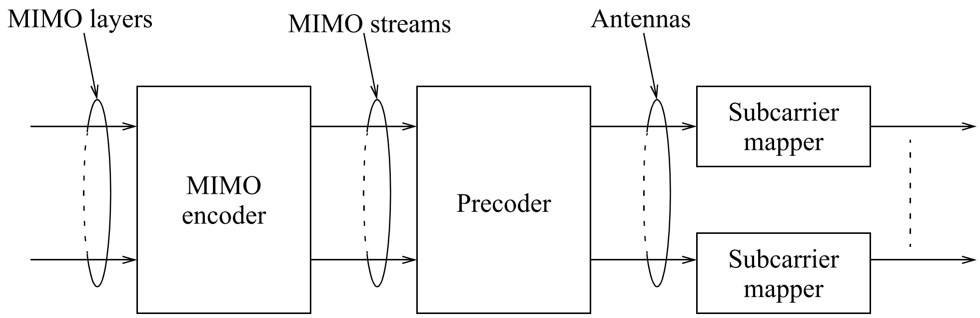


Figure 537—DL MIMO architecture

The MIMO encoder block maps L MIMO layers $(L \geq 1)$ onto M_t MIMO streams $(M_t \geq L)$, which are fed to the Precoder block. For the spatial multiplexing modes in SU-MIMO, "rank" is defined as the number of MIMO streams to be used for the user allocated to the Resource Unit (RU).

For SU-MIMO, only one user is scheduled in one Resource Unit (RU), and only one FEC block exists at the input of the MIMO encoder (vertical MIMO encoding at transmit side).

For MU-MIMO, multiple users can be scheduled in one RU, and multiple FEC blocks exist at the input of the MIMO encoder (horizontal MIMO encoding or combination of vertical and horizontal MIMO encoding at transmit side, which is called multi-layer encoding).

The precoder block maps MIMO stream(s) to antennas by generating the antenna-specific data symbols according to the selected MIMO mode.

The subcarrier mapping blocks map antenna-specific data to the OFDM symbol

16.3.7.1.1 MIMO layer to MIMO stream mapping

MIMO layer to MIMO stream mapping is performed by the MIMO encoder. The MIMO encoder is a batch processor that operates on M input symbols at a time.

The input to the MIMO encoder is represented by an M×1 vector as specified in Equation (229)

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_M \end{bmatrix} \tag{229}$$

Where s_i is the i-th input symbol within a batch. In case of MU-MIMO transmissions, the M symbols belong to different AMSs. Two consecutive symbols may belong to a single MIMO layer. One AMS shall have at most one MIMO layer.

MIMO layer to MIMO stream mapping of the input symbols is done in the space dimension first. The output of the MIMO encoder is an $M_t \times N_F$ MIMO STC matrix as given in Equation (230), which serves as the input to the precoder.

$$\mathbf{x} = S(\mathbf{s}) \tag{230}$$

Where

M_t is the number of MIMO streams
N_F is the number of subcarriers occupied by one MIMO block
$\mathbf{x}$ is the output of the MIMO encoder
$\mathbf{s}$ is the input MIMO layer vector
$S()$ is a function that maps an input MIMO layer vector to an STC matrix
$S(\mathbf{s})$ is an STC matrix

The STC matrix $\mathbf{x}$ can be expressed as in Equation (231):

$$\mathbf{x} = \begin{bmatrix} x_{1,1} & x_{1,2} & \dots & x_{1,N_F} \\ x_{2,1} & x_{2,2} & \dots & x_{2,N_F} \\ \dots & \dots & \dots & \dots \\ x_{M_t,1} & x_{M_t,2} & \dots & x_{M_t,N_F} \end{bmatrix} . \tag{231}$$

The four MIMO encoder formats (MEF) are SFBC, vertical encoding (VE), multi-layer encoding (ME), and CDR. For SU-MIMO transmissions, the STC rate is defined as in Equation (232)

$$R = \frac{M}{N_F} \tag{232}$$

For MU-MIMO transmissions, the STC rate per user (R) is equal to 1 or 2.

16.3.7.1.1.1 SFBC encoding

The input to the MIMO encoder is represented by a 2 × 1 vector.

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} . \quad (233)$$

The MIMO encoder generates the SFBC matrix.

$$\mathbf{x} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix} \quad (234)$$

Where **x** is a 2x2 matrix.

The SFBC matrix, **x**, occupies two consecutive subcarriers.

16.3.7.1.1.2 Vertical encoding

The input and the output of MIMO encoder is represented by an $M \times 1$ vector.

$$\mathbf{x} = \mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_M \end{bmatrix} . \quad (235)$$

Where s_i is the i-th input symbol within a batch.

For vertical encoding, $s_1 \dots s_M$ belong to the same MIMO layer. The encoder is an identity operation.

16.3.7.1.1.3 Multi-layer encoding

The input and output of the MIMO encoder is represented by an $M \times 1$ vector.

$$\mathbf{x} = \mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_M \end{bmatrix} \quad (236)$$

Where s_i is the i-th input symbol within a batch.

For multi-layer encoding, $s_1 \dots s_M$ belong to different MIMO layers, where two consecutive symbols may belong to a single MIMO layer.

Multi-layer encoding is only used for MU-MIMO mode. The encoder is an identity operation.

16.3.7.1.1.4 CDR encoding

The input to the MIMO encoder is represented by a 1 × 1 vector.

$$s = s_1 \quad (237)$$

The MIMO encoder generates the CDR matrix.

$$\mathbf{X} = \begin{bmatrix} s_1 & s_1^* \end{bmatrix} \quad (238)$$

The CDR matrix, **x**, occupies two consecutive subcarriers.

16.3.7.1.2 MIMO stream to antenna mapping

MIMO stream to antenna mapping is performed by the precoder. The output of the MIMO encoder is multiplied by an $N_t \times M_t$ precoder, **W**. The output of the precoder is denoted by an $N_t \times N_F$ matrix, **z**. The mapping can be defined in Equation (239).

$$\mathbf{z} = \mathbf{W}\mathbf{x} = \begin{bmatrix} z_{1,1} & z_{1,2} & \cdots & z_{1,N_F} \\ z_{2,1} & z_{2,2} & \cdots & z_{2,N_F} \\ \cdots & \cdots & \cdots & \cdots \\ z_{N_t,1} & z_{N_t,2} & \cdots & z_{N_t,N_F} \end{bmatrix} \quad (239)$$

Where N_t is the number of transmit antennas and $z_{j,k}$ is the output symbol to be transmitted via the *j*-th physical antenna on the *k*-th subcarrier. Pilots within PRU are precoded in the same way as the data subcarriers.

16.3.7.1.2.1 Non-adaptive precoding

With non-adaptive precoding, the precoding matrix is an $N_t \times M_t$ matrix **W**(*k*), where N_t is the number of transmit antennas, M_t is the number of MIMO streams, and *k* is the physical index of the subcarrier where **W**(*k*) is applied. The matrix **W** is selected from the base codebook or from a subset of size N_w precoders of the base codebook for a given rank. **W** belongs to the base codebook or to one of the subsets of the base codebook, according to the type of allocation, MEF, N_t, $MaxM_t$ and M_t, as specified in Table 842 and Table 843. The notation $\mathbf{C}_{\mathrm{DL,OL,SU}}(N_t, M_t, N_w)$ denotes a DL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t. The base codebook and the codebook subsets are defined in 16.3.7.2.5.5.

Table 842—Codebook subsets used for non-adaptive precoding in DL DLRU and NLRU

MEF	RU with M_t pilot MIMO streams outside OL region	RU in OL region with $MaxM_t$ MIMO streams
SFBC	N_t=2: $C_{DL,OL,SU}$ (2, M_t, 1), M_t=2 N_t=4: $C_{DL,OL,SU}$ (4, M_t, 4), M_t=2 N_t=8: $C_{DL,OL,SU}$ (8, M_t, 4), M_t=2	N_t=2: $C_{DL,OL,SU}$ (2,$MaxM_t$, 1), $MaxM_t$=2 N_t=4: $C_{DL,OL,SU}$ (4,$MaxM_t$, 4), $MaxM_t$=2 N_t=8: $C_{DL,OL,SU}$ (8,$MaxM_t$, 4), $MaxM_t$=2
VE	N_t=2: $C_{DL,OL,SU}$ (2, M_t, N_w), M_t=1,2 N_t=4: $C_{DL,OL,SU}$ (4, M_t, N_w), M_t=1,2,3,4 N_t=8: $C_{DL,OL,SU}$ (8, M_t, N_w), M_t=1,2,3,4 N_w depends on M_t	N_t=2: $C_{DL,OL,SU}$ (2,$MaxM_t$, 1), $MaxM_t$=2 N_t=4: $C_{DL,OL,SU}$ (4,$MaxM_t$, 4), $MaxM_t$=2 N_t=8: $C_{DL,OL,SU}$ (8,$MaxM_t$, 4), $MaxM_t$=2
ME	n.a	n.a
CDR	n.a	N_t=2: $C_{DL,OL,SU}$ (2, $MaxM_t$, 2), $MaxM_t$=1 N_t=4: $C_{DL,OL,SU}$ (4, $MaxM_t$, 4), $MaxM_t$=1 N_t=8: $C_{DL,OL,SU}$ (8, $MaxM_t$, 8), $MaxM_t$=1

Table 843—Codebook subsets used for non-adaptive precoding in DL SLRU

MEF	RU with M_t pilot MIMO streams outside OL region	RU in OL region with $MaxM_t$ MIMO streams
SFBC	n.a	n.a
VE	N_t=2: C(2, M_t, 3), M_t = 1, …, $MaxM_t$ N_t=4: C(4, M_t, 4), M_t = 1, …, $MaxM_t$ N_t=8: C(8, M_t, 4), M_t = 1, …, $MaxM_t$	N_t=2: C(2, $MaxM_t$, 3), $MaxM_t$ = 2 N_t=4: C(4, $MaxM_t$, 4), $MaxM_t$ = 2 N_t=8: C(8, $MaxM_t$, 4), $MaxM_t$ = 2
ME	N_t=2: C(2, M_t, 3), M_t = 2, …, $MaxM_t$ N_t=4: C(4, M_t, 4), M_t = 2, …, $MaxM_t$ N_t=8: C(8, M_t, 4), M_t = 2, …, $MaxM_t$	N_t=2: C(2, $MaxM_t$, 3), $MaxM_t$ = 2 N_t=4: C(4, $MaxM_t$, 4), $MaxM_t$ = 2 N_t=8: C(8, $MaxM_t$, 4), $MaxM_t$ = 2
CDR	n.a	N_t=2: C(2,$MaxM_t$, 3), $MaxM_t$ = 1 N_t=4: C(4,$MaxM_t$, 4), $MaxM_t$ = 1 N_t=8: C(8,$MaxM_t$, 4), $MaxM_t$ = 1

The notation C(4, M_t, 4) in Table 843 refer CL SU-MIMO codebook subset of rank M_t for four transmit antennas defined in 16.3.7.2.5.5.

Non-adaptive precoding outside the OL region

In a RU allocated outside the OL region, with MEF using SFBC or VE and non-adaptive precoding,the matrix **W** changes every $N_1 P_{SC}$ contiguous physical subcarriers according to Equation (240), and it does not depend on the AAI subframe number. The $N_t \times M_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in physical subband s is selected as the codeword of index i in the codebook of rank M_t specified in Table 842 or Table 843, where i is given by

$$i = s \bmod N_w, \qquad s = 0 \ldots N_{sub}-1 \tag{240}$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

In a RU allocated outside the OL region, with MEF using ME and non-adaptive precoding, the matrix **W** changes every N_1 PRUs according to Equation (240), and it does not depend on the AAI subframe number. The $N_t \times M_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in subband s is selected as any M_t unordered columns of the codeword of index i in the codebook of rank $MaxM_t$ specified in Table 843, where i is given by Equation (240),and $MaxM_t$ is specified in Feedback Allocation A-MAP IE or Feedback Polling A-MAP IE. The AMS shall assume $M_t = MaxM_t$ in the codebook of Table 843— for its feedback of stream index.

Non-adaptive precoding inside the OL region

In a RU allocated in the $MaxM_t$ MIMO streams OL Region, the matrix W changes every N PRUs.

$N = N_1$ in all OL regions except in the OL region of type 1 with NLRU. The $N_t \times MaxM_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in physical subband s is selected as the codeword of index i in the codebook of rank $MaxM_t$ specified in Table 842 or Table 843, where i is given by

$$i = s \bmod N_w, \qquad s = 0 \ldots N_{sub}-1 \tag{241}$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

In the OL region of type 1 with NLRU, $N = N_2$, and the $N_t \times 1$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in PRU m in AAI subframe number t is selected as the codeword of index i in the codebook of rank $MaxM_t$=1 specified in Table 842, where i is given by

$$i = (m + (t \bmod 2)) \bmod N_w, \qquad m = 0 \ldots N_{PRU}-1 \tag{242}$$

where N_{PRU} denotes the number of physical PRUs across the entire system bandwidth.

16.3.7.1.2.2 Adaptive precoding

With adaptive precoding, the precoder **W** is derived from the feedback of the AMS.

For codebook-based adaptive precoding (codebook feedback), there are 3 feedback modes: Base mode, transformation mode and differential mode.

For TDD sounding-based adaptive precoding, the value of **W** is derived from the AMS sounding feedback.

16.3.7.1.3 Downlink MIMO modes

There are six MIMO transmission modes for unicast DL MIMO transmission as listed in Table 844.

.

Table 844—Downlink MIMO modes

Mode index	Description	MIMO encoding format (MEF)	MIMO precoding
Mode 0	OL SU-MIMO (Tx diversity)	SFBC	non-adaptive
Mode 1	OL SU-MIMO (SM)	VE	non-adaptive
Mode 2	CL SU-MIMO (SM)	VE	adaptive
Mode 3	OL MU-MIMO (SM)	ME	non-adaptive
Mode 4	CL MU-MIMO (SM)	ME	adaptive
Mode 5	OL SU-MIMO (Tx diversity)	CDR	non-adaptive

The allowed values of the parameters for each DL MIMO mode are shown in Table 845.

Table 845—DL MIMO parameters

	Number of transmit antennas	STC rate per MIMO layer	Number of MIMO streams	Number of subcarriers	Number of MIMO layers
	N_t	R	M_t	N_F	L
MIMO mode 0	2	1	2	2	1
	4	1	2	2	1
	8	1	2	2	1

Table 845—DL MIMO parameters

	Number of transmit antennas	STC rate per MIMO layer	Number of MIMO streams	Number of subcarriers	Number of MIMO layers
	N_t	R	M_t	N_F	L
MIMO mode 1 and MIMO mode 2	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1
	4	4	4	1	1
	8	1	1	1	1
	8	2	2	1	1
	8	3	3	1	1
	8	4	4	1	1
	8	5	5	1	1
	8	6	6	1	1
	8	7	7	1	1
	8	8	8	1	1
MIMO mode 3 and MIMO mode 4	2	1	2	1	2
	4	1	2	1	2
	4	1	3	1	3
	4	1	4	1	4
	8	1	2	1	2
	8	1	3	1	3
	8	1	4	1	4
MIMO mode 4	4	2 and 1*	3	1	2
	4	2 and 1**	4	1	3
	4	2	4	1	2
	8	2 and 1*	3	1	2
	8	2 and 1**	4	1	3
	8	2	4	1	2

Table 845—DL MIMO parameters

	Number of transmit antennas	STC rate per MIMO layer	Number of MIMO streams	Number of subcarriers	Number of MIMO layers
	N_t	R	M_t	N_F	L
MIMO mode 5	2	1/2	1	2	1
	4	1/2	1	2	1
	8	1/2	1	2	1

* 2 streams to one AMS and 1 stream to another AMS, with 1 layer each.
** 2 streams to one AMS and 1 stream each to the other two AMSs, with 1 layer each.

M_t refers to the number of MIMO streams transmitted to one AMS with MIMO modes 0, 1, 2 and 5.

M_t refers to the total number of MIMO streams transmitted to multiple AMS on the same RU with MIMO modes 3 and 4.

16.3.7.2 Transmission schemes for data channels

16.3.7.2.1 Encoding and precoding of SU-MIMO

16.3.7.2.1.1 Encoding of SU-MIMO modes

- **MIMO mode 0**: SFBC encoding of 16.3.7.1.1.1 shall be used with MIMO mode 0.
- **MIMO mode 1**: Vertical encoding of 16.3.7.1.1.2 shall be used with MIMO mode 1. The number of MIMO streams is , $M_t \le min(N_t, N_r)$ where N_r is the number of receive antennas and M_t is no more than 8.
- **MIMO mode 2**: Vertical encoding of 16.3.7.1.1.2 shall be used with MIMO mode 2. The number of MIMO streams is , $M_t \le min(N_t, N_r)$ where M_t is no more than 8.
- **MIMO mode 5**: CDR encoding of 16.3.7.1.1.4 shall be used with MIMO mode 5.

16.3.7.2.1.2 Precoding of SU-MIMO modes

- **MIMO mode 0**: Non-adaptive precoding of 16.3.7.1.2.1 with M_t=2 MIMO streams shall be used with MIMO mode 0.
- **MIMO mode 1**: Non-adaptive precoding of 16.3.7.1.2.1 with M_t MIMO streams shall be used with MIMO mode 1.
- **MIMO mode 2**: Adaptive precoding of 16.3.7.1.2.2 shall be used with MIMO mode 2.
- **MIMO mode 5**: Non-adaptive precoding of 16.3.7.1.2.1 with M_t = 1 steam shall be used with MIMO mode 5.

16.3.7.2.2 Encoding and precoding of MU-MIMO

Multi-user MIMO schemes are used to enable a resource allocation to communicate data to two or more AMSs. Multi-user transmission with one or two MIMO streams per AMS is supported for MU-MIMO.

MU-MIMO includes the MIMO configuration of 2Tx antennas to support up to two AMSs, and 4Tx or 8Tx antennas to support up to four AMSs, with one MIMO stream per AMS.

Both OL MU-MIMO (mode 3) and CL MU-MIMO (mode 4) are supported.

16.3.7.2.2.1 Encoding of MU-MIMO modes

- **MIMO mode 3**: Multi-layer encoding of 16.3.7.1.1.3 shall be used with MIMO mode 3.
- **MIMO mode 4**: Multi-layer encoding of 16.3.7.1.1.3 shall be used with MIMO mode 4.

16.3.7.2.2.2 Precoding of MU-MIMO modes

- **MIMO mode 3**

Non-adaptive precoding of 16.3.7.1.2.1 shall be used with MIMO mode 3.

With OL MU MIMO inside the OL region, the precoder **W** with two MIMO streams is predefined and fixed over time. With OL MU MIMO outside the OL region, the precoder **W** is an $N_t \times M_t$ sub-matrix of a pre-defined $N_t \times MaxM_t$ matrix.

The precoding matrix **W** used by the ABS is represented in Equation (243).

$$\boldsymbol{W}(k) = [v_1(k) \quad v_2(k) \quad \dots \quad v_{M_t}(k)] \tag{243}$$

Where $v_i(k)$ is the precoding vector for the *i*-th AMS on the *k*-th subcarrier.

$v_i(k)$ shall be used for precoding the pilot symbols on the *i*-th pilot MIMO stream on the *k*-th subcarrier.

- **MIMO mode 4**

Adaptive precoding of 16.3.7.1.2.2 shall be used with MIMO mode 4.

In CL MU MIMO, the precoder **W** is an $N_t \times M$ matrix for each subcarrier. It is used to communicate to up to *M* AMSs simultaneously. The form and derivation of the precoding matrix does not need to be known at the AMS. The ABS determines the precoding matrix based on the feedback received from the AMS.

The ABS shall construct the precoding matrix **W** as represented in Equation (244).

$$\boldsymbol{W}(k) = \left[\boldsymbol{v}_1(k)\ \boldsymbol{v}_2(k)\ \dots\ \boldsymbol{v}_{M_t}(k)\right] \tag{244}$$

Where, $\boldsymbol{v}_i(k)$ is the precoding vector for the *i*-th MIMO stream on the *k*-th subcarrier.

$v_i(k)$ shall be used for precoding the pilot symbols on the *i*-th pilot MIMO stream on the *k*-th subcarrier.

16.3.7.2.3 Mapping of data and pilot subcarriers

Consecutive symbols for each antenna at the output of the MIMO precoder are mapped in a frequency domain first order across LRUs of the allocation, starting from the data subcarrier with the smallest OFDM symbol index and smallest subcarrier index, and continuing to subcarrier index with increasing subcarrier index. When the edge of the allocation is reached, the mapping is continued on the next OFDM symbol.

16.3.7.2.4 Usage of MIMO modes

Table 846 shows permutations supported for each MIMO mode outside the OL region. The definitions of DLRU, NLRU, and SLRU are in 16.3.5

Table 846—Supported Permutation for each DL MIMO mode outside the OL region

	DLRU	NLRU	SLRU
MIMO mode 0	Yes	Yes	No
MIMO mode 1	Yes, with M_t=2	Yes, with $M_t \le 4$	Yes
MIMO mode 2	No	Yes, with $M_t \le 4$	Yes
MIMO mode 3	No	No	Yes
MIMO mode 4	No	Yes	Yes
MIMO mode 5	No	No	No

Table 847 shows permutations supported for each MIMO mode inside the OL region with $MaxM_t$ streams.

Table 847—Supported Permutation for each DL MIMO mode in the OL region

	DLRU	NLRU	SLRU
MIMO mode 0	Yes, with $MaxM_t = 2$	No	No
MIMO mode 1	Yes, with $MaxM_t = 2$	No	Yes, with $MaxM_t = 2$
MIMO mode 2	No	No	No
MIMO mode 3	No	No	Yes, with $MaxM_t = 2$
MIMO mode 4	No	No	No
MIMO mode 5	No	Yes, with $MaxM_t = 1$	Yes, with $MaxM_t = 1$

All pilots are precoded regardless of the number of transmit antennas and allocation type.

16.3.7.2.5 Feedback mechanisms and operation

16.3.7.2.5.1 Open-Loop Region

An open-loop region with $MaxM_t$ MIMO streams is defined as a time-frequency resource using the $MaxM_t$ MIMO streams pilot pattern and a given open-loop MIMO mode with $M_t = MaxM_t$ without rank adaptation. The open-loop region allows base stations to coordinate their open-loop MIMO transmissions, in order to offer a stable interference environment where the precoders and numbers of MIMO streams are not time-varying. The LRUs used for the open-loop region are indicated in the AAI_SCD message. These LRUs shall be aligned across cells.

Only a limited set of open-loop MIMO modes are allowed for transmission in the open-loop region, as specified in Table 847. All open-loop MIMO modes can also be used outside the open-loop region except for MIMO mode 5, as specified in Table 846.

An open-loop region is associated with a specific set of parameters:

- Type (number of MIMO streams MaxMt, MIMO mode, MIMO feedback mode, type of permutation)
- LRUs

There are three types of open-loop regions, as specified in Table 848.

Table 848—Types of open-loop regions

	MaxMt	MIMO mode	MIMO feedback mode	Supported permutation
OL region type 0	2 MIMO streams	MIMO mode 0 MIMO mode 1 (M_t = 2 MIMO streams)	MFM 0	DLRU
OL region type 1	1 MIMO stream	MIMO mode 5 (M_t = 1 MIMO stream)	MFM 1	NLRU
			MFM 2	SLRU
OL region type 2	2 MIMO streams	MIMO mode 1 (M_t = 2 MIMO streams) MIMO mode 3 (M_t = 2 MIMO streams)	MFM 5	SLRU

Dynamic switching between MIMO mode 1 and MIMO mode 3 in downlink transmissions in OL region type 2 is allowed. The rank-2 precoders for transmission with MIMO mode 1 or MIMO mode 3 in OL region type 2 are the same on a given subband.

All base stations that are coordinated over the same open loop region should use the same number of MIMO streams, in order to guarantee low interference fluctuation and thus improve the CQI prediction at the AMS. All pilots are precoded by non-adaptive precoding with $MaxM_t$ MIMO streams in the open-loop region. CQI measurements should be taken by the AMS on the precoded demodulation pilots rather than on the downlink midamble.

The $MaxM_t$ precoded pilots streams shall be transmitted in all the LRUs in the OL region even if data is not being transmitted by the ABS on some or all of the LRUs.

16.3.7.2.5.2 MIMO feedback mode selection

An AMS may send an unsolicited event-driven report to indicate its preferred MIMO feedback mode to the ABS. Event-driven reports for MIMO feedback mode selection may be sent on the P-FBCH during any allowed transmission interval for the allocated P-FBCH. The P-FBCH codewords allocated to event-driven reports are specified in 16.3.9.3.

16.3.7.2.5.3 MIMO feedback modes

Each MIMO transmission mode can be supported by one or several MIMO feedback modes. When allocating a feedback channel, the MIMO feedback mode shall be indicated to the AMS, and the AMS will feedback information accordingly.

The description of MIMO feedback modes and corresponding supported MIMO transmission modes is shown in Table 849. The detailed description of feedback and AMS processing are in the following subsections.

The feedback of the quantized wideband correlation matrix shall be requested by the ABS for operation with transformation codebook-based feedback mode using the Feedback Polling A-MAP IE. The ABS may request the feedback of the quantized wideband correlation matrix independently of the MIMO feedback mode requested in the Feedback Allocation A-MAP IE. The quantized wideband correlation matrix may be used for wideband beamforming.

MIMO feedback mode 0 is used for the OL-SU SFBC and SM adaptation in diversity permutation. The AMS estimates the wideband CQI for both SFBC and SM, and reports the CQI and STC Rate. STC Rate 1 means SFBC with precoding and STC Rate 2 means rank-2 SM with precoding. MIMO feedback mode 0 may also be used for CQI feedback for sounding based beamforming defined in 16.3.7.2.5.6. The AMS shall estimate the wideband CQI for SFBC mode ($MaxM_t$ = 0b00), and report the CQI.

MIMO feedback mode 1 is used for the OL-SU CDR with STC rate 1/2 in diversity permutation.

MIMO feedback mode 2 is used for the OL-SU SM in localized permutation for frequency selective scheduling. The STC Rate indicates the preferred number of MIMO streams for SM. The subband CQI shall correspond to the selected rank.

Table 849—MIMO feedback modes

MIMO Feedback Mode	Description and type of RU	Feedback content	Supported MIMO transmission mode outside the OL region (when Measurement Method Indication = 0b0)	Supported MIMO transmission mode inside the OL region (when Measurement Method Indication = 0b1)
0	OL SU MIMO SFBC/SM (Diversity: DLRU, NLRU) Sounding based CL SU and MU MIMO	1. STC Rate 2. Wideband CQI	MIMO mode 0 and MIMO mode 1. Flexible adaptation between the two modes STC Rate = 1: SFBC CQI 2 <= STC Rate <= 4: SM CQI In DLRU: M_t=2 for SM. In NLRU: M_t >= 2 for SM For sounding based CL SU MU MIMO, STC Rate = 1: SFBC CQI	MIMO mode 0 and MIMO mode 1. Flexible adaptation between the two modes STC Rate = 1: SFBC CQI STC Rate = 2: SM CQI In DLRU only.
1	OL SU MIMO SM (Diversity: NLRU)	1. Wideband CQI	NA.	MIMO mode 5 STC Rate = 1/2
2	OL SU MIMO SM (localized: SLRU)	1. STC Rate 2. Subband CQI 3. Subband Selection	MIMO mode 1 1 <= STC Rate <= 8	MIMO mode 5 STC Rate = 1/2
3	CL SU MIMO (localized: SLRU)	1. STC Rate 2. Subband CQI 3. Subband PMI 4.Subband selection 5. Wideband correlation matrix	MIMO mode 2 1 <= STC Rate <= 8	n.a
4	CL SU MIMO (Diversity: NLRU)	1. Wideband CQI 2. Wideband PMI 3. Wideband correlation matrix	MIMO mode 2 ($M_t \leq 4$)	n.a
5	OL MU MIMO (localized: SLRU)	1. Subband CQI 2. Subband Selection 3. MIMO stream indicator	MIMO mode 3	MIMO mode 3
6	CL MU MIMO (localized: SLRU)	1. Subband CQI 2. Subband PMI 3. Subband Selection 4. Wideband correlation matrix	MIMO mode 4	n.a

Table 849—MIMO feedback modes

MIMO Feedback Mode	Description and type of RU	Feedback content	Supported MIMO transmission mode outside the OL region (when Measurement Method Indication = 0b0)	Supported MIMO transmission mode inside the OL region (when Measurement Method Indication = 0b1)
7	CL MU MIMO (Diversity: NLRU)	1. Wideband CQI 2. Wideband PMI 3. Wideband correlation matrix	MIMO mode 4	n.a

MIMO feedback mode 3 is used for the CL-SU SM in localized permutation for frequency selective scheduling. The STC Rate indicates the preferred number of MIMO streams for SM. The subband CQI shall correspond to the selected rank.

The MIMO feedback mode 4 is used for the CL SU MIMO using wideband beamforming with rank 1. In this mode, AMS shall feedback the wideband CQI. The wideband CQI shall be estimated at the AMS assuming short-term or long-term precoding at the ABS, according to the feedback period. The channel state information may be obtained at the ABS via the feedback of the correlation matrix, or via the feedback of the wideband PMI.

The MIMO feedback mode 5 is used for OL MU MIMO in localized permutation with frequency selective scheduling. In the mode, AMS shall feedback the subband selection, MIMO stream indicator and the corresponding CQI.

The MIMO feedback mode 6 is used for CL MU MIMO in localized permutation with frequency selective scheduling. In the mode, AMS shall feedback the subband selection, corresponding CQI and subband PMI. The subband CQI refers to the CQI of the best PMI in the subband. Rank-1 base codebook (or its subset) is used to estimate the PMI in one subband.

The MIMO feedback mode 7 is used for CL MU MIMO in diversity permutation using wideband beamforming MU MIMO. In this mode, AMS shall feedback the wideband CQI. The wideband CQI shall be estimated at the AMS assuming short-term or long-term precoding at the ABS, according to the feedback period. The channel state information may be obtained at the ABS via the feedback of the correlation matrix. or via the feedback of the wideband PMI.

16.3.7.2.5.4 Downlink signaling support of DL-MIMO modes

The BS shall send some parameters necessary for DL MIMO operation in a broadcast message. The broadcast information is carried in the S-SFH SP3 IE or in the additional broadcast information such as AAI_SCD or AAI_DL_IM messages..

The BS shall send some parameters necessary for DL MIMO operation in a unicast message. The unicast information is carried in the DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent A-MAP IE, Feedback Polling A-MAP IE, and Feedback Allocation A-MAP IE.

Table 850 specifies the DL control parameters required for MIMO operation.

Table 850—DL MIMO control parameters

Parameter	Description	Value	Notes
Broadcast Information			
N_t	Number of transmit antennas at the BS	2, 4, 8	Indicated in S-SFH (system information) SP3 IE
OL_Region	OL MIMO region, which signaling is used to indicate MS where is the predefined OL MIMO region and number of MIMO streams (1 or 2)	OL-Region-ON (1 bit): Signal the existence of OL region. OL-Rank1-Config (3 bit): to signal the combination of subband and mini-band in OL region type 1. Refer to Table 848. SB-OL-Region-2-Size (4 bit) : signal the number of subbands in OL region type 2.	Indicated in AAI_SCD Message
BC_SI	Rank-1 base codebook subset indication for interference mitigation with PMI coordination	BitMAP: 8 bits if Nt = 2 16 bits if Nt = 4, 8	Rank-1 codebook element restriction or recommendation information It shall be ignored if Codebook_mode = 0b00, 0b01 or 0b10 It is indicated in AAI_DL_IM Message Its usage is enabled by Codebook_mode or Codebook_coordination.
Unicast Information			
MEF	MIMO encoder format	SFBC Vertical encoding Horizontal encoding	MIMO encoder format. Indicated in DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent A-MAP IE

Table 850—DL MIMO control parameters

Parameter	Description	Value	Notes
M_t	Number of MIMO streams in transmission	1 to 8	Number of MIMO streams in the transmission. Indicated in DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent A-MAP IE
SI	Index of allocated pilot MIMO stream	1 to 4	SI shall be indicated if MEF is HE Indicated in DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent A-MAP IE
MFM	MIMO feedback mode	Refer to Table 849	To decide the feedback content and related MS processing Indicated in Feedback Allocation A-MAP IE, Feedback Polling A-MAP IE
$MaxM_t$	Maximum number of MIMO streams	If N_t=2 (any MFM): 0b0: 1 0b1: 2 If N_t=4 (any MFM): 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If N_t=8 (SU-MIMO MFM 0, 1, 2, 3, 4): 0b00: 1 0b01: 2 0b10: 4 0b11: 8 If N_t=8 (MU-MIMO MFM 5, 6, 7): 0b00: 1 0b01: 2 0b10: 3 0b11: 4	If MFM indicates a SU feedback mode: the maximum STCrate scheduled for each user If MFM indicates a MU feedback mode: the maximum number of users scheduled on each RU Indicated in Feedback Allocation A-MAP IE, Feedback Polling A-MAP IE
CS indication	Codebook subset type for CL MIMO modes 2 and 4	Base codebook or codebook subset	Depending on the MFM and CS indication, the MS shall feedback a PMI from the SU or MU base codebook, or from a subset of the SU or MU of the base codebook. Indicated in Feedback Allocation A-MAP IE, Feedback Polling A-MAP IE

Table 850—DL MIMO control parameters

Parameter	Description	Value	Notes
CM	Codebook feedback mode for CL MIMO modes 2 and 4	0b00: base mode with code-book coordination disabled 0b01: transformation mode with codebook coordination disabled 0b10: differential mode with codebook coordination dis-abled 0b11: base mode with code-book coordination enabled	This field specifies the code-book feedback mode. If codebook coordination is enabled by setting Codebook_mode to 0b11 or by setting Codebook_coordination to 0b1, and if the AMS reports STC rate equal to 1, then the AMS shall find the rate-1 PMI from the codebook entries broadcasted in BC_SI in AAI_DL_IM Message.

When CS indication indicates the use of a codebook subset and MFM indicates a CL SU MIMO mode (MFM = 3 and 4), the MS shall use the SU base codebook subset of Table 866 when N_t=4. When CS indication indicates the use of a codebook subset and MFM indicates a CL MU MIMO mode (MFM = 6 and 7), the MS shall use the MU base codebook subset of Table 866 when N_t =4.

16.3.7.2.5.5 Quantized MIMO feedback for closed-loop transmit precoding

Quantized feedback modes

An AMS feedbacks a Preferred Matrix Index (PMI) to support DL precoding.

There are three types of codebook feedback modes.

The operation of the codebook feedback modes for the PMI is summarized below:

1) **The base mode**: the PMI feedback from a AMS shall represent an entry of the base codebook. It shall be sufficient for the ABS to determine a new precoder.
2) **The transformation mode**: the PMI feedback from a AMS shall represent an entry of the transformed base codebook according to long term channel information.
3) **The differential mode**: the PMI feedback from a AMS shall represent an entry of the differential codebook or an entry of the base codebook at PMI reset times. The feedback from a AMS provides a differential knowledge of the short-term channel information. This feedback represents information that is used along with other feedback information known at the ABS for determining a new precoder.

Mobile station shall support the base and transformation mode and may support the differential mode.

The transformation and differential feedback modes are applied to the base codebook or to a subset of the base codebook.

Base mode for codebook-based feedback

The base codebook is a unitary codebook. A codebook is a unitary codebook if each of its matrices consists of columns of a unitary matrix.

The AMS selects its preferred matrix from the base codebook based on the channel measurements. The AMS sends back the index of the preferred codeword, and the ABS computes the precoder **W** according to the index. Both ABS and AMS use the same codebook for correct operation.

For the base mode, the PMI feedback from a mobile station shall represent an entry of the base codebook, where the base codebooks are defined as follows for two, four, and eight transmit antennas at the ABS.

The notation C(N_t, M_t, NB) denotes the codebook, which consists of 2^{NB} complex, matrices of dimension N_t by M_t, and M_t denotes the number of MIMO streams.

The notation C(N_t, M_t, NB, i) denotes the i-th codebook entry of C(N_t, M_t, NB).

Base codebook for two transmit antennas

SU-MIMO base codebook

The base codebook of SU-MIMO with two transmit antennas consist of rank-1 codebook C(2,1,3) and rank-2 codebook C(2,2,3), as illustrated in Table 851 and Table 852, respectively.

Table 851—C(2,1,3)

Index	*m*	C(2,1,3,*m*) = [c1; c2]	
		c_1	c_2
000	0	0.7071	-0.7071
001	1	0.7071	-0.5000 - 0.5000i
010	2	0.7071	-0.7071i
011	3	0.7071	0.5000 - 0.5000i
100	4	0.7071	0.7071
101	5	0.7071	0.5000 + 0.5000i
110	6	0.7071	0.7071i
111	7	0.7071	-0.5000 + 0.5000i

Table 852—C(2,2,3)

Index	*m*	$C(2,2,3,m) = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}^T$	
		c_{11} c_{21}	c_{12} c_{22}
000	0	0.7071 0.7071	-0.7071 0.7071
001	1	0.7071 0.7071	-0.5000 - 0.5000i 0.5000 + 0.5000i
010	2	0.7071 0.7071	-0.7071i 0.7071i
011	3	0.7071 0.7071	0.5000 - 0.5000i -0.5000 + 0.5000i
100~111	4~7	-	-

MU-MIMO base codebook

The base codebook for MU-MIMO is the same as the rank 1 base codebook for SU-MIMO.

Base codebook for four transmit antennas

SU-MIMO base codebook

The base codebooks of SU-MIMO with four transmit antennas consist of rank-1 codebook C(4,1,6), rank-2 codebook C(4,2,6), rank-3 codebook C(4,3,6) and rank-4 codebook C(4,4,6). Table 853, Table 854, Table 855 and Table 856 are included to illustrate the rank-1,2,3,4 base codebooks.

Table 853—C(4,1,6)

Binary Index	*m*	$C(4,1,6,m) = [c_1;c_2;c_3;c_4]$			
		c_1	c_2	c_3	c_4
000000	0	0.5000	-0.5000	0.5000	-0.5000
000001	1	-0.5000	-0.5000	0.5000	0.5000
000010	2	-0.5000	0.5000	0.5000	-0.5000
000011	3	0.5000	-0.5000i	0.5000	-0.5000i
000100	4	-0.5000	-0.5000i	0.5000	0.5000i

Table 853—C(4,1,6)

Binary Index	*m*	$C(4,1,6,m) = [c_1;c_2;c_3;c_4]$			
		c_1	c_2	c_3	c_4
000101	5	-0.5000	0.5000i	0.5000	-0.5000i
000110	6	0.5000	0.5000	0.5000	0.5000
000111	7	0.5000	0.5000i	0.5000	0.5000i
001000	8	0.5000	0.5000	0.5000	-0.5000
001001	9	0.5000	0.5000i	-0.5000	0.5000i
001010	10	0.5000	-0.5000	0.5000	0.5000
001011	11	0.5000	-0.5000i	-0.5000	-0.5000i
001100	12	0.5000	0.3536 + 0.3536i	0.5000i	-0.3536 + 0.3536i
001101	13	0.5000	-0.3536 + 0.3536i	-0.5000i	0.3536 + 0.3536i
001110	14	0.5000	-0.3536 - 0.3536i	0.5000i	0.3536 - 0.3536i
001111	15	0.5000	0.3536 - 0.3536i	-0.5000i	-0.3536 - 0.3536i
010000	16	0.5000	-0.4619 - 0.1913i	0.3536 + 0.3536i	-0.1913 - 0.4619i
010001	17	0.3117	0.6025 + 0.1995i	-0.4030 - 0.4903i	-0.1122 - 0.2908i
010010	18	0.3117	-0.6025 - 0.1995i	-0.1122 - 0.2908i	0.4030 + 0.4903i
010011	19	0.3058	0.1901 - 0.6052i	0.1195 + 0.2866i	0.4884 - 0.4111i
010100	20	0.5000	-0.1913 + 0.4619i	-0.3536 - 0.3536i	0.4619 - 0.1913i
010101	21	0.5000	0.1913 - 0.4619i	-0.3536 - 0.3536i	-0.4619 + 0.1913i
010110	22	0.5000	0.4619 + 0.1913i	0.3536 + 0.3536i	0.1913 + 0.4619i
010111	23	0.3082	0.0104 + 0.3151i	0.4077 + 0.4887i	-0.4783 + 0.4145i
011000	24	0.3117	0.3573 - 0.2452i	0.6025 - 0.1995i	-0.1578 + 0.5360i
011001	25	0.3117	0.2452 + 0.3573i	-0.6025 + 0.1995i	0.5360 + 0.1578i
011010	26	0.3082	-0.3666 + 0.2426i	0.6092 - 0.1842i	0.1615 - 0.5298i
011011	27	0.3117	-0.2452 - 0.3573i	-0.6025 + 0.1995i	-0.5360 - 0.1578i
011100	28	0.3117	0.4260 + 0.0793i	0.1995 + 0.6025i	0.2674 + 0.4906i
011101	29	0.3117	-0.0793 + 0.4260i	-0.1995 - 0.6025i	0.4906 - 0.2674i
011110	30	0.3117	-0.4260 - 0.0793i	0.1995 + 0.6025i	-0.2674 - 0.4906i
011111	31	0.3117	0.0793 - 0.4260i	-0.1995 - 0.6025i	-0.4906 + 0.2674i
100000	32	0.5636	-0.3332 - 0.2672i	0.1174 + 0.5512i	-0.3308 - 0.2702i
100001	33	0.5587	0.3361 + 0.2735i	-0.3361 - 0.2735i	-0.1135 - 0.5471i
100010	34	0.5587	-0.3361 - 0.2735i	-0.1135 - 0.5471i	0.3361 + 0.2735i

Table 853—C(4,1,6)

Binary Index	*m*	*C*(4,1,6,*m*) = [c_1;c_2;c_3;c_4]			
		c_1	c_2	c_3	c_4
100011	35	0.5587	0.2735 - 0.3361i	0.1135 + 0.5471i	0.2735 - 0.3361i
100100	36	0.3082	-0.4887 + 0.4077i	-0.6092 - 0.1842i	0.2837 - 0.1205i
100101	37	0.5636	0.2673 - 0.3331i	-0.1222 - 0.5501i	-0.2673 + 0.3331i
100110	38	0.5636	0.3691 + 0.5142i	0.3331 + 0.2673i	0.0862 + 0.3032i
100111	39	0.5587	-0.2990 + 0.0880i	0.3361 + 0.2735i	-0.5216 + 0.3616i
101000	40	0.5587	0.0880 - 0.2990i	0.3361 - 0.2735i	-0.3616 + 0.5216i
101001	41	0.5587	0.2990 + 0.0881i	-0.3362 + 0.2735i	0.5216 + 0.3616i
101010	42	0.5587	-0.0880 + 0.2990i	0.3361 - 0.2735i	0.3616 - 0.5216i
101011	43	0.5587	-0.2990 - 0.0880i	-0.3361 + 0.2735i	-0.5216 - 0.3616i
101100	44	0.5636	0.2741 - 0.1559i	0.2672 + 0.3332i	0.1081 + 0.6236i
101101	45	0.5636	0.1559 + 0.2741i	-0.2672 - 0.3332i	0.6236 - 0.1081i
101110	46	0.5587	-0.2737 + 0.1492i	0.2735 + 0.3361i	-0.1132 - 0.6245i
101111	47	0.5587	-0.1492 - 0.2737i	-0.2735 - 0.3361i	-0.6245 + 0.1132i
110000	48	0.5000	-0.4619 + 0.1913i	0.3536 - 0.3536i	-0.1913 + 0.4619i
110001	49	0.3117	0.4030 + 0.4903i	-0.6025 - 0.1995i	-0.1122 - 0.2908i
110010	50	0.3117	-0.4029 - 0.4904i	-0.1184 - 0.2883i	0.6067 + 0.1865i
110011	51	0.3082	0.4887 - 0.4077i	0.1205 + 0.2837i	0.1842 - 0.6092i
110100	52	0.5000	0.1913 + 0.4619i	-0.3536 + 0.3536i	-0.4619 - 0.1913i
110101	53	0.5000	-0.1913 - 0.4619i	-0.3536 + 0.3536i	0.4619 + 0.1913i
110110	54	0.5000	0.4619 - 0.1913i	0.3536 - 0.3536i	0.1913 - 0.4619i
110111	55	0.3117	-0.2452 + 0.3573i	0.6025 + 0.1995i	-0.5360 + 0.1578i
111000	56	0.3117	0.3117	0.4030 - 0.4903i	-0.4030 + 0.4903i
111001	57	0.3117	0.3117i	-0.4030 + 0.4903i	0.4903 + 0.4030i
111010	58	0.3082	-0.3152 - 0.0036i	0.4076 - 0.4888i	0.4040 - 0.4872i
111011	59	0.3082	0.0036 - 0.3152i	-0.4076 + 0.4888i	-0.4872 - 0.4040i
111100	60	0.3117	0.2204 + 0.2204i	0.4903 + 0.4030i	0.0618 + 0.6317i
111101	61	0.3117	-0.2204 + 0.2204i	-0.4903 - 0.4030i	0.6317 - 0.0618i
111110	62	0.3082	-0.2154 - 0.2302i	0.4887 + 0.4077i	-0.0451 - 0.6313i
111111	63	0.3082	0.2254 - 0.2204i	-0.4888 - 0.4076i	-0.6302 + 0.0588i

Table 854—C(4,2,6)

$$C(4, 2, 6, m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \end{bmatrix}^T$$

Index	m	c_{11} / c_{21}	c_{12} / c_{22}	c_{13} / c_{23}	c_{14} / c_{24}
000000	0	0.5000 0.5000	0.5000 -0.5000	0.5000 0.5000	0.5000 -0.5000
000001	1	0.5000 -0.5000	0.5000 -0.5000	0.5000 0.5000	0.5000 0.5000
000010	2	0.5000 -0.5000	0.5000 0.5000	0.5000 0.5000	0.5000 -0.5000
000011	3	0.5000 -0.5000	-0.5000 -0.5000	0.5000 0.5000	-0.5000 -0.5000
000100	4	0.5000 -0.5000	-0.5000 0.5000	0.5000 0.5000	-0.5000 -0.5000
000101	5	-0.5000 -0.5000	-0.5000 0.5000	0.5000 0.5000	0.5000 -0.5000
000110	6	0.5000 -0.5000	0.5000i - 0.5000i	0.5000 0.5000	0.5000i 0.5000i
000111	7	0.5000 -0.5000	0.5000i 0.5000i	0.5000 0.5000	0.5000i - 0.5000i
001000	8	0.5000 -0.5000	- 0.5000i - 0.5000i	0.5000 0.5000	- 0.5000i 0.5000i
001001	9	0.5000 -0.5000	- 0.5000i 0.5000i	0.5000 0.5000	- 0.5000i - 0.5000i
001010	10	0.5000 -0.5000	0.5000 - 0.5000i	0.5000 0.5000	0.5000 0.5000i
001011	11	0.5000 -0.5000	0.5000 0.5000i	0.5000 0.5000	0.5000 - 0.5000i
001100	12	0.5000 -0.5000	0.5000i -0.5000	0.5000 0.5000	0.5000i 0.5000
001101	13	0.5000 -0.5000	0.5000i 0.5000	0.5000 0.5000	0.5000i -0.5000
001110	14	0.5000 0.5000	0.5000 -0.5000	0.5000 0.5000	-0.5000 0.5000
001111	15	0.5000 0.5000	-0.3536 + 0.3536i 0.3536 - 0.3536i	– 0.5000i – 0.5000i	0.3536 + 0.3536i -0.3536 - 0.3536i
010000	16	0.5000 -0.5000	-0.5000 - 0.5000i	0.5000 0.5000	-0.5000 0.5000i
010001	17	0.5000 -0.5000	-0.5000 0.5000i	0.5000 0.5000	-0.5000 - 0.5000i

Table 854—C(4,2,6)

010010	18	0.5000 0.5587	-0.5000 0.3361 + 0.2735i	0.5000 -0.3361 - 0.2735i	-0.5000 -0.1135 - 0.5471i
010011	19	-0.5000 0.5000	-0.5000 - 0.5000i	0.5000 0.5000	0.5000 - 0.5000i
010100	20	-0.5000 0.5587	-0.5000 -0.3361 - 0.2735i	0.5000 -0.1135 - 0.5471i	0.5000 0.3361 + 0.2735i
010101	21	-0.5000 0.3117	-0.5000 -0.2452 + 0.3573i	0.5000 0.6025 + 0.1995i	0.5000 -0.5360 + 0.1578i
010110	22	-0.5000 0.5000	0.5000 - 0.5000i	0.5000 0.5000	-0.5000 - 0.5000i
010111	23	0.5000 0.5000	0.5000 0.5000i	0.5000 -0.5000	-0.5000 0.5000i
011000	24	-0.5000 0.5587	0.5000 -0.2990 + 0.0880i	0.5000 0.3361 + 0.2735i	-0.5000 -0.5216 + 0.3616i
011001	25	0.5000 0.5000	0.5000 - 0.5000i	0.5000 -0.5000	-0.5000 - 0.5000i
011010	26	0.5000 0.3117	0.5000 -0.2452 - 0.3573i	0.5000 -0.6025 + 0.1995i	-0.5000 -0.5360 - 0.1578i
011011	27	0.5000 0.5000	0.5000i -0.5000	-0.5000 0.5000	0.5000i 0.5000
011100	28	0.5000 0.5587	0.5000i -0.0880 + 0.2990i	-0.5000 0.3361 - 0.2735i	0.5000i 0.3616 - 0.5216i
011101	29	0.5000 0.5000	-0.5000 - 0.5000i	0.5000 -0.5000	0.5000 - 0.5000i
011110	30	0.5000 0.5587	-0.5000 -0.2990 - 0.0880i	0.5000 -0.3361 + 0.2735i	0.5000 -0.5216 - 0.3616i
011111	31	0.5000 0.5000	0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000i – 0.5000i	-0.3536 + 0.3536i 0.3536 + 0.3536i
100000	32	0.5000 0.5000	0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000i 0.5000i	-0.3536 + 0.3536i 0.3536 - 0.3536i
100001	33	0.5000 0.5000	0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000i – 0.5000i	-0.3536 + 0.3536i -0.3536 - 0.3536i
100010	34	0.5000 0.3117	0.3536 + 0.3536i 0.0793 - 0.4260i	0.5000i -0.1995 - 0.6025i	-0.3536 + 0.3536i -0.4906 + 0.2674i
100011	35	0.5000 0.5000	-0.3536 + 0.3536i -0.3536 - 0.3536i	– 0.5000i 0.5000i	0.3536 + 0.3536i 0.3536 - 0.3536i
100100	36	-0.5000 0.3082	0.5000i 0.0104 + 0.3151i	0.5000 0.4077 + 0.4887i	- 0.5000i -0.4783 + 0.4145i
100101	37	0.5000 0.5000	-0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000i – 0.5000i	0.3536 - 0.3536i -0.3536 - 0.3536i
100110	38	0.5000 0.5587	-0.3536 - 0.3536i -0.1492 - 0.2737i	0.5000i -0.2735 - 0.3361i	0.3536 - 0.3536i -0.6245 + 0.1132i

Table 854—C(4,2,6)

100111	39	0.3117 -0.5000	0.6025 + 0.1995i 0.5000	-0.4030 - 0.4903i 0.5000	-0.1122 - 0.2908i -0.5000
101000	40	0.3117 0.5000	0.6025 + 0.1995i -0.5000	-0.4030 - 0.4903i 0.5000	-0.1122 - 0.2908i -0.5000
101001	41	0.3117 0.3058	-0.6025 - 0.1995i 0.1901 - 0.6052i	-0.1122 - 0.2908i 0.1195 + 0.2866i	0.4030 + 0.4903i 0.4884 - 0.4111i
101010	42	0.3117 0.5000	-0.6025 - 0.1995i 0.5000	-0.1122 - 0.2908i 0.5000	0.4030 + 0.4903i 0.5000
101011	43	0.3117 0.5000	0.3573 - 0.2452i 0.5000i	0.6025 - 0.1995i -0.5000	-0.1578 + 0.5360i 0.5000i
101100	44	0.3117 0.5000	0.2452 + 0.3573i -0.5000	-0.6025 + 0.1995i 0.5000	0.5360 + 0.1578i 0.5000
101101	45	0.3117 0.5000	0.4260 + 0.0793i -0.3536 + 0.3536i	0.1995 + 0.6025i – 0.5000i	0.2674 + 0.4906i 0.3536 + 0.3536i
101110	46	0.3117 0.5000	-0.0793 + 0.4260i -0.3536 - 0.3536i	-0.1995 - 0.6025i 0.5000i	0.4906 - 0.2674i 0.3536 - 0.3536i
101111	47	0.3117 0.5000	-0.4260 - 0.0793i 0.3536 - 0.3536i	0.1995 + 0.6025i – 0.5000i	-0.2674 - 0.4906i -0.3536 - 0.3536i
110000	48	0.5636 0.5587	-0.3332 - 0.2672i -0.3361 - 0.2735i	0.1174 + 0.5512i -0.1135 - 0.5471i	-0.3308 - 0.2702i 0.3361 + 0.2735i
110001	49	0.5587 0.5587	-0.3361 - 0.2735i 0.2735 - 0.3361i	-0.1135 - 0.5471i 0.1135 + 0.5471i	0.3361 + 0.2735i 0.2735 - 0.3361i
110010	50	0.5587 0.5000	0.2735 - 0.3361i 0.5000i	0.1135 + 0.5471i 0.5000	0.2735 - 0.3361i 0.5000i
110011	51	0.5587 0.5000	0.0880 - 0.2990i - 0.5000i	0.3361 - 0.2735i -0.5000	-0.3616 + 0.5216i - 0.5000i
110100	52	0.5587 0.5587	0.2990 + 0.0881i -0.2990 - 0.0880i	-0.3362 + 0.2735i -0.3361 + 0.2735i	0.5216 + 0.3616i -0.5216 - 0.3616i
110101	53	0.5636 0.5587	0.2741 - 0.1559i -0.2737 + 0.1492i	0.2672 + 0.3332i 0.2735 + 0.3361i	0.1081 + 0.6236i -0.1132 - 0.6245i
110110	54	0.5636 0.5587	0.1559 + 0.2741i -0.1492 - 0.2737i	-0.2672 - 0.3332i -0.2735 - 0.3361i	0.6236 - 0.1081i -0.6245 + 0.1132i
110111	55	0.3117 0.5000	0.4030 + 0.4903i 0.5000	-0.6025 - 0.1995i 0.5000	-0.1122 - 0.2908i 0.5000
111000	56	0.5000 0.5000	0.1913 + 0.4619i -0.1913 - 0.4619i	-0.3536 + 0.3536i -0.3536 + 0.3536i	-0.4619 - 0.1913i 0.4619 + 0.1913i
111001	57	0.3117 0.5000	0.3117 -0.5000	0.4030 - 0.4903i 0.5000	-0.4030 + 0.4903i 0.5000
111010	58	0.3117 0.3082	0.3117 -0.3152 - 0.0036i	0.4030 - 0.4903i 0.4076 - 0.4888i	-0.4030 + 0.4903i 0.4040 - 0.4872i
111011	59	0.3117 0.5000	0.3117i - 0.5000i	-0.4030 + 0.4903i -0.5000	0.4903 + 0.4030i - 0.5000i

Table 854—C(4,2,6)

111100	60	0.3117 0.3082	0.3117i 0.0036 - 0.3152i	-0.4030 + 0.4903i -0.4076 + 0.4888i	0.4903 + 0.4030i -0.4872 - 0.4040i
111101	61	0.3117 0.5000	0.2204 + 0.2204i -0.3536 - 0.3536i	0.4903 + 0.4030i 0.5000i	0.0618 + 0.6317i 0.3536 - 0.3536i
111110	62	0.3117 0.5000	-0.2204 + 0.2204i 0.3536 - 0.3536i	-0.4903 - 0.4030i – 0.5000i	0.6317 - 0.0618i -0.3536 - 0.3536i
111111	63	0.3117 0.3082	-0.2204 + 0.2204i 0.2254 - 0.2204i	-0.4903 - 0.4030i -0.4888 - 0.4076i	0.6317 - 0.0618i -0.6302 + 0.0588i

Table 855—C(4,3,6)

Binary Index	*m*	$C(4,3,4,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \end{bmatrix}^T$			
		c_{11} c_{21} c_{31}	c_{12} c_{22} c_{32}	c_{13} c_{23} c_{33}	c_{14} c_{24} c_{34}
000000	0	0.5000 0.5000 -0.5000	0.5000 -0.5000 -0.5000	0.5000 0.5000 0.5000	0.5000 -0.5000 0.5000
000001	1	0.5000 0.5000 -0.5000	0.5000 -0.5000 0.5000	0.5000 0.5000 0.5000	0.5000 -0.5000 -0.5000
000010	2	0.5000 -0.5000 -0.5000	0.5000 -0.5000 0.5000	0.5000 0.5000 0.5000	0.5000 0.5000 -0.5000
000011	3	0.5000 -0.5000 -0.5000	-0.5000 -0.5000 0.5000	0.5000 0.5000 0.5000	-0.5000 0.5000 -0.5000
000100	4	0.5000 0.5000 -0.5000	0.5000 -0.5000i -0.5000i	0.5000 0.5000 0.5000	0.5000 -0.5000i 0.5000i
000101	5	0.5000 0.5000 -0.5000	0.5000i -0.5000i 0.5000	0.5000 0.5000 0.5000	0.5000i -0.5000i -0.5000i
000110	6	0.5000 -0.5000 -0.5000	0.5000i -0.5000i 0.5000	0.5000 0.5000 0.5000	0.5000i 0.5000i -0.5000i
000111	7	0.5000 0.5000 -0.5000	0.5000i -0.5000i -0.5000	0.5000 0.5000 0.5000	0.5000i -0.5000i 0.5000i
001000	8	0.5000 0.5000 -0.5000	0.5000 -0.5000 -0.5000i	0.5000 0.5000 0.5000	0.5000 -0.5000 0.5000i

Table 855—C(4,3,6)

001001	9	0.5000 -0.5000 -0.5000	0.5000 -0.5000i 0.5000	0.5000 0.5000 0.5000	0.5000 0.5000i -0.5000i
001010	10	0.5000 0.5000 -0.5000	0.5000i -0.5000i -0.5000	0.5000 0.5000 0.5000	0.5000i -0.5000i 0.5000
001011	11	0.5000 -0.5000 -0.5000	0.5000i -0.5000 0.5000	0.5000 0.5000 0.5000	0.5000i 0.5000 -0.5000
001100	12	0.5000 0.5000 0.5000	0.5000 0.5000i -0.5000	0.5000 -0.5000 0.5000	-5000 0.5000i 0.5000
001101	13	0.5000 0.5000 0.5000	0.5000 -0.5000 -0.5000i	0.5000 0.5000 -0.5000	-0.5000 0.5000 -0.5000i
001110	14	0.5000 0.5000 0.5000	0.3536+0.3536i -0.3536+0.3536i 0.3536-0.3536i	0.5000i -0.5000i -0.5000i	-0.3536+0.3536i 0.3536+0.3536i -0.3536-0.3536i
001111	15	0.5000 0.5000 0.5000	-0.3536+0.3536i -0.3536-0.3536i 0.3536-0.3536i	-0.5000i 0.5000i -0.5000i	0.3536+0.3536i 0.3536-0.3536i -0.3536-0.3536i
001111 ≈ 111111	16 ≈ 63	n.a			

The indexes from 16 to 63 are not used in 6-bits downlink PMI feedback for M_t = 3 codebook.

Table 856—C(4,4,6)

Binary Index	***m***	$C(4,3,4,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \\ c_{41} & c_{42} & c_{43} & c_{44} \end{bmatrix}^T$			
		c_{11} c_{21} c_{31} c_{41}	c_{12} c_{22} c_{32} c_{42}	c_{13} c_{23} c_{33} c_{43}	c_{14} c_{24} c_{34} c_{44}
000000	0	0.5000 0.5000 -0.5000 -0.500	0.5000 -0.5000 -0.5000 0.5000	0.5000 0.5000 0.5000 0.5000	0.5000 -0.5000 0.5000 -0.5000
000001	1	0.5000 0.5000 -0.5000 -0.5000	0.5000i -0.5000i -0.5000i 0.5000i	0.5000 0.5000 0.5000 0.5000	0.5000i -0.5000i 0.5000i -0.5000i

Table 856—C(4,4,6)

000010	2	0.5000 0.5000 -0.5000 -0.5000	0.5000 -0.5000 -0.5000i 0.5000i	0.5000 0.5000 0.5000 0.5000	0.5000 -0.5000 0.5000i -0.5000i
000011	3	0.5000 0.5000 -0.5000 -0.5000	0.0000+0.5000i 0.0000-0.5000i -0.5000 0.5000	0.5000 0.5000 0.5000 0.5000	0.5000i -0.5000i 0.5000 -0.5000
000100	4	0.5000 0.5000 0.5000 0.5000	0.5000 0.0000+0.5000i -0.5000 0.0000-0.5000i	0.5000 -0.5000 0.5000 -0.5000	-0.5000 0.5000i 0.5000 0.000-0.5000i
000101	5	0.5000 0.5000 0.5000 0.5000	0.3536+0.3536i -0.3536+0.3536i -0.3536-0.3536i 0.3536-0.3536i	0.5000i -0.5000i 0.5000i -0.5000i	-0.3536+0.3536i 0.3536+0.3536i 0.3536-0.3536i -0.3536-0.3536i
000110 ≈ 111111	6 ≈ 63	n.a			

The indexes from 6 to 63 are not used in 6-bits downlink PMI feedback for M_t =4 codebook.

MU-MIMO base codebook

The base codebook for MU-MIMO is same as the rank 1 base codebook for SU-MIMO.

Base codebook for eight transmit antennas

SU-MIMO base codebook

The base codebooks of SU-MIMO with eight transmit antennas consist of rank-1 codebook C(8,1,4), rank-2 codebook C(8,2,4), rank-3 codebook C(8,3,4), rank-4 codebook C(8,4,4), rank-5 codebook C(8,5,4), rank-6 codebook C(8,6,4), rank-7 codebook C(8,7,4) and rank-8 codebook C(8,8,4). Table 857 illustrates the rank-1 base codebook, and Table 858 illustrates the ranks 2,3,4,5,6,7,8 base codebooks.

Table 857—C(8, 1, 4)

Binary Index	**m**	**C(8,1,4,*m*) = [c_1; c_2; c_3; c_4; c_5; c_6; c_7; c_8]**							
		c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8
0000	0	0.3536	-0.3051 - 0.1786i	0.1732 + 0.3082i	0.0062 - 0.3535i	-0.1839 + 0.3020i	0.3112 - 0.1677i	-0.3533 - 0.0124i	0.2987 + 0.1892i
0001	1	0.3536	-0.2514 - 0.2486i	0.0041 + 0.3535i	0.2456 - 0.2543i	-0.3535 + 0.0082i	0.2571 + 0.2427i	-0.0123 - 0.3533i	-0.2397 + 0.2599i

Table 857—C(8, 1, 4)

Binary Index	m	C(8,1,4,*m*) = [c_1; c_2; c_3; c_4; c_5; c_6; c_7; c_8]							
		c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8
0010	2	0.3536	-0.1697 - 0.3102i	-0.1907 + 0.2977i	0.3527 + 0.0244i	-0.1479 - 0.3211i	-0.2107 + 0.2839i	0.3502 + 0.0486i	-0.1254 - 0.3306i
0011	3	0.3536	-0.0614 - 0.3482i	-0.3322 + 0.1210i	0.1768 + 0.3062i	0.2708 - 0.2273i	-0.2709 - 0.2272i	-0.1767 + 0.3062i	0.3323 + 0.1208i
0100	4	0.3536	0.0638 - 0.3478i	-0.3306 - 0.1254i	-0.1830 + 0.3025i	0.2646 + 0.2345i	0.2784 - 0.2180i	-0.1642 - 0.3131i	-0.3376 + 0.1050i
0101	5	0.3536	0.1881 - 0.2994i	-0.1534 - 0.3185i	-0.3513 - 0.0395i	-0.2204 + 0.2764i	0.1168 + 0.3337i	0.3447 + 0.0786i	0.2499 - 0.2501i
0110	6	0.3536	0.2892 - 0.2034i	0.1196 - 0.3327i	-0.0936 - 0.3409i	-0.2727 - 0.2251i	-0.3525 - 0.0272i	-0.3040 + 0.1805i	-0.1449 + 0.3225i
0111	7	0.3536	0.3461 - 0.0721i	0.3241 - 0.1412i	0.2885 - 0.2044i	0.2407 - 0.2590i	0.1828 - 0.3026i	0.1172 - 0.3336i	0.0467 - 0.3505i
1000	8	0.3536	0.3461 + 0.0721i	0.3241 + 0.1412i	0.2885 + 0.2044i	0.2407 + 0.2590i	0.1828 + 0.3026i	0.1172 + 0.3336i	0.0467 + 0.3505i
1001	9	0.3536	0.2892 + 0.2034i	0.1196 + 0.3327i	-0.0936 + 0.3409i	-0.2727 + 0.2251i	-0.3525 + 0.0272i	-0.3040 - 0.1805i	-0.1449 - 0.3225i
1010	10	0.3536	0.1881 + 0.2994i	-0.1534 + 0.3185i	-0.3513 + 0.0395i	-0.2204 - 0.2764i	0.1168 - 0.3337i	0.3447 - 0.0786i	0.2499 + 0.2501i
1011	11	0.3536	0.0638 + 0.3478i	-0.3306 + 0.1254i	-0.1830 - 0.3025i	0.2646 - 0.2345i	0.2784 + 0.2180i	-0.1642 + 0.3131i	-0.3376 - 0.1050i
1100	12	0.3536	-0.0614 + 0.3482i	-0.3322 - 0.1210i	0.1768 - 0.3062i	0.2708 + 0.2273i	-0.2709 + 0.2272i	-0.1767 - 0.3062i	0.3323 - 0.1208i
1101	13	0.3536	-0.1697 + 0.3102i	-0.1907 - 0.2977i	0.3527 - 0.0244i	-0.1479 + 0.3211i	-0.2107 - 0.2839i	0.3502 - 0.0486i	-0.1254 + 0.3306i
1110	14	0.3536	-0.2514 + 0.2486i	0.0041 - 0.3535i	0.2456 + 0.2543i	-0.3535 - 0.0082i	0.2571 - 0.2427i	-0.0123 + 0.3533i	-0.2397 - 0.2599i
1111	15	0.3536	-0.3051 + 0.1786i	0.1732 - 0.3082i	0.0062 + 0.3535i	-0.1839 - 0.3020i	0.3112 + 0.1677i	-0.3533 + 0.0124i	0.2987 - 0.1892i

The four rank-8 matrices used for rank-2 to rank-8 transmission for SU-MIMO are

$$V1 = \begin{bmatrix} 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & 0.25+0.25i & -0.25-0.25i & -0.25+0.25i & 0.25-0.25i \\ 0.3536 & 0.3536 & -0.3536 & -0.3536 & 0.3536i & 0.3536i & -0.3536i & -0.3536i \\ 0.3536 & -0.3536 & -0.3536i & 0.3536i & -0.25+0.25i & 0.25-0.25i & 0.25+0.25i & -0.25-0.25i \\ 0.3536 & 0.3536 & 0.3536 & 0.3536 & -0.3536 & -0.3536 & -0.3536 & -0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & -0.25-0.25i & 0.25+0.25i & 0.25-0.25i & -0.25+0.25i \\ 0.3536 & 0.3536 & -0.3536 & -0.3536 & -0.3536i & -0.3536i & 0.3536i & 0.3536i \\ 0.3536 & -0.3536 & -0.3536i & 0.3536i & 0.25-0.25i & -0.25+0.25i & -0.25-0.25i & 0.25+0.25i \end{bmatrix}$$

$$V2 = \begin{bmatrix} 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & 0.25+0.25i & -0.25-0.25i & -0.25+0.25i & 0.25-0.25i \\ 0.25+0.25i & 0.25+0.25i & -0.25-0.25i & -0.25-0.25i & -0.25+0.25i & -0.25+0.25i & 0.25-0.25i & 0.25-0.25i \\ 0.25+0.25i & -0.25-0.25i & 0.25-0.25i & -0.25+0.25i & -0.3536 & 0.3536 & 0.3536i & -0.3536i \\ 0.3536i & 0.3536i & 0.3536i & 0.3536i & -0.3536i & -0.3536i & -0.3536i & -0.3536i \\ 0.3536i & -0.3536i & -0.3536 & 0.3536 & 0.25-0.25i & -0.25+0.25i & 0.25+0.25i & -0.25-0.25i \\ -0.25+0.25i & -0.25+0.25i & 0.25-0.25i & 0.25-0.25i & 0.25+0.25i & 0.25+0.25i & -0.25-0.25i & -0.25-0.25i \\ -0.25+0.25i & 0.25-0.25i & 0.25+0.25i & -0.25-0.25i & 0.3536i & -0.3536i & 0.3536 & -0.3536 \end{bmatrix}$$

$$V3 = \begin{bmatrix} 0.5 & 0.5 & 0.5 & 0.5 & 0 & 0 & 0 & 0 \\ 0.5 & -0.5 & 0.5i & -0.5i & 0 & 0 & 0 & 0 \\ 0.5 & 0.5 & -0.5 & -0.5 & 0 & 0 & 0 & 0 \\ 0.5 & -0.5 & -0.5i & 0.5i & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0 & 0 & 0 & 0 & 0.5 & -0.5 & 0.5i & -0.5i \\ 0 & 0 & 0 & 0 & 0.5 & 0.5 & -0.5 & -0.5 \\ 0 & 0 & 0 & 0 & 0.5 & -0.5 & -0.5i & 0.5i \end{bmatrix}$$

$$V4 = \begin{bmatrix} 0.5 & 0.5 & 0.5 & 0.5 & 0 & 0 & 0 & 0 \\ a+ai & -a-ai & -a+ai & a-ai & 0 & 0 & 0 & 0 \\ 0.5i & 0.5i & -0.5i & -0.5i & 0 & 0 & 0 & 0 \\ -a+ai & a-ai & a+ai & -a-ai & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0 & 0 & 0 & 0 & a+ai & -a-ai & -a+ai & a-ai \\ 0 & 0 & 0 & 0 & 0.5i & 0.5i & -0.5i & -0.5i \\ 0 & 0 & 0 & 0 & -a+ai & a-ai & a+ai & -a-a \end{bmatrix}, where \quad a = 0.3536$$

The 4bits 8Tx base codebook for ranks 2 to 8 is constructed from the four 8×8 base matrices and is specified in Table 858. Note that only the column indices of the corresponding base matrices are shown in Table 858 for brevity.

Table 858—Ranks 2 to 8 of SU MIMO 4bit 8Tx base codebook

Codebook Matrix Index (CMI)	Base Matrix	C(8,2,4)	Base Matrix	C(8,3,4)	C(8,4,4)	C(8,5,4)	C(8,6,4)	C(8,7,4)	C(8,8,4)
0	*V1*	1 5	*V1*	1 3 5	1537	12357	123567	1234567	12345678
1		2 6		2 4 6	2648	12468	124568	1234568	n/a
2		3 7		2 3 7	3726	23467	234678	1234678	n/a
3		4 8		1 4 8	4815	13458	134578	1234578	n/a
4		5 3		3 5 7	5372	23567	234567	2345678	n/a
5		4 6		4 6 8	6481	14568	134568	1345678	n/a
6		2 7		2 6 7	7264	24678	124678	1245678	n/a
7		8 1		1 5 8	8153	13578	123578	1235678	n/a
8	*V3*	1 5	*V2*	1 2 3	1234	12345	123456	1234567	12345678
9		2 6		1 2 4	1246	12456	124567	1245678	n/a
10		3 7		2 3 4	2437	23478	123478	1234578	n/a
11		4 8		1 3 4	1348	13478	134678	1234678	n/a
12	*V4*	1 5		5 7 8	3578	23578	235678	1235678	n/a
13		2 6		6 7 8	4678	14678	145678	1345678	n/a
14		3 7		5 7 6	5678	35678	345678	2345678	n/a
15		4 8		5 6 8	1568	13568	123568	1234568	n/a

The indexes from 1 to 7 and 9 to 15 are not used in 4-bits downlink PMI feedback for M_t =8 codebook.

