

~~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 (working document)

~~Sponsor-~~

~~LAN/MAN Standards Committee
of the
IEEE Computer Society~~

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Draft Amendment to IEEE Standard for

Local and metropolitan area networks

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

Amendment for 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 802.16-200X.

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

1.2 Purpose

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3. Definitions

[Insert the following definitions:]

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

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

3.97 multi-carrier transmission: More than 1 carrier is used to exchange data between BS and MSs.

3.98 primary carrier: An OFDMA carrier on which BS and the MS 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 MS operation, such as network entry. Each MS shall have only one carrier it considers to be its primary carrier in a cell.

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

3.100 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.

3.101 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.

3.102 physical resource unit (PRU): The basic resource allocation unit that consists of 18 adjacent carriers in consecutive symbols in same subframe.

3.103 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.

3.104 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.

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

3.106 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 subframes. The default TTI is 1 subframe.

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

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

3.109 rank: For the spatial multiplexing modes in SU-MIMO, the number of streams to be used for the user allocated to the Resource Unit (RU)

1 **3.110 rate:** The number of QAM symbols signaled per array channel use.
2

3 **3.111 horizontal encoding:** Indicates transmitting multiple separately FEC-encoded layers over multiple
4 antennas. The number of encoded layers may be more than 1
5

6
7 **3.112 vertical encoding:** Indicates transmitting a single FEC-encoded layer over multiple antennas. The
8 number of encoded layers is always 1.
9

10 **3.113 resource unit:** A granular unit in frequency and time, described by the number of OFDMA subcarri-
11 ers and OFDMA symbols
12

13
14 **3.114 single user MIMO:** A MIMO transmission scheme in which a single MS is scheduled in one RU
15

16 **3.115 multi-user MIMO:** A MIMO transmission scheme in which multiple MSs are scheduled in one RU,
17 by virtue of spatial separation of the transmitted signals
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4. Abbreviations and acronyms

[Insert the following abbreviations:]

AAI	advanced air interface
A-MAP	advanced MAP
A-Preamble	advanced preamble
CAS	CRU allocation size
CL	closed-loop
CMI	codebook matrix index
CRU	contiguous resource unit
CoRe	constellation re-arrangement
CSG	closed subscriber group
CSM	collaborative spatial multiplexing
DL	downlink
DLUR	distributed LRU
DRU	distributed resource unit
FP	frequency partition
FMT	UL feedback mini-tile
FPC	frequency partition configuration
FPCT	frequency partition count
FPS	frequency partition size
FPSC	frequency partition subband count
GRA	group resource allocation
HARQ	hybrid ARQ
HE	horizontal encoding
HMT	UL HARQ mini-tiles
IE	information element
IR	incremental redundancy

1	LRU	logical resource unit
2		
3	MCS	modulation and coding scheme
4		
5		
6	MLRU	minimum A-MAP logical resource unit
7		
8	MU	multi-user
9		
10		
11	OL	open-loop
12		
13	PA	persistent allocation
14		
15	PA-Preamble	primary advanced preamble
16		
17		
18	PFBCH	UL primary fast feedback channel
19		
20		
21	PMI	preferred matrix index
22		
23	PRU	physical resource unit
24		
25	P-SFH	primary superframe header
26		
27		
28	RCP	ranging cyclic prefix
29		
30	RFMT	Reordered UL feedback mini-tile
31		
32		
33	RHMT	Reordered UL HARQ mini-tile
34		
35		
36	RP	ranging preamble
37		
38	RU	resource unit
39		
40	S-ABS	serving ABS
41		
42		
43	SAC	subband allocation count
44		
45	SA-Preamble	secondary advanced preamble
46		
47		
48	SFBC	space-frequency block code
49		
50	SFBCH	UL secondary fast feedback channel
51		
52		
53	SFH	superframe header
54		
55	SPID	subpacket ID
56		
57		
58	S-SFH	secondary superframe header
59		
60	STC	space-time coding
61		
62	SU	single-user
63		
64		
65	T-ABS	target ABS

1	UCAS	uplink CRU allocation size
2		
3	UFPC	uplink frequency partition configuration
4		
5	UL	uplink
6		
7		
8	USAC	uplink subband allocation count
9		
10	VE	vertical encoding
11		
12		
13		
14		
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17		
18		
19		
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21		
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[Insert the following clause:]

15. Advanced Air Interface

15.1 Introduction

15.2 Medium access control

15.2.1 Addressing

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

15.2.1.1 MAC Address

The AMS, ARS and ABS are identified by the globally unique 48-bit IEEE Extended Unique Identifier (EUI-48™) based on the 24-bit Organizationally Unique Identifier (OUI) value administered by the IEEE Registration Authority.

15.2.1.2 Logical Identifiers

The following logical identifiers are defined in the following subsections.

15.2.1.2.1 Station Identifier (STID)

The ABS assigns a 12 bits long STID to the AMS during network entry, and, in some cases, network re-entry, that uniquely identifies the AMS within the domain of the ABS. Each AMS registered in the network has an assigned STID. Some specific “STIDs” are reserved, for example, for broadcast, multicast, and ranging.

15.2.1.2.2 Flow Identifier (FID)

Each AMS connection is assigned a 4bits long FID that uniquely identifies the connection within the AMS. FIDs identify management connections and transport connections. Some specific FIDs may be pre-assigned.

15.2.1.2.3 Temporary Identifier (TempID)

The network may assign a Temporary Identifier and combines it with paging cycle and paging offset configurations to uniquely identify an AMS in the idle mode in a particular paging group. The temporary identifier is assigned during idle mode entry or location update due to paging group change. Such identifier remains valid as long as the AMS stays in the same paging group. The temporary identifier and paging cycle configuration bits are used in paging messages to identify the AMS. The temporary identifier together with the paging cycle and paging offset configuration bits is used by the AMS to identify itself during its network re-entry procedure as response to paging or location update when paging group is not changed.

15.2.2 Bandwidth request procedure

The random access based bandwidth request procedure for MZone or LZone with AMC is described in Figure 387—. In these cases, a 5-step regular procedure or an optional 3-step quick access procedure (steps 1,4 and 5) may be supported concurrently. Steps 2 and 3 are used only in 5-step regular procedure. In step 1, the AMS sends a bandwidth request indicator and a message for quick access that may indicate information

such as AMS addressing and/or request size (FFS) and/or uplink transmit power report (FFS), and/or QoS identifiers (FFS), and the ABS may allocate uplink grant based on certain policy. The 5-step regular procedure is used independently or as a fallback mode for the 3-step bandwidth request quick access procedure. The AMS may piggyback additional BW REQ information along with user data during uplink transmission (step 5). Following step 1 and step 3, ABS may acknowledge the reception of bandwidth request. If AMS does not receive any acknowledgement or UL grant, it waits until the expiration of a pre-defined period and restarts the bandwidth request. The pre-defined period may be differentiated by factors such as QoS parameters (e.g. scheduling type, priority, etc). In case BW is granted immediately, there is no need for ABS to send explicit ACK.

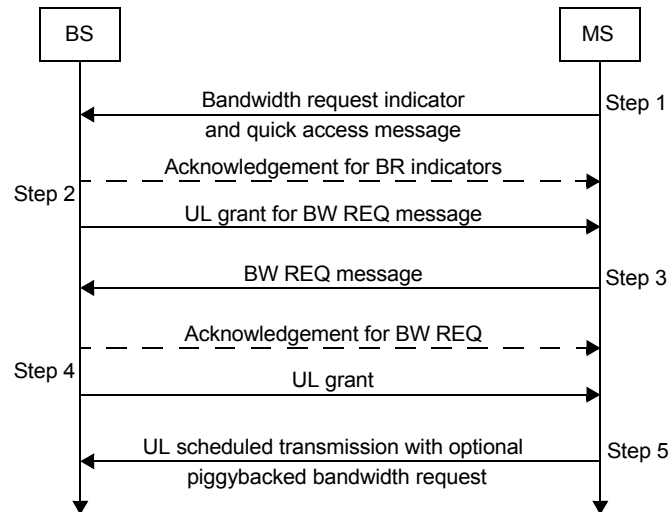


Figure 387—Bandwidth request procedure in the MZone or the LZone with AMC

The bandwidth request procedure for an MS that is FDM in the LZone with PUSC is described in Figure 388. In LZone with PUSC, only a 5-step regular procedure is supported. In step 1, AMS sends a bandwidth request indicator only. The rest of LZone with PUSC bandwidth request procedure shall be the same as the 5-step procedure in Figure 387.

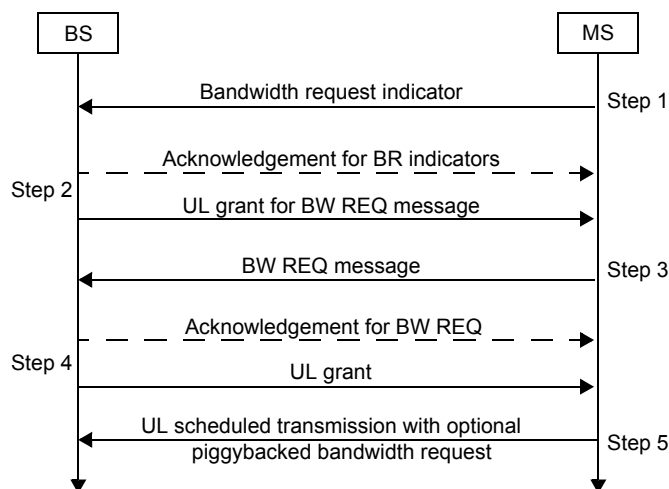


Figure 388—Bandwidth request procedure in the LZone with PUSC

15.2.3 MAC PDU formats

MAC PDUs shall be of the form illustrated in Figure 389—. Each PDU shall begin with a MAC header. The header may be followed one or more extended headers. The MAC PDU may also contain 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.

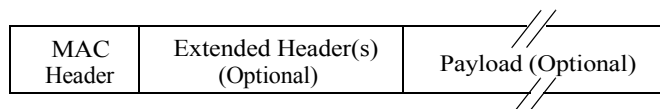


Figure 389—MAC PDU formats

15.2.3.1 MAC header formats

There are two defined MAC header formats. The first is the generic MAC header that begins each DL and UL MAC PDUs containing either MAC management messages or CS data. The second is the compact MAC header that begins MAC PDUs of the connections using persistent allocation or group allocation.

15.2.3.1.1 Generic MAC header (GMH)

The GMH format is defined in Table x.1. Its fields are defined in Table 1—.

Table 1—GMH Format

Syntax	Size (bit)	Notes
Genewric MAC Header() {		
Flow ID	4	Flow Identifier
EH	1	Extended header presence indicator
Length	11	Length of payload
}		

Table 2—GMH fields

Names	Size (bit)	Description
Flow ID	4	This field indicates the service flow that is addressed.
EH	1	When set to '1', this field indicates that an Extended Header is present following this GMH.
Length	11	This field indicates the length of the payload in bytes

15.2.3.1.2 Compact MAC header (CMH)

The CMH format is defined in Table 3— Its fields are defined in Table 4—.

Table 3—CMH Format

Syntax	Size (bit)	Notes
Compact MAC Header() {		
EH	1	Extended header presence indicator
Length	7	Length of payload
}		

Table 4—GMH fields

Names	Size (bit)	Description
EH	1	When set to '1', this field indicates that an Extended Header is present following this CMH.
Length	11	This field indicates the length of the payload in bytes

15.2.3.2 Extended header formats

The inclusion of Extended Header is indicated by EH bit in MAC Header. The Extended header format is defined in Table 5— and will be used unless specified otherwise.

Table 5—Extended Header Format

Syntax	Size (bit)	Notes
Extended HeaderHeader() {		
LAST	4	Last Extended Header indication: 0 = one or more extended header follows the current extended header unless specified otherwise; 1 = this extended header is the last extended header unless specified otherwise
Type	TBD	Type of extended header
Body Contents	<i>Variable</i>	Type dependent content
}		

Table 6—Description of Extended Header Types

Extended Header Types	Names	Description
-	Fragmentation and packing extended header	See 15.2.3.2.1
TBD	Fragmentation extended header	See 15.2.3.2.2
TBD	Multiplexing extended header	See 15.2.3.2.3
TBD	Reserved	

15.2.3.2.1 Fragmentation and packing extended header (FPEH)

The FPEH shall be used when MAC PDU contains payload from single transport connection. The FPEH exists after the last extended header (i.e. the extended header with 'Last' = '1') if 'EH' in GMH set to '1' or after the GMH if 'EH' in GMH set to '0'. The FPEH format is defined in Table 7— and its fields are defined in Table 8—

Table 7—FPEH Format

Syntax	Size (bit)	Notes
FPEH() {		
SN	10	payload sequence number
FC	2	Fragmentation control (see table)
Do {		
End	1	
if (End == 0) {		
Length	11	Length of SDU or SDU fragment
}		
} while (!End)		
Reserved	variable	
}		

Table 8—FPEH fields

Names	Size (bit)	Description
SN	10	Payload sequence number
FC	2	Fragmentation Control bits (encoding shown in Table x.9)
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
Length	11	This field indicates the length of SDU or SDU fragment. If a payload consists of 'N' SDU/SDU fragments, N-1 'Length' fields are present in FPEH. The length of the first SDU or SDU fragment in the payload is indicated by the 'Length' field in GMH.
Rsvd	variable	Reserved bits are added at the end of FPEH for byte alignment

Table 9—Encoding of FC field

FC	Meaning	Examples
00	The first byte of data in the MPDU payload is the first byte of a MAC SDU. The last byte of data in the MPDU payload is the last byte of a MAC SDU.	<ul style="list-style-type: none"> One or Multiple Full SDUs packed in an MPDU
01	The first byte of data in the MPDU payload is the first byte of a MAC SDU. The last byte of data in the MPDU payload is not the last byte of a MAC SDU.	<ul style="list-style-type: none"> MPDU with only First fragment of an SDU MPDU with one or more unfragmented SDUs, followed by first fragment of subsequent SDU
10	The first byte of data in the MPDU payload is not the first byte of a MAC SDU. The last byte of data in the MPDU payload is the last byte of a MAC SDU.	<ul style="list-style-type: none"> MPDU with only Last fragment of an SDU MPDU with Last fragment of an SDU, followed by one or more unfragmented subsequent SDUs
11	The first byte of data in the MPDU payload is not the first byte of a MAC SDU. The last byte of data in the MPDU payload is not the last byte of a MAC SDU.	<ul style="list-style-type: none"> a) MPDU with only middle fragment of an SDU MPDU with Last fragment of an SDU, followed by zero or more unfragmented SDUs, followed by first fragment of a subsequent SDU

15.2.3.2.2 Fragmentation extended header (FEH)

The FEH shall be used when MAC PDU contains payload from single management connection. The FEH format is defined in Table 10—.

Table 10—FEH Format

Syntax	Size (bit)	Notes
FEH () {		
LAST	1	Always set to '1'
Type	TBD	Type of extended header
SN	8	Type dependent content
FC	2	
}		

15.2.3.2.3 Multiplexing extended header (MEH)

The format of MEH is defined in Table 11—. It is used when SDUs/SDUs fragments from different connections are included in the same MPDU. Each MEH contains multiple Multiplexing Extended Header Blocks (MEHBs). The SDUs or SDU fragments belonging to the same connection are packed together and the information related to these SDUs or SDU fragments is included in one MEHB. The fields of MEH are defined in Table 12—. The M bit in MEHB indicates if there is more MEHB followed.

Table 11—Multiplexing Extended Header Format

Syntax	Size (bit)	Notes
MEH () {		
LAST	1	0 = Another extended header follows MEH 1 = another extended header does not follow MEH
Type	TBD	MEH type
Do {		
MEHB (M)	1	Multiplexing extended header block
} while (!M)		
Reserved	variable	
}		

Table 12—Multiplexing Extended Header Fields

Name	Length (bits)	Description
LAST	1	Last Extended Header Indicator (always set to 1)
Type	TBD	Extended Header Type
MEHB	variable	Multiplexing extended header block (format shown in)

The format of MEHB is shown in Table 13—, except the first MEHB. The format of the first MEHB is shown in Table 14—. The first MEHB doesn't contain the Flow ID and the length for the first SDU/SDU fragment associated with the Flow ID. The Flow ID and the Length fields in the generic MAC header represent the flow ID and the length of the first SDU/SDU fragment associated with the first MEHB. The fields of MEHB are defined in Table 15—.

Table 13—MEHB Format

Syntax	Size (bit)	Notes
MEHB() {		
M	1	0 = Another MEHB follows this MEHB 1 = This is the last MEHB in MEH
FlowID	4	Flow Identifier
FC	2	Fragmentation Control
SN	10	
Do {		
Length	11	SDU or SDU fragment length
End	1	
} while (!End)		
}		

Table 14—First MEHB Format

Syntax	Size (bit)	Notes
First MEHB() {		
M	1	0 = Another MEHB follows this MEHB 1 = This is the last MEHB in MEH
FC	2	Fragmentation Control
SN	10	
Do {		
End	1	
If (End == 0)		
Length	11	SDU or SDU fragment length
}		
} while (!End)		
}		

Table 15—MEHB Fields

Name	Length (bits)	Description
M	1	Indication of more MEHB 0 = no more MEHB follows the current MEHB 1 = one or more MEHB follows the current MEHB
Flow ID	4	Flow ID of the SDU/SDUs fragment identified in the MEHB
FC	2	Fragmentation Control bits (encoding shown in Table x.9)
SN	10	Sequence number for the payload identified in the MEHB
Length	11	Length of the correspondent SDU/SDU fragment
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

15.2.4 Security Enhancements

15.2.4.1 Security Architecture

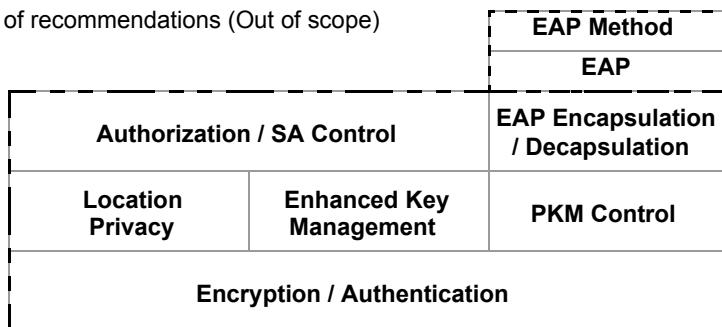
The security functions provide subscribers with privacy, authentication, and confidentiality across the IEEE 802.16m network. It does this by applying cryptographic transforms to MAC PDUs carried across connections between AMS and ABS.

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 below.