MU-MIMO base codebook

The base codebook for MU-MIMO is same as the rank 1 base codebook for SU-MIMO.

Codebook subset selection

In codebook-based precoding with CL MIMO operation, the precoding matrix **W(***k***)** shall be derived from a PMI within the base codebook or a subset thereof. Subset information is transmitted in BC_SI and Codebook_subset indication.

Base Codebook Subset Indication (BC_SI) field determines which elements of the rank-1 codebook are restricted or recommended for PMI feedback in case of MIMO mode 2 and 4. If the *i*-th element of BC_SI is set to 0, then the *i*-th element of the rank-1 codebook, C(N_t, 1, N_B, *i*), is restricted for PMI feedback. This field shall be ignored when Codebook_mode is not set to 0b11. If Codebook_mode is set to 0b11 or

Codebook_coordination is set to 0b1 when the ABS has 4 transmit antennas, then Codebook_subset shall be set to 0b1. CM Codebook_mode and Codebook_coordination are transmitted in the Feedback Allocation A-MAP IE or Feedback Polling A-MAP IE.

Codebook subsets

OL MIMO subset

The OL SU-MIMO codebook subset shall be used for non-adaptive precoding with MIMO mode 0, MIMO mode 1, and MIMO mode 5.

The notation $C_{DL,OL,SU}(N_t, M_t, N_w)$ denotes the DL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t, and M_t denotes the number of MIMO streams. The notation $C_{DL,OL,SU}(N_t, M_t, N_w, i)$ denotes the i-th codebook entry of $C_{DL,OL,SU}(N_t, M_t, N_w)$.

OL SU-MIMO subset for two transmit antennas

Table 859 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 2Tx.

Table 859—Size of the DL 2TX OL SU-MIMO codebook subset

Rank	1	2
N_w	2	1

The codewords of the OL SU-MIMO codebook subset for two transmit antennas are given in Table 860 for each rank. The corresponding codewords of the DL base codebook for two transmit antennas are also given in Table 860.

Table 860—$C_{DL,OL,SU}(2,1,2)$ and $C_{DL,OL,SU}(2,2,1)$

$C_{DL,OL,SU}(2, 1, 2, n)$		$C_{DL,OL,SU}(2, 2, 1, n)$	
n	**C(2,1,3,*m*) in downlink base codebook**	***n***	**C(2,2,3,*m*) in downlink base codebook**
0	C(2,1,3,2)	0	C(2,2,3,2)
1	C(2,1,3,6)		

OL SU-MIMO subset for four transmit antennas

Table 861 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 4Tx.

Table 861—Size of the DL 4TX OL SU-MIMO codebook subset

Rank	1	2	3	4
N_w	4	4	2	1

The codewords of the OL SU-MIMO codebook subset for four transmit antennas are given in Table 862 for each rank. The corresponding codewords of the DL base codebook for four transmit antennas are given in Table 862.

Table 862—$C_{DL,OL,SU}(4,1,4)$, $C_{DL,OL,SU}(4,2,4)$, $C_{DL,OL,SU}(4,3,2)$ and $C_{DL,OL,SU}(4,4,1)$

$C_{DL,OL,SU}(4, 1, 4, n)$		$C_{DL,OL,SU}(4, 2, 4, n)$		$C_{DL,OL,SU}(4, 3, 2, n)$		$C_{DL,OL,SU}(4, 4, 1, n)$	
n	**C(4,1,6,*m*) in base codebook**	***n***	**C(4,2,6,*m*) in base codebook**	***n***	**C(4,3,6,*m*) in base codebook**	***n***	**C(4,4,6,*m*) in base codebook**
0	C(4,1,6,8)	0	C(4,2,6,23)	0	C(4,3,6,12)	0	C(4,4,6,4)
1	C(4,1,6,10)	1	C(4,2,6,29)	1	C(4,3,6,13)		
2	C(4,1,6,9)	2	C(4,2,6,27)				
3	C(4,1,6,11)	3	C(4,2,6,25)				

OL SU-MIMO subset for eight transmit antennas

Table 863 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 8Tx.

Table 863—Size of the DL 8Tx OL SU-MIMO codebook subset

Rank	1	2	3	4	5	6	7	8
N_w	8	4	4	2	2	2	2	1

The codewords of the OL SU-MIMO codebook subset for eight transmit antennas are given in Table 864 and Table 865 for each rank. The corresponding codewords of the DL base codebook for eight transmit antennas are given in Table 864 and Table 865.

Table 864—$C_{DL,OL,SU}(8,1,8)$, $C_{DL,OL,SU}(8,2,4)$, $C_{DL,OL,SU}(8,3,4)$ and $C_{DL,OL,SU}(8,4,2)$

$C_{DL,OL,SU}(8, 1, 8, n)$		$C_{DL,OL,SU}(8, 2, 4, n)$		$C_{DL,OL,SU}(8, 3, 4, n)$		$C_{DL,OL,SU}(8, 4, 2, n)$	
n	C(8,1,4,*m*) in base codebook	*n*	C(8,2,4,*m*) in base codebook	*n*	C(8,3,4,*m*) in base codebook	*n*	C(8,4,4,*m*) in base codebook
0	C(8,1,4,0)	0	C(8,2,4,0)	0	C(8,3,4,0)	0	C(8,4,4,0)
1	C(8,1,4,3)	1	C(8,2,4,1)	1	C(8,3,4,1)	1	C(8,4,4,1)
2	C(8,1,4,5)	2	C(8,2,4,2)	2	C(8,3,4,2)		
3	C(8,1,4,7)	3	C(8,2,4,3)	3	C(8,3,4,5)		
4	C(8,1,4,9)						
5	C(8,1,4,11)						
6	C(8,1,4,13)						
7	C(8,1,4,15)						

Table 865—$C_{DL,OL,SU}(8,5,2)$, $C_{DL,OL,SU}(8,6,2)$, $C_{DL,OL,SU}(8,7,2)$ and $C_{DL,OL,SU}(8,8,1)$

$C_{DL,OL,SU}(8, 5, 2, n)$		$C_{DL,OL,SU}(8, 6, 2, n)$		$C_{DL,OL,SU}(8, 7, 2, n)$		$C_{DL,OL,SU}(8, 8, 1, n)$	
n	C(8,5,4,*m*) in base codebook	*n*	C(8,6,4,*m*) in base codebook	*n*	C(8,7,4,*m*) in base codebook	*n*	C(8,8,4,*m*) in base codebook
0	C(8,5,4,0)	0	C(8,6,4,0)	0	C(8,7,4,0)	0	C(8,8,**4**,0)
1	C(8,5,4,1)	1	C(8,6,4,1)	1	C(8,7,4,1)		

CL SU-MIMO subset for four transmit antennas

Codebook subset selection for four transmit antennas is specified in Table 866.

Table 866—Subset selection of the base codebok for four transmit antennas

Rank	One	Two	Three	Four
Subset selection	C(4,1,6,m) m = 0 to15	C(4,2,6,m) m = 0 to15	C(4,3,6,m) m = 0 to15	C(4,4,6,m) m = 0 to5

CL MU-MIMO subset for four transmit antennas

The base codebook subset for MU-MIMO is the same as the rank 1 of the base codebook subset for SU-MIMO, defined in Table 866.

16.3.7.2.5.5.1 Transformation codebook based feedback mode

The base codebooks and their subsets of rank 1 for SU and MU MIMO can be transformed as a function of the ABS transmit correlation matrix. A quantized representation of the ABS transmit correlation matrix shall be fed back by the AMS as instructed by the ABS

For the transformation mode, the PMI feedback from a mobile station shall represent an entry of the transformed base codebook according to long term channel information.

In transformation mode, both ABS and AMS transform the rank 1 base codebook to a rank 1 transformed codebook using the correlation matrix.

The transformation for codewords of rank 1 is of the form in Equation (245)

$$\tilde{\boldsymbol{v}}_i = \frac{\boldsymbol{R}\boldsymbol{v}_i}{\|\boldsymbol{R}\boldsymbol{v}_i\|} \tag{245}$$

$\boldsymbol{v}_i$ is the i-th codeword of the base codebook,

$\tilde{\boldsymbol{v}}_i$ is the i-th codeword of the transformed codebook,

$\mathbf{R}$ is the $N_t \times N_t$ transmit correlation matrix.

After obtaining the transformed codebook, both AMS and ABS shall use the transformed codebook for the feedback and precoding process of rank 1. The codebooks of rank > 1 shall be used without transformation when the AMS is operating with transformation codebook-based feedback mode.

The correlation matrix **R** shall be fed back to support transformation mode of codebook-based precoding.

R is fed back periodically and one correlation matrix is valid for whole band.

During some time period and in the whole band, the correlation matrix is measured as

$$\mathbf{R} = \mathrm{E}(\mathbf{H}_{ij}^H \mathbf{H}_{ij}) \tag{246}$$

Where $\mathbf{H}_{ij}$ is the correlated channel matrix in the i-th OFDM symbol period and j-th subcarriers.

The measured correlation matrix has the format of

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} \\ \mathrm{conj}(r_{12}) & r_{22} \end{bmatrix} \qquad (N_t = 2) \tag{247}$$

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} \\ \mathrm{conj}(r_{12}) & r_{22} & r_{23} & r_{24} \\ \mathrm{conj}(r_{13}) & \mathrm{conj}(r_{23}) & r_{33} & r_{34} \\ \mathrm{conj}(r_{14}) & \mathrm{conj}(r_{24}) & \mathrm{conj}(r_{34}) & r_{44} \end{bmatrix} \qquad (N_t = 4) \tag{248}$$

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} & r_{16} & r_{17} & r_{18} \\ \mathrm{conj}(r_{12}) & r_{22} & r_{23} & r_{24} & r_{25} & r_{26} & r_{27} & r_{28} \\ \mathrm{conj}(r_{13}) & \mathrm{conj}(r_{23}) & r_{33} & r_{34} & r_{35} & r_{36} & r_{37} & r_{38} \\ \mathrm{conj}(r_{14}) & \mathrm{conj}(r_{24}) & \mathrm{conj}(r_{34}) & r_{44} & r_{45} & r_{46} & r_{47} & r_{48} \\ \mathrm{conj}(r_{15}) & \mathrm{conj}(r_{25}) & \mathrm{conj}(r_{35}) & \mathrm{conj}(r_{45}) & r_{55} & r_{56} & r_{57} & r_{58} \\ \mathrm{conj}(r_{16}) & \mathrm{conj}(r_{26}) & \mathrm{conj}(r_{36}) & \mathrm{conj}(r_{46}) & \mathrm{conj}(r_{56}) & r_{66} & r_{67} & r_{68} \\ \mathrm{conj}(r_{17}) & \mathrm{conj}(r_{27}) & \mathrm{conj}(r_{37}) & \mathrm{conj}(r_{47}) & \mathrm{conj}(r_{57}) & \mathrm{conj}(r_{67}) & r_{77} & r_{78} \\ \mathrm{conj}(r_{18}) & \mathrm{conj}(r_{28}) & \mathrm{conj}(r_{38}) & \mathrm{conj}(r_{48}) & \mathrm{conj}(r_{58}) & \mathrm{conj}(r_{68}) & \mathrm{conj}(r_{78}) & r_{88} \end{bmatrix} \qquad (N_t = 8) \tag{249}$$

where the diagonal entries are positive and the non-diagonal entries are complex. Because of the symmetry of the correlation matrix, only the upper triangular elements shall be fed back after quantization.

The **R** matrix is normalized by the maximum element amplitude, and then quantized to reduce the feedback overhead.

The equation of normalization is

$$\bar{R} = \frac{R}{max(abs(r_{ij}))} \qquad (i, j = 1, \ldots, N_t) \tag{250}$$

The normalized diagonal elements are quantized by 1 bit, and the normalized complex elements are quantized by 4 bits.

The equation for quantization is

$$q = a \cdot e^{(j \cdot b \cdot 2\pi)} \tag{251}$$

a=[0.6 0.9] and b=0 for diagonal entries

Table 867—Quantization parameters for diagonal entries of *R*

Diagonal Entries	Binary encoding	a	b	q
q_1	0	0.6	0	0.6000
q_2	1	0.9	0	0.9000

a=[0.1 0.5] and *b*=[0 1/8 1/4 3/8 1/2 5/8 3/4 7/8] for non-diagonal upper trangular entries

Table 868—Quantization parameters for non-diagonal entries of *R*

Non-Diagonal Entries	Binary encoding	a	b	q
q_1	0000	0.1	0	0.1000
q_2	0001	0.1	1/8	0.0707 + 0.0707i
q_3	0010	0.1	1/4	0.1000i
q_4	0011	0.1	3/8	-0.0707 + 0.0707i
q_5	0100	0.1	1/2	-0.1000
q_6	0101	0.1	5/8	-0.0707 - 0.0707i
q_7	0110	0.1	3/4	- 0.1000i
q_8	0111	0.1	7/8	0.0707 - 0.0707i
q_9	1000	0.5	0	0.5000
q_{10}	1001	0.5	1/8	0.3536 + 0.3536i
q_{11}	1010	0.5	1/4	0.5000i
q_{12}	1011	0.5	3/8	-0.3536 + 0.3536i
q_{13}	1100	0.5	1/2	-0.5000
q_{14}	1101	0.5	5/8	-0.3536 - 0.3536i
q_{15}	1110	0.5	3/4	- 0.5000i
q_{16}	1111	0.5	7/8	0.3536 - 0.3536i

The total number of bits of feedback is 6 bits for 2 transmit antennas, 28 bits for 4 transmit antennas, and 120 bits for 8 transmit antennas. The AMS and ABS shall use the same transformation based on the correlation matrix fed back by the AMS.

16.3.7.2.5.5.2 Differential codebook-based feedback mode

The differential feedbacks exploit the correlation between precoding matrixes adjacent in time or frequencies. The feedback shall start initially and restart periodically by sending a one-shot feedback that fully depicts the precoder by itself. At least one differential feedback shall follow the start and restart feedback. The start and restart feedback employs the codebook defined for the base mode and is sent through long term report defined in Feedback Allocation A-MAP IE for MFM 3 and 6. The differential feedback is sent through short term report defined in Feedback Allocation A-MAP IE for MFM 3 and 6.

Denote the feedback index, the corresponding feedback matrix, and the corresponding precoder by t, $\boldsymbol{D}(t)$, and $\boldsymbol{V}(t)$, respectively. The sequential index is reset to 0 at $T_{max} + 1$. The index for the start and restart feedbacks are 0. Let $\boldsymbol{A}$ be a vector or a matrix and $\boldsymbol{Q_A}$ be the rotation matri determined by $\boldsymbol{A}$. The indexes of the subsequent differential feedbacks are 1, 2, ..., T_{max} and the corresponding precoders are

$$\boldsymbol{V}(t) = \boldsymbol{Q}_{\boldsymbol{V}(t\text{-}1)}\boldsymbol{D}(t), \text{ for } t = 0,1, 2, ..., T_{max}$$

where the rotation matrix $\boldsymbol{Q}_{\boldsymbol{V}(t\text{-}1)}$ is a unitary $N_t \times N_t$ matrix computed from the previous precoder $\boldsymbol{V}(t\text{-}1)$; N_t is the number of transmit antennas. The dimension of the feedback matrix $\boldsymbol{D}(t)$ is $N_t \times M_t$, where M_t is the number of spatial streams.

$\boldsymbol{Q}_{\boldsymbol{V}(t\text{-}1)}$ has the form $\boldsymbol{Q}_{V(t-1)} = \left[\boldsymbol{V}(t-1)\ \boldsymbol{V}^{\perp}(t-1)\right]$, where $\boldsymbol{V}^{\perp}(t-1)$ consists of columns each of which has a unit norm and is orthogonal to the other columns of $\boldsymbol{Q}_{\boldsymbol{V}(t\text{-}1)}$. For $M_t = 1$, where $\boldsymbol{V}(t\text{-}1)$ is a vector,

$$\boldsymbol{Q}_{V(t-1)} = \begin{cases} \boldsymbol{I} - \dfrac{2}{\|\omega\|^2}\omega\omega^H, \text{ for } \|\omega\| > 0 \\ \boldsymbol{I}, \text{ otherwise} \end{cases}$$

where $\|\boldsymbol{V}(t-1)\| = 1$ and $\omega = e^{-j\theta}\boldsymbol{V}(t-1) - \boldsymbol{e}_1$; θ is the phase of the first entry of $\boldsymbol{V}(t\text{-}1)$, and $\boldsymbol{e}_1 = [1\ 0\ ...\ 0]^T$. For $M_t > 1$, let $L = N_t - M_t$. For computing $\boldsymbol{Q}_{\boldsymbol{V}(t\text{-}1)}$, L columns are appended to $\boldsymbol{V}(t\text{-}1)$ forming a square matrix $\boldsymbol{M} = [\boldsymbol{V}(t\text{-}1)\ \boldsymbol{E}]$ and the appended columns are

$$\boldsymbol{E} = \left[\boldsymbol{e}_{\tau_1}\ \ldots\ \boldsymbol{e}_{\tau_L}\right]$$

where $\boldsymbol{e}_{\tau_j}$ is the $N_t \times 1$ vector whose entry on the τ_j -th row is one and whose other entries are zeros. $\boldsymbol{Q}_{\boldsymbol{V}(t\text{-}1)}$ is computed by orthogonalizing and normalizing the columns of $\boldsymbol{M}$. The indexes τ_j for $j = 1, ..., L$ are selected for the numerical stability of the orthogonalization and normalization process. Let

$$\boldsymbol{g} = (|\mathrm{Re}(\boldsymbol{V}(t-1))| + |\mathrm{Im}(\boldsymbol{V}(t-1))|)\boldsymbol{a}$$

where $\boldsymbol{a}$ is the $1 \times M_t$ vector with all entries equal to one; Re() and Im() take the real and imaginary parts of the input matrix, respectively; | | takes the absolute values of the input matrix entry by entry. The i-th row of the vector $\boldsymbol{g}$ has the sum of the absolute values of all the real and imaginary parts of $\boldsymbol{V}(t\text{-}1)$ on the same row. The entries of $\boldsymbol{g}$ are stored in an increasing order. If $\boldsymbol{g}_i = \boldsymbol{g}_j$ and $i < j$, then $\boldsymbol{g}_i < \boldsymbol{g}_j$ is used in the order list. The order list is

$$\boldsymbol{g}_{k_1} < \ldots < \boldsymbol{g}_{k_{N_t}}$$

where k_i for i =1, ..., $\boldsymbol{N}_t$ are row indexes of $\boldsymbol{g}$. The first L indexes in the list are assigned to the indexes τ_j in $\boldsymbol{E}$ as

$$\tau_j = k_j \text{, for } j = 1, \ldots, L$$

The Gram-Schmidt orthogonalization and a normalization process are applied to the last L columns of $\boldsymbol{M}$ column by column and result in $\boldsymbol{Q}_{\boldsymbol{V}(t\text{-}1)}$ as

For $j = 1: L$

For $k = 1: j + M_t - 1$

$$\boldsymbol{m}_{j+M_t} = \boldsymbol{m}_{j+M_t} - \boldsymbol{m}^*_{\tau_j,k}\boldsymbol{m}_k$$

End

$$\boldsymbol{m}_{j+M_t} = \frac{\boldsymbol{m}_{j+M_t}}{\|\boldsymbol{m}_{j+M_t}\|}$$

End

$$\boldsymbol{Q}_{\boldsymbol{V}(t-1)} = M$$

where $\boldsymbol{m}^*_{\tau_j,k}$ is the conjugate of $\boldsymbol{M}$'s entry on the τ_j -th row and k^{th} column.

The feedback matrix $\boldsymbol{D}(t)$ is selected from a differential codebook. Denote the codebook by $D(N_t, M_t\, N_w)$, where N_w is the number of codewords in the codebook. The codebooks D(2,1,4), D(2,2,4), D(4,1,16), D(4,2,16), D(8,1,16), D(8,2,16), D(8,3,16) and D(8,4,16) are listed in Table 869, Table 870, Table 871, Table 872, Table 873, Table 874, Table 875 and Table 876. Denote $\boldsymbol{D}_i(N_t,M_t,N_w)$ the i^{th} codeword of $D(N_t, M_t\, N_w)$. The rotation matrixes $\boldsymbol{Q}_{D_i(N_t, M_t, N_w)}$ s of the $\boldsymbol{D}_i(N_t,M_t,N_w)$s comprises a set of N_t by N_t matrixes that is denoted by $\boldsymbol{Q}_{D(N_t, M_t, N_w)}$.

The differential codebook $D(4,3,N_w)$ is computed from $\boldsymbol{Q}_{D(4,1,N_w)}$. The i^{th} codeword of $D(4,3,N_w)$ denoted by $\boldsymbol{D}_i(4,3,N_w)$ is computed as

$$\boldsymbol{D}_i(4, 3, N_w) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} \tilde{\boldsymbol{Q}}_i(4, 1, N_w),$$

where $\tilde{Q}_i(4, 1, N_w)$ consists of the last three columns of the i^{th} matrix in $\boldsymbol{Q}_{D(4, 1, N_w)}$. The differential codebook $D(4,4,N_w)$ is computed from $\boldsymbol{Q}_{D(4, 2, N_w)}$. The i^{th} codeword of $D(4,4,N_w)$ is the i^{th} matrix in $\boldsymbol{Q}_{D(4, 2, N_w)}$. The differential codebooks $D(8,5,N_w)$, $D(8,6,N_w)$, and $D(8,7,N_w)$ are computed from $D(8,3,N_w)$, $D(8,2,N_w)$, and $D(8,1,N_w)$, respectively. The i^{th} codewords $\mathbf{D}_i(8,5,N_w)$, $\mathbf{D}_i(8,6,N_w)$, and $\mathbf{D}_i(8,7,N_w)$ of $D(8,5,N_w)$, $D(8,6,N_w)$, and $D(8,7,N_w)$ are computed, respectively as

$$\boldsymbol{D}_i(8, 5, N_w) = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \tilde{\boldsymbol{Q}}_i(8, 3, N_w)$$

$$\boldsymbol{D}_i(8, 6, N_w) = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \tilde{\boldsymbol{Q}}_i(8, 2, N_w)$$

$$\boldsymbol{D}_i(8, 7, N_w) = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \tilde{\boldsymbol{Q}}_i(8, 1, N_w)$$

where $\tilde{\boldsymbol{Q}}_i(8, k, N_w)$ consists of the last 8-k columns of the i^{th} matrix in $\mathbf{Q}_{D(8,k,Nw)}$. The differential codebook $D(8,8,N_w)$ is computed from $D(8,4,N_w)$. The i^{th} code word of $D(8,8,N_w)$ is the i^{th} matrix in $\mathbf{Q}_{D(8,4,Nw)}$.

Table 869—*D*(2,1,4) codebook

Index	Codeword	Index	Codeword
1	$\begin{bmatrix}1 & 0\end{bmatrix}^T$	3	$\begin{bmatrix}\cos(15°) & \sin(15°)\exp(j120°)\end{bmatrix}^T$
2	$\begin{bmatrix}\cos(15°) & \sin(15°)\end{bmatrix}^T$	4	$\begin{bmatrix}\cos(15°) & \sin(15°)\exp(-j120°)\end{bmatrix}^T$

Table 870—*D*(2,2,4) codebook

Index	Codeword	Index	Codeword
1	$\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}$	3	$\begin{bmatrix}\cos(15°) & \sin(15°)\exp(j120°)\\ \sin(15°)\exp(j120°) & -\cos(15°)\end{bmatrix}$
2	$\begin{bmatrix}\cos(15°) & \sin(15°)\\ \sin(15°) & -\cos(15°)\end{bmatrix}$	4	$\begin{bmatrix}\cos(15°) & \sin(15°)\exp(-j120°)\\ \sin(15°)\exp(-j120°) & -\cos(15°)\end{bmatrix}$

Table 871—D(4,1,16) codebook

Index	Codeword	Index	Codeword
1	[1 0 0 0]^T	9	[cos(20^o) 0.2553 + 0.1430i 0.0282 + 0.0897i 0.1469 + 0.0308i]^T
2	[cos(20^o) 0.2062 - 0.0657i 0.0485 - 0.2038i -0.0885 + 0.1358i]^T	10	[cos(20^o) 0.0507 - 0.3289i 0.0276 + 0.0448i 0.0508 - 0.0297i]^T
3	[cos(20^o) -0.0531 - 0.0765i 0.0806 - 0.1811i -0.1432 - 0.2203i]^T	11	[cos(20^o) -0.0352 + 0.2445i 0.0560 + 0.1197i -0.1178 - 0.1569i]^T
4	[cos(20^o) -0.0762 - 0.1024i -0.2492 - 0.1865i 0.0616 + 0.0028i]^T	12	[cos(20^o) -0.0505 - 0.0233i -0.1061 + 0.3140i 0.0505 + 0.0382i]^T
5	[cos(20^o) -0.0475 - 0.0535i 0.0266 - 0.0109i 0.1997 + 0.2668i]^T	13	[cos(20^o) -0.3407 - 0.0014i 0.0280 + 0.0108i 0.0021 + 0.0020i]^T
6	[cos(20^o) -0.0478 - 0.0010i -0.0229 + 0.0325i 0.2359 - 0.2397i]^T	14	[cos(20^o) -0.0180 - 0.0100i 0.3300 + 0.0502i 0.0685 - 0.0205i]^T
7	[cos(20^o) 0.0030 + 0.1854i -0.1733 -0.1136 + 0.1992i]^T	15	[cos(20^o) -0.0401 - 0.0885i 0.0946 + 0.1084i -0.2792 + 0.0942i]^T
8	[cos(20^o) 0.1926 - 0.0378i -0.1914 + 0.0534i -0.1467 - 0.1320i]^T	16	[cos(20^o) -0.0436 + 0.2160i 0.0596 - 0.2318i 0.1057 + 0.0002i]^T

Table 872—D(4,2,16) codebook

Index	Codeword	Index	Codeword
1	[1 0 0 0 0 1 0 0]^T	9	[0.9770 0.1518 + 0.0929i 0.0606 - 0.0773i 0.0063 - 0.0647i -0.0507 - 0.1011i -0.0981 + 0.8703i -0.1618 - 0.0957i -0.3914 + 0.1776i]^T
2	[0.9571 -0.0238 + 0.0314i -0.0454 - 0.2541i -0.0790 + 0.0977i -0.0965 + 0.0299i 0.9114 + 0.0872i -0.0431 - 0.3386i -0.1023 + 0.1567i]^T	10	[-0.6295 -0.5472 - 0.3123i -0.0136 - 0.1891i 0.2222 - 0.3486i 0.5496 - 0.3201i -0.7539 - 0.0022i 0.0440 + 0.0657i -0.0189 + 0.1434i]^T
3	[-0.0262 0.7460 - 0.6224i 0.2085 + 0.1061i 0.0104 - 0.0226i 0.6933 + 0.5709i 0.1217 + 0.0055i -0.1479 - 0.3702i -0.1061 - 0.0917i]^T	11	[0.3622 -0.8103 - 0.3554i 0.0797 - 0.2550i -0.1050 + 0.0596i -0.8270 + 0.3289i -0.2410 - 0.0429i -0.1349 - 0.3222i -0.0937 + 0.1311i]^T
4	[0.9990 0.0386 - 0.0212i 0.0035 - 0.0023i 0.0002 + 0.0019i -0.0343 - 0.0200i 0.8730 + 0.0488i 0.3473 - 0.1714i 0.2857 - 0.0483i]^T	12	[-0.4402 -0.8115 - 0.0841i 0.0434 + 0.1299i -0.1636 + 0.3083i -0.7666 + 0.1113i 0.5535 + 0.0180i 0.0170 + 0.1186i -0.1660 + 0.2268i]^T
5	[0.9556 0.1479 - 0.0806i -0.0215 + 0.1307i -0.0706 - 0.1894i -0.0844 + 0.0610i 0.8284 - 0.3568i 0.1996 - 0.1472i -0.1478 + 0.3037i]^T	13	[1 0 0 0 0 -0.8741 + 0.0445i 0.3194 - 0.1760i 0.3172 – 0.0173i]^T
6	[-0.8726 0.1100 - 0.0735i -0.4250 - 0.1821i -0.0795 + 0.0325i 0.1648 + 0.1221i 0.9722 - 0.0007i -0.0410 - 0.1039i 0.0018 + 0.0180i]^T	14	[-0.8851 -0.3025 + 0.3449i 0.0049 + 0.0437i -0.0340 - 0.0557i 0.2630 + 0.2692i -0.7941 - 0.0049i 0.2671 - 0.0632i -0.2947 + 0.2561i]^T
7	[-0.6845 -0.0048 - 0.7234i 0.0310 - 0.0167i 0.0831 + 0.0006i 0.0085 + 0.6243i 0.6200 + 0.0054i -0.3294 - 0.2343i 0.2292 - 0.0994i]^T	15	[0.8990 -0.1582 - 0.1183i 0.1246 - 0.0775i -0.3616 - 0.0214i 0.0035 + 0.2203i -0.8650 + 0.3492i -0.0464 + 0.0693i 0.2338 + 0.1398i]^T
8	[0.5617 0.8043 + 0.1719i -0.0617 - 0.0099i 0.0607 - 0.0241i 0.7006 - 0.1414i -0.5130 - 0.0152i -0.1561 + 0.2422i 0.3191 + 0.2023i]^T	16	[0.5212 0.3746 + 0.7570i 0.0670 + 0.1016i -0.0085 - 0.0003i 0.3025 - 0.7018i -0.4381 + 0.0708i -0.2495 - 0.2784i 0.2622 - 0.1028i]^T

Table 873—D(8,1,16) codebook

Index	Codeword	Index	Codeword
1	[cos(20^o) 0 -0.1449 - 0.1483i 0.0019 + 0.0060i 0.0336 + 0.0253i -0.0242 - 0.1235i -0.2259 + 0.0069i 0.0409 - 0.0598i]^T	9	[cos(20^o) 0 0.1314 + 0.0144i 0.0509 + 0.0237i 0.0301 + 0.0390i 0.0311 + 0.0019i -0.0091 + 0.0202i 0.2958 + 0.0708i]^T
2	[cos(20^o) 0 -0.0005 + 0.0004i 0.0334 + 0.0152i 0.0022 + 0.0207i -0.0651 + 0.1824i 0.0153 + 0.2095i -0.0093 - 0.1830i]^T	10	[cos(20^o) 0 0.0292 + 0.0247i -0.3217 + 0.1076i -0.0073 + 0.0175i 0.0049 + 0.0013i 0.0048 - 0.0017i -0.0004 - 0.0001i]^T

Table 873—D(8,1,16) codebook

Index	Codeword	Index	Codeword
3	[cos(20^{o}) 0.3402 - 0.0352i 0 0 0 0 0 0]^T	11	[cos(20^{o}) 0 0.0702 - 0.0699i 0.0279 - 0.0024i 0.0380 + 0.0396i -0.0493 - 0.0118i -0.0215 + 0.1480i -0.1441 + 0.2401i]^T
4	[cos(20^{o}) 0 -0.0264 - 0.0267i 0.0602 + 0.0858i 0.0281 + 0.0282i 0.2700 + 0.1283i -0.0290 - 0.0870i -0.0700 + 0.0173i]^T	12	[cos(20^{o}) 0 -0.1352 + 0.2709i 0.0727 + 0.1069i -0.0037 - 0.0066i -0.0406 - 0.0670i -0.0100 + 0.0186i -0.0156 + 0.0413i]^T
5	[cos(20^{o}) -0.2005 - 0.2771i 0 0 0 0 0 0]^T	13	[cos(20^{o}) 0 -0.1771 - 0.1261i 0.0068 + 0.0073i 0.0303 - 0.0033i -0.0678 + 0.0243i 0.2320 - 0.0669i 0.0581 + 0.0424i]^T
6	[cos(20^{o}) 0 -0.0368 + 0.0937i -0.0494 - 0.3041i 0.0844 + 0.0300i 0.0619 + 0.0044i 0.0004 - 0.0052i -0.0043 - 0.0018i]^T	14	[cos(20^{o}) 0 0.0091 - 0.0155i 0.0183 - 0.0622i -0.3302 + 0.0486i 0.0145 - 0.0213i 0.0072 - 0.0162i -0.0063 + 0.0050i]^T
7	[cos(20^{o}) 0 0.1291 - 0.0176i 0.0518 + 0.0286i 0.0540 + 0.0451i 0.0479 - 0.2164i 0.1215 + 0.0023i -0.0800 - 0.1457i]^T	15	[cos(20^{o}) 0 0.0473 - 0.0160i 0.0085 - 0.0123i 0.0046 - 0.3373i 0.0003 - 0.0018i -0.0172 - 0.0097i -0.0070 - 0.0022i]^T
8	[cos(20^{o}) 0 0.1048 + 0.0160i 0.0387 - 0.0003i 0.0357 + 0.0531i -0.1838 + 0.0992i -0.0685 - 0.2188i -0.0579 - 0.0243i]^T	16	[cos(20^{o}) -0.1397 + 0.3122i 0 0 0 0 0 0]^T

Table 874—D(8,2,16) codebook

Index	Codeword	Index	Codeword
1	[0.7331 0.5926 - 0.0231i -0.0036 - 0.1045i -0.0006 + 0.2627i 0.0545 + 0.1414i -0.0320 - 0.0143i 0.0665 - 0.0168i 0.0219 - 0.0397i 0.5425 + 0.1393i -0.7031 - 0.2625i 0.0237 + 0.0141i -0.1884 + 0.1499i -0.2074 - 0.0770i 0.0188 + 0.0326i 0.0117 - 0.0680i -0.0831 + 0.0480i]^T	9	[0.4805 0.4783 + 0.6827i 0.0742 - 0.1408i -0.0160 - 0.1621i 0.0606 + 0.1005i -0.0429 - 0.0279i 0.0086 - 0.0629i 0.0331 - 0.0307i 0.4265 - 0.6231i -0.5197 + 0.0132i -0.2630 - 0.1531i -0.1293 - 0.0967i 0.0014 + 0.1463i -0.0259 - 0.0655i 0.0028 + 0.0110i -0.1108 - 0.0468i]^T
2	[0.9982 -0.0307 + 0.0185i 0.0165 - 0.0095i -0.0101 + 0.0149i 0.0172 + 0.0310i -0.0025 + 0.0122i -0.0153 + 0.0006i 0.0036 + 0.0045i 0.0119 + 0.0176i 0.8584 + 0.1763i 0.2087 + 0.1178i 0.0105 + 0.1397i 0.0008 + 0.1248i 0.1068 - 0.0086i -0.2813 + 0.0375i -0.2150 - 0.0270i]^T	10	[0.7753 -0.3773 + 0.3664i 0.1663 - 0.0282i -0.0184 - 0.0221i -0.0261 + 0.0896i 0.0229 + 0.0120i -0.1158 + 0.1945i 0.1034 + 0.1477i -0.3397 - 0.3554i -0.8030 - 0.0429i 0.0130 - 0.1029i -0.0238 + 0.1384i 0.0673 - 0.0364i -0.1714 + 0.1669i 0.0240 - 0.0733i 0.0818 - 0.0731i]^T

Table 874—D(8,2,16) codebook

Index	Codeword	Index	Codeword
3	[0.7810 -0.3012 - 0.4935i -0.0369 + 0.0117i 0.0702 + 0.0235i 0.0389 - 0.1200i -0.0083 + 0.0028i -0.0039 - 0.0031i 0.0042 - 0.1812i -0.2917 + 0.4051i -0.7501 - 0.1000i 0.0137 - 0.2081i 0.0161 + 0.0871i -0.0084 - 0.0017i -0.1035 + 0.1564i -0.1068 + 0.0323i 0.0652 + 0.2736i]^T	11	[0.3182 -0.2057 - 0.8830i -0.2196 + 0.0726i 0.0033 - 0.0454i -0.0636 + 0.0583i -0.1093 + 0.0243i -0.0271 + 0.0176i -0.0090 - 0.0040i -0.1635 + 0.8561i -0.2843 + 0.0466i -0.1400 + 0.0865i 0.0591 - 0.0841i 0.0559 - 0.0177i 0.0486 + 0.0383i -0.0666 + 0.0772i 0.1809 - 0.2632i]^T
4	[0.8043 0.3748 + 0.3648i -0.0533 - 0.0589i -0.0633 + 0.1438i 0.0348 - 0.0730i 0.0961 - 0.0319i -0.1343 + 0.0879i -0.0682 - 0.0365i 0.3215 - 0.3635i -0.7751 + 0.0967i 0.1544 - 0.0618i 0.0828 - 0.1355i -0.0084 - 0.0067i 0.0014 - 0.2908i -0.0191 + 0.0942i -0.0372 - 0.0792i]^T	12	[-0.3234 0.7888 - 0.3649i 0.0076 + 0.0156i 0.0357 - 0.1612i 0.0339 - 0.2275i 0.0959 + 0.0443i 0.0004 + 0.0168i 0.0497 + 0.2136i 0.8260 + 0.3813i 0.2801 + 0.0005i 0.0038 + 0.0874i 0.0225 - 0.0316i 0.1892 - 0.1231i -0.1147 - 0.0750i 0.0119 - 0.0018i 0.1037 + 0.0647i]^T
5	[0.5906 0.6836 + 0.3391i 0.0254 - 0.0522i -0.0033 - 0.0064i -0.0742 - 0.0233i 0.0578 + 0.2084i 0.0648 + 0.0566i 0.0582 - 0.0438i 0.6312 - 0.3373i -0.5667 + 0.0404i 0.0895 - 0.0844i -0.0327 + 0.1047i 0.2891 + 0.0104i 0.0371 + 0.0600i 0.1394 - 0.1392i -0.0530 - 0.0871i]^T	13	[0.3656 0.8256 + 0.4141i -0.0588 - 0.0494i 0.0423 + 0.0338i 0.0143 + 0.0201i 0.0300 + 0.0266i -0.0221 - 0.0407i 0.0002 - 0.0009i 0.7251 - 0.3787i -0.3311 + 0.0195i 0.0826 + 0.1751i 0.2469 - 0.2065i 0.0006 + 0.1599i -0.0584 + 0.0225i -0.0095 - 0.1962i 0.0985 + 0.0436i]^T
6	[0.7608 -0.3305 - 0.4863i 0.0327 - 0.0252i 0.0042 + 0.0409i 0.1037 - 0.1133i -0.0175 + 0.0343i -0.0551 - 0.2083i -0.0130 + 0.0173i -0.3420 + 0.4389i -0.7238 - 0.0889i -0.0077 - 0.0605i 0.2502 - 0.0639i -0.0380 - 0.0235i -0.1133 + 0.0376i 0.0260 + 0.0954i -0.1004 - 0.2282i]^T	14	[0.8383 0.3273 - 0.3389i -0.1469 + 0.0138i 0.0247 - 0.1717i 0.0374 + 0.0834i -0.1073 + 0.0159i 0.0011 + 0.0009i -0.0285 + 0.0499i 0.2951 + 0.4061i -0.7403 - 0.2034i 0.1478 - 0.0082i -0.0665 + 0.1009i 0.1452 - 0.2706i 0.1000 - 0.1133i 0.0176 + 0.0080i 0.0547 - 0.0409i]^T
7	[0.8091 -0.0679 + 0.4526i -0.1428 + 0.0777i 0.0297 + 0.0645i 0.0349 - 0.0672i 0.1223 - 0.1543i 0.0695 - 0.1274i 0.0416 + 0.1928i -0.0559 - 0.5020i -0.8029 - 0.0460i -0.0144 + 0.0600i 0.0463 + 0.1478i 0.1112 + 0.1072i -0.0349 - 0.0328i 0.1677 + 0.0966i -0.0813 + 0.0025i]^T	15	[0.5673 -0.7044 - 0.1966i 0.0361 - 0.0742i -0.0432 - 0.1203i -0.0975 + 0.0120i 0.1570 + 0.1415i 0.0797 - 0.0941i 0.0535 + 0.2187i -0.7468 + 0.1299i -0.5644 - 0.1277i 0.0756 - 0.0076i 0.0581 - 0.0054i 0.0732 + 0.2159i 0.0866 - 0.0548i -0.1056 - 0.0838i 0.0239 - 0.0117i]^T
8	[0.4004 -0.0626 + 0.9120i 0.0169 + 0.0173i 0.0287 - 0.0063i 0.0118 - 0.0260i 0.0212 - 0.0010i 0.0001 + 0.0000i 0.0036 + 0.0353i -0.0445 - 0.8045i -0.3473 - 0.0162i -0.0098 + 0.0361i 0.0631 - 0.0504i 0.0326 - 0.0490i 0.3000 + 0.1502i 0.1134 + 0.3039i -0.0242 + 0.0144i]^T	16	[0.7254 0.3107 - 0.5519i 0.1002 - 0.1052i 0.0985 - 0.0160i -0.0267 + 0.0652i 0.0733 + 0.0504i 0.0221 - 0.1643i -0.0161 - 0.0314i 0.3179 + 0.5933i -0.6201 - 0.0324i -0.2257 + 0.0442i -0.0206 - 0.0281i 0.0571 - 0.0204i 0.0177 - 0.2066i -0.2054 + 0.0506i -0.0695 + 0.1044i]^T

Table 875—D(8,3,16) codebook

Index	Codeword	Index	Codeword
1	[0.0623 0.1129 - 0.5018i 0.8368 + 0.1673i -0.0478 - 0.0049i 0.0014 + 0.0129i -0.0019 - 0.0002i 0.0079 + 0.0269i 0.0003 + 0.0028i -0.1646 + 0.3583i 0.7292 - 0.1312i -0.0792 - 0.4633i -0.0540 - 0.0072i -0.0122 - 0.1037i 0.0510 + 0.0261i 0.0304 + 0.1643i -0.1684 + 0.0353i -0.2248 + 0.7132i -0.3654 + 0.0609i 0.0484 + 0.1682i -0.2036 - 0.0051i -0.0259 + 0.1150i -0.2556 + 0.1771i 0.0827 + 0.1981i -0.2471 - 0.1172i]^T	9	[0.7649 0.3205 - 0.0211i 0.4153 + 0.1314i 0.2189 - 0.1860i 0.0114 - 0.0216i -0.0591 + 0.0580i 0.0881 - 0.1073i 0.0818 + 0.0783i 0.0433 - 0.0716i 0.7711 + 0.1015i -0.5195 - 0.2159i 0.0542 + 0.1110i -0.0109 + 0.0316i -0.0634 - 0.1481i -0.1228 + 0.0577i 0.0534 - 0.0890i -0.6047 + 0.1834i 0.4269 - 0.0363i 0.5060 - 0.0612i 0.1320 - 0.2992i 0.0146 + 0.0117i -0.1467 + 0.0661i 0.0274 - 0.1175i 0.0839 + 0.0509i]^T
2	[0.9444 0.0451 + 0.0621i -0.1710 - 0.1408i -0.0372 - 0.1402i 0.0058 - 0.0476i 0.0289 + 0.0006i 0.1531 + 0.0643i 0.0265 + 0.0255i -0.1452 + 0.0054i 0.7877 + 0.1580i -0.1993 - 0.3990i -0.2059 - 0.1390i -0.0455 + 0.1035i 0.1068 + 0.0248i -0.1816 + 0.0824i 0.0408 - 0.0812i 0.1620 + 0.1411i 0.4152 + 0.0123i 0.4263 + 0.6605i -0.0451 - 0.0270i -0.1498 + 0.0377i 0.1237 - 0.0730i 0.0116 - 0.1950i 0.1459 - 0.2379i]^T	10	[0.1626 -0.3784 + 0.5088i -0.6973 + 0.1601i 0.0820 - 0.0051i -0.0966 - 0.0036i -0.0536 - 0.1617i -0.1011 + 0.0023i 0.0483 - 0.0450i 0.1615 - 0.1424i 0.6698 - 0.1625i -0.5284 - 0.3342i -0.1095 - 0.0522i 0.0093 + 0.0938i -0.0986 - 0.1179i 0.1195 - 0.1129i -0.1081 + 0.0421i 0.8287 + 0.1736i -0.0376 - 0.1688i 0.1016 + 0.1985i -0.1190 - 0.0607i -0.0126 + 0.0011i 0.3017 + 0.0170i 0.0026 - 0.1741i -0.1258 - 0.2192i]^T
3	[0.6233 0.3116 - 0.5557i -0.2372 + 0.2738i 0.0849 + 0.0743i -0.1592 - 0.1101i 0.0482 + 0.0168i 0.0044 - 0.0966i -0.0984 - 0.0499i -0.1445 - 0.1013i 0.5635 - 0.1294i 0.7616 - 0.0079i 0.1523 + 0.0460i 0.0261 - 0.0154i 0.1047 - 0.1106i 0.0352 - 0.0366i -0.0252 - 0.0422i 0.2570 + 0.6345i -0.3767 - 0.0482i 0.3817 + 0.1385i 0.0660 + 0.1481i -0.0911 + 0.0578i 0.1511 - 0.0914i -0.0112 + 0.0803i 0.2612 + 0.2798i]^T	11	[0.5185 -0.2285 + 0.6623i 0.3636 + 0.0405i 0.0078 + 0.0787i -0.0052 - 0.0770i -0.1586 + 0.1123i 0.2355 - 0.0028i -0.0217 + 0.0219i 0.0846 - 0.2347i 0.2266 - 0.2278i 0.5401 + 0.6248i -0.0321 - 0.0359i 0.2265 + 0.1207i 0.1348 + 0.0184i -0.1527 + 0.0586i -0.1406 + 0.1384i -0.6968 - 0.3143i -0.2364 + 0.4102i -0.0008 + 0.3152i -0.0810 + 0.0232i -0.1986 + 0.0099i 0.0221 - 0.0360i 0.1266 - 0.0178i 0.1305 + 0.1018i]^T
4	[0.6374 -0.1498 + 0.0607i -0.1408 + 0.6914i 0.0761 + 0.0183i 0.0350 + 0.0642i -0.0805 + 0.1466i -0.0971 + 0.1408i -0.0055 + 0.0325i -0.4748 + 0.4760i 0.0273 + 0.2762i 0.2106 + 0.4471i 0.2757 - 0.1364i 0.0699 + 0.0025i 0.2155 - 0.1142i -0.0094 + 0.1743i -0.1700 - 0.0918i 0.1273 + 0.0052i -0.6189 + 0.6553i -0.0051 - 0.3419i 0.0826 - 0.1341i 0.0049 + 0.0494i -0.1083 - 0.0427i -0.0074 + 0.0725i -0.0863 + 0.0285i]^T	12	[0.3208 -0.4724 - 0.5827i 0.0569 - 0.5034i 0.1230 - 0.2071i 0.0171 - 0.0017i 0.0907 - 0.0061i -0.0177 + 0.0117i 0.0909 + 0.0492i -0.6005 + 0.4090i 0.0543 - 0.2307i -0.5085 - 0.1488i 0.0152 - 0.1414i -0.2251 - 0.1175i -0.0424 + 0.0148i -0.1367 - 0.1070i 0.0909 + 0.1003i -0.4689 + 0.0911i -0.5511 - 0.0486i 0.4621 + 0.3378i 0.0997 - 0.0133i 0.1922 - 0.0990i 0.0061 - 0.0216i -0.0024 - 0.2627i -0.0747 - 0.0775i]^T

Table 875—D(8,3,16) codebook

Index	Codeword	Index	Codeword
5	[0.7116 0.1098 - 0.1420i -0.4070 - 0.4459i -0.0617 - 0.1544i 0.1110 - 0.1449i 0.0058 + 0.0464i -0.1114 + 0.0924i 0.0863 - 0.0731i 0.4453 - 0.3348i 0.0342 + 0.3467i 0.6196 + 0.1892i -0.1520 + 0.1149i 0.0936 - 0.1814i -0.0510 + 0.0551i -0.1728 - 0.0188i 0.1861 - 0.0133i -0.0632 - 0.0713i -0.8608 - 0.1798i 0.0977 - 0.3203i -0.0148 + 0.1692i 0.0050 - 0.0433i -0.0621 + 0.1089i -0.1588 - 0.1010i 0.1444 - 0.0514i]^T	13	[0.2897 -0.4685 - 0.0591i 0.5619 - 0.4945i 0.0934 - 0.0930i -0.1566 + 0.1616i 0.1164 + 0.0406i 0.0956 + 0.2012i -0.0010 + 0.0015i 0.0053 + 0.1052i 0.8080 + 0.0699i 0.3344 - 0.3716i -0.0605 + 0.0326i -0.1045 + 0.0988i 0.0039 - 0.1072i -0.0685 - 0.0204i -0.0368 + 0.1945i -0.5489 - 0.7016i -0.0039 - 0.2045i 0.1641 - 0.0288i -0.0655 - 0.0561i -0.2975 - 0.1380i -0.0073 - 0.0844i 0.0624 + 0.0671i -0.0782 + 0.0142i]^T
6	[0.2614 -0.1370 + 0.5858i 0.1097 + 0.6460i 0.0177 - 0.0575i 0.1146 - 0.0620i 0.0608 - 0.0818i -0.1700 + 0.0766i 0.0103 + 0.2732i -0.5352 + 0.2236i 0.3268 + 0.4659i -0.4239 - 0.1265i 0.0426 + 0.0915i -0.1397 - 0.2335i -0.0117 + 0.0842i 0.0362 + 0.0620i 0.0903 + 0.1980i 0.2966 + 0.6434i -0.1531 + 0.3473i 0.2742 - 0.4608i -0.0174 + 0.1615i -0.0097 + 0.1606i -0.0665 - 0.0428i -0.0047 + 0.0425i -0.0486 - 0.0612i]^T	14	[0.8373 -0.0367 - 0.1572i 0.3562 + 0.1839i -0.0490 + 0.1270i -0.0017 - 0.0040i -0.2275 - 0.0826i -0.0470 + 0.1656i 0.0509 + 0.0525i -0.1455 + 0.1112i 0.7103 - 0.1155i 0.4911 - 0.2546i -0.1153 + 0.0862i 0.0657 - 0.0736i -0.1471 + 0.0674i 0.0643 - 0.1407i -0.0876 - 0.2332i 0.4214 + 0.1331i 0.1834 + 0.5492i -0.2700 - 0.5480i -0.0180 + 0.0210i -0.0267 + 0.0821i 0.2553 - 0.0716i 0.1072 - 0.0287i -0.0727 - 0.0078i]^T
7	[0.7413 -0.4689 - 0.3009i -0.2631 - 0.0569i -0.0549 - 0.0272i 0.0898 + 0.0299i -0.1226 - 0.1509i -0.0405 - 0.1002i 0.0633 + 0.0379i 0.2595 + 0.0303i 0.5407 + 0.3566i -0.6573 - 0.0578i 0.0957 + 0.1435i -0.0209 + 0.1006i -0.0772 + 0.0252i 0.1666 + 0.0158i 0.0439 + 0.0047i 0.4311 - 0.3220i 0.3708 - 0.0513i 0.5058 - 0.3286i 0.0712 + 0.1456i -0.3255 + 0.1288i -0.0164 + 0.1743i -0.1206 - 0.0812i -0.0617 + 0.0456i]^T	15	[0.7950 0.3058 - 0.1929i -0.3777 - 0.1081i 0.1373 - 0.0379i 0.0086 - 0.0471i -0.0500 + 0.0732i -0.1767 - 0.0332i 0.1397 + 0.0239i 0.3852 + 0.1401i 0.2130 + 0.1535i 0.5181 + 0.6151i -0.2271 + 0.0412i -0.0029 - 0.0262i 0.1315 - 0.1187i 0.1463 + 0.0761i -0.0220 - 0.0572i -0.1151 + 0.3849i 0.0022 - 0.8198i 0.0921 + 0.0792i 0.0853 - 0.0361i 0.1365 - 0.1593i -0.0165 + 0.1069i 0.2159 + 0.1546i -0.0589 - 0.1160i]^T
8	[0.8019 -0.2979 + 0.3746i -0.2344 - 0.1283i -0.0178 + 0.0426i -0.1032 - 0.0078i -0.0415 - 0.1073i -0.0212 - 0.0520i -0.0874 - 0.1401i -0.1877 - 0.4626i -0.4474 - 0.3408i -0.3370 - 0.4130i 0.1179 + 0.1355i 0.0712 - 0.0044i 0.1632 - 0.0970i 0.1706 + 0.0835i 0.0673 - 0.1906i 0.0137 - 0.2336i -0.5159 - 0.0224i 0.6560 + 0.3227i 0.0766 + 0.0025i -0.1502 + 0.1952i -0.1497 - 0.2203i 0.0690 - 0.0061i 0.0423 - 0.0082i]^T	16	[0.1591 -0.1981 + 0.3209i -0.8341 + 0.3484i 0.0567 + 0.0176i -0.0559 + 0.0073i -0.0039 + 0.0324i 0.0119 - 0.0857i -0.0060 - 0.0043i -0.3398 - 0.4595i 0.6623 + 0.0214i -0.3295 - 0.2138i -0.0669 - 0.0500i 0.0724 + 0.0674i 0.0937 - 0.0889i 0.0583 + 0.1206i 0.0071 + 0.1692i -0.3365 - 0.5480i -0.5606 - 0.0625i 0.0799 + 0.0796i -0.2330 - 0.0567i 0.0395 + 0.2882i 0.0848 + 0.2292i 0.1172 - 0.0988i 0.0806 + 0.1540i]^T

Table 876—D(8,4,16) codebook

Index	Codeword	Index	Codeword
1	[0.4681 0.0162 - 0.0499i 0.0845 + 0.1896i 0.7535 - 0.2741i -0.0161 - 0.0022i -0.0920 - 0.1711i 0.0626 - 0.1573i -0.1422 - 0.0726i -0.3778 + 0.1850i 0.5134 - 0.0411i -0.0459 - 0.6095i 0.2602 - 0.1834i -0.1178 - 0.0337i -0.0273 - 0.1778i -0.0512 + 0.0912i -0.1565 + 0.0009i -0.1567 + 0.1463i -0.0921 + 0.7413i -0.4705 + 0.1808i -0.0346 - 0.2501i -0.0897 - 0.0700i -0.0053 - 0.1725i 0.0726 - 0.1359i -0.0996 - 0.0422i -0.5246 - 0.3717i 0.1408 - 0.1536i -0.2346 + 0.4128i 0.3202 - 0.0216i 0.1447 + 0.2814i 0.1175 + 0.1721i 0.1625 + 0.1685i 0.0083 + 0.1278i]^T	9	[0.5744 0.2016 - 0.2475i -0.2441 + 0.2734i -0.5093 + 0.2849i -0.1351 + 0.1452i -0.0010 + 0.0012i 0.1562 + 0.0448i 0.1522 + 0.0667i 0.1263 + 0.1821i 0.3519 - 0.0128i 0.0879 + 0.6611i 0.4627 - 0.2616i 0.1069 + 0.1412i 0.0173 + 0.1092i -0.1726 + 0.0766i 0.0952 + 0.1067i -0.2624 - 0.5040i 0.2127 - 0.3820i -0.4695 + 0.0516i -0.0286 - 0.3182i -0.1628 - 0.0452i 0.0784 + 0.0251i -0.1701 + 0.1382i -0.1146 - 0.2535i -0.3880 + 0.0127i 0.6716 + 0.0412i 0.3069 - 0.0014i -0.1780 + 0.3955i -0.0306 - 0.2290i -0.1657 + 0.0777i 0.0075 + 0.1506i -0.0367 - 0.0569i]^T
2	[0.7710 -0.0391 - 0.2436i 0.0566 - 0.2808i 0.3547 - 0.1960i 0.0521 - 0.0951i -0.2212 - 0.0036i 0.0944 - 0.0284i -0.0580 + 0.1571i -0.4304 + 0.0154i 0.3932 - 0.4551i 0.2774 - 0.3351i 0.0827 - 0.3953i 0.1221 + 0.0238i 0.0367 + 0.2192i 0.0883 - 0.0997i 0.0732 + 0.1118i -0.0679 + 0.0192i -0.6031 + 0.0756i 0.6821 + 0.0757i 0.0297 - 0.1369i -0.1600 + 0.0574i 0.0954 - 0.0158i 0.2833 - 0.1220i 0.0403 - 0.0034i 0.0720 + 0.3526i 0.0805 + 0.3719i -0.1308 + 0.3319i 0.1544 - 0.6639i 0.0179 - 0.0900i 0.2288 + 0.0458i -0.1123 + 0.0174i 0.2103 + 0.1179i]^T	10	[0.2903 -0.0452 - 0.2873i -0.3908 - 0.7921i 0.0090 - 0.1659i -0.0117 + 0.0020i 0.0616 + 0.0857i 0.1041 - 0.0258i -0.0107 - 0.0203i 0.1425 + 0.0628i 0.4357 + 0.0617i -0.0510 + 0.2129i -0.0838 - 0.7602i 0.1845 - 0.1039i -0.0525 + 0.0494i 0.1210 - 0.1036i 0.0023 - 0.2717i -0.2872 + 0.7606i -0.3242 - 0.2050i -0.1539 + 0.0834i -0.0668 - 0.0881i 0.1774 - 0.2077i -0.1659 + 0.1490i 0.0314 + 0.0614i -0.1234 + 0.0686i -0.3408 + 0.0822i -0.1413 + 0.6338i 0.0048 - 0.3175i -0.4275 - 0.1600i -0.2443 + 0.0022i 0.1535 - 0.1516i 0.0174 + 0.1009i -0.0391 - 0.1675i]^T
3	[0.8029 -0.3042 + 0.0521i -0.0674 - 0.3480i 0.0355 - 0.2275i 0.0395 - 0.1708i 0.0530 - 0.0432i -0.1567 + 0.1413i 0.0103 + 0.0379i -0.1918 + 0.2392i 0.3048 + 0.4199i -0.3435 - 0.4540i 0.4022 - 0.1852i -0.1267 + 0.1453i 0.0518 + 0.1367i 0.0603 + 0.2122i -0.0950 + 0.0179i 0.2076 + 0.3797i 0.0919 + 0.6106i 0.1819 + 0.3312i -0.3495 + 0.1688i -0.0150 - 0.0403i -0.1273 - 0.0804i 0.1914 + 0.2661i -0.0421 - 0.0660i 0.1696 + 0.1246i -0.1856 - 0.0249i -0.5531 + 0.1969i 0.2601 + 0.6136i -0.1118 - 0.0557i 0.0930 - 0.0200i 0.0296 - 0.1801i -0.1142 - 0.2465i]^T	11	[0.4643 -0.5194 - 0.4287i 0.0702 - 0.2408i -0.3517 - 0.1887i -0.2283 + 0.0446i -0.0033 - 0.1952i 0.0272 + 0.0242i 0.0627 + 0.1057i -0.3338 + 0.3960i 0.2473 + 0.1169i -0.2613 - 0.1217i -0.6924 + 0.0126i -0.1830 + 0.0569i 0.0013 - 0.1585i -0.0527 - 0.0129i 0.1696 - 0.0253i -0.0664 + 0.5044i -0.2981 + 0.3297i 0.5439 - 0.3380i 0.0348 + 0.1336i 0.0735 - 0.0980i -0.1873 + 0.0970i -0.0550 - 0.0388i -0.2034 - 0.0958i -0.3407 + 0.2657i -0.3034 - 0.2311i -0.4672 - 0.2766i 0.4697 - 0.0453i -0.0095 + 0.1137i -0.2069 - 0.0222i -0.0769 + 0.1834i 0.2295 - 0.0442i]^T

Table 876—D(8,4,16) codebook

Index	Codeword	Index	Codeword
4	[0.5481 -0.1069 - 0.3964i -0.2595 - 0.4355i 0.3975 - 0.0779i -0.1128 + 0.0024i -0.0284 + 0.0093i 0.2860 - 0.0007i 0.1034 - 0.0616i -0.0047 + 0.3999i 0.4310 + 0.0905i -0.2821 + 0.4415i 0.3849 - 0.3975i -0.0423 + 0.0598i 0.2123 + 0.0030i 0.1007 - 0.0196i -0.0603 + 0.0297i -0.2857 + 0.6050i -0.3651 - 0.3189i -0.2968 - 0.0570i -0.3222 - 0.0277i 0.0702 + 0.0076i -0.1065 - 0.0600i 0.1150 - 0.1548i -0.2071 - 0.1463i 0.1905 + 0.1028i 0.3912 + 0.3276i -0.2220 - 0.4390i -0.4776 - 0.2271i 0.0586 + 0.2070i -0.0755 + 0.2823i -0.0602 - 0.1556i 0.1042 + 0.0270i]^T	12	[0.8084 0.2334 + 0.1928i -0.0226 + 0.3112i -0.1853 - 0.0576i -0.1212 - 0.2131i 0.1366 + 0.0531i -0.1855 + 0.0194i 0.0583 - 0.0072i 0.3711 - 0.0001i 0.2420 - 0.3733i -0.4158 - 0.4229i 0.4450 + 0.1192i 0.1215 + 0.0593i 0.0527 - 0.0448i 0.2612 + 0.0523i -0.0585 - 0.0547i 0.2976 + 0.1603i -0.5239 - 0.3294i 0.5202 - 0.0261i 0.1678 - 0.1223i 0.1322 + 0.2226i 0.2782 + 0.0601i -0.0727 + 0.0589i -0.0758 - 0.1607i -0.0480 - 0.0720i 0.2016 + 0.3748i 0.3281 + 0.1399i 0.7540 - 0.2376i -0.0517 - 0.1442i -0.1050 + 0.1090i 0.0781 - 0.0021i -0.0736 + 0.0369i]^T
5	[-0.1145 -0.7399 - 0.4223i -0.0152 - 0.0274i -0.1625 + 0.4493i 0.0317 + 0.0218i 0.0129 - 0.0024i -0.0918 - 0.0510i -0.1069 + 0.0881i -0.4708 + 0.3985i 0.3533 + 0.0861i -0.0133 + 0.0157i -0.1260 + 0.5341i 0.2119 - 0.1205i -0.1454 - 0.2100i 0.0814 - 0.1505i 0.1785 - 0.0021i -0.0118 + 0.2967i -0.2027 + 0.0290i 0.8063 + 0.0162i -0.1477 - 0.2563i 0.1807 + 0.0934i -0.0771 + 0.0885i 0.1569 - 0.0608i 0.1805 - 0.1263i 0.4886 - 0.2539i 0.1601 + 0.1723i 0.2460 + 0.4552i -0.2529 + 0.4377i 0.1786 - 0.1530i -0.0621 + 0.1120i -0.1029 + 0.0988i -0.1583 + 0.0342i]^T	13	[0.1343 0.2346 + 0.4950i -0.1357 - 0.3848i -0.6727 + 0.0688i 0.0762 + 0.0182i 0.0055 + 0.1005i 0.1342 - 0.0879i 0.0780 - 0.1004i 0.1776 - 0.4037i 0.5019 + 0.0078i -0.2502 - 0.1460i 0.2639 - 0.5741i -0.0359 - 0.0007i -0.1237 - 0.0605i -0.1633 - 0.0398i 0.1462 + 0.0203i -0.3624 + 0.6139i 0.1279 + 0.3034i -0.4505 + 0.2464i 0.0971 - 0.1836i -0.0267 + 0.1311i 0.0063 - 0.1959i -0.1033 - 0.0110i 0.0682 - 0.0693i -0.3472 - 0.1653i 0.3018 + 0.3529i 0.4939 + 0.3554i -0.0567 - 0.0098i -0.3034 - 0.3221i 0.0013 + 0.0168i -0.1103 - 0.2170i -0.0809 + 0.0321i]^T
6	[0.2755 -0.1482 + 0.4541i 0.3150 - 0.6512i 0.2816 + 0.2597i 0.0123 + 0.0859i -0.1116 - 0.0496i -0.0199 - 0.0338i 0.0164 + 0.0406i 0.2379 - 0.1765i 0.5344 - 0.1852i 0.0102 + 0.0167i -0.2585 + 0.6599i 0.1352 + 0.1457i 0.0402 - 0.0000i 0.0346 + 0.1149i -0.1523 + 0.1047i 0.3554 + 0.4813i 0.3734 - 0.1837i 0.1413 + 0.1028i 0.3620 - 0.1641i -0.0672 + 0.2124i 0.2214 - 0.0329i -0.0685 - 0.3971i 0.0210 - 0.1338i -0.4320 - 0.0777i 0.4116 - 0.2453i 0.4938 - 0.3972i -0.1551 - 0.2833i -0.1000 - 0.1466i -0.0855 - 0.0253i 0.1409 - 0.0647i -0.0913 - 0.0094i]^T	14	[0.7755 -0.4092 + 0.1933i 0.0340 + 0.1979i -0.2508 - 0.0735i 0.1223 + 0.1079i -0.0355 - 0.0901i 0.0467 + 0.0973i -0.0034 + 0.1937i 0.0967 + 0.0588i 0.0849 + 0.0238i 0.7218 + 0.1724i 0.4424 - 0.3768i 0.0755 + 0.0490i -0.0060 + 0.2240i -0.0919 + 0.0974i 0.0653 - 0.1023i 0.2793 - 0.2710i 0.0099 - 0.7202i -0.0247 - 0.1517i 0.2675 + 0.0810i 0.0425 - 0.1991i -0.2862 - 0.2233i -0.0376 + 0.0603i 0.2125 + 0.0679i 0.2014 + 0.0977i -0.0648 + 0.4039i -0.2215 - 0.4748i 0.6583 + 0.1046i -0.0636 + 0.0359i -0.0240 - 0.1358i 0.1308 + 0.0818i -0.1135 - 0.0520i]^T

Table 876—D(8,4,16) codebook

Index	Codeword	Index	Codeword
7	[0.7811 -0.4244 - 0.1198i 0.0607 + 0.0057i 0.2210 - 0.3018i -0.0895 + 0.1509i -0.0345 - 0.0831i -0.0276 - 0.0367i -0.0088 + 0.1035i -0.4041 + 0.2043i -0.3532 + 0.1749i 0.6207 - 0.1381i 0.1909 - 0.3159i 0.1746 + 0.1310i 0.1335 - 0.0517i -0.1042 + 0.0514i -0.1167 + 0.0619i 0.1250 + 0.1343i 0.3987 - 0.0736i 0.3833 + 0.4478i -0.3750 - 0.4499i -0.0675 - 0.0284i -0.0862 - 0.0801i 0.1790 - 0.0098i 0.1278 - 0.2092i 0.3263 - 0.0791i 0.3210 + 0.4369i 0.3774 + 0.0716i 0.2260 + 0.4348i -0.0100 - 0.0025i 0.4238 - 0.0756i 0.1110 + 0.0725i -0.0097 + 0.0504i]^T	15	[0.3775 0.7059 + 0.4102i 0.1520 - 0.3368i -0.0680 - 0.1728i 0.0292 + 0.0815i -0.0004 - 0.0324i -0.0794 + 0.0366i 0.0158 + 0.0589i 0.0518 - 0.0147i 0.1590 - 0.0174i 0.1448 - 0.0307i 0.4950 + 0.7803i -0.0444 + 0.0889i -0.0020 + 0.0504i -0.0849 - 0.1368i 0.2379 + 0.0290i 0.7864 + 0.0570i -0.1268 - 0.2526i 0.1516 + 0.4064i 0.0015 - 0.0990i -0.1399 - 0.0453i -0.0171 + 0.0751i 0.0708 + 0.1044i 0.2376 + 0.0229i 0.3060 + 0.2074i -0.3789 - 0.0027i -0.2630 - 0.5826i -0.1656 + 0.1788i 0.0543 + 0.1477i -0.1058 + 0.1281i -0.2509 + 0.1682i 0.0165 - 0.3285i]^T
8	[0.3343 -0.6511 - 0.4260i -0.0414 - 0.0479i 0.2028 - 0.4232i -0.0384 - 0.0202i -0.1068 + 0.0353i 0.1152 - 0.0420i -0.1454 + 0.0886i -0.3713 + 0.3790i 0.1843 + 0.1331i -0.1978 - 0.2772i 0.0418 - 0.6803i 0.0470 - 0.0367i -0.0504 + 0.1593i -0.0963 + 0.2050i 0.0578 + 0.0131i 0.5969 - 0.1579i 0.3344 + 0.1591i 0.2926 - 0.4724i 0.0231 - 0.2180i 0.1365 + 0.1733i 0.0515 + 0.0484i -0.0054 - 0.1132i -0.0533 - 0.2355i 0.2311 - 0.1081i 0.1602 + 0.2906i -0.5570 + 0.3705i 0.4111 - 0.1001i -0.1839 - 0.1143i -0.0538 + 0.0635i 0.0917 - 0.1108i -0.1149 - 0.3326i]^T	16	[0.8972 -0.0244 + 0.0245i -0.2142 - 0.2167i -0.1533 + 0.2114i -0.0685 + 0.0046i 0.0648 + 0.0254i -0.0190 + 0.0135i 0.1176 + 0.0938i 0.1690 + 0.0059i 0.9082 - 0.0388i 0.1429 + 0.2136i -0.0324 - 0.1111i 0.0925 - 0.0127i -0.1655 + 0.0804i -0.0729 + 0.0140i -0.0866 - 0.1005i 0.1011 + 0.0414i -0.1505 + 0.1226i 0.6742 + 0.2873i 0.0566 + 0.5795i -0.0460 + 0.0690i -0.0743 + 0.1149i -0.0393 + 0.1314i 0.0566 - 0.1629i 0.2734 + 0.1941i -0.1614 - 0.2031i -0.0078 + 0.3565i 0.5286 - 0.3442i -0.1402 - 0.1657i 0.0839 - 0.2928i -0.1511 + 0.2129i 0.0024 - 0.2954i]^T

16.3.7.2.5.6 Unquantized MIMO feedback for closed-loop transmit precoding

To assist the ABS in determining the precoding matrix to use for SU-MIMO or MU-MIMO, the ABS may request the AMS transmit a sounding signal in an UL sounding channel. The ABS may translate the measured UL channel response to an estimated DL channel response. The transmitter and receiver hardware of ABS may be calibrated to assist the channel response translation.

The derived precoding matrix shall be the same for all subcarriers within a PRU.

16.3.7.3 Transmission schemes for control channels

SFH and A-MAP shall be transmitted using SFBC defined in 16.3.7.1.1.1. The two-stream pilot pattern defined in 16.3.5.4.1 is used for SFH and A-MAP transmission.

16.3.7.4 MIMO transmission schemes for E-MBS

MIMO modes 0 and 1 specified in Table 844 shall be used for MIMO transmissions in E-MBS. When MIMO mode 1 is used for E-MBS, the number of MIMO streams shall be no more than 2.

16.3.8 Uplink physical structure

Each uplink AAI subframe is divided into 4 or fewer frequency partitions; each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the AAI subframe. Each frequency partition can include contiguous (localized) and/or non-contiguous (distributed) physical resource units. Each frequency partition can be used for different purposes such as fractional frequency reuse (FFR). Figure 538 illustrates the uplink physical structure in the example of two frequency partitions with frequency partition 2 including both contiguous and distributed resource allocations, where Sc stands for Subcarrier.

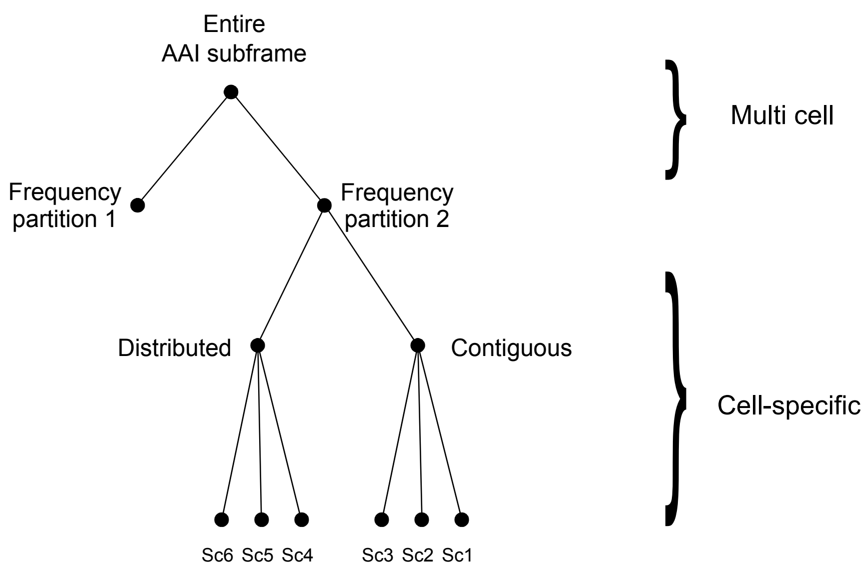


Figure 538—Example of uplink physical structure

16.3.8.1 Physical and logical resource unit

A physical resource unit (PRU) is the basic physical unit for resource allocation that comprises Psc consecutive subcarriers by N_{sym} consecutive OFDMA symbols. P_{sc} is 18 and N_{sym} is 6, 7, 5, and 9 OFDMA symbols for type-1, type-2, type-3, and type-4 AAI subframes, respectively. A logical resource unit (LRU) is the basic logical unit for distributed and localized resource allocations. An LRU has $P_{sc} \cdot N_{sym}$ subcarriers.

The LRU size for control channel transmission should be same as for data transmission. Multiple users are allowed to share one control LRU. The effective number of data subcarriers in an LRU depends on the number of allocated pilots and control channel presence.

16.3.8.1.1 Distributed logical resource unit

The distributed logical resource unit (DLRU) contains a group of subcarriers that are spread across the distributed resource allocations within a frequency partition. The size of the DLRU equals the size of a PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The minimum unit for forming the DLRU is a tile. The uplink tile size is 6 x Nsym, where the value of N_{sym} depends on the AAI subframe type.

16.3.8.1.2 Contiguous logical resource unit

The localized logical resource unit, also known as contiguous logical resource unit (CLRU) contains a group of subcarriers that are contiguous across the resource allocations. The size of the CLRU equals the size of a PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols.

16.3.8.2 Multi-cell resource mapping

The UL multi-cell resource mapping consists of subband partitioning, miniband permutation and frequency partitioning and is defined in the following sub-clauses.

16.3.8.2.1 Subband Partitioning

The PRUs are first divided into subbands and minibands; a subband comprises of N_1 adjacent PRUs and a miniband comprises of N_2 adjacent PRUs where N_1 = 4 and N_2 = 1. Subbands are suitable for frequency selective allocations as they provide a continuous allocation of PRUs in frequency. Minibands are suitable for frequency diverse allocation and are permuted in frequency.

The number of subbands is denoted by K_{SB}. The number of PRUs allocated to subbands is $L_{SB} = N_1 \cdot K_{SB}$. A 5, 4 or 3-bit field called Uplink Subband Allocation Count (*USAC*) determines the value of K_{SB} depending on FFT size. The *USAC* is transmitted in the SFH. The remaining PRUs are allocated to minibands. The number of minibands in an allocation is denoted by K_{MB}. The number of PRUs allocated to minibands is $L_{MB} = N_2 \cdot K_{MB}$. The total number of PRUs is $N_{PRU} = L_{SB} + L_{MB}$. The maximum number of subbands that can be formed is denoted as N_{sub} where $N_{sub} = \lfloor N_{PRU}/N_1 \rfloor$. Mappings between *USAC* and K_{SB} are shown in Table 877 through Table 879 for FFT sizes of 2048, 1024 and 512, respectively.

For those system bandwidths in range of (10, 20], the relation between the system bandwidth and supported N_{PRU} is listed in Table 777. The mapping between *USAC* and K_{SB} is based on Table 877, the maximum valid value of K_{SB} is N_{PRU}/4-3.

For those system bandwidths in range of [5, 10], the relation between the system bandwidth and supported N_{PRU} is listed in Table 778. The mapping between *USAC* and K_{SB} is based on Table 878, the maximum valid value of K_{SB} is N_{PRU}/4-2.

Table 877—Mapping between *USAC* and K_{SB} for 2048 FFT size

USAC	Number of subbands allocated (K_{SB})	*USAC*	Number of subbands allocated (K_{SB})
0	0	16	16
1	1	17	17
2	2	18	18
3	3	19	19
4	4	20	20
5	5	21	21
6	6	22	NA.
7	7	23	NA.
8	8	24	NA.
9	9	25	NA.
10	10	26	NA.
11	11	27	NA.
12	12	28	NA.
13	13	29	NA.
14	14	30	NA.
15	15	31	NA.

Table 878—Mapping between *USAC* and K_{SB} for 1024 FFT size

USAC	Number of subbands allocated (K_{SB})	*USAC*	Number of subbands allocated (K_{SB})
0	0	8	8
1	1	9	9
2	2	10	10
3	3	11	NA.
4	4	12	NA.
5	5	13	NA.
6	6	14	NA.
7	7	15	NA.

Table 879—Mapping between *USAC* and K_{SB} for 512 FFT size

USAC	Number of subbands allocated (K_{SB})	*USAC*	Number of subbands allocated (K_{SB})
0	0	4	4
1	1	5	NA.
2	2	6	NA.
3	3	7	NA.

The PRUs are partitioned and reordered into two groups: subband PRUs (PRU_{SB}), and miniband PRUs (PRU_{MB}). The set of PRU_{SB} is numbered from 0 to (L_{SB} - 1) and the set of PRU_{MB} from 0 to (L_{MB} - 1).

Equation (252) defines the mapping of PRUs into PRU_{SB}s. Equation (253) defines the mapping of PRUs to PRU_{MB}s. Figure 539 illustrates the PRU to PRU_{SB}s and PRU_{MB}s mapping for a 10 MHz bandwidth with K_{SB} equal to 7.

$$PRU_{SB}[j] = PRU[i]; \qquad 0 \le j \le L_{SB} - 1 \tag{252}$$

where

$$i = N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{j + L_{MB}}{N_1} \right\rfloor + \left\lfloor \left\lfloor \frac{j + L_{MB}}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub} \S K_{SB} \rceil)}{N_{sub}} \right\rfloor \right\} \bmod \{N_{sub}\} + \{j + L_{MB}\} \bmod \{N_1\}$$

$$PRU_{MB}[k] = PRU[i]; \quad k = 0, 1, \ldots, L_{MB} - 1 \tag{253}$$

where

$$i = \begin{cases} N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{k}{N_1} \right\rfloor + \left\lfloor \left\lfloor \frac{k}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\rfloor \right\} \bmod \{N_{sub}\} + \{k\} \bmod \{N_1\} & K_{SB} > 0 \\ k & K_{SB} = 0 \end{cases}$$

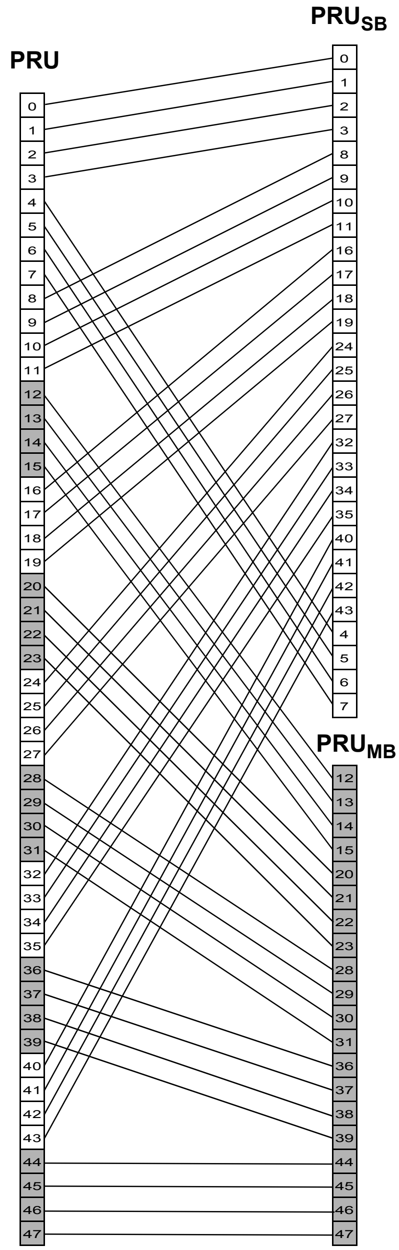


Figure 539—PRU to PRU_{SB} and PRU_{MB} mapping for BW=10 MHz, K_{SB}=7

16.3.8.2.2 Miniband permutation

The miniband permutation maps the PRU_{MB}s to permuted-$\mathrm{PRU_{MB}}$s ($PPRU_{MB}$s) to insure allocation of frequency diverse PRUs to each frequency partition. Equation (254) describes the mapping from PRU_{MB}s to $PPRU_{MB}$s.

$$PPRU_{MB}[j] = PRU_{MB}[i]; \qquad 0 \le j \le L_{MB} - 1 \tag{254}$$

where:

$$i = (q(j) mod D) \cdot P + \left\lfloor \frac{q(j)}{D} \right\rfloor$$

$$P = min(K_{MB}, N_1/N_2)$$

$$r(j) = max\{j - ((K_{MB} mod P) \cdot D), 0\}$$

$$q(j) = j + \left\lfloor \frac{r(j)}{D-1} \right\rfloor$$

$$D = \left\lfloor \frac{K_{MB}}{P} + 1 \right\rfloor$$

Figure 540 illustrates the mapping from PRU to PRU_{SB} and PRU_{MB}.

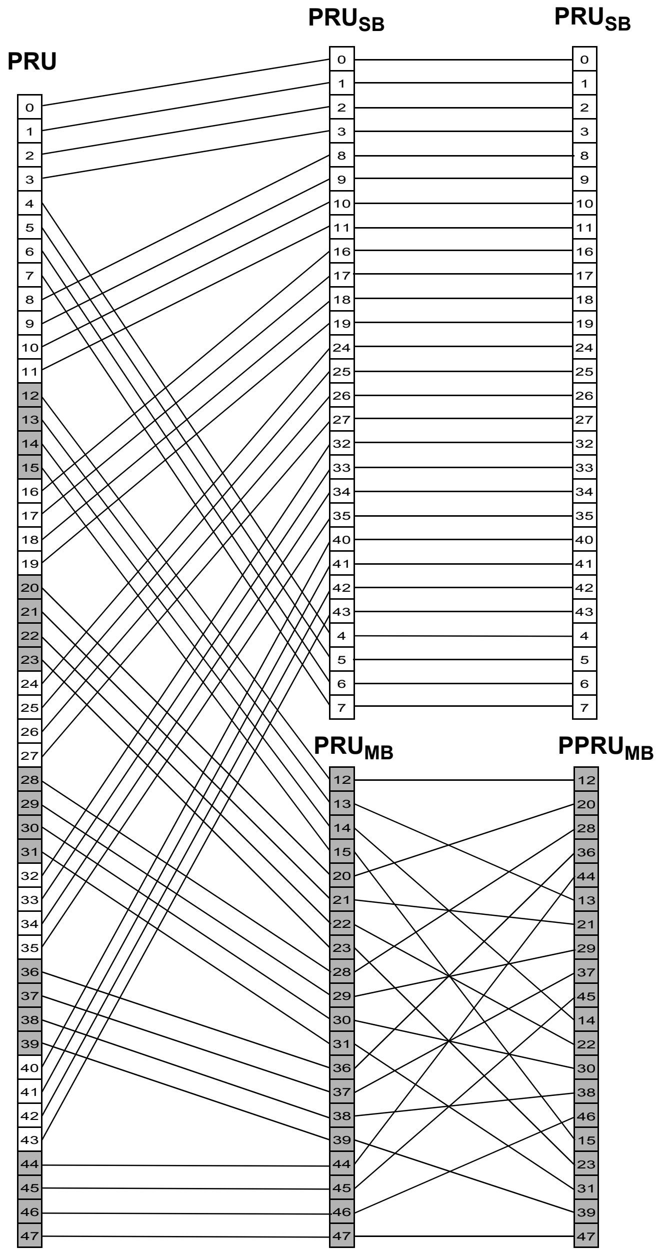


Figure 540—Mapping from PRUs to PRU_{SB} and $PPRU_{MB}$ mapping for *BW*=10 MHz, K_{SB}=7

16.3.8.2.3 Frequency partitioning

The PRU_{SB}s and $PPRU_{MB}$s are allocated to one or more frequency partitions. By default, only one partition is present. The maximum number of frequency partitions is 4. The frequency partition configuration is transmitted in the S-SFH SP2 in a 4 or 3-bit composite field called the Uplink Frequency Partition Configuration (*UFPC*), depending on FFT size. The Frequency Partition Count (*FPCT*) defines the number of frequency partitions. The Frequency Partition Size (FPS_i) defines the number of PRUs allocated to FP_i. *FPCT* and FPS_i are determined from *UFPC* as shown in Table 867 through Table 882.

A field of length 1, 2, or 3 bits, called the Uplink Frequency Partition Subband Count (*UFPSC*), defines the number of subbands allocated to FP_i, for $i > 0$. When *UFPC* = 0, *UFPSC* is equal to 0.

Table 880—Mapping between *UFPC* and frequency partitioning for 2048 FFT size

UFPC	Freq. Partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i (i>0)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$FPS_1 = N_{PRU} - 2$*floor(N_{PRU}/3) FPS_2 = floor(N_{PRU}/3) FPS_3 = floor(N_{PRU}/3)
2	1 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/4)	floor(N_{PRU}/4)
3	3 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/6)	floor(N_{PRU}/6)
4	5 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/8)	floor(N_{PRU}/8)
5	9 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/12)	floor(N_{PRU}/12)
6	9 : 5 : 5 : 5	4	N_{PRU}-3*floor(N_{PRU}*5/24)	floor(N_{PRU}*5/24)
7	0 : 1 : 1 : 0	2	0	N_{PRU}/2 for i = 1,2 0 for i=3
8	1 : 1 : 1 : 0	3	N_{PRU}-2*floor(N_{PRU}/3)	floor(N_{PRU}/3) for i = 1,2 0 for i = 3
9-15	Reserved			

Table 881—Mapping between *UFPC* and frequency partitioning for 1024 FFT size

UFPC	Freq. Partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i (i>0)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$FPS_1 = N_{PRU} - 2*floor(N_{PRU}/3)$ FPS_2 = floor(N_{PRU}/3) FPS_3 = floor(N_{PRU}/3)
2	1 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/4)	floor(N_{PRU}/4)
3	3 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/6)	floor(N_{PRU}/6)
4	5 : 1 : 1 : 1	4	N_{PRU}-3*floor(N_{PRU}/8)	floor(N_{PRU}/8)
5	9 : 5 : 5 : 5	4	N_{PRU}-3*floor(N_{PRU}*5/24)	floor(N_{PRU}*5/24)
6	0 : 1 : 1 : 0	2	0	N_{PRU}/2 for i = 1,2 0 for i=3
7	1 : 1 : 1 : 0	3	N_{PRU}-2*floor(N_{PRU}/3)	floor(N_{PRU}/3) for i = 1,2 0 for i = 3

Table 882—Mapping between *UFPC* and frequency partitioning for 512 FFT size

UFPC	Freq. Partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i (i>0)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	N_{PRU}/3
2	1 : 1 : 1 : 1	4	N_{PRU}/4	N_{PRU}/4
3	3 : 1 : 1 : 1	4	N_{PRU}/2	N_{PRU} 1/6
4	9 : 5 : 5 : 5	4	N_{PRU} *3/8	N_{PRU}*5/24
5	0 : 1 : 1 : 0	2	0	N_{PRU}/2 for i = 1,2 0 for i=3
6	1 : 1 : 1 : 0	3	N_{PRU}/3	N_{PRU}/3 for i = 1,2 0 for i = 3
7	Reserved			

The number of subbands in the i^{th} frequency partition is denoted by $K_{SB,FPi}$, as shown in Equation (255),

$$K_{SB,FP_i} = \begin{cases} K_{SB} - (FPCT - 1) \cdot UFPSC & i = 0,\ FPCT = 4 \\ UFPSC & i > 0,\ FPCT = 4 \\ UFPSC & i > 0,\ FPCT = 3,\ UFPC = 1 \\ K_{SB} - (FPCT - 1) \cdot UFPSC & i = 0,\ FPCT = 3,\ UFPC \neq 1 \\ UFPSC & i = 1,2,\ FPCT = 3,\ UFPC \neq 1 \\ UFPSC & i = 1,2,\ FPCT = 2 \\ K_{SB} & i = 0,\ FPCT = 1 \end{cases} \quad (255)$$

When FPCT = 2, *UFPSC* shall be $K_{SB}/2$.

The number of minibands in the i^{th} frequency partition is denoted by $K_{MB,FPi}$ as shown in Equation (256),

$$K_{MB,FPi} = (FPS_i - K_{SB,FPi} \cdot N_1)/N_2 \qquad 0 \le i < FPCT \quad (256)$$

The numbers of subband PRUs and miniband PRUs in each frequency partition are $L_{SB,FPi} = N_1 \cdot K_{SB,FPi}$ and $L_{MB,FPi} = N_2 \cdot K_{MB,FPi}$ respectively.

The mapping of subband PRUs and miniband PRUs to the frequency partition *i* is given by the following equations:

$$PRU_{FPi}(j) = \begin{cases} PRU_{SB}(k_1) & 0 \le j < L_{SB,FPi} \\ PPRU_{MB}(k_2) & L_{SB,FPi} \le j < (L_{SB,FPi} + L_{MB,FPi}) \end{cases} \quad (257)$$

where $k_1 = \sum_{m=0}^{i-1} L_{SB,FPm} + j$ and $k_2 = \sum_{m=0}^{i-1} L_{MB,FPm} + j - L_{SB,FPi}$.

Figure 541 depicts the frequency partitioning for BW of 10 MHz, $K_{SB} = 7$, FPCT = 4, $FPS_0 = FPS_i = 12$, and $UFPSC = 2$.

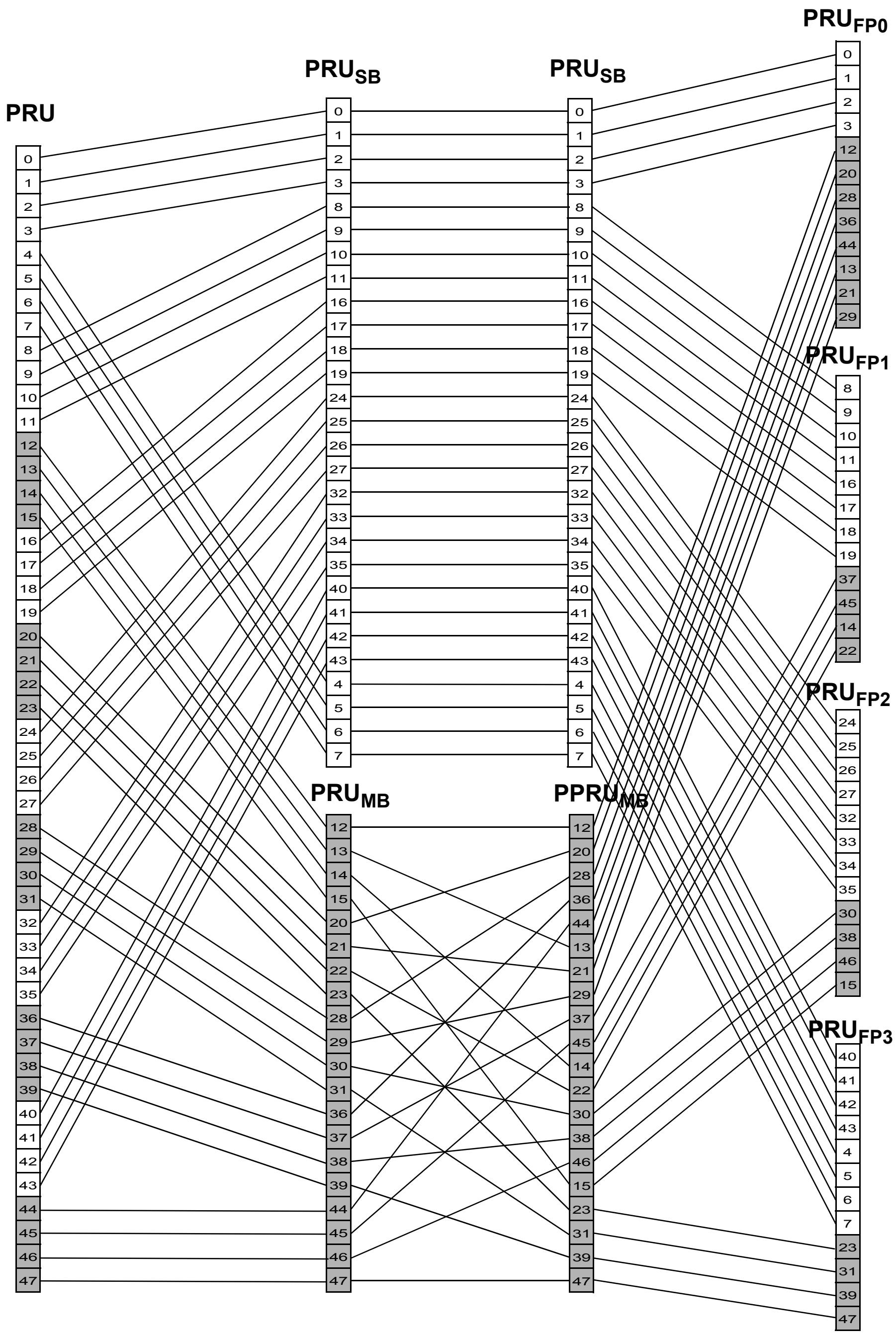


Figure 541—Frequency partition for *BW*=10 MHz, K_{SB}=7, FPCT=4, FPS_0=FPS_i=12, *UFPSC*=2

16.3.8.3 Cell-specific resource mapping

PRU_{FPi}s are mapped to LRUs. All further PRUs and tile permutations are constrained to the PRUs within a frequency partition.

16.3.8.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector specific basis. Let $L_{SB\text{-}CRU,FPi}$ and $L_{MB\text{-}CRU,FPi}$ denote the numbe of allocated subband CRUs and miniband CRUs for FP_i ($i \geq 0$). The number of total allocated CRUs, in units of a subband (i.e. N_1 PRUs), for FP_i (for $i \geq 0$) is given by uplink CRU allocation size, $UCAS_i$. The numbers of subband-based and miniband-based CRUs in FP_0 are given by $UCAS_{SB,0}$ and $UCAS_{MB,0}$, in units of a subband and miniband, respectively.

For FP_0, the value of $UCAS_{SB,0}$ is explicitly signaled in the SFH as a 5, 4 or 3-bit field to indicate the number of subbands in unsigned-binary format. $JCAS_{SB,0} \leq K_{SB,\,FP_0}$. A 5, 4, or 3-bit uplink miniband-based CRU allocation size ($UCAS_{MB,0}$) is sent in the SFH only for FP_0, depending on FFT size. The number of subband-based CRUs for FP_0 is given by the Equation (258).

$$L_{SB-CRU,\,FP_0} = N_1 \cdot UCAS_{SB,\,0} \tag{258}$$

The mapping between $UCAS_{MB,0}$ and the number of miniband-based CRUs for FP_0 is shown in the Table 883 through Table 885 for FFT sizes of 2048, 1024 and 512, respectively.

For those system bandwidths in range of (10, 20], the mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 is based on Table 883, the maximum valid value of $L_{MB\text{-}CRU,FP0}$ is less than floor(88*N_{PRU}/96).

For those system bandwidths in range of [5, 10], the mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 is based on Table 884, the maximum valid value of $L_{MB\text{-}CRU,FP0}$ is less than floor(42*N_{PRU}/48)

.

Table 883—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 2048 FFT size

$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)	$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)
0	0	16	28
1	2	17	32
2	4	18	36
3	6	19	40
4	8	20	44
5	10	21	48
6	12	22	52
7	14	23	56
8	16	24	60
9	18	25	64
10	19	26	68
11	20	27	72
12	21	28	76
13	22	29	80
14	23	30	84
15	24	31	88

Table 884—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 1024 FFT size

$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)	$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)
0	0	8	16
1	2	9	18
2	4	10	20
3	6	11	22
4	8	12	24
5	10	13	38
6	12	14	40
7	14	15	42

Table 885—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 512 FFT size

$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)	$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)
0	0	4	8
1	2	5	10
2	4	6	18
3	6	7	20

For $FP_i(i > 0, FPCT \neq 2)$, only one value for $UCAS_i$ is explicitly signaled for all $i > 0$, in the SFH as a 3, 2 or 1-bit field to signal the same numbers of allocated CRUs for $FP_i(i > 0, FPCT \neq 2)$. When $UFPC = 0$, $UCAS_i = 0$. For $FP_i(i > 0, FPCT \neq 2)$ the number of subband CRUs ($L_{SB\text{-}CRU,FPi}$) and miniband CRUs ($L_{MB\text{-}CRU,FPi}$) are derived using Equation (259) and Equation (260) respectively.

$$L_{SB-CRU,FPi} = N_1 \cdot min\{UCAS_i, K_{SB,FPi}\} \tag{259}$$

$$L_{MB-CRU,FPi} = \begin{cases} 0, & UCAS_i \leq K_{SB,FPi} \\ (UCAS_i - K_{SB,FPi}) \cdot N_1 & UCAS_i > K_{SB,FPi} \end{cases} \tag{260}$$

When $FPCT = 2$, $UCAS_{SB,i}$ and $UCAS_{MB,i}$ for $i = 1$ and 2 are signaled using the $UCAS_{SB,0}$ and $UCAS_{MB,0}$ fields in the SFH. Since FP_0 and FP_3 are empty, $L_{SB\text{-}CRU,FP0} = L_{MB\text{-}CRU,FP0} = L_{DRU,FP0}$ and $L_{SB\text{-}CRU,FP3} = L_{MB\text{-}CRU,FP3} = L_{DRU,FP3} = 0$. For $i = 1$ and 2, $L_{SB\text{-}CRU,FPi} = N_1 * UCAS_{SB,0}$ and $L_{MB\text{-}CRU,FPi}$ is obtained from $UCAS_{MB,0}$ using the mapping in Table 883 through Table 885 for system bandwidths of 20 MHz, 10 MHz and 5 MHz, respectively.

The total number of CRUs in frequency partition FP_i, for $0 \leq i < FPCT$, is denoted by $L_{CRU,FPi}$, calculated as shown in Equation (261).

$$L_{CRU,FPi} = L_{SB-CRU,FPi} + L_{MB-CRU,FPi} \tag{261}$$

The number of DRUs in each frequency partition is denoted by $L_{DRU,FPi}$, calculated as shown in Equation (262)

$$L_{DRU,FPi} = FPS_i - L_{CRU,FPi} \qquad \text{for } 0 \leq i < FPCT \tag{262}$$

The mapping from PRU_{FPi} to CRU_{FPi} (for $0 \leq i < FPCT$)is given by Equation (263):

$$CRU_{FPi}[j] = \begin{cases} PRU_{FPi}[j], & 0 \le j < L_{SB-CRU,FPi} \\ PRU_{FPi}[k + L_{SB-CRU,FPi}], & L_{SB-CRU,FPi} \le j < L_{CRU,FPi} \end{cases} \quad (263)$$

where $k = s[j - L_{SB\text{-}CRU,FPi}]$.

$s[]$ is the CRU/DRU allocation sequence defined in Equation (264) and $0 \le s[j] < FPS_i - L_{SB-CRU,FPi}$.

$$s[j] = \{\mathrm{PermSeq}(j) + \mathrm{UL\_PermBase}\} \bmod (FPS_i - L_{SB-CRU,FPi}) \quad (264)$$

where PermSeq() is the permutation sequence of length (FPS_i- $L_{SB\text{-}CRU,FPi}$) and is determined by $SEED$={$IDcell$*343} mod 2^{10}. The permutation sequence is generated by the random sequence generation algorithm specified in 16.3.5.3.3. The UL_PermBase is set to preamble *IDcell*.

The mapping of PRU_{FPi} to DRU_{FPi} is given by Equation (265):

$$DRU_{FPi}[j] = PRU_{FPi}[k + L_{SB-CRU,FPi}], \quad 0 \le j < L_{DRU,FPi} \quad (265)$$

where $k = s[j + L_{CRU,FPi} - L_{SB\text{-}CRU,FPi}]$.

Figure 542 presents an example to illustrate the various steps of subband partitioning, miniband permutation, frequency partitioning, and cell-specific resource mapping (CRU/DRU allocation) for the case of 10 MHz system bandwidth. For this example, K_{SB} = $USAC$ = 7, $FPCT$ = 4, FPS_i = 12 (for $i \ge 0$), $UFPSC$ = 2, $UCAS_{SB,0}$ = 1, $UCAS_{MB,0}$ = 1, and $UCAS_i$ = 2.

Table 886 presents a summary of the parameters used to configure the UL PHY structure.

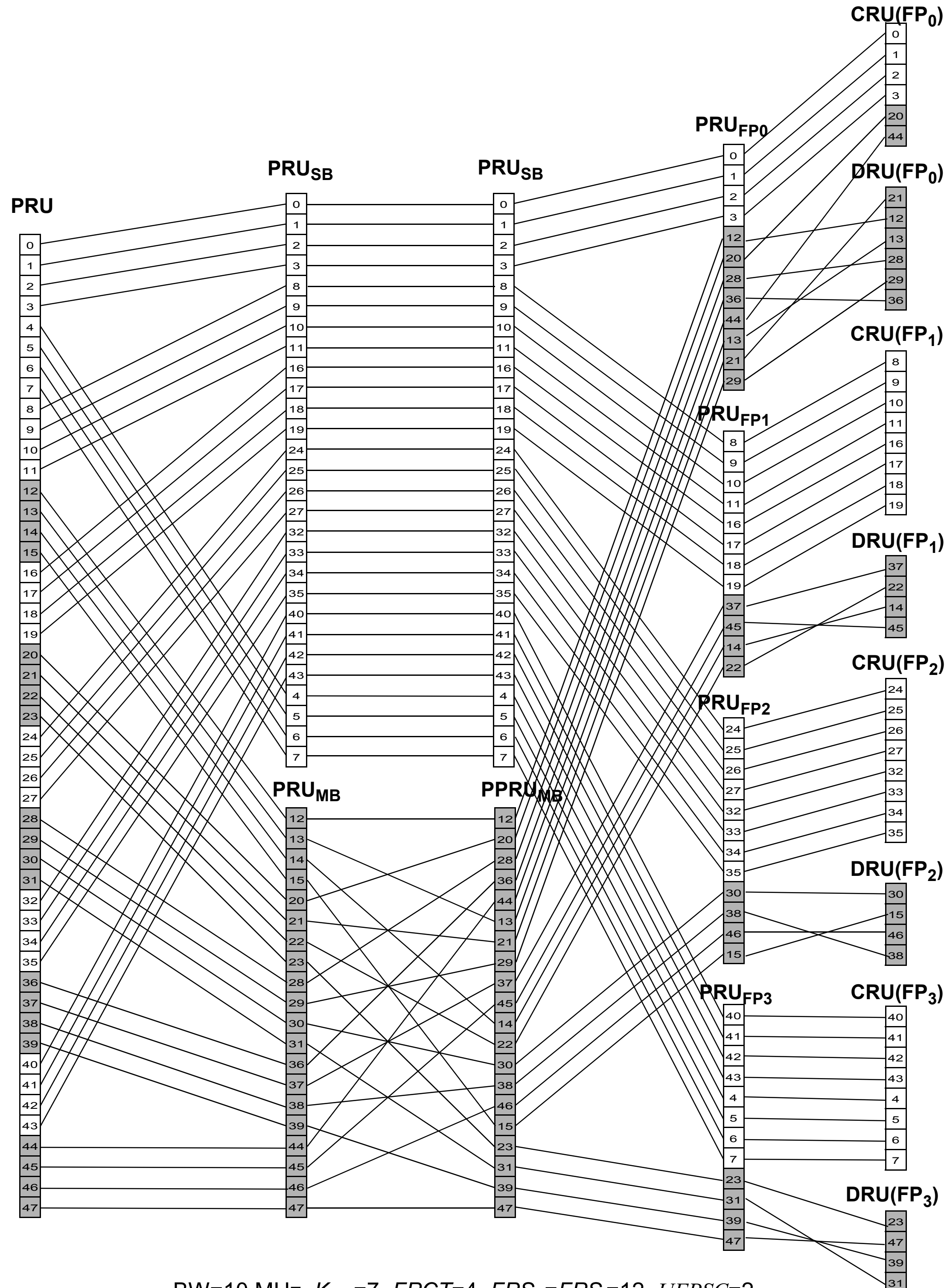
Table 886—UL PHY Structure - Summary of parameters

<table>
<tr><th></th><th>Operation Procedure</th><th>Related Signaling Field (BW20/ 10/5MHz)</th><th>Channel for Signaling</th><th>Parameters Calculated from Signaled Fields</th><th>Definition</th><th>Units</th></tr>
<tr><td rowspan="10">Sector Com-mon</td><td rowspan="3">Sub-band Partitioning

Mini-band Partitioning</td><td rowspan="3">USAC (5/4/3) bits</td><td rowspan="10">SFH - SP2</td><td>K_{SB}</td><td>Number of subbands</td><td>Sub-bands</td></tr>
<tr><td>$L_{SB} = N_1 * K_{SB}$</td><td>Number of PRUs assigned to subbands</td><td>PRUs</td></tr>
<tr><td>L_{MB}</td><td>Number of PRUs assigned to minibands</td><td>PRUs</td></tr>
<tr><td rowspan="7">Frequency Partitioning</td><td rowspan="2">UFPC (4/3/3 bit)</td><td>$FPCT$</td><td>Number of frequency partitions</td><td>Frequency Partitions</td></tr>
<tr><td>FPS_i</td><td>Number of PRUs in FP_i</td><td>PRUs</td></tr>
<tr><td rowspan="5">UFPSC (3/2/ 1 bit)</td><td>$K_{SB, FPi}$</td><td>Number of subbands assigned to FP_i</td><td>Sub-bands</td></tr>
<tr><td>$K_{MB, FPi}$</td><td>Number of minibands assigned to FP_i</td><td>Sub-bands (Groups of N_1 PRUs)</td></tr>
<tr><td>$L_{SB, FPi} = N_1 * K_{SB, FPi}$</td><td>Number of PRUs assigned to minibands in FP_i</td><td>PRUs</td></tr>
<tr><td>$L_{MB, FPi} = N_2 * K_{MB, FPi}$</td><td>Number of PRUs assigned to be subbands in FP_i</td><td>PRUs</td></tr>
<tr style="display:none"></tr>
<tr><td rowspan="5">Sector Specific</td><td rowspan="4">CRU/DRU Allocation</td><td rowspan="4">$UCAS_{SB,0}$ (5/ 4/3 bit)

$UCAS_{MB,0}$ (5/ 4/3 bit)

$UCAS_i$ (3/2/1) bit</td><td rowspan="4">SFH - SP1</td><td>$L_{SB\text{-}CRU, FPi}$</td><td>Number of subband-based CRUs in FP_i</td><td>CRUs</td></tr>
<tr><td>$L_{MB\text{-}CRU, FPi}$</td><td>Number of miniband-based CRUs in FP_i</td><td>CRUs</td></tr>
<tr><td>$L_{CRU,FPi} = L_{SB\text{-}CRU, FPi} + L_{MB\text{-}CRU, FPi}$</td><td>Number of CRUs in FP_i</td><td>CRUs</td></tr>
<tr><td>$L_{DRU,FPi} = FPS_i - L_{CRU,FPi}$</td><td>Number of DRUs in FP_i</td><td>DRUs</td></tr>
<tr><td>Tile Permutation</td><td>IDcell (10bit)</td><td>Obtained from SA-Preamble</td><td></td><td></td><td></td></tr>
</table>



BW=10 MHz, K_{SB}=7, *FPCT*=4, FPS_0=FPS_i=12, *UFPSC*=2 ,
$UCAS_{SB,0}$ = 1, $UCAS_{MB,0}$ = 1, $UCAS_i$=2, and *IDcell*=2.

Figure 542—Frequency partition for BW=10 MHz

16.3.8.3.2 Tile permutation

Each of the DRUs of an UL frequency partition is divided into 3 tiles of 6 adjacent subcarriers over N_{sym} symbols. The tiles within a frequency partition are collectively tile-permuted to obtain frequency-diversity across the allocated resources.

The tile permutation that allocates physical tiles of DRUs to logical tiles of subchannels is performed in the following manner:

$$Tile(s, n, t) = L_{DRU, FPi} \cdot n + g(PermSeq(), s, n, t) \quad (266)$$

where

Tiles(*s*,*n*,*t*) is the tile index of the n^{th} tile in the s^{th} distributed LRU of the t^{th} AAI subframe.

n is the tile index, 0 to 2, in a distributed LRU.

t is the AAI subframe index with respect to the frame.

s is the distributed LRU index, 0 to $L_{DRU, FPi}$-1.

PermSeq() is the permutation sequence of length $L_{DRU,FPi}$ and is determined by SEED={*IDcell**343} mod 2^{10}. The permutation sequence is generated by the random sequence generation algorithm specified in 16.3.5.3.3, and

$g(PermSeq(),s,n,t) = \{PermSeq[(n + 107 * s + 1213 * t) \bmod L_{DRU,FPi}] + UL\_PermBase\} \bmod L_{DRU,FPi}$, where the *UL_PermBase* is set to preamble *IDcell*.

16.3.8.3.3 Resource allocation and tile permutation for control channels

The distributed LRUs in each of uplink frequency partition may be further divided into data, bandwidth request, and feedback regions. A feedback region consists of feedback channels can be used for both HARQ ACK/NACK and fast feedback. In a multicarrier system with active DL-only carriers, the primary UL carrier should contain multiple feedback regions for the primary DL carrier and the active DL-only carriers. The primary UL carrier should contain one feedback region corresponding to each DL carrier with a predefined mapping. The allocation order of data channels and UL control channels are UL HARQ feedback channels, UL fast feedback channels, UL bandwidth request channels, and UL data channels as Figure 544.

When frame structure is supporting the WirelessMAN-OFDMA with FDM-based uplink PUSC zone, the ranging channel is located in the lowest DLRU index, which is followed by UL HARQ feedback channels, UL fast feedback channels, UL bandwidth request channels, and UL data channels as Figure 543. If there is no ranging channel in a subframe, the uplink control channel starts from lowest index as Figure 544.

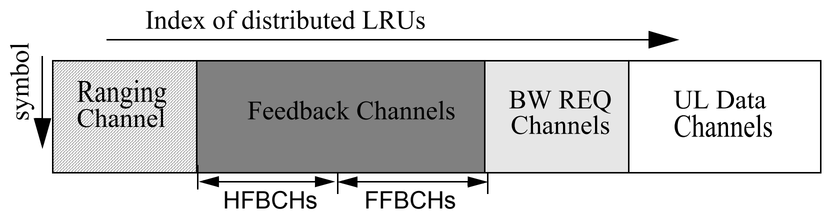


Figure 543—The allocation order of UL channels in the FDM-based UL PUSC zone

If FFR is used in anUL AAI subframe, the UL control channels can be used in the reuse 1 partition and the power-boosted reuse 3 partition.

16.3.8.3.3.1 Bandwidth request channels

The number of bandwidth request channels in frequency partition FP_i in a UL AAI subframe is N_{bwr}. N_{bwr} is 1 in MZone and 2 in LZone with PUSC.

In MZone, the bandwidth request channels are of same size as LRUs, i.e. three 6-by-6 tiles. In LZone with PUSC, the bandwidth request channels consist of three 4-by-6 tiles. The bandwidth request channels use LRUs constructed from the tile permutation specified in 16.3.8.3.2.

16.3.8.3.3.2 Feedback Channels

Let *UL_FEEDBACK_SIZE* distributed LRUs in frequency partition FP_i be reserved for feedback channels in the units of LRU. The number of feedback channels in frequency partition FP_i, is $L_{FB,FPi}$.

$$L_{FB,FPi} = N_{fb} \cdot UL\_FEEDBACK\_SIZE \quad (267)$$

where N_{fb} is 3 in MZone and 4 in LZone with PUSC.

The feedback channels are formed by 3 permuted 2-by-6 mini-tiles. The mini-tile reordering process applied to each distributed LRU is described below:

1) The uplink tiles in the distributed LRUs reserved for feedback channels are divided into 2-by-6 feedback mini-tiles (FMTs). The FMTs so obtained are numbered from 0 to $3 \cdot L_{FB,FPi} - 1$.

a) A mini-tile reordering is applied to the available 2-by-6 FMTs as specified by Equation (268) and Equation (269) to obtain the reordered FMTs (RFMTs).

a) Each group of three consecutive RFMTs forms a feedback channel.

The closed form expressions for the FMT reordering function used in step 2 above are as Equation (268) in MZone and Equation (269) in the LZone with PUSC:

$$MiniTile(s, n) = 9 \cdot floor\left(\frac{s}{3}\right) + mod(s, 3) + 3 \cdot n \quad (268)$$

$$MiniTile(s, n) = 6 \cdot floor\left(\frac{s}{2}\right) + mod(s, 2) + 2 \cdot n \quad (269)$$

where

MiniTile(s,n) is the n^{th} mini-tile of the s^{th} feedback channel.
n is the mini-tile index in a feedback channel. *n* can take a value of 0, 1 or 2.
s is the feedback channel index. *s* can take an integer value in the range 0 to $L_{FB,FPi}$-1.

HARQ feedback channels

Each feedback channel constructed according to 16.3.8.3.3.2 can be used to transmit six HARQ feedback channels. The number of HARQ feedback channels is denoted by $L_{HFB,FPi}$.

A pair of HARQ feedback channels is formed by three 2-by-2 reordered HARQ mini-tiles (RHMT). The HMTs reordering process and the construction of HARQ feedback channel are described below and illustrated in Figure 571.

1) Each 2x6 RFMT is divided into three consecutively indexed 2-by-2 HMTs. The HMTs so obtained are numbered from 0 to $3 \cdot L_{HFB,FPi} - 1$.

a) A HMT reordering is applied to the HMTs as specified by Equation (270) to obtain the RHMTs.

a) Each group of three consecutive RHMTs forms a pair of HARQ feedback channels.

The closed form expression for the HMT reordering function used in step 2 above is as Equation (270).

$$HMT(k, m) = 9 \cdot floor\left(\frac{k'}{3}\right) + mod(k' + m, 3) + 3 \cdot \quad (270)$$

where

HMT(*k*,*m*) is the *m*-th HMT of the *k*-th HARQ feedback channel.
m is the HMT index in a HARQ feedback channel. *m* can take a value 0, 1 or 2.
k is the HARQ feedback channel index. *k* can take an integer value in the range 0 to $L_{HFB,FPi}$ -1.
$k' = \lfloor k/2 \rfloor$

In FDD, there is one HARQ feedback region in each UL AAI subframe. In TDD, with notation in Table 753 in 16.2.14.2.2.2.1, for HARQ feedback channel in UL AAI subframe *n*, the associated DL bursts can start from a set of DL AAI subframe indices denoted by $M = \{m_0, m_1, ..., m_{K-1}\}$, where $m_0 < m_1 < ... m_{K-1}$. The number of HARQ feedback regions is equal to the size of set *M*. For DL bursts starting at AAI subframe m_k, the index of the associated HARQ Feedback region is the order of m_k in set *M*, with index 0 corresponding to the 1st HARQ feedback region. Within each HARQ feedback region, the index for HARQ feedback channel is calculated as follows.

For the deallocation of a persistent allocation, index k is specified in HFA of the DL Persistent Allocation A-MAP IE.

For group resource allocation, index k for the l^{th} AMS in GRA allocation is $(i_{start} + \lfloor l \cdot L_{HFB} / N_{GRA} \rfloor) mod N_{HFB}$, where i_{start} is the ACK Channel Offset in the DL Group Resource Allocation A-MAP IE, L_{HFB} is the total number of HFBCH configured per HARQ feedback region, and N_{GRA} is the Use Bit Map Size in the DL Group Resource Allocation A-MAP IE.

For resource allocation using the DL Basic Assignment A-MAP IE, DL Subband Assignnment A-MAP IE, DL Persistent Allocation A-MAP IE, Feedback Allocation A-MAP IE, and Feedback Polling A-MAP IE, the index k is $(M(j) + n) mod L_{HFB}$, where j is HFBCH Index Parameter in the Non-user Specific A-MAP IE, n is a 3 bit HFA value signaled in each Assignment A-MAP IEs, L_{HFB} is the total number of HFBCH configured per HARQ feedback region, $M(j)$ is STID when $j = 0$ and $M(j)$ is lowest LRU index of the corresponding DL transmission when $j = 1$.For the DL persistent allocation A-MAP IE, $M(j)$is always STID regardless of value j.

Fast Feedback Channels

A fast feedback channel consists of one feedback channel. It is allocated after HARQ feedback regions and the total number of the feedback channels is L_{FB}-floor(L_{HFB}/3).

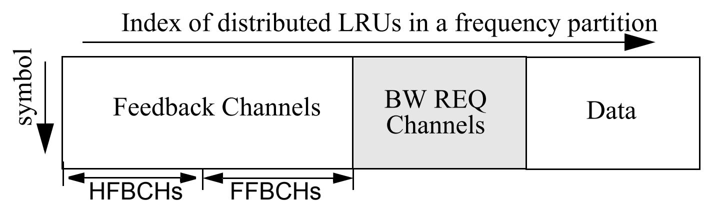


Figure 544—Allocation of channels in the UL frequency partition

16.3.8.3.4 Logical Resource Unit Mapping

Both contiguous and distributed LRUs are supported in the uplink. The CRUs are directly mapped into contiguous LRUs. Precoding and/or boosting applied to the data subcarriers will also be applied to the pilot subcarriers. The DRUs are permuted as described in 16.3.8.3.2 to form distributed LRUs.

16.3.8.3.5 WirelessMAN-OFDMA Systems Support

When frame structure is supporting the WirelessMAN-OFDMA MSs in PUSC zone by FDM manner as defined in 16.3.3.5, a new symbol structure and subchannelization defined in the subclause are used.

16.3.8.3.5.1 Basic Symbol Structure for FDM based UL PUSC Zone Support

The subcarriers of an OFDMA are partitioned into $N_{g,left}$ left guard subcarriers, $N_{g,right}$ right guard subcarriers, and N_{used} used subcarriers. The DC subcarrier is not loaded. The N_{used} subcarriers are divided into multiple PUSC tiles. Basic symbol structures for various bandwidths are shown in Table 887, Table 888, and Table 889.

Table 887—512 FFT OFDMA UL subcarrier allocations for DRU

Parameters	Value	Comments
Number of DC subcarriers	1	Index 256 (counting from 0)
$N_{g,left}$	52	Number of left guard subcarriers
$N_{g,right}$	51	Number of right guard subcarriers
N_{used}	409	Number of all subcarriers used in WirelessMAN-OFDMA PUSC zone within a symbol, including DC carrier

Table 888—1024 FFT OFDMA UL subcarrier allocations for DRU

Parameters	Value	Comments
Number of DC subcarriers	1	Index 512 (counting from 0)
$N_{g,left}$	92	Number of left guard subcarriers
$N_{g,right}$	91	Number of right guard subcarriers
N_{used}	841	Number of all subcarriers used in WirelessMAN-OFDMA PUSC zone within a symbol, including DC carrier

16.3.8.3.5.2 Resource Block for FDM based UL PUSC Zone Support

When supporting FDM based UL PUSC zone, a tile consists of 4 consecutive subcarriers and 6 OFDMA symbols, as shown in Figure 545.

Table 889—2048 FFT OFDMA UL subcarrier allocations for DRU

Parameters	Value	Comments
Number of DC subcarriers	1	Index 1024 (counting from 0)
$N_{g,left}$	184	Number of left guard subcarriers
$N_{g,right}$	183	Number of right guard subcarriers
N_{used}	1681	Number of all subcarriers used in WirelessMAN-OFDMA PUSC zone within a symbol, including DC carrier

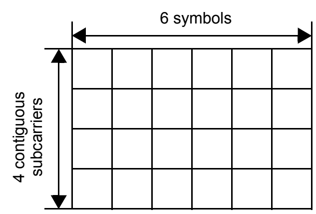


Figure 545—Resource block for FDM based UL PUSC zone support

16.3.8.3.5.3 Subchannelization for FDM based UL PUSC Zone Support

When supporting FDM based UL PUSC zone, UL subchannelization shall conform the following rules:

1) For the WirelessMAN-OFDMA system bandwidth, all usable subcarriers given in Table 887, Table 888, and Table 889 are divided into PUSC tiles.
2) UL PUSC subchannelization is performed as described in 8.4.6.2.2.
3) All PUSC tiles of specified subchannels from step 2 are extended in time domain from 3 OFDM symbols to N_{sym} OFDM symbols, where N_{sym} is dependent of AAI subframe type.
4) Based on specified subchannels of step 2 with symbol extension tiles of step 3, DRUs for Advanced Air Interface are made up.
5) Repeat step 3 and step 4 for remained OFDMA symbols of every uplink AAI subframe.
6) Renumber the DLRU index in reverse order of PUSC subchannel index.

Overall process of subcarrier to subchannel mapping is shown in Figure 546.

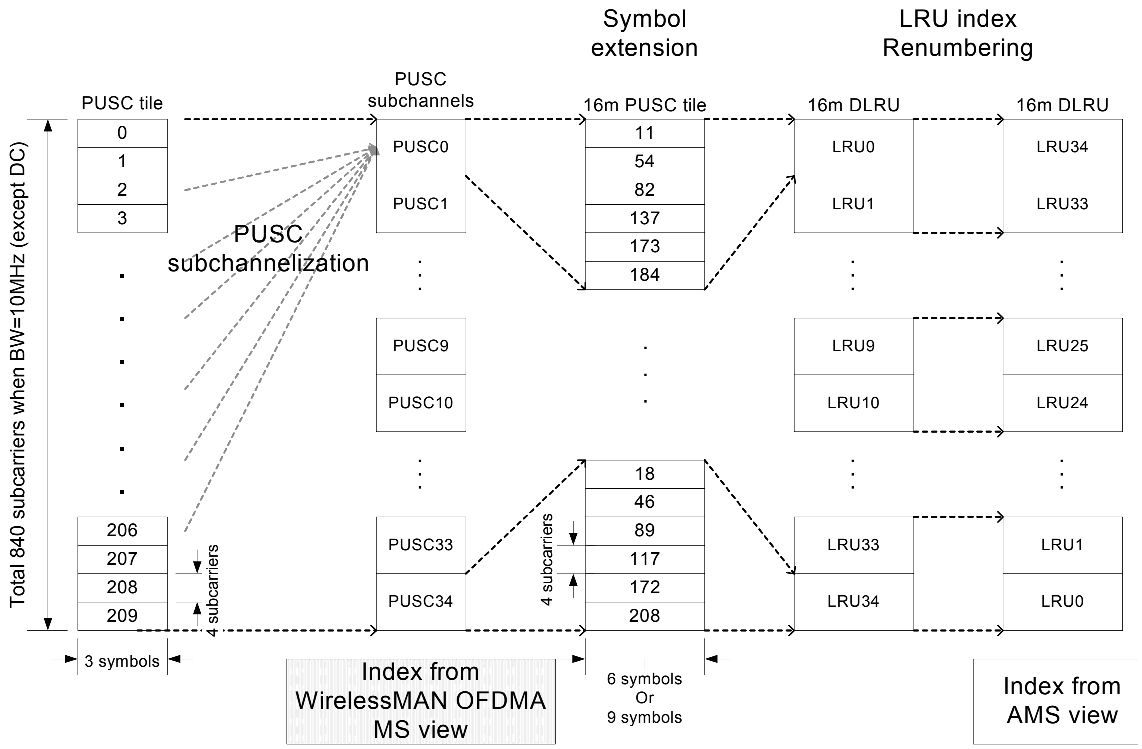


Figure 546—Example of subchannelization for FDM base UL PUSC zone support

16.3.8.4 Pilot structure

Uplink pilot is dedicated to each user and can be precoded or beamformed in the same way as the data subcarriers of the resource allocation. The pilot structure is defined for up to 4 transmission streams.

The pilot pattern may support variable pilot boosting. When pilots are boosted, each data subcarrier should have the same Tx power across all OFDM symbols in a resource block.

Figure 547 and Figure 548 show the pilot structure for distributed LRUs where the number of streams is one or two, respectively. Figure 549 and Figure 550 contain the one and two-stream pilot patterns for the distributed PUSC LRU. Figure 551, Figure 552, Figure 553 and Figure 554 show the pilot structure for contiguous LRUs where the number of streams is one, two, three or four. Note that the pilot patterns for UL contiguous LRUs are same as in the downlink case.

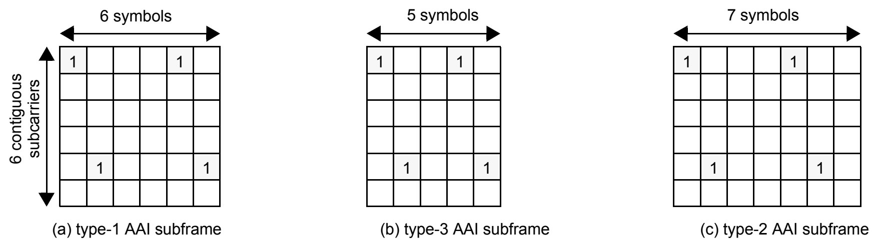


Figure 547—Pilot patterns of 1-Tx stream for distributed LRUs

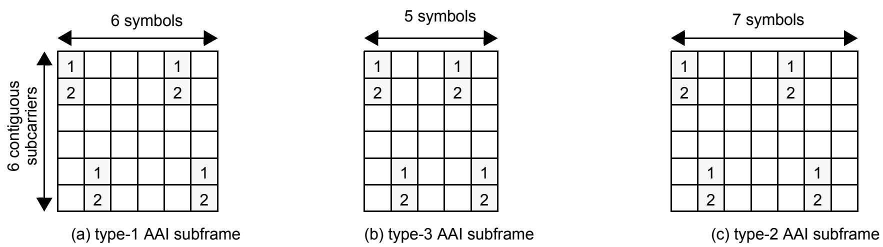


Figure 548—Pilot patterns of 2-Tx streams for distributed LRUs

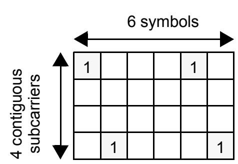


Figure 549—Pilot pattern of 1-Tx stream for distributed PUSC LRUs

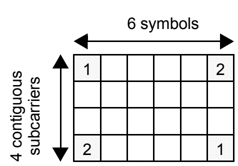


Figure 550—Pilot pattern of 2-Tx stream for distributed PUSC LRUs

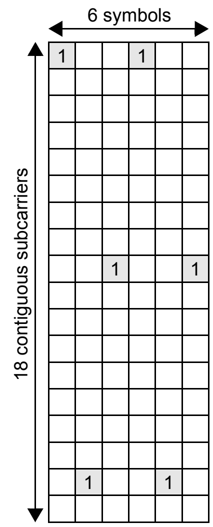


Figure 551—Pilot patterns for contiguous LRUs for 1 Tx stream

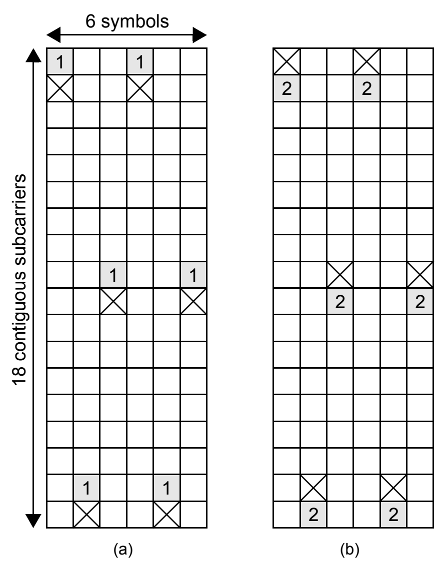


Figure 552—Pilot patterns for contiguous LRUs for 2 Tx streams

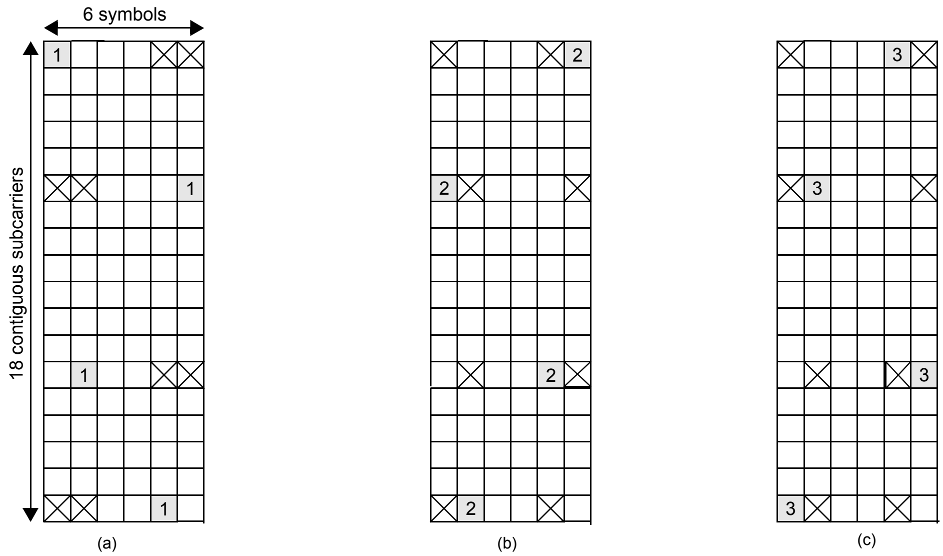


Figure 553—Pilot patterns for contiguous LRUs for 3 Tx streams

For 3 streams MIMO transmissions, the first three of the four pilot streams will be used and the unused pilot stream is allocated for data transmission.

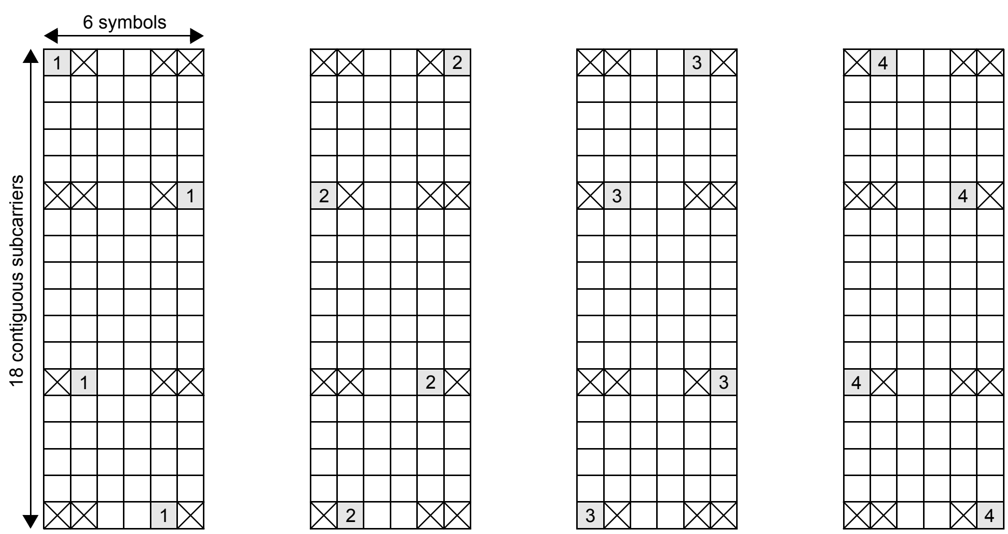


Figure 554—Pilot patterns for contiguous LRUs for 4 Tx streams

The pilot patterns of type-4 AAI subframe are derived from the type-2 AAI subframe patterns. The first seven symbols of type-4 AAI subframe pilot patterns are identical to the type-2 AAI subframe patterns. The last two symbols of type-4 AAI subframe pilot patterns are generated by appending the first two symbols of type-2 AAI subframe pilot patterns.

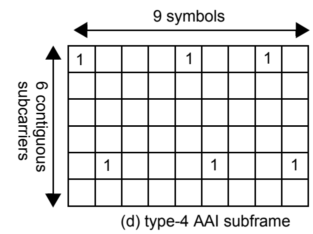


Figure 555—Pilot patterns of 1-Tx stream for type-4 AAI subframe distributed LRUs

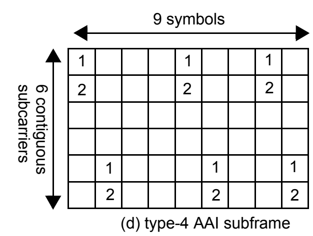


Figure 556—Pilot patterns of 2-Tx stream for type-4 AAI subframe distributed LRUs

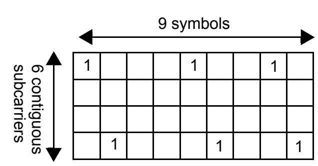


Figure 557—Pilot patterns of 1-Tx stream for type-4 AAI subframe distributed PUSC LRUs

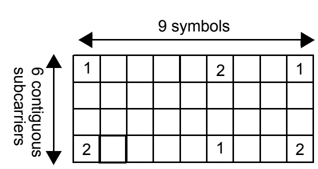


Figure 558—Pilot patterns of 2-Tx stream for type-4 AAI subframe distributed PUSC LRUs

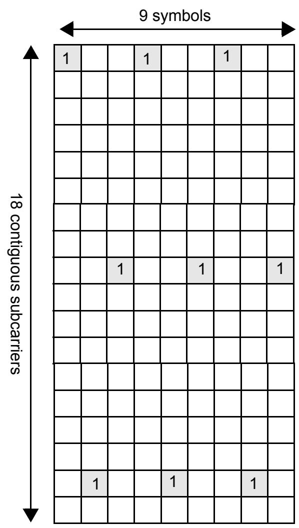


Figure 559—Pilot patterns of 1-Tx stream for type-4 AAI subframe contiguous LRUs

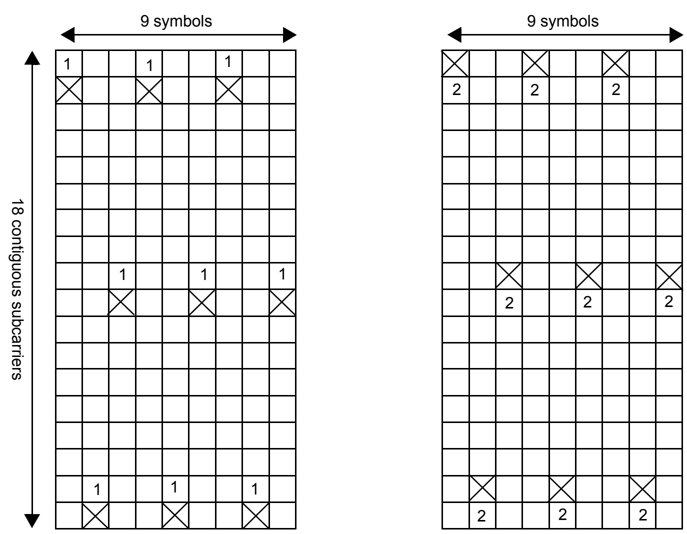


Figure 560—Pilot patterns of 2-Tx stream for type-4 AAI subframe contiguous LRUs

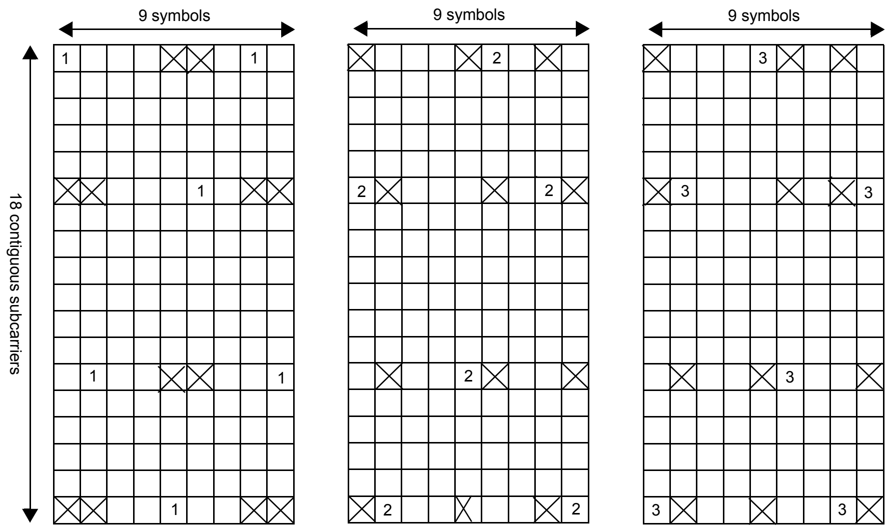


Figure 561—Pilot patterns of 3-Tx streams for type-4 AAI subframe contiguous LRUs

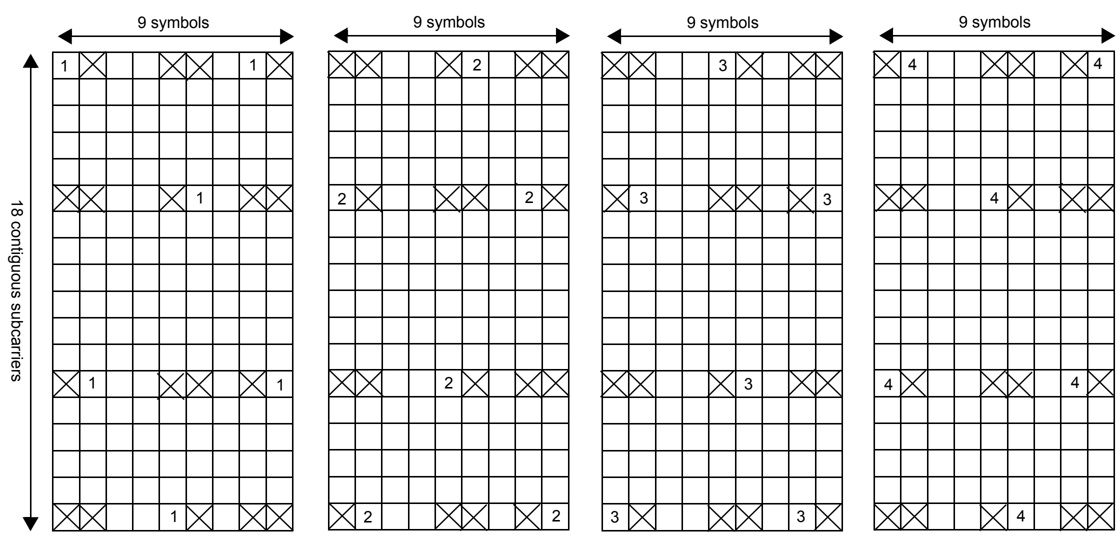


Figure 562—Pilot patterns of 4-Tx stream for type-4 AAI subframe contiguous LRUs

16.3.8.5 Uplink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRU is the same as the structure defined in16.3.8.1 and 16.3.8.4. The guard PRUs are used as miniband CRUs at partition FP_0 for data transmission only. The number of useable guard subcarriers is predefined and should be known to both AMS and ABS based on carrier bandwidth.The number of guard PRUs in left and right edge of each carrier are shown in Table 890. Denote the number of guard PRUs in the left (right) edge of carrier by N_{LGPRU} (N_{RGPRU}). The total number of guard PRUs are N_{GPRU}.= N_{LGPRU} + N_{RGPRU}.

Table 890—Number of guard PRUs

BW	Number of guard PRUs in the left edge of carrier[1)]	Number of guard PRUs in the right edge of carrier[2)]
5 MHz	0	0
10 MHz	1	1
20 MHz	2	2
7 MHz	0	0
8.75 MHz	0	0

1) When a carrier occupies the left most spectrum among multiple contiguous carriers the number of guard PRUs in the left edge of carrier is zero.

1) 2) When a carrier occupies the right most spectrum among multiple contiguous carriers the number of guard PRUs in the right edge of carrier is zero.

Denote left guard PRUs and right guard PRUs by $GPRU_L[0]$,…. $GPRU_L[N_{LGPRU}$ -1] and $GPRU_R[0]$,…. $GPRU_R[N_{RGPRU}$ -1] from the lowest frequency. Then, guard PRUs are indexed by interleaving $GPRU_L$ and $GPRU_R$ one by one. That is, GPRU[*i*] = $GPRU_L[i/2]$, for *i* is an even number and GPRU[*i*] = $GPRU_R[(i-1)/2]$, for *i* is an odd number, If N_{LGPRU} = 0, then GPRU[*i*]= $GPRU_R[i]$. If N_{RGPRU} = 0, then GPRU[*i*]= $GPRU_L[i]$.

The N_{GPRU} guard PRUs are used as mini-band LRUs, i.e., NLRUs at frequency partition FP0 without any permutation for data transmission only. In detail, *i*-th guard NLRU, i.e., GNLRU[*i*] is always allocated along with the *i*-th last NLRU at partition FP0. In other words, when an allocation including the *i*-th last NLRU at partition FP0 is made to an AMS for multicarrier support, the *i*-th guard NLRU, i.e., GNLRU[*i*] is allocated together. The mapping to the GNLRU[*i*] is made after mapping to the *i*-th NLRU at partition FP0.

When adjacent carrier is not an active carrier of the AMS, the guard sub-carriers in between active and non-active carriers shall not be utilized for data transmission for that AMS.

When the overlapped guard sub-carriers are not aligned in the frequency domain, they shall not be used for data transmission.

16.3.9 Uplink control channel

16.3.9.1 Physical uplink control channel

16.3.9.1.1 Fast feedback control channel

The DRUs are permuted by UL tile permutation as described in 16.3.8.3.2 to form distributed LRUs for both data and control resource/channel. A UL feedback mini-tile (FMT) is defined as 2 contiguous subcarriers by 6 OFDM symbols. The UL feedback control channels are formed by applying the UL mini-tile permutation to the LRUs allocated to the control resource. The fast feedback channels are comprised of 3 RFMTs. The details of feedback mini-tile permutation and the subchannelization of fast feedback are described in 16.3.8.3.3.2.

16.3.9.1.1.1 Primary fast feedback channel

The primary fast feedback channel is comprised of 3 RFMTs. The construction process of primary fast feedback channels is described in 16.3.8.3.3.2.

16.3.9.1.1.2 Secondary fast feedback channel

The secondary fast feedback channel has the same physical control channel structure as the primary fast feedback channel. The secondary fast feedback channels are comprised of 3 RFMTs. The construction process of secondary fast feedback is described in 16.3.8.3.3.2

16.3.9.1.2 HARQ feedback control channel

Each UL HARQ feedback resource consists of three RFMTs. A total resource of three distributed 2x6 RFMTs supports 6 UL HARQ feedback channels. The 2x6 RFMTs are further divided into UL HARQ mini-tiles (HMT). A UL HARQ mini-tile has a structure of 2 subcarriers by 2 OFDM symbols.

16.3.9.1.3 Sounding channel

Uplink channel sounding provides the means for the ABS to determine UL channel response for the purpose of UL closed-loop MIMO transmission and UL scheduling. In TDD systems, the ABS can also use the estimated UL channel response to perform DL closed-loop transmission to improve system throughput, coverage and link reliability. In this case ABS can translate the measured UL channel response to an estimated DL channel response when the transmitter and receiver hardware of ABS are appropriately calibrated.

16.3.9.1.3.1 Sounding PHY structure

The sounding signal occupies a single OFDMA symbol in the UL sub-frame. The sounding symbol in the UL sub-frame is located in the first symbol. Each UL sub-frame can contain only one sounding symbol. For type-1 AAI subframe, the sounding signal shall not be transmitted in the LRU which contains other control channels. For type-2 AAI subframe, sounding signals can be transmitted in any resource unit. For the six-symbol PRU case, the remaining 5 consecutive symbols are formed to be a five-symbol PRU used for data transmission, as shown in Figure 563. For the seven-symbol PRU case, the remaining 6 consecutive symbols are formed to be a six-symbol PRU for data transmission, as shown in Figure 563. Multiple UL AAI subframes in a 5-ms radio frame can be used for sounding. The number of subcarriers for the sounding in a PRU is 18 adjacent subcarriers.

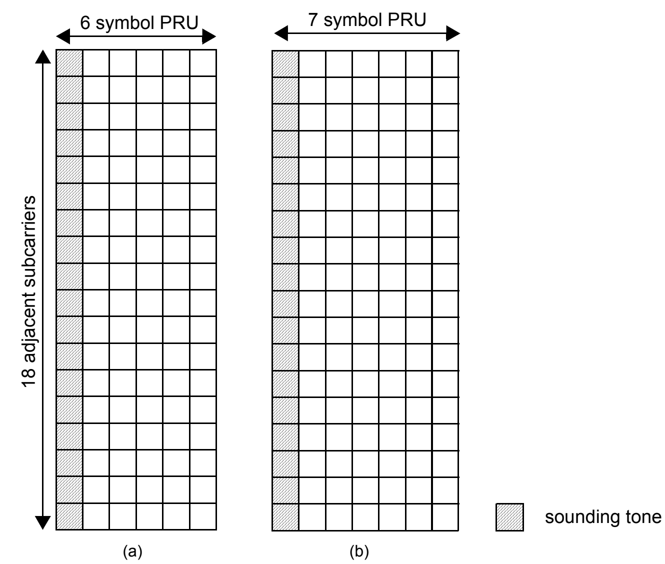


Figure 563—Sounding PHY structures for (a) 6-symbol PRU and (b) 7-symbol PRU cases.