If during pre-authentication capabilities negotiation, an AMS specifies that it does not support IEEE 802.16m security, steps of authorization and key exchange shall be skipped. The ABS, if provisioned so, shall consider the AMS authenticated; otherwise, the AMS shall not be serviced. Neither the key exchange nor data encryption performed.

— — — — Scope of IEEE 802.16m specification

- - - - - Scope of recommendations (Out of scope)

**Figure 390—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, 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)
- Authentication and Security Association (SA) control: This stack controls the authorization 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.
- Management message authentication processing: This stack executes message authentication function such as CMAC.
- Management message confidentiality protection: This stack encrypts or decrypts the management data and executes the authentication function for the traffic data.

15.2.4.2 Key Management Protocol (PKMv3)

15.2.4.2.1 Key Management

15.2.4.2.2 SA Management

15.2.4.2.3 Security Context

15.2.4.3 Cryptographic Methods

15.2.4.4 AMS Privacy

15.2.5 AAI MAC Management Messages

15.2.5.1 AAI HO-IND

The AMS may send the AAI_HO-IND MAC management message in a variety of scenarios, including HO preparation, HO execution and HO cancellation. To distinguish between the different scenarios, the AAI_HO-IND message shall contain an event code which takes the following values:

- Code 1: Target ABS selection for multiple candidate T-ABS case.
- Code 2: 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.
- Code 3: AMS unable to stay connected to serving ABS until expiration of disconnect time
- Code 4: HO cancel.

The specific format of the AAI_HO-IND message is TBD

15.2.5.2 AAI_HO-REQ

In MS-initiated HO, the AMS shall send the AAI_HO-REQ to S-ABS to initiate the HO procedure. The specific format of the AAI_HO-REQ message is TBD.

15.2.5.3 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 serves one of the following purposes.

- HO command
- HO rejection in response of AAI_HO-REQ from AMS

In case of HO command function, AAI_HO-CMD message should include one or more target ABS. For each target ABS, the following parameters are included:

- 1) Target ABS preamble index
- 2) Optional T-ABS MAC identity if preamble index has ambiguity (placeholder for dense overlay deployment or femtocell deployment)
- 3) HO_Reentry_Mode
- 4) Action Time
- 5) Disconnect Time (if HO_Reentry_Mode=1, disconnect time > action time; if HO_Reentry_Mode=0, Disconnect Time <= Action Time)
- 6) Optional EBB configuration if HO_Reentry_Mode = 1
 - i) HO_Reentry_interval
- 7) Resource_Retain_Time
- 8) CDMA_RNG_FLAG
- 9) Optional dedicated CDMA ranging code/opportunity if CDMA_RNG_FLAG=1
- 10) HO optimization related context, e.g., Indication of which components of the AMS' static and dynamic context are available at the target ABS.
- 11) Ranging initiation deadline.
- 12) Service level prediction, which indicates the level of service the MS can expect from this BS. The following encodings apply:
 - i) 0 = No service possible for this MS
 - ii) 1 = Some service is available for one or several service flows authorized for the MS or No service level prediction available.
 - iii) 2 = For each authorized service flow, a MAC connection can be established with QoS specified by the AuthorizedQoSParamSet.
 - iv) 3 = No service level prediction available.

In case of HO rejection function, AAI_HO-CMD message shall not include any target ABS.

15.2.5.4 AAI_NBR-ADV

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

- 1) BS type (macro, micro, femto, relay, TBD)
- 2) carrier frequency
- 3) MAC version
- 4) TDD/FDD and related definitions (expected to be the same given carrier frequency)
- 5) BW, CP info: may not be required if carried in P/S-SCH channel

6) Multi-carrier capability and configuration

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 MS 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.

15.2.5.5 CLC-REQ (Co-Located Coexistence Request) message

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

Table 16—CLC-REQ message parameters

Management Message Type
Request Action
Request Action Parameters

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, MS may keep existing configuration, request to re-configure or replace existing CLC class.

The request action parameters may be included as follows:

CLC Information compound

These parameters may be present more than once if AMS wants to include multiple CLC information fields (Table 18—).

15.2.5.6 CLC-RSP (Co-Located Coexistence Request) message

The AMS sends the CLC-RSP message to AMS on the MS's basic CID in response to CLC-REQ.

Table 17—CLC-RSP message parameters

Syntax	Notes
Confirmed Action	
Parameter set for each Type II or III CLC class that ABS wants to configure its starting time differently from what is recommended by AMS	
CLC ID	
Start Superframe Number	
Start Frame Index	shall be set to 0 for type III CLC class

Parameters shall be as follows:

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 ID

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

Start Time information

Start Superframe Number

The 3 LSB of the superframe number of CLC start time

Start Frame Index

The frame index of CLC start time

15.2.5.7 CLC_INFO

The CLC_INFO parameters applicable to REG-REQ, REG-RSP, CLC-REQ, SBC-REQ, SBC-RSP messages. The following sets of parameters will be included into the CLC_INFO parameters encodings.

Table 18—Parameters to be applied into parameters encoding for CLC information fields

Parameters	Note	Scope
CLC Limit	If (Information Type == 0)	REG-RSP

Table 18—Parameters to be applied into parameters encoding for CLC information fields

Parameters	Note	Scope
CLC Request	If (Information Type == 1)	RNG-REQ, SBC-REQ, CLC-REQ
CLC Response	If (Information Type == 2)	RNG-RSP, SBC-RSP
CLC Report	If (Information Type == 3)	CLC-REQ

Table 19—Parameters to be applied into CLC Limit field

the bit field set to 1 indicates the CLC limits are provided for Type I CLC class
the bit field set to 1 indicates the CLC limits are provided for Type II CLC class
maximum number of active CLC classes of the type
maximum CLC active ratio in unit of 1/100
maximum CLC active interval in unit of subframes

Table 20—Parameters to be applied into CLC Request field

Parameters	Notes
Parameter set for each requested Type I, II, or III CLC class	
CLC ID	
Scheduling Impact	
Start Superframe Numbe	
Start Frame Index	
Flag	
CLC active interval of Type I CLC class	If (Flag == 0b00)
CLC active cycle of Type I CLC class	If (Flag == 0b00)
Start Subframe Index	If (Flag == 0b00)
CLC Active Interval of Type II CLC class with subtype 1	If (Flag == 0b01)
CLC Active cycle of Type II CLC class with subtype 1	If (Flag == 0b01)
Extended Bitmap Indicator	If (Flag == 0b10)
CLC Active Bitmap	If (Extended Bitmap Indicator == 0)

Table 20—Parameters to be applied into CLC Request field

Parameters	Notes
Length of Extended CLC Active Bitmap (k)	If (Extended Bitmap Indicator == 1)
Extended CLC Active Bitmap	m: number of subframes per frame
CLC Active Interval of Type III CLC class }	If (Flag == 0b11)

Parameters in the CLC Request field shall be as follows:

Flag

- b00: Type I CLC class;
- b01: Type II CLC class subtype 1;
- b10: Type II CLC class subtype 2 or 3;
- b11: Type III CLC class

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

CLC active interval of Type I CLC class

The number of subframes of the CLC Active Interval for Type I CLC class

CLC active cycle of Type I CLC class

The number of microseconds of the CLC Active Cycle for Type I CLC class

CLC active interval of Type II CLC class with subtype 1

The number of subframes of the CLC Active Interval for Type II CLC class

CLC active cycle of Type II CLC class with subtype 1

The number of frames of the CLC Active Cycle for Type II CLC class

Extended CLC Active Bitmap Indicator

Indicate whether the Extended CLC Active Bitmap field is used

CLC Active Bitmap

Setting a bit of the field to "1" indicates the corresponding subframe in each frame is in CLC active interval

Extended CLC Active Bitmap

Setting a bit of the field to "1" indicates the corresponding subframe in each CLC active cycle is in CLC active interval

CLC Active Interval of Type III CLC class

The number of superframes of the CLC Active Interval for Type III CLC class

Table 21—Parameters to be applied into CLC Response field

Parameters
CLC ID
Start Superframe Number
Start Frame Index

Table 22—Parameters to be applied into of CLC Report

Parameters
CLC Report Information Elements

The CLC Report field may include one or multiple CLC Report information elements (Table 23—)

Table 23—Parameters to be applied into CLC Report Information Element

Parameters	Note
CLC Report Type	Table 24—
CLC Report Parameter	Table 24—

Table 24—Parameters to be applied into CLC Report Information

CLC Report Parameter
Interference Level

Interference Level

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

15.2.6 MAC HO procedures

This subclause specifies the HO procedures for the AAI. An AMS/ABS shall perform HO using the procedures defined in 15.2.5

15.2.6.1 Network topology acquisition

15.2.6.1.1 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 shall not include information of neighbor Closed Subscriber Group (CSG) femtocells. Special handling of neighbor information of femtocell is described in section 15.2.x.

A serving ABS may unicast the AAI_NBR-ADV message to an AMS. The AAI_NBR-ADV message may include parameters required for cell selection e.g., cell load and cell type. The ABS may broadcast different fragment of AAI_NBR-ADV independently.

15.2.6.1.2 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 target ABSs or ABS types the AMS shall scan and/or averaging parameters that override the default value defined in DCD (TBD).

The AMS may use any unavailable interval to perform autonomous scanning

An AMS performing intra-frequency preamble measurement shall not interrupt its communication with the serving ABS.

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. ABS may prioritize the scanning candidates in the AAI_SCN-RSP message.

An AMS measures the selected scanning candidate ABSs and may report the measurement result back to the serving ABS.

An AMS may request an allocation of a scanning interval to an ABS by sending the AAI_SCN-REQ message to scan 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.

15.2.6.2 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
- 2) Conditions that define when the AMS shall report scanning measurement results to the serving ABS
- 3) Conditions that define when AMS shall initiate HO by sending AAI_HO-REQ.
- 4) Conditions for defining when a target ABS is unreachable

- 5) Conditions for defining when AMS is unable to maintain communication with the serving ABS
- 6) Conditions for HO cancellation

The trigger TLV (type xx) in Table xxx is encoded using the description in Table 25—.

Table 25—Trigger TLV Description

Name	Type	Length (Bytes)	Value
Type/Function/Action	xx.1	1	See Table 26—for description
Trigger Value	xx.2	1	Trigger value is the value used in comparing measured metric for determining a trigger condition

The Type/function/action byte field of the trigger description in Table 25— is described in Table 26—

Table 26—Trigger; Type/Function/Action Description

Name	Length (Bits)	Value
Type	2(MSB)	Trigger metric type: 0x0: CINR metric 0x1: RSSI metric 0x2: RTD metric 0x3: Number of missed frames metric
Function	3	Computation defining trigger condition: 0x0: Reserved 0x1: Metric of neighbor BS is greater than absolute value 0x2: Metric of neighbor BS is less than absolute value 0x3: Metric of neighbor BS is greater than serving BS metric by relative value 0x4: Metric of neighbor BS is less than serving BS metric by relative value 0x5: Metric of serving BS greater than absolute value 0x6: Metric of serving BS 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 0x1 or function 0x2
Action	3(LSB)	Action performed upon reaching trigger condition: 0x0: Reserved 0x1: Respond on trigger with AAI_SCN-RSP 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, 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 BS metrics are defined (i.e., only Function values 0x5 or 0x6 are applicable).

When performing measurements, the AMS shall use the averaging parameters defined in DCD with TLV "Default HO RSSI and CINR averaging parameters", Type 121 as defined in section 11.4.1 and Table 574.

The ABS may define multiple 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 xx2).

Whenever the condition of a simple trigger or all the conditions of multiple triggers are met, the MS shall invoke the action of the trigger. If more than one trigger conditions are met simultaneously the MS shall invoke the action of at least one of the triggers.

15.2.6.3 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.

15.2.6.3.1 HO Framework

The handover procedures are divided into three phases, namely, HO initiation, HO preparation and HO execution. When HO execution is complete, the AMS is ready to perform Network re-entry procedures at target ABS. In addition, HO cancellation procedure is defined for AMS to cancel the HO procedure.

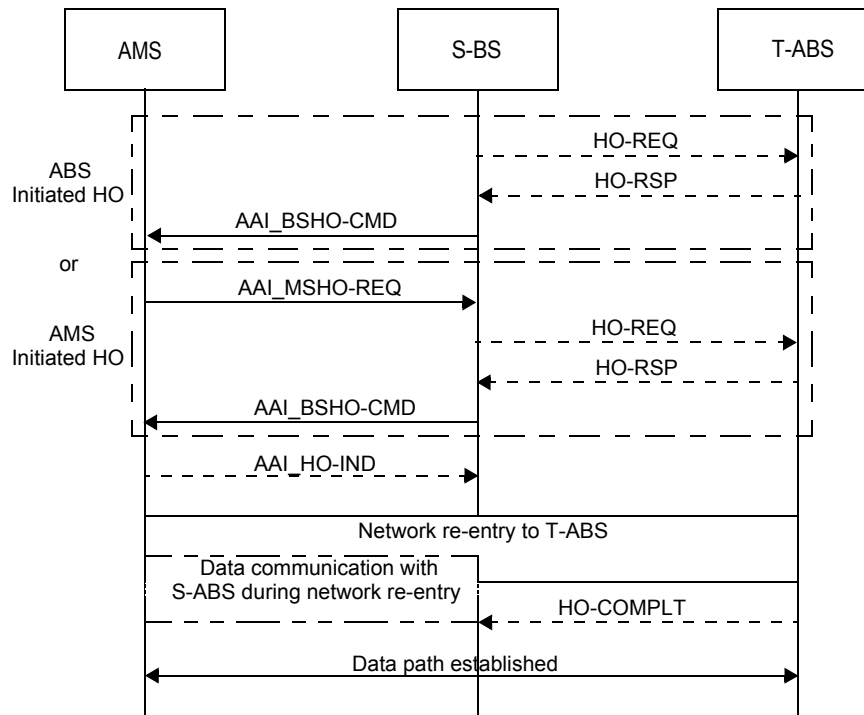


Figure 391—Generic HO Procedure

15.2.6.3.2 HO decision and initiation

The handover initiation may originate either at AMS or the serving ABS. When handover is initiated by the AMS, the serving ABS shall define the trigger conditions based on which the AMS initiates a handover.

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.

During handover initiation, the serving ABS indicates whether the AMS maintains communication with the serving ABS while performing network reentry with the target ABS by setting the HO_Reentry_Mode in

AAI_HO-CMD. If the AMS doesn't maintain communication with the serving ABS while performing network reentry in the target ABS, the HO_Reentry_Mode is set to 0; otherwise, it is set to 1.

The AMS shall not perform HO to a cell with Cell Bar bit=1 in its S-SFH.

15.2.6.3.3 HO Preparation

During HO preparation phase, the serving ABS communicates with target ABS(s) selected for HO. 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 or opportunity to the AMS via the serving ABS through the AAI_HO-CMD message. The target ABS shall select the dedicated ranging code from the group of codes which are allocated for handover purpose. After the target ABS sends the selected dedicated ranging code/opportunity to the serving ABS over the backhaul, the serving ABS shall deliver the dedicated ranging code/opportunity to the AMS in AAI_HO-CMD.

Information regarding AMS identity (e.g. STID) or security context (e.g., nonce), may 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. Rejection of each service flow 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 HO_Reentry parameters. In the single carrier handover case, the HO_Reentry parameters include the HO_Reentry_interval information used in serving ABS for the AMS to communicate with the serving ABS. In the multi-carrier handover case, the HO_Reentry 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 code 1. The AAI_HO-CMD message shall include an Action Time for the AMS to start network re-entry at each target ABS. The AAI_HO-CMD message shall also include a Disconnect Time for each candidate target ABS. When HO_Reentry_Mode is set to 0, the Disconnect Time shall be set to the Action Time in the AAI_HO-CMD message.

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.

15.2.6.3.4 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 expiration of the disconnect time included in the AAI_HO-CMD message or upon receiving AAI_HO-IND with code 3, 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 upon expiration of the disconnect time or after receiving HO completion confirmation from target ABS, whichever occurs first.

If HO_Reentry_Mode is set to 0, at the expiration of Disconnect Time, the serving ABS shall start the Resource_Retain_Time 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 include in AAI_HO-CMD shall be used instead of the value included in AAI_REG-RSP. The serving ABS shall retain the connections, 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 re-entry, the MS finds that the target BS is unreachable as defined in the 'target BS unreachable condition' in section 15.2.5.2. 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 code 3 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 informs the S-ABS of its selection by sending an AAI_HO-IND message with code 1 to the S-ABS before the expiration of Disconnect Time.

The serving ABS defines error 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 error conditions are defined as triggers with action code 0x5, as specified in section 15.2.5.2

If all the target ABSs that are included in the AAI_HO-CMD message are unreachable, and if the AMS has a preferred target ABS not included in the AAI_HO-CMD message, the AMS informs the serving ABS of its preferred target ABS by sending AAI_HO-IND message with code 2 before the expiration of Disconnect Time, and the AMS performs network re-entry at the new target ABS as indicated in the AAI_HO-IND message. The AMS shall also indicate the BSID of its old serving ABS and previous used STID to the new target ABS during network entry at the new target ABS.

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 its preferred target ABS by sending the AAI_HO-IND message with code 2 before expiration of Disconnect Time. If a serving ABS receives the AAI_HO-IND message with code 2, it shall respond to the AMS by sending AAI_HO-CMD with a target ABS which may include the target ABS proposed by the MS 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.

An AMS may request bandwidth for the residual data in the buffer before the expiration of Action 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.

15.2.6.3.5 Network Re-entry

15.2.6.3.5.1 CDMA-based HO Ranging Procedure

If CDMA-based HO ranging is not omitted and a dedicated ranging code/opportunity is assigned to the AMS by target ABS, the AMS transmits the dedicated ranging code to the target ABS during network re-entry. If a ranging channel is scheduled by the target ABS for handover purpose only, 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 TBD 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 BS, the AMS shall transmit a random handover ranging code at the earliest available ranging opportunity.

If the serving ABS indicates in AAI_HO-CMD that CDMA based ranging can be skipped while performing network entry at the target ABS, 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 serving ABS indicates that CDMA ranging cannot be skipped, the serving ABS may allocate a dedicated ranging code/opportunity to the AMS in AAI_HO-CMD message. If a dedicated ranging code or a dedicated ranging opportunity is included in HO-CMD, the AMS shall perform CDMA ranging at the target ABS using the dedicated ranging code and/or ranging opportunity.

The serving ABS may explicitly inform the AMS to omit CDMA ranging through AAI_HO-CMD if it determines that the AMS will be well-synchronized with the target ABS after self-adjustment of its timing based on the following conditions:

- Intra-FA HO
- SBS and TBS belong to the same synchronized network (e.g. not applicable to femtocell deployment where femtocell BS only achieves rough synchronization over the air.)
- Cell sizes are smaller than TBD threshold

15.2.6.3.5.2 Network Re-entry Procedure

The network re-entry 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 re-entry at the target ABS.