16.3.9.1.4 Ranging channel

The UL ranging channel is used for UL synchronization. The UL ranging channel can be further classified into ranging channel for non-synchronized and synchronized AMSs. The ranging channel for synchronized AMSs is used for periodic ranging. The ranging channel for non-synchronized AMSs is used for initial access and handover. AMS shall not transmit any other uplink burst or uplink control channel signal in the AAI subframe where it transmits a ranging channel for non-synchronized AMSs.

16.3.9.1.4.1 Ranging channel structure for non-synchronized AMSs

The ranging channel for non-synchronized AMSs is used for initial network entry and association and for ranging against a target BS during handover.

A physical ranging channel for non-synchronized AMSs consists of the ranging preamble (RP) with length of T_{RP} depending on the ranging subcarrier spacing Δf_{RP}, and the ranging cyclic prefix (RCP) with length of T_{RCP} in the time domain.

A ranging channel occupies a localized bandwidth corresponding to 1 subband.

Power control operation described in 16.3.9.4.4 applies to ranging signal transmission.

Table 891 contains ranging channel formats and parameters.

Table 891—Ranging channel formats and parameters

Format No.	T_{RCP}	T_{RP}	Δf_{RP}
0	$k_1 \times T_g + k_2 \times T_b$	$2 \times T_b$	$\Delta f / 2$
1	$3.5 \times T_g + 7 \times T_b$	$8 \times T_b$	$\Delta f / 8$

where T_b, T_g and Δf are defined in 16.3.2.4.

The T_{RCP} for Formats 0 depends on OFDMA parameters, and AAI subframe types as:

$$k_1 = (N_{sym} + 1)/2 \quad \text{and} \quad k_2 = (N_{sym} - 4)/2 \quad .$$

where N_{sym} is the number of OFDMA symbols in a AAI subframe as defined in 16.3.8.1.

Ranging channel for non-synchronized AMSs is allocated in one or three UL AAI subframes for Format 0 or Format 1, respectively. Format 0 has a repeated structure as shown in Figure 564. RCP is the copy of the rear part of RP, without phase discontinuity between RCP and RP. The transmission start time of the ranging channel is aligned with the UL AAI subframe start time at the AMS. The remaining time duration of the AAI subframes is reserved to prevent interference between the adjacent AAI subframes.

AMS shall not transmit any other uplink burst or uplink control channel signal in the subframe where a ranging channel is transmitted for non-synchronized AMSs.

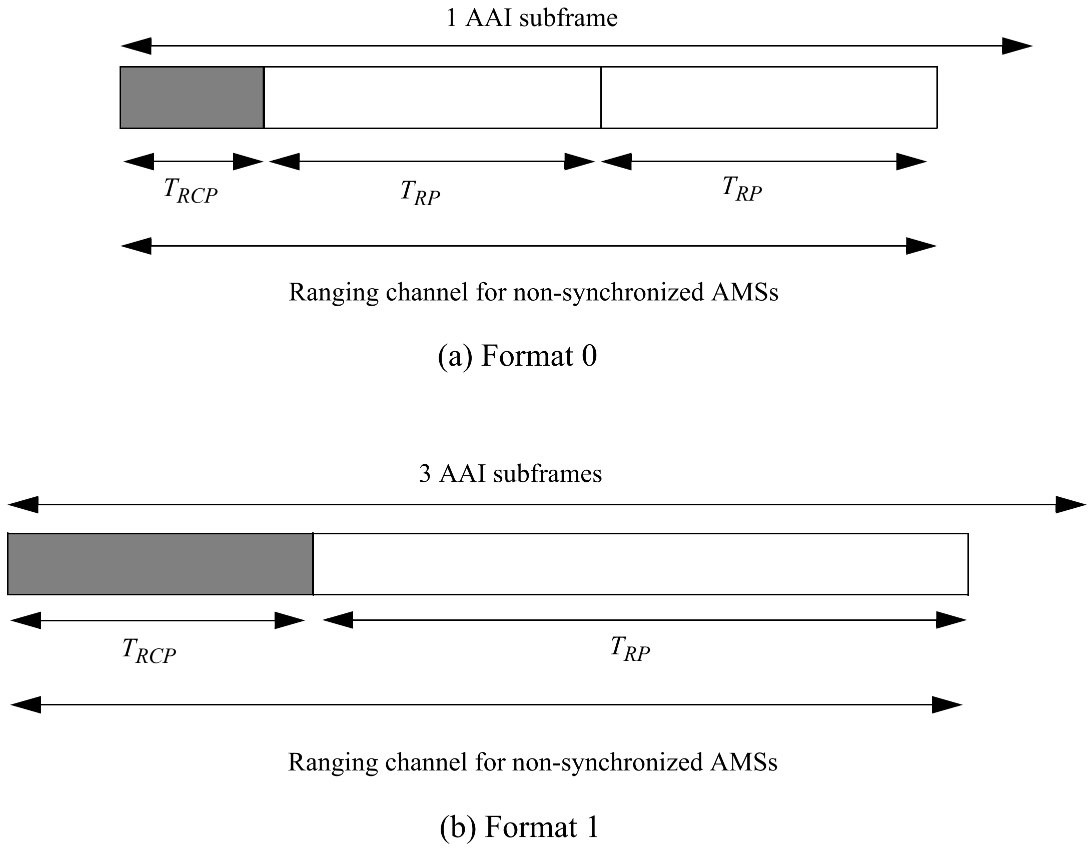


Figure 564—Ranging channel allocations in AAI subframe(s)

16.3.9.1.4.2 Ranging channel structure for synchronized AMSs

The ranging channel for synchronized AMSs is used for periodic ranging. The AMSs that are already synchronized to the target ABS are allowed to transmit the periodic ranging signal. Ina femtocell, AMSs shall perform initial ranging, handover ranging, and periodic ranging by using the ranging channel for synchronized AMSs.

The physical structure in the ranging channel for synchronized AMSs occupies 72 subcarriers by 6 OFDMA symbols starting from the first OFDMA symbol within a subframe, where there are two repeated signal waveforms and each signal waveform as a basic unit is generated by the ranging preamble code over 72 subcarriers by 3 OFDMA symbols.

Figure 565 illustrates the physical structure with a basic unit of ranging channel structure in the time domain where T_g and T_b are defined in 16.3.2.4.

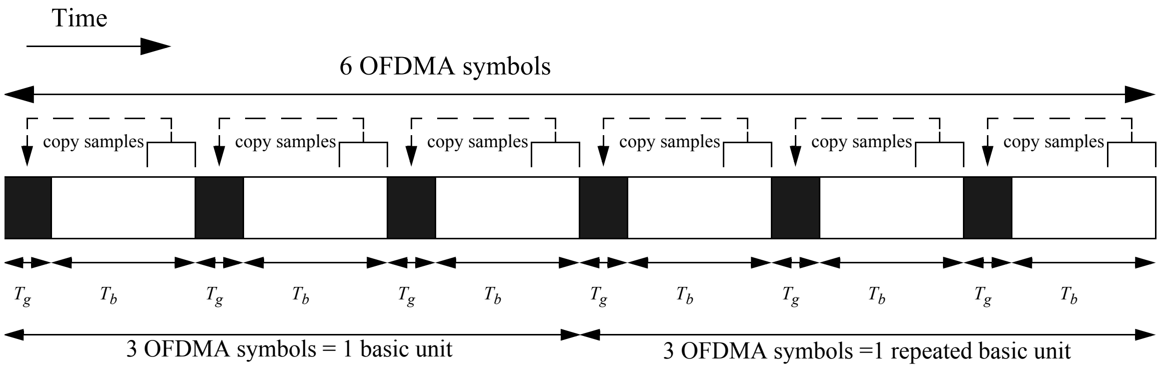


Figure 565—Ranging channel structure for synchronized AMSs in the time domain

Power control operation described in 16.3.9.4.4 applies to ranging signal transmission.

16.3.9.1.4.3 Ranging Channel for FDM-based UL PUSC Zone Support

The ranging channel for FDM-based UL PUSC Zone Support is composed of 6 distributed LRUs by using the symbol structure defined in 16.3.8.3.5.1.

A ranging transmission for non-synchronized AMSs shall be performed during two consecutive symbols same as Figure 253 in 8.4.7.1. The same ranging code is transmitted on the ranging channel during each symbol, with no phase discontinuity between the two symbols. A time-domain illustration of the ranging transmission for non-synchronized AMSs is shown in Figure 566 (a).

A ranging transmission for synchronized AMSs shall be performed during a symbol same as Figure 255 in 8.4.7.2. A time-domain illustration of the ranging transmission for synchronized AMSs is shown in Figure 566 (b).

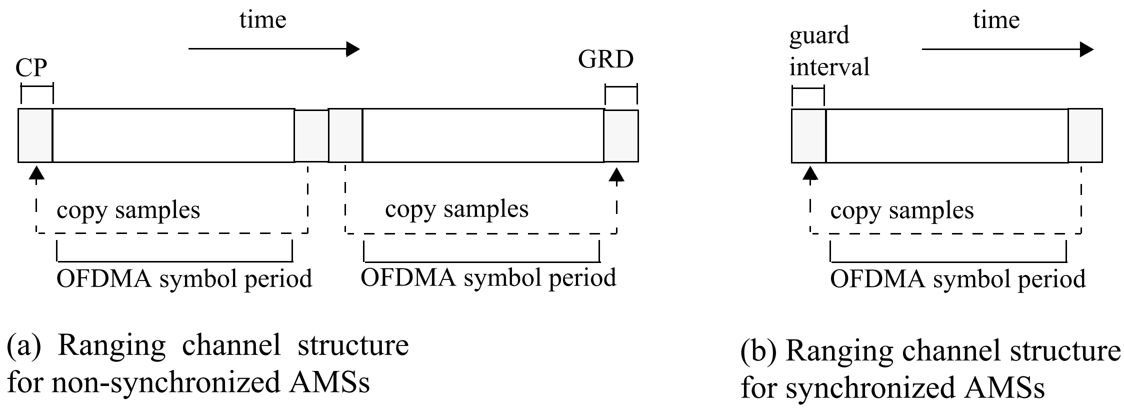


Figure 566—Ranging channel structure for FDM-based UL PUSC Zone Support

For ranging channel for non-synchronized AMSs, the transmitted signal is according to 16.3.2.5, Equation (175), except that $0 \le t \le 2T_s$.

Ranging channels for non-synchronized AMSs and ranging channel for synchronized AMSs are allocated in a UL AAI subframe. Within the allocated ranging AAI subframe, first 4 symbols in a UL AAI subframe are occupied for the ranging structure for non-synchronized AMSs. The last symbol in the same UL AAI subframe is occupied for the ranging channel for synchronized AMSs. A time-domain illustration of the ranging AAI subframe is shown in Figure 567.

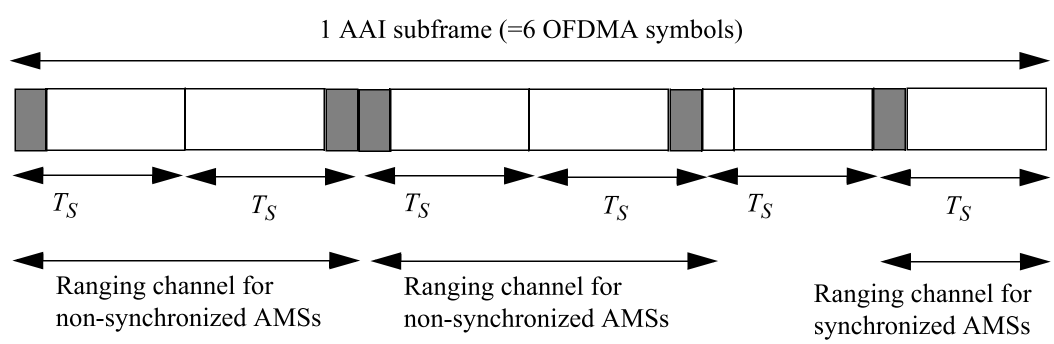


Figure 567—Ranging channel structures and allocations for FDM based UL PUSC Zone Support

16.3.9.1.5 Bandwidth request channel

Bandwidth request information is transmitted using contention based random access on this control channel.The bandwidth request (BR) channel contains resources for the AMS to send a BR preamble and an optional quick access message.

In the LZone with PUSC, a BW REQ tile is defined as four contiguous subcarriers by six OFDMA symbols. The number of BW REQ tiles per BW REQ channel is three. Each BW REQ tile carries a BW REQ preamble only.

In the Mzone, a BW REQ tile is defined as six contiguous subcarriers by six OFDMA symbols. Each BW REQ channel consists of three distributed BW-REQ tiles. Each BW REQ tile carries a BW REQ preamble and a quick access message. The AMS may transmit the access sequence only and leave the resources for the quick access message unused.

16.3.9.2 Uplink control channels physical resource mapping

16.3.9.2.1 Fast feedback control channel

There are two types of UL fast feedback control channels: primary fast feedback channel (PFBCH) and secondary fast feedback channels (SFBCH).

16.3.9.2.1.1 Primary fast feedback control channel

The primary fast feedback channels are comprised of three distributed FMTs. Figure 568 illustrates the mapping of the PFBCH.

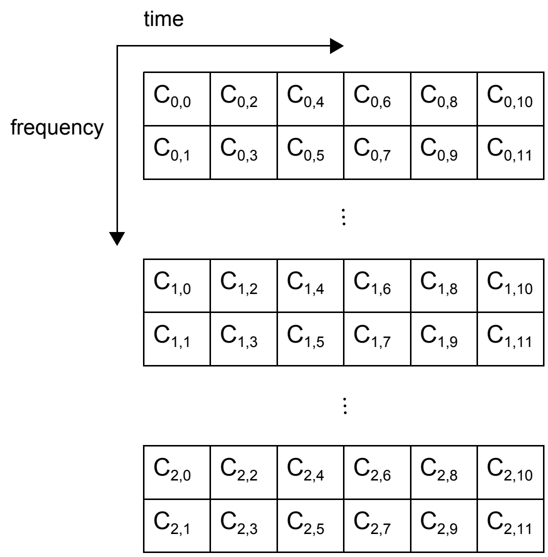


Figure 568—PFBCH comprised of three distributed 2x6 UL FMTs

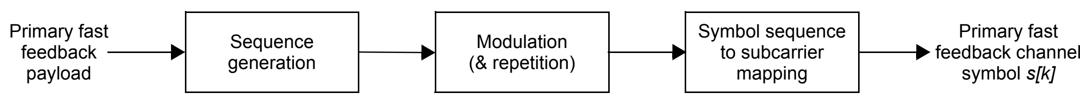


Figure 569—Mapping of information in the PFBCH

The process of composing the PFBCH is illustrated in Figure 569. The l PFBCH payload bits are used to generate PFBCH sequence according to Table 892. The resulting bit sequence is modulated, repeated and mapped to uplink PFBCH symbol $s[k]$ (0 mapped to +1 and 1 mapped to -1). The mapping of primary fast feedback channel symbol $s[k]$ to the UL FMTs is given by Equation (271). This set of sequences can carry up to six information bits.

$$C_{i,j} = s[K_i[j]] \text{, for } i = 0, 1, 2 \text{ , } 0 \le j \le 11 \qquad (271)$$

where

$K_i[j]$ denotes the j^{th} element of K_i

$K_0 = \{0,1,2,3,4,5,6,7,8,9,10,11\}$

$K_1 = \{9,10,11,3,4,5,0,1,2,6,7,8\}$

$K_2 = \{3,4,5,6,7,8,9,10,11,0,1,2\}$

Table 892—Sequences for PFBCH

Index	Sequence	Index	Sequence
0	111111111111	32	101011001001
1	101111010110	33	111011100000
2	011010111101	34	001110001011
3	001010010100	35	011110100010
4	101010101010	36	100111111010
5	111010000011	37	110111010011
6	001111101000	38	000010111000
7	011111000001	39	010010010001
8	110011001100	40	111110011100
9	100011100101	41	101110110101
10	010110001110	42	011011011110
11	000110100111	43	001011110111
12	100110011001	44	101010011111
13	110110110000	45	111010110110
14	000011011011	46	001111011101
15	010011110010	47	011111110100
16	101011111100	48	111111001010
17	111011010101	49	101111100011
18	001110111110	50	011010001000
19	011110010111	51	001010100001
20	111110101001	52	110010101111
21	101110000000	53	100010000110

Table 892—Sequences for PFBCH

Index	Sequence	Index	Sequence
22	011011101011	54	010111101101
23	001011000010	55	000111000100
24	100111001111	56	100110101100
25	110111100110	57	110110000101
26	000010001101	58	000011101110
27	010010100100	59	010011000111
28	110010011010	60	110011111001
29	100010110011	61	100011010000
30	010111011000	62	010110111011
31	000111110001	63	000110010010

16.3.9.2.1.2 Secondary fast feedback control channel

The SFBCH is comprised of 3 distributed FMTs with 2 pilots allocated in each FMT. Pilot sequence $p_0p_1p_2p_3p_4p_5$ are modulated as [1 1 1 1 1 1] with pilot boosting.

The SFBCH symbol generation procedure is as follows. First, the SFBCH payload information bits $a_0a_1a_2\ldots a_{l-1}$ are encoded to M bits $b_0b_1b_2\ldots b_{M-1}$ using the TBCC encoder described in 16.3.11.2.1.

The values of parameters L and M are set to l and 60, respectively. The value of $K_{bufsize}$ should be set as Equation (272)

$$K_{bufsize} = \begin{cases} 30 & (l = 7, 8, 9) \\ 5l & (l = 10, 11) \\ 60 & (12 \le l \le 24) \end{cases} \quad (272)$$

The coded sequence $b_0b_1b_2\ldots b_{M-1}$ is then modulated to $M/2$ symbols $c_0c_1c_2\ldots c_{\frac{M}{2}-1}$ using QPSK. The modulated symbols are mapped to the data subcarriers of the SFBCH FMTs as shown in Figure 570.

When the length of feedback message is less than 7 bits, ones are padded at the end of feedback message to ensure that length reaches 7 bits boundary.

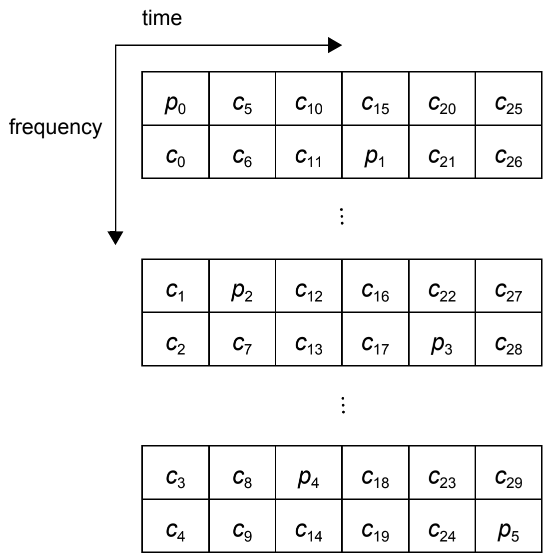


Figure 570—SFBCH comprising of three distributed 2x6 UL FMTs

16.3.9.2.2 HARQ feedback control channel

The HARQ feedback control channel resource of three RFMTs shall be further divided into nine HARQ mini-tiles (HMTs), each having a structure of two subcarriers by two OFDMA symbols. Each pair of HARQ feedback channels are allocated in three HMTs, identified by similar patterns in the structure shown in Figure 571. The orthogonal sequence ($C_{i,0}$, $C_{i,1}$, $C_{i,2}$, $C_{i,3}$, where i=0,1 and 2) as shown in Table 893 is mapped to each HMT to form HARQ feedback channels, where and i denotes HMT index. Each group of three RFMTs can therefore support six HARQ feedback channels.

When each channel carries one bit of HARQ feedback, two sequences are used to signal each ACK or NACK feedback. In one unit, four sequences are used for two HARQ channels, 1^{st} and 2^{nd} HARQ feedback channel. The sequence and mapping of the HARQ feedback are shown in Table 893.

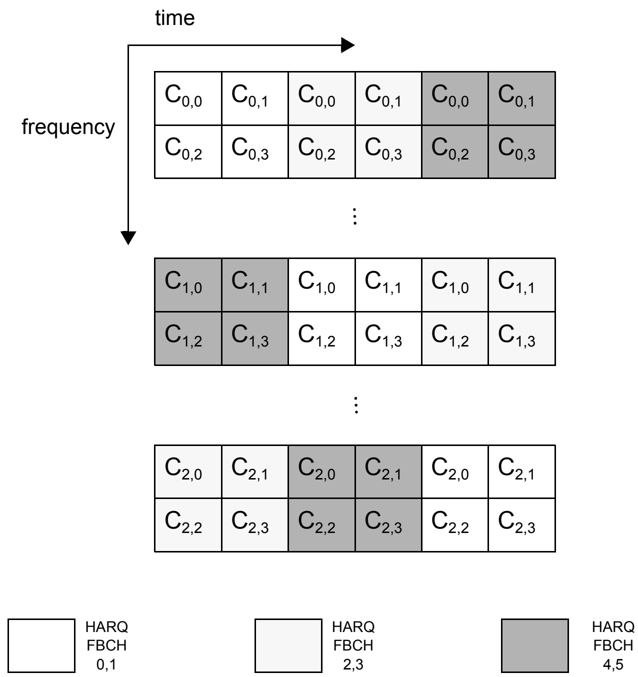


Figure 571—2x2 HMT structure

Table 893—Orthogonal sequences for UL HARQ feedback channel

Sequence index	Orthogonal sequence	1-bit Feedback
0	[+1 +1 +1 +1]	Even numbered channel ACK
1	[+1 -1 +1 -1]	Even numbered channel NACK
2	[+1 +1 -1 -1]	Odd numbered channel ACK
3	[+1 -1 -1 +1]	Odd numbered channel NACK

16.3.9.2.3 Sounding channel

16.3.9.2.3.1 Sounding sequence

Define b_k as the complex coefficients modulating all subcarriers in the sounding symbol, $0 \le k \le N_{used} - 1$ (N_{used} is used a number of used subcarriers dependent on FFT size), such that the signal transmitted by the AMS is defined by Equation (273):

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{\substack{k=0 \\ k \neq \frac{N_{used}-1}{2}}}^{k=N_{used}-1} b_k \cdot e^{j2\pi\left(k - \frac{N_{used}-1}{2}\right)\Delta f(t-T_g)} \right\} \qquad (273)$$

For decimation separation (multiplexing type 0), the occupied subcarriers are decimated (where D is a subcarrier decimation value transmitted in the AAI_SCD message) starting with offset g relative to the first used subcarrier (k = 0). The occupied subcarriers for each transmit device (AMS or AMS antenna) shall be modulated by BPSK symbols extracted from the Golay sequence according to Equation (274):

$$b_k = \begin{cases} 2 \cdot \sqrt{D} \cdot \left(\frac{1}{2} - G([k + u + offset_D(fft)] \bmod 2048)\right), & k \in B, k \neq \frac{N_{used}-1}{2}, k \bmod D = g \\ 0, & otherwise \end{cases} \qquad (274)$$

where k is the subcarrier index ($0 \le k \le N_{used} - 1$), N_{used} is the number of used subcarriers in the sounding symbol, $G(x)$ is the Golay sequence defined in Table 894 $0 \le x \le 2047$. fft is the FFT size used, u is a shift value, where the actual value of u is transmitted in SFH, $offset_D(fft)$ is an FFT size specific offset as defined in Table 895, B is the group of all allocated subcarriers according to the sounding instructions, D is the decimation value, g is the actual decimation offset.

For cyclic shift separation (multiplexing type 1), the sequence used by a Tx device (AMS or AMS antenna) associated with the n-th cyclic shift index is determined according to Equation (275):

$$b_k = \begin{cases} 2 \cdot \left(\frac{1}{2} - G([k + u + offset_D(fft)] \bmod 2048)\right) \cdot e^{-j2\pi\frac{k}{P}n}, & k \in B, k \neq \frac{N_{used}-1}{2} \\ 0, & otherwise \end{cases} \qquad (275)$$

where k is the subcarrier index $0 \le k \le N_{used} - 1$, N_{used} is the number of used subcarriers in the sounding symbol, $G(x)$ is the Golay sequence defined in Table 894 ($0 \le x \le 2047$), P is the max cyclic shift index (transmitted in AAI_SCD message), n is the cyclic time shift index, which ranges from 0 to P-1, B is the group of allocated subcarriers according to the sounding instructions, u is a shift value transmitted in SFH, fft is the FFT size used, and $offset_D(fft)$ is an FFT size specific offset as defined in Table 895.

Table 894—Golay sequence of length 2048 bits

0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,

Table 894—Golay sequence of length 2048 bits

0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0x121D,	0x12E2,	0x121D,	0xED1D,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D

Note: hexadecimal series should be read, left-to-right, as a sequence of bits where each 16 bit word is started at the MSB and ends at the LSB where the second word MSB follows. First bit of sequence is referenced as offset 0.

Table 895—Sounding sequence offset values

FFT Size	$offset_D$
2048	30
1024	60
512	542

16.3.9.2.3.2 Multiplexing for multi-antenna and multi-AMS

The uplink sounding channels of multiple AMS and multiple antennas per AMS can be multiplexed through decimation separation or cyclic shift separation in each sounding allocation. Also, in case of multiple UL AAI subframes for sounding, time division separation can be applied by assigning different AMS to different UL AAI subframe. For cyclic shift separation each AMS occupies all subcarriers within sounding allocation and uses the different sounding waveform. For frequency decimation separation each AMS uses decimated subcarrier subset from the sounding allocation set with different frequency offset.

For antenna switching capable AMS and multi-antenna AMS, ABS can command the AMS to switch the physical transmit antenna(s) for sounding transmission. For sounding with antenna switching, the AMS shall transmit sounding symbol with the i-th antenna (1, …, N_t) on frames $t = j \cdot 2^{(p-1)} + i-1$, where $t = 0$ corresponds to the frame where UL Sounding Command A-MAP IE is received, p is periodicity in UL Sounding Command A-MAP IE, and j is a running index ($j = 0, 1, 2, \ldots$ for $p \neq 0$ and $j = 0$ for $p = 0$). For sounding with antenna switching and periodical sounding allocation ($p \neq 0$), the assigned periodicity $2^{(p-1)}$ shall be larger or equal to the number of AMS transmit antenna chains N_t.

16.3.9.2.4 Ranging channel

16.3.9.2.4.1 Ranging channel for non-synchronized AMSs

Ranging preamble codes

The ranging preamble codes are classified into initial ranging and handover ranging preamble codes. The initial ranging preamble codes shall be used for initial network entry and association. Handover ranging preamble codes shall be used for ranging against a target ABS during handover. For a ranging code opportunity, each AMS randomly chooses one of the ranging preamble codes from the available ranging preamble codes set in a cell, except that in the handover ranging case where a dedicated ranging code is assigned, the AMS shall use the assigned dedicated preamble code.

The Zadoff-Chu sequences with cyclic shifts are used for the ranging preamble codes. The p^{th} ranging preamble code $x_p(k)$ is defined by

$$x_p(k) = \exp\left(-j \cdot \pi \cdot \frac{r_p \cdot k(k+1) + 2 \cdot k \cdot s_p \cdot N_{CS}}{N_{RP}}\right), k = 0, 1, \ldots, N_{RP} - 1 \quad (276)$$

where

p is the index for p^{th} ranging preamble code which is made as the s_p^{th} cyclic shifted sequence from the root index r_p of Zadoff-Chu sequence.

$$r_p = \mathrm{mod}((1 - 2 \cdot \mathrm{mod}(\lfloor p/M_{ns} \rfloor, 2)) \cdot (\lfloor p/M_{ns}/2 \rfloor + r_{ns0}) + N_{RP}, N_{RP}),$$

$$p = 0, 1, \ldots N_{cont} - 1, N_{cont}, \ldots, N_{cont} + N_{dedi} - 1 \quad (277)$$

$$s_p = \mathrm{mod}(p, M_{ns}), p = 0, 1, \ldots N_{cont} - 1, N_{cont}, \ldots, N_{cont} + N_{dedi} - 1 \quad (278)$$

where r_{ns0} is broadcasted in the S-SFH and M_{ns} is the number of cyclic shifted codes per ZC root index according to Table 896. N_{cont} is the total number of initial ($0 \sim N_{IN}$-1) and handover preamble codes ($N_{IN} \sim N_{IN}+N_{HO}$-1) per sector for contention-based approach. N_{dedi} is the total number of dedicated handover preamble code ($N_{cont} \sim N_{cont}+N_{dedi}$-1) per sector where maximum possible N_{dedi} per sector is 32.

N_{CS} is the unit of cyclic shift according to the cell size. It is defined by $N_{CS} = \lfloor N_{RP}/M_{ns} \rfloor$, where M_{ns} is the number of cyclic shifted codes per ZC root index according to Table 896.

N_{RP} is the length of ranging preamble codes defined as N_{RP} =139 for ranging channel Format 0 in Table 891 and N_{RP} =557 for ranging channel Format 1 in Table 891.

The number of cyclic shifted codes per root index (M_{ns}), the start root index of ZC code (r_{ns0}), and the ranging preamble code partition information are broadcasted by S-SFH. The number of cyclic shifted codes per root index is defined in Table 896. The start root index of ZC code is defined by $r_{ns0} = 4 \times k_{ns} + 1$ and $r_{ns0} = 16 \times k_{ns} + 1$ for ranging Format 0 and Format 1, respectively, where k_{ns} (= 0, 1, 2, …, or 15) is a cell specific value broadcasted through S-SFH. The ranging preamble code partition information indicates the number of initial and handover ranging preamble codes and is defined in Table 897.

Table 896—The number of cyclic shifted codes per ZC root index, M_{ns}

index	0	1	2	3
M_{ns}	1	2	4	8

Table 897—Ranging preamble code partition information table, N_{IN} and N_{HO}

Partition Index	0	1	2	3	4	5	6	7	8	9	0	11	12	13	14	15
Number of initial ranging preamble codes, N_{IN}	8	8	8	8	16	16	16	16	24	24	24	24	32	32	32	32
Number of handover ranging preamble codes, N_{HO}	8	16	24	32	8	16	24	32	8	16	24	32	8	16	24	32

Ranging channel configurations

The information for ranging time resource allocation is indicated by the S-SFH in a regular allocation. The information of ranging channel allocation consists of the ranging configuration with AAI subframe-offset (O_{SF}) for ranging resource allocation in the time domain. The information for ranging frequency resource allocation, i.e., the subband index for ranging resource allocation is determined by the *IDcell* and the allocated number of subbands Y_{SB} according to the Equation (279), where *IDcell* is defined in 16.3.6.1.2 and Y_{SB} is defined in 16.3.6.5.2.4.3 with exception of L_{SB-CRU,FP_i} is the number of allocated subband CRUs in 16.3.8.3.

$$I_{SB} = \mathrm{mod}(IDcell, Y_{SB}) \tag{279}$$

where I_{SB} denotes the subband index (0,…, Y_{SB}-1) for ranging resource allocation among Y_{SB} subbands.

Table 898 shows the information of ranging channel allocation in a regular allocation, which is indicated by the S-SFH.

Table 898—Ranging channel allocations by S-SFH

Configurations	The AAI subframe allocating Ranging channel
0	$O_{SF}{}^{th}$ UL AAI subframe in every frame
1	$O_{SF}{}^{th}$ UL AAI subframes in the first frame in every superframe
2	$O_{SF}{}^{th}$ UL AAI subframe in the first frame in every even numbered superframe, i.e., mod(superframe number, 2) = 0
3	$O_{SF}{}^{th}$ UL AAI subframe of the first frame in every 4^{-th} superframe, i.e. mod(superframe number, 4) = 0

Table 898 indicates the AAI subframe allocating ranging channel for Format 0 and 1. For Format 1, it indicates the starting AAI subframe for allocating ranging channel AAI subframe in contiguous 3 AAI subframes.

The ranging channel for handover ranging can also be allocated by A-MAP based on ABS scheduling decision in any AAI subframe, except the AAI subframe that has already been used for a regular allocation.

Ranging signal transmission

Equation (280) specifies the transmitted signal voltage to the antenna, as a function of time, during ranging channel format 0 or 1.

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_C t} \sum_{k=-(N_{RP}-1)/2}^{(N_{RP}-1)/2} x_p(k+(N_{RP}-1)/2) \cdot e^{j2\pi(k+K_{offset})\Delta f_{RP}(t-T_{RCP})} \right\} \tag{280}$$

where

t is the elapsed time since the beginning of the subject ranging channel, with $0<t<(T_{RCP}+2\times T_{RP})$ for Format 0 or $0<t<(T_{RCP}+T_{RP})$ for Format 1.

N_{RP} is the length of ranging preamble code in frequency domain.

$x_p(n)$ is the p-th ranging preamble code with length N_{RP}.

K_{offset} is the parameter related to the frequency position and is defined by

$$K_{offset} = -\{(N_{used}-1)/2 - P_{SC}\cdot(k_0-2) + \lfloor 2\cdot k_0/N_{PRU}\rfloor\}\cdot\Delta f/\Delta f_{RP}$$

N_{PRU} is the total number of PRUs as defined in 16.3.8.2.1.

k_0 is the lowest PRU index of the assigned ranging channel.

P_{sc} is the number of the consecutive subcarriers within a PRU in frequency domain as defined in 16.3.8.1.

Δf_{RP} is the ranging subcarrier spacing.

16.3.9.2.4.2 Ranging channel for synchronized AMSs

Ranging Preamble Codes

The Padded Zadoff-Chu codes with cyclic shifts are used for the ranging preamble codes. The p^{th} ranging preamble code $x_p(n,k)$ for nth OFDMA symbol within a basic unit is defined by

$$x_p(n,k) = \exp\left(-j\cdot\pi\left(\frac{r_p\cdot(n\cdot 71+k)\cdot(n\cdot 71+k+1)}{211}+\frac{2\cdot k\cdot s_p\cdot N_{TCS}}{N_{FFT}}\right)\right),\quad k = 0, 1, \ldots, N_{RP}-1; n = 0,1,2 \qquad (281)$$

where

p is the index for p^{th} ranging preamble code within a basic unit which is made as the s_p^{th} cyclic shifted sequence from the root index r_p of Zadoff-Chu sequence.

$$r_p = \mathrm{mod}((1-2\cdot\mathrm{mod}(\lfloor p/M_s\rfloor,2))\cdot(\lfloor p/M_s/2\rfloor + r_{s0}) + 211, 211)$$

$$p=0,1,\ldots N_{cont}-1, N_{cont},\ldots,N_{cont}+N_{dedi}-1$$

$$s_p = \mathrm{mod}(p,M_s), p=0,1,\ldots N_{cont}-1, N_{cont},\ldots,N_{cont}+N_{dedi}-1$$

The start root index, r_{s0}, is broadcasted. M_s is the number of cyclic shift per ZC root index and defined by $M_s = 1/G$. N_{TOTAL} is the number of periodic ranging preamble codes per sector (0~N_{PE} -1) which is defined by Table 899 for contention-based approach. For femtocell, N_{cont} is the total number of initial (0~N_{IN}-1), handover (N_{IN}~N_{IN}+N_{HO}-1) and periodic ranging preamble codes ($N_{IN} + N_{HO} \sim N_{IN} + N_{HO} + N_{PE}$ - 1) per sector which is defined by Table 900 for contention-based approach. N_{dedi} is the total number of dedicated handover preamble code (N_{cont}~ N_{cont}+N_{dedi}-1) per sector where maximum possible N_{dedi} per sector is 32.

N_{TCS} is theis the unit of time domain cyclic shift per OFDMA symbol according to the CP length and defined by $N_{TCS} = G \cdot N_{FFT}$, where G and N_{FFT} are the CP ratio and FFT size defined in Table 775, respectively.

N_{RP} is the length of ranging preamble codes per OFDMA symbol, i.e., N_{RP} =72.

The start root index of ZC code (r_{s0}), and the ranging preamble code information are broadcasted by AAI_SCD message for periodic ranging in non-femto deployment and S-SFH SP1 for femtocell initial, handover, and periodic ranging. The start root index of ZC code is defined by $r_{s0} = 6 \times k_s + 1$ where k_s is a cell specific value. The ranging preamble code information indicates the number of periodic ranging preamble codes, and is defined by Table 899. For femtocell, the ranging preamble code partition information indicate the number of initial, handover and periodic ranging preamble codes and is defined in Table 900.

Table 899—Ranging preamble code information table, N_{PE}

index	Number of periodic ranging preamble codes, N_{PE}
0	8
1	16
2	24
3	32

Ranging channel configurations

The information of ranging channel allocation consists of the ranging configuration with AAI subframe-offset (O_{SF}) for ranging resource allocation in the time domain where O_{SF} is same AAI subframe-offset of ranging channel for non-synchronized AMSs defined in 16.3.9.2.4.1. The information for ranging frequency

Table 900—Ranging preamble code partition information table for Femtocell, N_{IN}, N_{HO} and N_{PE}

Partition Index	Number of initial ranging preamble codes, N_{IN}	Number of handover ranging preamble codes, N_{HO}	Number of periodic ranging preamble codes, N_{PE}
0	4	4	4
1	4	8	4
2	4	16	4
3	4	24	4
4	8	4	8
5	8	8	8
6	8	16	8
7	8	24	8
8	16	4	16
9	16	8	16
10	16	16	16
11	16	24	16
12	24	4	24
13	24	8	24
14	24	16	24
15	24	24	24

resource allocation, i.e., the subband index for ranging resource allocation is determined by the *IDcell* and the allocated number of subbands Y_{SB} according to the Equation (282) where *IDcell* is defined in 16.3.6.1.2 and Y_{SB} is defined in 16.3.6.5.2.4.3 with exception of L_{SB-CRU,FP_i} is the number of allocated subband CRUs in 16.3.8.3.

$$I_{SB,\,s} = \mathrm{mod}(\,IDcell{+}1,\ Y_{SB}) \qquad (282)$$

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

Table 901 shows the information of ranging channel allocation where N_{UL} is the number of UL AAI subframe per frame.

When Y_{SB} = 1 and N_{UL} = 1, the configuration 0 shall be not used for ranging channel allocation for synchronized AMSs.

Table 901—Ranging channel allocations for synchronized AMSs

Configurations	AAI subframe allocating ranging channel
0	mod(O_{SF}+1, N_{UL})th UL AAI subframe in every frame
1	mod(O_{SF}+1, N_{UL})th UL AAI subframe in the second frame in every superframe
2	mod(O_{SF}+1, N_{UL})th UL AAI subframe in the second frame in every 4th superframe, i.e., mod(superframe number, 4)=0
3	mod(O_{SF}+1, N_{UL})th UL AAI subframe in the second frame in every 8th superframe, i.e., mod(superframe number, 8)=0

16.3.9.2.4.3 Ranging Channel for FDM-based UL PUSC Zone Support

Ranging Preamble Codes

When frame structure is supporting the WirelessMAN-OFDMA MSs in UL PUSC zone by FDM manner as defined in 16.3.8.3.5, the ranging codes for WirelessMAN-OFDMA in 8.4.7.3 are used for AMSs.

The binary codes are the pseudonoise codes produced by the PRBS described in Figure 572, which implements the polynomial generator $1+X^1+X^4+X^7+X^{15}$. The PRBS generator shall be initialized by the seed b14...b0 = 0,0,1,0,1,0,1,1,s0,s1,s2,s3,s4,s5,s6, where s6 is the LSB of the PRBS seed, and s6:s0 = UL_PermBase, where s6 is the MSB of the UL_PermBase.

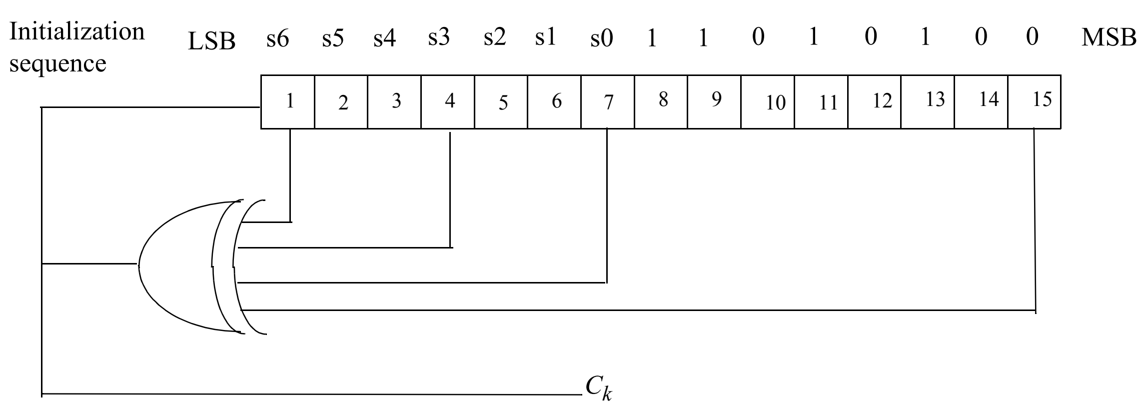


Figure 572—PRBS generator for ranging code generation

The binary ranging codes are subsequences of the pseudonoise sequence appearing at its output C_k. The length of each ranging code is 144 bits. These bits are used to modulate the subcarriers in a group of six adjacent distributed LRUs, where distributed LRUs are considered adjacent if they have successive LRU numbers. The bits are mapped to the subcarriers in increasing frequency order of the subcarriers so that the lowest indexed bit modulates the subcarrier with the lowest frequency index and the highest indexed bit modulates the subcarrier with the highest frequency index. The six distributed LRUs are called a ranging LRU.

The number of available codes is 256, numbered 0, ... , 255. Each ABS uses a subgroup of these codes, where the start index of subgroup is defined by a number S, $S = 16 \times k_{ns} + 1$ where k_{ns} (= 0, 1, 2, …, or 15) is a cell specific value broadcasted by S-SFH. The group of codes shall be between S and $((S + O + N + M + D) \bmod 256)$.

— The first N codes produced are for contention-based initial ranging. Clock the PRBS generator $144 \times (S \bmod 256)$ times to $144 \times ((S + N) \bmod 256) - 1$ times.
— The next O codes produced are for contention-based handover ranging. Clock the PRBS generator $144 \times ((S + N) \bmod 256)$ times to $144 \times ((S + N + O) \bmod 256) - 1$ times.
— The next M codes produced are for contention-based periodic ranging. Clock the PRBS generator $144 \times ((S + N + O) \bmod 256)$ times to $144 \times ((S + N + O + M) \bmod 256) - 1$ times.
— The next D codes produced are for dedicated handover ranging where maximum possible D per sector is 32. Clock the PRBS generator $144 \times ((S + N + O + M) \bmod 256)$ times to $144 \times ((S + N + O + M + D) \bmod 256) - 1$ times.

The start index of subgroup (S) and the number of code in each group (N, O, and M) is broadcasted by S-SFH. The number of initial, handover and periodic ranging codes is defined in Table 902.

Table 902—Ranging preamble code partition information table for FDM-based UL PUSC Zone Support, N, O and M

Partition Index	Number of initial ranging codes, N	Number of handover ranging codes, O	Number of periodic ranging codes, M
0	8	8	8
1	8	16	8
2	8	24	8
3	8	32	8
4	16	8	16
5	16	16	16

Table 902—Ranging preamble code partition information table for FDM-based UL PUSC Zone Support, N, O and M

Partition Index	Number of initial ranging codes, *N*	Number of handover ranging codes, *O*	Number of periodic ranging codes, M
6	16	24	16
7	16	32	16
8	24	8	24
9	24	16	24
10	24	24	24
11	24	32	24
12	32	8	32
13	32	16	32
14	32	24	32
15	32	32	32

Ranging Channel Configurations

The information for ranging time/frequency resource allocation is indicated by the S-SFH. The information of ranging channel allocation consists of the ranging configuration with subframe-offset (O_{SF}) for ranging resource allocation in the time domain. The lowest distributed LRU index for ranging frequency resource allocation is indicated by the S-SFH.

The periodicity of ranging channel allocation is the same as that of ranging channel for non-synchronized AMSs defined in Table 898.

16.3.9.2.5 Bandwidth request channel

Each BR channel shall comprise of 3 distributed BR tiles for frequency diversity. A BR tile in the M-Zone is defined as 6 contiguous subcarriers by 6 OFDMA symbols. As shown in Figure 573, the BR tile is made up of two parts - a preamble portion and a data portion. The preamble portion transmits the BR preamble on a resource that spans 4 subcarriers by 6 OFDMA symbols. The data portion of the BR tile spans 2 contiguous subcarriers by 6 OFDMA symbols and transmits the quick access message for the 3-step BR. The procedure for the formation of BR channel is defined in 16.3.8.3.3.1.

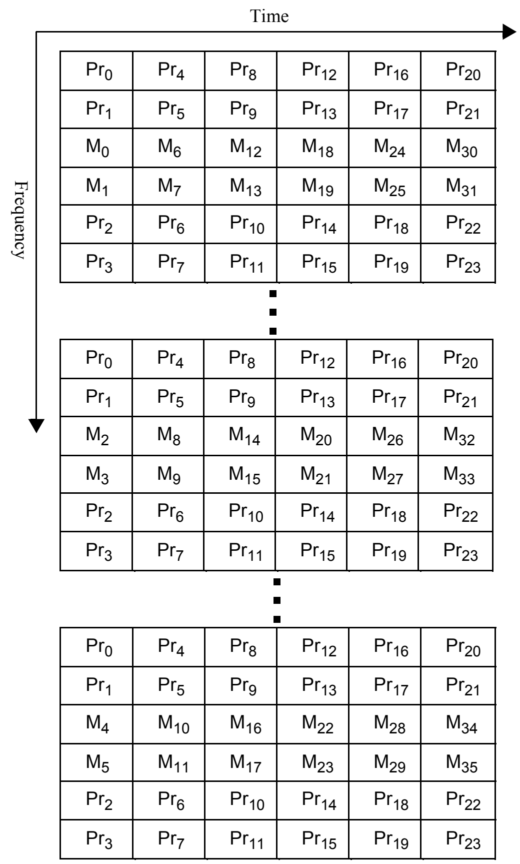


Figure 573—6×6 BR Tile Structure in the Advance Air Interface

For the 3-step BR, 16 bits of BW request information is constructed from 12 bits of STID and 4bits of pre-defined BR information described in 16.3.11.1.5.1. Let $s_0 s_1 s_2 s_3 s_4 s_5 s_6 s_7 s_8 s_9 s_9 s_{10} s_{11}$ and $s_{12} s_{13} s_{14} s_{15}$ denote the STID and pre-defined BR information respectively. By reordering the bits of STID and pre-defined BR information, 16bits of BW request information is formed as

$$b_0 b_1 b_2 b_3 b_4 b_5 b_6 b_7 b_8 b_9 b_{10} b_{11} b_{12} b_{13} b_{14} b_{15} = s_0 s_1 s_2 s_3 s_4 s_5 s_6 s_7 s_8 s_9 s_{10} s_{11} s_{12} d_0 d_1 d_2 \quad (283)$$

where

$$d_i = \mathrm{mod}(s_i + s_{i+3} + s_{i+6} + s_{i+9} + s_{i+13}, 2) \qquad 0 \le i < 3$$

3 bits of the 16 information bits shall be carried in the BR preamble using the preamble index. The combined resource in the data portions of the three tiles that form the BR channel shall be used to transmit the remaining 13 bits of information. The frame number and 16 bits of the bandwidth request message shall be used to select a sequence of length 24 from Table 903. The selected preamble sequence is transmitted in the preamble portion of all the three BW REQ tiles.

Table 903—BR channel Preamble sequences

u	$P_u(K), 0 \le k < 24$																						
0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
1	1	0	1	0	1	1	1	0	0	0	1	0	1	0	1	0	1	1	1	0	0	0	1	0
2	1	0	0	1	0	1	1	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0	1
3	1	1	0	0	1	0	1	1	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0
4	1	0	1	0	0	1	0	1	1	1	0	0	1	0	1	0	0	1	0	1	1	1	0	0
5	1	0	0	1	0	0	1	0	1	1	1	0	1	0	0	1	0	0	1	0	1	1	1	0
6	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1
7	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1	1
8	1	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1
9	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0
10	1	0	1	1	1	0	0	0	1	0	0	1	1	0	1	1	1	0	0	0	1	0	0	1
11	1	1	0	1	1	1	0	0	0	1	0	0	1	1	0	1	1	1	0	0	0	1	0	0
12	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
13	1	0	1	0	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1
14	1	0	0	1	0	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	1	1	1	0
15	1	1	0	0	1	0	1	1	1	0	0	0	0	0	1	1	0	1	0	0	0	1	1	1
16	1	0	1	0	0	1	0	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	1	1
17	1	0	0	1	0	0	1	0	1	1	1	0	0	1	1	0	1	1	0	1	0	0	0	1
18	1	0	0	0	1	0	0	1	0	1	1	1	0	1	1	1	0	1	1	0	1	0	0	0
19	1	1	0	0	0	1	0	0	1	0	1	1	0	0	1	1	1	0	1	1	0	1	0	0
20	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	0
21	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0	1	1	0	1
22	1	0	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0
23	1	1	0	1	1	1	0	0	0	1	0	0	0	0	1	0	0	0	1	1	1	0	1	1

The preamble sequences transmitted in the three BR tiles of a BR channel are defined as

$$P_u(k), 0 \le k < 24 \tag{284}$$

where k is symbol index, and u is sequence index.

The mapping between the combination of the frame number and the 16 bits of the bandwidth request message $b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11}b_{12}b_{13}b_{14}b_{15}$ to the physical preamble index u is as below equation.

$$u = \mathrm{mod}(q + \mathrm{bin2dec}(b_{13}b_{14}b_{15}) + 8r, 24) \quad (285)$$

where

$$r = \mathrm{mod}\left(\sum_{i=0}^{4} bin2dec(b_{3i}b_{3i+1}b_{3i+2}), 3\right)$$

$$q = \lfloor \mathrm{bin2dec}(b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11})/24 \rfloor \times t$$

and t is frame number calculated as four times superframe number plus frame number within a superframe (in range of 0 to 3)..

The selected preamble sequence $P_u(0), P_u(1), \ldots, P_u(23)$ shall be BPSK modulated (0 mapped to +1 and 1 mapped to -1) and mapped to Pr_0, Pr_1,… Pr_{23}.

The 16 bit information in the quick access message transmitted in the BR channel shall be used to generate 5 bits CRC $r_0r_1r_2r_3r_4$ using generating polynomial $G(x) = x^5 + x^4 + x^2 + 1$. The 13 bits information together with the 5 CRC bits, $b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11}b_{12}r_0r_1r_2r_3r_4$, shall be encoded into 72 bits $c_0, c_1, c_2, \ldots, c_{71}$ using the TBCC code with parameters L=18, $K_{bufsize}$ = 72 and M = 72. The 72 coded bits shall then be QPSK modulated to generate 36 data symbols $M_0, M_1, \ldots, M_{35}$. The combined resource of the data portion in the three distributed BR tiles that form the BR channel shall be used to transmit these data symbols.

To calculate 5 bits CRC the following procedure is applied:

a) The first bit b_0 corresponds to the x^{12} term and the last bit b_{12} corresponds to the x^0 term of the information polynomial

b) The information polynomial multiplied by x^5 is divided by polynomial $G(x)= x^5+x^4+x^2+1$

c) The 5 bits of the CRC are set so that the first bit of r_0 corresponds to x^4 term of the remainder polynomial and the last bit r_4 corresponds to x^0 term of the remainder polynomial

In order to support operation in the legacy mode, a BR tile shall be defined as 4 contiguous subcarriers by 6 OFDMA symbols. As shown in Figure 574, only the BR preamble shall be transmitted in all 24 subcarriers that form the BR tile. In this case, the preamble index u shall be randomly selected from 0 to 23.

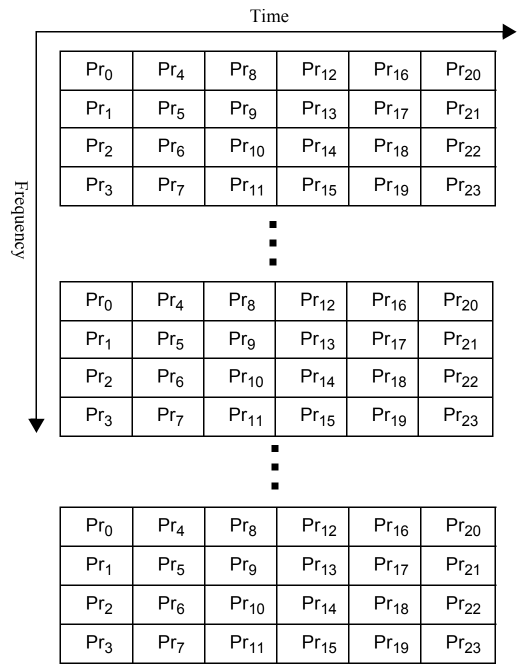


Figure 574—4x6 BR tile structure

For AMS with multiple transmission antennas, the multi-antenna transmission of BR shall be limited to 1-stream mode 1 uplink MIMO scheme defined in 16.3.10.

16.3.9.3 Uplink control information content

The UL control channels carry multiple types of control information to support air interface procedures. Information carried in the control channels is classified into the following categories:

1) Channel quality feedback
2) MIMO feedback
3) HARQ feedback (ACK/NACK)
4) Uplink synchronization signals
5) Bandwidth requests
6) Frequency partition selection (for MFM 0, 1, 4, and 7).

16.3.9.3.1 Fast feedback control channel

The UL fast feedback channel shall carry channel quality feedback and MIMO feedback. There are two types of UL fast feedback control channels: primary fast feedback channel (PFBCH) and secondary fast feedback channels (SFBCH). The UL fast feedback channel starts at a pre-determined location, with the size defined in a DL broadcast control message. Fast feedback allocations to an AMS can be periodic and the allocations are configurable. The number of UL fast feedback channels that the ABS allocates to an AMS shall be less than or equal to one. This allocation may include requests for interleaved PFBCH and SFBCH reports.

16.3.9.3.1.1 Primary fast feedback control channel

The UL PFBCH carries 6 bits of information, providing feedback contents in Table 904.

Table 904—PFBCH Feedback Content

PFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
CQI	0,1,2,3,4,5,6,7	1) Wideband CQI 2) Subband CQI for Best -1 subband
STC Rate Indicator	0,1,2,3	
Subband index	2,3,5,6	Subband selection for best-1 subband
PMI	3,4,6,7	1) wideband PMI 2) subband PMI for best-1 subband
Event-driven Indicator (EDI) for request for switching MFM	N/A	Indicate request to switch MIMO feedback mode between distributed and localized allocations.
Event-driven Indicator (EDI) for Bandwidth Request Indicator	N/A	This is used to request UL bandwidth. 2 sequences (two services)
Event-driven Indicator (EDI) for Frequency partition selection (FPS)	N/A	AMS informs ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
Event-driven Indicator (EDI) for Buffer management	N/A	Indicates occupancy status of HARQ soft buffer

For PFBCH transmission, four encoding types are defined. Encoding type corresponding to MFM and feedback format in Feedback Allocation A-MAP IE is used.

PFBCH Encoding Type 0

PFBCH Encoding Type 1

Table 905—Contents Encoding Type 0 in PFBCH

Index	Content (Value)	Description/Notes
0	STC rate = 1, MCS=0000	
1	STC rate = 1, MCS=0001	
2	STC rate =1, MCS=0010	
3	STC rate =1, MCS=0011	
4	STC rate =1, MCS=0100	
5	STC rate =1, MCS=0101	
6	STC rate =1, MCS=0110	
7	STC rate =1, MCS=0111	
8	STC rate =1, MCS=1000	
9	STC rate =1, MCS=1001	
10	STC rate =1, MCS=1010	
11	STC rate =1, MCS=1011	
12	STC rate =1, MCS=1100	
13	STC rate =1, MCS=1101	
14	STC rate =1, MCS=1110	
15	STC rate =1, MCS=1111	
16	STC rate =2, MCS=0000	
17	STC rate =2, MCS=0001	
18	STC rate =2, MCS=0010	
19	STC rate =2, MCS=0011	
20	STC rate =2, MCS=0100	
21	STC rate =2, MCS=0101	
22	STC rate =2, MCS=0110	
23	STC rate =2, MCS=0111	
24	STC rate =2, MCS=1000	
25	STC rate =2, MCS=1001	
26	STC rate =2, MCS=1010	
27	STC rate =2, MCS=1011	
28	STC rate =2, MCS=1100	
29	STC rate =2, MCS=1101	
30	STC rate =2, MCS=1110	
31	STC rate =2, MCS=1111	
32	STC rate =3, MCS=0100	

Table 905—Contents Encoding Type 0 in PFBCH

Index	Content (Value)	Description/Notes
33	STC rate =3, MCS=0101	
34	STC rate =3, MCS=0110	
35	STC rate =3, MCS=0111	
36	STC rate =3, MCS=1000	
37	STC rate =3, MCS=1001	
38	STC rate =3, MCS=1010	
39	STC rate =3, MCS=1011	
40	STC rate =3, MCS=1100	
41	STC rate =3, MCS=1101	
42	STC rate =3, MCS=1110	
43	STC rate =3, MCS=1111	
44	STC rate =4, MCS=1000	
45	STC rate =4, MCS=1001	
46	STC rate =4, MCS=1010	
47	STC rate =4, MCS=1011	
48	STC rate =4, MCS=1100	
49	STC rate =4, MCS=1101	
50	STC rate =4, MCS=1110	
51	STC rate =4, MCS=1111	
52	Reserved	
53	Reserved	

Table 905—Contents Encoding Type 0 in PFBCH

Index	Content (Value)	Description/Notes
54	Reserved	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven indicator for buffer management
56	Event-driven Indicator (EDI) for Buffer management (overflow)	
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	AMS informs ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request
63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	

PFBCH Encoding Type 2

Encoding Type 2 in PFBCH is used for PMI reporting. The PMI of the *i* -th codebook entry, C (N_t, M_t, N_B, i), is mapped into sequence index *i* in PFBCH.

PFBCH Encoding Type 3

Table 906—Contents Encoding Type 1 in PFBCH

Index	Content (Value)	Description/Notes
0	Subband index 0	Subband index for Best-1 subband (see 16.3.9.3.1.4)
1	Subband index 1	
2	Subband index 2	
3	Subband index 3	
4	Subband index 4	
5	Subband index 5	
6	Subband index 6	
7	Subband index 7	
8	Subband index 8	
9	Subband index 9	
10	Subband index 10	
11	Subband index 11	
12	Subband index 12	
13	Subband index 13	
14	Subband index 14	
15	Subband index 15	
16	Subband index 16	
17	Subband index 17	
18	Subband index 18	
19	Subband index 19	
20	Subband index 20	
21	Subband index 21	
22	Subband index 22	
23	Subband index 23	

Table 906—Contents Encoding Type 1 in PFBCH

Index	Content (Value)	Description/Notes
24	Reserved	Reserved
…	…	
54	Reserved	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven for buffer management
56	Event-driven Indicator (EDI) for Buffer management (full)	
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	AMS informs ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request
63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	

Table 907—Contents Encoding type 3 in PFBCH

Index	Content (Value)	Description/Notes
0	STC rate = 1/2, MCS=0000	
1	STC rate = 1/2, MCS=0001	
2	STC rate =1/2, MCS=0010	
3	STC rate =1/2, MCS=0011	
4	STC rate =1/2, MCS=0100	
5	STC rate =1/2, MCS=0101	
6	STC rate =1/2, MCS=0110	
7	STC rate =1/2, MCS=0111	
8	STC rate =1/2, MCS=1000	
9	STC rate =1/2, MCS=1001	
10	STC rate =1/2, MCS=1010	
11	STC rate =1/2, MCS=1011	
12	STC rate =1/2, MCS=1100	
13	STC rate =1/2, MCS=1101	
14	STC rate =1/2, MCS=1110	
15	STC rate =1/2, MCS=1111	
16~54	Reserved	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven for buffer management
56	Event-driven Indicator (EDI) for Buffer management (full)	
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	AMS informs ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request

Table 907—Contents Encoding type 3 in PFBCH

63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	

16.3.9.3.1.2 Secondary fast feedback control channel

The UL SFBCH carries narrowband CQI and MIMO feedback information. The number of information bits carried in the SFBCH ranges from 7 to 24. The number of bits carries in the fast feedback channel can be adaptive.

Table 908—SFBCH Feedback Content

SFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
Subband CQI	2,3,5,6	Reporting of average and differential CQI of selected sub-bands.
Subband index	2,3,5,6	Indicating the selected subbands
Subband PMI	3,6	Precoding Matrix Indicator of one sub-band for CL MIMO
Stream Indicator	5	It is needed for OL MU MIMO only and used to indicate which spatial stream to estimate CQI
STC Rate Indicator	2,3,5,6	
PFBCH Indicator	2,3,5,6	One bit indicator is used for indicating the transmission of PFBCH in the next SFBCH opportunity. In the transmission of PFBCH, encoding type 0 is used.

16.3.9.3.1.3 Channel quality indicator (CQI) definition

The CQI feedback together with the STC rate feedback (when applicable) composes the spectral efficiency value reported by the AMS. This value corresponds to the measured block error rate which is the closest, but not exceeding, a specific target error rate.

The AMS reports the CQI by selecting a nominal MCS index from Table 909. MCS index should be selected assuming 4 LRUs in type-1 AAI subframe as a resource allocation, and 10% as a target error rate for the first HARQ transmission and considering varying channel conditions during the delay from the reference signal that the CQI measurement is made on and to the point of time that the CQI is reported. That is, the reported CQI in frame *N* measured from the reference siganl(s) at least up to frame *N*-1 corresponds to an appropriate MCS index for the frame *N*. In order to allocate the AMS with MCS level and rank appropriate for the actual requirements, the ABS should make further adjustments to the AMS reported spectral efficiency, by considering parameters values different from the reference ones and by adapting to delay and mobility conditions.

The nominal MCS for CQI feedback shall be selected from Table 909.

Table 909—MCS table for CQI

MCS Index	Modulation	Code Rate
0000	QPSK	31/256
0001	QPSK	48/256
0010	QPSK	71/256
0011	QPSK	101/256
0100	QPSK	135/256
0101	QPSK	171/256
0110	16QAM	102/256
0111	16QAM	128/256
1000	16QAM	155/256
1001	16QAM	184/256
1010	64QAM	135/256
1011	64QAM	157/256
1100	64QAM	181/256
1101	64QAM	205/256
1110	64QAM	225/256
1111	64QAM	237/256

For MU-MIMO feedback modes with codebook-based feedback, the CQI is calculated at the AMS assuming that the interfering users are scheduled by the serving ABS using rank-1 precoders orthogonal to each other and orthogonal to the rank-1 precoder represented by the reported PMI.

16.3.9.3.1.4 Representation of Subband Indices

For AMS selected subband feedback, the MS shall report the *M* selected subbands indices using a combinatorial index *r* defined as

$$r = \sum_{i=1}^{M} \left\langle {S_i \atop i} \right\rangle$$

where

the set $\{S_i, i = 1, 2, \ldots, M\}, (0 \le S_i \le N-1, S_i < S_{i+1})$ contains the M selected subband indices.

$\left\langle {x \atop y} \right\rangle = \begin{cases} \binom{x}{y}, & x \ge y \\ 0, & x < y \end{cases}$ is the extended binomial coefficient.

Resulting in unique label in the range: $r \in \left\{0, \ldots, \binom{N}{M} - 1\right\}$.

16.3.9.3.1.5 Feedback formats

Feedback formats define the information content carried by the fast feedback channels. The format of the content of the PFBCH is determined by the PFBCH encoding type. The SFBCH payload information bits may carry subbands index (Best_subbands_index), STC rate, wideband STC rate, PFBCH indicator, subband CQI , subband avg_CQI, differential CQI, stream index, wideband PMI, subband PMI, base PMI and differential PMI. The SFBCH payload information bits $a_0a_1...a_{23}$ are defined in the order specified in Table 910 to Table 918.

STC rate and wideband STC rate shall be encoded with 1, 2 or 3 bits when the ABS has 2, 4 or 8 transmit antennas, respectively.

Subband CQI and subband avg_CQI shall be encoded with 4 bits corresponding to the nominal MCS of Table 886.

Differential CQI shall be encoded with 2 bits indicating values {-1, 0, +1, +2}.

Wideband PMI, subband PMI and base PMI shall be encoded with 3, 4 or 6 bits according to the codebook size.

Differential PMI shall be encoded with 2, 4 or 4 bits when the ABS has 2, 4 or 8 transmit antennas, respectively.

When the AMS estimates PMI by using the midamble, AMS should consider channel variation and report the PMI with reference to the frame the PMI is reported. That is, the reported PMI in frame N measured from the midamble(s) at least up to frame N-1 corresponds to an appropriate value of PMI estimated for the frame N.

Stream index shall be encoded with ceil($\log_2(MaxM_t)$) bits.

Best_subbands_index shall be encoded with $\left\lceil \log_2\binom{Y_{SB}}{M} \right\rceil$ bits, where $\binom{x}{y}$ is the combination operation.

The total number of subbands Y_{SB} available for feedback is shown in Equation (286):

$$Y_{SB} = \sum_{m=0}^{3} \frac{L_{SB-CRU,FP_m}}{N_1} \tag{286}$$

Where $L_{SB-CRU,FP|_m}$ is the number of allocated subband CRUs for FP_m.

Feedback format for MFM 0,1,4,7

Feedback formats for MFM 0, 4, and 7 are listed in Table 910. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report if MFM = 4 or 7, or by puncturing the 2^q-th short period report if MFM = 0, where q is defined in the Feedback Allocation A-MAP IE. When q = 0, only the short period reports shall be sent. If MFM = 4 or 7 and q = 0, the ABS should allocate the feedback of the transmit correlation matrix using Feedback Polling A-MAP IE before allocating MFM 4 or 7 to the AMS.

The wideband CQI is one average CQI corresponding to the MIMO mode signaled by the combination MFM and STC rate, with averaging over the whole band. In the case where the number of DL frequency partitions FPCT > 1, the wideband CQI is one average CQI over the corresponding frequency partition.

When MFM = 4 or 7 and q > 0, AMS should calculate CQI assuming that ABS will calculate the beamforming matrix utilizing the latest PMI which is fed back to the ABS. When MFM = 4 or 7 and q = 0, AMS should calculate CQI assuming that ABS will calculate the beamforming matrix utilizing the latest successfully received transmit correlation matrix which is fed back to the ABS.

Table 910 shows feedback formats for MIMO feedback mode 0, 4, and 7 when Measurement Method Indication = 0b0 in Feedback Allocation A-MAP IE (operation outside the open-loop region):

Table 911 shows feedback formats for MIMO feedback mode 0 and 1 when Measurement Method Indication = 0b1 in Feedback Allocation A-MAP IE (operation inside the open-loop region). The ABS shall not assign a feedback channel on the short periods.

Table 910—Feedback formats for MFM 0, 4, and 7(outside OL region)

MFM	FBCH	Number of reports	Report Period	Feedback Fields	Description/Notes
0	PFBCH	2	Short	Wideband CQI and STC rate	Joint encoding of CQI and STC rate Encoding type 0
			Long	Wideband CQI and STC rate	Joint encoding of CQI and STC rate Encoding type 0 Long term FPI for FFR No long term report when $q = 0$
4	PFBCH	2	Short	Wideband CQI and STC rate	Encoding type 0
			Long	Wideband PMI	PMI Encoding type 2 No long term report when $q = 0$
7	PFBCH	2	Short	Wideband CQI	STC rate = 1 Encoding type 0
			Long	Wideband PMI	PMI for rank 1 Encoding type 2 No long term report when $q = 0$

Table 911—Feedback formats for MFM 0 and 1 (inside OL region)

MFM	FBCH	Number of Reports	Report Period	Feedback Fields	Description/Notes
0	PFBCH	1	Long	Wideband CQI and STC rate	Joint encoding of CQI and STC rate Encoding type 0
1	PFBCH	1	Long	Wideband CQI	CQI for STC rate = 1/2 Encoding type 3

Feedback format for MFM 2

The detailed format is listed in Table 912. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding type 0. When $q = 0$, only the long period reports shall be sent. $q = 0$ shall not be set if Measurement Method Indication = 0b1.

The CQI of subband m shall be computed as follows: (Subband *m* CQI index) = (Subband avg CQI index) + (Subband *m* differential CQI), using the latest available reports of Subband avg CQI and Subband differential CQI. Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are {-1, 0, +1, +2}. The AMS shall ensure that the reported differential CQI will produce a value of subband *m* CQI in the range of 0 to 15.

Table 912 shows feedback formats for MIMO feedback mode 2 when Measurement Method Indication = 0b0 in Feedback Allocation A-MAP IE (operation outside the open-loop region)

Table 912—Feedback formats for MFM 2 (outside OL region)

Feedback Format	FBCH	Number of reports	Report Period	Feedback Fields	Description/Notes
0 (M = 1)	PFBCH	2	Short	Subband CQI and STC rate	Joint encoding of CQI and STC rate with PFBCH encoding Type 0 No short term report when *q*=0
			Long	Best_subbands_ index	PFBCH encoding Type 1
1 (M = 1)	SFBCH	1	Long	Best_subbands_ index Subband CQI STC rate PFBCH indicator	Support of STC rate 1 to 8

2 (M=min{5 ,Y_{SB}}	SFBCH	2	Short	Subband avg CQI-
				for (m=1:M){
				differential CQI
				}
					No short term report when *q*=0

			Long	Best_subbands_ index Wideband STC rate PFBCH indicator	Support of STC rate 1 to 8

3 (M=min{1 0,Y_{SB}}	SFBCH	2	Short	Subband avg CQI-
				for (m=1:M){
				differential CQI
				}
					No short term report when *q*=0

			Long	Best_subbands_ index Wideband STC rate PFBCH indicator	Support of STC rate 1 to 8

Table 913 shows Feedback formats for MIMO feedback mode 2 when Measurement Method Indication = 0b1 in Feedback Allocation A-MAP IE (operation inside the open-loop region)

Table 913—Feedback formats for MFM 2 (inside OL region)

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Description/Notes
0 (M=1)	PFBCH	2	Short	Subband CQI for STC rate = 1/2	Joint encoding of CQI with STC rate = 1/2 PFBCH encoding type 3
			Long	Best_subbands_ index	PFBCH encoding type 1
1 (M=1)	SFBCH	1	Long	Best_subbands_ index Subband CQI PFBCH indicator	STC rate = 1/2

2 (M=min{5,Y_{SB}}	SFBCH	2	Short	Subband avg CQI
				for (m=1:M){
				Differential CQI
				}
					STC rate = 1/2

			Long	Best_subbands_ index PFBCH indicator	

2 (M=min{10,Y_{SB}}	SFBCH	2	Short	Subband avg CQI
				for (m=1:M){
				Differential CQI
				}	

			Long	Best_subbands_ index PFBCH indicator	

Feedback format for MFM 3

The detailed format is listed in Table 914. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. For feedback format 0 with 3 reports using the PFBCH, Subband PMI shall be transmitted first after every report of Best_subbands_ index. Subband CQI and subband PMI are then transmitted alternately and Best_subbands_index is transmitted in the long term period. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted using encoding type 0 by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback. When q=0, only the long period reports shall be sent. q=0 shall not be set with the differential feedback mode.

The CQI of subband m shall be computed as follows for the first short period report following a long period report: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI). Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are {-1, 0, +1, +2}. The AMS shall ensure that the reported differential CQI will produce a value of subband *m* CQI in the range of 0 to 15.

If the ABS has 4 transmit antennas and assigns MFM3 with feedback format 3, then it shall set Codebook_subset = 0b1 except if Codebook_mode indicates the differential codebook-based feedback mode.

The detailed format for MIMO feedback mode 3 with differential codebook is in Table 915. Short term report happens in every reporting period as defined in Feedback Allocation A-MAP IE. For $M > 1$, two long term reports will puncture two short term reports continuously according to long term feedback period in Feedback Allocation A-MAP IE. The long term feedback which conveys Best_subband_index shall be transmitted first. For $M = 1$, the long term report will puncture one short term report according to long term feedback period in Feedback Allocation A-MAP IE.

Feedback format for MFM 5

The detailed format is listed in Table 916. Short term report happens in every reporting period as defined in Feedback Allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in Feedback Allocation A-MAP IE. The long period report shall start by puncturing the first short period report. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding type 0. When $q = 0$, only the long period reports shall be sent. $q = 0$ shall not be set if Measurement Method Indication = 0b1.

The CQI of subband m shall be computed as follows: (Subband *m* CQI index) = (Subband avg CQI index) + (Subband *m* differential CQI), using the latest available reports of Subband avg CQI and Subband differential CQI. Subband avg CQI index is an average measure of the CQI over the *M* reported subbands. The possible differential CQI values are {-1, 0, +1, +2}. The AMS shall ensure that the reported differential CQI will produce a value of subband *m* CQI in the range of 0 to 15.

The feedback formats for MIMO feedback mode 5 are the same for operation inside or outside the open-loop region.

Feedback format for MFM 6

Table 914—Feedback formats for MFM 3

Feedback Format	FBCH	Number of reports	Report Period	Feedback Fields	Description/Notes
0(M = 1)	PFBCH	3	Short	Subband CQI	PFBCH encoding Type 0 No short term report when $q = 0$
			Short	Subband PMI	PFBCH encoding Type 2 STC rate = 1 No short term report when $q = 0$
			Long	Best_subband_index	PFBCH encoding Type 1

1(M = 2)	SFBCH	2	Short	for (m=1:M){
				Subband differential CQI
				Subband PMI
				}
					No short term report when $q = 0$

			Long	Best_subband_index Wideband STC rate Subband avg CQI PFBCH indicator	

1(M = 2)	SFBCH	2	Short	for (m=1:M){
				Subband differential CQI
				Subband PMI
				}
					No short term report when $q = 0$

			Long	Best_subband_index Wideband STC rate Subband avg CQI PFBCH indicator	

3(M = 4)	SFBCH	2	Short	for (m=1:M){
				Subband differential CQI
				Subband PMI
				}
					No short term report when $q = 0$

			Long	Best_subband_index Wideband STC rate Subband avg CQI PFBCH indicator	

The detailed format is listed in Table 917. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. For feedback format 0 with 3 reports using the PFBCH, Subband PMI shall be transmitted first after every report of Best_subbands_index. Subband CQI and subband PMI are then transmitted alternately and Best_subbands_index is transmitted in the long term period. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted using encoding type 0 by puncturing SFBCH in the next feedback

Table 915—Feedback formats for MFM 3 for differential codebook

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Description/Notes

0 (M =1)	SFBCH	2	Short	for (m=1:M){
				Subband differential CQI
				Subband PMI
				}
				Padding
					Padding
					1 bit: if Nt = 2
					0 bit: otherwise

			Long	Best_subband_ index STC rate Base PMI PFBCH indicator	PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

1 (M=2)	SFBCH	3	Short	for (m=1:M){
				Subband differential CQI
				Subband differential PMI
				}	

			Long	Best_subband_ index Subband avg_CQI PFBCH indicator	

			Long	for (m=1:M){
				Base PMI
				}
				Wideband STC rate
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

2 (M =3)	SFBCH	3	Short	for (m=1:M){
				Subband differential CQI
				Subband differential PMI
				}	

			Long	Best_subbands_ index Wideband STC rate Subband avg_CQI PFBCH indicator	

			Long	for (m=1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

3 (M =4)	SFBCH	3	Short	for (m=1:M){
				Subband differential CQI
				Subband differential PMI
				}	

			Long	Best_subbands_ index Wideband STC rate Subband avg_CQI PFBCH indicator	

			Long	for (m=1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

Table 916—Feedback formats for MFM 5

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Description/ Notes
0 (M =1)	SFBCH	1	Long	Best_subbands_ index Subband CQI Stream Index PFBCH indicator	

1 (M=2)	SFBCH	2	Short	Subband avg_CQI
				for m=1:M{
				Subband differential CQI
				Stream Index
				}
					No short term report when q = 0

			Long	Best_subbands_ index PFBCH indicator	

2 (M =3)	SFBCH	2	Short	Subband avg_CQI
				for m=1:M{
				Subband differential CQI
				Stream Index
				}
					No short term report when q = 0

			Long	Best_subbands_ index PFBCH indicator	

3 (M =5)	SFBCH	3	Short	Subband avg_CQI
				for m=1:M{
				Subband differential CQI
				Stream Index
				}
					No short term report when q = 0

			Long	Best_subbands_ index PFBCH indicator	

opportunity regardless of short-term and long-term feedback. When q=0, only the long term reports shall be sent. q = 0 shall not be set with the differential feedback mode.

The CQI of subband m shall be computed as follows: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI), using the latest available reports of Subband avg CQI and Subband differential CQI. Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are {-1, 0, +1, +2}. The AMS shall ensure that the reported differential CQI will produce a value of subband m CQI in the range of 0 to 15.

If the ABS has 4 transmit antennas and assigns MFM 6 with feedback format 3, then it shall set Codebook_subset = 0b1 except if Codebook_mode indicates the differential codebook-based feedback mode.

Table 917—Feedback formats for MFM 6

Feedback Format	FBCH	Number of reports	Report Period	Feedback Fields	Description/Notes
0(M = 1)	PFBCH	3	Short	Subband CQI	PFBCH encoding Type 0 No short term report when $q = 0$
			Short	Subband PMI	PFBCH encoding Type 2 No short term report when $q = 0$
			Long	Best_subbands_index	PFBCH encoding Type 1

1(M = 2)	SFBCH	2	Short	for (m=1:M){
				Subband differential CQI
				Subband PMI
				}
					No short term report when $q = 0$

			Long	Best_subbands_index Subband avg CQI PFBCH indicator	

2(M = 3)	SFBCH	2	Short	for (m=1:M){
				Subband differential CQI
				Subband PMI
				}
					No short term report when $q = 0$

			Long	Best_subbands_index Subband avg CQI PFBCH indicator	

3(M = 4)	SFBCH	2	Short	for (m=1:M){
				Subband differential CQI
				Subband PMI
				}
					No short term report when $q = 0$

			Long	Best_subbands_index Subband avg CQI PFBCH indicator	

The detailed format for MIMO feedback mode 6 with differential codebook is in Table 918. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE . For M>1, two long term reports will puncture two short term reports continuously according to long term feedback period in Feedback Allocation A-MAP IE. For M=1, the long term report will puncture one short term report according to long term feedback period in Feedback Allocation A-MAP IE

16.3.9.3.2 HARQ feedback control channel

16.3.9.3.3 Bandwidth request channel

The quick access messaage contains a 12-bit MSID and 4-bit predefined BR information defined in 16.2.11.1.5.1.

Table 918—Feedback formats for MFM 6 for differential codebook

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Description/Notes
0 (M =1)	SFBCH	2	Short	Subband CQI Differential PMI Padding	Padding 1 bit: if N_t=2 0 bit: otherwise
			Long	Subband index Base PMI PFBCH indicator	PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

1 (M=2)	SFBCH	3	Short	for (m=1:M){
				Subband differential CQI
				Suband differential PMI
				}	

			Long	Best_subbands_index subband avg_CQI PFBCH indicator	

			Long	for (m=1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

2 (M =3)	SFBCH	3	Short	for (m=1:M){
				Subband differential CQI
				Suband differential PMI
				}	

			Long	Best_subbands_index subband avg_CQI PFBCH indicator	

			Long	for (m=1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

3 (M =4)	SFBCH	3	Short	for (m=1:M){
				Subband differential CQI
				Suband differential PMI
				}	

			Long	Best_subbands_index subband avg_CQI PFBCH indicator	

			Long	for (m=1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

16.3.9.4 Uplink Power Control

Uplink power control is supported for both an initial calibration and periodic adjustment on transmit power without loss of data. The uplink power control algorithm determines the transmission power of an OFDM symbol to compensate for the pathloss, shadowing and fast fading. Uplink power control shall intend to control inter-cell interference level.

A transmitting AMS shall maintain the transmitted power density, unless the maximum power level is reached. In other words, when the number of active LRU allocated to a user is reduced, the total transmitted power shall be reduced proportionally by the AMS, as long as there is no additional change of parameters for power control. When the number of LRU is increased, the total transmitted power shall also be increased proportionally. However, the transmitted power level shall not exceed the maximum levels dictated by signal integrity considerations and regulatory requirements.

For interference level control, current interface level of each ABS may be shared among ABSs.

The power per subcarrier and per stream shall be calculated according to Equation (287).

$$P(dBm) = L + SINR_{Target} + NI + Offset \tag{287}$$

Where

$SINR_{Target}$ is the target uplink SINR received by the ABS.

P is the TX power level (dBm) per stream and per subcarrier for the current transmission.

L is the estimated average current DL propagation loss calculated by AMS. It shall include AMS's Tx antenna gain and path loss.

NI is the estimated average power level (dBm) of the noise and interference per subcarrier at the ABS, as indicated in the AAI_ULPC_NI message.

$Offset$ is a correction term for AMS-specific power offset. It is controlled by the ABS through power control messages. There are two kinds of $Offset$ values ($Offset_{data}$ and $Offset_{Control}$) that are used for data and control, respectively. Further details are given in

The estimated average current DL propagation loss, L, shall be calculated based on the total power received on the active subcarriers of the frame preamble.

16.3.9.4.1 Power Control for Data Channel

For data channel transmission, the $SINR_{Target}$ term in Equation (287) is calculated according to Equation ():

$$SINR_{Target} = 10\log 10\left(max\left(10^{\wedge}\left(\frac{SINR_{MIN}(dB)}{10}\right), \gamma_{IoT} \times SIR_{DL} - \alpha\right)\right) - \beta \times 10\log 10(TNS) \tag{288}$$

where Equation () is the target SINR value for IoT control and tradeoff between overall system throughput and cell edge performance, decided by the control parameter γ_{IoT} and $SINR_{MIN}$(dB). The parameters used in

Equation () are broadcasted in AAI_SCD message unless otherwise noted. The explanation for the parameters is as follows:

$SINR_{MIN}$(dB) is the SINR requirement ($SINR_{MIN}$_*Data*) for the minimum rate expected by ABS.

γ_{IoT} is the fairness and IoT control factor broadcasted.

SIR_{DL} is the linear ratio of the downlink signal to. interference power, measured by the AMS.

α is the factor according to the number of receive antennas at the ABS.

β is set to be zero or one to determine the influence of *TNS* on $SINR_{Target}$.

TNS is the Total Number of Streams in the LRU indicated by UL A-MAP IE. In case of SU-MIMO, this value shall be set to M_t where M_t is the number of streams for AMS. In case of CSM, *TNS* is the aggregated number of streams.

When calculated data channel $SINR_{Target}$ is higher than $SINR_{max}$_*Data* defined in AAI_SCD message, $SINR_{Target}$ shall be set to $SINR_{max}$_*Data*.

For a data channel transmission, the *Offset* in Equation (287) shall be set to the value $Offset_{Data}$ conveyed in an AAI UL_POWER_ADJUST message. The value used shall be taken from the most recent message which preceded the first uplink subframe of the frame by more than T_{proc}. The default value of $Offset_{Data}$ shall be initialized to 0 if AMS never get AAI_UL_POWER_ADJUST message.

16.3.9.4.2 Power Control for Control Channels

In the case of control channel transmission, except for initial ranging and sounding transmission, $SINR_{Target}$ in Equation (287) is set according to Table 919. The parameters in Table 919 are conveyed in the AAI_SCD message.

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Table 919—$SINR_{Target}$ Parameters for Control Channels

Control Channel Type	$SINR_{Target}$ Parameters
HARQ Feedback	*SINR_Target_HARQ*
Synchronized Ranging	*SINR_Target_SyncRanging*
P-FBCH	*SINR_Target_PFBCH*
S-FBCH	*SINR_Target_SFBCH_Base*
	SINR_Target_SFBCH_Delta
Bandwidth Request	*SINR_Target_BWRequest*

For HARQ Feedback, Synchronized Ranging, P-FBCH and Bandwidth Request, the $SINR_{Target}$ values are indicated directly in Table 919. For S-FBCH channel, the $SINR_{Target}$ value is defined in Table 289:

$$SINR_{Target}(SFBCH) = SFBCH_{Base} + (l - l_{min}) \times SFBCH_{Delta} \quad (289)$$

where

$SFBCH_{Base}$ is base $SINR_{Target}$ value signaled by *SINR_Target_SFBCH_Base*;

$SFBCH_{Delta}$ is differential $SINR_{Target}$ value signaled by *SINR_Target_SFBCH_Delta*;

l is S-FBCH payload information bits number defined in 16.3.9.2.1.2;

l_{min} is minimum S-FBCH payload information bits number (l_{min} = 7) defined in 16.3.9.2.1.2.

For a control channel transmission, the *Offset* in Equation (287) shall be set to the value $Offset_{Control}$ conveyed in an AAI UL_POWER_ADJUST message. The value used shall be taken from the most recent message which preceded the first uplink subframe of the frame by more than T_{proc}. The default value of $Offset_{Control}$ shall be initialized to 0 if AMS never get AAI_UL_POWER_ADJUST message.

16.3.9.4.3 Power Correction using PC-A-MAP

The ABS may change the AMS's TX power through direct power adjustment by PC-A-MAP. When AMS receives its PC-A-MAP IE from the ABS, it shall modify its $Offset_{Control}$ value according to Equation (290).

$$Offset_{Control} = Offset_{Control} + \Delta_{PowerAdjust} \quad (290)$$

where $\Delta_{PowerAdjust}$ is the power correction value indicated by ABS through PC-A-MAP.

Note that $Offset_{Control}$ is initially set to zero until AMS receives the first AAI_UL_POWER_ADJUST message. And if AMS receives AAI_UL_Power_ADJUST message at *i*-th frame, the AMS's $Offset_{Control}$ shall be replaced by the value indicated by the message from the (*i*+1)th frame. Also PC-A-MAP IE from (*i*+1)th frame is effective on this new value.

16.3.9.4.4 Initial Ranging Channel Power Control

For initial ranging, AMS sends initial ranging code at a randomly selected ranging channel. The initial transmission power is decided according to measured RSS. If AMS does not receive a response, it may increase its power level by $P_{IR,Step}$ and may send a new initial ranging code, where $P_{IR,Step}$ is the step size to ramp up, which is 2 dB. AMS could further increase the power until maximum transmit power is reached.

The initial transmission power of AMS is calculated as:

$$P_{TX\_IR\_MIN} = EIRxP_{IR,min} + BS\_EIRP - RSS \quad ,$$

where $EIRxP_{IR,min}$ is the minimum targeting receiving power and BS_EIRP is the transmission power of the BS, which are obtained from S-SFH SP2 and SP1, respectively, and RSS is the received signal strength measured by the AMS.

In the case that the Rx and Tx gain of the AMS antenna are different, the AMS shall use Equation (273):

$$P_{TX\_IR\_MIN} = EIRxP_{IR,\,min} + BS\_EIRP - RSS + (G_{Rx\_MS} - G_{Tx\_MS}) \qquad (291)$$

where G_{Rx_MS} is the antenna gain of AMS RX, and G_{Tx_MS} is the antenna gain of AMS TX.

16.3.9.4.5 Sounding Channel Power Control

Power control for the UL sounding channel is supported to manage the sounding quality. AMS's transmit power for UL sounding channel is controlled separately according to its sounding channel target SINR value. The power per subcarrier shall be maintained for the UL sounding transmission as shown in Equation (287) of 16.3.9.4.1.

In Equation (287), $SINR_{Target}$ is the sounding channel target SINR, which is set according to the DL SIR of the AMS defined by parameter SIR_{DL}. In order to maintain the UL sounding quality, the different target SINR values are assigned according to the DL SIR of each AMS; the AMS with high DL SIR applies relatively high target SINR and the AMS with low DL SIR applies relatively low target SINR.

The $SINR_{Target}$ for sounding channel shall be calculated from Equation () using the following parameter settings: $SINR_{MIN}$ is the minimum SINR requirement expected by ABS which is set to $SINR_{min}$*_SOUNDING*, γ_{IoT} is set to the IoT control factor for sounding channel *GAMMA_IOT_SOUNDING*, SIR_{DL} is the ratio of the downlink signal vs. noise and interference power, measured by the AMS, α and β parameters shall be set to 0.

When calculated sounding $SINR_{Target}$ is higher than $SINR_{max}$*_SOUNDING*, the $SINR_{Target}$ shall be set to $SINR_{max}$*_SOUNDING*.

All parameters necessary for sounding channel power control are transmitted through AAI_SCD message in 16.2.3.29.

16.3.9.4.6 Concurrent transmission of uplink control channel and data

In case of simultaneous transmission among control channels, uplink transmission power of assigned channels is determined based on the channel list in Table 920 in descending order until the total transmission power reaches maximum power limitation of AMS.

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Table 920—The priority of uplink transmit channels

Channel Type
HARQ feedback
PFBCH/SFBCH
Synchronized Ranging
Sounding
DATA
Bandwidth Request

16.3.9.4.7 Uplink Power Status Reporting

16.3.9.4.7.1 Power Status Reporting Information

There are two key parameters for power status reporting: the base uplink transmission PSD and the SIR_{DL} defined in 16.3.9.4.1.

The base uplink transmission PSD is derived from Equation (287) by setting $SINR_{Target} = 0$ and $Offset = 0$:

$$PSD(base) = L + NI \tag{292}$$

The parameter is reported in dBm and is coded using 8 bits in 0.5 dBm steps ranging from -74 dBm (coded 0x00) to 53.5 dBm (coded 0xFF).

The reported SIR_{DL} value is coded using 10 bits in 0.05 dB steps ranging from -10dB (coded 0x000) to 41.15 dB (coded 0x3ff).

After the ABS has received $PSD(base)$ and SIR_{DL} from the AMS, the PSD for all uplink channels can be estimated in ABS.

16.3.9.4.7.2 Status Transmission Condition

The AMS shall send the status reporting message AAI_UL_PSR_Message (TBD) to the ABS when the conditions listed below are met:

$$|M(n_{last}) - M(n)| \geq \text{Tx\_Power\_Report\_Threshold(dB)} \tag{293}$$

and

$$n - n_{last} \geq \text{Tx\_Power\_Minimum\_Interval} \tag{294}$$

or

$$n - n_{last} \geq \text{Tx\_Power\_Periodical\_Interval} \quad (295)$$

Where M is defined in Equation (296):

$$M = L + SINR_{Target}\,(Reported) \quad (296)$$

L is the pathloss defined in Equation (287).

n_{last} is the frame index when the last AMS status reporting message was sent.

n is the current frame index.

Tx_Power_Report_Threshold(dB) is a 4 bit unsigned integer value in 0.5 dB steps, the specific value “0b1111” shall be interpreted as “infinite”;

Tx_Power_Report_Minimum_Interval and Tx_Power_Report_Periodical_Interval are coded by 4 bit unsigned integer values d representing 2^d frames, the specific value d = 0b1111 shall be interpreted as “infinite”

The status reporting configuration parameters Tx_Power_Report_Threshold(dB), Tx_Power_Report_Minimum_Interval and Tx_Power_Report_Periodical_Interval are sent from ABS to AMS in the message AAI_UL_PSR_Config (TBD).

16.3.9.5 Uplink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRU is the same as the structure defined in 16.3.8.1 and 16.3.8.4. The guard PRUs are used as miniband CRUs at partition FP_0 for data transmission only. The number of useable guard subcarriers is predefined and should be known to both AMS and ABS based on carrier bandwidth.

16.3.10 Uplink MIMO transmission schemes

16.3.10.1 Uplink MIMO architecture and data processing

The architecture of uplink MIMO at the transmitter side is shown in Figure 575.

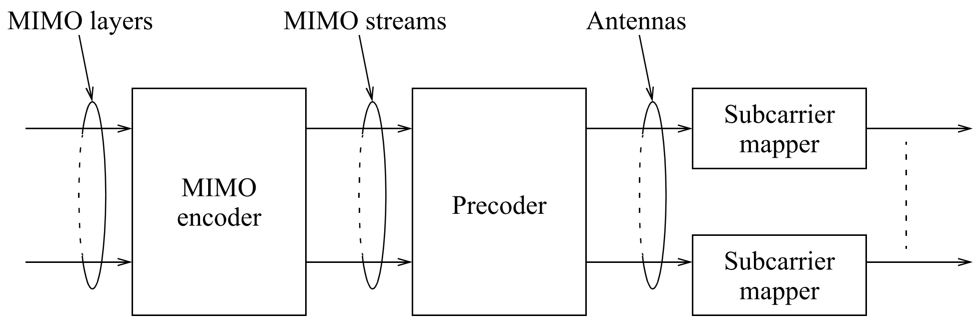

Figure 575—UL MIMO architecture

The MIMO encoder block maps a single MIMO layer (L = 1) onto M_t $(M_t \geq L)$ MIMO streams, which are fed to the Precoder block.

For SU-MIMO and collaborative spatial multiplexing (MU-MIMO), only one FEC block exists in the allocated RU (vertical MIMO encoding at transmit side).

The precoder block maps MIMO stream(s) to antennas by generating the antenna-specific data symbols according to the selected MIMO mode.

The MIMO encoder and precoder blocks shall be omitted when the AMS has one transmit antenNA.

The subcarrier mapping blocks map antenna-specific data to the OFDM symbol.

16.3.10.1.1 MIMO layer to MIMO stream mapping

MIMO layer to MIMO stream mapping is performed by the MIMO encoder. The uplink MIMO encoder is identical to the downlink MIMO encoder described in 16.3.7.1.1.

Horizontal encoding (MEF = 0b10) is not supported for uplink transmissions. Collaborative spatial multiplexing (CSM) is achieved with vertical encoding (MEF = 0b01) at the AMS. The STC rate per AMS for uplink SU-MIMO and MU-MIMO (CSM) transmissions is defined as $R = M/N_F$.

An AMS with 1 transmit antenna shall use vertical encoding (MEF = 0b01) for uplink transmissions.

16.3.10.1.1.1 SFBC encoding

Uplink SFBC encoding is identical to the downlink SFBC encoding described in 16.3.7.1.1.1.

SFBC encoding format shall not be allocated to an AMS with 1 transmit antenNA.

16.3.10.1.1.2 Vertical encoding

Uplink vertical encoding is identical to the downlink vertical encoding described in 16.3.7.1.1.2.

Vertical encoding with 1 MIMO stream (M_t = 1) format shall be allocated to an AMS with 1 transmit antenNA.

16.3.10.1.2 MIMO stream to antenna mapping

MIMO stream to antenna mapping is performed by the precoder. The uplink mapping is identical to the downlink mapping described in 16.3.7.1.2.

16.3.10.1.2.1 Non-adaptive precoding

There is no precoding if there is only one transmit antenna at the MS.

With non-adaptive precoding, the precoding matrix is an $N_t \times M_t$ matrix $\mathbf{W}(k)$, where N_t is the number of transmit antennas, M_t is the numbers of MIMO streams, and k is the physical index of the subcarrier where $\mathbf{W}(k)$ is applied. The matrix $\mathbf{W}$ is selected from a subset of size N_w precoders of the base codebook for a given rank. $\mathbf{W}$ belongs to one of the subsets of the base codebook specified in 16.3.10.4.1, according to the type of allocation, MEF, N_t and M_t, as specified in Table 921 and Table 922.

Table 921—Codebook subsets used for non-adaptive precoding in UL DLRU and NLRU

MEF	RU with M_t pilot MIMO streams
SFBC	$C_{UL,OL,SU}(N_t, M_t, N_w)$, $M_t = 2$
VE	$C_{UL,OL,SU}(N_t, M_t, N_w)$, $M_t = 1, ..., 4$

Table 922—Codebook subsets used for non-adaptive precoding in UL SLRU

MEF	RU with M_t pilot MIMO streams
SFBC	na
VE	N_t=2: $C_{base,UL}(2, M_t, 4)$, M_t=1,2 N_t=4: $C_{base,UL}(4, M_t, 6)$, M_t=1,2,3,4

In a RU allocated in a AAI subframe with MEF = 0b00 (SFBC) or 0b01 (VE) and non-adaptive precoding, the matrix **W** changes every $N_1 P_{SC}$ contiguous physical subcarriers according to Equation (297), and it does not depend on the AAI subframe number. The $N_t \times M_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in physical subband s is selected as the codeword of index i in the open-loop codebook subset of rank M_t, where i is given by

$$i = s \bmod N_w, \qquad s = 0 \ldots N_{sub} - 1 \tag{297}$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

16.3.10.1.2.2 Adaptive precoding

There is no precoding if there is only one transmit antenna at the AMS.

With adaptive precoding, the precoder **W** is derived at the ABS or at the AMS, as instructed by the ABS.

With 2Tx or 4Tx at the AMS in FDD and TDD systems, unitary codebook based adaptive precoding is supported. In this mode, a AMS transmits a sounding signal on the uplink to assist the precoder selection at the ABS. The ABS then signals the uplink precoding matrix index to be used by the AMS in the UL Basic Assignment A-MAP IE and UL Subband Assignment A-MAP IE.

With 2Tx or 4Tx at the AMS in TDD systems, adaptive precoding based on the measurements of downlink reference signals is supported. The AMS chooses the precoder based on the downlink measurements. The form and derivation of the precoding matrix does not need to be known at the ABS.

16.3.10.1.3 Uplink MIMO transmission modes

There are five MIMO transmission modes for UL MIMO transmission as listed in Table 923.

The allowed values of the parameters for each UL MIMO mode are shown in Table 924.

M_t refers to the number of MIMO streams transmitted from one AMS.

In mode 3 and 4, N_t refers to the number of transmit antennas at one AMS involved in CSM.

Table 923—Uplink MIMO modes

Mode Index	Description	MIMO encoding format (MEF)	MIMO Precoding
Mode 0	OL SU-MIMO	SFBC	non-adaptive
Mode 1	OL SU-MIMO (SM)	VE	non-adaptive
Mode 2	CL SU-MIMO (SM)	VE	adaptive
Mode 3	OL Collaborative spatial multiplexing (MU-MIMO)	VE	non-adaptive
Mode 4	CL Collaborative spatial multiplexing (MU-MIMO)	VE	adaptive

Table 924—UL MIMO parameters

	Number of transmit antennas	STC rate per MIMO layer	Number of MIMO streams	Number of subcarriers	Number of MIMO layers
	N_t	R	M_t	N_F	L
MIMO mode 0	2	1	2	2	1
	4	1	2	2	1
MIMO mode 1	1	1	1	1	1
MIMO mode 1 and MIMO mode 2	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1
	4	4	4	1	1
MIMO mode 3 and MIMO mode 4	1	1	1	1	1
	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1

16.3.10.2 Transmission schemes for data channels

16.3.10.2.1 Encoding and precoding of SU-MIMO modes

16.3.10.2.1.1 Encoding of SU-MIMO modes

- **MIMO mode 0:** SFBC encoding of 16.3.10.1.1.1 shall be used with MIMO mode 0.
- **MIMO mode 1:** Vertical encoding of 16.3.10.1.1.2 shall be used with MIMO mode 1. The number of MIMO streams is $M_t \le min(N_t, N_r)$, where N_r is the number of receive antennas and M_t is no more than 4.
- **MIMO mode 2:** Vertical encoding of 16.3.10.1.1.2 shall be used with MIMO mode 2. The number of MIMO streams is $M_t \le min(N_t, N_r)$, where M_t is no more than 4.

16.3.10.2.1.2 Precoding of SU-MIMO modes

- **MIMO mode 0:** Non-adaptive precoding with $M_t = 2$ MIMO streams shall be used with MIMO mode 0.
- **MIMO mode 1:** Non-adaptive precoding with M_t MIMO streams shall be used with MIMO mode 1.
- **MIMO mode 2:** Adaptive precoding shall be used with MIMO mode 2.

16.3.10.2.2 Encoding and precoding of collaborative spatial multiplexing (MU-MIMO)

AMSs can perform collaborative spatial multiplexing onto the same RU. In this case, the ABS assigns different pilot patterns for each AMS.

16.3.10.2.2.1 Encoding of MU-MIMO modes

- **MIMO mode 3:** Vertical encoding shall be used with MIMO mode 3.
- **MIMO mode 4:** Vertical encoding shall be used with MIMO mode 4.

16.3.10.2.2.2 Precoding of MU-MIMO modes

- **MIMO mode 3:** Non-adaptive precoding shall be used with MIMO mode 3.
- **MIMO mode 4:** Adaptive precoding shall be used with MIMO mode 4.

16.3.10.2.3 Mapping of data subcarriers

Consecutive symbols for each antenna at the output of the MIMO precoder are mapped in a frequency domain first order across LRUs of the allocation, starting from the data subcarrier with the smallest OFDM symbol index and smallest subcarrier index, and continuing to subcarrier index with increasing subcarrier index. When the edge of the allocation is reached, the mapping is continued on the next OFDM symbol.

16.3.10.2.4 Usage of MIMO modes

Table 925 shows the permutations supported for each MIMO mode.

Table 925—Supported permutation for each UL MIMO mode

	DLRU	NLRU	SLRU
MIMO mode 0	Yes	Yes	No
MIMO mode 1	Yes, with $M_t \le 2$	Yes	Yes
MIMO mode 2	Yes, with $M_t \le 2$	Yes	Yes
MIMO mode 3	Yes, with $M_t = 1$	Yes	Yes
MIMO mode 4	Yes, with $M_t = 1$	Yes	Yes

16.3.10.2.5 Downlink signaling support of UL-MIMO modes

16.3.10.2.5.1 Broadcast information

The ABS shall send parameters necessary for UL MIMO operation in a unicast message. The parameters may be transmitted depending on the type of operation. The unicast information is carried in the UL basic Assignment A-MAP IE, UL Subband Assignment A-MAP IE, and UL Persistent A-MAP IE.

Table 926 specifies the DL control parameters required for UL MIMO operation.

16.3.10.3 Codebook for closed-loop transmit precoding

The notation $C_{base,\,UL}(N_t, M_t, NB)$ denotes the rank-M_t uplink base codebook, which consists of 2^{NB} complex matrices of dimension N_t by M_t, and M_t denotes the number of MIMO streams.

The notation $C_{base,\,UL}(N_t, M_t, NB, i)$ denotes the i^{th} codebook entry of $C_{base,\,UL}(N_t, M_t, NB)$.

16.3.10.3.1 Base codebook for two transmit antenna

16.3.10.3.1.1 SU-MIMO base codebook

The base codebooks of SU-MIMO with two transmit antennas consist of rank-1 codebook $C_{base,UL}(2,1,4)$ and rank-2 codebook $C_{base,UL}(2,2,3)$. Table 927 is included to illustrate the rank-1 base codebooks.

The rank-2 base codebook $C_{base,UL}(2,2,3)$ for uplink 2 Tx is the same as the downlink 2 Tx rank-2 base codebook

16.3.10.3.1.2 MU-MIMO base codebook

The base codebook for UL collaborative spatial multiplexing MIMO is the same as the base codebook for SU-MIMO, defined in 16.3.10.3.1.1.

Table 926—UL MIMO control parameters

Parameter	Description	Value	Notes
MEF	MIMO Encoding Format	SFBC Vertical encoding	MIMO encoding format
CSM	Collaborative Spatial Multiplexing	Disabled or enabled	SU MIMO if CSM is disabled MU MIMO if CSM is enabled
M_t	Number of MIMO streams	1 to 4	Number of MIMO streams in the AMS transmission.
TNS	Total number of MIMO streams in the LRU	1 to 4	Enabled when CSM is enabled. Indication of the total number of MIMO streams in the LRU
SI	First pilot index	1 to 4	Enabled when CSM is enabled. 1 bit for 2Tx, 2 bit for 4Tx
PF	Precoding flag	non adaptive precoding or adaptive codebook precoding	Cannot be applied to AMS with 1 transmit antenna
PMI Indicator	PMI indicator	0b0: the AMS shall use the precoder of rank M_t of its choice 0b1: the indicated PMI of rank M_t shall be used by the AMS for precoding	This field is relevant only when PF indicates adaptive codebook precoding. PMI indication = 0b0 may be used in TDD When PMI indication = 0b1, the ABS selects the precoder to use at the AMS.
PMI	Precoding matrix index in the UL base codebook	0 to 9 when $N_t = 2$ 0 to 63 when $N_t = 4$	Enabled when PF indicates adaptive codebook precoding, and PMI indication = 0b1.

16.3.10.3.2 Base codebook for four transmit antennas

16.3.10.3.2.1 SU-MIMO base codebook

The uplink base codebook of SU-MIMO with four transmit antennas consist of rank-1 codebook $C_{base,\,UL}(4, 1, 6)$, rank-2 codebook $C_{base,\,UL}(4, 2, 6)$, rank-3 codebook $C_{base,\,UL}(4, 3, 6)$ and rank-4 codebook $C_{base,\,UL}(4, 4, 6)$. Rank-1 codebook entry $C_{base,\,UL}(4, 1, 6, m)$ consists of the first column of $C_{base,\,UL}(4, 4, 6, m)$. Rank-2 codebook entry $C_{base,\,UL}(4, 2, 6, m)$ consists of the first two columns of $C_{base,\,UL}(4, 4, 6, m)$. Rank-3 codebook entry $C_{base,\,UL}(4, 3, 6, m)$ consists of the first three columns of $C_{base,\,UL}(4, 4, 6, m)$. Table 928 specifies the rank-4 base codebook.

Table 927—$C_{base,UL}(2,1,4)$

Binary Index	m	$C_{base,UL}(2,1,4,m)=[c_1;c_2]$	
		c_1	c_2
0000	0	0.7071	-0.7071
0001	1	0.7071	-0.5000 - 0.5000i
0010	2	0.7071	- 0.7071i
0011	3	0.7071	0.5000 - 0.5000i
0100	4	0.7071	0.7071
0101	5	0.7071	0.5000 + 0.5000i
0110	6	0.7071	0.7071i
0111	7	0.7071	-0.5000 + 0.5000i
1000	8	1	0
1001	9	0	1
1010-1111	10-15	-	-

16.3.10.3.2.2 MU-MIMO base codebook

The base codebook for UL collaborative spatial multiplexing MIMO is same as the base codebook for UL SU-MIMO, defined in 16.3.10.3.2.1.

16.3.10.4 Codebook subsets for open-loop non-adaptive transmit precoding

16.3.10.4.1 OL SU-MIMO subset

The UL OL SU-MIMO codebook subset shall be used for non-adaptive precoding with MIMO mode 0 and MIMO mode 1.

The notation $C_{UL,OL,SU}(N_t, M_t, N_w)$ denotes the UL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t, and M_t denotes the number of MIMO streams. The notation $C_{UL,OL,SU}(N_t, M_t, N_w, i)$ denotes the i-th codebook entry of $C_{UL,OL,SU}(N_t, M_t, N_w)$.

$C_{UL,OL,SU}(N_t, M_t, N_w)$ shall be used for precoding with N_t transmit antennas and M_t MIMO streams with MIMO mode 0 and MIMO mode 1.

Table 928—$C_{base,UL}(4,4,6)$

Binary Index	*m*	$C_{base,UL}(4,4,6,m)=[\mathbf{c}_1;\mathbf{c}_2;\mathbf{c}_3;\mathbf{c}_4]$			
		$\mathbf{c}_1$	$\mathbf{c}_2$	$\mathbf{c}_3$	$\mathbf{c}_4$
000000	0	0.5000 0.5000i -0.5000 - 0.5000i	0.5000 -0.5000 0.5000 -0.5000	0.5000 - 0.5000i -0.5000 0.5000i	0.5000 0.5000 0.5000 0.5000
000001	1	0.5000 0.2357 - 0.4410i -0.4619 - 0.1913i -0.4619 - 0.1913i	0.5000 0.4410 + 0.2357i 0.4619 + 0.1913i -0.1913 + 0.4619i	0.5000 -0.2357 + 0.4410i -0.4619 - 0.1913i 0.4619 + 0.1913i	0.5000 -0.4410 - 0.2357i 0.4619 + 0.1913i 0.1913 - 0.4619i
000010	2	0.5000 -0.4157 + 0.2778i -0.3536 - 0.3536i -0.3536 + 0.3536i	0.5000 -0.2778 - 0.4157i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.4157 - 0.2778i -0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 0.2778 + 0.4157i 0.3536 + 0.3536i -0.3536 - 0.3536i
000011	3	0.5000 0.4976 - 0.0490i -0.1913 - 0.4619i 0.1913 + 0.4619i	0.5000 0.0490 + 0.4976i 0.1913 + 0.4619i 0.4619 - 0.1913i	0.5000 -0.4976 + 0.0490i -0.1913 - 0.4619i -0.1913 - 0.4619i	0.5000 -0.0490 - 0.4976i 0.1913 + 0.4619i -0.4619 + 0.1913i
000100	4	0.5000 -0.4619 - 0.1913i - 0.5000i 0.5000	0.5000 0.1913 - 0.4619i 0.5000i - 0.5000i	0.5000 0.4619 + 0.1913i - 0.5000i -0.5000	0.5000 -0.1913 + 0.4619i 0.5000i 0.5000i
000101	5	0.5000 0.3172 + 0.3865i 0.1913 - 0.4619i 0.1913 - 0.4619i	0.5000 -0.3865 + 0.3172i -0.1913 + 0.4619i -0.4619 - 0.1913i	0.5000 -0.3172 - 0.3865i 0.1913 - 0.4619i -0.1913 + 0.4619i	0.5000 0.3865 - 0.3172i -0.1913 + 0.4619i 0.4619 + 0.1913i
000110	6	0.5000 -0.0975 - 0.4904i 0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 0.4904 - 0.0975i -0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 0.0975 + 0.4904i 0.3536 - 0.3536i 0.3536 + 0.3536i	0.5000 -0.4904 + 0.0975i -0.3536 + 0.3536i 0.3536 - 0.3536i
000111	7	0.5000 -0.1451 + 0.4785i 0.4619 - 0.1913i -0.4619 + 0.1913i	0.5000 -0.4785 - 0.1451i -0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 0.1451 - 0.4785i 0.4619 - 0.1913i 0.4619 - 0.1913i	0.5000 0.4785 + 0.1451i -0.4619 + 0.1913i -0.1913 - 0.4619i
001000	8	0.5000 0.3536 - 0.3536i 0.5000 0.5000i	0.5000 0.3536 + 0.3536i -0.5000 0.5000	0.5000 -0.3536 + 0.3536i 0.5000 - 0.5000i	0.5000 -0.3536 - 0.3536i -0.5000 -0.5000
001001	9	0.5000 -0.4785 + 0.1451i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 -0.1451 - 0.4785i -0.4619 - 0.1913i 0.1913 - 0.4619i	0.5000 0.4785 - 0.1451i 0.4619 + 0.1913i -0.4619 - 0.1913i	0.5000 0.1451 + 0.4785i -0.4619 - 0.1913i -0.1913 + 0.4619i
001010	10	0.5000 0.4904 + 0.0975i 0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000 -0.0975 + 0.4904i -0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 -0.4904 - 0.0975i 0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 0.0975 - 0.4904i -0.3536 - 0.3536i 0.3536 + 0.3536i
001011	11	0.5000 -0.3865 - 0.3172i 0.1913 + 0.4619i -0.1913 - 0.4619i	0.5000 0.3172 - 0.3865i -0.1913 - 0.4619i -0.4619 + 0.1913i	0.5000 0.3865 + 0.3172i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 -0.3172 + 0.3865i -0.1913 - 0.4619i 0.4619 - 0.1913i

Table 928—$C_{base,UL}(4,4,6)$

001100	12	0.5000 0.1913 + 0.4619i 0.5000i -0.5000	0.5000 -0.4619 + 0.1913i - 0.5000i 0.5000i	0.5000 -0.1913 - 0.4619i 0.5000i 0.5000	0.5000 0.4619 - 0.1913i - 0.5000i - 0.5000i
001101	13	0.5000 0.0490 - 0.4976i -0.1913 + 0.4619i -0.1913 + 0.4619i	0.5000 0.4976 + 0.0490i 0.1913 - 0.4619i 0.4619 + 0.1913i	0.5000 -0.0490 + 0.4976i -0.1913 + 0.4619i 0.1913 - 0.4619i	0.5000 -0.4976 - 0.0490i 0.1913 - 0.4619i -0.4619 - 0.1913i
001110	14	0.5000 -0.2778 + 0.4157i -0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 -0.4157 - 0.2778i 0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 0.2778 - 0.4157i -0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000 0.4157 + 0.2778i 0.3536 - 0.3536i -0.3536 + 0.3536i
001111	15	0.5000 0.4410 - 0.2357i -0.4619 + 0.1913i 0.4619 - 0.1913i	0.5000 0.2357 + 0.4410i 0.4619 - 0.1913i -0.1913 - 0.4619i	0.5000 -0.4410 + 0.2357i -0.4619 + 0.1913i -0.4619 + 0.1913i	0.5000 -0.2357 - 0.4410i 0.4619 - 0.1913i 0.1913 + 0.4619i
010000	16	0.5000 -0.5000 -0.5000 - 0.5000i	0.5000 - 0.5000i 0.5000 -0.5000	0.5000 0.5000 -0.5000 0.5000i	0.5000 0.5000i 0.5000 0.5000
010001	17	0.5000 0.4410 + 0.2357i -0.4619 - 0.1913i -0.4619 - 0.1913i	0.5000 -0.2357 + 0.4410i 0.4619 + 0.1913i -0.1913 + 0.4619i	0.5000 -0.4410 - 0.2357i -0.4619 - 0.1913i 0.4619 + 0.1913i	0.5000 0.2357 - 0.4410i 0.4619 + 0.1913i 0.1913 - 0.4619i
010010	18	0.5000 -0.2778 - 0.4157i -0.3536 - 0.3536i -0.3536 + 0.3536i	0.5000 0.4157 - 0.2778i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.2778 + 0.4157i -0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 -0.4157 + 0.2778i 0.3536 + 0.3536i -0.3536 - 0.3536i
010011	19	0.5000 0.0490 + 0.4976i -0.1913 - 0.4619i 0.1913 + 0.4619i	0.5000 -0.4976 + 0.0490i 0.1913 + 0.4619i 0.4619 - 0.1913i	0.5000 -0.0490 - 0.4976i -0.1913 - 0.4619i -0.1913 - 0.4619i	0.5000 0.4976 - 0.0490i 0.1913 + 0.4619i -0.4619 + 0.1913i
010100	20	0.5000 0.1913 - 0.4619i - 0.5000i 0.5000	0.5000 0.4619 + 0.1913i 0.5000i - 0.5000i	0.5000 -0.1913 + 0.4619i - 0.5000i -0.5000	0.5000 -0.4619 - 0.1913i 0.5000i 0.5000i
010101	21	0.5000 -0.3865 + 0.3172i 0.1913 - 0.4619i 0.1913 - 0.4619i	0.5000 -0.3172 - 0.3865i -0.1913 + 0.4619i -0.4619 - 0.1913i	0.5000 0.3865 - 0.3172i 0.1913 - 0.4619i -0.1913 + 0.4619i	0.5000 0.3172 + 0.3865i -0.1913 + 0.4619i 0.4619 + 0.1913i
010110	22	0.5000 0.4904 - 0.0975i 0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 0.0975 + 0.4904i -0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 -0.4904 + 0.0975i 0.3536 - 0.3536i 0.3536 + 0.3536i	0.5000 -0.0975 - 0.4904i -0.3536 + 0.3536i 0.3536 - 0.3536i
010111	23	0.5000 -0.4785 - 0.1451i 0.4619 - 0.1913i -0.4619 + 0.1913i	0.5000 0.1451 - 0.4785i -0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 0.4785 + 0.1451i 0.4619 - 0.1913i 0.4619 - 0.1913i	0.5000 -0.1451 + 0.4785i -0.4619 + 0.1913i -0.1913 - 0.4619i
011000	24	0.5000 0.3536 + 0.3536i 0.5000 0.5000i	0.5000 -0.3536 + 0.3536i -0.5000 0.5000	0.5000 -0.3536 - 0.3536i 0.5000 -0.5000i	0.5000 0.3536 - 0.3536i -0.5000 -0.5000

Table 928—$C_{base,UL}(4,4,6)$

011001	25	0.5000 -0.1451 - 0.4785i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 0.4785 - 0.1451i -0.4619 - 0.1913i 0.1913 - 0.4619i	0.5000 0.1451 + 0.4785i 0.4619 + 0.1913i -0.4619 - 0.1913i	0.5000 -0.4785 + 0.1451i -0.4619 - 0.1913i -0.1913 + 0.4619i
011010	26	0.5000 -0.0975 + 0.4904i 0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000 -0.4904 - 0.0975i -0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 0.0975 - 0.4904i 0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 0.4904 + 0.0975i -0.3536 - 0.3536i 0.3536 + 0.3536i
011011	27	0.5000 0.3172 - 0.3865i 0.1913 + 0.4619i -0.1913 - 0.4619i	0.5000 0.3865 + 0.3172i -0.1913 - 0.4619i -0.4619 + 0.1913i	0.5000 -0.3172 + 0.3865i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 -0.3865 - 0.3172i -0.1913 - 0.4619i 0.4619 - 0.1913i
011100	28	0.5000 -0.4619 + 0.1913i 0.5000i -0.5000	0.5000 -0.1913 - 0.4619i - 0.5000i 0.5000i	0.5000 0.4619 - 0.1913i 0.5000i 0.5000	0.5000 0.1913 + 0.4619i -0.5000i -0.5000i
011101	29	0.5000 0.4976 + 0.0490i -0.1913 + 0.4619i -0.1913 + 0.4619i	0.5000 -0.0490 + 0.4976i 0.1913 - 0.4619i 0.4619 + 0.1913i	0.5000 -0.4976 - 0.0490i -0.1913 + 0.4619i 0.1913 - 0.4619i	0.5000 0.0490 - 0.4976i 0.1913 - 0.4619i -0.4619 - 0.1913i
011110	30	0.5000 -0.4157 - 0.2778i -0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.2778 - 0.4157i 0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 0.4157 + 0.2778i -0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000 -0.2778 + 0.4157i 0.3536 - 0.3536i -0.3536 + 0.3536i
011111	31	0.5000 0.2357 + 0.4410i -0.4619 + 0.1913i 0.4619 - 0.1913i	0.5000 -0.4410 + 0.2357i 0.4619 - 0.1913i -0.1913 - 0.4619i	0.5000 -0.2357 - 0.4410i -0.4619 + 0.1913i -0.4619 + 0.1913i	0.5000 0.4410 - 0.2357i 0.4619 - 0.1913i 0.1913 + 0.4619i
100000	32	0.5000 - 0.5000i -0.5000 - 0.5000i	0.5000 0.5000 0.5000 -0.5000	0.5000 0.5000i -0.5000 0.5000i	0.5000 -0.5000 0.5000 0.5000
100001	33	0.5000 -0.2357 + 0.4410i -0.4619 - 0.1913i -0.4619 - 0.1913i	0.5000 -0.4410 - 0.2357i 0.4619 + 0.1913i -0.1913 + 0.4619i	0.5000 0.2357 - 0.4410i -0.4619 - 0.1913i 0.4619 + 0.1913i	0.5000 0.4410 + 0.2357i 0.4619 + 0.1913i 0.1913 - 0.4619i
100010	34	0.5000 0.4157 - 0.2778i -0.3536 - 0.3536i -0.3536 + 0.3536i	0.5000 0.2778 + 0.4157i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 -0.4157 + 0.2778i -0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 -0.2778 - 0.4157i 0.3536 + 0.3536i -0.3536 - 0.3536i
100011	35	0.5000 -0.4976 + 0.0490i -0.1913 - 0.4619i 0.1913 + 0.4619i	0.5000 -0.0490 - 0.4976i 0.1913 + 0.4619i 0.4619 - 0.1913i	0.5000 0.4976 - 0.0490i -0.1913 - 0.4619i -0.1913 - 0.4619i	0.5000 0.0490 + 0.4976i 0.1913 + 0.4619i -0.4619 + 0.1913i
100100	36	0.5000 0.4619 + 0.1913i - 0.5000i 0.5000	0.5000 -0.1913 + 0.4619i 0.5000i - 0.5000i	0.5000 -0.4619 - 0.1913i -0.5000i -0.5000	0.5000 0.1913 - 0.4619i 0.5000i 0.5000i
100101	37	0.5000 -0.3172 - 0.3865i 0.1913 - 0.4619i 0.1913 - 0.4619i	0.5000 0.3865 - 0.3172i -0.1913 + 0.4619i -0.4619 - 0.1913i	0.5000 0.3172 + 0.3865i 0.1913 - 0.4619i -0.1913 + 0.4619i	0.5000 -0.3865 + 0.3172i -0.1913 + 0.4619i 0.4619 + 0.1913i

Table 928—$C_{base,UL}(4,4,6)$

100110	38	0.5000 0.0975 + 0.4904i 0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 -0.4904 + 0.0975i -0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 -0.0975 - 0.4904i 0.3536 - 0.3536i 0.3536 + 0.3536i	0.5000 0.4904 - 0.0975i -0.3536 + 0.3536i 0.3536 - 0.3536i
100111	39	0.5000 0.1451 - 0.4785i 0.4619 - 0.1913i -0.4619 + 0.1913i	0.5000 0.4785 + 0.1451i -0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 -0.1451 + 0.4785i 0.4619 - 0.1913i 0.4619 - 0.1913i	0.5000 -0.4785 - 0.1451i -0.4619 + 0.1913i -0.1913 - 0.4619i
101000	40	0.5000 -0.3536 + 0.3536i 0.5000 0.5000i	0.5000 -0.3536 - 0.3536i -0.5000 0.5000	0.5000 0.3536 - 0.3536i 0.5000 -0.5000i	0.5000 0.3536 + 0.3536i -0.5000 -0.5000
101001	41	0.5000 0.4785 - 0.1451i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 0.1451 + 0.4785i -0.4619 - 0.1913i 0.1913 - 0.4619i	0.5000 -0.4785 + 0.1451i 0.4619 + 0.1913i -0.4619 - 0.1913i	0.5000 -0.1451 - 0.4785i -0.4619 - 0.1913i -0.1913 + 0.4619i
101010	42	0.5000 -0.4904 - 0.0975i 0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000 0.0975 - 0.4904i -0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 0.4904 + 0.0975i 0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 -0.0975 + 0.4904i -0.3536 - 0.3536i 0.3536 + 0.3536i
101011	43	0.5000 0.3865 + 0.3172i 0.1913 + 0.4619i -0.1913 - 0.4619i	0.5000 -0.3172 + 0.3865i -0.1913 - 0.4619i -0.4619 + 0.1913i	0.5000 -0.3865 - 0.3172i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 0.3172 - 0.3865i -0.1913 - 0.4619i 0.4619 - 0.1913i
101100	44	0.5000 -0.1913 - 0.4619i 0.5000i -0.5000	0.5000 0.4619 - 0.1913i - 0.5000i 0.5000i	0.5000 0.1913 + 0.4619i 0.5000i 0.5000	0.5000 -0.4619 + 0.1913i -0.5000i -0.5000i
101101	45	0.5000 -0.0490 + 0.4976i -0.1913 + 0.4619i -0.1913 + 0.4619i	0.5000 -0.4976 - 0.0490i 0.1913 - 0.4619i 0.4619 + 0.1913i	0.5000 0.0490 - 0.4976i -0.1913 + 0.4619i 0.1913 - 0.4619i	0.5000 0.4976 + 0.0490i 0.1913 - 0.4619i -0.4619 - 0.1913i
101110	46	0.5000 0.2778 - 0.4157i -0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.4157 + 0.2778i 0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 -0.2778 + 0.4157i -0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000 -0.4157 - 0.2778i 0.3536 - 0.3536i -0.3536 + 0.3536i
101111	47	0.5000 -0.4410 + 0.2357i -0.4619 + 0.1913i 0.4619 - 0.1913i	0.5000 -0.2357 - 0.4410i 0.4619 - 0.1913i -0.1913 - 0.4619i	0.5000 0.4410 - 0.2357i -0.4619 + 0.1913i -0.4619 + 0.1913i	0.5000 0.2357 + 0.4410i 0.4619 - 0.1913i 0.1913 + 0.4619i
110000	48	0.5000 0.5000 -0.5000 -0.5000i	0.5000 0.5000i 0.5000 -0.5000	0.5000 -0.5000 -0.5000 0.5000i	0.5000 -0.5000i 0.5000 0.5000
110001	49	0.5000 -0.4410 - 0.2357i -0.4619 - 0.1913i -0.4619 - 0.1913i	0.5000 0.2357 - 0.4410i 0.4619 + 0.1913i -0.1913 + 0.4619i	0.5000 0.4410 + 0.2357i -0.4619 - 0.1913i 0.4619 + 0.1913i	0.5000 -0.2357 + 0.4410i 0.4619 + 0.1913i 0.1913 - 0.4619i
110010	50	0.5000 0.2778 + 0.4157i -0.3536 - 0.3536i -0.3536 + 0.3536i	0.5000 -0.4157 + 0.2778i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 -0.2778 - 0.4157i -0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 0.4157 - 0.2778i 0.3536 + 0.3536i -0.3536 - 0.3536i

Table 928—$C_{base,UL}$(4,4,6)

110011	51	0.5000 -0.0490 - 0.4976i -0.1913 - 0.4619i 0.1913 + 0.4619i	0.5000 0.4976 - 0.0490i 0.1913 + 0.4619i 0.4619 - 0.1913i	0.5000 0.0490 + 0.4976i -0.1913 - 0.4619i -0.1913 - 0.4619i	0.5000 -0.4976 + 0.0490i 0.1913 + 0.4619i -0.4619 + 0.1913i
110100	52	0.5000 -0.1913 + 0.4619i - 0.5000i 0.5000	0.5000 -0.4619 - 0.1913i 0.5000i - 0.5000i	0.5000 0.1913 - 0.4619i -0.5000i -0.5000	0.5000 0.4619 + 0.1913i 0.5000i 0.5000i
110101	53	0.5000 0.3865 - 0.3172i 0.1913 - 0.4619i 0.1913 - 0.4619i	0.5000 0.3172 + 0.3865i -0.1913 + 0.4619i -0.4619 - 0.1913i	0.5000 -0.3865 + 0.3172i 0.1913 - 0.4619i -0.1913 + 0.4619i	0.5000 -0.3172 - 0.3865i -0.1913 + 0.4619i 0.4619 + 0.1913i
110110	54	0.5000 -0.4904 + 0.0975i 0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 -0.0975 - 0.4904i -0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 0.4904 - 0.0975i 0.3536 - 0.3536i 0.3536 + 0.3536i	0.5000 0.0975 + 0.4904i -0.3536 + 0.3536i 0.3536 - 0.3536i
110111	55	0.5000 0.4785 + 0.1451i 0.4619 - 0.1913i -0.4619 + 0.1913i	0.5000 -0.1451 + 0.4785i -0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 -0.4785 - 0.1451i 0.4619 - 0.1913i 0.4619 - 0.1913i	0.5000 0.1451 - 0.4785i -0.4619 + 0.1913i -0.1913 - 0.4619i
111000	56	0.5000 -0.3536 - 0.3536i 0.5000 0.5000i	0.5000 0.3536 - 0.3536i -0.5000 0.5000	0.5000 0.3536 + 0.3536i 0.5000 -0.5000i	0.5000 -0.3536 + 0.3536i -0.5000 -0.5000
111001	57	0.5000 0.1451 + 0.4785i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 -0.4785 + 0.1451i -0.4619 - 0.1913i 0.1913 - 0.4619i	0.5000 -0.1451 - 0.4785i 0.4619 + 0.1913i -0.4619 - 0.1913i	0.5000 0.4785 - 0.1451i -0.4619 - 0.1913i -0.1913 + 0.4619i
111010	58	0.5000 0.0975 - 0.4904i 0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000 0.4904 + 0.0975i -0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 -0.0975 + 0.4904i 0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 -0.4904 - 0.0975i -0.3536 - 0.3536i 0.3536 + 0.3536i
111011	59	0.5000 -0.3172 + 0.3865i 0.1913 + 0.4619i -0.1913 - 0.4619i	0.5000 -0.3865 - 0.3172i -0.1913 - 0.4619i -0.4619 + 0.1913i	0.5000 0.3172 - 0.3865i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 0.3865 + 0.3172i -0.1913 - 0.4619i 0.4619 - 0.1913i
111100	60	0.5000 0.4619 - 0.1913i 0.5000i -0.5000	0.5000 0.1913 + 0.4619i - 0.5000i 0.5000i	0.5000 -0.4619 + 0.1913i 0.5000i 0.5000	0.5000 -0.1913 - 0.4619i -0.5000i - 0.5000i
111101	61	0.5000 -0.4976 - 0.0490i -0.1913 + 0.4619i -0.1913 + 0.4619i	0.5000 0.0490 - 0.4976i 0.1913 - 0.4619i 0.4619 + 0.1913i	0.5000 0.4976 + 0.0490i -0.1913 + 0.4619i 0.1913 - 0.4619i	0.5000 -0.0490 + 0.4976i 0.1913 - 0.4619i -0.4619 - 0.1913i
111110	62	0.5000 0.4157 + 0.2778i -0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 -0.2778 + 0.4157i 0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 -0.4157 - 0.2778i -0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000 0.2778 - 0.4157i 0.3536 - 0.3536i -0.3536 + 0.3536i
111111	63	0.5000 -0.2357 - 0.4410i -0.4619 + 0.1913i 0.4619 - 0.1913i	0.5000 0.4410 - 0.2357i 0.4619 - 0.1913i -0.1913 - 0.4619i	0.5000 0.2357 + 0.4410i -0.4619 + 0.1913i -0.4619 + 0.1913i	0.5000 -0.4410 + 0.2357i 0.4619 - 0.1913i 0.1913 + 0.4619i

16.3.10.4.1.1 OL SU-MIMO subset for two transmit antennas

The UL OL SU-MIMO codebook subset for 2Tx is the same as the DL OL SU-MIMO codebook subset for 2Tx. $C_{UL,OL,SU}(2, M_t, N_w) = C_{DL,OL,SU}(2, M_t, N_w)$, and it shall be used for precoding with 2 transmit antennas and M_t MIMO streams with MIMO mode 0 and MIMO mode 1.

16.3.10.4.1.2 OL SU-MIMO subset for four transmit antennas

Table 929 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for four transmit antennas.

Table 929—Size of the UL 4Tx OL SU-MIMO codebook subset

Rank	1	2	3	4
N_w	4	4	4	4

The codewords $C_{UL,OL,SU}(4, M_t, 4, n)$ of the OL SU-MIMO codebook subset for four transmit antennas, $C_{UL,OL,SU}(4, M_t, 4)$ are given in Table 930 for each rank M_t. The corresponding codewords $C_{base,UL}(4, M_t, 6, m)$ of the uplink base codebook for four transmit antennas $C_{base,UL}(4, M_t, 6)$ are given in Table 930.

Table 930—$C_{UL,OL,SU}(4,1,4)$, $C_{UL,OL,SU}(4,2,4)$, $C_{UL,OL,SU}(4,3,4)$ and $C_{UL,OL,SU}(4,4,4)$

$C_{UL,OL,SU}(4, 1, 4, n)$		$C_{UL,OL,SU}(4, 2, 4, n)$		$C_{UL,OL,SU}(4, 3, 4, n)$		$C_{UL,OL,SU}(4, 4, 4, n)$	
n	$C_{base,UL}(4, 1, 6, m)$	n	$C_{base,UL}(4, 2, 6, m)$	n	$C_{base,UL}(4, 3, 6, m)$	n	$C_{base,UL}(4, 4, 6, m)$
0	$C_{base,UL}(4, 1, 6, 9)$	0	$C_{base,UL}(4, 2, 6, 9)$	0	$C_{base,UL}(4, 3, 6, 9)$	0	$C_{base,UL}(4, 4, 6, 9)$
1	$C_{base,UL}(4, 1, 6, 15)$	1	$C_{base,UL}(4, 2, 6, 15)$	1	$C_{base,UL}(4, 3, 6, 15)$	1	$C_{base,UL}(4, 4, 6, 15)$
2	$C_{base,UL}(4, 1, 6, 49)$	2	$C_{base,UL}(4, 2, 6, 49)$	2	$C_{base,UL}(4, 3, 6, 49)$	2	$C_{base,UL}(4, 4, 6, 49)$
3	$C_{base,UL}(4, 1, 6, 55)$	3	$C_{base,UL}(4, 2, 6, 55)$	3	$C_{base,UL}(4, 3, 6, 55)$	3	$C_{base,UL}(4, 4, 6, 55)$

16.3.11 Channel coding and HARQ

16.3.11.1 Channel coding for the data channel

Channel coding procedures for downlink and uplink data channels are shown in Figure 576.

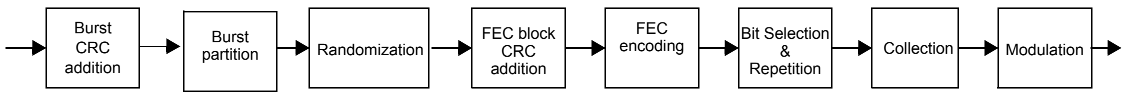

Figure 576—Channel coding procedure for data channel

16.3.11.1.1 Burst CRC encoding

Cyclic Redundancy Code (CRC) bits are used to detect errors in the received packets. A 16-bit burst CRC, for which CRC16-CCITT as defined in ITU-T recommendation X.25 is used, shall be appended to the data burst using the cyclic generator polynomial in Equation (298) if the number of FEC block partitions K_{FB} is larger than 1:

$$g_{DB-CRC}(D) = D^{16} + D^{12} + D^{5} + 1 \qquad (298)$$

Denote the bits of the input data burst by $d_1, d_2, d_3, \ldots, d_{N_{PL}}$ where d_1 is the MSB and N_{PL} is the size of the input data burst. Denote the parity bits produced by the burst CRC generator by $p_1, p_2, p_3, \ldots, p_{16}$. The burst CRC encoding is performed in a systematic form, which means that in GF(2), the polynomial in Equation (299):

$$d_1 D^{N_{PL}+15} + d_2 D^{N_{PL}+14} + \ldots + d_n D^{16} + p_1 D^{15} + p_2 D^{14} + \ldots + p_{15} D^{1} + p_{16} \qquad (299)$$

yields a remainder equal to 0 when divided by $g_{DB-CRC}(D)$.

As an example, if the input data of 4 bytes in hexadecimal is 0x1234ABCD, the burst CRC encoding above yields 16-bit burst CRC of 0x5DF0. Note that this is just for the purpose of giving an example for the burst CRC encoding itself and the burst CRC shall be appended only when the data burst is partitioned into multiple FEC blocks (or $K_{FB} > 1$).

The data burst, including the CRC if appended when $K_{FB} > 1$, is further processed by the burst partition as described in 16.3.11.1.2.

16.3.11.1.2 Burst partition

Only the burst sizes N_{DB} listed in Table 931 are supported in the PHY layer. These sizes include the addition of CRC (per burst and per FEC block) when applicable. Other sizes require padding to the next burst size.

When the burst size including 16 CRC bits for a data burst and/or FEC blocks exceeds the maximum FEC block size, N_{FB_MAX}, the burst is partitioned into K_{FB} FEC blocks.

Table 931—Burst size

idx	N_{DB} (byte)	K_{FB}	idx	N_{DB} (byte)	K_{FB}	idx	N_{DB} (byte)	K_{FB}
1	6	1	23	90	1	45	1200	2
2	8	1	24	100	1	46	1416	3
3	9	1	25	114	1	47	1584	3
4	10	1	26	128	1	48	1800	3
5	11	1	27	144	1	49	1888	4
6	12	1	28	164	1	50	2112	4
7	13	1	29	180	1	51	2400	4
8	15	1	30	204	1	52	2640	5
9	17	1	31	232	1	53	3000	5
10	19	1	32	264	1	54	3600	6
11	22	1	33	296	1	55	4200	7
12	25	1	34	328	1	56	4800	8
13	27	1	35	368	1	57	5400	9
14	31	1	36	416	1	58	6000	10
15	36	1	37	472	1	59	6600	11
16	40	1	38	528	1	60	7200	12
17	44	1	39	600	1	61	7800	13
18	50	1	40	656	2	62	8400	14
19	57	1	41	736	2	63	9600	16
20	64	1	42	832	2	64	10800	18
21	71	1	43	944	2	65	12000	20
22	80	1	44	1056	2	66	14400	24

The burst size index is calculated as

$$idx = I_{MinimalSize} + I_{SizeOffset} \quad ,$$

where $I_{SizeOffset} \in \{0, 1, \ldots, 31\}$ is a 5 bits index in A-MAP IE, and $I_{MinimalSize}$ is calculated based on the allocation size as shown in Table 932. The allocation size is defined as the number of LRUs multiplied by the STC rate allocated for the burst . In the case of long TTI, the number of LRUs is calculated as the number of AAI subframes in TTI multiplied by the number of LRUs per AAI subframe. For allocaton size 185~192, $I_{SizeOffset}$ = 31 is invalid.

Table 932—Minimal size index as a function of the allocation size

Allocation size	$I_{MinimalSize}$	Allocation size	$I_{MinimalSize}$	Allocation size	$I_{MinimalSize}$
1 ~ 3	1	16 ~ 18	15	58 ~ 64	26
4	2	19 ~ 20	16	65 ~ 72	27
5	4	21 ~ 22	17	73 ~ 82	28
6	6	23 ~ 25	18	83 ~ 90	29
7	8	26 ~ 28	19	91 ~ 102	30
8	9	29 ~ 32	20	103 ~ 116	31
9	10	33 ~ 35	21	117 ~ 131	32
10 ~ 11	11	36 ~ 40	22	132 ~ 145	33
12	12	41 ~ 45	23	146 ~ 164	34
13	13	46 ~ 50	24	165 ~ 184	35
14 ~ 15	14	51 ~ 57	25	185 ~ 192	36

The modulation order N_{mod} (2 for QPSK, 4 for 16-QAM and 6 for 64-QAM) depends on the parameter $I_{SizeOffset}$ according to Table 933. Allocation size of 1 or 2 LRUs are special cases (separate columns in the table). For allocation of at least 3 LRUs the modulation order depends only on $I_{SizeOffset}$. The allocation size and the value of $I_{SizeOffset}$ are set by the ABS scheduler, which takes into account the resulting modulation order and effective code rate, and according to the link adaptation.

Table 933—Rules for modulation order

$I_{SizeOffset}$	N_{mod} (allocation size > 2)	N_{mod} (allocation size = 2)	N_{mod} (allocation size = 1)
0 ~ 9	2	2	2
10 ~ 15	2	2	4
16 ~18	2	4	6
19 ~ 21	4	4	6
22 ~ 23	4	6	6
24 ~ 31	6	6	6

If a burst is partitioned into more than one FEC block, each partitioned FEC block has same size. The size of the FEC encoder input is denoted by N_{FB}. The set of supported FEC encoder input sizes including FEC block CRC when applicable is the subset of the burst size table, i.e., N_{DB} of idx from 1 to 39 in Table 931.

The burst size N_{DB} including burst CRC and FEC block CRC is defined by Equation (300):

$$N_{DB} = K_{FB} \times N_{FB} \tag{300}$$

The payload size excluding burst CRC and FEC block CRC is defined by Equation (301):

$$N_{PL} = N_{DB} - I_{MFB}N_{DB-CRC} - K_{FB}N_{FB-CRC} \tag{301}$$

where:

I_{MFB} equals 0 when $K_{FB} = 1$, 1 when $K_{FB} > 1$
$N_{FB\text{-}CRC}$ equals 16, which is the size of the FEC block CRC
$N_{DB\text{-}CRC}$ equals 16, which is the size of the burst CRC.

The burst partition block generates K_{FB} FEC blocks, with each FEC block processed by the randomization block as described in 16.3.11.1.3.

16.3.11.1.3 Randomization

The randomization bits are generated using a PRBS generator as shown in Figure 577. The generator polynomial of the PRBS generator is $1 + X^{14} + X^{15}$. The initial vector of the PRBS generator shall be designated $b_0 \ldots b_{14}$.

The data byte to be transmitted shall enter sequentially into the randomization, MSB first. The data bits are XOR-ed with the output of the PRBS generator, with the MSB of the data burst XOR-ed with the first bit of the PRBS generator output.

The randomization is initialized with the initial vector for each FEC block.

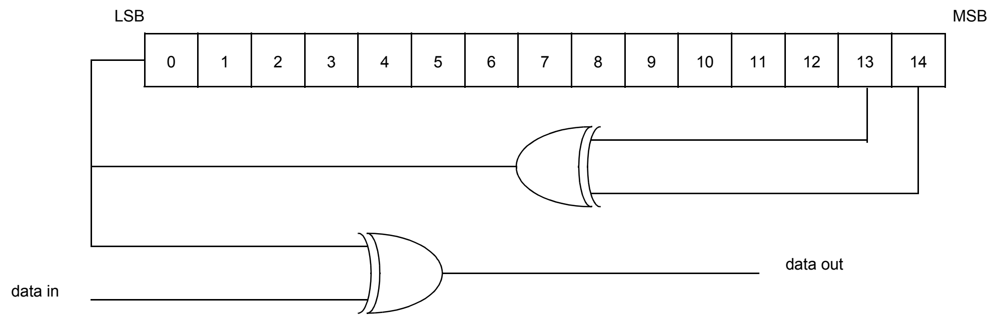

Figure 577—The Data randomization with a PRBS generator

The output of the data randomization is further processed by FEC block CRC addition block as described in 16.3.11.1.4.

16.3.11.1.4 FEC block CRC encoding

The burst partition procedure generates K_{FB} FEC blocks for each burst. The FEC block CRC generator appends a 16-bit FEC block CRC for each FEC block. For the 16-bit FEC block CRC, CRC16-ANSI is used with the CRC register preset to all-zeros but without post-inversion of the CRC encoding result. The cyclic generator for FEC block CRC encoding is shown in Equation (302):

$$g_{FB-CRC}(D) = D^{16} + D^{15} + D^2 + 1 \quad (302)$$

Denote the bits of FEC encoder input by $d_1, d_2, ..., d_{N_{FB}}$ with d_1 being the MSB and N_{FB} being the size of the FEC encoder input, including the 16-bit FEC block CRC. Denote the parity bits produced by the FEC block CRC generator by $p_1, p_2, ..., p_{16}$. The FEC block CRC encoding is performed in a systematic form, which means that in GF(2), the polynomial in Equation (303):

$$d_1 D^{N_{FB}-1} + d_2 D^{N_{FB}-2} + \ldots + d_{N_{FB}-16} D^{16} + p_1 D^{15} + p_2 D^{14} + \ldots + p_{15} D^1 + p_{16} \quad (303)$$

yields a remainder equal to 0 when divided by $g_{FB-CRC}(D)$.

As an example, if the input data of 4 bytes in hexadecimal is 0x1234ABCD, the FEC block CRC encoding above yields 16-bit CRC of 0x9332.

16.3.11.1.5 FEC encoding

Each FEC block shall be encoded using the convolutional turbo codes specified in 16.3.11.1.5.1.

16.3.11.1.5.1 Convolutional turbo codes

CTC encoder

The CTC encoder, including its constituent encoder, is depicted in Figure 578.

It uses a double binary CRSC (Circular Recursive Systematic Convolutional) code.

The bits of the data to be encoded are alternatively fed to A and B, starting with the MSB of the first byte being fed to A, followed by the next bit being fed to B. The encoder is fed by blocks of N_{FB} bits or N couples ($N_{FB} = 2N$ bits).