If HO_Reentry_Mode is set to 1, the AMS performs network re-entry with the target ABS at action time while continuously communicating with the serving ABS. However, the AMS stops communication with serving ABS after network re-entry at target ABS is completed. In addition, AMS does not exchange data with target ABS prior to completion of network re-entry. In the single carrier handover case, the AMS communicates with the serving ABS during HO_Reentry_Interval, and with the target ABS using the remaining communication opportunity. In the multi-carrier handover case, AMS performs network reentry while continuing communication with the serving ABS concurrently via multiple radio carriers. 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 re-entry procedure is depicted in Figure 392— (HO_Reentry_Mode = 0) and Figure XX3 (HO_Reentry_Mode = 1) respectively. This procedure corresponds to the block arrow entitled "Network Re-entry" in Figure 391— and is described in detail in the following.

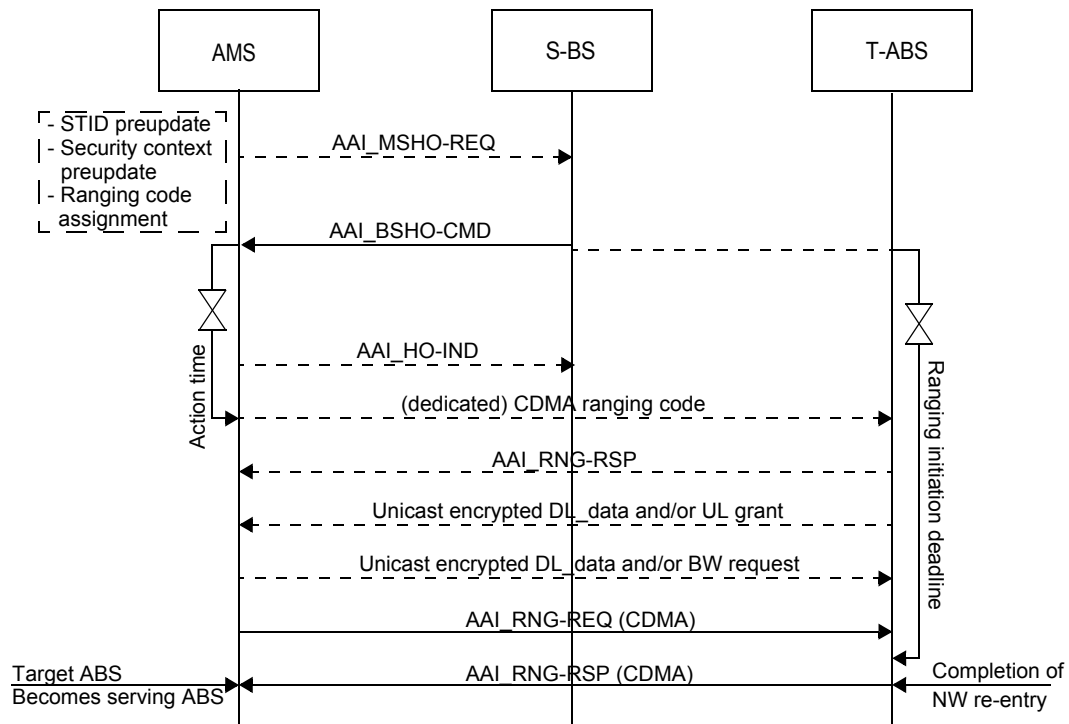


Figure 392—Network re-entry procedure with HO_Reentry_Mode set to 0. Messages depicted with dotted lines are transmitted only in certain HO scenarios. The dash-line (optional) AAI_RNG-RSP carries time adjustment parameters, etc

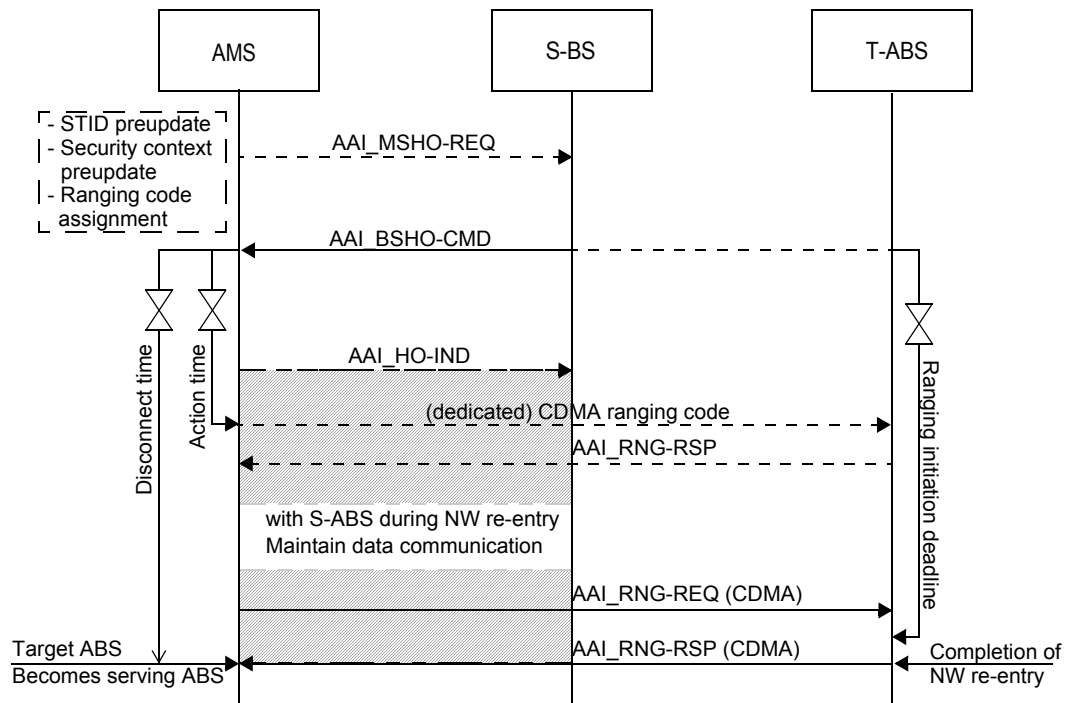


Figure 393—Network re-entry procedure with HO_Reentry_Mode set to 1. Messages depicted with dotted lines are transmitted only in certain HO scenarios. The dash-line (optional) AAI_RNG-RSP carries time adjustment parameters, etc

During network re-entry, 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.

The AAI_RNG-REQ/RSP transaction for HO is shown in Figure XX2. 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, CMAC_KEY_COUNT and a valid CMAC tuple, but not include AMS MAC address or previous serving ABSID. When ABS receives the AAI_RNG-REQ message, the ABS shall respond to the AAI_RNG-REQ message by transmitting AAI_RNG-RSP message with valid CMAC tuple. 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, previously used STID. When ABS receives the AAI_RNG-REQ message, the ABS shall respond to the AAI_RNG-REQ message by transmitting AAI_RNG-RSP message with valid CMAC tuple. The AAI_RNG-RSP message shall include a Temporary STID for the AMS.

15.2.6.3.6 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 code 4 (HO cancel) or by sending UL BW request header after Disconnect Time. The serving ABS shall explicitly acknowledge to the HO cancellation message upon receiving it through MAC signaling or DL/UL resource allocation to the AMS. 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 MS cancels the HO.

15.2.6.3.7 Drops during HO

15.2.6.4 Handover between WirelessMAN-OFDMA Advanced and Reference Systems

15.2.6.4.1 Handover from WirelessMAN-OFDMA Reference to Advanced System

15.2.6.4.1.1 Network Topology Acquisition

15.2.6.4.1.1.1 Network Topology Advertisement

A YBS 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 YMS 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 BS is indicated in the MAC version TLV in the MOB_NBR-ADV message transmitted in either the YBS or the LZone of the ABS.

An ABS uses one reserved bit in FCH to indicate the presence of its MZone.

The MAC version may be used for AMS to distinguish between WirelessMAN-OFDMA Reference System/WirelessMAN-OFDMA Advanced co-existing System. A MAC version of 9 indicates an ABS of WirelessMAN-OFDMA Reference/Advanced co-existing system.

1 The AMS may acquire full system information by scanning of target WirelessMAN-OFDMA Advanced
2 only System.
3

4 **15.2.6.4.1.1.2 AMS Scanning**

6 The AMS shall follow the same scanning procedure as defined in section 6.3.21.1.2.

8
9 In addition, an AMS may use the scanning interval to perform a scanning for the MZone of a neighboring
10 WirelessMAN-OFDMA Advanced/WirelessMAN OFDMA Reference co-existence System.
11

12 **15.2.6.4.1.2 Handover Procedure**

14
15 An AMS performs handover from a YBS to an ABS either by using zone switching based handover process
16 or direct handover process. The detailed procedures for zone switch based handover and direct handover are
17 described in 15.2.6.4.1.2.1 and 15.2.5.3.1.2.2.2 respectively. The zone switching based handover is applica-
18 ble to the ABS supporting WirelessMAN-OFDMA Reference System/WirelessMAN-OFDMA Advanced
19 co-existing System. The direct handover based handover is applicable to the ABS which only supports
20 WirelessMAN-OFDMA Advanced System. An ABS may also decide to keep an AMS in the LZone of a
21 WirelessMAN-OFDMA Reference System/WirelessMAN-OFDMA Advanced co-existing System.
22
23

24 **15.2.6.4.1.2.1 Zone Switch based Handover Procedure**

25
26 The zone switch based HO begins with a decision for an AMS to HO from the serving YBS to the LZone of
27 a target ABS. The HO decision, initiation and cancellation follow the same procedures as defined in section
28 6.3.21.2. Zone Switch is initiated either by AMS or ABS while the final decision shall be made by ABS. In
29 case of an AMS initiated zone switch, the AMS transmits an RNG-REQ message with the 'Ranging purpose
30 indicator' bit set to 4, which implies the zone switch request. Upon reception of such RNG-REQ message,
31 the ABS sends a RNG-RSP message including the zone switch TLV. Before zone switch is initiated, the
32 AMS may inform the target ABS that whether or not it already acquired SFH of the MZone in the target
33 ABS together with the change count of the SFH it acquired.
34
35

36
37 The AMS performs network reentry in the LZone of the target ABS following the same procedures as
38 defined in section 6.3.21.2.7. In addition, upon knowing the AMS capability of supporting WirelessMAN-
39 OFDMA Advanced System based on the MAC version obtained either from the RNG-REQ sent from AMS
40 in the LZone or from the serving ABS over the backbone, the ABS may direct the AMS to switch from
41 LZone to MZone during or after AMS network re-entry to the LZone.
42
43

44
45 If ABS knows that MS has acquired the MZone system information (e.g. SFH) and decides that the zone
46 switch operation is needed and the network re-entry procedure at LZone requires more subsequent steps
47 after the ranging process and the delay due to network reentry at MZone is less than the subsequent network
48 reentry procedures at LZone, the ABS directs the AMS to stop the LZone network re-entry and switch from
49 LZone to MZone immediately after receiving the RNG-RSP message of LZone ranging process containing
50 Zone Switch TLV, as shown in Figure 394—.
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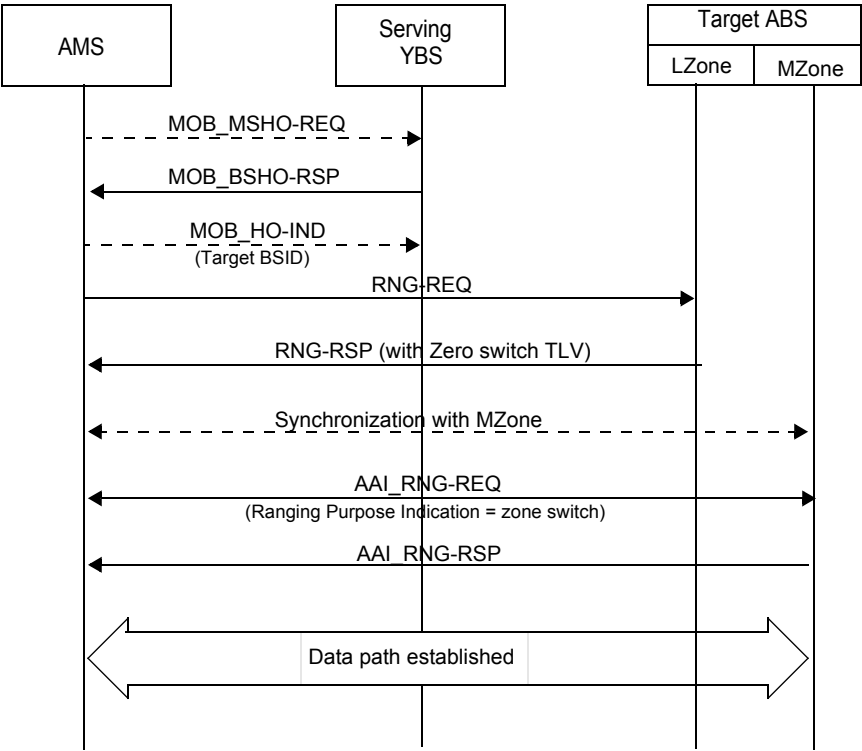


Figure 394—Handover procedure from YBS to ABS: the T-ABS instructs AMS to switch zone through RNG-RSP with Zone switch TLV

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 395—.

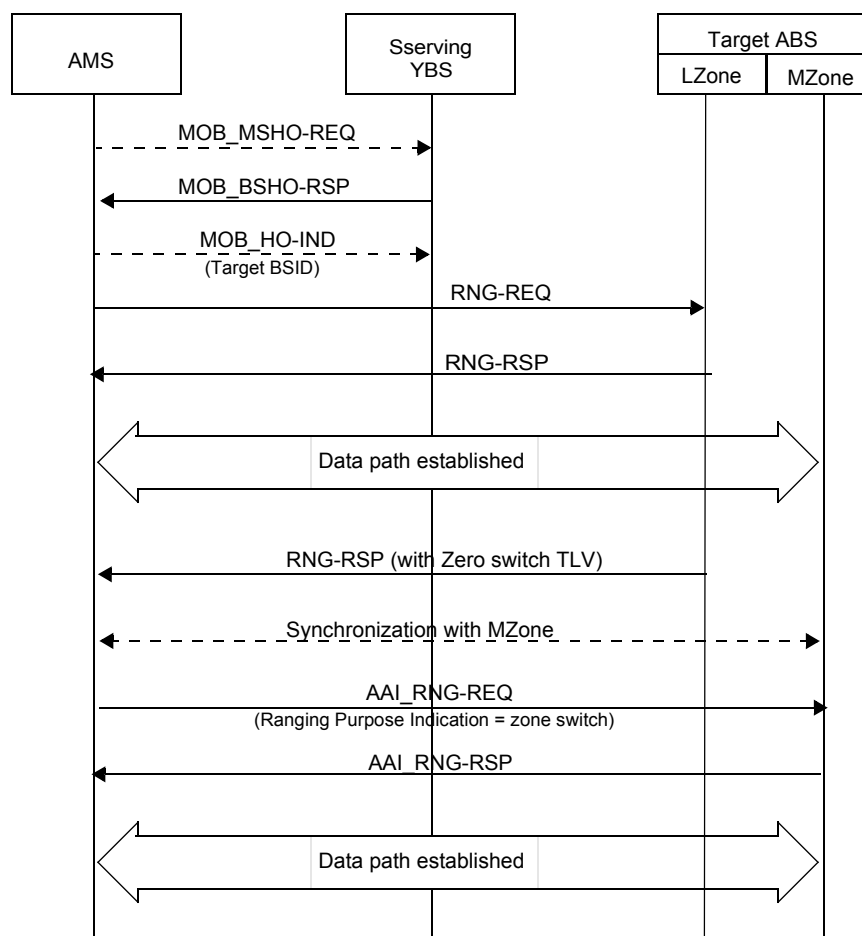


Figure 395—Handover procedure from YBS to ABS: the T-ABS instructs AMS to switch zone after completion of network reentry at LZone

The Zone Switch TLV shall include the following:

{TBD}

The Zone Switch TLV may also include the following:

- UL grant for the AMS to send AAI_RNG-REQ message in Mzone
- STID for being used in MZone

After receiving zone switch command through RNG-RSP in LZone, the AMS performs network reentry in MZone. The AMS maintains its normal operation in LZone (e.g., exchanging user data with the ABS in LZone) while performing network re-entry in MZone if data path in LZone has been established before the start of zone switch operation.

If synchronization with the MZone has not been accomplished, the AMS starts network reentry in MZone by performing DL synchronization with the MZone using the system information provided in the Zone Switch TLV through RNG-RSP message sent by the ABS in LZone. If the AMS hasn't acquired SFH of the MZone, the AMS shall acquire the system information of the MZone by listening to the ABS's SFH.

Then the AMS shall start the ranging process in MZone by sending AAI_RNG-REQ message with Ranging Purpose Indication being "Zone Switch". The ABS then responds with the AAI_RNG-RSP message.

If UL grant is provided in the MZone at Zone_Switch_Action_time, the AMS uses the grant to send AAI_RNG-REQ message with Ranging Purpose Indication set to "Zone Switch". Otherwise, the AMS shall request UL bandwidth to send the AAI_RNG-REQ by using the pre-assigned STID 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_REG-REQ/RSP message. AMS context mapping from LZone to MZone is performed by the ABS per section 15.2.x.4.2.3.

15.2.6.4.1.2.2 Direct Handover Procedure

Direct HO procedure for AMS from YBS to WirelessMAN-OFDMA Advanced System only ABS is FFS.

15.2.6.4.1.3 Context Mapping

With zone switch based handover, the context management process from serving YBS 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.

15.2.6.4.1.3.1 MAC Identifiers

The FIDs for the management 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.

15.2.6.4.1.4 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 HO-Command message is used to trigger the zone switch from MZone to LZone which is specified in TBD. Zone switch from LZone to MZone follows the procedure per section 15.2.5.3.1.2. During the request or command of the zone switch to LZone, the AMS is provided with LZone information in prior, such as CID, FID, security parameters or capability information in the MZone via the AAI-HO-CMD message.

15.2.6.4.2 Handover from Advanced WirelessMAN-OFDMA System to WirelessMAN-OFDMA Reference System

Handover of an AMS/YMS from LZone of an ABS to a YBS 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 YBS.

15.2.6.4.2.1 Network Topology Acquisition

15.2.6.4.2.1.1 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 YBS in its LZone using MOB_NBR-ADV message. An AMS always obtains the neighbor YBS information from the MOB_NBR-ADV message

transmitted in LZone. A reference pointer indicating the time offset of the MOB_NBR_ADV message transmission in LZone is provided.