The polynomials defining the connections are described in octal and symbol notations as follows:

For the feedback branch: 13, equivalently $1 + D + D^3$ (in octal notation)
For the Y parity bit: 15, equivalently $1 + D^2 + D^3$
For the W parity bit: 11, equivalently $1 + D^3$

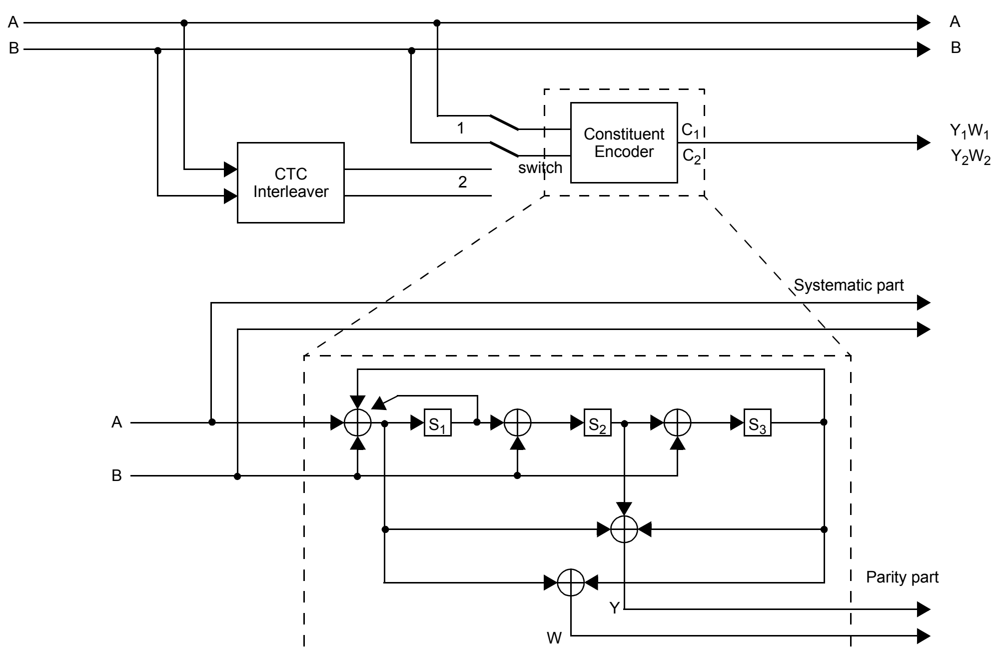

Figure 578—CTC encoder

First, the encoder (after initialization by the circulation state S_{c1}, see 8.4.9.2.3.) is fed the sequence in the natural order (switch 1 in Figure 578) with incremental address $i = 1, 2, \ldots, N$. This first encoding is called C_1 encoding.

Next, the encoder (after initialization by the circulation state S_{C_2}, see 8.4.9.2.3.3) is fed by the interleaved sequence (switch 2 in Figure 578) with incremental address $i = 1, 2, \ldots, N$. This second encoding is called C_2 encoding.

The order in which the encoded bits shall be fed into the bit separation block (see 8.4.9.2.3.4) is:

$$A,B,Y_1,Y_2,W_1,W_2 = A_0,A_1,A_2...,A_{N-1},B_0,B_1,B_2,B_{N-1},Y_{1,0},Y_{1,1},Y_{1,2},...Y_{1,N-1}, Y_{2,0},Y_{2,1},Y_{2,2},...Y_{2,N-1},W_{1,0},W_{1,1},W_{1,2},...W_{1,N-1},W_{2,0},W_{2,1},W_{2,2},...W_{2,N-1}.$$

CTC interleaver

The CTC interleaver requires the parameters *P*0, *P*1, *P*2, and *P*3 shown in Table 934.

The detailed interleaver structures except table for interleaver parameters correspond to 8.4.9.2.3.2.

Table 934—Interleaver Parameters

Index	N_{FB}	P_0	P_1	P_2	P_3	Index	N_{FB}	P_0	P_1	P_2	P_3
1	48	5	0	0	0	21	568	19	102	140	226
2	64	11	12	0	12	22	640	23	84	296	236
3	72	11	18	0	18	23	720	23	130	156	238
4	80	7	4	32	36	24	800	23	150	216	150
5	88	13	36	36	32	25	912	29	14	264	94
6	96	13	24	0	24	26	1024	29	320	236	324
7	104	7	4	8	48	27	1152	31	534	372	246
8	120	11	30	0	34	28	1312	31	214	160	506
9	136	13	58	4	58	29	1440	41	288	556	672
10	152	11	38	12	74	30	1632	29	334	564	66
11	176	17	52	68	32	31	1856	47	576	212	728
12	200	11	76	0	24	32	2112	43	96	720	980
13	216	11	54	56	2	33	2368	47	228	440	724
14	248	13	6	84	46	34	2624	47	378	1092	1250
15	288	17	74	72	2	35	2944	41	338	660	646
16	320	17	84	108	132	36	3328	37	258	28	1522
17	352	17	106	56	50	37	3776	53	772	256	408
18	400	19	142	0	142	38	4224	59	14	668	1474
19	456	17	184	0	48	39	4800	53	66	24	2
20	512	19	64	52	124						

Determination of CTC circulation states

Correspond to 8.4.9.2.3.3.

Bit separation

Correspond to 8.4.9.2.3.4.1.

Subblock interleaving

The subblock interleaver requires the parameters *m* and *J* shown in Table 935.

The detailed subblock interleaver structures except table for subblock interleaver parameters correspond to 8.4.9.2.3.4.2.

Table 935—Parameters for the subblock interleavers

Index	N_{FB}	*m*	*J*	*Index*	N_{FB}	*m*	*J*	*Index*	N_{FB}	*m*	*J*	*Index*	N_{FB}	*m*	*J*
1	48	3	3	11	176	5	3	21	568	7	3	31	1856	9	2
2	64	4	2	12	200	5	4	22	640	7	3	32	2112	9	3
3	72	4	3	13	216	5	4	23	720	7	3	33	2368	9	3
4	80	4	3	14	248	6	2	24	800	7	4	34	2624	9	3
5	88	4	3	15	288	6	3	25	912	8	2	35	2944	9	3
6	96	4	3	16	320	6	3	26	1024	8	2	36	3328	9	4
7	104	4	4	17	352	6	3	27	1152	8	3	37	3776	10	2
8	120	5	2	18	400	6	4	28	1312	8	3	38	4224	10	3
9	136	5	3	19	456	7	2	29	1440	8	3	39	4800	10	3
10	152	5	3	20	512	7	2	30	1632	8	4				

Bit grouping

The interleaved subblocks shall be multiplexed into four blocks; those four blocks consist of an interleaved A subblock, an interleaved B subblock, a bit-by-bit multiplexed sequence of the interleaved Y1 and Y2 subblock sequences, which is referred to Y, and a bit-by-bit multiplexed sequence of the interleaved W2 and W1 subblock sequences, which is referred to W. Information subblocks, A and B, are by-passed while parity subblocks are multiplexed bit by bit. The bit-by-bit multiplexed sequence of interleaved Y1 and Y2 subblock sequences shall consist of the first output bit from the Y1 subblock interleaver, the first output bit from the Y2 subblock interleaver, the second output bit from the Y1 subblock interleaver, the second output bit from the Y2 subblock interleaver, etc. The bit-by-bit multiplexed sequence of interleaved W2 and W1 subblock sequences shall consist of the first output bit from the W2 subblock interleaver, the first output bit from the W1 subblock interleaver, the second output bit from the W2 subblock interleaver, the second output bit from the W1 subblock interleaver, etc.

After multiplexing subblocks into four blocks, Subblock B and Subblock W are circularly left-shifted by k bits. Subblock Y is circularly left-shifted by 1 bit. When the FEC block size N_{FB} is equal to multiple of the modulation order, k is set as 1. Otherwise, let k be 0. Figure 579 shows interleaving scheme as explained above.

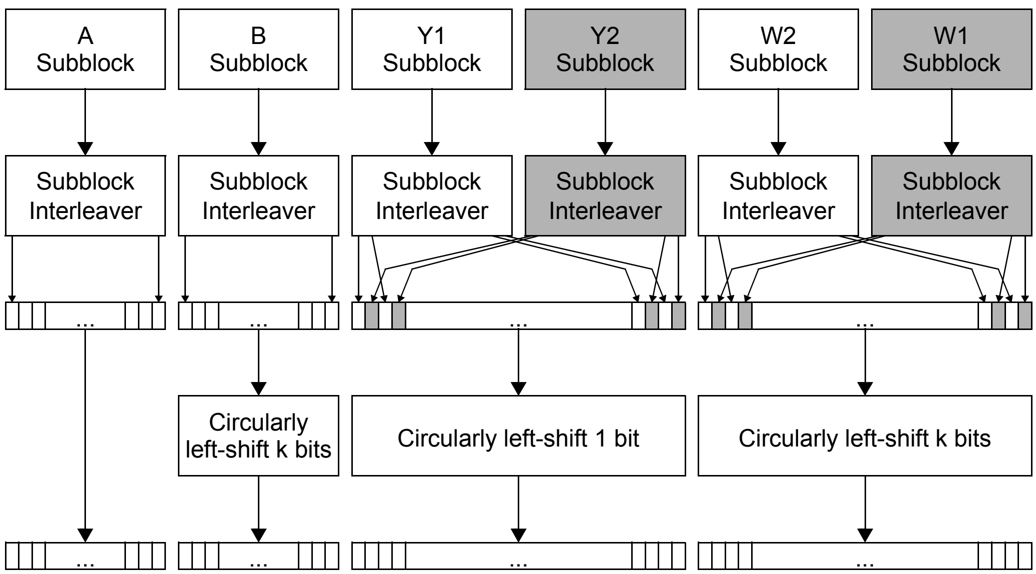

Figure 579—Block diagram of interleaving scheme

Resource segmentation

If $K_{FB} > 1$, the N_{RE} data tones allocated for the subpacket are segmented into K_{FB} blocks, one for each FEC block. The number of data tones for the k^{th} FEC block is defined by Equation (304).

$$N_{RE,k} = 2 \cdot \left\lfloor \frac{\frac{N_{RE}}{2} + (K_{FB} - k - 1)}{K_{FB}} \right\rfloor, 0 \le k < K_{FB} \quad (304)$$

16.3.11.1.6 Bit selection and repetition

Bit selection and repetition are performed to generate the subpacket.

Let $N_{CTC,k}$ be the number of coded bits that shall be transmitted for the k^{th} FEC block. The value of $N_{CTC,k}$ is calculated by Equation (305):

$$N_{CTC,k} = N_{RE,k} \cdot N_{SM} \cdot N_{mod} \quad (305)$$

where N_{SM} is equal to the STC rate allocated for the burst.

The index in the HARQ buffer for the j^{th} bit transmitted for the k^{th} FEC block $u_{k,j,i}$ shall be:

$$N_{shift,i} = i \cdot N_{mod} \quad ;$$

$$index_{k,j,i} = (N_{CTC,k} - N_{shift,i} + j) mod(N_{CTC,k})$$

$$u_{k,j,i} = (P_{i,k} + index_{k,j,i}) \mathrm{mod} N_{FB\_Buffer,k} \;;$$

for $k = 0, \ldots, K_{FB} - 1$, and $j = 0, 1, \ldots, N_{CTC,k} - 1$,where i is the subpacket ID of the subpacket (SPID = i), $P_{i,k}$ is the starting position for subpacket i of the k^{th} FEC block as specified in 16.3.11.4.1, and $N_{FB\_Buffer,k} = 3 \times N_{FB,k}$ is the buffer size for the k^{th} FEC block.

16.3.11.1.7 Bit collection

The selected bits from each FEC block are collected in the order of FEC block for the HARQ transmission.

16.3.11.1.8 Modulation

Corresponds to 8.4.9.4.2.

16.3.11.2 Channel coding for control channel

Tail-biting convolutional codes (TBCC) are used for most of uplink and downlink control channels. The structure of TBCC encoder is depicted in Figure 580. The output encoded bits of rate-1/5 TBCC encoder are separated to five subblocks and each subblock goes through its subblock interleaver. In bit selection block, rate-matching mechanism is implemented by puncture or repetition operation.

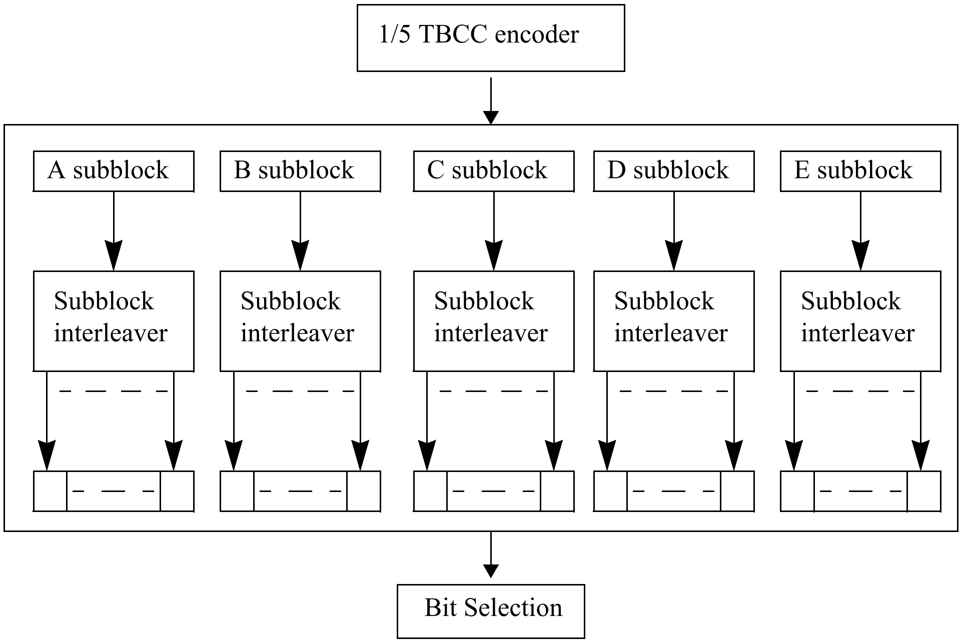

Figure 580—Block diagram of TBCC structure

16.3.11.2.1 TBCC encoder

The binary TBCC shall have mother code rate of 1/5, a constraint length equal to K=7, and shall use the generator polynomials in Equation (306) to derive its five code bits:

$$\begin{aligned} G_1 &= 171_{\mathrm{OCTAL}} && \text{for A} \\ G_2 &= 133_{\mathrm{OCTAL}} && \text{for B} \\ G_3 &= 165_{\mathrm{OCTAL}} && \text{for C} \\ G_4 &= 117_{\mathrm{OCTAL}} && \text{for D} \\ G_5 &= 127_{\mathrm{OCTAL}} && \text{for E} \end{aligned} \tag{306}$$

The TBCC encoder using above generator polynomials is depicted in Figure 581.

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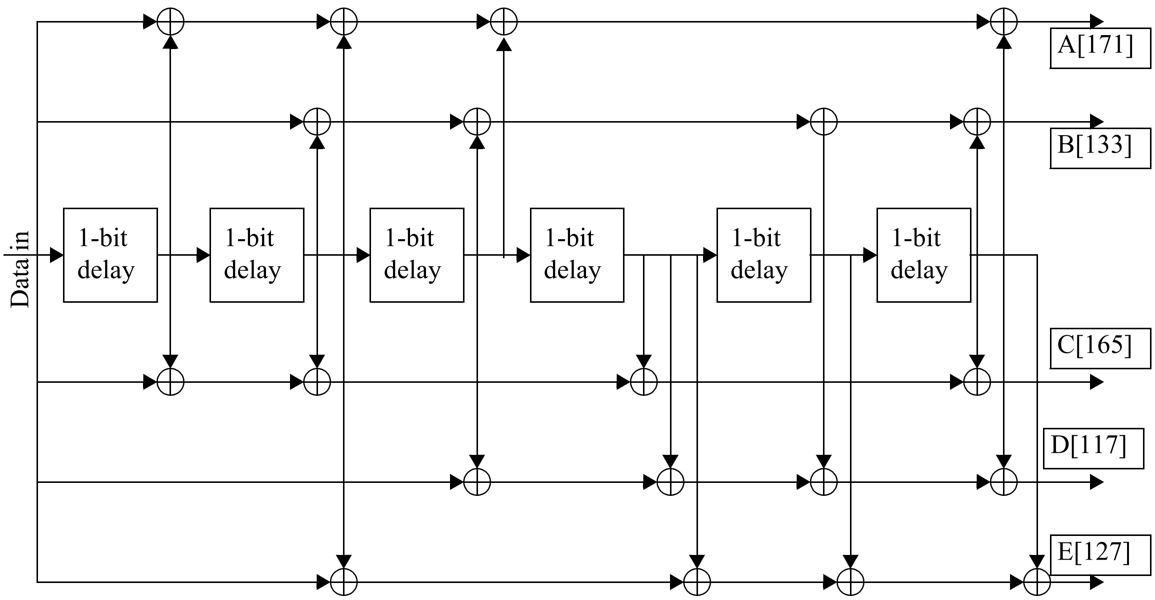

Figure 581—TBCC encoder of rate 1/5

16.3.11.2.2 Bit separation

All of the encoded bits shall be demultiplexed into five subblocks denoted A, B, C, D, and E. Suppose L information bits are input to the encoder. The encoded bits $u[i]$ with $i = 0, \ldots, 5L-1$ shall be distributed into five subblocks with $y^A[k] = u[5k]$, $y^B[k] = u[5k+1]$, $y^C[k] = u[5k+2]$, $y^D[k] = u[5k+3]$, and $y^E[k] = u[5k+4]$ where $k = 0, \ldots, L-1$.

16.3.11.2.3 Subblock interleaver

The five subblocks shall be interleaved separately. The interleaving is performed by the unit of bits. The output of the subblock interleaver $z^j[k]$ with $j = \text{A,B,C,D,E}$ and $k = 0, \ldots, L-1$ is related to the input sequence $y^j[k]$. It can be expressed as $z^j[k] = y^j[\Pi_k]$ where Π_k is the interleaver index. It can be calculated by the following four steps:

a) Initialize x and k to 0.

b) Form a tentative output address $T[x]$ according to the following formula: $T[x] = (15(x+1) + 32(x+1)^2) \bmod 128$

c) If $T[x]$ is less than L, $\Pi_k = T[x]$ and increment x and k by 1. Otherwise, discard $T[x]$ and increment x only.

d) Repeat steps b) and c) until all L interleaver output addresses are obtained.

The maximum value of L must be not greater than 128.

16.3.11.2.4 Bit grouping

The output sequence of subblock interleaver shall consist of the interleaved A, B, C, D, and E subblock sequences. Let the bit grouping output denoted by $w[i]$ with $i = 0, \ldots, 5L-1$. It can be expressed as $w[k] = z^A[k]$, $w[k+L] = z^B[k]$, $w[k+2L] = z^C[k]$, $w[k+3L] = z^D[k]$, and $w[k+4L] = z^E[k]$ with $k = 0, \ldots, L-1$.

16.3.11.2.5 Bit selection

Suppose the desired number of the output bits is M. The output sequence $c[n]$ can be expressed as $c[n] = w[n \bmod K_{bufsize}]$, $n = 0, \ldots, M-1$ where $K_{bufsize} \le 5L$ is the size of buffer used for repetition.

16.3.11.3 Subcarrier randomization

16.3.11.3.1 PRBS for subcarrier randomization

The PRBS generator depicted on Figure 582 shall be used to produce a bit sequence w_k. The polynomial for the PRBS generator shall be $x^{15} + x^{11} + 1$.

The initialization vector of the PRBS generator for both DL and UL shall be designated $b_{14}...b_0$ so that

$b_0 \ldots b_9$ = 10 bits of *IDcell*, where *IDcell* is corresponds to SA-Preamble (in the range 0 to 767)

$b_{10} \ldots b_{14}$ = 1, the values of these bits are always set to 1 for avoiding initial state of all zeros.

The value of the subcarrier randomization sequence, on subcarrier k, are derived from bit w_{k+n}, where n = mod(7*m+f, 64), m = OFDMA symbol number within a frame (the first symbol in frame is indexed 0) and f = frame number within a superframe (in the range 0 to 3). Subcarrier randomization sequence shall be generated for every subcarrier up to the highest numbered usable subcarrier, in order of physical subcarriers, including the DC subcarrier and usable subcarriers that are not allocated. The first usable subcarrier is indexed 0. The output bits of PRBS shall be counted from zero.

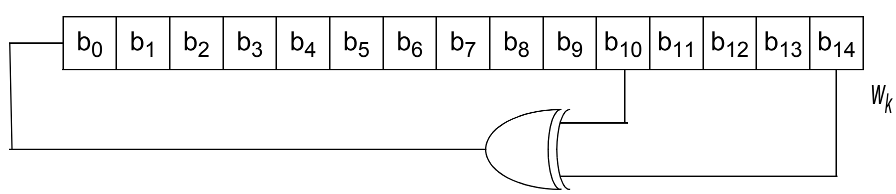

Figure 582—PRBS generator for subcarrier randomization

The subcarrier randomization sequence shall not be applied to the subcarriers belonging to the PA- and SA-Preamble, MIMO midamble, uplink sounding, Initial/HO ranging region, Periodic Ranging and pilot subcarriers of CDR allocations.

For data and pilot subcarriers belonging to E-MBS allocation alternative subcarrier randomization sequence is applied. The sequence is generated as described above, but 10 least significant bits of multicast STID shall be used as $b_0 \ldots b_9$ in PRBS initialization vector instead of *IDcell*.

16.3.11.3.2 Data subcarrier randomization

The constellation-mapped data z_k after precoding shall be subsequently modulated onto the allocated data subcarriers for each antenNA. The data subcarrier symbols z_k of each transmit antenna shall be modulated according to the subcarrier physical index k using Equation (307),

$$c_k = \sqrt{B_d}(1 - 2w_{k+n})z_k; \tag{307}$$

where B_d value shall be set according to number of streams as indicated in Table 936 and Table 937 for downlink and uplink respectively.

Table 936—Downlink data and pilot subcarriers power

number of streams M_t	per stream power on data subcarriers B_d	per stream pilot power B_p	per stream pilot boosting level, dB
1-2	$1 / M_t$	1.5849	2+10*log10(M_t)
3-4		1	10*log10(M_t)
5-8		1	10*log10(M_t)

Table 937—Uplink data and pilot subcarriers power

number of streams M_t	per stream power on data subcarriers B_d	per stream pilot power B_p	per stream pilot boosting level, dB
1-2	$1 / M_t$	1	10*log10(M_t)
3-4		1	10*log10(M_t)

The operation shall be also applied for the subcarriers for the fast-feedback and ACK channels with $B_d = 1$.

16.3.11.3.3 Pilot subcarrier randomization

The pilot subcarriers of each stream shall be modulated after precoding according to Equation(308),

$$c_k = \sqrt{B_p}(1 - 2w_{k+n})z_k; \tag{308}$$

where k corresponds to the physical subcarrier index, the pilot boosting value B_p shall be set according to number of streams as indicated in Table 936 and Table 937 for downlink and uplink respectively.

For UL CSM (collaborative spatial multiplexing) mode, the pilot subcarriers shall be further amplified by $\sqrt{\frac{TNS}{M_t}}$ after applying Equation(308), where *TNS* is a total number of streams in CSM mode.

The per stream pilot boosting provided in Table 936 and Table 937 is defined as power of pilot subcarrier relative to average power of data subcarrier on corresponding data stream.

In Type 1 OL MIMO region, the pilot sequence used to modulate the CoFIP pilot subcarriers shall be obtained from the set of pilot modulation sequences defined in Table 938. The sequence index used for modulation of PRU pilot subcarriers is derived from i= mod(s+t+mod(mod(*IDcell*,256), 7),7), where s is the physical PRU index, t is the physical subframe index.

Table 938—Pilot Modulation Sequences for CoFIP

Sequence index	Pilot Modulation Sequence
0	[-1 -1 1 1 1 -1]
1	[-1 1 -1 -1 1 1]
2	[-1 1 1 1 -1 1]
3	[1 -1 -1 1 1 1]
4	[1 -1 1 -1 -1 1]
5	[1 1 -1 1 -1 -1]
6	[1 1 1 -1 1 -1]

16.3.11.4 HARQ

16.3.11.4.1 IR HARQ

HARQ IR (Incremental Redundancy) is performed by changing the starting position, $P_{i,k}$, of the bit selection for HARQ retransmissions.

For downlink HARQ, the starting point for the bit selection algorithm as described in 16.3.11.1.6 is determined as a function of SPID using Table 939.

Table 939—Starting position determination for downlink HARQ

SPID	Starting position $P_{i,k}$
0	0
1	$(-N_{CTC,k})\bmod N_{FB\_Buffer,k}$
2	$(N_{FB\_Buffer,k}/2 - N_{CTC,k}/2) mod (N_{FB\_Buffer,k})$
3	$(N_{FB\_Buffer,k} - N_{CTC,k}/2) mod (N_{FB\_Buffer,k})$

For uplink HARQ, the starting position for the bit selection algorithm as described in 16.3.11.1.6 is determined as a function of SPID for Equation (309).

$$P_{i,k} = (SPID \cdot N_{CTC,k})\bmod N_{FB\_Buffer,k} \tag{309}$$

For uplink HARQ, subpackets shall be transmitted in cyclic order of SPIDs starting from 0 (or, 0 ->1 -> 2-> 3 -> 0-> ...). In other words, for the t^{th} transmission, the subpacket ID shall be set to SPID = t mod 4.

16.3.11.4.2 Constellation rearrangement

Two constellation re-arrangement (CoRe) versions shall be supported. The costellation rearrangement only applies to 16QAM and 64QAM. In case of QPSK, it is transparent.

Table 940 and Table 941 describes the operations that produce two different CoRe versions for 16QAM and 64QAM according to the number of MIMO streams, respectively, so that the four bits in a 16QAM symbol (the six bits in a 64 QAM) are of the same resilience. In other words, the two bits of higher quality at CoRe-version 0 are of lower quality at CoRe-version 1 while the two bits of lower quality at CoRe-version 0 are of higher quality at CoRe-version 1.

Table 940—Constellation rearrangement version (MIMO stream = 1)

Constellation	Ncbps	CRV	Mapping rule					
16 QAM	4	0	b_0	b_1	b_2	b_3	-	-
16 QAM	4	1	b_3	b_2	b_1	b_0	-	-
64 QAM	6	0	b_0	b_1	b_2	b_3	b_4	b_5
64 QAM	6	1	b_5	b_4	b_3	b_2	b_1	b_0

Table 941—Constellation rearrangement version (MIMO stream > 1)

Constellation	Ncbps	CRV	Mapping rule											
			Even symbol						Odd symbol					
16 QAM	4	0	b_0	b_1	b_2	b_3	-	-	b_4	b_5	b_6	b_7	-	-
16 QAM	4	1	b_1	b_4	b_3	b_6	-	-	b_5	b_0	b_7	b_2	-	-
64 QAM	6	0	b_0	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9	b_{10}	b_{11}
64 QAM	6	1	b_2	b_7	b_0	b_5	b_{10}	b_3	b_8	b_1	b_6	b_{11}	b_4	b_9

In DL HARQ operation, CRV(Constellation Rearrangement Version) is signaled for each subpacket to an AMS as a starting value for CRV. For data initially transmitted using persistent allocated resources, the value of the CRV indicated by DL Persistent Allocation A-MAP IE shall be zero. In UL HARQ operation, the information on CRVs is implicitly known at AMS and ABS and the starting value for CRV of the subpacket i shall be $\lfloor (i \cdot N_{CTC,k}) / N_{FB\_Buffer,k} \rfloor \bmod 2$. The CRV shall be changed to the other version of CoRe in DL and UL HARQ operation whenever the transmitted bits wraparound at the end of circular buffer per SPID.

In DL and UL HARQ operation, the CRV is determined assuming that $N_{shift,i}$ is 0 for all subpakcet i.

16.3.12 Link Adaptation

This section introduces the Link Adaptation scheme which adaptively adjusts radio link transmission formats in response to change of radio channel for both downlink and uplink.

16.3.12.1 DL Link Adaptation

The serving ABS may adapt the modulation and coding scheme (MCS) level based on the channel quality indicator (CQI) and/or HARQ ACK/NACK reported by the AMS.

The serving ABS may adapt the MIMO mode, according to CQI reports from the AMS and considering system parameters, such as: traffic load, number of users, ACK/NACK, CQI variation, preferred MFM etc.

AMS shall measure the DL channel quality and report back to ABS. The exact measurement method used to derive the CQI feedback is implementation specific.

16.3.12.2 UL Link Adaptation

Adaptive modulation and channel coding scheme for UL transmission shall be supported.

The serving ABS may adapt the MCS level based on the UL channel quality estimation, allocated resource size and the maximum transmission power of the AMS. UL control channel (excluding initial ranging channel) transmit power should be adapted based on UL power control.

16.3.13 Modulation accuracy and error vector magnitude (EVM)

The method for calculation of the EVM in IEEE 802.16m shall be the same as that described in 8.1.8.2.3 of IEEE Std 802.16-2009.

16.3.14 Channel quality measurements

16.3.14.1 Introduction

RSSI and CINR measurements and associated statistics can help characterizing signal quality as well as assisting BS in selection/assignment of radio resources to the mobile stations according to their channel conditions. As channel behavior is time-variant, both mean and standard deviation are required to be defined.

16.3.14.2 RSSI mean and standard deviation

The method for calculation of the RSSI and its mean and standard deviation in IEEE 802.16m shall be the same as that described in 8.4.12.2 of IEEE Std 802.16-2009.

16.3.14.3 CINR mean and standard deviation

The method for calculation of the CINR and its mean and standard deviation in IEEE 802.16m shall be the same as that described in 8.4.12.3 of IEEE Std 802.16-2009.

16.4 Support for Femto ABS

16.4.1 General Description

A Femto ABS is an ABS with low transmit power, typically installed by a subscriber in the home or SOHO to provide the access to closed or open group of users as configured by the subscriber and/or the access provider. A Femto ABS is typically connected to the service provider's network via one or multiple wired and/or wireless broadband connection, e.g., Cable, DSL, Wireless-OFDMA reference systems, Advanced WirelessMAN-OFDMA systems, etc.

Femto ABSs operate in licensed spectrum and may use the same or different frequency as macro ABSs. Their coverage may overlap with a macro ABS.

Femto ABS is intended to serve public users like an Open Subscriber Group (OSG), or to serve a Closed Subscriber Group (CSG), which is a set of subscribers authorized by the Femto ABS owner or the network service provider. CSG can be modified by the service level agreement between the subscriber and the network service provider.

16.4.2 Femto base station subscription types

A Femto ABS may belong to one of the following subscription types:

a) CSG-Closed Femto ABS: A CSG-Closed Femto ABS is accessible only to the AMSs, which are in its CSG, except for emergency services. AMSs which are not the members of the CSG, should not try to access CSG-Closed Femto ABSs.

b) CSG-Open Femto ABS: A CSG-Open Femto ABS is primarily accessible to the AMSs that belong to its CSG, while other AMSs, outside CSG, may also access such Femto ABS, and will be served at lower priority. CSG-Open Femto ABS will provide service to such AMSs as long as the QoS of AMSs in its CSG is not compromised.

c) OSG (Open Subscriber Group) Femto ABS: An OSG Femto ABS is accessible to any AMS.

16.4.3 Femto ABS State Diagram

A Femto ABS transitions through multiple states during its operation, as illustrated in Figure 583. On Power-On, it enters the Initialization State. In this state, procedures like configuration of radio interface parameters and time/frequency synchronization should be performed. After attachment to service provider's core network, which may include synchronization to the Macro ABS, it enters the Operational State. In the Operational State, if the Femto ABS becomes unattached to the service providers network or if it fails to meet operational requirements (may include failed synchronization), it reverts to the Initialization State.

In the Operational State, normal and low-duty operation modes are supported. In low-duty mode, the Femto ABS reduces radio interface activity in order to reduce interference to neighbor cells. In the low duty mode, the Femto ABS will alternate between available and unavailable interval (i.e., low-duty operation cycle). A further functional description of low-duty operation mode of Femto ABS can be found in 16.4.10.

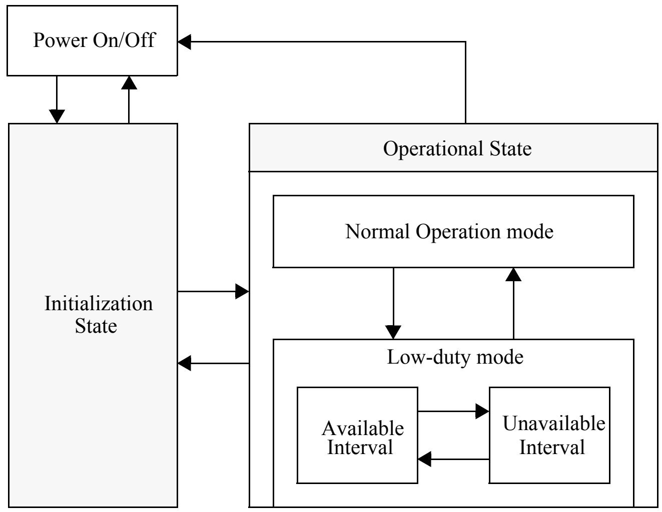

Figure 583—Functional overview of Femto ABS states and operational modes

16.4.4 PHY and MAC level identifier

Femto ABSs are distinguished from Macro ABSs by the use of different SA-Preambles sequences in order to enable early distinction of Femto from the Macro which helps the AMS to avoid unnecessary network (re)entry and handovers to/from a Femto ABS.

A large number of Femto ABSs may be configured with the same CSG, which has the same group of authorized AMSs. A common identifier may be assigned to all CSG femto ABSs which are part of the same CSG. An AMS may use this identifier for accessibility check for the CSG femto ABSs.

The common identifier, CSG ID, is used to identify the BSs belonging to the same CSG. CSG ID shall be unique within the same operator ID. The CSG ID, as a part of the BS ID, may be derived from the full BS ID or may be provided to the CSG Femto ABS during initial network entry in the AAI_REG-RSP or may be pre-provisioned by the network. How to derive the CSG ID from BS ID is out of scope. AMS’s CSG white list may contain the identifiers of allowable femto ABSs.

16.4.4.1 PHY level cell identifier

The indication of a Femto ABS type, i.e. whether it is CSG/OSG is in the SA-Preamble (see 16.3.6.1.2) partitioning of the preamble code space. This partitioning information is broadcasted in the AAI_SCD and SP3 of S-SFH.

16.4.4.2 CSG White list

The CSG white list, is a list of Femto ABSs to which the AMS is subscribed and can access. These femto ABSs are identified based on the common identifier defined in 16.4.4.

AMS's local white list may contain the allowable BS IDs or common identifiers of CSGs and relevant information to help derivation of the allowable BS IDs from common identifier.

The CSG white list may be provided to the AMS by the Femto service provider through the network using messaging that is outside the scope of this standard.

16.4.5 Femto ABS Initialization

The Femto ABS shall perform Femto ABS initialization procedures to register itself to the network and to configure itself through the backhaul connection.

16.4.5.1 Femto ABS attachment to the Macro ABS

For a Femto ABS that uses air interface connection with the overlaid Macro ABS for exchanging control messages, the Femto ABS shall perform the following additional initialization procedure during the Femto ABS initialization procedure.

a) Scan for DL channel and establish synchronization with the Macro ABS

b) Perform ranging

The details of Femto ABS initialization procedure including obtaining and configuring Femto ABS air interfaces operation parameters through the backhaul connection are out of scope of this specification.

16.4.5.2 Femto ABS de-attachment from Network

The Femto ABS de-registration procedure is performed through the backhaul network.

In the case of power down of the Femto ABS, the Femto ABS may send out-of-service information to its associated AMSs. Before powering down or changing to the initialization state, the Femto ABS may request its associated AMSs to perform handover to neighbor cell. When the backhaul link of the Femto ABS is down or the connection with the service provider network is lost for a configurable pre-defined time, the Femto ABS should consider itself de-attached from the network. In such a case, the Femto ABS shall follow the procedure described in 16.4.13 before transitioning to the Initialization or Power Down State.

16.4.6 Network Synchronization for Femto ABS

A Femto ABS should be synchronized with the overlay ABS network, where the synchronization means the aligned frame boundary, and the aligned DL / UL split in TDD systems. The network synchronization may be achieved by Femto ABS scanning the A-Preamble transmitted by the Macro ABSs. If the Femto ABS can successfully detect the Macro ABS A-Preamble, it shall synchronize its downlink transmission with the received A-Preamble signal from Macro ABSs. The Macro ABS A-Preamble scanning for Femto ABS network synchronization may be performed before Femto ABS activation or during the unavailability interval of low duty mode. The Femto ABS may also achieve network synchronization from GPS or backhaul network (e.g. IEEE 1588).

When Femto ABS performs network synchronization by scanning the A-Preamble transmitted by macro ABSs, it may obtain the A-Preamble index of the nearby macro ABSs through the backhaul network. Femto ABS can utilize this information to help on more precise estimation on the frame boundary of the overlay macro cells. When the A-Preambles from neighboring macro ABSs are detected at different time instance within an OFDM symbol duration, Femto ABS should configure its A-Preamble transmission timing to be synchronized with the first A-Preamble it detected within that duration.

When the F-ABS and the macro-ABS operate on the same frequency, the F-ABS shall ensure that the uplink transmission of its associated AMS is aligned with the receive frame of the overlay macro ABS. In order to do this, the Femtocell ABS may add the propagation delay between itself and the macro ABS to the timing offset sent to the AMS in the AAI_RNG_ACK message. The Femtocell ABS may obtain the propagation delay between itself and the macro ABS, through initial ranging with the macro ABS or it can obtain it over the backhaul.

16.4.7 Network Entry

16.4.7.1 Femto ABS detection, identification and selection

The AMS selects the target femto ABS for network entry based on the subscription types of the femto ABS and the membership to the relevant subscribers groups or accessibility to the service providers network (ex: Cell bar).

An AMS shall follow the procedure shown in Figure 584 for discovery of and association with femto ABS. An AMS is considered Femto-Preferred if it has a preference of selecting a femto ABS while macro ABS is within reach.

Figure 584 only applies to macro ABSs, OSG and CSG femto ABSs; nevertheless, if the detected Cell_ID belongs to the set of CSG femto ABSs which may allow limited services to mobile stations that are not subscribed and the AMS is not a member of any CSG, the AMS may continue to detect P-SFH and S-SFH and may proceed to ACCESS STATE, if the AMS cannot be served by other neighboring macro or OSG femto ABSs.

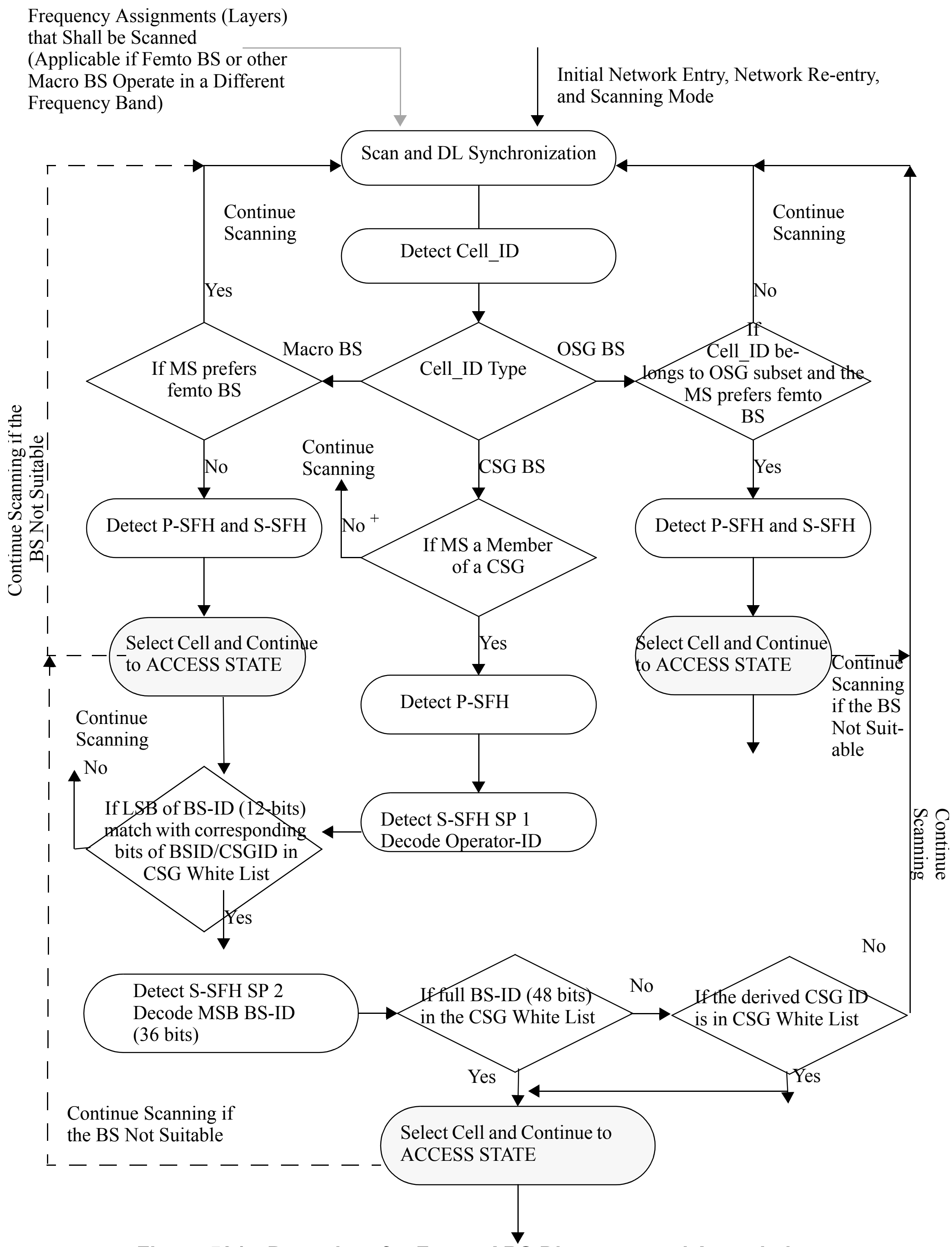

Figure 584—Procedure for Femto ABS Discovery and Association

During network entry or re-entry, the AMS shall begin scanning of the neighbor base stations through RF measurements. The detection of the Cell_ID helps categorizing the ABS type and depending on the preference of the AMS, a macro or femto candidate is selected. Failure in any stage of the cell search and cell selection will result in repeating the scanning and DL synchronization. Cell_ID and associated FA index, and the LSB of BS-ID (or the MSB of BS-ID if SP2 is decoded early prior to SP1) will also help the AMS to quickly exclude the CSG femto ABSs to which it is not subscribed. Full BSID (48 bits) or the derived CSGID is the exact identifier for the AMS to determine whether it is authorized to access to the target ABS. The AMS have the common identifiers in its *White List* (i.e., a local table in the AMS containing the identities of all the CSG femto base stations to which the AMS is subscribed and is authorized to access) in order to be authorized to access to the target femto ABS.

The algorithm illustrated in Figure 584, provides the procedures that the AMS shall follow to complete cell selection/re-selection when femto and macro base stations are deployed on the same or a different FA. If the Femto base stations are deployed in a different FA (inter-FA), the same algorithm shall be applicable except that the AMS scans a different frequency band and conducts RF measurements during scanning in that frequency. The other procedures remain intact and the detected Cell_IDs will only belong to open and/or closed subscriber group femto base stations.

If the Femto and Macro base stations are deployed in the same FA (intra-FA), the same algorithm shall be applicable and the AMS conducts RF measurements during scanning in the same frequency. Combination of the inter-FA and intra-FA scanning is also possible where the neighbor macro base stations operate in the same frequency band and femto base stations operate in a different frequency band(s).

The above algorithm shall be applied to a Femto-Aware mobile station. For a legacy MS WirelessMAN-OFDMA MS or a Femto-Unaware AMS, the cell search and cell selection procedures are identical to those specified in IEEE Std 802.16-2009 and this specification, respectively, and some transparent optimizations may be made that are outside the scope of this specification.

16.4.7.2 Manual Femto ABS Selection

Manual femto ABS selection enables a human user to select a femto ABS and override automatic selection. In manual femto ABS selection, the AMS may scan neighbor femto ABSs accessible to the AMS and reports the list of accessible femto ABS to the user.

An AMS may attempt to access a femto ABS not contained in the CSG white list based on manual selection provided the access credentials can be obtained. Based on the result of the network entry at the femto ABS, the AMS’s CSG white list may be updated.

16.4.7.3 Femto ABS Access Restrictions

AMS should not attempt to access or initiate handover to a CSG-closed femto ABS, which is not contained in the CSG whitelist, except in case of emergency call or manual Femto BS selection (see 16.4.7.2).

16.4.7.4 Ranging

16.4.7.4.1 Ranging Channel Configuration

The ranging channel for synchronized AMSs is used for initial ranging, handover ranging and periodic ranging of a femto cell. BW REQ is done in exactly the same manner as in a regular Macro cell.

16.4.7.5 FemtoABS reselection by AMS

When the AMS is trying to perform initial network entry or network re-entry with a Femto ABS in 802.16m, it first performs initial ranging by sending AAI_RNG-REQ message. AMS may include one or more CSGID(s) as part of the AAI_RNG-REQ message to the Femto ABS, if one or more CSGID(s) is(are) provisioned in the AMS. If the Femto ABS is a CSG Femto ABS, it may have one or more CSGID(s) provisioned in it as well. If it is an open Femto ABS, then there shall be no CSGID provisioned for it.

If the Femto ABS is an open Femto ABS, then the Femto ABS ignores the CSGID(s) (if sent by the AMS) in the AAI_RNG-REQ and goes ahead with the next steps. If the Femto ABS is a CSG Femto ABS, the Femto ABS receives the AAI_RNG-REQ and if needed it looks at the received CSGID(s) and checks if it matches with at least one of its CSGID(s). If there is match of the CSGID, then the Femto ABS knows that the AMS is a member of the Femto ABS and goes ahead with the next steps.

If the received CSGID(s) from the AMS does not match any of the CSGID(s) of the Femto ABS itself, then the Femto ABS shall determine that the AMS is not a member of the Femto ABS and therefore cannot be granted access. In this case, the Femto ABS shall send a AAI_RNG-RSP and in the AAI_RNG-RSP it indicates the rejection of access for this AMS. In order to help the AMS to attach to nearby Femto ABSs, the Femto ABS provides "Redirection Info" to the AMS in the AAI_RNG-RSP message. The "Redirection Info" consists of the ABSID, preamble index and center frequency of other nearby cells.

If the Femto ABS has CSGID info of nearby Femto ABSs, then it may filter the "Redirection Info" based on the CSGID(s) provided by the AMS in the AAI_RNG-REQ message and only provide the open Femto ABSs as well as matching CSG Femto ABSs with matching CSGID(s) to the AMS in the "Redirection Info".

The AMS then can use this "Redirection Info" and try to attach to the other candidate ABSs.

In case the AMS does not support CSG whitelist capability or does not have any CSGID(s) provisioned in its CSG whitelist, the "Redirection Info" may be provided in the AAI_REG-RSP message.

Figure 585 shows the procedure.

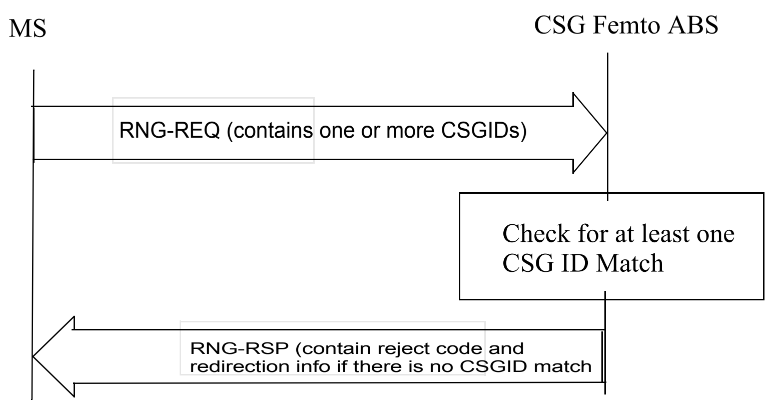

Figure 585—Femto ABS reselection procedure

16.4.8 Handover (HO)

The handover process of an AMS between a Femto ABS and a Macro ABS or between two Femto ABSs will follow the same procedure as described in section 16.2.6 with the exception of procedures described in this section. The handover process of an AMS between a femto ABS and a legacy system BS will follow the same procedure as described in section 16.2.6.4 with the exception of procedures described in this section. For Femto ABSs that support the WirelessMAN-OFDMA MSs they shall follow the same procedure as described in section 6.3.21 for WirelessMAN-OFDMA Reference System.

The AMS with high mobility should not handover into a Femto ABS.

16.4.8.1 Network Topology Acquisition

16.4.8.1.1 Network Topology Advertisement

Femto ABS shall broadcast a list of neighboring macro ABSs, and may broadcast OSG femto ABSs and/or macro hotzone ABSs via AAI_NBR-ADV.

After the AMS associateds with femto ABS, the femto ABS may unicast a list of accessible neighboring femto ABSs. The accessible femto ABS list may contain OSG femto ABSs, CSG-closed femto ABSs serving CSGs that the AMS belonging to, and CSG-open femto ABSs. An AMS may request accessible femto ABS list from the femto ABS by sending the AAI_NBR-REQ message.

The macro ABS may broadcast system information of OSG Femto ABSs in AAI_NBR-ADV message.

16.4.8.1.2 AMS scanning of neighbor Femto ABSs

For neighbor Femto ABSs, an AMS performs the scanning procedure as per 16.2.6.1.2 with exceptions described in this subsection. An AMS may scan femto ABSs according to the FAs included in the broadcast AAI_NBR-ADV message. AMS may scan femto ABSs that are not included in AAI_NBR-ADV based on SA-preamble partitioning information (see 16.4.4). In addition, an AMS may scan allowed femto ABSs based on the CSG White List. Based on location information, AMS may initiate the scanning procedure (See 16.2.6.1.2). The AMS may request additional scanning opportunity by sending AAI-SCN-REQ including the detected SA-preamble index and FA information. Upon reception of the AAI_SCN-REQ, the ABS shall respond with an AAI_SCN-RSP including neighbor accessible Femto ABS list based on the SA-preamble index.

Alternatively, an overlapped Macro ABS may recommend CSG Femto ABS to monitor UL signaling of accessible AMS which is served by the Macro ABS. If CSG Femto ABS is in low-duty mode, the CSG Femto ABS can try to receive A-MAP information from overlapped Macro ABS and then monitor accessible AMS's UL signaling in associated allocations. If CSG Femto ABS is not in low-duty mode, overlapped Macro ABS may trigger dedicated periodic ranging (see 15.4.7.4.2) for the AMS. A CSG Femto ABS can monitor the ranging preamble at the dedicated ranging slot of Macro ABS. When the received signaling quality (e.g RSSI) of an AMS is stronger than a threshold, CSG Femto ABS can request overlapped Macro ABS to send unsolicited AAI_SCN-RSP for the AMS to scan the CSG Femto ABS.

When the AMS has to request for information of neighboring Femto ABSs belonging to a CSG then the AMS can provide the desired CSGID(s) in the AAI_SCN-REQ message to the serving ABS. The ABS can respond with a list of ABSs, addressed by BSID belonging to the requested CSGID(s) in AAI_SCN-RSP message.

ABS may send an unsolicited AAI_SCN-RSP for the AMS to scan the Femto ABS.

After scanning, the AMS may report FA and preamble indices or BS IDs by sending AAI_NBR-REQ or AAI-SCN-REP with neighbor request indication, to which the ABS may unicast an AAI_NBR-ADV that includes a list of femto ABSs which is formed based on the reported FA, A-preamble indexor BSIDs, or the reported measurement, or any other recommended Femto ABSs based on location information.

Upon identifying the existence of any Femto ABSs, the AMS may transmit an AAI_SCN-REP message including the list of the detected Femto ABSs and measurement results according to the Trigger conditions included in the AAI_SCD message.

If the AMS decides to perform HO to any Femto ABS, it may request more detailed system information of the detected neighbor Femto ABSs to the serving ABS using an AAI_NBR-REQ message.

AMS may include the CSGID(s) of the subscribed CSG femto BSs in the AAI_NBR-REQ message.

16.4.8.2 Trigger condition definitions

Per BS type, an AMS and a ABS may apply different trigger condition for scanning and handover.

16.4.8.3 HO Decision

AMS may access unsubscribed CSG-Open femto ABSs if no candidate ABSs are available at the AMS after scanning macro and accessible femto ABSs.

After the decision of HO to a Femto ABS, the AMS shall follow the HO procedures as described in 16.2.6.

16.4.8.4 HO from Macro ABS to Femto ABS

When an AMS hands over from a Macro ABS to a femto ABS, the AMS shall follow the procedure in 16.2.6.

16.4.8.5 HO from Femto ABS to Macro ABS or other Femto ABS

The handover procedures from a serving Femto ABS to a target macro ABS shall be the same as defined per 16.2.6 with the exceptions as defined in this subsection.

16.4.8.6 HO between femto ABS and legacy system BS

An AMS served by a WirelessMAN-OFDMA BS may discover an AAI only Femto ABS through blind scanning and decides to directly HO to the Femto ABS. In this case, the AMS perform direct HO procedure per 16.2.6.4.1.2.2.

An AMS served by an AAI only Femto ABS may discover a WirelessMAN-OFDMA BS through blind scanning or scanning directed by indication information in AAI_NBR-ADV.

16.4.9 Idle Mode

Femto ABS shall support idle mode.

The Femto ABSs operate like macro ABSs in Idle mode.

An AMS with CSG white list shall not attach to an unsubscribed CSG-Closed Femto ABS in Idle mode.

A CSG-Closed Femto ABS should not broadcast paging for a non-member AMS.

16.4.10 Low-duty Operation Mode

16.4.10.1 General description

Besides the normal mode, Femto ABSs may support low-duty mode, in order to reduce interference to neighbor cells.

The low-duty mode consists of available intervals (AI) and unavailable intervals (UAI). During an AI, the Femto ABSs may become active on the air interface for activities such as paging, transmitting system information, ranging or for data traffic transmission. During a UAI, it does not transmit on the air interface. A

UAI may be used for synchronization with the overlay macro BS or measuring the interference from neighbor cells.

The Femto ABS may enter low-duty mode if there are no AMSs attached to the Femto ABS and there are no AMSs in the process of network entry.

The Femto ABS in low-duty mode schedules an AI whenever there is an operational requirement for this. This means that the AIs at the Femto ABS comprise at least all AIs of the paging cycle and of the Default LDM pattern. Figure xxx provides an example with one AMS in idle mode.

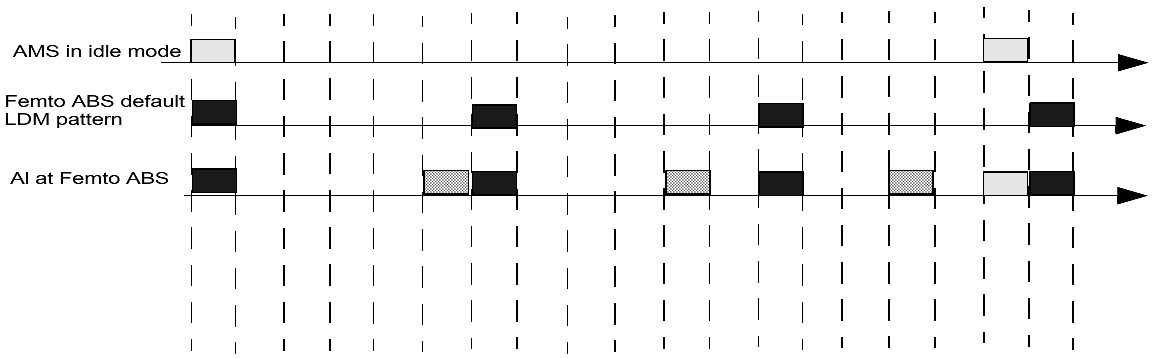

Figure 586—Example of operation in low-duty mode

16.4.10.2 Default LDM pattern(s)

A Sequence of availability and unavailability intervals forms an LDM pattern. The Default LDM pattern is the iteration of one available interval and one unavailable interval. An available interval for Default LDM pattern begins with the frame including the PA-Preamble. The Default LDM pattern is a subset of the available intervals at the Femto ABS.

The Default LDM pattern parameters include:

– Available interval (in units of four frames)

– Unavailable interval (in units of four frames)

– Start Superframe offset

The AI starts at the Superframe number 'N' where

N modulo (AI+ UAI) == Start Superframe Offset

Once a Femto ABS enters low duty mode, the Default LDM pattern of the Femto ABS may be activated.

There may be one or more default LDM patterns in a Femto ABS deployment. The Default LDM pattern(s) parameters can be pre-provisioned or unicasted to the AMS during initial network entry with the Femto ABS in the AAI_REG-RSP message.

16.4.11 Interference Avoidance and Interference Mitigation

Large interference from an inaccessible Femto ABS may trigger a nearby AMS to report the interference to the serving ABS, and the report information should include system information of the inaccessible Femto ABS (e.g., BS_ID of the Femto ABS).

An AMS may initiate or be requested to report the signal strength measurements of its neighbor ABSs to its serving ABS. The reported information can be used by the serving ABS to coordinate interference mitigation (e.g. reducing transmission power and/or blocking resource regions) with its neighbor ABSs.

If an AMS is placed into outage by a CSG-closed Femto ABS of which it is not a member, it can indicate this problem to that Femto ABS by sending an AAI_RNG-REQ with the "Femto Interference" bit set to 1.

The interference between Femto and/or macro can be mitigated by static or semi-static radio resource reservation and resource sharing using FDM and/or TDM manner and/or DL power control. The operation of resource reservation shall not contradict with the FFR operation defined in 20.1. Femto ABSs shall also utilize FFR partitions in the DL and UL using the same signaling and procedures as used by the macro ABSs. FFR partitions used by the Femto ABSs may be different in terms of size, subchannel assignment, and transmit power level than those used on macro ABSs. One or more FFR partitions may be used as the radio resource region where Femto ABSs are not allowed to transmit. The blocked region size may increase if the number of AMSs interfered by Femto ABS becomes larger ; and the blocked region size may decrease if the number of AMSs interfered by Femto ABS becomes smaller. A Femto ABS may detect and reserve the resources autonomously, or in cooperation with the overlay macro ABS.

A Femto ABS may select the carrier frequency, or frequency partition to avoid the mutual interference between macro/micro and Femto ABSs or among Femto ABSs based on the measurement result of surrounding reception power.

Femto ABS may measure the signal strength for the carrier frequency, or frequency partition of the neighbor macro/micro/femto cells. In addition, the Femto ABS may receive A-Preamble from the neighbor macro/micro/femto cells and obtain information on cell type. The Femto ABS may select its carrier frequency, or frequency partition based on signal strength and the cell type information of its neighbors.

AMS sends AAI_RNG-REQ with the "Femto Interference" bit set to 1 based on configured trigger conditions.

Upon CSG-Closed Femto ABS receiving an AAI_RNG-REQ with the "Femto Interference" bit set to 1, it may either reduce its transmit power locally or communicate with the network entity.

Upon communication with the network entity, the CSG-Closed Femto ABS may convert to a CSG-Open Femto ABS or reduce its transmit power as directed by the network entity or refrain from transmitting on certain resource regions as indicated by the network entity.

16.4.12 Power Control

Both uplink and downlink power control should be supported by the Femto ABSs.

16.4.12.1 Downlink Power Control

The Femto ABS shall set the maximum downlink transmit power and should take into account building penetration losses.

16.4.13 Femto ABS Reliability

The Femto ABS shall disable downlink air interface transmitter as soon as the connection with the service provider network is lost for a configurable pre-defined time. Before disabling the air interface, the Femto ABS shall broadcast AAI_SON-ADV message. In such a case, the Femto ABS should support the mechanisms to ensure service continuity of the AMSs prior to disabling air interface. For example, the BS initiated handover depicted in 16.2.6. When a Femto ABS is going to disable the air interface, it shall set the cell bar bit to 1 in order to prevent AMS (re)entry and should broadcast that the air interface is going down through AAI_SON-ADV with Action type 4 with the appropriate Reason bit 0b00 and 0b11, as specified in section <<16.2.3.6>>, repeatedly until it disables the air interface. If handover is to be performed, the indicator may also inform whether the handover will be coordinated or not for AMS to decide what handover procedure it will perform. The AMS may initiate HO to a BS based on the recommended list given by AAI_SON-ADV message or any previously cached neighbor BS list of its preference.

The Femto ABS may store MAC context information of the serving AMSs (e.g. Basic capabilities, Security capabilities, etc.). Such context information allows AMS to perform optimized network reentry when returning back to the Femto ABS upon its recovery.

At the expected uptime, if provided, the AMS may scan the previous Femto ABS if not directed by the network to decide whether to return to it via HO or not.

In the case of Femto ABS resource adjustment due to interference mitigation which may affect some AMS that are originally connected with the Femto ABS, the Femto ABS may send resource-adjustment information to the subordinated AMSs to prevent MSs from out of service using the AAI_SON-ADV with Action Type 4 of Reason bit 01 or 10.

Before executing resource adjustment, the Femto ABS may request some subordinated AMSs to perform handover to neighbor cell if required. The MAC message may be unicast/multicast to the AMSs. The Femto ABS should finish HO initiation and HO preparation phases before it does resource adjustment.

When supporting the Femto ABS reliability improvement functions, the Femto ABS is assumed to equip with backup power buffer to ensure the functions can be performed in a period of time when normal power supply is not available. It is also assumed that Femto ABS is capable to learn the backhaul connection status from the modem (e.g. xDSL or DOCSIS) and configure the message/signaling to support the functions identified in this section.

16.5 Multi-BS MIMO

16.5.1 DL Multi-BS MIMO

Multi-BS MIMO techniques improve sector throughput and cell-edge throughput through multi-BS cooperative signaling. These include single-BS precoding with multi-BS coordination and multi-BS joint processing.

16.5.1.1 DL/UL Signaling

Table 942—Control parameters for DL Multi-BS MIMO

Parameter	Description	Value	Contol channel (IE)	Notes
ICT	Interference coordination type	0b00: PMI restriction 0b01: PMI recommendation 0b10: CL-MD 0b11: Co-MIMO	Feedback Polling A-MAP IE	Indicates which Multi-BS MIMO mode
TRU	Target resource unit	0b00: Latest best subbands reported for single BS MIMO 0b01: Whole bandwidth 0b10: FFR partition 0 0b11: boosted FFR partition	Feedback Polling A-MAP IE	Indicates resource units for feedback measurements
MaxUser	Maximum number of users supported in Co-MIMO	0b00: MaxUser = 2 0b01: MaxUser = 3 0b10: MaxUser = 4 0b10: Reserved	Feedback Polling A-MAP IE	Maximum number of users supported for MU-MIMO transmission with Co-MIMO.
NIP_th_1	NIP threshold for Single BS precoding with Multi-BS Coordination trigger	4 bits	AAI_DL_IM	
NIP_th_2	NIP threshold for DL Multi-BS Joint MIMO Processing trigger	4 bits	AAI_DL_IM	
CINR_th	CINR threshold for Single BS precoding with Multi-BS Coordination and Multi-BS Joint MIMO Processing trigger	4 bits	AAI_DL_IM	Used together with NIP_th_1 or NIP_th_2 for requesting Multi-BS MIMO by the AMS

Co-MIMO and CL-MD can be supported as instructed by the BS in the UL Sounding Command A-MAP IE.

Table 943—Feedback information for DL Multi-BS MIMO supported by codebook based feedback

	Feedback information type	Description
Periodic feedback	Base station ID	Report BS_ID using Temp_BSID. Temp_BSID is diversity set member ID assigned to this ABS.
	PMI report for serving and neighboring cell	For PMI coordination among multiple ABSs
	PMI_coordination_subset indication	Indicating one correlation level or two correlation levels associated with the PMI report for neighboring cell
	Additional measurement metric	SINR gain assuming the reported PMI set is coordinated. This can be used for resolving conflict from multiple AMS.
	Normalized interference power (NIP)	Ratio of average interference power (with or without transmitter precoder) from ABS with BS-ID, to the total interference power plus noise received by AMS, which serves as an indicator of severity of interference.
	CPMI for neighboring cell	Concatenating PMI for neighboring cell
Event-driven feedback	Requesting Multi-BS MIMO	For AMS reporting of its preference on single BS precoding with Multi-BS MIMO coordination or multi-BS joint MIMO processing using the AAI_MULTI_BS_MIMO-REQ control message

Uplink sounding can be used to support Co-MIMO and CL-MD.

For multi-BS MIMO joint processing mode (i.e. CL-MD or Co-MIMO), an ABS shall inform the corresponding AMS of the set of ABSs participating in multi-BS MIMO using the AAI_MULTI_BS_MIMO-RSP control message.

16.5.1.2 Single BS precoding with Multi-BS Coordination

This subclause describes interference mitigation techniques applicable with DL MIMO modes 2 and 4 with codebook-based feedback mode, with additional inter-ABS coordination mechanisms and interference measurement support. The inter-ABS coordination mechanisms in this subclause do not require data forwarding between different ABSs.

16.5.1.2.1 Operation procedure

Two types of single BS precoding techniques with Multi-BS coordination may be supported in AAI. One is PMI coordination, supported by codebook-based feedback, and the other is interference nulling, supported by codebook-based feedback or by uplink sounding.

Single BS precoding with Multi-BS Coordination may be enabled by the ABS for one or several AMSs when CL MIMO precoding with DL MIMO mode 2 or 4 is applied in the serving and neighboring cells. The inter-cell interference can be mitigated by coordinating the precoders applied in neighboring cells via higher layer signaling, based on feedback from AMSs to their respective serving ABSs.

With codebook-based feedback, PMI coordination can be applied as either PMI recommendation or PMI restriction, as instructed by the ABS in Feedback Polling A-MAP IE.

If ICT (interference coordination type) is set to 0b00 in Feedback Polling A-MAP IE, then the AMS finds the PMI which acts as the strongest interference for the neighboring cell in the frequency resource unit indicated by TRU (target resource unit) indicated in Feedback Polling A-MAP IE.

If ICT (interference coordination type) is set to 0b01 in Feedback Polling A-MAP IE, then the AMS finds the PMI which acts as the weakest interference for the neighboring cell in the frequency resource unit indicated by TRU (target resource unit) indicated in Feedback Polling A-MAP IE.

Restricting or recommending the usage of rank-1 codebook elements as a response to the neighboring cell's request is done by the BS transmission of BC_SI in AAI_DL_IM message. Details are in 16.3.7.2.5.6.

The operation procedure of PMI coordination follows the steps below.

1) Once an AMS receives a Feedback Polling A-MAP IE, it shall send AAI_MultiBS_MIMO_FBK periodically with the requested information. This information may include a PMI or a set of PMIs, Temp_BSID (diversity member ID) and additional measurements.

For reporting a set of PMIs, the following procedure shall be performed at the AMS after determining the recommended (or restricted) PMI w_k:

- Considering all PMIs (w_0, w_1, …, w_m) in the rank-1 DL base codebook C(2,1,3,m) for m = 0 to 8 with 2Tx, or in the rank-1 DL base codebook subset C(4,1,6,m) for m = 0 to 15 with 4Tx, or in the rank-1 DL base codebook C(8,1,4,m) for m = 0 to 15 with 8Tx, the AMS calculates the cross correlation of each PMI to the recommended (or restricted) PMI w_k. The cross-correlation between PMIs i and k is defined in Equation (310), with superscript ^{H} indicating conjugate transpose.

$$\rho_{i,k} = \left|w_i^H \times w_k\right| \qquad i = 1, \ldots, N \tag{310}$$

Assume that the N correlation values $\rho_{1,k} \ldots \rho_{N,k}$ are sorted in descending order and then renamed as $r_1 \ldots r_N$ such that:

$$r_1 = \rho_{k,k} = 1 > r_2 = \ldots = r_{n_1} > r_{n_1+1} = \ldots = r_{n_2} > r_{n_2+1} = \ldots = r_{n_3} > \ldots > r_N \tag{311}$$

The AMS determines the size of the subset of PMIs to be jointly recommended (or restricted), based on two fixed correlation levels determined by n_1 and n_2 in Equation (311). The AMS indicates the selection of n_1 or n_2 via PMI_coordination_subset in a AAI_MultiBS_MIMO_FBK. The value of PMI_coordination_subset is specified in Table 944.

Table 944—PMI_coordination_subset

PMI_coordination_subset	Value
0b0	n_1
0b1	n_2

2) Upon receiving feedback from multiple AMSs, an ABS should communicate with neighboring ABSs to coordinate their usage of PMIs via higher layer signaling. The ABS should then broadcast codebook subset information in BC_SI in AAI_DL_IM message to all AMSs in its cell. BC_SI is indicated by a bitmap.

3) The ABS may send a Feedback Allocation A-MAP IE with CM set to 0b11 to selected AMS. Consequently, these AMSs should feedback their desired PMI in the codebook subset broadcasted in BC_SI.

Inter-cell interference nulling can be done using PMI which acts as a strongest interference for the neighboring cell or overhearing neighboring cell's sounding signal.

16.5.1.3 DL Multi-BS Joint MIMO Processing

This subclause introduces interference mitigation techniques based on joint MIMO transmission across multiple ABSs. The ABS and AMS may optionally support one or both adaptive precoding based multi-BS joint processing techniques, e.g. Closed-loop Macro Diversity (CL-MD) and Collaborative MIMO (Co-MIMO) transmission. CL-MD is used with DL MIMO mode 2, while Co-MIMO is used with DL MIMO mode 4. Multi-BS joint MIMO processing may be enabled by the ABS for one or several AMSs when adaptive precoding is applied in the serving and neighboring cells and user data is shared among multiple cells.

16.5.1.3.1 Operation procedure

With adaptive precoding, the precoder matrix **W** is derived from the feedback of the AMS, with codebook-based feedback or sounding-based feedback. Two types of adaptive precoding based multi-BS joint processing are supported, CL-MD and Co-MIMO. When CL-MD is enabled, a single AMS is served jointly by multiple coordinating ABSs. When Co-MIMO is enabled, several AMSs are served jointly by the multiple coordinating ABSs through MU-MIMO scheduling and precoding.

For codebook-based feedback, the AMS(s) choose the PMIs for the serving cell and the neighboring cells based on the respective estimated channel state information. Optionally, the serving ABS can also instruct the AMS(s) to feedback a 3-bit uniformly quantized phase information for each neighboring cell, such that ABS can form a concatenating PMI based on the phase information for the neighboring cells to further improve the system performance. The equation for phase quantization is $p = e^{j2\pi b}$, where b is defined in Table 945:

Table 945—Quantization parameters for *b*

Index	*b*
0	0
1	1/8
2	2/8
3	3/8
4	4/8
5	5/8
6	6/8
7	7/8

When DL Multi-BS joint processing is enabled, radio resource allocation, data mapping and pilot pattern allocation should be aligned among coordinating ABSs. The same data packet is transmitted by the coordinating ABSs on the same time and frequency resources. The same pilot patterns without interlacing shall apply to the coordinating BSs.

The operation procedure of DL Multi-BS Joint Processing follows the steps below.

1) Once an AMS receives a Feedback Polling A-MAP IE, it shall send AAI_MultiBS_MIMO_FBK periodically with the requested information in case of codebook feedback, or send UL sounding as instructed by UL Sounding Command A-MAP IE in case of sounding feedback.
2) Upon receiving feedback from multiple AMSs, in case of codebook feedback, the ABS shall forward the PMIs and CPMI to neighboring ABSs to coordinate the usage of PMIs. In case of sounding feedback, each involved ABS can perform precoding based on the received sounding signal(s) from single AMS for CL-MD or from multiple AMSs for Co-MIMO.

The default number of neighboring ABSs coordinated to support Collaborative MIMO (Co-MIMO) transmission is three.

The Collaborative MIMO Zone (Co-MIMO Zone) is defined to facilitate inter-ABS coordination for supporting Co-MIMO transmission. Co-MIMO Zone is a radio resource region composed by LRUs and sub-frames, where the Co-MIMO Zone utilized by neighboring ABSs for Co-MIMO transmission will associate to the same LRU and sub-frames. The permutation of the Co-MIMO Zone for these ABSs shall be the same.

The Co-MIMO transmission is activated by the backhaul network, which includes the determination of the ABSs involved in Co-MIMO transmission. When activating sounding based Co-MIMO transmission, each Co-MIMO Zone will be allocated for serving one or multiple AMS, and each ABS can have multiple Co-MIMO Zones to different AMS. The associated LRUs, permutation and sub-frames for each Co-MIMO Zone will be negotiated by the ABSs involved in Co-MIMO transmission through the backhaul network before the allocation.

16.5.1.4 Multi-BS MIMO trigger mechanism

ABS broadcasts normalized interference power (NIP) thresholds for 2 types of multi-BS MIMO schemes and one common CINR threshold. The NIP is defined as ratio of average interference power (with or without transmitter precoder) from one dominant interference BS to the total interference power plus noise received by AMS. The AMS may accordingly request the preferred multi-BS MIMO scheme. The operation procedure of the multi-BS MIMO trigger follows the steps below.