15.2.6.4.2.1.2 AMS Scanning

The scanning procedure for an YMS/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.

15.2.6.4.2.2 Handover Procedure

The handover procedure for YMS/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 YBS.

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 15.2.5 (intra-16m HO), if the selected target BS is a YBS. The ABS may allocate Basic CID to the AMS to be used in target YBS 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 YBS as defined in section 6.3.21.2. If the AMS information is required to be transferred to the target BS 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 YBS over the backbone. In addition, the serving ABS may indicate the time of the fast ranging opportunity negotiated with the potential target YBSs in the AAI_HO-CMD message. The AMS and target YBS 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 YBS as defined in section 6.3.21.2.7.

15.2.6.4.2.3 Context Mapping

15.2.6.4.2.3.1 MAC Identifiers

The management connections with Flow IDs xx (TBD) are mapped to Basic CID and Primary Management CID respectively. The Basic CID is allocated to the AMS by the target YBS and provide to the AMS via the serving ABS using AAI_HO-CMD message. The AMS derives the Primary Management CID based on the procedure defined in section 6.3.21.2. 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 2. The Station Identifier is released after the AMS handover to the target YBS.

15.2.6.5 Handover between Wireless-OFDMA Advanced System and Other RAT Systems

15.2.6.5.1 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 27—

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

15.2.6.5.2 Inter-RAT Handover Procedure

15.2.6.5.2.1 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. 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.

15.2.6.5.2.1.1 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.

SFH defines other RAT information flag. If the value of the other RAT information flag is set, this implies that current super frame carries other RAT information. SFH can be able to contain SFN (start frame number) where AAI_ORAT-MSG is transmitted in order to notify AMS of the start frame of the message.

AAI_ORAT-MSG message is structured in MAC management message on traffic channel and can be transmitted as broadcast (see Table 1). Other RAT information indicated by SFH is illustrated in Figure 396—

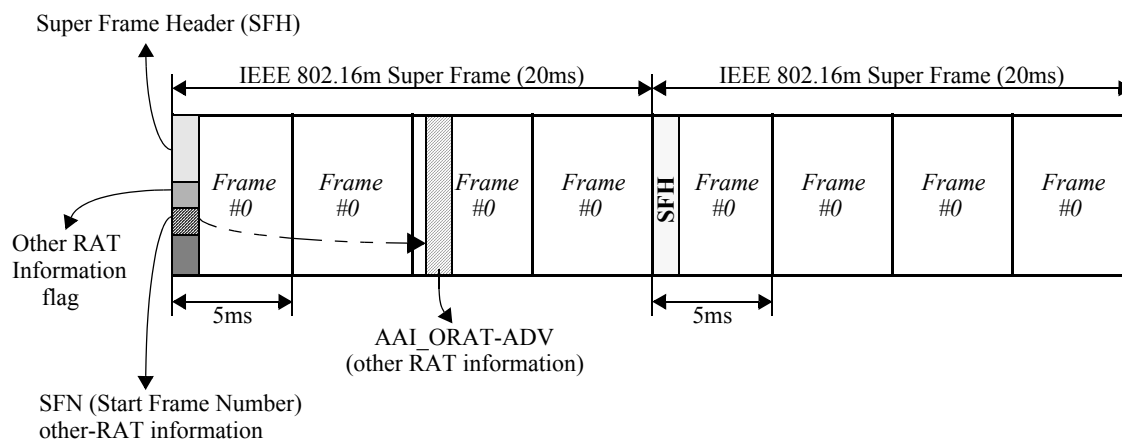


Figure 396—Other RAT information delivery

The AAI_ORAT-MSG message includes 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 802.16m 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).

15.2.6.5.2.1.2 Active Other RAT Discovery

15.2.6.5.2.1.2.1 Active Other RAT Discovery with MIHF Support

The 802.16m entity may send or receive a generic MAC container to or from the peer 802.16m 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

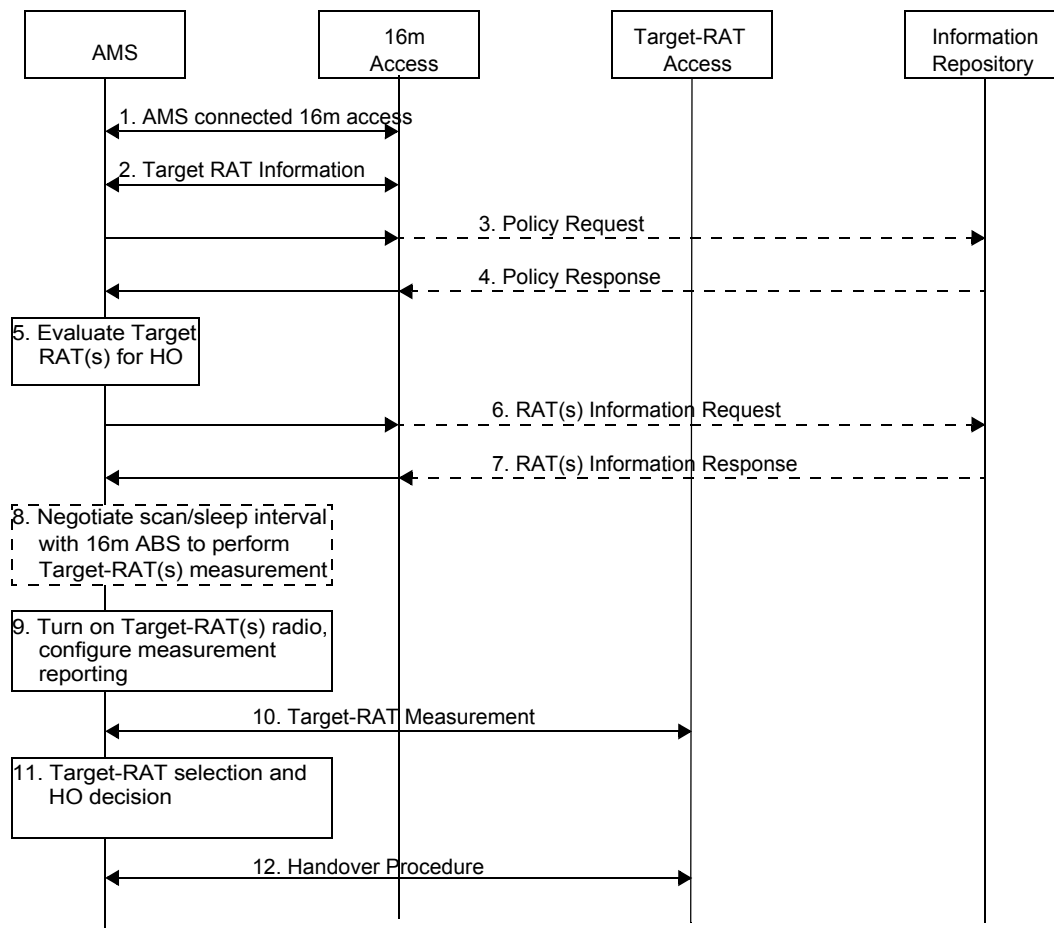
1 Bandwidth Request PDU, the ABS shall abort the network entry procedure for the AMS, otherwise it shall
2 send an AAI_PKM-RSP message with MIH Comeback Response code containing the encapsulated MIH
3 response. The MIH Comeback Response message shall also contain the Query ID previously sent in the
4 MIH Acknowledge message, which the AMS may use to correlate the MIH response with the MIH query.
5 When a broadcast delivery method has been negotiated, then if the ABS is ready to transmit the MIH
6 response, the ABS shall transmit an AAI_SII-ADV message containing the MIH response in the MAC
7 frame indicated by the Cycle TLV. If the ABS is not ready to transmit the MIH response at the time indi-
8 cated by the Cycle TLV, the AMS and ABS shall wait for another cycle and repeat the procedures specified
9 in the preceding paragraph. The maximum number of times the AMS and ABS shall perform those proce-
10 dures is determined by the MIH max cycles system parameter.
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14 **15.2.6.5.2.1.2.2 Active Other RAT Discovery Using 802.16m Scanning**

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16 AMS shall initiate other RAT discovery using scanning procedure. The single radio AMS shall negotiate
17 scanning procedure before scanning commencement. If an AMS's location information is available, the
18 AMS may transmit its location information with scanning request message and the ABS may respond with
19 recommended RAT information based on the MS's location information.
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22 **15.2.6.5.2.1.2.3 Generic Active Network Discovery and Selection Procedure**

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24 During the target RAT selection process, the AMS may communicate with an information repository using
25 its 16m connection to obtain operator-defined rules and preferences that affect the inter-RAT handoff deci-
26 sions. The handoff policy may be pre-provisioned in the AMS and may be updated when AMS requests the
27 information repository for network discovery and selection information. The target RAT discovery and
28 selection procedure is shown as follows.
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**Figure 397—**

- 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 management 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 802.16m BS 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/ABS selects a target RAT for handover.
- 12) The AMS in conjunction with ABS and target access conducts the handover procedure.

15.2.6.5.2.2 Generic inter RAT HO procedure

The WirelessMAN-OFDMA Advanced system provides mechanisms for conducting inter-RAT measurements and reporting; they are FFS. Further, it 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.

15.2.6.5.2.2.1 15.2.5.4.2.2.1 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.

15.2.6.5.2.2.2 Measurements

While the AMS is attached to the IEEE 802.16m network and is in active mode, the AMS may need to perform radio measurements on other RATs when directed by the IEEE 802.16m network. The IEEE 802.16m network will provide the AMS required neighbor cell list information and measurement controls. When needed the IEEE 802.16m 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 IEEE 802.16m 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 IEEE 802.16m network.

In order to assist the IEEE 802.16m 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 IEEE 802.16m 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.

15.2.6.5.2.2.2.1 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 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

15.2.6.5.2.2.2.2 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

15.2.6.5.2.2.3 Measurement Reporting

After completion of scanning, AMS reports scanning results to a serving ABS via AAI_SCN-REP.

15.2.6.5.2.3 Enhanced inter-RAT HO procedure

15.2.6.5.2.3.1 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 BS is kept alive until handover completes.

In order to reduce the battery consumption, the second radio is only switched on when needed. After detecting the presence indication of another RAT, the dual mode AMS may switch on the secondary radio to scan for the different RATs, based on its PRL (Preferred Roaming List) and other policies defined.

15.2.6.5.2.3.2 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

Since only one radio can be active at a time in these types of devices, they use the source radio and the back-end connection between the source and target network to prepare the target network for handover. The control signaling and flow for single transmitter/receiver based handovers are shown below.

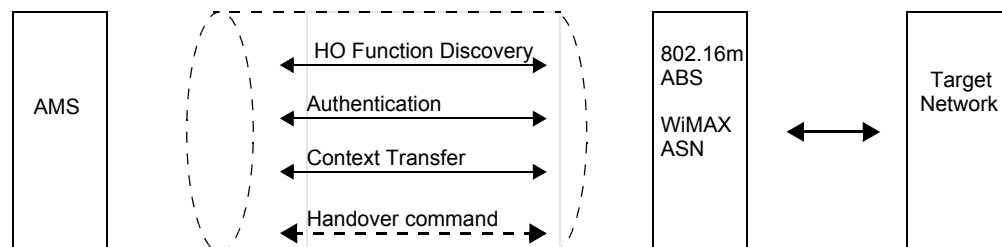


Figure 398—Control Signaling through MAC Container

15.2.6.5.2.3.2.1 Handover Execution & Completion

Once an AMS decides other RAT handover, the AMS requests other RAT handover to a serving ABS. Upon receiving handover response from the ABS, AMS switches its radio over the target RAT and turns off a serving 16m radio.

15.2.7 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 Individual Persistent Allocation A-MAP IE for DL allocations and the UL Individual Persistent Allocation A-MAP IE for UL allocations. To allocate resources persistently to multiple connections, the ABS shall transmit the DL Composite Persistent Allocation A-MAP IE for DL allocations

and the UL Composite Persistent Allocation A-MAP IE for UL allocations. The persistently allocated resource size, position and the MCS 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 DL Basic Assignment A-MAP IE.

15.2.7.1 Allocation Mechanism

15.2.7.1.1 Allocation Mechanism for an Individual Connection

For individual persistent allocation in the DL/UL, the ABS shall transmit the DL/UL Individual Persistent A-MAP IE. Allocation of the persistently assigned resource begins in the DL/UL subframe that is referenced by the DL/UL Individual Persistent A-MAP IE and repeats after an allocation period that is specified in the DL/UL Individual Persistent A-MAP IE. The attributes of the persistently allocated resource including size, location, MIMO encoder format and MCS are maintained as per the DL/UL Individual Persistent A-MAP IE. The values of ACID field and N_ACID field in the DL/UL Individual Persistent A-MAP IE are used together to specify an implicit cycling of HARQ channel identifiers. The allocation period and number of ACIDs required for persistent operation are configured in the DL/UL Individual Persistent A-MAP IE.

In order to facilitate link adaptation and avoid resource holes, the attributes of a persistently allocated resource can be changed. To change an individual persistent assignment, the ABS shall transmit the DL Individual Persistent A-MAP IE for DL reallocation and the UL Individual Persistent A-MAP IE for UL reallocation respectively. If an AMS has an existing individual persistent allocation in a particular subframe and receives a new individual persistent allocation in the same subframe, the new individual persistent allocation replaces the original allocation (i.e., the original persistent allocation is de-allocated).

15.2.7.1.2 Allocation Mechanism for Multiple Connections

For multiple persistent allocations in the DL/UL, the ABS shall transmit the DL/UL Composite Persistent A-MAP IE. Allocation of the persistently assigned resource for each connection begins in the DL/UL subframe that is referenced by the DL/UL Composite Persistent A-MAP IE and repeats after an allocation periods that are specified in the DL/UL Composite Persistent A-MAP IE. The attributes of the persistently allocated resource for each connection including size, location, MIMO encoder format and MCS are maintained as per the DL/UL Composite Persistent A-MAP IE. The values of ACID field and N_ACID field in the DL/UL Composite Persistent A-MAP IE are used together to specify an implicit cycling of HARQ channel identifiers. The allocation period and number of ACIDs required for persistent operation are configured in the DL/UL Composite Persistent A-MAP IE.

In order to facilitate link adaptation and avoid resource holes, the attributes of a persistently allocated resource can be changed. To change persistent assignments for multiple connections, the ABS shall transmit a DL Composite Persistent A-MAP IE for DL reallocation and the UL Composite Persistent A-MAP IE for UL reallocation respectively. If an AMS has an existing persistent allocation in a particular subframe and receives a new persistent allocation in the same subframe, the new persistent allocation replaces the original allocation (i.e., the original persistent allocation is de-allocated).

15.2.7.2 Deallocation Mechanism

15.2.7.2.1 Deallocation Mechanism for an Individual Connection

For deallocation of individual persistent allocations in the DL/UL, the ABS shall transmit the DL/UL Individual Persistent A-MAP IE. When the Allocation Period is set to 0b00 in the DL/UL Individual Persistent A-MAP IE, the assigned persistent resource in DL/UL Individual Persistent A-MAP IE is deallocated in referenced DL/UL subframe and the ABS terminates the persistent allocation.

15.2.7.2.2 Deallocation Mechanism for Multiple Connections

For deallocation of multiple persistent allocations in the DL/UL, the ABS shall transmit the DL/UL Composite Persistent A-MAP IE. When the Allocation Period is set to 0b00 for each connection that is being deallocated in the DL/UL Composite Persistent A-MAP IE, the assigned persistent resource in DL/UL Composite Persistent A-MAP IE is deallocated in referenced DL/UL subframe and the ABS terminates the persistent allocation.

15.2.7.3 HARQ Retransmissions

Asynchronous HARQ retransmission is used for downlink individual and composite persistent allocations. The DL Basic Assignment A-MAP IE is transmitted to signal control information for HARQ retransmission. Synchronous HARQ retransmission is used for uplink individual and composite persistent allocations. The UL Basic Assignment A-MAP IE is transmitted to signal control information for HARQ retransmission.

15.2.7.4 Error Handling Procedure

15.2.7.4.1 Error Handling Procedure for an Individual Connection

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 or a NACK for the initial data burst identified by the DL/UL Individual Persistent A-MAP IE is detected in the assigned HARQ Feedback channel, the ABS shall assume that the DL/UL Individual Persistent A-MAP IE is correctly received.

In the absence (NULL detection) of an ACK or a NACK in the HARQ feedback channel assigned in the DL/UL Individual Persistent A-MAP IE, the ABS shall assume that the AMS has not received the DL/UL Individual Persistent A-MAP IE and the same DL/UL Persistent A-MAP IE can be transmitted again.

In the case of deallocation of individual persistent allocations in the DL/UL, the ABS shall transmit a HARQ Feedback Allocation in the DL/UL Individual Persistent A-MAP IE. This allocation is used to identify the HARQ channel in which the ACK for the DL/UL Individual Persistent A-MAP IE signaling the deallocation is transmitted. In the absence (NULL detection) of an ACK, the shall assume that the AMS has not received the DL/UL Individual Persistent A-MAP IE, and the same DL/UL Persistent A-MAP IE that signaled the deallocation can be transmitted again.

15.2.7.4.2 Error Handling Procedure for Multiple Connections

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 or a NACK for all the initial data bursts identified by the DL/UL Composite Persistent A-MAP IE is detected in the assigned HARQ Feedback channel, the ABS shall assume that the DL/UL Composite Persistent A-MAP IE is correctly received by all the connections.

In the absence (NULL detection) of an ACK or a NACK in the HARQ feedback channel assigned to one or more connections in the DL/UL Composite Persistent A-MAP IE, the ABS shall assume that the corresponding AMSs have not received the DL/UL Composite Persistent A-MAP IE and the DL/UL Composite A-MAP IE can be transmitted again for these connections. If the persistent allocation needs to be transmitted to only one connection the DL/UL Individual A-MAP IE can be transmitted again for this connection.

In the case of deallocation of multiple persistent allocations in the DL/UL, the ABS shall transmit HARQ Feedback Allocations in the DL/UL Composite Persistent A-MAP IE. These allocations are used to identify the HARQ channels in which the ACK for the DL/UL Composite Persistent A-MAP IE signaling the deallocations are transmitted. In the absence (NULL detection) of an ACK from one or more connections, the ABS

shall assume that the corresponding AMSs have not received the DL/UL Composite Persistent A-MAP IE, and the same DL/UL Composite A-MAP IE that signaled the deallocation can be transmitted again. If the deallocation needs to be transmitted to only one connection the DL/UL Individual A-MAP IE can be transmitted again for this connection.

15.2.8 Group Resource Allocation

Group Resource Allocation mechanism allocates resources to multiple users as a group in order to save control overhead. The mechanism takes advantage of common traffic characteristics and grouping is done based on some common parameters such as MCS (modulation and coding scheme) and resource size, which further saves overhead.

15.2.8.1 Grouping Mechanism

AMSs are assigned to groups based on the combination of MCS used and the resource allocation size (number of LRUs) required. A set of n-bit codes can be used to represent the different combinations of MCSs and resource sizes that are used by a group. These codes are included in a bitmap as part of the group's resource allocation information.

15.2.8.2 Group Configuration

A group facilitates the dynamic link adaptation on the limited set of MIMO mode, MCS level and HARQ data burst size.

ABS configures a Group MIMO Mode Set for each group among the predefined candidate sets listed in Table xxx for downlink and Table yyy for uplink. When an AMS is added into the group, the configured Group MIMO Mode Set ID is indicated through Group Configuration IE. The assigned MIMO mode to AMS in the group shall be chosen from the configured set.

Table 28—DL MIMO mode set candidates

ID	DL Group MIMO mode set	SM Restriction
0b00	Mode 0	
0b01	Mode 0, Mode 1	Mt = 2
0b10	Mode 2	Mt = 1
0b11	Mode2, Mode 4	Mt = 1

Table 29—UL MIMO mode set candidates

ID	UL Group MIMO mode set	SM Restriction
0b00	Mode 0	

Table 29—UL MIMO mode set candidates

ID	UL Group MIMO mode set	SM Restriction
0b01	Mode 0, Mode 1	Mt = 2
0b10	Mode 3	Mt = 1
0b11	Mode2, Mode 4	Mt = 1

ABS configures a MCS Set for each group among the predefined candidate sets listed in Table aaa for both downlink and uplink. When an AMS is added into the group, the configured MCS Set ID is indicated through Group Configuration IE. The assigned MCS to AMS in the group shall be chosen from the configured set.

Table 30—DL MIMO mode set candidates

ID	MCS Set			
000	0000	0001	0010	0011
	0100	0101	0110	0111
	1000	1001	1010	1011
	1100	1101	1110	1111
001	0000	0001	0010	0011
	0100	0101	0110	0111
010	1000	1101	1010	1011
	1100	1101	1110	1111
011	0000	0001	0010	0011
100	0100	0101	0110	0111
101	1000	1001	1010	1011
110	1100	1101	1110	1111

ABS configures a HARQ Burst Size Set for each group among the predetermined [4, TBD] HARQ Burst Size Set Candidates. Those candidates are signaled to AMSs via the S-SFH(TBD). When an AMS is added into the group, the configured HARQ Burst Size Set ID is indicated through Group Configuration IE. The assigned HARQ burst size to AMS in the group shall be chosen from the configured set.

As an optional, the combinations of MCS/MIMO mode/Resource size can be signaled explicitly by the ABS to the AMS (TBD).

15.2.8.3 Group Management

15.2.8.3.1 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 AMS in a group moves to other group. For inclusion, the group information shall be informed to AMS in order to interpret resource assignment information from Group Resource Allocation A-MAP IE. The information is transmitted through Group Configuration A-MAP IE. The Group Configuration A-MAP IE can be either unicast or broadcast. The details on broadcasting this IE are TBD.

15.2.8.3.1.1 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 A-MAP IE which includes the added Group ID and the assigned User Bitmap Index to the AMS.

Once the AMS is added to the group, resources used for initial transmission of HARQ data burst may be allocated as part of the group until the AMS is deleted from the group.

15.2.8.3.1.2 AMS Operation

Upon receiving Group Configuration A-MAP IE, the AMS receives the required information to interpret the assigned MIMO mode, MCS level and resource index from the bitmaps in the corresponding Group Resource Allocation A-MAP IE. Once the AMS receives a Group Configuration A-MAP IE, the AMS shall monitor its allocation in the Group Resource Allocation A-MAP IE until it is deleted from the group.

15.2.8.3.2 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) the connection is terminated (ii) the MIMO mode/MCS/HARQ burst size suitable for the AMS no longer belongs to the MIMO Mode Set/MCS set/HARQ burst size set corresponding to the group.

15.2.8.3.2.1 ABS Operation

ABS may delete multiple AMSs from a group in a subframe. The deletion is informed by listing the User Bitmap Index of deleted AMS in Group Resource Allocation A-MAP IE. The deletion shall apply from the subframe in which the deletion information is sent.

15.2.8.3.2.2 AMS Operation

15.2.8.3.3 Bitmaps in Group Resource Allocation

GRA uses of bitmaps to signal resource allocation information for users within a group. These bitmaps are sent in the Group Resource Allocation IE. The first bitmap is the User Bitmap which uses 1 bit per user to signal which users are scheduled in the frame.

The second bitmap is MIMO Bitmap which are used to indicate the assigned MIMO mode, when multiple MIMO modes and SM parameters are supported in the group. The existence of second bitmap and the length of bits per scheduled AMS are listed in Table 31 and Table 32.

Table 31—Second Bitmap Information for DL

MIMO Mode Set	Existence of Second Bitmap	Length of Bit Per Scheduled AMS	MIMO Mode Indication
0b00	No	=	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	=	CL SU-MIMO with $M_t=1$
0b11	Yes	1	0b0: CL SU-MIMO with $M_t=1$ 0b1: CL MU-MIMO with $M_t=1$, $N_t=2$

Table 32—Second Bitmap Information for UL

MIMO Mode Set	Existence of Second Bitmap	Length of Bit Per Scheduled AMS	MIMO Mode Indication
0b00	No	=	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	=	CL SU-MIMO with $M_t=1$, $TNS=2$
0b11	Yes	1	0b0: CL SU-MIMO with $M_t=1$ 0b1: CL MU-MIMO with $M_t=1$, $TNS=2$

When MIMO Mode Set of the group contains MU-MIMO, PSI Bitmap and Pairing Bitmap are appeared to determine AMS pair sharing same resource. PSI Bitmap uses 1 bit per scheduled AMS to indicate the assigned pilot stream index(PSI).

Pairing Bitmap uses to indicate a pair of two AMSs using different PSI. The number of bits per pair in the Pairing Bitmap depends on the total number of pairs in the group. If there are n pairs in the group, the number of bits per pair is $p = \text{ceil}(\log_2(n))$. The AMSs using $PSI=0$ is assigned an index starting from 0 to $n-1$ in the same order in which they appear in the bitmap. Every p bits in the pairing bitmap are assigned to the AMS using $PSI=1$ in the same order in which they appear in the PSI Bitmap. These p bits carry the index of AMS with $PSI=0$ that is paired with corresponding AMS with $PSI=1$.

The third bitmap is the Resource Allocation bitmap which uses n bits per AMS to signal the MCS and Resource Size for the scheduled AMS in the subframe or extended subframe that are scheduled in the frame. An example of bitmaps is shown in Figure 399. The scheduled AMSs may have different number of bits in the third bitmap when they are assigned different MIMO mode and SM parameter.

The bit length used for a scheduled AMS is determined by the total number of effective combinations for MCS and resource size for the assigned MIMO mode with SM parameter. Effective combinations are derived by subtracting useless combinations among all possible combinations. The following steps are needed to find the effective combinations.

- Step 1: List all possible combination set $C = \{ C(0,0), C(0,1), \dots, C(M,B) \}$

Table 33—Combination Indexes

MCS/HARQ data burst size	1	2	B (Highest burst size)
1	$C(1, 1)$	$C(1, 2)$...	$C(1, B)$
2	$C(2, 1)$	$C(2, 2)$...	$C(2, B)$
...
M (Highest MCS)	$C(M, 1)$	$C(M, 2)$...	$C(M, B)$

$C(m,b)$: Combination index for MCS m , HARQ data burst size b

- Step 2: For each HARQ data burst size, useless combination is chosen when it requires same resource size with a lower MCS level comparing to others due to the resource granularity. For $b \in I_B$, $m \in I_M$, $n \in I_M$, and $m > n$,

$$\{C(m, b)\} \rightarrow U1 \text{ if } N(m, b) = N(n, b)$$

Where

U1 : Useless combination set type 1

I_M : Group MCS set

I_B : Group HARQ burst size set

$N(m, b)$: Required number of RUs for MCS m , HARQ data burst size b

- Step 3: For a given MCS, useless combination is chosen when it requires same resource size supporting a smaller HARQ data burst size than others due to the resource granularity. For $m \in I_M$, $b \in I_B$, $d \in I_B$, and $b > d$,

$$\{C(m, b)\} \rightarrow U2 \text{ if } N(m, b) = N(m, d)$$

Where U2 is useless combination set type 2

- Step 4: Derive effective combination set (E) which is

$$E = C - U1 - U2$$

An index code is identified to each effective combination from lower MCS level and lower HARQ data burst size where n is determined by $\lceil \log_2(\text{Total number of effective combinations}) \rceil$.

Examples of the utilizing bitmaps are shown in Figure 399—, Figure 400—, and Figure 401—.

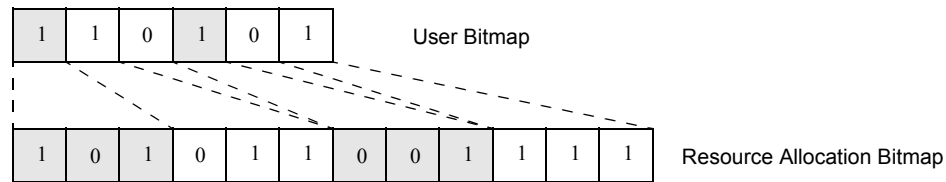


Figure 399—Example of Bitmaps with Group MIMO Mode Set: DL (0b00, 0b10), UL(0b00)

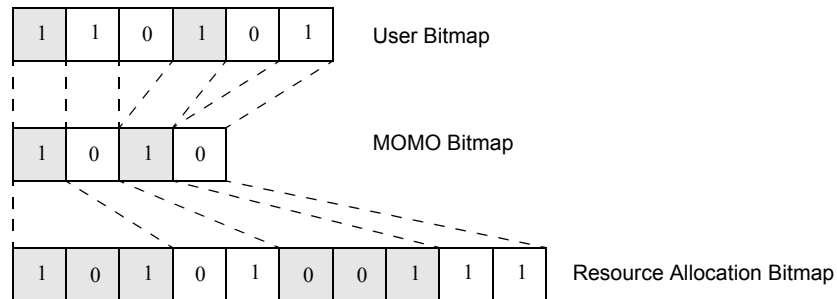


Figure 400—Example of Bitmaps for Group MIMO Mode Set: DL (0b01), UL(0b01)

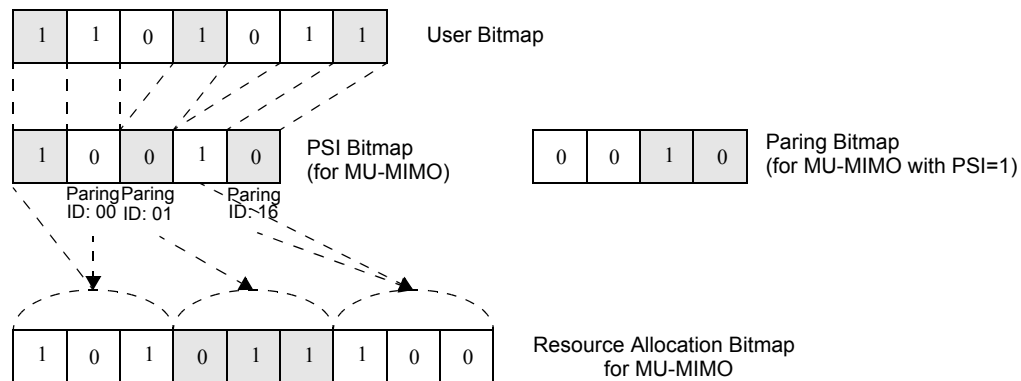


Figure 401—Example of Bitmaps for Group MIMO Mode Set: UL(0b10)

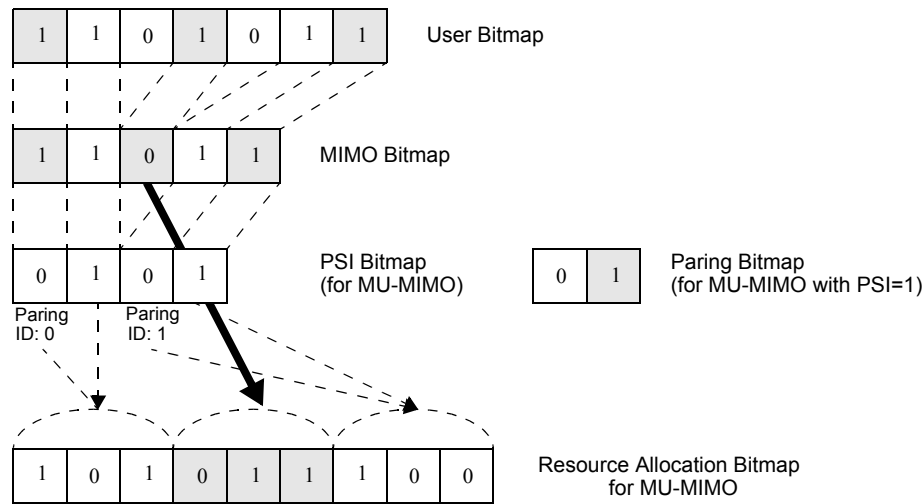


Figure 402—Example of Bitmaps for Group MIMO Mode Set: DL(0b11), UL(0b11)

15.2.8.4 Error Handling Procedure

FFS

15.2.9 Multi-carrier operation

15.2.9.1 Multi-carrier Types and Operational Modes

The carriers involved in multi-carrier 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 management 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.

In the multicarrier operation a common MAC can utilize radio resources in 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 multi-carrier 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 multi-carrier 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 IEEE 802.16m 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

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 car-

rier for other AMS's. Multiple AMSs, each with a different primary RF carrier may also share the same secondary carrier. The following multi-carrier operation modes are identified, which may all or independently be supported:

- **Multi-Carrier 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 RF 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.
- **Multi-Carrier 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 physical layer connection to the primary carrier. This mode is used for switching to partially configured carriers for downlink transmission only service.

The following is common to all multi-carrier modes of operation:

- The system defines N standalone fully configured RF carriers; each fully configured with all synchronization, broadcast, multicast and unicast control signaling channels. 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 ($M \geq 0$) 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 multiple carriers may be in different parts of the same spectrum block or in non-contiguous spectrum blocks. Support of non-contiguous spectrum blocks may require additional control information on the secondary carriers.
- In addition to information about the (serving) primary carrier an ABS, supporting any multicarrier mode, also provides AMSs with some basic information about other available carriers through such primary carrier. The basic multicarrier configuration informs AMS's of the presence, bandwidth, duplexing, and location in the spectrum for all available carriers to help AMS prepare for any multicarrier operation. The primary carrier may also provide an AMS the extended information about the configuration of the secondary carrier.

15.2.9.2 MAC operation

15.2.9.2.1 Addressing

A multi-carrier supporting ABS or AMS follows the same MAC addressing mechanism defined in 15.2.1 [5].

15.2.9.2.2 Security

A multi-carrier supporting AMS follows the same security procedure defined in 10.6[3]. 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.

15.2.9.2.3 Network Entry

An AMS can only perform network entry (or network re-entry) 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 where the ABS indicates its configuration, and its support for multi-carrier feature.

The AMS can decide on proceeding with network entry with the current carrier or going to alternative carriers based on this information. The initial network entry/re-entry follows the procedures defined in 10.8[3] with the exception of operations described in below.

The ABS indicates if it supports any of multicarrier modes to AMS in a cell. The ABS also provides AMS's with basic radio configuration for other available carriers in the ABS through a MAC management message. This message is periodically broadcast by BS, supporting any multicarrier mode. The same configuration information may also be unicast per AMS request. The multi-carrier configuration information is relevant to and may be used by all AMS's in any of multicarrier modes.

The multicarrier configuration information includes information such as center frequency, duplexing mode, bandwidth and other parameters if different than the serving carrier and it also assigns each carrier a physical carrier index, which is used by ABS and AMS for any reference to any available carrier. The configuration information is applicable to all MS's supporting any of multicarrier modes.

The following information shall be included in multicarrier configuration information MC-CONFIG-ADV

- Physical Carrier Index
- Center Frequency (eg. Band Class Index and channel index)
- Channel Bandwidth
- Carrier Type (fully/partially configured)
- Duplexing Mode
- Preamble Index

After successful ranging, the AMS follows the capability negotiation procedure. During capability negotiation, the AMS and ABS shall exchange their multi-carrier capabilities, such as supported multicarrier modes, the number of supportable RF carriers in the downlink and uplink and maximum throughput. These Capabilities are negotiated via post authentication as they do not affect network entry and operation in basic single carrier mode through REG-REQ/RSP messages.

Based on AMS's multicarrier capabilities, the ABS may assign one or more carriers from its available carriers to an AMS as Assigned secondary carriers (see 15.2.x.2.11.).

The AMS may not be able to communicate with the ABS over the secondary carrier(s), if it needs ranging to adjust time/frequency synchronization and power for the carrier(s). Under the assumption of high channel correlation between the carriers, the transmission parameters of secondary carrier(s) could be quite similar with those of primary carrier. Since 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, over the secondary carrier(s), the periodic ranging instead of initial ranging may be performed. So once secondary carriers are assigned, the AMS may perform the periodic ranging over the assigned secondary carrier(s) if directed by the ABS.

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. 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).

15.2.9.2.4 Ranging

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 assigned secondary carrier(s) if directed by the ABS. Upon moving to a target ABS, the AMS shall initiate CDMA handover ranging as defined in section 15.2.5.2.5.1[5]. CDMA handover ranging shall be done only with one of the fully configured carriers of target ABS. Upon moving to a target ABS, the AMS shall initiate CDMA handover ranging as defined in section 15.2.5.2.5.1[5].

15.2.9.2.5 MPDU 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 10.4[3].

15.2.9.2.6 Bandwidth Request and Resource Allocation

All bandwidth requests are transmitted on the AMS's primary carrier using the assigned bandwidth request channel following the same procedures as defined in 15.2.2[5]. Bandwidth request using piggyback may be transmitted in MPDUs over the secondary carrier(s) as well as the primary carrier.

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.

15.2.9.2.7 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.

15.2.9.2.8 DL CINR report operation

An ABS may assign CQI channels to each carrier of an AMS. When CQI channel is assigned, the AMS reports CINR for a carrier over the assigned CQI channel of the corresponding carrier. ABS may also direct AMS to report CINRs of active carriers through CQI channel(s) on the primary carrier. 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.

15.2.9.2.9 Handover

The multi-carrier handover (MCHO) is defined as the handover procedure which involves multiple radio carriers. An AMS with multi-carrier capability may follow the single-carrier handover procedure per section 15.2.5. It may also decide to perform MCHO procedure as defined in this section.