1) AMS in normal process of Single-Cell CL MIMO feeds back information for CL MIMO operation.
2) ABS selects a NIP threshold NIP_th_1 for single-BS precoding with multi-BS coordination, a threshold NIP_th_2 for multi-BS joint MIMO processing and a common CINR_th based on network measurements. Then the ABS broadcasts the NIP thresholds NIP_th_1, NIP_th_2 and CINR_th in AAI_DL_IM message.
3) AMS computes its average NIP and checks the trigger conditions. If $\mathrm{NIP} \geq \mathrm{NIP\_th\_1}$ and $\mathrm{NIP} < \mathrm{NIP\_th\_2}$ and $CINR < CINR\_\mathrm{th}$ AMS may request operation with single-BS precoding with multi-BS coordination using the AAI_MULTI_BS_MIMO-REQ message.
    a) AMS feedback its event-driven request to operate single-BS precoding with multi-BS coordination to its serving BS through AAI_MULTI_BS_MIMO-REQ which includes a NIP difference measurement with respect to NIP_th_1.
    b) Once an AMS receives a Feedback Polling A-MAP IE, the procedure outlined in 16.5.1.2.1 will be followed.
4) If $\mathrm{NIP} \geq \mathrm{NIP\_th2}$ and CINR < CINR_th, AMS may request operation with multi-BS joint MIMO processing using the AAI_MULTI_BS_MIMO-REQ message.

a) AMS feedback its event-driven request to operate with multi-BS joint MIMO processing to its serving BS through AAI_MULTI_BS_MIMO-REQ which includes a NIP difference measurement with respect to NIP_th_2.

b) Once an AMS receives a Feedback Polling A-MAP IE, the procedure outlined in 16.5.1.3.1 will be followed.

16.5.2 UL Multi-BS MIMO

16.5.2.1 Single BS precoding with Multi-BS Coordination

This subclause describes interference mitigation techniques applicable with UL MIMO modes 2 and 4 with adaptive codebook precoding, with additional inter-ABS coordination mechanisms and interference measurement support. The inter-ABS coordination mechanisms in this subclause do not require data forwarding between different ABSs.

16.5.2.1.1 DL Signaling

Table 946 shows the control parameters for UL multi-BS MIMO.

Table 946—Control parameters for UL Multi-BS MIMO

Parameter	Description	Value	Contol channel (IE)	Notes
PMImin	PMI minimizing interference		AAI_MultiBS_PMI_COM message	
PCR	PMI combination ratio		AAI_MultiBS_PMI_COM message	

16.5.2.1.2 Operation procedure

Single BS precoding with Multi-BS Coordination is performed by combining two PMIs in TDD or FDD UL transmission for mitigating inter-cell interference (ICI) when CL MIMO precoding is applied for the serving and neighboring cells. One of PMIs maximizes the transmission power of the serving cell; another minimizes interference generated to the neighboring cell.

The operation procedure of PMI combination follows the steps below.

1) PMI combination may be triggered by an ABS in an unsolicited manner. By using UL sounding signals, the serving and neighboring ABSs may measure channels of AMSs. Upon the channel measurements, the serving and neighboring ABSs may determine *PMI* maximizing transmission power and PMI_{min} minimizing interference, respectively. The neighboring ABS may inform the serving ABS of PMI_{min} through the backhaul network.

Two PMIs of the predefined codebook $\{\mathbf{w}_i\}$, should be selected based on the following procedure:

$$PMI = \arg\max_i \|(\boldsymbol{H}_s \boldsymbol{W}_i)\|^2$$
$$PMI_{Min} = \arg\min_i \|(\boldsymbol{H}_I \boldsymbol{W}_i)\|^2 \qquad (312)$$

where $\boldsymbol{H}_S$ and $\boldsymbol{H}_I$ denote information of channels from the AMS to its serving and corresponding neighboring ABS, respectively.

2) The serving ABS shall inform the *PMI* in A-MAP IE and PMI_{min} and PCR (PMI combination ratio) in an AAI_MultiBS_PMI_COM message to the AMS.

The transmitted precoder **W** combining two precoders $(\boldsymbol{W}_{PMI}, \boldsymbol{W}_{PMI_{Min}})$ should be generated as follows:

$$\boldsymbol{W} = \frac{PCR \cdot \boldsymbol{W}_{PMI} + (1 - PCR) \cdot \boldsymbol{W}_{PMI_{Min}}}{\|PCR \cdot \boldsymbol{W}_{PMI} + (1 - PCR) \cdot \boldsymbol{W}_{PMI_{Min}}\|}, \qquad 0 \le PCR \le 1 \qquad (313)$$

(314)

16.5.2.2 UL Multi-BS Joint MIMO Processing

The Advanced Air Interface may support uplink multi-BS MIMO to allow joint reception by multiple ABSs, e.g. macro-diversity combining and cooperative beamforming.

— Collaborative zone initialization: A common radio resource allocation shall be allocated as a collaborative zone among those BSs involved in uplink multi-BS MIMO operation. Uplink sounding signals shall be allocated orthogonally among MSs in the collaborative zone.

— Inter-BS information exchanging and joint processing: With macro-diversity combining enabled, soft decision information in the form of log-likelihood ratios are generated at neighboring BSs, transmitted to anchor BS accompanied with scheduling information through M-SAP/C-SAP primitives (TBD) over backhaul network, and combined at anchor BS. With cooperative beamforming enabled, quantized versions of received signals are generated at neighboring BSs, transmitted to anchor BS accompanied with channel state information and scheduling information through M-SAP/C-SAP primitives (TBD) over backhaul network, and jointly processed at anchor BS.

16.6 Support for Relay

16.6.1 Relay Modes and General Description

In Advance WirelessMAN-OFDMA System, support for relay is an optional feature. The AMSs may associate either with an ARS or an ABS and receive services from the ARS or ABS that they are attached to.

Relaying in Advance WirelessMAN-OFDMA System is performed using a decode and forward paradigm. Both, TDD and FDD modes for Duplexing the DL and UL are supported. In TDD deployments ARSs operate in TTR mode, whereby the access and relay link communications are multiplexed using time division multiplexing within a single RF carrier.

In Advance WirelessMAN-OFDMA System, the ARSs operate in non-transparent mode which essentially means that

a) the ARSs compose the SFH and the A-MAPs for the subordinate stations

b) the ARSs transmit the A-Preamble, SFH and A-MAPs for the subordinate stations.

In Advance WirelessMAN-OFDMA deployment supporting relay, a distributed scheduling model is used where in each infrastructure station (ABS or ARS) schedules the radio resources on its subordinate link. In case of an ARS, the scheduling of the resources is within the radio resources assigned by the ABS. The ABS notifies the ARSs and AMSs of the frame structure configuration. The radio frame is divided into access and relay zones as described in 16.6.3.1.

In the access zone, the ABS and the ARS transmit to, or receive from, the AMSs. In the relay zone, the ABS transmits to the ARSs and the AMSs, or receives from the ARSs and AMSs. The start times of the frame structures of the ABS and ARSs are aligned in time. The ABS and ARSs transmit A-Preamble, SFH, and A-MAPs to the AMSs at the same time.

16.6.2 Medium access control

16.6.2.1 Addressing

16.6.2.1.1 Station Identifier (STID)

The ABS assigns an STID to the ARS during network entry. The STID uniquely identifies the ARS within the domain of the ABS. The structure of the STID is described in 16.2.1.2.1.

The ARS manages and assigns the STID for the AMS during the AMS initial network entry into the ARS.

16.6.2.1.2 Flow Identifier (FID)

The ARS assigns and manages the FID for the AMS during the AMS DSA procedure with the ARS. The ABS manages and assigns the FID for the ARS on the relay link.

16.6.2.2 MPDU Formats

ASN data traffic for AMSs sent on the relay connections on the relay link shall be encapsulated into a relay MAC PDU. The format of the relay MAC PDU is illustrated in Figure 587.

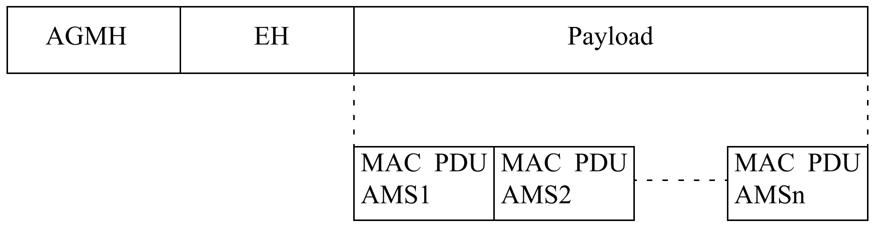

Figure 587—Relay MAC PDU Format

Each relay MAC PDU shall begin with an Advanced Generic MAC Header. The format of AGMH is same as defined in 16.2.2.1.1. The AGMH may be followed by one or more extended headers. The relay MAC PDU shall also contain a payload. The payload consists of one or more AMSs' ASN data traffic.

MAC PDUs for the ARS sent on the control connections on the relay link shall follow the same format as shown in Figure 385.

16.6.2.3 Construction and Transmission of MPDUs

16.6.2.3.1 Data Forwarding Scheme

For DL transmission via an ARS, when an ABS transmits data to AMSs via the ARS, the ABS shall encapsulate ASN data traffic of one or multiple target AMSs into a relay MAC PDU of the ARS and appends an STID Extended header. The ARS shall decode the DL basic assignment A-MAP IE to receive relay MAC PDUs. The ARS shall de-encapsulate received relay MAC PDU and transmits the ASN data traffic to target AMSs in format of MAC PDU.

For UL transmission via an ARS, the ARS shall encapsulate the ASN data traffic from one or multiple AMSs into a relay MAC PDU.

16.6.2.3.2 Forwarding control messages between the RS and the ASN

Upon ABS receiving the downlink control messages from the ASN, it performs classification to recognize that it is an ARS related control message from the ASN. Then the ABS translates the control message between the two interfaces by means of encapsulating the control message in a "AAI_L2-XFER" MAC management message and sends it to the target ARS with FID=1. In order to optimize the message size, the ABS may remove ASN transport network headers of the control message before transmitting the same to the ARS - the details of which are outside the scope of this specification.

On the uplink, the ARS sends the control message using AAI_L2-XFER message on FID=1. Upon ABS receiving the uplink control messages from the ARS, it attaches the ASN transport network headers and forwards the message to the ASN.

16.6.2.4 Security

An ARS uses the same security architecture and procedures as an AMS to provide privacy, authentication and confidentiality between itself and an ABS on the relay link.

An ARS is operating as distributed security mode. The AK established between an AMS and an authenticator is derived as follows and distributed to this ARS during key agreement.

AK = Dot16KDF(PMK, MSID*|RSID|AK_COUNT|"AK", 160)

As shown in Figure 588—, after authorization for an AMS completes and the MSK for the AMS is established, the ARS starts key agreement with the AMS. During the key agreement, the authenticator shall transfer the relevant Authorization Key (AK) context associated with the AMS to its ARS. On obtaining AK context the ARS derives necessary security keys such as CMAC keys and TEK from the AK and the ARS is responsible for key management of AK, CMAC keys and TEK, and interacts with the AMS as if it were an ABS in the AMS's perspectives.

During the key agreement, similarly to macro ABS, the Security Association shall be established between an AMS and an ARS. The ARS uses the set of active keys shared with the AMS to perform encryption/decryption and integrity protection on the access link.

The ARS runs a secure encapsulation protocol with the ABS based on the primary SA, which is established between the ARS and the ABS. The access ARS uses the set of active keys shared with the ABS to perform encryption/decryption and integrity protection on the relay link.

MPDUs are encapsulated into one relay MAC PDU and en/decrypted at once by primary SA, which is established between the ARS and the ABS.

The security context used for relay link (between an ABS and an ARS) and access links (between an ARS and an AMS) are different and maintained independently. The key management follows as the same method as a macro ABS defined in 16.2.5.2.

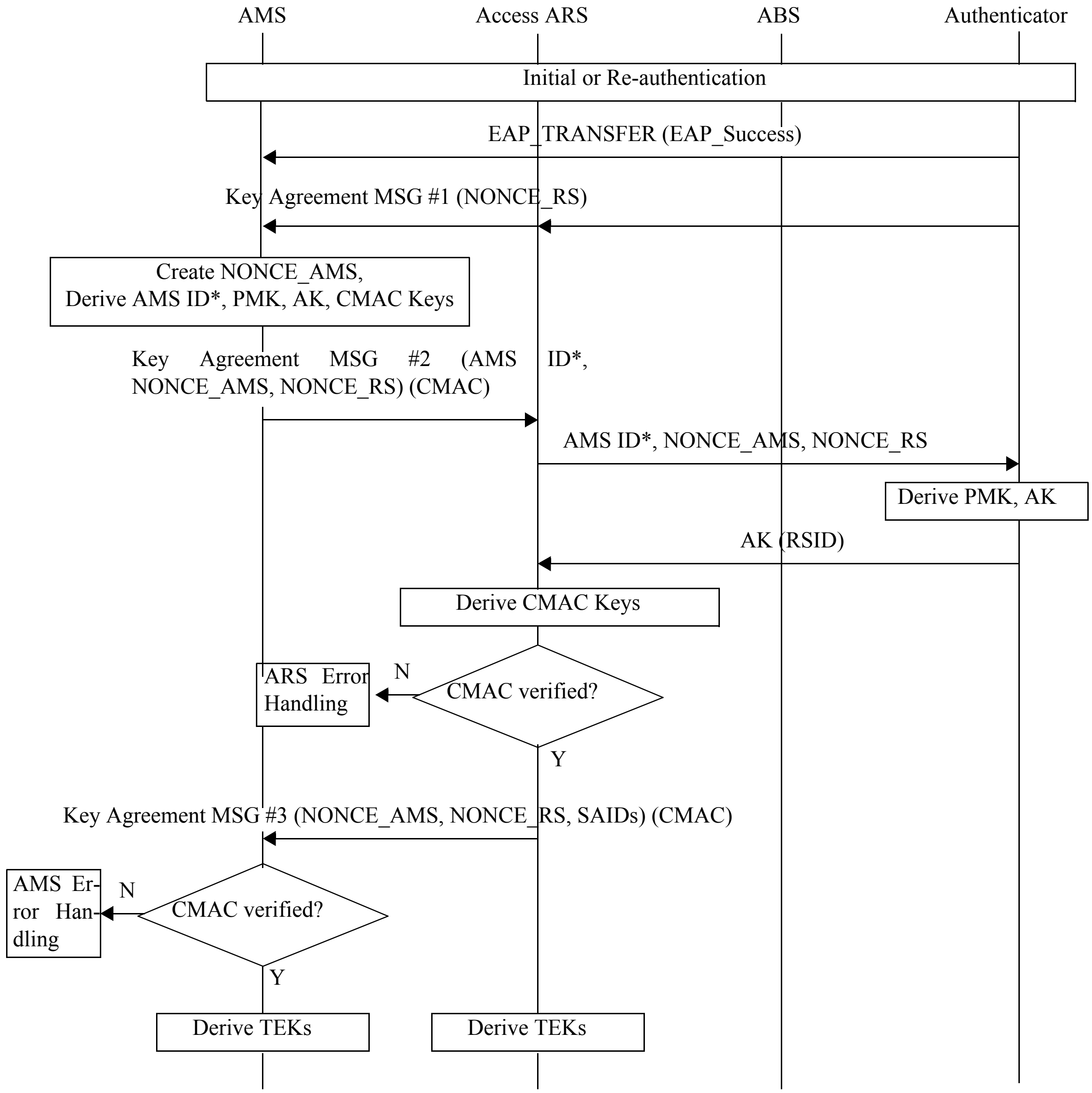

Figure 588—Key agreement procedure

16.6.2.5 Handover

16.6.2.5.1 Network topology advertisement

The ARS shall broadcast information about the neighbor ABSs/ARSs that are present in the network using the AAI_NBR-ADV message defined in 16.2.3.12. The ARS may obtain the information to be included in the AAI_NBR-ADV message from its management plane. Each ARS can broadcast a different AAI_NBR-ADV message that is suitable for its service area.

16.6.2.5.2 AMS scanning of neighbor ABSs/ARSs

The scanning follows the same procedure as described in Section 16.2.6.1.2, with the exception that when serving station is an ARS, the ARS defines the corresponding trigger/action, controls the scanning procedure and initiates handover based on received scanning report.

16.6.2.5.3 AMS Handover process

The handover process follows the same procedure as described in Section 16.2.6, with every instance of ABS replaced by ARS.

During handover, serving station (ABS or ARS) may exchange AMS context with the target station (ABS or ARS) for handover optimization using AAI_L2-XFER messages carrying ASN control messages. The target station shall allocate the STID for the AMS, during handover.

16.6.2.6 Scheduling and QoS

The ABS may use persistent allocations (as described in 16.2.7) and group resource allocations (as described in 16.2.9) on the relay link. ARSs shall support the use of persistent scheduling and group resource allocations on the relay link.

The ARS shall schedule air link resources on the access link for communications with its associated AMSs. Frame-by-frame scheduling decisions are made by the ARS.

16.6.2.6.1 Connection management

ARS controls the connection management for the associated AMS, i.e., AAI_DSx messages shall be terminated at the ARS. ARS performs FID assignments for the AMS. ARS communicates with the other network entities in the Data path (eg: ABS, ASN entities etc) using AAI_L2-XFER messages carrying ASN control messages to complete the data path setup for this FID of the AMS. Besides these messages, after receiving DSx messages from AMSs, the ARSs may send DSA or DSC messages to the ABS to reflect the changed QoS requirements on the relay link.

16.6.2.7 Bandwidth Request and Grant Management

ARSs directly handle the bandwidth requests that they receive from associated AMSs. An ARS may receive bandwidth requests from its associated AMSs via any of the mechanisms described in16.2.11.1.1. ARSs shall handle all bandwidth requests from AMSs locally, using the same protocol as ABSs (as described in 16.2.11).

ARSs may request uplink bandwidth from the ABS using one of the BW request mechanisms defined in 16.2.11.1. An ARS shall request bandwidth using the FID of one of the connections established between itself and the ABS. The ARS may request bandwidth for multiple connections using a single bandwidth request.

The bandwidth grant messages and procedures defined in 16.2.11.2 shall be used by the ARS and the AMS on the access link and between the ABS and the ARS on the relay link.

16.6.2.8 ARQ

The ARS performs ARQ operation independently with an ABS on the relay link and an AMS on the access link. The two ARQ instances on two links have independent fragmentation/reassembly state maintenance. In fact, it is not necessary that both flows use ARQ. For example, an access link flow may use ARQ, but this flow's data may be multiplexed on a relay flow that is non-ARQ.

In downlink, an ABS generates and sends an ARQ block to an ARS in the relay link. If the ARQ block is corrupted in the relay link, the ARS shall send a NACK to the ABS, and then the ABS shall prepare and perform retransmission. If the ARS receives the ARQ block correctly in the relay link, the ARS shall forward the ARQ block to the AMS in the access link. In the access link, if the ARQ block is corrupted and the ARS receives a NACK from the AMS, the ARS shall prepare and perform retransmission to the AMS.

In uplink, the AMS generates and sends ARQ block to the ARS in the access link. If the ARQ block is corrupted in the access link, the ARS sends a NACK to the AMS, and then the AMS shall prepare and perform retransmission. If the ARS receives the ARQ block is correctly in the access link, the ARS shall forward ARQ block to the ABS. In the relay link, if the ARQ block is corrupted and the ARS receives a NACK from the ABS, the ARS shall prepare and perform retransmission.

16.6.2.9 HARQ

16.6.2.9.1 Generic HARQ signaling and timing

An ARS shall perform HARQ operation with an ABS in the relay link and an AMS in the access link independently.

The HARQ signaling and timing protocol between ABS and its AMS follows the generic procedure described in 16.2.14.2. The HARQ signaling protocol between ABS and ARS stations and between ARS and AMS stations follows the procedure in 16.2.14.2

The HARQ timing for transmissions between ARS and AMS stations is described in 16.6.2.9.1.1. The HARQ timing for transmissions between ABS and ARS stations is described in 16.6.2.9.1.2.

The following notations are used in this section: D_{AZ} is the number of AAI subframes in the 16m DL Access zone, D_{RZ} is the number of AAI subframes in the 16m DL Relay zone, U_{AZ} is the number of AAI subframes in the 16m UL Access zone, U_{RZ} is the number of AAI subframes in the 16m UL Relay zone, D' is the whole number of DL AAI subframes with $D'=D_{AZ}+D_{RZ}$, and U' is the whole number of UL AAI subframes with $U'=U_{AZ}+U_{RZ}$.

16.6.2.9.1.1 A-MAP relevance and HARQ timing between ARS and AMS

The transmissions of a DL Basic Assignment A-MAP IE, a DL HARQ subpacket, a HARQ feedback in UL and an UL Basic Assignment A-MAP IE, an UL HARQ subpacket, a HARQ feedback in DL between ARS and AMS stations shall be done in the 16m DL and the 16m UL Access zones of ARS frames.

16.6.2.9.1.1.1 FDD

The A-MAP relevance and HARQ timing for TDD defined in 16.2.14.2.2.2 shall be applied to the transmissions between ARS and AMS stations in case of FDD frame structures supporting the Relays described in 16.6.3.2.1.

The same equations and rule in Table 763 and Table 764 shall be applied for deciding HARQ timing between ARS and AMS stations. The values of D, U, l, m, n shall be redefined as follows. The value of D shall be set equal to D_{AZ}, the value U shall be set equal to U_{AZ}, the AAI subframe indexes l, m, and n are the renumbered indexes of AAI subframes in the 16m DL and the 16m UL Access zones of ARS frame. The DL AAI subframe index shall range from 0 to D_{AZ}-1. The UL AAI subframe index shall range from 0 to U_{AZ}-1. Parameters z and v are incremented by 1 from the Equation (172) and Equation (173) respectively. Parameter w shall be calculated as Equation (174). In these equations, N_{TTI} is 1 for the default TTI, D_{AZ} for the long TTI in FDD DL, and U_{AZ} for the long TTI in FDD UL.

Figure 589 shows an example of AAI subframe indexing for 5, 10 and 20 MHz channel bandwidths. In this example, the duration of the 16m DL Access zone D_{AZ} is 5 AAI subframes and the duration of the 16m UL Access zone U_{AZ} is 4 AAI subframes. Then, for A-MAP relevance and HARQ timing between ARS and AMS stations the ratio of DL to UL AAI subframes is 5 : 4.

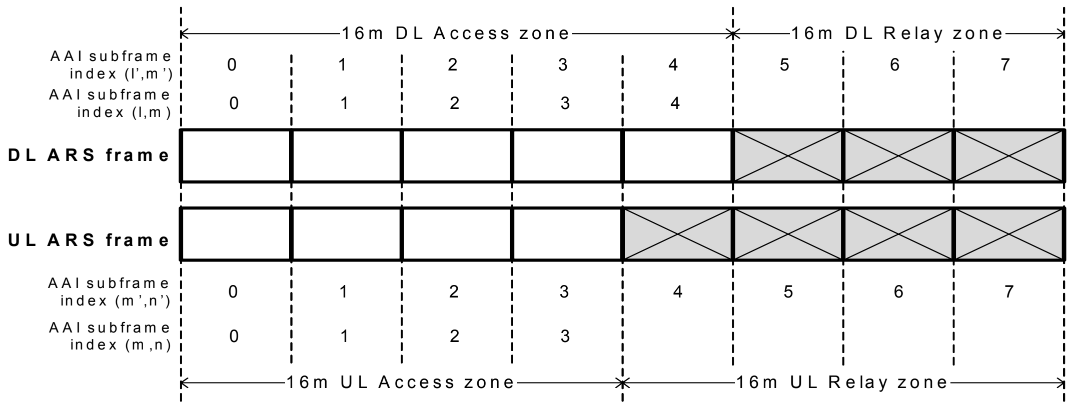

Figure 589—Example of AAI subframe indexing in 16m DL and UL access zones of FDD

Figure 590 shows an example of the DL timing relationships between a DL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback, for 5, 10 and 20 MHz channel bandwidths. Figure 591 shows an example of the UL timing relationships between an UL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission, for 5, 10 and 20 MHz channel bandwidths. In these examples, D_{AZ} is 5 AAI subframes and U_{AZ} is 4 AAI subframes, the Tproc is 3.

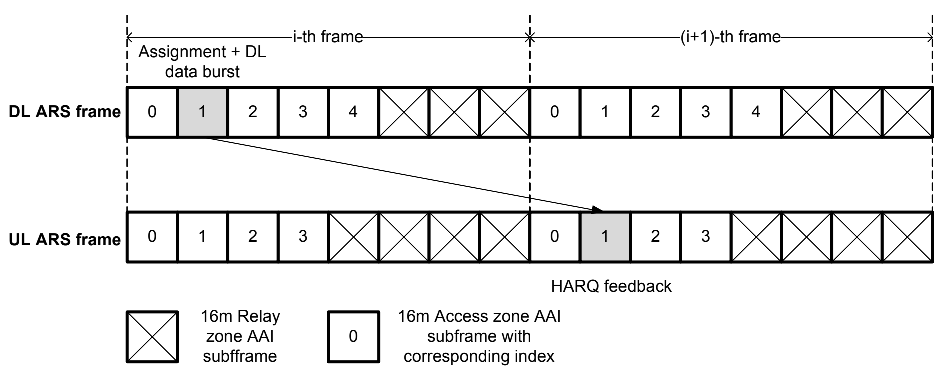

Figure 590—Example of FDD DL HARQ timing between ARS and AMS stations

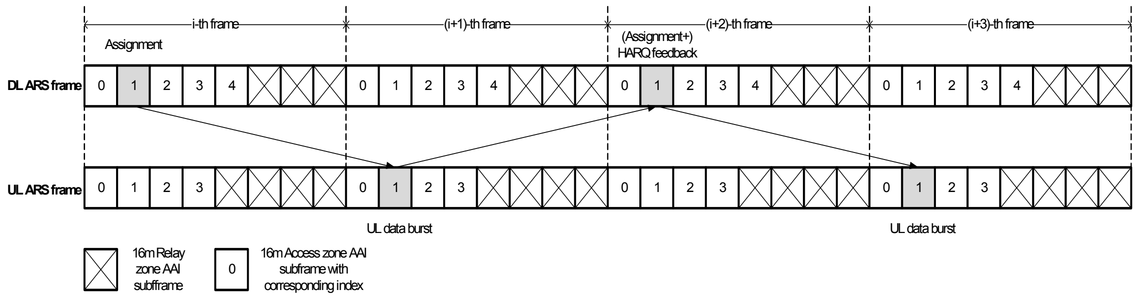

Figure 591—Example of FDD UL HARQ timing between ARS and AMS stations

16.6.2.9.1.1.2 TDD

The A-MAP relevance and HARQ timing for TDD defined in 16.2.14.2.2.2 shall be applied to the transmissions between ARS and AMS stations in case of TDD frame structures supporting the Relays described in 16.6.3.2.2.

The same equations and rule in Table 763 and Table 764 shall be applied for deciding HARQ timing between ARS and AMS stations. The values of D, U, l, m, n shall be redefined as follows. The value of D shall be set equal to D_{AZ}, the value U shall be set equal to U_{AZ}, the AAI subframe indexes l, m, and n are the renumbered indexes of AAI subframes in the 16m DL and the 16m UL Access zones of ARS frame. The DL AAI subframe index shall range from 0 to D_{AZ}-1. The UL AAI subframe index shall range from 0 to U_{AZ}-1. Parameters z, v and w shall be calculated as Equation (172), Equation (173) and Equation (174), respectively. In these equations, N_{TTI} is 1 for the default TTI, D_{AZ} for the long TTI in TDD DL, and U_{AZ} for the long TTI in TDD UL.

Figure 592 shows an example of AAI subframe indexing for 5, 10 and 20 MHz channel bandwidths. In this example, the ratio of the whole number of DL AAI subframes to the whole number of UL AAI subframes, D':U' is 5 : 3. The duration of the 16m DL Access zone D_{AZ} is 3 AAI subframes and the duration of the 16m UL Access zone U_{AZ} is 2 AAI subframes. Then, for A-MAP relevance and HARQ timing between ARS and AMS stations the ratio of DL to UL AAI subframes, D : U is 3 : 2.

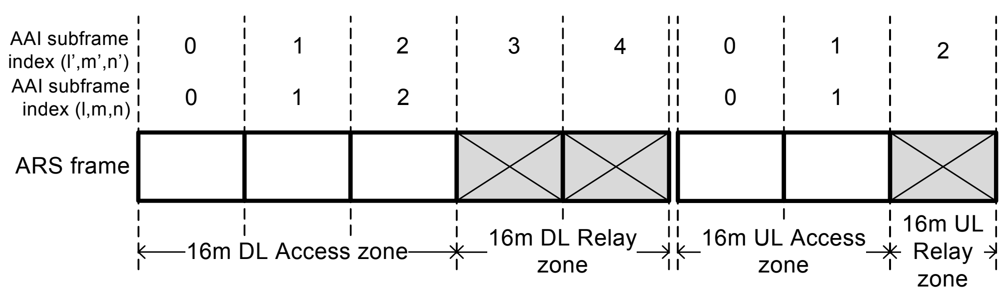

Figure 592—Example of AAI subframe indexing in 16m DL and UL Access zones of TDD

Figure 593 shows an example of the DL timing relationships between a DL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback, for 5, 10 and 20 MHz channel bandwidths. Figure 594 shows an example of the UL timing relationships between an UL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission, for 5, 10 and 20 MHz channel bandwidths. The ratio of the whole number of DL AAI subframes to the whole number of UL AAI subframes is 5 : 3. In these examples, D_{AZ} is 3 AAI subframes and U_{AZ} is 2 AAI subframes, *Tproc* is 3.

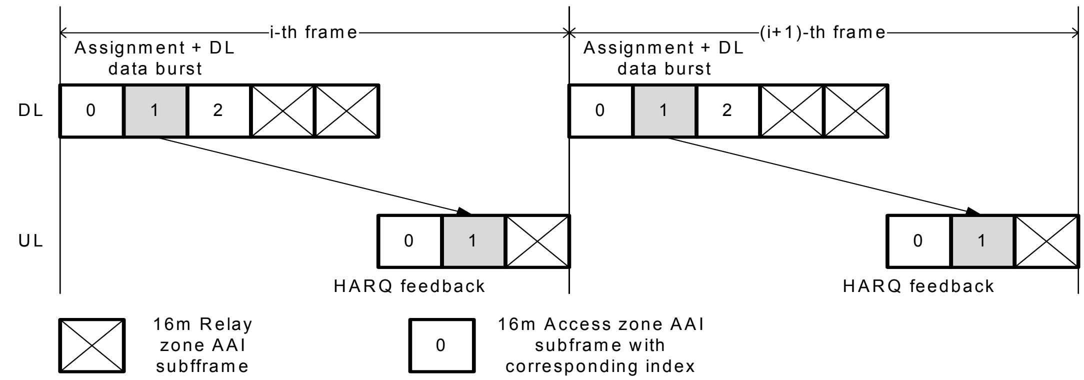

Figure 593—Example of TDD DL HARQ timing between ARS and AMS stations

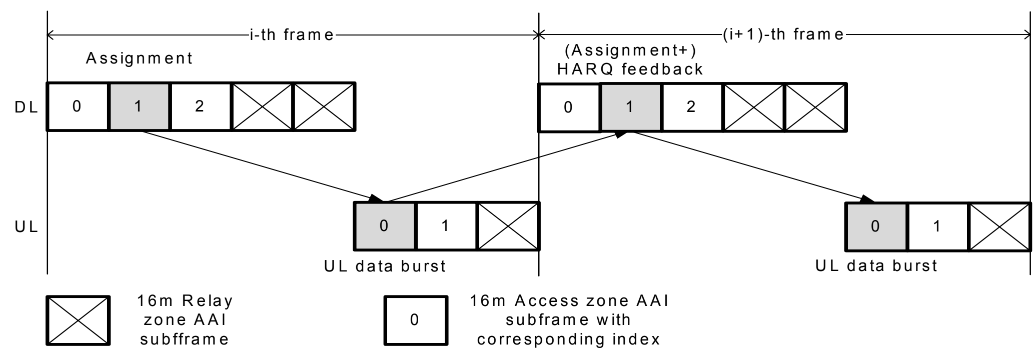

Figure 594—Example of TDD UL HARQ timing between ARS and AMS stations

16.6.2.9.1.2 A-MAP relevance and HARQ timing between ABS and ARS

The transmissions of a DL Basic Assignment A-MAP IE, a DL HARQ subpacket, a HARQ feedback in UL and an UL Basic Assignment A-MAP IE, an UL HARQ subpacket, a HARQ feedback in DL between ABS and ARS stations take place in the 16m DL and the 16m UL Access zones of ABS and ARS frames.

16.6.2.9.1.2.1 FDD

The A-MAP relevance and HARQ timing for TDD defined in 16.2.14.2.2.2 shall be applied to the transmissions between ABS and ARS stations in case of FDD frame structures supporting the Relays described in 16.6.3.2.1.

The same equations and rule in Table 763 and Table 764 shall be applied for deciding HARQ timing between ARS and AMS stations. The values of *D*, *U*, *l*, *m*, *n* shall be redefined as follows. The value of *D* shall be set equal to D_{RZ}, the value *U* shall be set equal to U_{RZ}, the AAI subframe indexes *l*, *m*, and *n* are the renumbered indexes of AAI subframes in the 16m DL and the 16m UL Access zones of ARS frame. The DL

AAI subframe index shall range from 0 to D_{RZ}-1. The UL AAI subframe index shall range from 0 to U_{RZ}-1. Parameters z and v are incremented by 1 from the Equation (172) and Equation (173) respectively. Parameter w shall be calculated as Equation (174). In these equations, N_{TTI} is 1 for the default TTI, D_{RZ} for the long TTI in FDD DL, and U_{RZ} for the long TTI in FDD UL.

Figure 595 shows an example of AAI subframe indexing for 5, 10 and 20 MHz channel bandwidths. In this example, the duration of the 16m DL Relay zone D_{RZ} is 3 AAI subframes and the duration of the 16m UL Relay zone U_{RZ} is 2 AAI subframes. Then, for A-MAP relevance and HARQ timing between ABS and ARS stations the ratio of DL to UL AAI subframes is 3 : 2.

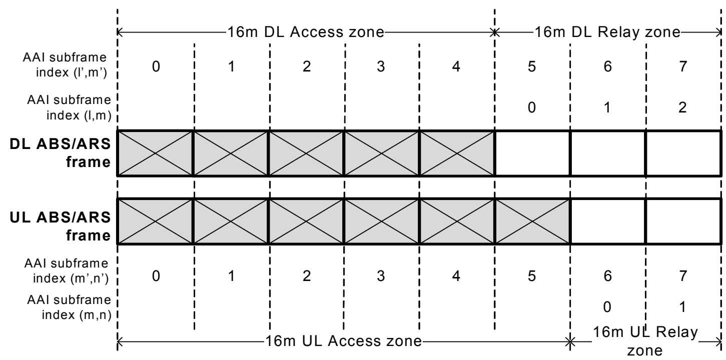

Figure 595—Example of AAI subframe indexing in 16m DL and UL Relay zones of FDD

Figure 596 shows an example of the DL timing relationships between a DL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback, for 5, 10 and 20 MHz channel bandwidths. Figure 597 shows an example of the UL timing relationships between an UL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission, for 5, 10 and 20 MHz channel bandwidths. In these examples, D_{RZ} is 3 AAI subframes and U_{RZ} is 2 AAI subframes, the *Tproc* is 3.

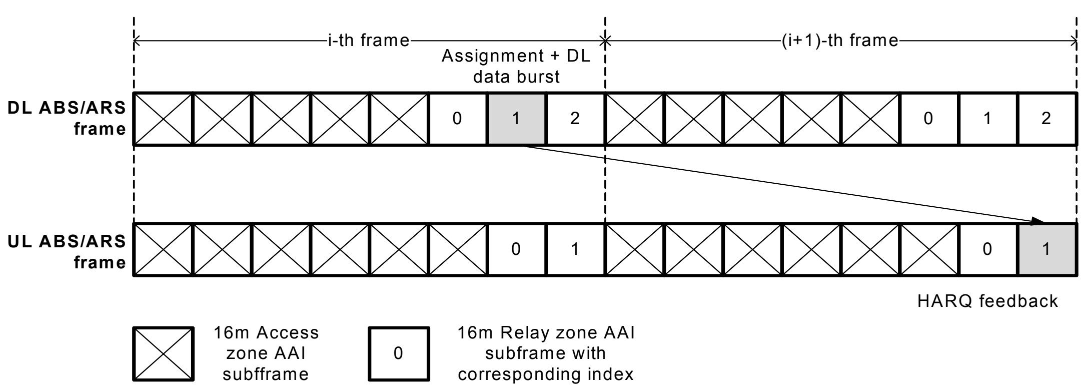

Figure 596—Example of FDD DL HARQ timing between ABS and ARS stations

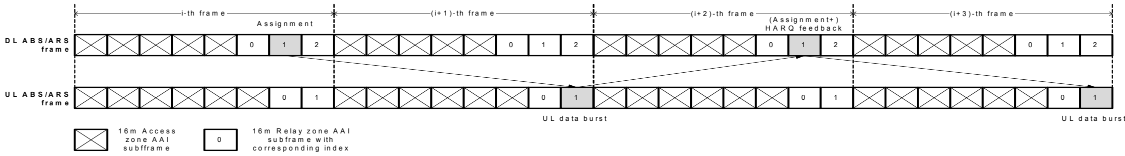

Figure 597—Example of FDD UL HARQ timing between ABS and ARS stations

16.6.2.9.1.2.2 TDD

The A-MAP relevance and HARQ timing for TDD defined in 16.2.14.2.2.2 shall be applied to the transmissions between ARS and AMS stations in case of TDD frame structures supporting the Relays described in 16.6.3.2.2.

The same equations and rule in Table 763 and Table 764 shall be applied for deciding HARQ timing between ARS and AMS stations. The values of *D*, *U*, *l*, *m*, *n* shall be redefined as follows. The value of *D* shall be set equal to D_{RZ}, the value *U* shall be set equal to U_{RZ}, the AAI subframe indexes *l*, *m*, and *n* are the renumbered indexes of AAI subframes in the 16m DL and the 16m UL Access zones of ARS frame. The DL AAI subframe index shall range from 0 to D_{RZ}-1. The UL AAI subframe index shall range from 0 to U_{RZ}-1. Parameters *z, v* and *w* shall be calculated as Equation (172), Equation (173) and Equation (174), respectively. In these equations, N_{TTI} is 1 for the default TTI, D_{RZ} for the long TTI in TDD DL, and U_{RZ} for the long TTI in TDD UL.

Figure 598 shows an example of AAI subframe indexing for 5, 10 and 20 MHz channel bandwidths. In this example, the ratio of the whole number of DL AAI subframes to the whole number of UL AAI subframes, D':U' is 5 : 3. The duration of the 16m DL Access zone D_{RZ} is 2 AAI subframes and the duration of the 16m UL Access zone U_{RZ} is 1 AAI subframes. Then, for A-MAP relevance and HARQ timing between ARS and AMS stations the ratio of DL to UL AAI subframes, *D* : *U* is 2: 1.

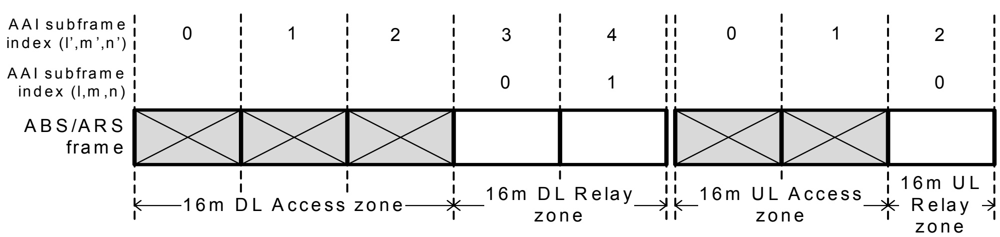

Figure 598—Example of AAI subframe indexing in 16m DL and UL Relay zones of TDD

Figure 599 shows an example of the DL timing relationships between a DL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback, for 5, 10 and 20 MHz channel bandwidths. Figure 600 shows an example of the UL timing relationships between an UL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission, for 5, 10 and 20 MHz channel bandwidths. The ratio of the whole number of DL AAI subframes to the whole number of UL AAI subframes is 5 : 3. In these examples, D_{RZ} is 3 AAI subframes and U_{RZ} is 2 AAI subframes, the *Tproc* is 3.

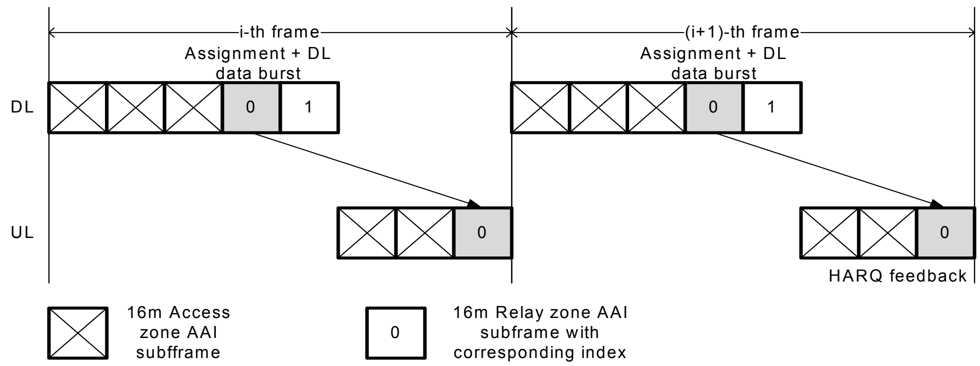

Figure 599—Example of TDD DL HARQ timing between ABS and ARS stations

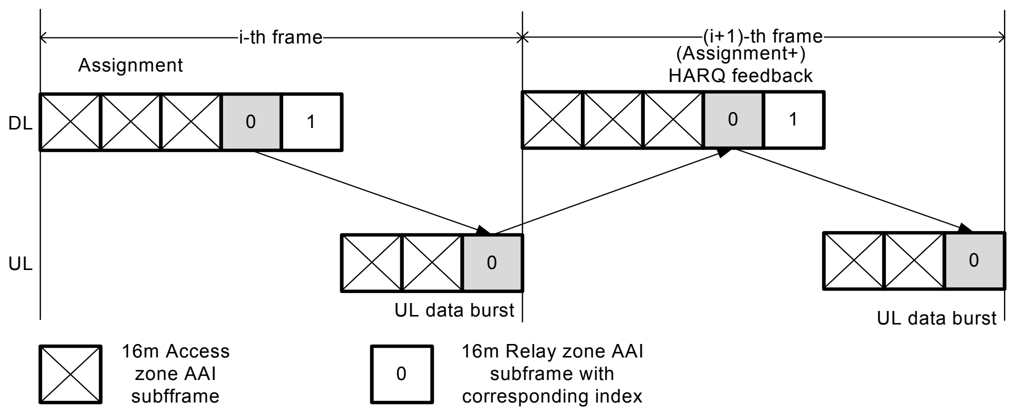

Figure 600—Example of TDD UL HARQ timing between ABS and ARS stations

16.6.2.9.2 Group resource allocation HARQ Signaling and Timing at ARS

An ARS shall perform Group resource allocation with an ABS in the relay link and an AMS in the access link independently. The HARQ signaling and timing protocol between with adjacent stations (ABS and ARS or ARS and AMS) follows the procedure in 16.2.14.3.

16.6.2.9.3 Persistent allocation HARQ Signaling and Timing at ARS

An ARS shall perform persistent resource allocation with an ABS in the relay link and an AMS in the access link independently. The HARQ signaling and timing protocol between with adjacent stations (ABS and ARS or ARS and AMS) follows the procedure in 16.2.14.4

16.6.2.10 Network Entry

16.6.2.10.1 AMS Network Entry

In DL channel scanning phase, an AMS may select an ARS as its access station. The AMS shall establish synchronization with the ARS and obtain DL/UL parameters by reading SFHs and AAI_SCD message from the ARS.

After ranging procedure described in 16.2.15.3, the ARS and AMS shall finish capability negotiation, authentication/key agreement and registration procedures including default service flow setup. The ARS communicates with the ASN entities using AAI_L2-XFER messages carrying ASN control messages, during the AMS network entry. The ARS assigns the STID to the AMS.

16.6.2.10.2 ARS Network Entry

16.6.2.10.2.1 Relay station network entry

The network entry and initialization for relay station follows the procedures defined in 16.2.15. In addition, after the registration phase, the ARS shall perform configuration of the operational parameters as indicated below:

a) Scan for DL channel and establish synchronization with the ABS
b) Obtain DL/UL parameters (from SuperFrameHeader)
c) Perform ranging
d) Basic capability negotiation
e) Authorization, authentication, and key exchange
f) Registration with ABS
g) Configure operational parameters

The procedure for initialization of an ARS shall be as shown in Figure 601.

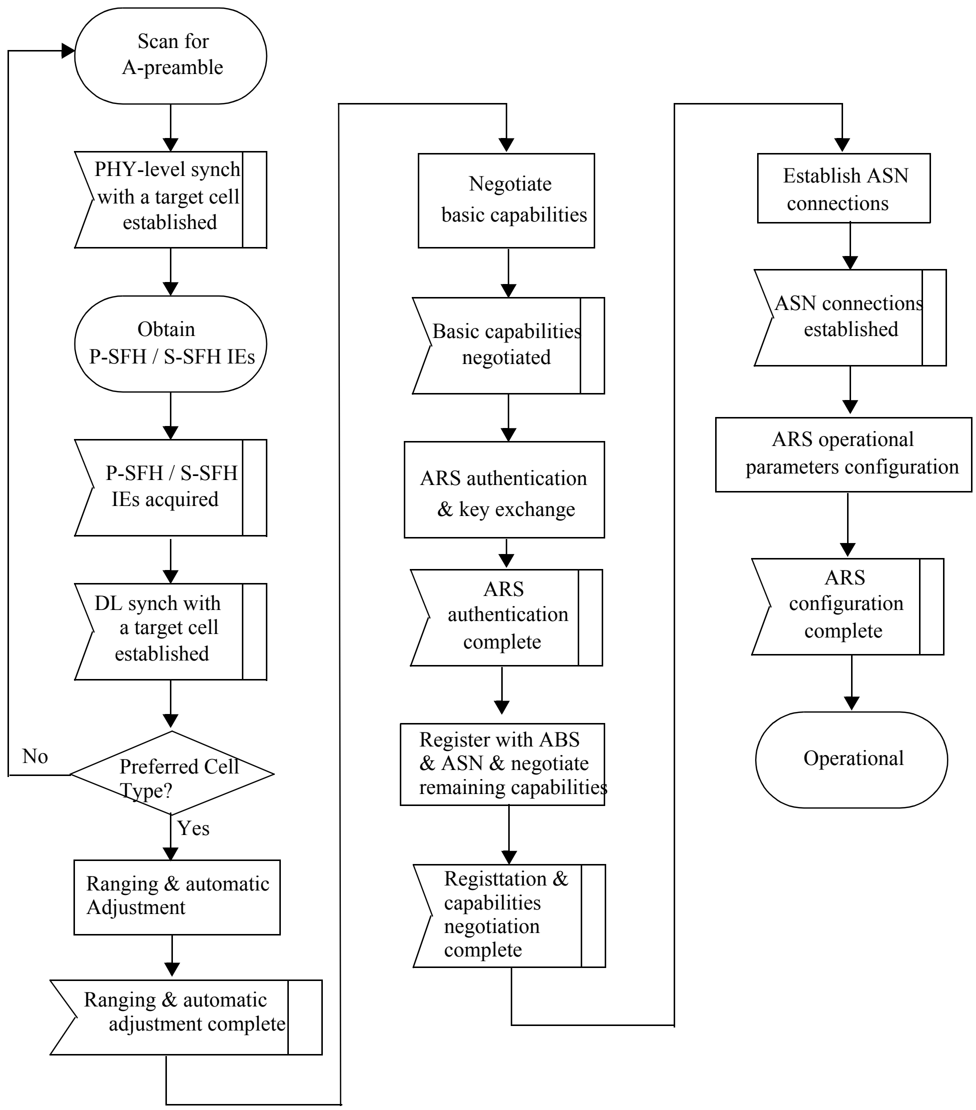

Figure 601—ARS initialization overview

16.6.2.10.2.2 Handing of AMS Initial Ranging by the ARS

ARS allocates its own ranging opportunities and ARS ranging channel configuration is carried in ARS's SFH. ARS handles the ranging procedure.

When the ARS detects a ranging sequence on the access link, the adjustments related to physical ARS-AMS link, if necessary, are performed by the ARS directly with the AMS (without any interaction with the ABS).

When the ARS receives the AAI_RNG-REQ message associated with initial network entry of AMS, it assigns the TSTID to the AMS and responds back with AAI_RNG-RSP message to AMS.

When an ARS wishes to perform initial ranging with an ABS, the ARS shall follow the same steps as an AMS would, when the AMS performs initial ranging with the ABS as described in 16.2.15.3.

16.6.2.11 Ranging

16.6.2.11.1 ARS Initial Ranging

When an ARS wishes to perform initial ranging with an ABS, the ARS shall follow the same steps as an AMS would, when the AMS performs initial ranging with the ABS as described in 16.2.15.3.

16.6.2.11.2 Handing of AMS and ARS Periodic Ranging

When an ARS detects a periodic ranging sequence on the access link, it shall perform adjustments directly with the AMS with no interaction with the ABS. The ARS decides on the appropriate adjustments if required.

When an ARS initiates a periodic ranging on the relay link to the ABS, the ARS shall perform the same tasks as an AMS performs with the ABS.

The ranging channel for synchronized AMSs, as described in section 16.3.9.1.4.2 is also used for ARS periodic ranging.

16.6.2.12 Sleep Mode

When an AMS is attached to an ARS for idle mode operation, procedures defined in section 16.2.16 where each instances of ABS is replaced by ARS.

16.6.2.13 Idle Mode

When an AMS is attached to an ARS for idle mode operation, procedures defined in section 16.2.17 where each instances of ABS is replaced by ARS.

16.6.2.14 ARS Configuration

16.6.2.14.1 Parameter configuration during ARS network entry

After ARS registration, the ABS shall send a RS_Config-CMD message to configure the PHY layer operational parameters for relay operation. When an ARS receives RS_Config-CMD message, it shall transmit an AAI_MSG-ACK message. The ARS shall start RS operation and apply the PHY operational parameters from the time specified by 'Super-frame number action' in RS_Config-CMD.

16.6.2.14.2 Parameter configuration update for ARS operational mode

During ARS operation mode, when the PHY layer operational parameters for relay operation is changed, an ABS shall send RS_Config-CMD message. When an ARS receives RS_Config-CMD message, it shall transmit an AAI_MSG-ACK message. The ARS can use Message ACK Extended Header as well as the AAI_MSG-ACK message. The ARS shall apply the system information in SFH or the configuration parameters from the time specified by 'Super-frame number action' in RS_Config-CMD.

16.6.2.15 ARS De-registration

In MR networks, an ARS may end its service and be removed from the networks. During the ARS de-registration process, all subordinate AMSs of the ARS shall be transferred to another ARS or ABS prior to ARS de-registration. An ARS may transmit an AAI_DREG-REQ message to an ABS so that it initiates the de-registration procedure and requests handover of all its subordinate AMSs. Upon receiving the AAI_DREG-REQ message, the ABS decides whether it allows the ARS de-registration. If the request is accepted, the ABS may transmit the AAI_DREG-RSP message to inform the acceptance and start ABS-initiated handover process for the requested AMSs. After handover procedures between the ABS and ARS's subordinate AMSs are completed, the ABS informs the ARS that handover is completed by transmitting an AAI_DREG-RSP message. Upon receiving the AAI_DREG-RSP message, the ARS starts de-registration process. If the ABS rejects the request, the ABS informs the ARS the rejection of the request by transmitting the AAI_DREG-RSP message. Upon receiving the AAI_DREG-RSP message with rejection information, the ARS continues normal operation. After REQ-duration expires, the ARS retransmits an AAI_DREG-REQ message to the ABS.

The de-registration process may be initiated by an ABS through transmitting an unsolicited AAI_DREG-RSP message.

After de-registration, all the connections and resource are released between the ABS and the ARS.

16.6.2.16 Update of SFH

16.6.2.16.1 Update of SFH inforamtion during ARS network entry

An ARS performs update of SFH as described in the subclause 15.2.23.

16.6.2.16.2 Update of SFH inforamtion during ARS operational mode

When the essential system information in SFH is changed, an ABS shall send the information through a RS_ESI management message in the 16m DL Relay Zone. If an ARS receives RS_ESI message, it shall transmit AAI_MSG-ACK message. The ARS shall apply the information from the super-frame specified by Super-Frame Number Action in the RS-ESI.

Table 947—RS_ERI message format

Name	Size (bit)	Notes
Message type	8	
S-SFH change count	4	Change count of S-SFH transmitted in this message
S-SFH information bitmap	3	If Bit #0 is 0b1, S-SFH SP 1 is included. If Bit #1 is 0b1, S-SFH SP 2 is included. If Bit #2 is 0b1, S-SFH SP 3 is included.
If (S-SFH information bitmap Bit #0 == 0b1) {		
Superframe number	12	

Table 947—RS_ERI message format

Name	Size (bit)	Notes
Number of UL ACK/NACK channels per HARQ feedback region	2	Channel numbers represented by the two bits (0, 1,2, 3) are as follows. For 5 MHz band, 6, 12, 18, 24 For 10 MHz band, 6, 12, 24, 30 For 20 MHz band, 12, 24, 48, 60
Number of UL ACK/NACK channels per HF-A-MAP egion	2	Channel numbers represented by the two bits (0, 1,2, 3) are as follows. For 5 MHz band, 4, 8, 12, 16 For 10 MHz band, 8, 16, 24, 32 For 20 MHz band, 16, 32, 48, 64
Power control channel resource size indicator	2	
Non-user specific A-MAP location	1	Reuse 1 or reuse 3
A-A-MAPMCS selction	1	
DL permutation configuration (CRU, DRU partitioning and signaling related to that)	13	For 20 MHz, DL_CAS_SB0 (4 bits), DL_CAS_MB0 (6 bits), DL_CAS_SBi (3 bits)
UL permutation configuration (CRU, DRU partitioning and signaling related to that)	13	For 20 MHz, UL_CAS_SB0 (4 bits), UL_CAS_MB0 (6 bits), UL_CAS_SBi (3 bits)
Ranging channel formats for non-synchronized AMSs	1	Indicates the ranging channel formats number of Table 871. For FDM-based UL PUSC zone support, TBD.
Ranging channel allocation periodicity for non-synchronized AMSs	2	Indicates the periodicity of ranging channel allocation according to the Table 878.
Subframe offset of ranging channel for non-synchronized AMSs	2	Indicates the subframe offset (O_{SF}) of ranging channel allocation related to the Table 878. The range of values is $0 \le O_{SF} \le 3$
Number of cyclic shifted ranging preamble codes per root index for non-synchronized AMSs	2	Indicates the number of cyclic shifted codes per root index (M_{ns}) for ranging preamble codes according to the Table 876. For FDM-based UL PUSC zone support, TBD
Start code information of ranging channel for non-synchronized AMSs	4	Indicates the kns which is the parameter controlling the start root index of ranging preamble codes (r_{ns0}). $r_{ns0}(k_{ns}) = 4 \times k_{ns} + 1$ for ranging channel format 0. $r_{ns0}(k_{ns}) = 16 \times k_{ns} + 1$ for ranging channel format 1. The range of values is $0 \le k_{ns} \le 15$

Table 947—RS_ERI message format

Name	Size (bit)	Notes
Ranging preamble code partition information for non-synchronized AMSs	4	Indicates the number of initial and handover ranging preamble codes (N_{IN} and N_{HO}) according to the Table 877. For FDM-based UL PUSC zone support, it indicates the number of initial, handover and periodic codes (N, O, and M) according to the Table xxx.
ABS EIRP	7	Signed in units of 1 dBm
Cell bar information	1	If Cell Bar bit = 1, this cell is not allowed for network entry or re-entry
Super-Frame Number Action of SP 1	4	LSBs of the super-frame number when the SP 1 is applied
}		
If (S-SFH information bitmap Bit #1 == 0b1) {		
Frame configuration index	6	The mapping between value of this index and frame configuration is listed in Table TBD
MAC protocol revision	4	version number of IEEE 802.16m supported on this channel
FFR partitioning info for DL region	12	For 20 MHz, DL_SAC(5 bits), DL_FPSC(3 bits), DL_FPC(4 bits) For 5 MHz, DL_SAC(3 bits), DL_FPSC(1 bit), DL_FPC(3 bits)
FFR partitioning info for UL region	12	For 20 MHz, UL_SAC(5 bits), UL_FPSC(3 bits), UL_FPC(4 bits) For 5 MHz, UL_SAC(3 bits), UL_FPSC(1 bit), UL_FPC(3 bits)
AMS Transmit Power Limitation Level	5	Unsigned 5-bit integer. Specifies the maximum allowed AMS transmit power. Values indicate power levels in 1 dB steps starting from 0 dBm
$EIRP_{IR,min}$	5	
Super-Frame Number Action of SP 2	4	LSBs of the super-frame number when the SP 2 is applied
}		
If (S-SFH information bitmap Bit #2 == 0b1) {		
SA-sequence soft partitioning information	4	
UL Fast FB Size	4	Specifies the size of UL feedback channel per a UL subframe

Table 947—RS_ERI message format

Name	Size (bit)	Notes
# Tx antenna	2	0b00: 2 antennas 0b01: 4 antennas 0b10: 8 antennas 0b11: reserved
SP scheduling periodicity information	TBD	
HO Ranging backoff start	4	Initial backoff window size for MS performing initial ranging during HO process, expressed as a power of 2. Values of n range 0-15 (the highest order bits shall be unused and set to 0)
HO Ranging backoff end	4	Final backoff window size for MS performing initial ranging during HO process, expressed as a power of 2. Values of n range 0-15
Initial ranging backoff start	4	Initial backoff window size for initial ranging contention, expressed as a power of 2. Values of n range 0-15
Initial ranging backoff end	4	Final backoff window size for initial ranging contention, expressed as a power of 2. Values of n range 0-15
UL BW REQ channel information	3	
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)
Bandwidth request backoff end	4	Final backoff window size for contention BRs, expressed as a power of 2. Values of n range 0-15
Uplink subframe bitmap for sounding	8	
Sounding multiplexing type (SMT) for sounding	1	
Decimation value D/ Max Cyclic Shift Index P for sounding	3	
Super-Frame Number Action of SP 3	4	LSBs of the super-frame number when the SP 3 is applied.
}		

16.6.3 Physical Layer

16.6.3.1 Basic frame structure supporting ARS

The advanced air interface supports two hop data transmission between an ABS and an AMS using an intermediate ARS. Figure 602 shows an example of the basic frame structure for system supporting ARSs. When an ARS is deployed it shall use the same OFDMA signal parameters (defined in Table 775) as its serving ABS. The ABS and ARS superframes shall be time aligned and shall consist of the same number of frames and AAI subframes. Every ARS superframe shall contain a superframe header (SFH). The SFH transmitted by the ARS shall have the same location and format as the SFH transmitted by the ABS. The ARS preambles (SA-Preamble and PA-Preamble) shall be transmitted synchronously with superordinate ABS preambles.

When ARSs are supported the ABS frame is divided on 16m Access zone and 16m Relay zone. The 16m Access zone position precedes the 16m Relay zone position inside the frame. The duration of the 16m Access zone and 16m Relay zone may be different in DL and UL directions. The zone configuration of 16m Access zone and 16m Relay zone is informed to the ARS by the ABS in RS_config-CMD message.

The ABS frame 16m Access zone shall consist of 16m DL Access zone and 16m UL Access zone, and 16m Relay zone shall consist of 16m DL Relay zone and 16m UL Relay zone. The ABS frame 16m Access zone shall be used for communication with AMSs only. The ABS frame 16m Relay zone shall be used for communication with ARSs and may be used for communication with AMSs. In the 16m DL Relay zone the ABS shall transmit to its subordinate ARS and in the 16m UL Relay zone the ABS shall receive transmissions from its subordinate ARS.

The ARS frame 16m Access zone shall consist of 16m DL Access zone and 16m UL Access zone and 16m Relay zone shall consist of 16m DL Relay zone and 16m UL Relay zone. The ARS frame 16m Access Zone shall be used for communication with AMSs only. In the 16m DL Relay zone the ARS shall receive transmissions from its superordinate ABS and in the 16m UL Relay zone the ARS shall transmit to its superordinate ABS.

The position of 16m DL/UL relay zone is indicated for AMS using AAI_System Configuration Descriptor message when 16m_Relay_zone_AMS_allocation_indicator is equal to 0.

In each ARS frame, the relay transmit to receive transition interval (R-TTI) may be inserted in order to make allowances for ARSTTG and RTD between the ARS and its superordinate station.

In each ARS frame, the relay receive to transmit transition interval (R-RTI) may be inserted in order to make allowances for ARSRTG and RTD between the ARS and its superordinate station.

The duration and the positions of R-TTI and R-RTI are defined in FDD (see 16.6.3.2.1) and TDD (see 16.6.3.2.2), respectively. The each R-TTI and R-RTI shall be equal or less than one OFDMA symbol.

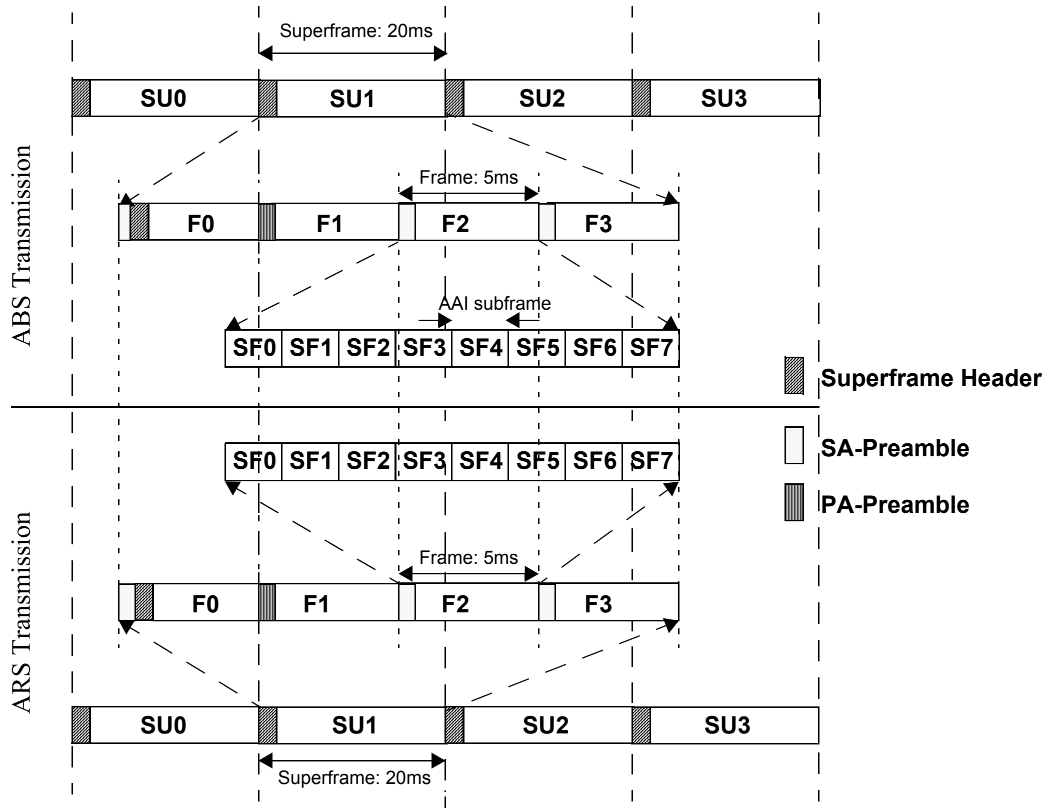

Figure 602—Superframe structure for system with ARS support

When an ARS is supported, the long TTI allocations in ABS-ARS link shall span the entire 16m Relay zone in any DL or UL directions and the long TTI allocations in ARS-AMS link shall span the entire 16m Access zone in any DL or UL directions. When *16m_Relay_zone_AMS_allocation_indicator* is equal to 0, the long TTI allocations in ABS-AMS link shall span the entire 16m Access zone in any DL or UL directions. When *16m_Relay_zone_AMS_allocation_indicator* is equal to 1, the long TTI allocations in ABS-AMS link shall span the entire DL or UL subframes in a TDD frame or occupy 4 AAI subframes for both DL and UL in a FDD frame.

16.6.3.2 Frame structure

16.6.3.2.1 FDD frame structure

The FDD frame shall be constructed on the basis of the basic frame structure defined in 15.3.3.

An ARS supporting FDD mode shall communicate with the ABS using full duplex FDD mode and it shall be able to simultaneously support half duplex and full duplex AMSs operating on the same RF carrier.

An ARS in FDD systems shall use DL carrier frequency (F_{DL}) for receiving from the ABS in the 16m DL Relay zone and shall use UL carrier frequency (F_{UL}) for transmission to the ABS in the 16m UL Relay zone.

In ARS radio frame, the ARS idle state time interval (R_IdleTime) shall be inserted between two ARS frames. The duration of the R_IdleTime is signaled by the ARS to its AMSs through the AAI_System Configuration Descriptor. In ARS DL frame, R_IdleTime shall be same as IdleTime of ABS. In ARS UL frame, the duration of R_IdleTime shall be less or equal to the duration of IdleTime of ABS. The ARS UL frame may be time-advanced for a Tadv interval referring to the start of the ABS UL frame. The duration of T_{adv} is calculated according to the following equation:

$$T_{\mathrm{adv}} = \text{IdleTime - R\_IdleTime} \qquad (315)$$

When an ARS switches transceiver states from transmit to receive or from receive to transmit, a DL ARS radio frame in FDD system may have a R-TTI between 16m Access and 16m Relay zone and a R-RTI between 16m Relay zone and 16m Access zone in the next DL ARS frame. The location of the R-TTI is the last OFDM symbol of the last AAI subframe of 16m Access zone and the location of the R-RTI is the last OFDM symbol of the last AAI subframe of 16m Relay zone. The duration of R-TTI and R-RTI in DL shall be calculated by following equations:

$$\text{R-TTI} = \begin{cases} 0 & \text{if } RTD/2 \geq ARSTTG \\ T_s & \text{if } RTD/2 < ARSTTG \end{cases} \qquad (316)$$

$$\text{R-RTI} = \begin{cases} 0 & \text{if IdleTime - } RTD/2 \geq ARSRTG \\ T_s & \text{if IdleTime - } RTD/2 < ARSRTG \end{cases} \qquad (317)$$

Where the RTD is the round trip delay between the ARS and its superordinate station and T_s is defined in <<Table 762>>.

If the R-TTI is present (i.e. its duration is equal to T_s), then the ARS DL Access zone AAI subframe with the R-TTI is formed by type-3 or type-1 AAI subframe when the corresponding ABS DL Access zone AAI subframe is type-1 or type-2 AAI subframe, respectively. If there is no R-TTI (i.e. its duration is equal to zero), the AAI subframes in the DL Access zone at ARS are the same as those at ABS.

When an ARS switches transceiver states from receive to transmit or from transmit to receive, an UL ARS radio frame in FDD system may have a R-RTI between 16m Access and 16m Relay zone and a R-TTI between 16m Relay zone and 16m Access zone in the next UL ARS frame. The location of the R-RTI is the first OFDM symbol of the first AAI subframe of 16m Relay zone and the location of R-TTI is the last OFDM symbol of the last AAI subframe of 16m Relay zone. The duration of R-RTI and R-TTI in UL shall be calculated by following equations:

$$\text{R-RTI} = \begin{cases} 0 & \text{if } T_{adv} - (RTD)/2 \geq ARSRTG \\ T_s & \text{if } T_{adv} - (RTD)/2 < ARSRTG \end{cases} \qquad (318)$$

$$\text{R-TTI} = \begin{cases} 0 & \text{if R\_IdleTime} + RTD/2 \geq ARSRTTG \\ T_s & \text{if R\_IdleTime} + RTD/2 < ARSRTTG \end{cases} \qquad (319)$$

Where the RTD is the round trip delay between the ARS and its superordinate station and T_s is defined in <<Table 762>>.

Figure 603— illustrates an example frame structure with ARS support for FDD mode, which is applicable to the nominal channel bandwidth of 5, 10, 20 MHz with G = 1/8. All transition intervals R-TTI and R-RTI in the figure example are equal to the duration of one OFDMA symbol.

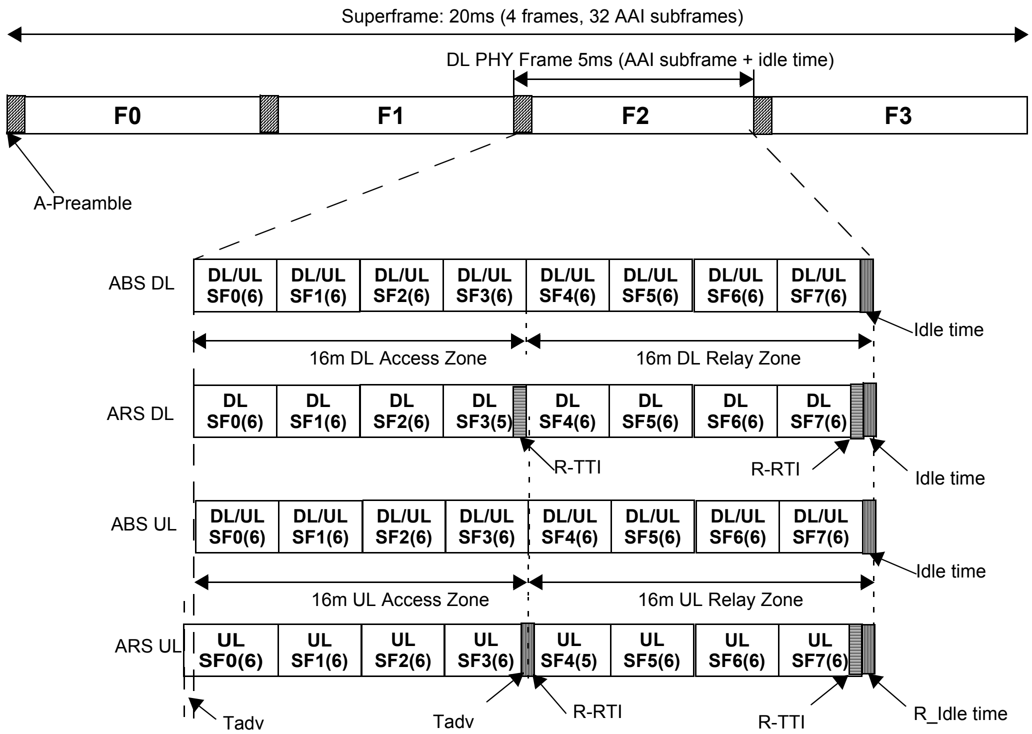

Figure 603—Example of ARS FDD frame structure with G=1/8 in 5/10/20MHz

16.6.3.2.2 TDD frame structure

The TDD frame shall be constructed on the basis of the basic frame structure defined in 15.3.3.

In ARS radio frame, the ARS idle state time interval (R_IdleTime) shall be inserted before the switching point from DL to UL. The duration of the R_IdleTime is signaled by the ARS to its AMSs through the AAI_System Configuration Descriptor. The ARS UL frame may be advanced (T_{adv}) referring to the start of ABS UL frame. The duration of Tadv is calculated according to the following equation:

$$T_{adv} = TTG - \text{R\_IdleTime} \quad (320)$$

The duration of R_IdleTime shall be less or equal to the TTG. In each ARS radio frame, the RTG interval shall be inserted before the switching point from UL to DL.

An ARS radio frame in TDD system shall have a R-TTI transition interval in DL between 16m Access and 16m Relay zones. The duration of the R-TTI shall be calculated by following equation:

$$\text{R-TTI} = \begin{cases} 0 & \text{if } RTD/2 \geq ARSTTG \\ T_s & \text{if } RTD/2 < ARSTTG \end{cases} \quad (321)$$

where the RTD is the round trip delay between the ARS and its superordinate station and Ts is defined in <<Table 762>>.

If the R-TTI is present (i.e. its duration is equal to T_s), then ARS DL Access zone AAI subframe with the R-TTI is formed by type-3 or type-1 AAI subframe when the corresponding ABS DL Access zone AAI subframe is type-1 or type-2 AAI subframe, respectively. If there is no R-TTI (i.e. its duration is equal to zero), the AAI subframes in the DL Access zone at ARS are the same as those at ABS.