15.2.9.2.9.1 Network topology acquisition

15.2.9.2.9.1.1 Network topology advertisement

The AAI_NBR-ADV message shall carry neighbor ABS's multi-carrier configuration information to facilitate AMS's scanning of neighbor ABSs' fully configured carriers.

15.2.9.2.9.1.2 AMS scanning of target carriers

The AMS with multi-carrier capability may perform the single-carrier scanning procedure per section 15.2.5.1.2. It may also perform multi-carrier scanning procedure, i.e. scanning procedure which involves multiple radio carriers, as defined in this subsection.

The AMS scans each fully configured carrier of the neighbor ABSs as advertised in the AAI_NBR-ADV message. The AMS may also scan other fully configured carriers of the serving ABS which are not in use by

the AMS. Figure 403— illustrates the example message flows for neighbor ABS advertisements and scanning of fully configured carriers of serving and neighbor ABSs.

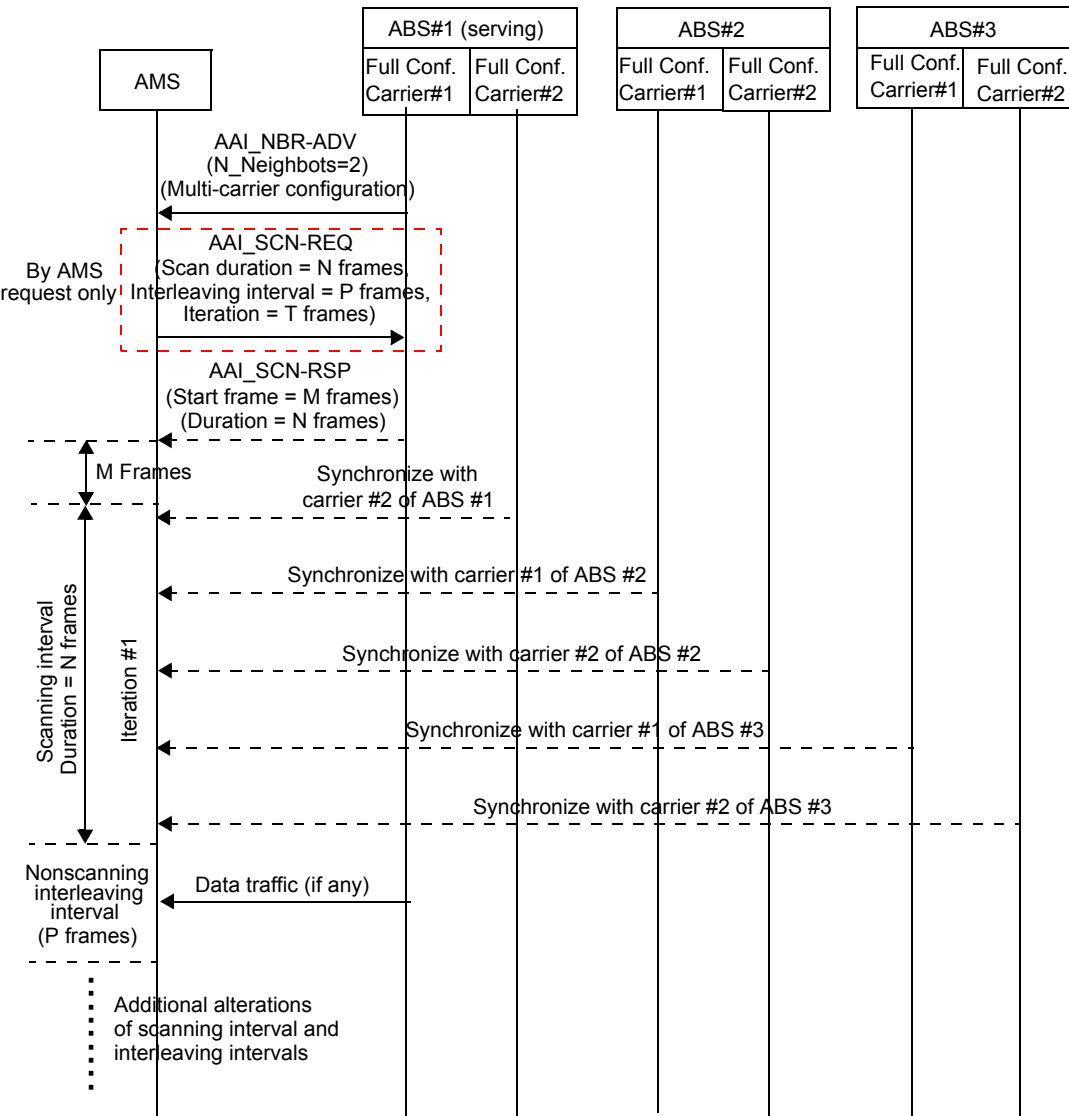


Figure 403—Example message flows for neighbor ABS advertisement and scanning of fully configured carriers of serving and neighbor ABSs

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 may inform the serving ABS through AAI_SCN-REQ its carriers to be assigned for scanning operations to avoid resource allocation on those carriers, as illustrated in Figure 404—. The physical carrier index should be included in AAI_SCN-REQ/RSP/REP.

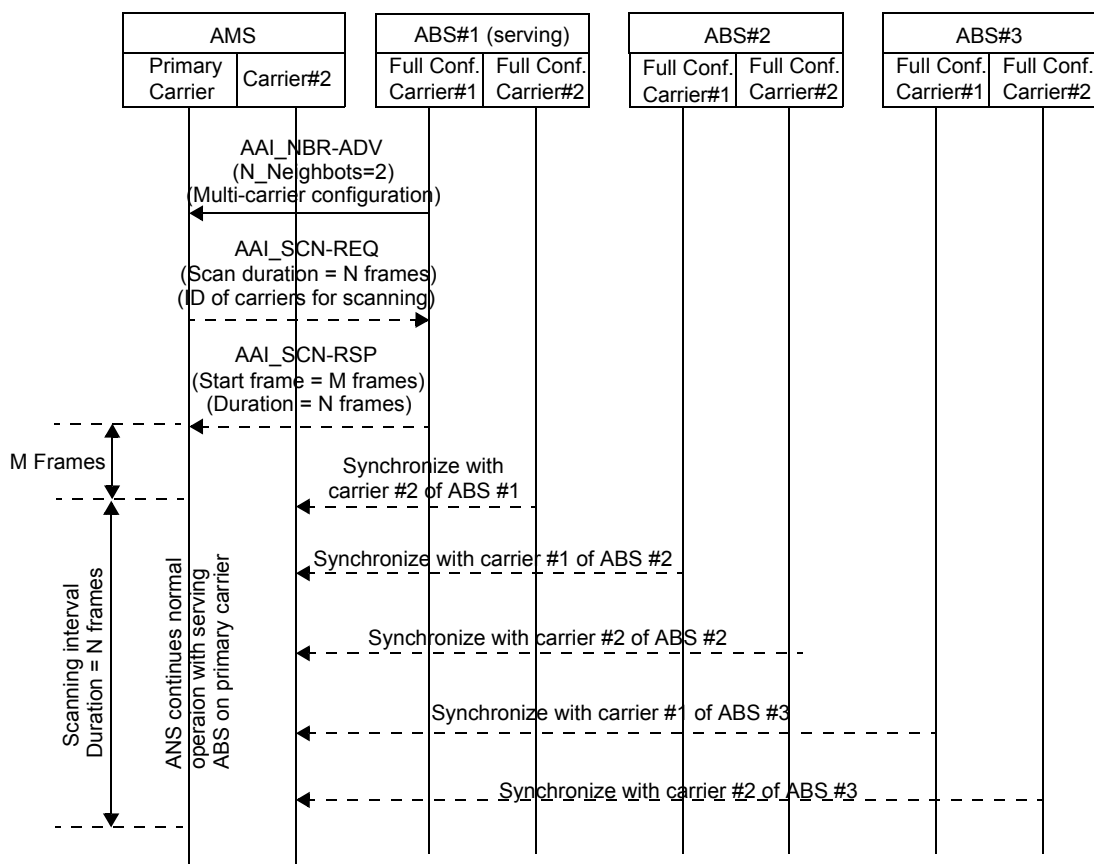


Figure 404—Example message flows for performing scanning using available radio carriers of the AMS while maintaining normal communication with its serving ABS

15.2.9.2.10 Multi-carrier handover (MCHO) procedure

The multi-carrier handover (MCHO) is defined as the handover procedure which involves multiple radio carriers, as described in this section.

15.2.9.2.10.1 MCHO preparation

An AMS in multi-carrier operation follows the handover operations defined in 15.2.5.2. MAC management 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 indicate its multi-carrier capability through **AAI_MSHO-REQ** or **AAI_HO-IND** messages. The ABS may also inform AMS the multi-carrier configurations of one or more potential target ABSs through **AAI_BSHO-CMD** message. If the target ABS is supporting multicarrier mode, additional information may be included in the **AAI_MSHO-REQ**, **AAI_BSHO-CMD** and **AAI_HO-IND** messages.

15.2.9.2.10.2 MCHO execution and network re-entry

The AMS with multi-carrier capability follows the network re-entry procedure per section 15.2.5.2.5. The AMS may use the original primary carrier for network re-entry to the target ABS, as illustrated in Figure 405—. It may also use another carrier different from its original primary carrier for network re-entry procedures, as illustrated in Figure 406—. In both cases, if the Multi-carrier_Mode and HO_Reentry_Mode in AAI_BSHO-CMD message is set to 1, the AMS maintains normal communication with the serving ABS on another carrier not performing network re-entry procedure. 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_BSHO-CMD message. The AMS may inform the serving ABS through AAI_HO-IND the carrier to be used for network re-entry operations to avoid resource allocation by the serving ABS on that carrier.

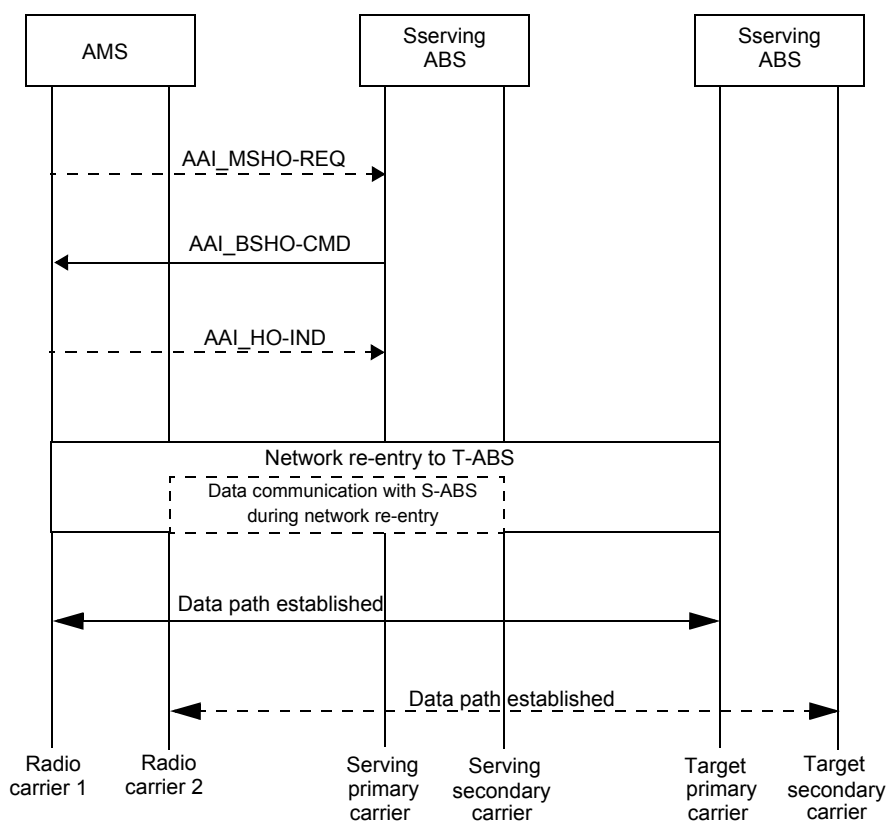


Figure 405—A call flow for multi-carrier HO in which the AMS performs network re-entry to the target ABS on one radio carrier while maintaining communication with the serving ABS on another carrier

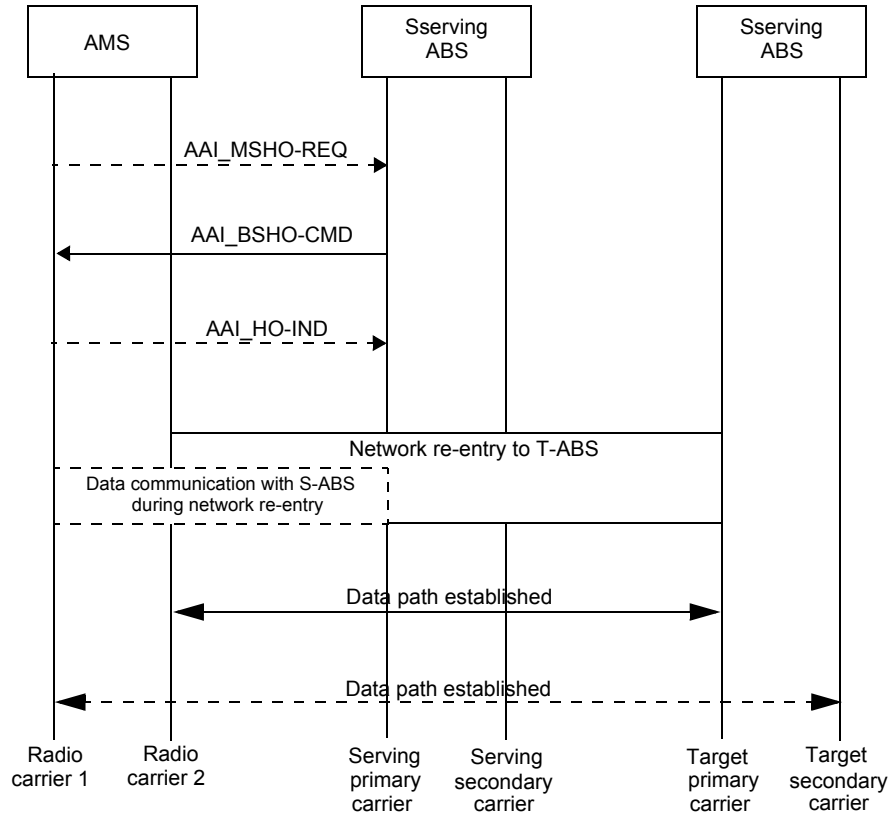


Figure 406—A call flow for multi-carrier HO in which the AMS performs network re-entry on the target primary carrier which is different from the serving primary carrier

From AMS point of view, if network entry is completed (see 15.2.5), the AMS shall stop communicating with the serving ABS. Then, the AMS may send UL data or BW-REQ message to the target ABS.

15.2.9.2.11 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 multi-carrier 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.

15.2.9.2.12 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 and all carriers power down according to the negotiated sleep mode parameters. 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 AMS to change its primary carrier upon entering the sleep mode or during the listening window using carrier management MAC message.

During the listening window, the traffic indication enabled AMS 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 mode. If positive traffic indication is received, the AMS continues to monitor the primary carrier. Data transmission follows the normal operation for multi-carrier mode.

15.2.9.2.13 Idle mode

A multi-carrier supporting AMS in idle state follows the same procedures defined in 10.5.2.

15.2.9.2.14 Carrier management

15.2.9.2.14.1 Secondary Carrier management

Based on AMS's multicarrier capabilities, the ABS may assign one or more carriers from its available carriers to an AMS as Assigned secondary carriers through AMAC message. This message refers to carriers using their physical carrier index and each assigned carrier is given implicitly or explicitly a logical carrier index.

The AMS does not start PHY/MAC processing of secondary carriers until directed by ABS.

The activation or deactivation of secondary carrier(s) is decided by ABS based on QoS requirement, load condition of carriers and other factors. The ABS may transmit the list of active carriers to the AMS as a QoS parameter.

Carrier management MAC message is transmitted on the primary carrier and shall include the following information:

- Indication Type: (including activation, deactivation)
- List of Secondary Carriers: (referred by logical carrier index)

15.2.9.2.14.2 Primary Carrier Change

The ABS may instruct the AMS, through control signaling on the current primary carrier, to change its primary carrier to one of the available fully configured carriers within the same ABS for load balancing purpose, carriers' varying channel quality or other reasons. AMS switches to the target fully configured carrier at action time specified by the ABS. The carrier change may also be requested by the AMS through control signaling on the current primary carrier. Given that a common MAC manages both serving and target primary carriers, network re-entry procedures at the target primary carrier is not required. ABS may provide the system information of the target primary carrier that is different from the serving primary carrier via the serving primary carrier. The logical carrier indices may be re-arranged if needed. ABS may direct an AMS to change the primary carrier without scanning.

The ABS may instruct AMS to perform scanning on other carriers which are not serving the AMS. 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.

15.2.9.2.14.3 Carrier switching mode

Primary to secondary carrier switching in multi-carrier mode is supported when secondary carrier is partially configured. The carrier switching between a primary carrier and a secondary carrier can be periodic or event-triggered with timing parameters defined by multi-carrier switching message on the primary carrier. When an AMS switches to a secondary carrier, its primary carrier may provide basic information such as timing and frequency adjustment to help with AMS's with fast synchronization with the secondary carrier.

15.2.10 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. Unicast connections are identified by the combination of a 12-bit STID and a 4-bit FID. Multicast and broadcast connections are identified by the reserved STIDs.

Two types of connections are used - management connections and transport connections. Management connections are used to carry MAC management 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 management message shall never be transferred over transport connection, and user data shall never be transferred over management connections.

15.2.10.1 Management connections

Two pairs of bi-directional unicast management connections - basic connection and primary management connection, are automatically established when an AMS performs initial network entry. The basic connection is used by the ABS MAC and AMS MAC to exchange short, time-urgent MAC management messages. The primary management connection is used by the ABS MAC and AMS MAC to exchange longer, more delay-tolerant MAC management messages. FID with value 0 and 1 are reserved for these two management connections respectively.

Once the STID is allocated to the AMS, the management connections are established automatically. FID for the management connection shall never be changed during WirelessMAN-OFDMA Advanced System handover or network reentry.

15.2.10.2 Transport connections

All the user data communications are in the context of transport connections. A transport connection is unidirectional and established with unique FID assigned using DSA procedure per section 15.2.z.3. 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 created, and released when the associated service flow becomes non-active. 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 management 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.

15.2.11 Bandwidth Request and Allocation Mechanism

15.2.11.1 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 indicator and an optional quick access message on BR channel, a standalone bandwidth request, a piggybacked bandwidth request carried in an Extended Header in the MAC PDU or a bandwidth request using fast feedback channel. Bandwidth requests in the standalone bandwidth request and a piggybacked bandwidth request shall be made in terms of the number of bytes needed to carry the MAC PDU excluding PHY overhead.

An AMS requests UL bandwidth on a per-connection basis. In addition, the AMS may request bandwidth for multiple connections in one piggyback BR.

15.2.11.1.1 Contention-based random access bandwidth request

The ABS may advertise a minimum access class in the BR channel configuration within a DL Control message. When an AMS has information to send and wants to enter the contention resolution process, 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 within a DL Control message. 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 within a DL Control message 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 the Request (or Ranging for initial ranging).

Contention-based random access bandwidth request follows the procedure defined in section 15.2.2

The 3-step random access based BR procedure is illustrated in Figure 407—. At step 1, the AMS transmits a BR indicator and a quick access message on a randomly selected slot within the bandwidth request channel. At step 2, the ABS may transmit explicit acknowledgement to AMS to indicate its success of decoding BR indicator or Quick access message in the next DL frame as a response to previous bandwidth request channel opportunity. If ABS fails to decode BR indicator or Quick access message, ABS shall transmit BW ACK A-MAP IE in the next DL frame indicating the negative acknowledgement for the corresponding bandwidth request opportunity. BW ACK A-MAP IE specifies to the decoding status of BR opportunity in the previous UL frame.

AMS shall only start BR timer upon one of the following conditions:

- 1) AMS does not receive any Negative-ACK or BW grant (i.e., implicit ACK);
- 2) Received BW ACK A-MAP IE indicating Quick access message decoding failure (with BR indicator successfully decoded) at the BR opportunity used by the AMS

On the first condition, the BR Timer value is the differentiated value defined for the service flow based on e.g. service type and priority. The differentiated values are transmitted in the DSx transaction. On the second condition, the BR Timer value is fixed.

- 1) AMS shall stop BR timer upon the receiving of the UL grant.

AMS considers the BR was failed and may restart the BR procedure upon one of the following conditions:

- 1) received a Negative-ACK; or
- 2) the BR timer expires.

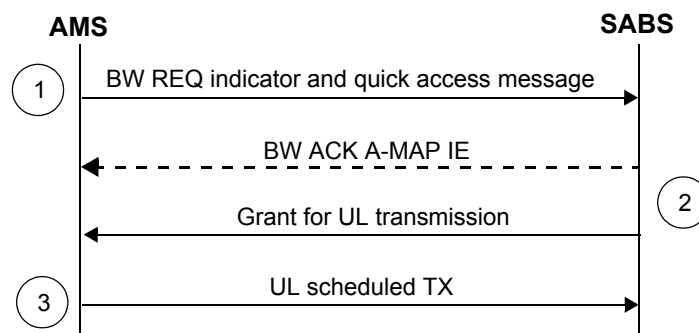


Figure 407—3-step random access BR procedure

In case the quick access message is not decodable, a 5-step BR procedure as a fallback mode for the 3-step BR procedure is illustrated in Figure 408—. The AMS obtains resource grant from ABS using CDMA Allocation A-MAP IE at step 2. At step 3, the AMS transmits a standalone BW REQ header or use the given UL resource for its uplink data transmission instead of the BW-REQ message. In both cases, STID shall be carried in the uplink transmission. ABS may allocate UL grant for uplink transmission at step 4. The AMS then performs its uplink transmission at step 5. After step 3, the AMS shall start the BR timer with the differentiated value defined during DSx transaction. The ABS shall transmit a negative acknowledgement for the corresponding standalone BW-REQ header in case it is not decoded in step 3. If AMS receives the negative acknowledge, it may restart the BR procedure, otherwise, it shall start the BR timer with the differentiated value defined during DSx transaction. The AMS may restart the BR procedure if timer is expired.

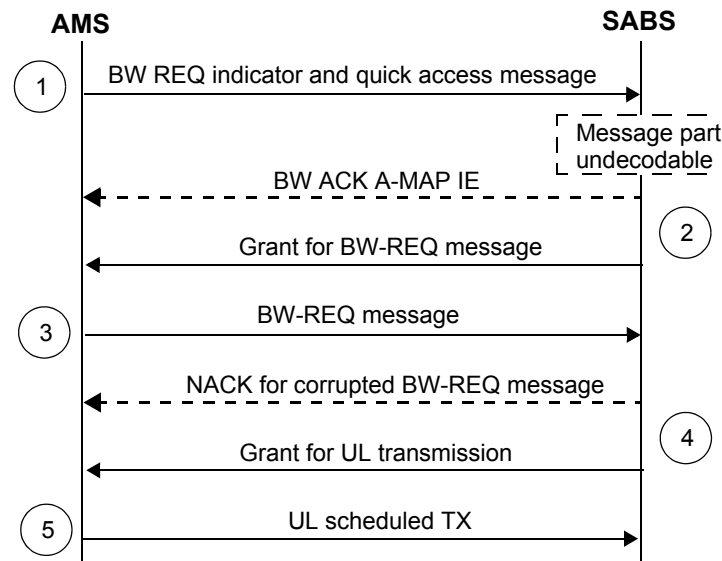


Figure 408—Example of 5-step random access BR procedure as a fallback mode for the 3-step BR procedure

In 5-step regular random access BR procedure, AMS sends a bandwidth request indicator only. After step 2, only fixed value timer is activated. The rest of the BR procedure shall be the same as the 5-step procedure in Figure 408—.

The BR Acknowledgement A-MAP IE indicates the decoding status of the BR opportunities in the previous UL frame. It includes the allocation information only for the fixed size of bandwidth such as BW-REQ message.

Table 34—BR-ACK A-MAP IE Format

Syntax	Size (bits)	Notes
ACK A-MAP IE() {		—
A-MAP Type	4	ACK A-MAP IE
BR-ACK Bitmap	N_BR_Slots	Each bit indicates the decoding status of BR code in the corresponding BR opportunity. 0b0: No BR code is detected, 0b1: At least one code is detected
Resource start offset	TBD	This field is the start offset of the Resource allocation for BR Header
For (i=0; N_BR_Slots; i++) {		
If (BR-ACK Bitmap[i] == 1) {		
Number of Received codes (L)	TBD	The number of BR code indices included in this ACK A-MAP IE.
For (j=0; j<L; j++) {		
Code index	5	Code index received in the BR opportunity
MSG decoding indicator	1	To indicate the decoding status of quick access message
Grant indicator	1	To indicate whether grant of BR Header for the code index is included or not If this bit is set, the UL resource is allocated with fixed size and MCS.
}	—	
}	—	
}	—	
MCRC	16	CRC masked by the reserved STID for ACK A-MAP
}	—	

15.2.11.1.2 Standalone Bandwidth Request Header

Standalone bandwidth request header is used by AMS to send bandwidth request in step 3 in the 5-step contention-based 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.

15.2.11.1.3 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.

15.2.11.1.4 Bandwidth Request using FFB

15.2.11.1.5 Bandwidth request message format

15.2.11.1.5.1 quick access message format

When 3-step BW-REQ procedure is used, in step-1 the quick access message carries 12 bit information including MS addressing information with TBD quick access sequences carrying additional BW-REQ information. The information bits are defined in the following format.

15.2.11.1.5.2 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 aGPS or minimum delay of the requested grant for BE, and it may contain the following parameters. ABS shall use the size of single flow standalone bandwidth request header for polling allocation.

- FID of the requesting connection
- Aggregate or incremental bandwidth to request for one or multiple flows
- New GPI value for aGPS or minimum delay of the requested grant for BE
- GPI change indicator for aGPS

15.2.11.1.5.3 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.

15.2.11.2 Grant

In the bandwidth request procedure, the grant for BW-REQ message is allocated by CDMA Allocation A-MAP IE, which is shown in Table 35. CDMA Allocation A-MAP IE is used for allocation of bandwidth to a user that requested bandwidth using a ranging code or BR code. AMS decodes the IE and checks the MCRC field by its specific 12-bit RA-ID and 4-bit Masking Indicator. The RA-ID is calculated by a hash function with the AMS' random access attributes (i.e., frame number index, sub-frame number index, opportunity index and code index). Masking indicator indicates the identifier used for CRC masking, as shown in Table 36.

Table 35—CDMA Allocation A-MAP IE format

Syntax	Size (bits)	Notes
CDMA_Allocation_A-MAP IE() {		—
A-MAP IE Type	4	
Resource assignment Information	TBD	Each bit indicates the decoding status of BR code in the corresponding BR opportunity. 0b0: No BR code is detected, 0b1: At least one code is detected
MCS	5	Modulation and coding scheme used for the burs
MCRC	6	CRC masked by RA-ID and Masking Indicator
}	—	

Table 36—Description of the Masking Indicator

Masking Indicator	Description
0b000	MCRC is masked by 12-bit STID
0b001	MCRC is masked by 12-bit RAID for Ranging
0b010	MCRC is masked by 12-bit RAID for bandwidth request

15.2.12 Quality of Service (QoS)

15.2.12.1 Global Service classes

Table 37—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 186 (value 0b111111 indicates TLV to follow)
I	Maximum traffic burst	6	Extensible look-up Table 186 (value 0b111111 indicates TLV to follow)
R	Minimum reserved traffic rate	6	Extensible look-up Table 186 (value 0b111111 indicates TLV to follow)

Table 37—Global Service Class Name Information Field Parameters

Position	Name	Size (bits)	Value
L	Maximum latency	6	Extensible look-up Table 187 (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 This field is included when I=0
L1	Tolerated Jitter	6	Extensible look-up Table (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.
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 is included when I=0 and S2=2 or 3 or 4 or 5.
S4	Unsolicited Grant Interval	6	Extensible look-up Table (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 (value 0b111111 indicates TLV to follow). This is available only for Uplink Grant Scheduling Type = rtPS. This field is included when I=0 and S2=4.
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.

15.2.12.2 Service Flow Management

In addition to the legacy scheduling services described in 6.3.5, IEEE 802.16m 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 DSA-REQ or DSC-REQ message related to establishing an admitted or active service flow. This field shall also be present in DSA-RSP and DSC-RSP messages related to the successful establishment of an admitted or active service flow.

If a service flow has been successfully admitted or activated (i.e., has an assigned FID) the SFID shall NOT be used for subsequent DSx message signaling as FID is the primary handle for a service flow. If a service flow is no longer admitted or active (via DSC-REQ), its FID may be reassigned by the BS.

15.2.12.3 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 Wireless-MAN-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.

15.2.12.3.1 Adaptive granting and polling service

The ABS may grant or poll AMS periodically and may negotiate only primary SF QoS parameter sets, or both primary and secondary QoS parameter sets with the AMS. Initially, ABS uses QoS parameters defined in the primary SF QoS parameter set including Primary Grant and Polling Interval (GPI) and Primary Grant Size.

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 SF QoS parameters as described below. Adaptation includes switching between primary and secondary SF QoS parameter sets or changing of GPI/Grant size to values other than what are defined in the primary or secondary SF QoS parameter set.

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 Piggybacked Bandwidth Request, Bandwidth request signaling, QACH 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 Piggybacked Bandwidth Request, bandwidth request signaling, QACH, 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.
- **Explicit, one time only:** GPI and grant size change is triggered by explicit signaling from AMS such as in Piggybacked Bandwidth Request, bandwidth request signaling, QACH, 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 38— describes the SF QoS parameters for Adaptive grant and polling scheduling service (aGPS).

Table 38—SF QoS parameters for aGPS 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)	aGPS
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)
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)	<ul style="list-style-type: none"> • Implicit adaptation • Explicit adaptation, sustained • Explicit adaptation, one time only
}	Padding bits to ensure byte aligned. Shall be set to zero.

15.2.12.3.1.1 Handover Support

During AMS handover from Mzone/ABS to LZone/YBS, a ABS can map an aGPS service flow to a service flow of legacy scheduling type.

If the "Adaptation Method" QoS parameter of aGPS indicates adaptation, the aGPS service flow can be mapped to an ertPS service flow if it is primarily granting based; or it can be mapped to a rtPS service flow if it is primarily polling based.

Table 39—mapping from aGPS (without adaptation) to ertPS/rtPS

16m aGPS service flow	Mapped 16e 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	<ul style="list-style-type: none"> • UGI = Primary GPI • and map equally all the other common QoS parameters between ertPS and aGPS
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	<ul style="list-style-type: none"> • UPI = Primary GPI • and map equally all the other common QoS parameters between rtPS and aGPS

15.2.12.4 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 predefined emergency preamble code or 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 bandwidth request.

15.2.12.5 Emergency Service Notification during initial ranging

The AMS may request for Emergency Service flow setup during initial ranging process by using a pre-defined ranging preamble code or 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).

15.2.12.6 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.

15.2.13 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.

15.2.13.1 ARQ feedback

15.2.13.1.1 ARQ feedback IE

Table 40— defines the ARQ Feedback IE for ARQ block. It is used by the receiver to signal positive or negative acknowledgments. A set of IEs of this format may be transported either as a packed payload ("piggy-backed") within a packed MAC PDU or as a payload of a standalone MAC PDU.

Table 40—ARQ feedback IE format for ARQ block

Syntax	Size (bits)	Notes
ARQ_feedback_IE(LAST) {	<i>Variable</i>	
Flow ID	4	The ID of the flow being referenced
LAST	1	0 = More ARQ Feedback IE in the list 1 = Last ARQ Feedback IE in the list
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) {		
Selective ACK MAP	7	Each bit represents ACK or NAK of corresponding ARQ block. '0' is NAK and '1' is ACK. First MSB of first ACK MAP represents ACK or NAK information of SN. Contiguous bits after first MSB of first ACK MAP is corresponding to contiguous SN.

Table 40—ARQ feedback IE format for ARQ block

Syntax	Size (bits)	Notes
FLAG	1	0 = No more selective ACK MAP 1 = Another set of selective ACK MAP and FLAG follows
}		
}		

15.2.13.1.2 ARQ feedback poll

Transmitter may send ARQ feedback poll to the receiver, to update the reception status of the transmitted ARQ blocks. The ARQ feedback poll is sent using a FPEH or MEH. When the transmitter is at the AMS side, the ARQ feedback poll may only be sent to the ABS by piggybacking an FPEH or MEH into an uplink data packet belonging to an existing uplink flow. The AMS shall not request uplink bandwidth solely for the purpose of sending an ARQ feedback poll to the ABS.

In downlink, an ABS may assign unsolicited bandwidth using extended header or MAC management message for the AMS to send the ARQ feedback in the same MPDU. The ABS indicates that the purpose of the unsolicited bandwidth is for sending ARQ feedback.

15.2.13.1.3 ARQ feedback triggering conditions

Receiver sends an ARQ feedback when an ARQ feedback poll is received from the transmitter or when an ARQ block has been missing for a predetermined period.

15.2.13.2 ARQ parameters**15.2.13.2.1 ARQ_SN_MODULUS**

ARQ_SN_MODULUS is equal to the number of unique SN values, i.e., $2^{(10)}$.

15.2.13.2.2 ARQ_WINDOW_SIZE

ARQ_WINDOW_SIZE is defined in 6.3.4.3.2.

15.2.13.2.3 ARQ_SUB_BLOCK_SIZE

ARQ_SUB_BLOCK_SIZE is the ARQ sub-block length when ARQ block is fragmented into ARQ sub-blocks prior to retransmission with rearrangement.

15.2.13.2.4 4 ARQ_BLOCK_LIFETIME

ARQ_BLOCK_LIFETIME is defined in 6.3.4.3.3.

15.2.13.2.5 ARQ_RX_PURGE_TIMEOUT

ARQ_RX_PURGE_TIMEOUT is defined in 6.3.4.3.6

15.2.13.2.6 MAXIMUM_ARQ_BUFFER_SIZE

This is a negotiation parameter between ABS and AMS. AMS shall inform maximum ARQ buffer size to ABS. ABS should send ARQ blocks not exceeding MAXIMUM_ARQ_BUFFER_SIZE.

15.2.13.3 ARQ block usage

15.2.13.3.1 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 can be 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 or MEH

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 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 connections.

The ARQ blocks of a connection are sequentially numbered. The ARQ block SN (sequence number) is included in MAC PDU using a FPEH or MEH. The original MAC SDU ordering shall be maintained.

15.2.13.3.2 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, single ARQ block may be fragmented into ARQ sub-blocks. A MPDU payload should be constructed from one or more ARQ sub-blocks. ARQ sub-blocks are sequentially numbered using ARQ block SUB_SN. The size of ARQ sub-block is defined by ARQ_SUB_BLOCK_SIZE (see 15.2.13.2.3), which is fixed in size. ARQ sub-block is maintained during retransmission.

Fragmentation and packing information corresponding to retransmitted ARQ sub-blocks shall be included in RFPEH (Rearrangement Fragmentation and Packing Extended Header).

15.2.14 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 HARQ channel identifier (ACID). UL HARQ channels are identified by both ACID and the index of UL subframe in which UL HARQ data burst is transmitted. Multiple UL HARQ channels in the same UL subframe shall be identified by different ACIDs, and UL HARQ channels in different UL subframes shall be identified by the index of UL subframe when the same ACID is addressed to them.

15.2.14.1 HARQ subpacket generation and transmission

Generating the HARQ subpackets shall follow 15.3.x [channel coding section]. 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.

15.2.14.2 Generic HARQ signaling and timing

15.2.14.2.1 HARQ Signaling

15.2.14.2.1.1 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.

In DL, the maximum number of total HARQ channels per AMS is 16. 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 [N_MAX_ReTx].

The timing for transmitting DL Basic Assignment A-MAP IE, DL HARQ subpacket, and HARQ feedback in UL are described in 15.2.14.2.2.

15.2.14.2.1.2 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 transmit the next subpacket through the resources assigned at the latest subpacket transmission with the same ACID. 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.

In UL, the maximum number of total HARQ channels per AMS is 16. The number of retransmissions of the same data burst shall not exceed the maximum $[N_MAX_ReTx]$.

The timing for transmitting UL Basic Assignment A-MAP IE, UL HARQ subpacket, and HARQ feedback in DL are described in 15.2.14.2.2.

15.2.14.2.2 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 subframe index. The frame index shall range from 0 to 3. In FDD, the index of DL or UL subframe shall range from 0 to $F-1$, where F is the number of subframes per frame. In TDD, the index of DL subframe shall range from 0 to $D-1$, where D is the number of DL subframes per frame, and the index of UL subframe shall range from 0 to $U-1$, where U is the number of UL subframes per frame.

15.2.14.2.2.1 FDD

15.2.14.2.2.1.1 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 41—.