An ARS radio frame in TDD system shall have a R-RTI transition interval in UL between 16m Access and 16m Relay zones. The duration of the R-RTI shall be calculated by the following equation:

$$\text{R-RTI} = \begin{cases} 0 & \text{if } T_{adv} - RTD/2 \geq ARSRTG \\ T_s & \text{if } T_{adv} - RTD/2 < ARSRTG \end{cases} \quad (322)$$

where the RTD is the round trip delay between the ARS and its superordinate station and Ts is defined in <<Table 762>>.

Figure 604— illustrates an example frame structure with ARS support for TDD mode D:U = 5:3, which is applicable to the nominal channel bandwidth of 5, 10, 20 MHz with G = 1/8. The number of AAI subframes allocated to the Relay zone in DL direction is two and in UL direction is one. The duration of R-TTI and R-RTI is equal to the duration of one OFDMA symbol.

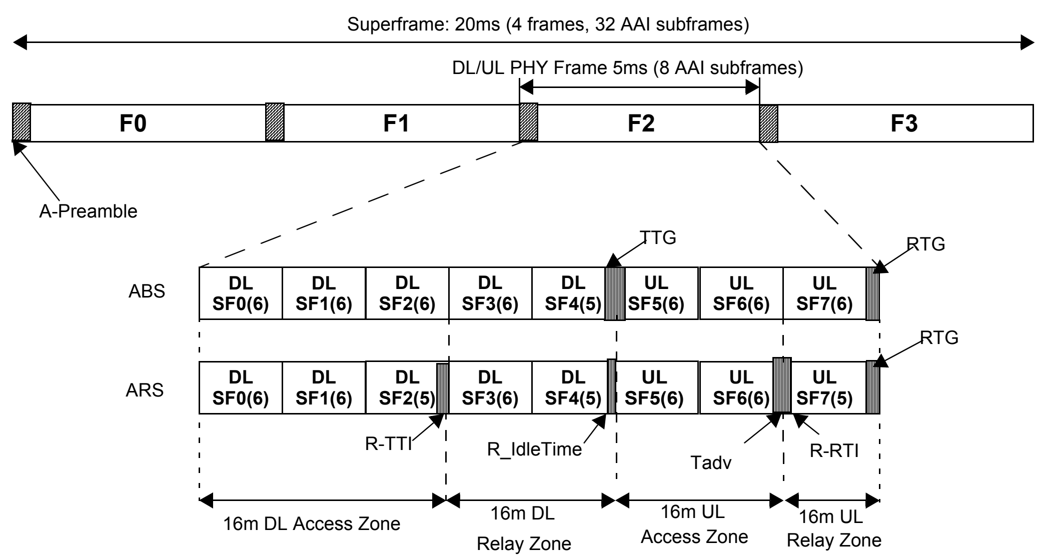

Figure 604—Example of ARS TDD frame structure with G=1/8 in 5/10/20MHz

16.6.3.3 Relay Downlink PHY Structure

16.6.3.3.1 Cell-specific resourcemapping

In the 16m DL Relay zone of ABS and ARS frames, cell-specific resource mapping shall be performed in accordance to the procedure described in the Section 15.3.5.3.

If 16m_Relay_zone_AMS_allocation_indicator field signaled in the AAI_System Configuration Descriptor message and RS_config-CMD message is equal to 1, which indicates that ABS may allocate AMS transmissions in the 16m Relay zone, then the values of DCASSB,0, DCASi, DCASMB,0 used in the 16m DL

Access zone shall be used for cell-specific resource mapping in the 16m DL Relay zones of ABS and ARS frames.

If 16m_Relay_zone_AMS_allocation_indicator field signaled in the AAI_System Configuration Descriptor message and RS_config-CMD message is equal to 0, which indicates that ABS does not allocate AMS transmissions in the 16m Relay zone, then the values of DCASSB,0, DCASi, DCASMB,0 used for cell-specific resource mapping in 16m DL Relay zones of ABS and ARS frames shall be set to the values R_DCASSB,0, R_DCASi, R_DCASMB,0 correspondingly. The values of cell specific 16m Relay zone parameters R_DCASSB,0, R_DCASi, R_DCASMB,0 are explicitly signaled in the RS_config-CMD message.

16.6.3.4 Downlink Control Structure

In the 16m DL Access zone of the ABS frame and ARS frame, all the DL control channels described in 16.3.6 are reused.

In the 16m DL Relay zone, only the A-MAP control channel described in 16.3.6 is reused for communication between the ABS and the ARS.

16.6.3.4.1 Advanced preamble for relay

An ARS reuses PA-preamble and SA-preamble in 16.3.6.1.

16.6.3.4.2 MIMO Midamble and Relay amble

The ABS transmits MIMO midamble for an ARS. The ARS transmits MIMO midamble for an AMS served by the ARS.

16.6.3.5 Relay Uplink physical structure

16.6.3.5.1 Cell-specific resourcemapping

In the 16m UL Relay zone of ABS and ARS frames, cell-specific resource mapping shall be performed in accordance to the procedure described in the Section 15.3.8.3.

If 16m_Relay_zone_AMS_allocation_indicator field signaled in the AAI_System Configuration Descriptor and RS_config-CMD message is equal to 1 which indicates that ABS may allocate AMS transmissions in the 16m Relay zone, then the values of UCASSB,0, UCASi, UCASMB,0 used in the 16m UL Access zone shall be used for cell-specific resource mapping in the 16m UL Relay zones of ABS and ARS frames.

If 16m_Relay_zone_AMS_allocation_indicator field signaled in the AAI_System Configuration Descriptor and RS_config-CMD message is equal to 0 which indicates that ABS does not allocate AMS transmissions in the 16m Relay zone, then the values of UCASSB,0, UCASi, UCASMB,0 used for cell-specific resource mapping in 16m UL Relay zones of ABS and ARS frames shall be set to the values R_UCASSB,0, R_UCASi, R_UCASMB,0 correspondingly. The values of cell specific 16m Relay zone parameters R_UCASSB,0, R_UCASi, R_UCASMB,0 are explicitly signaled in the RS_config-CMD message.

16.6.3.5.2 Uplink data subcarrier mapping

The data subcarrier mapping rule in UL Relay zone corresponds to the rule described in 16.3.10.2.3.

In the ARS TDD and FDD frames, to support an R-RTI insertion in the first OFDMA symbol of the first AAI subframe of the 16m UL Relay zone, the LRUs of the corresponding AAI subframe which are used for data transmissions shall be modified in the following way. For the six-symbol PRU case, the remaining 5

OFDMA symbols are formed to be a five-symbol PRU used for the data transmission. For the seven-symbol PRU case, the remaining 6 OFDMA symbols are formed to be a six-symbol PRU for the data transmission.

In the ARS FDD, to support an R-TTI insertion in the last OFDMA symbol of the last AAI subframe of the 16m UL Relay zone, the LRUs of the corresponding AAI subframe which are used for data transmissions shall be modified in the following way. For the six-symbol PRU case, the remaining 5 OFDMA symbols are formed to be a five-symbol PRU used for the data transmission. For the seven-symbol PRU case, the remaining 6 OFDMA symbols are formed to be a six-symbol PRU for the data transmission.

In the ARS FDD frames, when the 16m UL Relay zone occupies a single AAI subframe, to support a joint insertion of a R-RTI and a R-TTI in the first and the last OFDMA symbols, the LRUs of the corresponding AAI subframe which are used for the data transmission shall be modified in the following way. For the seven-symbol PRU case, the remaining 5 OFDMA symbols are formed to be a five-symbol PRU for the data transmission. The FDD frame structure configurations with the 16m UL Relay zone which comprise of a single type-1 AAI subframe shall not used if both a R-TTI and a R-RTI are present.

16.6.3.6 Uplink Control Structure

In both 16m UL Access zones of ABS/ARS frames, all UL control channels described in 16.3.9 are reused.

To support R-RTI and R-TTI transition intervals insertion in the 16m UL Relay zone the ARS shall perform resource mapping of fast feedback control channels described in 16.3.9 but shall not transmit them on sub-carriers that belong to the OFDMA symbol of the control channel of the AAI subframe where the R-RTI or R-TTI is placed. The ABS shall process the ARS UL control signals, assuming that ARS has punctured the subcarriers and pilots that belong to the OFDMA symbol of the AAI subframe where the R-RTI or R-TTI is placed. The UL BR channel for ARS is transmitted separately with the UL BR channel for AMS connected to ABS, and the UL HARQ and fast feedback channels transmitted by ARS to ABS are transmitted in the same region with those for AMS connected to ABS. In this case, the UL HARQ feedback channel for ARS is transmitted by puncturing one HMT described in 16.3.9.2.2. In case when the transition interval is inserted in the first OFDMA symbol of the control channel, HMT in the first and second symbols shall be punctured. In case when the transition interval is inserted in the last OFDMA symbol of the control channel, HMT in the last two symbols shall be punctured.

If an R-RTI is present, then the ARS shall not use sounding channel in the first AAI subframe of the 16m UL Relay zone. In the ARS FDD frames, if an R-TTI is present and the last AAI subframe of the 16m Relay zone is a type-1 subframe, then the ABS shall not allocate sounding channel in this AAI subframe.

16.7 Support for Self-organization

Self Organizing Network (SON) functions are intended for ABSs (e.g. Macro, Micro, Femto, Relay, TBD) to automate the configuration of ABS parameters and to optimize network performance, coverage and capacity.

16.7.1 Self-Organization Functional Diagram

ABS could perform self-organizing procedures to automate the configuration of ABS parameters and optimize network performance, coverage and capacity optimization. Self-Organization consists of two functions: self-configuration and self-optimization, as illustrated in Figure 605

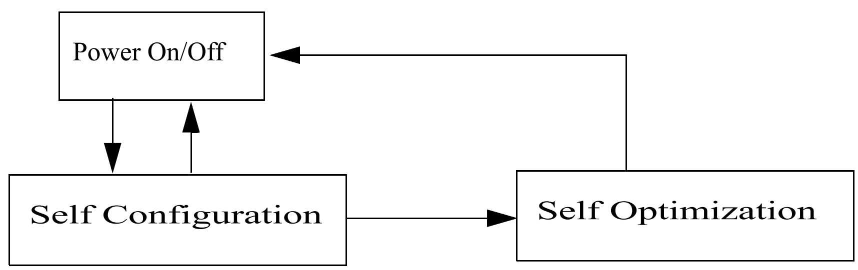

Figure 605—State Transition Diagram of Self-Organization

16.7.2 Self Configuration

Self-configuration is the process of initializing, configuring and re-configuring ABSs automatically with minimum human intervention.

16.7.2.1 Femto ABS Neighbor Discovery

Femto ABS may discover its surrounding network topology by collecting information from the core network, inter-BS network air-signaling and AMS's scan reports.

Upon installing a Femto ABS, the Femto ABS may receive a location based neighbor list from the core nework. Based on the initial neighbor list, the Femto ABS scans neighbor ABSs to refine the initial neighbor list.

In Operational State, femto ABS may schedule a scanning interval to scan neighbor ABSs. During the scanning interval, the Femto ABS listens to neighbor ABSs preambles. The Femto ABS broadcasts the AAI_SON-ADV message to inform such scanning intervals to AMSs.

16.7.2.2 Macro ABS Neighbor List Self-discovery

Cellular networks today still require much manual configuration of neighboring macro ABS to ensure neighboring cell sites work properly and hand off connections successfully that have greatly burdened the operators. Macro ABS Neighbor List Self-discovery provides a mechanism to enable an ABS to automatically update its neighboring ABS list and their associated attributes, as neighboring ABSs are going online / offline dynamically. Since the deployment of macro ABS is planned, and their locations are known by operators, its neighbors can be automatically identified by cell site and Sector Bearing. Macro ABS Neighbor List Self-discovery is to support the following 3 scenarios.

1. An ABS is going online

2. An ABS is going offline

3. An ABS has attribute changes

ABS should report BSID, location of ABS (i.e. longitude, latitude, and sector bearing - indicating the direction where the sector is pointing), and ABS attributes, as defined in AAI_NBR-ADV messages, in order to initiate Neighbor Macro ABS Self-configuration function. In response, neighbor ABS attributes (as defined in AAI_NBR-ADV messages) in the ABS should be updated.

16.7.2.3 Femto ABS Self-Configuration

In the initialization, Femto ABS may operate in the AMS mode to scan its neighbors. After the scanning, the Femto ABS may report BSID and DL RSSI attributes to the SON server. The SON server may choose and download the MAC and PHY parameters that may enable the Femto ABS to work harmoniously with its neighbors.

16.7.3 Self Optimization

Self-optimization is the process of analyzing the reported SON measurement from the ABS/AMS and fine-tuning the ABS parameters in order to optimize the network performance which includes QoS, network efficiency, throughput, cell coverage and cell capacity

SON functions can automate the configuration of ABS parameters for optimizing network performance, coverage and capacity. The air interface support for SON functions is to perform measurement/reporting of air interface performance metrics and the subsequent adjustments of ABS parameters.

16.7.3.1 Support of Interference Mitigation

When supporting femto interference mitigation by radio resource blocking, the allocation of the radio resource region among ABSs should be coordinated. An ABS can request to block a radio resource region identified by sub-frame index and sub-band CRU index for a target ABS. The target ABS may receive a response indicating if the target ABS should block such radio resource region that is identified by sub-frame index and sub-band CRU index.

16.7.3.2 Support of Multi-BS MIMO

Multi-BS MIMO operation may be supported by SON to coordinate the transmission among multiple ABSs. The ABS should report the feedback results defined in 15.3.14.3 received from AMSs for initiating the coordination to support multi-BS MIMO. The ABSs within the diversity set will be selected and a common zone will be assigned for those ABSs operating with DL or UL Multi-BS MIMO. The common zone used by the ABSs shall be aligned over the same time-frequency radio resource region. In case of Co-MIMO operation, this zone is the Co-MIMO zone.

16.7.4 Support of Reconfigurations and Restart

SON may trigger ABS(s) to reconfigure and/or restart. The ABS may announce the upcoming action of its reconfiguration and/or restart in advance using AAI_SON_ADV message.

Before ABS changes its FA, it may send AAI_SON-ADV message which includes the current FA down-time, new FA and its up time to AMS. The AMS may perform network re-entry into the same ABS, at the new FA uptime and continue with its session, when it receives this AAI_SON-ADV message.

16.7.5 MS assisted Femto ABS neighbor list update

Femto ABS Neighbor Discovery, as described in 16.7.2.11 is to provide the neighbor list for a Femto ABS at the time of Femto ABS initialization. A Femto ABS can be powered on or off intermittently at its owner's wish, so its neighbor list has to be updated periodically. Since the neighbor list is intended to assist MS handoff, MS is in the best position to discover the neighbor list. Figure 606 shows the control flow of Femto ABS neighbor list update. At each Neighbor List Update Interval, as defined in Table 554 , ABS may send AAI_SCN-RSP periodically to ask an AMS to scan neighbors that are not limited to BSID provided in AAI_NBR-ADV. The AMS is not to scan its neighbors blindly, since Femto ABS can only operate in the licensed spectrum or the PHY modes pre-determined by the operators. In each MS scanning, the ABS should collect and report MS measurements from AAI_SCN-REP, MS location, and time of the scanning to the SON server.

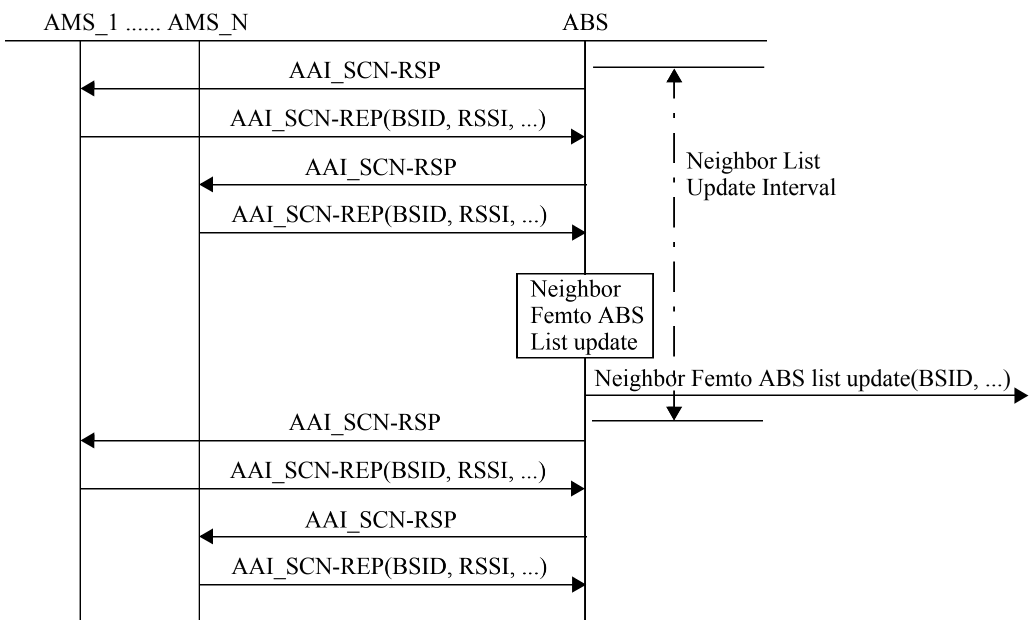

Figure 606—Femto ABS neighbor list update control flow

16.8 Support for Location Based Services (LBS)

The location determination feature includes support for over the air downlink and uplink measurements and reporting of AAI based transmissions to help relevant entities on the AMS and/or in the network to determine AMS's location. Location capabilities shall be supported in basic mode and may also be supported in enhanced mode as defined in the following:

The Basic LBS support (16.8.2) capability involves support of similar functionality and framework as Sections 6 to 14 adapted to new frame and control channel structure in the AAI. This mode of operation reuses the generic PHY and does not require any location specific PHY layer transmission.

Enhanced LBS support capability (16.8.3) may also be supported, involving over the air transmissions and measurements schemes which are specifically designed to optimize measurements needed for more accurate location determination.

16.8.1 Location Determination Capability Negotiation

The capability negotiation for LBS support and its mode are communicated through AAI_REG-REQ/RSP. (See 16.2.3.7 and 16.2.3.8)

All AMSs shall support basic location measurement capabilities including RSSI, RD and RTD measurements and report.

The capability negotiation also includes indications on whether the AMS supports special satellite based positioning capability, e.g. GPS.

16.8.2 Basic LBS Support

16.8.2.1 Basic functions supported using AAI-LBS-ADV message

AAI_LBS-ADV is a MAC management message broadcast by ABS to provide AMS with geo-location of neighboring ABS's, which can be used by the AMS for triangularization or trilaterization to enable location determination. This message may also contain time and frequency information to aid satellite based, e.g. GPS receivers for improved performance. The content of this message and its functionality is consistent with LBS-ADV message in Subclause 6.3.2.3.59.

16.8.2.2 Measurements and Reporting for Location Determination

The Location measurement and report capabilities needed to support Basic LBS are the following:

- The ABS ability to provide AMS with, and the AMS's ability to process, the AAI_LBS-ADV identifying the neighboring ABS's which need to be scanned by the AMS as well as their locations.
- ABS capability to direct AMS to start scanning using a MAC management message, with indication that is for location determination, and to report the results to ABS using a MAC management message. This direction shall include information about which parameter the AMS to measure and report, e.g. RSSI, RD, etc., and it may also include a flag to indicate if Enhanced LBS measurements should be used.
- AMS capability to request ABS for scanning time for LBS.
- AMS's capability for downlink scanning of SA-Preambles identified by a MAC management message to measure RSSI and RD.
- AMS and ABS capability to enable measurement of RTD based on ranging channel transmission (U-TDOA and TOA) (see Subclause 6.3.25).
- AMS providing scanning report to ABS with measurements results based on LBS specific direction in a MAC management message.

- MAC management message shall be used by ABS to trigger measurements in support of location. These a MAC management messages include indication that the purpose of scanning and report is for location calculation.

16.8.2.3 Assistance for Satellite Based Location Determination

The AAI support to assist satellite based location involves two functions:

The support of AAI_LBS-ADV which contain optional fields providing time and frequency information to aid satellite based, e.g. GPS, receivers for improved performance. The content of this message and its functionality is consistent with LBS-ADV message in Subclause 6.3.2.3.59.

To further assist satellite based location determination, the AAI_L2_XFER messages may be used for the following Transfer-Types: GNSS assistance and LBS measurement. (See section 16.2.3.28).

16.8.2.4 LBS Message formats

16.8.2.4.1 AAI_LBS-ADV Message

An ABS that supports LBS shall use the AAI_LBS-ADV message to broadcast the LBS related configuration information. The message may be broadcast periodically without solicitation by the AMS.

Table 948—AAI_LBS-ADV message format

Name	Value	Usage
Control Message Type	AAI_LBS-ADV	
Position Indication	Represents absolute position whether using long format or short format. The value indicates: 0b0: long format is used 0b1: short format is used	
Type indication of short format	0b0: short format including altitude is used 0b1: short format excluding altitude is used	It is included only if Position Indication is 0b1.

Table 948—AAI_LBS-ADV message format

Name		Value	Usage
Absolute Position (Long Format)	Longitude	Bit 0-5: longitude resolution 1-34 - # of valid bits in fixed-point value of longitude value 35 - LBS not supported Other - Reserved Bit 6-14: longitude integer Bit 15-39: longitude fraction	Shall be included when Position Indication is set to 0b0. The transmitting ABS's coordinates. This Absolute Position (Long Format) shall only be used for the transmitting ABS and includes Longitude, Latitude, and Altitude.
	Latitude	Bit 0-5: latitude resolution 1-34 - # of valid bits in fixed-point value of latitude value 35 - LBS not supported Other - Reserved Bit 6-14: latitude integer Bit 15-39: latitude fraction	
	Altitude	Bit 0-3: altitude type 1-meter 2-floors Other - Reserved Bit 4-9: altitude resolution 1-30 - # of valid bits in fixed-point value of altitude value 31 - LBS not supported Other - Reserved Bit 10-31: altitude integer Bit 32-39: altitude fraction	
Absolute Position (Short Format)	Longitude	Longitude expressed in 2-15 parts of a degree	The transmitting ABS's coordinates. This Absolute Position (Short Format) shall only be used for the transmitting ABS. It includes Longitude, Latitude, and Altitude if type indication of short format is 0b0. It includes Longitude and Latitude only if Position Indication is 0b1.
	Latitude	Latitude expressed in 2-16 parts of a degree	
	Altitude	Bit 0-15: altitude in meters above sea level	
GPS Time	GPS time in units of frame duration	22bits	Information about GPS time and time accuracy.
	GPS frame transmission time offset	10bits	
	GPS time accuracy	5bits	
Frequency Accuracy		8bits	Information about the frequency accuracy
Number of BS		8bits	Number of neighbor BSs included in this message that are identified using the BSID

Table 948—AAI_LBS-ADV message format

Name		Value	Usage
BSID		16bits	Shall be included when Number of BS > 0 16-bit LSB of unique 48-bit identifier of the Neighbor BS for number of BS.
Number of_BS_Index		8bits	Number of neighbor BSs included in this message that are identified using an index to their position in the AAI_NBR-ADV message
Configuration change count for AAI_NBR_ADV		8bits	Shall be included when Number of BS Indices > 0
Neighbor BS Index		8bits	Shall be included when Number of BS Indices > 0 Index that corresponds to the position of the BS in the NBR-ADV message
Relative Position Indication		Represents relative position whether including altitude. The value indicates: 0b0: altitude is included 0b1: altitude is not included	
Relative Position	Longitude	16bits Distance east of reference point in meters	Shall be included when Number of BS > 0 or when Number of BS Indices>0 This Relative Position is used to provide the absolute position of an ABS. When this Relative Position is included, it provides the position of a neighbor ABS relatively to the transmitting ABS. If the Relative position is set to 0b0, altitude is included. Otherwise, altitude in not included.
	Latitude	16 bits Distance north of reference point in meters	
	Altitude	16bits Distance above of reference point in meter	

16.8.2.4.2 LBS Measurement Message formats

The AAI defines MAC control messages to assign the unavailable interval for the AMS to measure its location by receiving the DL reference signals from the candidate ABSs.

The location measurement procedure may be initiated by either the AMS or the network, which is requested by the application associated with the AMS or the client attached at the core network.

An ABS may trigger a location measurement by sending a MAC management message to the AMS. The AMS responds to this with a MAC management message with the parameters that enable location determination.

16.8.3 Enhanced LBS Support

The Enhanced LBS (ELBS) is an optional LBS capability involving the following functions:

- ABS ability to transmit special ELBS waveforms to be used for location specific measurements to enable more accurate location determination.
- ABS's ability to signal to the AMS the location of the special ELBS waveforms.
- AMS's ability to detect, measure and report relevant measurements to the ABS.

16.9 Support for Enhanced Multicast Broadcast Service

Enhanced Multicast and Broadcast Service (E-MBS) provides an efficient method for concurrent transport of DL data common to a group of users, using a common multicast STID (MSTID) and a FID. E-MBS service is offered in the downlink only and may be coordinated and synchronized among a group of ABS to allow macro-diversity.

Each multicast/broadcast connection is associated with a service flow provisioned with the QoS and traffic parameters for that service flow.

Service flows to carry E-MBS data are instantiated on individual AMSs participating in the service while in normal operation. During such instantiation the AMS learns the parameters that identify the service and associated service flows.

Each ABS capable of providing E-MBS belongs to a certain E-MBS Zone and one ABS can belong to multiple E-MBS zones. An E-MBS zone defined as a set of ABSs where the same MSTID and FID is used for transmitting the content of certain service flow(s). Each E-MBS Zone is identified by a unique E-MBS_Zone_ID.

To ensure proper multicast operation on networks of ABS employing E-MBS, the MSTIDs and FIDs used for common E-MBS content and service shall be the same for all ABSs within the same E-MBS Zone. This allows the AMS which has already registered with a service to be seamlessly synchronized with E-MBS transmissions within an E-MBS Zone without communicating in the UL or re-registering with other ABS within that E-MBS Zone. The E-MBS_Zone_IDs shall not be reused across any two adjacent E-MBS Zones.

16.9.1 E-MBS Transmission Modes

Continuous reception of E-MBS transmissions within an E-MBS Zone rely on some coordination among ABS's in that E-MBS Zone. Such coordination is applied to achieve frame level synchronization of E-MBS in non-macro diversity transmission mode or to achieve symbol level synchronization with macro diversity transmission mode as described below.

An ABS may provide the AMS with E-MBS content locally within its coverage and independently of other ABSs. The single ABS provision of E-MBS is therefore a configuration where an E-MBS Zone is configured to consist of a single ABS only. This configuration may be provided as one of the possible cases of E-MBS. In this case, the ABS may use any MSTID and FID for providing the E-MBS service, independently of other ABSs, so the AMS receives the E-MBS data from its serving ABS, and the AMS should not expect the service flow for this E-MBS connection to continue when the AMS leave the serving ABS. However, if the AMS moves to an ABS that is transmitting the same E-MBS flows in another E-MBS Zone and updates its Service Flow management encodings, the AMS may continue to receive the same E-MBS flows.

16.9.1.1 Non-Macro Diversity Mode

Non-macro diversity mode is provided by frame level coordination only, in which the transmission of data across ABSs in an E-MBS Zone is not synchronized at the symbol level. However, such transmissions are coordinated to be in the same frame. This MBS transmission mode is supported when macro-diversity is not feasible. For all ABSs that belong to the same E-MBS Zone, the following coordination shall be assured:

— The set of MAC SDUs carrying E-MBS content shall be identical in the same frame in all ABS in the same E-MBS Zone;

— The mapping of MAC SDUs carrying E-MBS content onto MAC PDUs shall be identical in the same frame in all ABS in the same E-MBS Zone, meaning, in particular, identical SDU fragments and identical fragment sequence number and fragment size

Coordination in the E-MBS Zone assures that the AMS may continue to receive E-MBS transmissions from any ABS that is part of the E-MBS Zone, regardless of the AMS operating mode-Active Mode, Sleep Mode and Idle Mode-without need for the AMS to register to the ABS from which it receives the transmission.

16.9.1.2 Macro Diversity Mode

In addition to coordination, E-MBS transmissions may optionally be synchronized across all ABSs within an E-MBS Zone. This option enables an AMS to extract macro-diversity gains in the multicast or broadcast transmission from multiple ABS, thereby improve the reliability of reception. When macro-diversity is used, the mapping of SDUs into the E-MBS Bursts is identical, and the same E-MBS bursts are transmitted using the same time-frequency resource in all involved ABS; additional parameters may also be required to be identical across ABSs if macro-diversity is used.

In macro-diversity mode, within one E-MBS Zone all ABSs participating in the same E-MBS service shall be time and frequency synchronized in the transmissions of common E-MBS data to allow macro diversity gain at the AMS. When macro-diversity is enabled the E-MBS bursts positions and dimensions as well as PHY parameters shall be the same across all ABS's within the same E-MBS Zone. In addition to the coordination parameters such as E-MBS Zone ID, MSTID & FID, MSI, and Packet Classification Rule parameter(s), macro-diversity synchronization requires that all ABSs within the same E-MBS Zone shall use the same

— Transmission PHY parameters, MCS associated with each E-MBS Burst including FEC Type, Modulation Type, and Repetition Coding

— Mapping of SDUs to PDU (order of the SDUs and fragments) including Extended Headers)

— Mapping of PDUs to bursts

— Order of bursts in the zone/region

— E-MBS MAP construction

Mechanisms and procedures for multiple ABSs to accomplish the synchronized transmission (which implies performing functions like classification, fragmentation, scheduling at a centralized point like the E-MBS Server) are outside the scope of this standard.

16.9.2 E-MBS Operation

Establishment of E-MBSs for a specific AMS with respect to certain service flow, when needed, shall be performed while the AMS is in connected state. E-MBS service flows are not dedicated to the specific AMS and are maintained even though the AMS is either in Active/Sleep mode or in the Idle mode. When an AMS is registered at an ABS for receiving E-MBS, multicast and broadcast service flows shall be instantiated as multicast connections. Data of multicast and broadcast service flows may be transmitted from ABS and may be received at AMS also regardless of what mode the AMS is currently in. The ABS may establish a DL E-MBS by creating a multicast and broadcast service flows when the service commences. Mapping of multicast and broadcast service flows to corresponding MSTIDs and FIDs shall be known and be the same for all ABSs belonging to the same E-MBS Zone. The method of making all ABS in the same E-MBS Zone aware of E-MBS flows and associated E-MBS service flows-including multicast STID and FID assignment, QoS parameter set, and Classification Rule(s)-is outside the scope of the standard. As the classification and transmission of E-MBS flows may be supported on an ABS in an E-MBS Zone regardless of the presence or absence of any AMS in Active mode receiving the service, the ABS may retain E-MBS service flow management encodings to do classification and scheduling of E-MBS flows, even when no AMS in Active mode receiving the service is registered at the ABS.

In order to improve the efficiency of radio resource utilization, dynamic multicast service may be supported, in which the transmission of the multicast service data should be decided based on the number of the AMSs within the ABS. Dynamic multicast service may be supported regardless of the AMS operating state – Connected State and Idle State.

16.9.2.1 E-MBS Connection Establishment

To discover E-MBS service, AMS will inform ABS of support of E-MBS transmission by AAI_REG-REQ message and the ABS will indicate if it supports any of E-MBS modes for that AMS through AAI_REG-RSP message. The basic E-MBS capability exchange in AAI_REG-REQ/RSP message described in 16.2.3.7 and 16.2.3.8.

Following the discovery the E-MBS services and registers with the ABS for receiving multicast and broadcast services through upper layer signaling which are outside the scope of this standard.

To prepare for subsequent E-MBS operation, the AMS obtains the E-MBS related configuration information receiving AAI_E-MBS-CFG MAC Control message on the corresponding E-MBS carrier described in Table 949.

The AMS learns the E-MBS_Zone_ID(s) to which the ABS belongs through AAI_E-MBS_CFG message.

If E-MBS is supported by the AMS/ABS, support of DSx messaging for E-MBS flow establishment is mandatory on AMS/ABS. In addition the E-MBS flows may also be established optionally through upper layer signaling that is outside the scope of this specification.

The ABS or AMS may/shall initiate the DSA procedure with respect to multicast and broadcast connections. When supported, the E-MBS service flows shall be activated, changed or deleted through ABS/network Initiated DSA, DSC and DSD messaging respectively. The ABS initiated DSx messaging shall be supported and MS initiated DSx may also be supported. When E-MBS services involve multiple flows the compact form of DSx with group parameter should be used to reduce overhead and signaling delay associated with E-MBS flow management.

The ABS sends the AAI-DSA-RSP to the AMS containing the relevant E-MBS/MBS parameters. The parameters sent will indicate to the AMS whether to listen to E-MBS on a 16m zone or to listen to MBS on a legacy MBS zone. It also includes MSTIDs and FIDs, E-MBS zone IDs, E-MBS carrier information (physical carrier index). Selective decoding of content is at the granularity of FID's.

If multicarrier feature is supported by the AMS and the ABS, the ABS should use AAI_DSA-REQ/RSP message to redirect the MS to legacy MBS zones or 16m E-MBS zone of other carriers, if such redirection is needed.

A Start time parameter is included in AAI-DSA message for carrier switching mode to indicate the time the AMS performs carrier switching to the E-MBS carrier for detecting and decoding the AAI_E-MBS_CFG message.

The AMS may continue to receive E-MBS transmissions from any ABS that is part of the E-MBS Zone, regardless of the AMS operating mode-Active Mode, Sleep Mode, Idle Mode-without need for update to any service flow management encoding for the E-MBS flow.

To allow seamless transition from one E-MBS Zone to another without any interruption of E-MBS data service and operation, the AMS should update E-MBS service flow management encodings including MSTIDs and FIDs, Packet Classification Rule parameter(s), E-MBS Zone Identifier Assignment parameter. If the AMS has no MSTIDs and FIDs information regarding the new E-MBS Zone, then the AMS is required to acquire MSTIDs and FIDs context through the other procedures, i.e., location-update if AMS is in the idle mode and handover if MS is in connected mode.

After successful configuration, the AMS shall reuse the same configuration when it moves to another ABS in the same E-MBS Zone without re-configuration.

16.9.2.2 E-MBS Operation in Connected State

When an AMS moves across E-MBS zone boundaries in Active Mode or Sleep Mode, the AMS performs the handover procedure described in 16.2.6.3.

When the AMS transits to a new E-MBS Zone while in Active Mode or Sleep Mode, and the E-MBS service flow management encodings of the AMS have not been updated, the AMS shall send AAI_RNG-REQ message with Ranging Purpose Indication Bit#4 is set to 1 at the target ABS and the ABS shall include MSTID and FID Update in AAI_RNG-RSP parameters to provide updated service flow management encodings for any affected E-MBS flow as part of the handover procedure.

Once an AMS has received the E-MBS allocation information in the E-MBS-MAPs, it may not listen to the downlink channels till the next transmission of desired E-MBS flow or the next E-MBS-MAP.

When EMBS data is transmitted on an alternative carrier, i.e. other than the AMS's primary carrier where service flows are configured the AMS is redirected to relevant carrier through DSA as described in 16.9.2.1

During the transmission of EMBS configuration messages and the EMBS data to which AMS is subscribed, the AMS with only one transceiver may not be available for signaling exchange with ABS on the primary carrier.

The AMS with multiple transceivers may be able to receive EMBS data while communicating with ABS on primary carrier.

Other EMBS operations in idle and connection states as described in 16.9.2.2 and 16.9.2.3 also applicable to this scenario.

The AMS does monitor down link channels and follow the entire idle mode and connected mode procedures as required by other services. While receiving E-MBS data, the AMS may temporary interrupt the reception of E-MBS packets for any reason, e.g. if time critical scanning is needed, without notifying the ABS.

16.9.2.3 E-MBS Operation in Idle State

When an AMS in Idle mode moves to an ABS which does not belongs to AMS' previous E-MBS Zone, the AMS is expected to update the E-MBS service flow management encodings at that ABS to provide continuous reception of E-MBS content. The AMS may obtain the E-MBS information in the target E-MBS zone through broadcast messages in the E-MBS-Zone of the serving ABS. If the idle AMS has not received such information from the serving E-MBS Zone, the AMS shall use location update procedure to acquire updated E-MBS service flow management encodings. In order to perform the MBS location update process, the AMS shall transmit AAI_RNG-REQ message with Ranging Purpose Indication Bit # 4 set to 1. In response to the request for MBS location update, the ABS shall transmit AAI_RNG-RSP message which may include the E-MBS zone identifier, MSTID, FID, and E-MBS Zone Identifier Assignment parameter and etc. to provide update service flow management encodings for any affected E-MBS flow(s).

The AMS may also conduct re-entry from Idle mode if required by quality of service of corresponding E-MBS flow.

16.9.3 E-MBS Protocol Features and Functions

16.9.3.1 E-MBS Configuration Indicators

The information regarding E-MBS configuration is transmitted periodically to the AMSs interested in E-MBS using a MAC management message called the AAI-E-MBS_CFG message. The E-MBS configuration indicators specify the resources reserved for E-MBS traffic in the downlink physical resources and additional information necessary for E-MBS operation.

The E-MBS configuration information necessary for E-MBS operation include E-MBS-Zone_IDs of serving and neighboring ABSs, E-MBS MAP time offset (frequency offset), E-MBS MAP resource allocation, E-MBS MAP $I_{size\text{-}offset}$, E-MBS MAP MIMO Mode and MSTID and FID mappings between serving E-MBS Zone and neighboring E-MBS Zone for the same content. AAI_E-MBS-CFG shall be advertised in the superframe before the beginning of the largest MSI (16 superframes).

Table 949—AAI_E-MBS-CFG_Message format

Syntax	Size (bits)	Notes
AAI-E-MBS-CFG_Message_Format() {		
MAC Control Message Type	8	AAI_E-MBS-CFG
E-MBS_CFG_LIFETIME (*m*)	4	Indicates the duration of E-MBS_CFG_LIFETIME for which the E-MBS configuration information of the zone do not change. Duration of E-MBS_CFG_LIFETIME: 16 (m+1) superframes
Zone_Allocation Bit-MAP	variable	Indicates the zone configuration. The size is as below. 20 bits for 20 MHz 9 bits for 10MHz 3 bits for 5 MHz
ZF	1	Zone Flag bit. Indicates the use of the last zone. 0b0: Unicast 0b1: E-MBS
for (i = 0; i< Num_E-MBS_Zones; i++) {		

Table 949—AAI_E-MBS-CFG_Message format

Syntax	Size (bits)	Notes
E-MBS_Zone_ID	7	The E-MBS_Zone_ID to which this E-MBS MAP applies.
MSI Length (N_{MSI})	2	The length of an MSI in units of the number of superframes 0b00: 2 superframes, 40 ms (N_{MSI} = 2) 0b01: 4 superframes, 80 ms (N_{MSI} = 4) 0b10: 8 superframes, 160 ms (N_{MSI} = 8) 0b11: 16 superframes, 320 ms (N_{MSI} = 16)
E-MBS MAP Resource Index	11	Resource index includes location and allocation size.
E-MBS MAP ISizeOffset	5	
MSTID and FID Mappings List inclusion	1	Indicates whether MSTID and FID Mapping list is included or not 0b0: No Zone boundary or Zone boundary but no inter-zone service continuity in neighbor ABS 0b1: Zone boundary and inter-zone service continuity
if (MSTID and FID Mappings List inclusion ==1) {		
MSTID and FID Mappings List	Variable	MSTID and FID Mappings List between serving and neighbor E-MBS Zones
}		
}		
}		

Zone_Allocation Bit-MAP: Zone_Allocation Bit-MAP consists of sub-band indices reserved for all E-MBS zones the BS belongs to. The Zone Allocation Bit-MAP in the AAI-E-MBS-CFG message identifies the use of the resource comprising a set of contiguous subbands in a DL AAI subframe. The Bit-MAP determines the size (*S*) of each E-MBS zone in number of contiguous SLRUs in frequency domain within the subframe, the index (*L*) of each E-MBS zone from where the allocated zone begins and the total number (*Num_E-MBS_Zones*) of allocated zones.

The Zone Allocation Bit-MAP is constructed using the following rules:

- If the use of the resource is changed between one sub-band and the next sub-band, the bit '1' is set in the location the same as the index of the sub-band in the Bit-MAP.

- Otherwise, the bit '0' is set in the Bit-MAP.

For a given system bandwidth with maximum number of subbands, $DSAC_{max}$ = 21, 10, 4 for 20, 10 and 5 MHz respectively, the size of the Zone Allocation Bit-MAP is ($DSAC_{max}$ -1). Let the total number of the bit '1' in the Bit-MAP be denoted as *K* and the index in which the bit '1' in the Bit-MAP is located be denoted as J_i, where *i* is the E-MBS zone index which is from 1 to *Num_E-MBS_Zones*. J_0 is fixed to 0.

$$\text{Num\_E-MBS\_Zones} = \begin{cases} K+1, & \text{if ZF} = 0b1 \\ K, & \text{if ZF} = 0b0 \end{cases}$$

$$L_i = J_{i-1} + 1$$

$$S_i = \begin{cases} J_i - J_{i-1} & ,1 \le i \le K \\ DSAC_{max} - J_K & ,i = K+1 \end{cases}$$

For example, consider the case where the Zone Allocation Bit-MAP field = 000010010. The system bandwidth is 10MHz and $DSAC_{max}$ is 10. This is illustrated pictorially below in Figure 607. In this case, ZF=0b0 because the last zone is the unicast zone. *Num_E-MBS_Zones* = 2, L_i = {1, 6}, S_i = {5, 3} from K = 2, J_i = {0, 5, 8}. Hence, the number of zones is 2. Each index of two zones is 1, 6 respectively and each size of two zones is 5, 2 respectively.

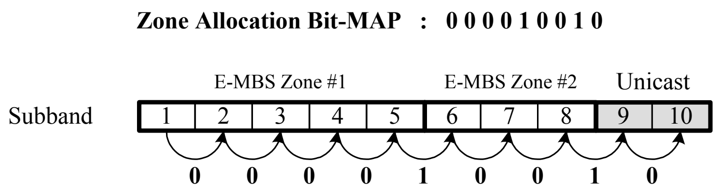

Figure 607—Zone Allocation Bit-MAP for 10 MHz

E-MBS MAP Resource Index: Resource Index indicating the starting SLRUE-MBS index and size of a single allocation spanning contiguous SLRUE-MBSs of the E-MBS MAP.

For each neighbor E-MBS_Zone, the MSTID and FID Mappings List between serving and neighbor E-MBS Zones shall be included if the serving and neighbor ABSs belong to different E-MBS Zones which provide service continuity.

The mappings list includes the followings:

Num_Neighbor_E-MBS_Zones (3 bits)

AAI_NBR-ADV Change Count (3 bits)

```
for (i = 0; i< Num_Neighbor_E-MBS_Zones; i++) {
    Neighbor_E-MBS_Zone_ID (7 bits)
    Physical Carrier Index (6 bits)
    Number_Neighbor_ABS (8 bits)
    for (j = 0; j< Number_Neighbor_ABS; j++) {
        Index of BS (8 bits)
    }
    Num_MSTID_FID Mappings (4 bits)
    for (k = 0; k< Num_MSTID_FID Mappings; k++) {
        Current_MSTID and FID (k),
        New_MSTID and FID (k),
    }

}
```

If a Current_MSTID and FID is not available in the E-MBS Zone of the neighbor ABS, the mapping for the Current_MSTID and FID shall not be included in the mapping list.

16.9.3.2 E-MBS Zone Configuration

Different MSTIDs and FIDs may be used in different E-MBS Zones for the same multicast and broadcast service flow. A multicast and broadcast zone identifier (E-MBS_ZONE_ID) is used to indicate a service area in which a MSTID and FID for a broadcast and multicast service flow are valid. An ABS that supports E-MBS shall include the E-MBS Zone identifier(s) to which it belongs in the AAI-E-MBS_CFG message. The E-MBS Zone identifier shall not be '0'.

When the E-MBS Zone identifier list appears in AAI_NBR_ADV message with only one value of '0' for some of ABS's, it indicates that the corresponding neighbor ABSs are not affiliated with any E-MBS zone.

When the ABS sends AAI_DSA message for establishment of connection for E-MBS_ZONE_ID, the E-MBS_ZONE_ID shall be encoded in the AAI-DSA message. One ABS may have multiple E-MBS_ZONE_IDs for different E-MBS services.

To support inter-MBS zone transition, AMSs need to get E-MBS_Zone_IDs to which the neighboring ABS's belong as well as any flow continuity across such neighboring zone.

16.9.3.3 E-MBS Scheduling Interval (MSI)

For each E-MBS Zone there is an E-MBS Scheduling Interval (MSI), which refers to a number of successive super-frames for which the access network may schedule traffic for the streams associated with the MBS Zone prior to the start of the interval. The MSI can span several super-frames and the length of this interval, denoted by NMSI, depends on the particular use case of E-MBS. The MSI can be, NMSI = 2, 4, 8 and 16 superframes long. The E-MBS_MAP message addresses the mapping of E-MBS data associated with an E-MBS Zone for an entire MSI. The MBS MAP message is structured such that it may be used to efficiently define multiple transmission instances for a given stream within an MSI. The MSI for a particular E-MBS zone is transmitted in the AAI-E-MBS-CFG message. Using the superframe number, Nsuperframe from SFH, and NMSI from AAI-E-MBS-CFG message, the AMS computes the beginning of the MSI as follows:

The MSI begins at the superframe when its Nsuperframe meets the following condition.

Nsuperframe modulo NMSI == 0

An AMS decodes only the E-MBS data bursts associated with user selected content. The AMS wakes up in each MSI in order to check whether there are E-MBS data bursts to be decoded.

16.10 Support for Advanced Air Interface in LZone

16.10.1 Support for network topology advertisement

16.10.1.1 DL frame prefix

Table 950 defines the structure of DL_Frame_Prefix to be transmitted in LZone of an ABS supporting WirelessMAN-OFDMA Reference System.

Table 950—OFDMA DL Frame Prefix format

Syntax	Size (bit)	Notes
DL_Frame_Prefix_Format() {		
Used subchannel bitmap	6	Bit #0: Subchannel group 0 Bit #1: Subchannel group 1 Bit #2: Subchannel group 2 Bit #3: Subchannel group 3 Bit #4: Subchannel group 4 Bit #5: Subchannel group 5
16e/16m coexistence indication	1	0b0: WirelessMAN OFDMA Reference System only 0b1: WirelessMAN OFDMA Reference/ Advanced System coexistence
Repetition_Coding_Indication		0b00: No repetition coding on DL-MAP 0b01: Repetition coding of 2 used on DL-MAP 0b10: Repetition coding of 4 used on DL-MAP 0b11: Repetition coding of 6 used on DL-MAP
Coding_Indication		0b000: CC encoding used on DL-MAP 0b001: BTC encoding used on DL-MAP 0b010: CTC encoding used on DL-MAP 0b011: ZT CC encoding used on DL-MAP 0b100: CC encoding with optional interleaver 0b101: LDPC encoding used on DL-MAP 0b110 to 0b111: Reserved
DL-Map_Length	8	-
Reserved	4	Shall be set to zero
}		

16.10.2 Support for zone switch operation

16.10.2.1 RNG-RSP management message encodings

The encodings in Table 951 are specific to the RNG-RSP message sent in LZone of an ABS supporting WirelessMAN-OFDMA Reference System.

Table 951—OFDMA-specific RNG-RSP message encodings

Name	Type (1 byte)	Length	Value
MZone A-Preamble index	41	1	
Time offset	42	1	Time offset
Action Time	43	1	Action time of zone switch from LZone to MZone. AMS performs zone switch at Action Time. If HO_Reentry_Mode=0, ABS stops all resource allocation for the AMS at LZone.
Zone Switch Mode	44	1	0x01: AMS maintains its data communication with the ABS in LZone while performing network reentry in MZone; 0x00: AMS breaks data communication in LZone before performing network reentry in MZone.
NONCE_BS	45	4	For AMSID* derivation. PMK is shared between LZone and MZone during zone switch.
Temporary STID	46	1	Temporary STID for being used in MZone
Ranging initiation deadline	47	1	Valid time for Temporary STID. Shall be included if Temporary STID is included.

16.10.3 Migrating to Advanced Air Interface without impacting the deployed legacy network

The migration to WirelessMAN OFDMA Advanced Air Interface may be done without impacting the deployed legacy network elements. The ABS should be able to connect to legacy access and core network elements. If the ABS is connected to legacy network, the ABS shall communicate to the AMSs that it is attached to the legacy network and the AMSs shall function in accordance to legacy network requirements.

Annex D.

(Informative)

D.2 Sleep mode MSCs

[Replace Figure D7 with the following figure:]

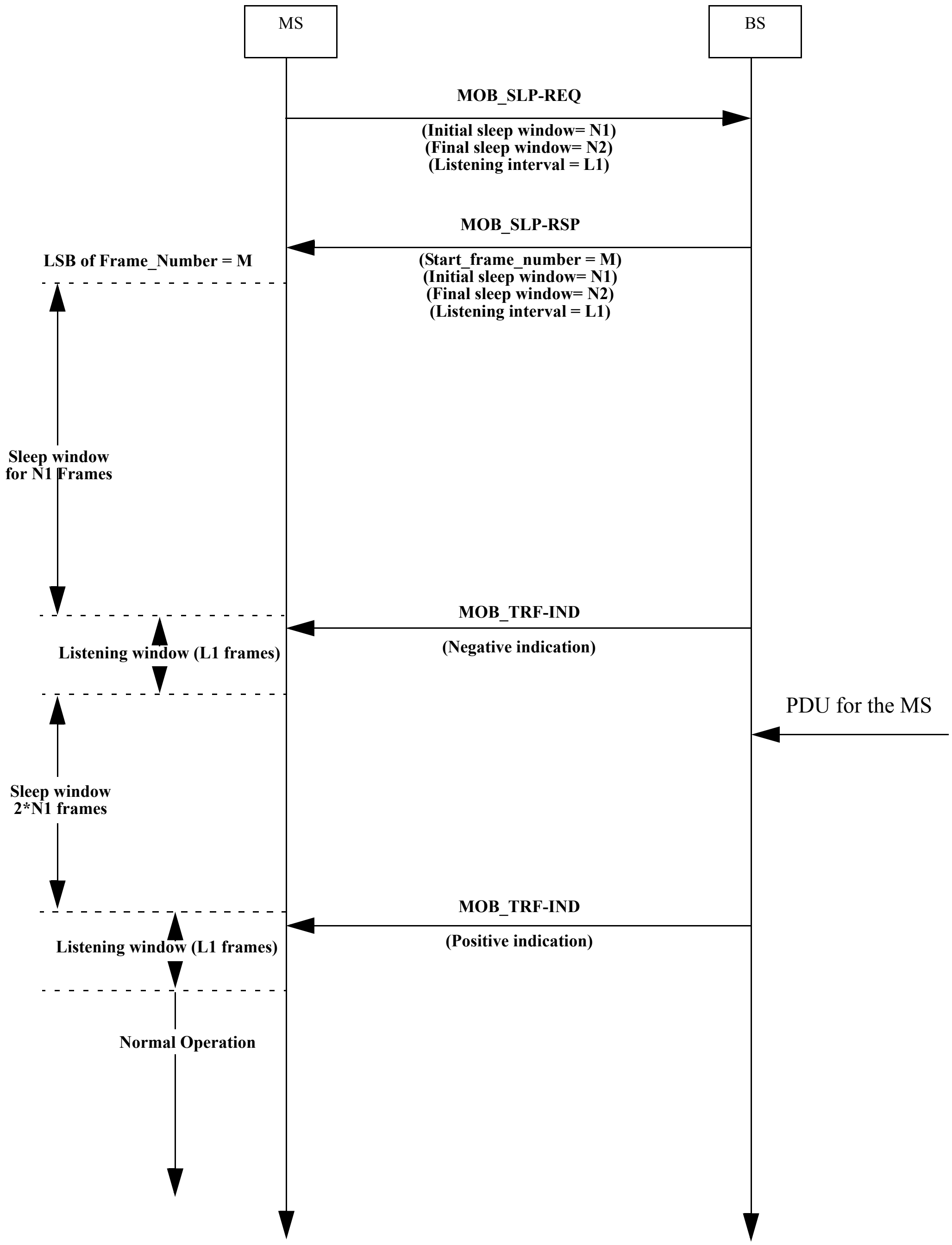

Figure D.7—Example sleep mode—MS-initiated in the case of TRF_IND_ required = 1 and Traffic_Triggered_wakening_flag = 1

[Replace Figure D.8 with the following figure:]

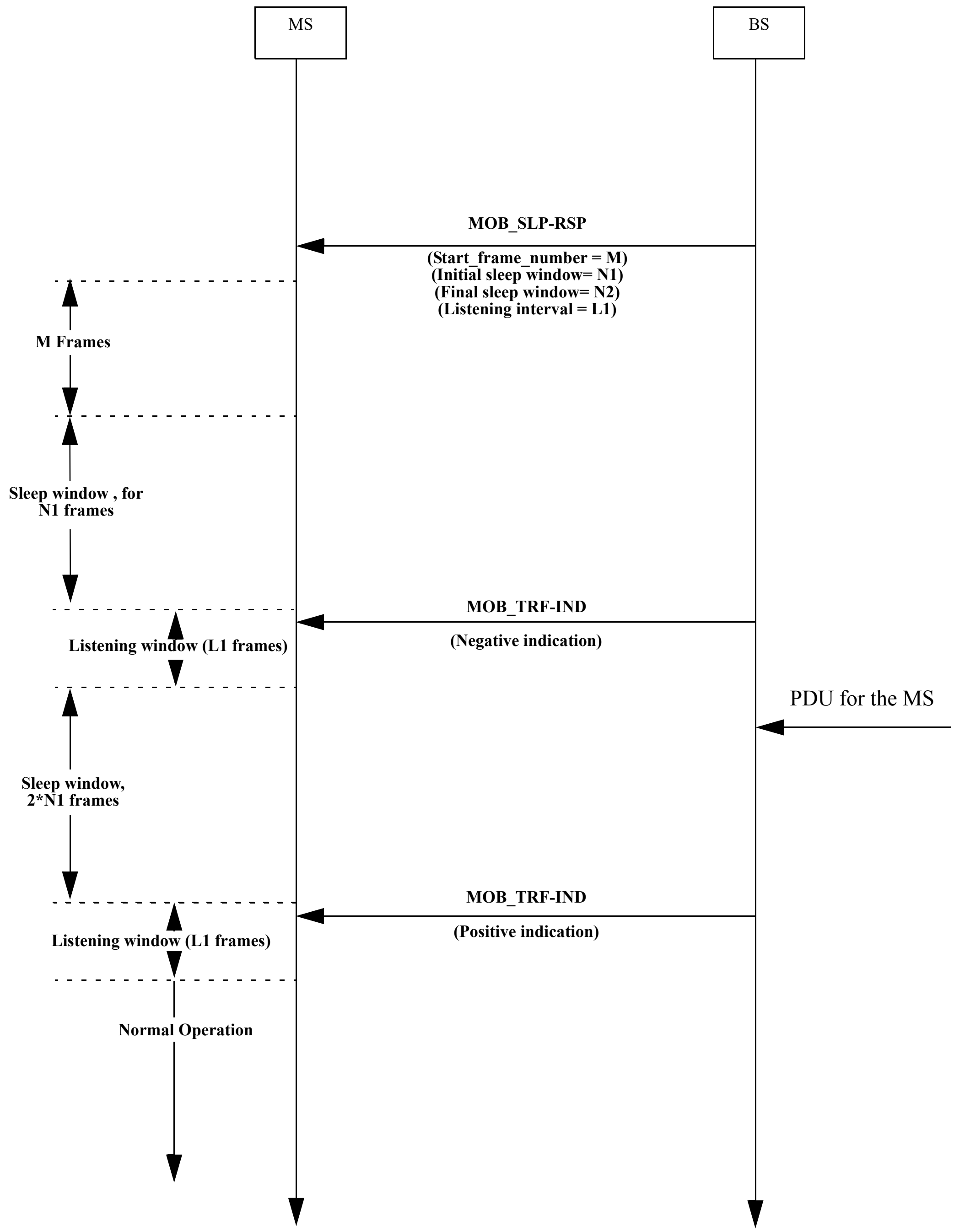

Figure D.8—Example sleep mode—BS-initiated for the case of TRF_IND = 1 andTraffic_triggering_wakening_flag = 1

Annex P.

(Normative)

Definition of AAI MAC control messages

This Appendix defines MAC control messages using ASN.1 notation. The Packed Encoding Rules (PER) shall be used to produce compact transfer syntax for MAC control message to be transmitted over the air interface efficiently.

Annex P.1 ASN.1 coding recommendations (Informative)

1) The template of a MAC control message is shown below. It consists of one or more attributes. Each attribute should associate with a TYPE (e.g. INTEGER, OCTET STRING) that defines the type of the attribute.

```
AAI-XXX-XXX ::= SEQUENCE {
    attributes                TYPE
}
```

   1) "Underscore "_" should not be used, as it is not accepted by ASN.1 compiler
   2) "Attribute should use lower case in the 1st letter. Lower cases and upper cases can be mixed to make the attribute easy to read (e.g. userBitmapSize).
   3) "User-defined type should use upper case in the 1st letter (e.g. ResourceBitmapList).
   4) "The ASN.1 coding should use Courier font and no Tap in spaces.
   5) "The length of attributes should be limited to 30 characters.
   6) "The length of TYPE should be limited to 20 characters.
   7) "The length of each line should be limiyed to 72 characters.
   8) "Attribute should avoid using keywords (e.g. *, +) in widely used languages (e.g. C, C++).
   9) "Each type should have range, when applicable, e.g.

```
flowId                    INTEGER (0..15),
```

   10) "Comments may be inserted to each attribute, e.g.

```
-- present when a flow is added to a GRA
graInfoForAddedFlow       GroupRsrcAllocInfo OPTIONAL
```

2) Example of FOR loop implementation.

For (i=1; i<=4; i++) {		
Burst size	5	ith burst size of the 4 burst sizes supported in the group
}		

```
BurstSizeList ::= SEQUENCE (SIZE (1..4)) OF INTEGER (0..31)
```

3) Example of If statement implementation.

Deletion Flag	1	Flag to signal whether this message includes addition or deletion information. 0: Flow is added to a group 1: Flow is explicitly deleted from a group
If (Deletion Flag == 0) {		ith burst size of the 4 burst sizes supported in the group
Group ID	5	ID of the group to which the flow is added
}		

```
graInfoForAddedFlow       GroupRsrcAllocInfo OPTIONAL
```

1) It is not necessary to define the Condition, since ASN.1 compiler will automatically define a control bit for each OPTIONAL attribute.

2) If a MAC control message contains OPTIONAL attributes, it should include a table explaining the conditions of such attributes.

4) Each MAC control message should be free of compilation errors. A free online ASN.1 compiler is available from http://lionet.info/asn1c/asn1c.cgi

5) Additional information on ASN.1 can be found in http://www.obj-sys.com/asn1tutorial/asn1only.html

Annex P.2 MAC Control Message Definitions

```
MacControlMsg DEFINITIONS AUTOMATIC TAGS ::= BEGIN

-- MAC Control Messages
MAC-Control-Message ::= SEQUENCE {
    message                       MAC-Control-Msg-Type
    }

MAC-Control-Msg-Type ::= CHOICE {
    aaiRngReq     AAI-RNG-REQ,      -- Message type = 1
    aaiRngRsp     AAI-RNG-RSP,      -- Message type = 2
    aaiRngAck     AAI-RNG-ACK,      -- Message type = 3
    aaiSbcReq     AAI-SBC-REQ,      -- Message type = 4
    aaiSbcRsp     AAI-SBC-RSP,      -- Message type = 5
    aaiSonAdv     AAI-SON-ADV,      -- Message type = 6
    aaiRegReq     AAI-REG-REQ,      -- Message type = 7
    aaiRegRsp     AAI-REG-RSP,      -- Message type = 8
    aaiHoInd      AAI-HO-IND,       -- Message type = 9
    aaiHoReq      AAI-HO-REQ,       -- Message type = 10
    aaiHoCmd      AAI-HO-CMD,       -- Message type = 11
    aaiNbrAdv     AAI-NBR-ADV,      -- Message type = 12
    aaiScnReq     AAI-SCN-REQ,      -- Message type = 13
    aaiScnRsp     AAI-SCN-RSP,      -- Message type = 14
    aaiScnRep     AAI-SCN-REP,      -- Message type = 15
    aaiClcReq     AAI-CLC-REQ,      -- Message type = 16
    aaiClcRsp     AAI-CLC-RSP,      -- Message type = 17
    aaiClcInfo    AAI-CLC-INFO,     -- Message type = 18
    aaiFfrCmd     AAI-FFR-CMD,      -- Message type = 19
    aaiFfrRep     AAI-FFR-REP,      -- Message type = 20
    aaiDregReq    AAI-DREG-REQ,     -- Message type = 21
    aaiDregRsp    AAI-DREG-RSP,     -- Message type = 22
    aaiSlpReq     AAI-SLP-REQ,      -- Message type = 23
    aaiSlpRsp     AAI-SLP-RSP,      -- Message type = 24
    aaiTrfInd     AAI-TRF-IND,      -- Message type = 25
    aaiTrfIndReq  AAI-TRF-IND-REQ,  -- Message type = 26
    aaiTrfIndRsp  AAI-TRF-IND-RSP,  -- Message type = 27
    aaiL2Xfer     AAI-L2-XFER,      -- Message type = 28
    aaiSysCfgDcp  AAI-SYS-CFG-DCP,  -- Message type = 29
    aaiUlNil      AAI-UL-NIL,       -- Message type = 30
    aaiDlIm       AAI-DL-IM,        -- Message type = 31
    aaiMsgAck     AAI-MSG-ACK,      -- Message type = 32
    aaiNbrReq     AAI-NBR-REQ,      -- Message type = 33
    aaiSbsMimoFbk AAI-SBS-MIMO-FBK, -- Message type = 34
    aaiMbsMimoFbk AAI-MBS-MIMO-FBK, -- Message type = 35
    aaiMbsMimoReq AAI-MBS-MIMO-REQ, -- Message type = 36
    aaiPkmReq     AAI-PKM-REQ,      -- Message type = 37
    aaiPkmRsp     AAI-PKM-RSP,      -- Message type = 38
    aaiArqFbk     AAI-ARQ-FBK,      -- Message type = 39
    aaiArqDsc     AAI-ARQ-DSC,      -- Message type = 40
    aaiArqRst     AAI-ARQ-RST,      -- Message type = 41
    aaiDsaReq     AAI-DSA-REQ,      -- Message type = 42
    aaiDsaRsp     AAI-DSA-RSP,      -- Message type = 43
```

```
        aaiDsaAck     AAI-DSA-ACK,      -- Message type = 44
        aaiDscReq     AAI-DSC-REQ,      -- Message type = 45
        aaiDscRsp     AAI-DSC-RSP,      -- Message type = 46
        aaiDscAck     AAI-DSC-ACK,      -- Message type = 47
        aaiDsdReq     AAI-DSD-REQ,      -- Message type = 48
        aaiDsdRsp     AAI-DSD-RSP,      -- Message type = 49
        aaiDsdAck     AAI-RNG-CFM,      -- Message type = 50
        aaiMbsPmiCom  AAI-MBS-PMI-COM,  -- Message type = 51
        aaiGrpCfg     AAI-GRP-CFG,      -- Message type = 52
        aaiResCmd     AAI-RES-CMD,      -- Message type = 53
        aaiSiiAdv     AAI-SII-ADV,      -- Message type = 54
        aaiMcReq      AAI-MC-REQ,       -- Message type = 55
        aaiMcRsp      AAI-MC-RSP        -- Message type = 56
    }

    END
```

Annex Q

(informative)

Test vectors

Q.1 Cryptographic method test vectors

Q.1.1 AES-CCM:

Q.1.1.1 Short payload and short ICV

- Plaintext PDU
    - •Advanced Generic MAC header = D0 06
    - •Payload = 9c 05 3f 24
    - •STID=0x234, FID=0xD
- Ciphertext PDU where TEK = 0xD50E18A844AC5BF38E4CD72D9B0942E5, EKS=0x1 (2bits), PN=0x17F6BC (22 bits) and ICV length is 4B:
    - •Advanced Generic MAC header = D0 0D
    - •Initial CCM block B0 (128bits): 19 D0 0D 23 4D 00 00 00 00 00 00 57 F6 BC 00 04
    - •Encrypted payload of EKS+PN (3B), encrypted payload (4B), encrypted ICV (4B):

      57 F6 BC 10 71 D1 B0 3C DF A2 28
- After decryption
    - •Plaintext ICV= 99 C7 97 F7

Q.1.1.2 Long payload and long ICV

- Plaintext PDU
    - •Advanced Generic MAC header = A0 CA

•Payload (200B):

00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F

20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F

30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F

40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F

50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F

60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F

70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F

80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F

90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F

A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF

B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF

C0 C1 C2 C3 C4 C5 C6 C7

•STID=0x234, FID=0xA

- Ciphertext PDU where TEK = 0xB74EB0E4F81AD63D121B7E9AECCD268F, EKS=0x3 (2bits), PN=0x3B5F11 (22 bits) and ICV length is 8B:

•Advanced Generic MAC header = A0 D5

•IV (128bits): 19 A0 D5 23 4A 00 00 00 00 00 00 FB 5F 11 00 C8

•Encrypted payload of EKS+PN (3B), encrypted payload (200B), encrypted ICV (8B):

FB 5F 11

EA 53 E1 74 89 B2 0B F3 F0 9B 0C 1B 84 9A A7 78

B8 D2 67 35 4F F6 95 D1 8B 60 79 F6 67 DB FF 3D

8C 76 AC C1 0C B5 A6 BB 6C 54 1B 61 FB 13 45 DA

4E A9 0A F4 B9 AC B5 AF 28 21 20 95 41 02 7B 4B

13 A8 BA 16 3B 9F 88 42 56 3E B4 0B 8C 4C EA 68

C0 74 F3 C1 CC BF D0 84 C2 7F D1 AC 48 44 E6 7D

63 63 1A F3 D9 39 F2 8F 6D F5 64 31 06 4B AA DE

2C AB C2 C9 8C BC 87 41 78 B7 85 27 C4 DD 33 D0

02 50 32 81 14 B2 32 8C 28 C7 11 72 75 CE FF 57

F2 E5 80 83 B2 08 24 4E 7A C4 18 63 3F CB 38 85

7C 7B DC AC E9 D1 1B 6B 8B EF E3 54 16 AE 3D 26

5A 10 7C FA 39 D6 51 17 67 16 46 3B 26 EE EF 85

EE 74 67 A7 13 DC 03 EF

2F 6B 08 CF 49 2A E1 04

- After decryption

•Plaintext ICV= C2 C4 36 8F 24 01 2F 1F

Q.1.2 AES-CTR:

Q.1.2.1 Short payload

- Plaintext PDU

- •Advanced Generic MAC header = 20 06
- •Payload = 9c 05 3f 24
- •STID=0x234, FID=0xD

- Ciphertext PDU where TEK = 0xD50E18A844AC5BF38E4CD72D9B0942E5, EKS=0x1 (2bits) and PN=0x17F6BC (22 bits):

- •Advanced Generic MAC header = D0 09
- •Encrypted payload of EKS+PN (3B), encrypted payload (4B): 57 F6 BC 86 FB 65 B7

Q.1.2.2 Long payload

- Plaintext PDU

- •Advanced Generic MAC header = A0 CA
- •Payload (200B):

00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F

20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F

30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F

40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F

50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F

60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F

70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F

80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F

90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F

A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF

B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF

C0 C1 C2 C3 C4 C5 C6 C7

- •STID=0x234, FID=0xA

- Ciphertext PDU where TEK = 0xB74EB0E4F81AD63D121B7E9AECCD268F, EKS=0x3 (2bits) and PN=0x3B5F11 (22 bits):

- •Advanced Generic MAC header = A0 CD
- •Encrypted payload of EKS+PN (3B), encrypted payload (200B):

FB 5F 11

EC 86 6C FF 73 C8 CF A6 25 A6 2D E5 8E 68 0E 35

CD 0E AC 0F 0B A6 EE 50 6C CC 13 81 67 6C 85 6E

83 99 58 DF B8 BB 89 74 10 37 3A C3 37 0B 7D C6

BF 52 34 9C 85 25 92 27 79 85 D3 5C 62 F1 A9 67

DA 21 2B 87 04 D6 70 6C CC FD 2E B6 AD 27 64 CD

F9 DA AD 86 5B 20 5F 8D 20 37 BA 36 13 CD E8 E0

51 43 D4 C8 D5 CF 0B FA 92 8D 49 0F 91 2B 70 9A

6C 7C A0 9F FB 48 14 EB 08 03 DA 9E 13 A0 1C A3

E5 01 86 12 22 BD 1C 8A B5 E3 4E 17 A5 00 FC C7

91 DA F2 98 C5 A2 49 EC FC 92 39 ED 6B 4C F4 6A

2E 0D D2 58 55 0F DB 7F 97 A6 3B 3B 67 E3 BF 29

43 F6 7A 31 E2 6F 1B EB 51 12 D4 1C 07 F6 48 B0

A6 BF AB C6 77 2E 6E 27

Q.1.3 AES-CMAC:

This section is assuming the CAMC calculation is performed according to the formula indicated in the approved contribution C80216m-09_2022r3.

2 flavors of test vectors are included- one with CMAC calculation that includes 16bit padding (as stated in the contribution above) and one with the suggested remedy of 24bit padding.

Q.1.3.1 Short message (assuming 24 bit padding):

- Plaintext PDU
  - •Payload = 9c 05 3f 24
  - •STID=0x234, FID=0xD
- -Signature where CMAC_KEY= 0xD50E18A844AC5BF38E4CD72D9B0942E5, PMKID=0xA67B1FE254CD290A (64bits) and CMAC_PN=0x57F6BC (24 bits):
  - •Message header (PMK ID | CMAC_PN |STID|FID|24-bit zero padding | MAC_Management_Message)= A6 7B 1F E2 54 CD 29 0A 57 F6 BC 23 4D 00 00 00
  - •CMAC value (8B)= 78 1C 63 71 6F 48 6A 6F

Q.1.3.2 Long message (assuming 24 bit padding):

- Plaintext PDU
  - •Payload (100B):

    00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

    10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F

    20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F

    30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F

    40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F

    50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F

    60 61 62 63
  - •STID=0xABC, FID=0xA
- Signature where CMAC_KEY= 0xB74EB0E4F81AD63D121B7E9AECCD268F, PMKID = 0xD5F725AE30F45B3C (64bits) and CMAC_PN=0x3B5F11 (24 bits):
  - •Message header (PMK ID | CMAC_PN |STID|FID|24-bit zero padding | MAC_Management_Message)= D5 F7 25 AE 30 F4 5B 3C 3B 5F 11 AB CA 00 00 00
  - •CMAC value (8B)= DA 0A 50 5D 04 2A 08 38

Q.1.3.3 Short message (assuming 16 bit padding):

- Plaintext PDU
  - •Payload = 9c 05 3f 24
  - •STID=0x234, FID=0xD
- Signature where CMAC_KEY= 0xD50E18A844AC5BF38E4CD72D9B0942E5, PMKID = 0xA67B1FE254CD290A (64bits) and CMAC_PN=0x57F6BC (24 bits):
  - •Message header (PMK ID | CMAC_PN |STID|FID|16-bit zero padding | MAC_Management_Message)= A6 7B 1F E2 54 CD 29 0A 57 F6 BC 23 4D 00 00
  - •CMAC value (8B)= 69 6F 20 E8 88 D9 E6 68

Q.1.3.4 Long message (assuming 16 bit padding):

- Plaintext PDU
  - •Payload (100B):

00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F

20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F

30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F

40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F

50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F

60 61 62 63

•STID=0xABC, FID=0xA

- Signature where CMAC_KEY= 0xB74EB0E4F81AD63D121B7E9AECCD268F, PMKID =0xD5F725AE30F45B3C (64bits) and CMAC_PN=0x3B5F11 (24 bits):

•Message header (PMK ID | CMAC_PN |STID|FID|16-bit zero padding | MAC_Management_Message) = D5 F7 25 AE 30 F4 5B 3C 3B 5F 11 AB CA 00 00

•CMAC value (8B)= DD F1 2E 6A F6 34 F1 2A