Table 41—FDD DL HARQ timing

Content	Subframe Index	Frame Index
Basic Assignment A-MAP IE Tx in DL	l	i
HARQ Subpacket Tx in DL	$m = l, \text{ or } l + N_{A-MAP} - 1$	i
HARQ feedback in UL	$n = \text{ceil}(m + F/2) \bmod F$	$j = \left(i + \text{floor}\left(\frac{\text{ceil}(m + F/2)}{F}\right) + Z \right) \bmod 4$

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 41—.

Note that the subframe index l shall range from 0 to $N_{A-MAP} \cdot (\text{ceil}(F/N_{A-MAP}) - 1)$ with an increment of N_{A-MAP} . For the case that the A-MAP transmission period is two subframes, i.e. $N_{A-MAP} = 2$, m shall be selected between l and $l+1$. The selection information of m shall be provided in DL Basic Assignment A-MAP IE.

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 the data burst processing time T_{proc} . Otherwise, z shall be set to 0. This rule shall be also applied to the long TTI transmission:

$$Z = \begin{cases} 0, & \text{if } ((\text{ceil}(F/2) - N_{TTI}) \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

where N_{TTI} is the number of 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 41— indicates the 1st subframe which a long TTI subpacket spans.

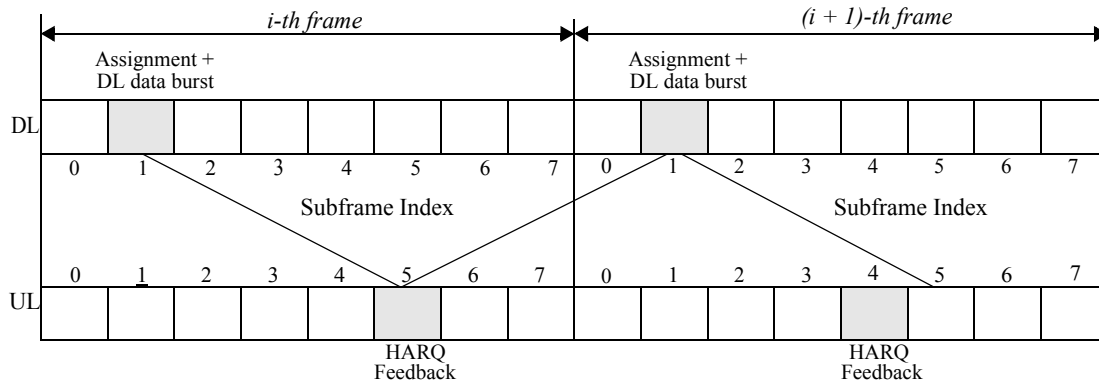


Figure 409—Example of FDD DL HARQ timing for 5, 10 and 20 MHz channel bandwidths

Figure 409— shows an example of the timing relationship between a DL Basic Assignment A-MAP IE with $N_{A-MAP} = 1$, 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_{proc} is 3.

15.2.14.2.2.1.2 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 42—.

Table 42—FDD UL HARQ timing

Content	Subframe Index	Frame Index
Basic Assignment A-MAP Tx IE in DL	l	i

Table 42—FDD UL HARQ timing

Content	Subframe Index	Frame Index
HARQ Subpacket Tx in UL	$m = n$, or $n + N_{A-MAP} - 1$ where $n = \text{ceil}(l + F/2) \bmod F$	$j = \left(i + \text{floor}\left(\frac{\text{ceil}(l + F/2)}{F}\right) + v \right) \bmod 4$
HARQ feedback in DL	l	$k = \left(j + \text{floor}\left(\frac{l + F/2}{F}\right) + w \right) \bmod 4$
HARQ Subpacket ReTx in UL	m	$p = \left(k + \text{floor}\left(\frac{\text{ceil}(l + F/2)}{F}\right) + v \right) \bmod 4$

UL HARQ subpacket transmission corresponding to a UL Basic Assignment A-MAP IE in l -th DL subframe of the i -th frame shall begin in the m -th UL subframe of the j -th frame. A HARQ feedback for the UL HARQ subpacket shall be transmitted in the l -th DL 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 subframe of the p -th frame. The subframe index m , n and frame index j , k , p shall be determined by using l and i , as shown in Table 42—.

Note that the subframe index l shall range from 0 to $N_{A-MAP} \cdot (\text{ceil}(F/N_{A-MAP}) - 1)$ with an increment of N_{A-MAP} . For $N_{A-MAP} = 2$, m shall be selected between n and $n+1$. The selection information of n shall be provided in UL Basic Assignment A-MAP IE.

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 the data burst processing time T_{proc} . Otherwise, v shall be set to 0:

$$v = \begin{cases} 0, & \text{if } ((\text{ceil}(F/2) - 1) \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

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 the data burst processing time T_{proc} . Otherwise, w shall be set to 0. This rule shall be also applied to the long TTI transmission:

$$w = \begin{cases} 0, & \text{if } ((\text{floor}(F/2) - N_{TTI}) \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

where N_{TTI} is the number of 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 42— indicates the 1st subframe which a long TTI subpacket spans.

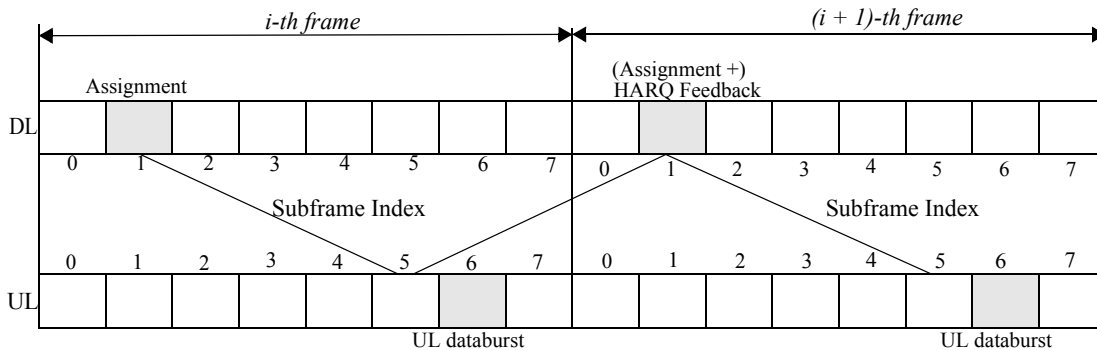


Figure 410—Example of FDD UL HARQ timing for 5, 10 and 20 MHz channel bandwidths

Figure 410— shows an example of the timing relationship between a UL Basic Assignment A-MAP IE with $N_{A-MAP} = 1$, 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_{proc} is 3.

15.2.14.2.2.2 TDD

15.2.14.2.2.2.1 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 43—.

Table 43—FDD UL HARQ timing

Content	Subframe Index	Frame Index
Basic Assignment A-MAP IE Tx in DL	l	i
HARQ Subpacket Tx in DL	$m = l$ or $m = l + N_{A-MAP} - 1$	i
HARQ feedback in UL	For $D > U$ $n = \begin{cases} 0, & \text{for } 0 \leq m < K \\ m - K, & \text{for } K \leq m < U + K \\ U - 1, & \text{for } U + K \leq m < D \end{cases}$	$j = (i + z) \bmod 4$
	For $D \leq U$, $n = m - K$	

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 43—. In the table, if the sum of D and U is an odd number and D is less than U/N_{A-MAP} , $K = \text{ceil}((D - U)/2)$ for $D \geq U$, and $K = -\text{ceil}((U - D)/2)$ for $D < U$. Otherwise, $K = -\text{floor}((D - U)/2)$ for $D \geq U$, and $K = -\text{floor}((U - D)/2)$ for $D < U$.

Note that the subframe index l shall range from 0 to $N_{A-MAP} \cdot (\text{ceil}(D/N_{A-MAP}) - 1)$ with an increment of N_{A-MAP} . For $N_{A-MAP} = 2$, m shall be selected between l and $l+1$. The selection information of m shall be provided in DL Assignment A-MAP IE.

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 the data burst processing time T_{proc} . Otherwise, z shall be set to 0. This rule shall be also applied to the long TTI transmission:

$$z = \begin{cases} 0, & \text{if } ((D - m - N_{TTI} - n) \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

where N_{TTI} is the number of subframes which a HARQ subpacket spans; i.e. 1 for the default TTI and D for the long TTI in TDD DL. The index m in Table 43— indicates the 1st subframe which a long TTI subpacket spans.

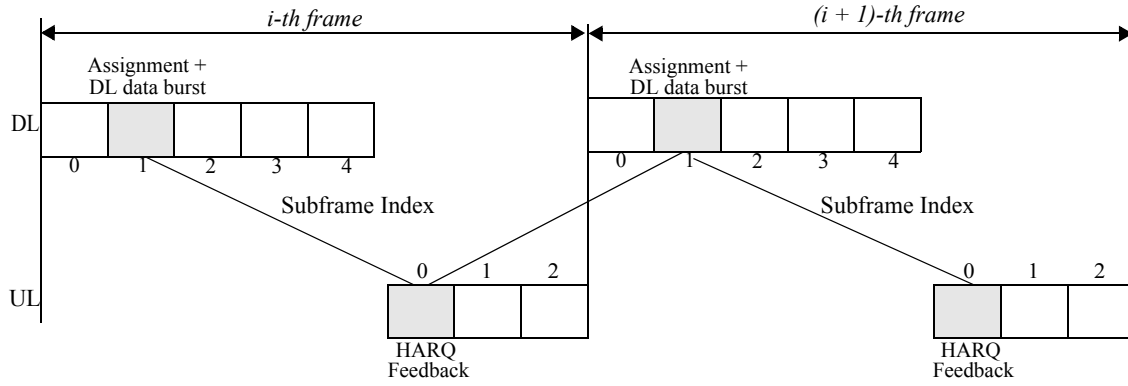


Figure 411—Example of TDD DL HARQ timing for 5, 10 and 20 MHz channel bandwidths

Figure 411—shows an example of the timing relationship between a DL Basic Assignment A-MAP IE with $N_{A-MAP} = 1$, 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_{proc} is 3.

15.2.14.2.2.2 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 44—.

Table 44—FDD UL HARQ timing

Content	Subframe Index	Frame Index
Basic Assignment A-MAP IE Tx in DL	l	i
HARQ Subpacket Tx in UL	For $\text{ceil}(D/N_{A-MAP}) \geq U$ $n = \begin{cases} 0, & \text{for } 0 \leq 0 < K \\ l - K, & \text{for } K \leq l < U + K \\ U - 1, & \text{for } U + K \leq l < D \end{cases}$	$j = (i + z) \bmod 4$
	For $1 < \text{ceil}(D/N_{A-MAP}) \leq U$ $n = \begin{cases} 0, \dots, \text{or } l - k + N_{A-MAP} - 1, & \text{for } l = 0 \\ l - K, \text{ or } l - k + N_{A-MAP} - 1, & \text{for } 0 < l < l_{max} \\ l - k, l - k - 1, \text{ or } U - 1, & \text{for } l = l_{max} \end{cases}$ where $l_{max} = N_{A-MAP} \cdot (\text{ceil}(D/N_{A-MAP}) - 1)$	
	For $\text{ceil}(D/N_{A-MAP}) = 1$ $m = 0, 1, \dots, \text{or } U - 1 \text{ for } l = 0$	
HARQ feedback in DL	l	$k = (j + 1 + w) \bmod 4$

Table 44—FDD UL HARQ timing

Content	Subframe Index	Frame Index
HARQ Subpacket ReTx in UL	m	$p = (k + v) \bmod 4$

UL HARQ subpacket transmission corresponding to a UL Basic Assignment A-MAP IE in l -th DL subframe of the i -th frame shall begin in the m -th UL subframe of the j -th frame. A HARQ feedback time for the HARQ subpacket shall be transmitted in the l -th DL 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 subframe of the p -th frame. The subframe index m , n and frame index j , k , p shall be calculated as shown in Table 44—.

In the table, if the sum of D and U is an odd number and D is less than U/N_{A-MAP} , $K = \text{ceil}((D - U)/2)$ for $D \geq U$, and $K = -\text{ceil}((U - D)/2)$ for $D < U$. Otherwise, $K = \text{floor}((D - U)/2)$ for $D \geq U$, and $K = -\text{floor}((U - D)/2)$ for $D < U$. Note that the subframe index l shall range from 0 to $N_{A-MAP} \cdot (\text{ceil}(D/N_{A-MAP}) - 1)$ with an increment of N_{A-MAP} .

For $\text{ceil}(D/N_{A-MAP}) < U$, m for a certain range of l shall be selected one of multiple values. The selection information of m shall be provided in UL Basic Assignment A-MAP IE.

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 the data burst processing time T_{proc} . Otherwise, v shall be set to 0:

$$v = \begin{cases} 0, & \text{if } ((D - l - 1 + m) \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

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 the data burst processing time T_{proc} . Otherwise, w shall be set to 0. This rule shall be also applied to the long TTI transmission:

$$w = \begin{cases} 0, & \text{if } ((U - m - N_{TTI} + l) \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

where N_{TTI} is the number of 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 44— indicates the 1st subframe which a long TTI subpacket spans.

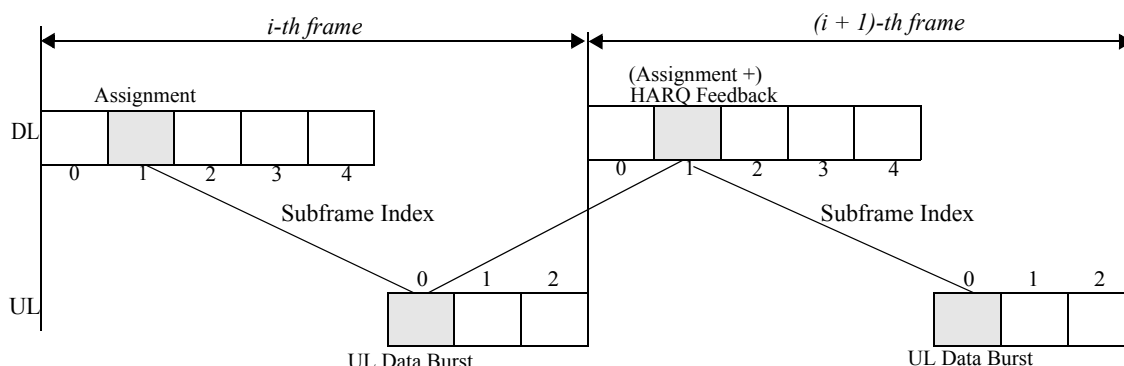


Figure 412—Example of TDD UL HARQ timing for 5, 10 and 20 MHz channel bandwidths

Figure 412— shows an example of the timing relationship between a UL Basic Assignment A-MAP IE with NA-MAP = 1, a UL HARQ subpacket with the default T_{TI} , corresponding HARQ feedback and retransmission in TDD frame structure, for 5, 10 and 20 MHz channel bandwidths. In this example, T_{proc} is 3.

15.2.14.2.2.3 HARQ Timing in frame structure supporting the WirelessMAN-OFDMA frames

The A-MAP relevance and HARQ timing defined in 15.2.14.2.2.2 shall be applied to the frame structure supporting the WirelessMAN-OFDMA TDD frames in 15.3.3.4.1.

Subframes in the frame supporting the WirelessMAN-OFDMA TDD frames shall be indexed as follows: the DL subframe index shall range from 0 to $D-1$, where D is the number of DL subframes dedicated to the Advanced Air Interface operation in frame. The UL subframe index shall range from 0 to $U-1$, where U is the number of UL subframes dedicated to the Advanced Air Interface operation in frame.

Figure 5 shows an example of subframe indexing for 5, 10 and 20 MHz channel bandwidths. In this example, the ratio of whole DL subframes to whole UL subframes, $D:U$ is 5:3. FRAME_OFFSET is 2, and UL subframes of the WirelessMAN-OFDMA and the Advanced Air Interface are frequency-division multiplexed. Then, the ratio of DL to UL subframes for the Advanced Air Interface, $D:U$ is 3:3. The subframe index, l , m , and n are the renumbered index of l' , m' , and n' , respectively.

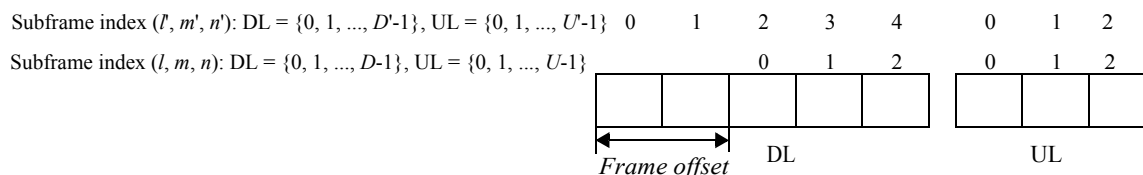


Figure 413—Example of subframe indexing in frame structure supporting the WirelessMAN-OFDMA frame

The same equations and rule in Table 43— and Table 44— 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:

$$z = \begin{cases} 0, & \text{if } ((D' - m' - N_{TTI} - n') \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

$$v = \begin{cases} 0, & \text{if } ((D' - l' - 1 + m') \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

$$w = \begin{cases} 0, & \text{if } ((U' - m' - N_{TTI} + l') \geq T_{proc}) \\ 1, & \text{else} \end{cases}$$

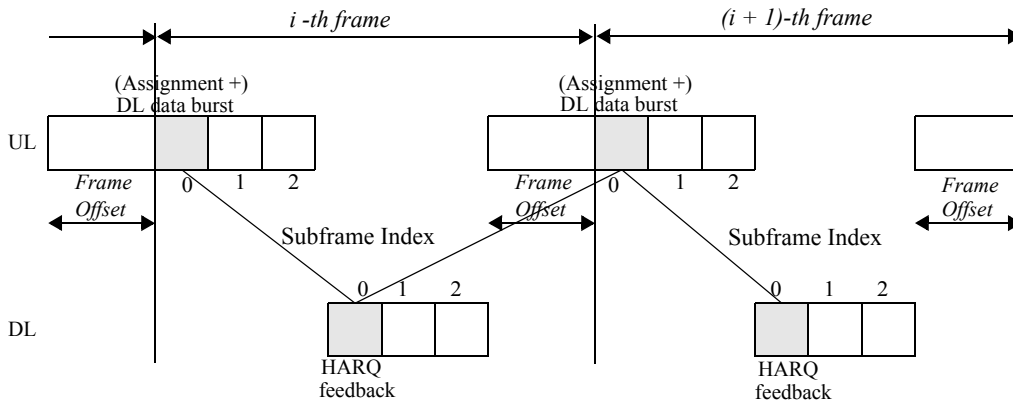


Figure 414—Example of TDD DL HARQ timing in frame structure supporting the Wireless-MAN-OFDMA frame

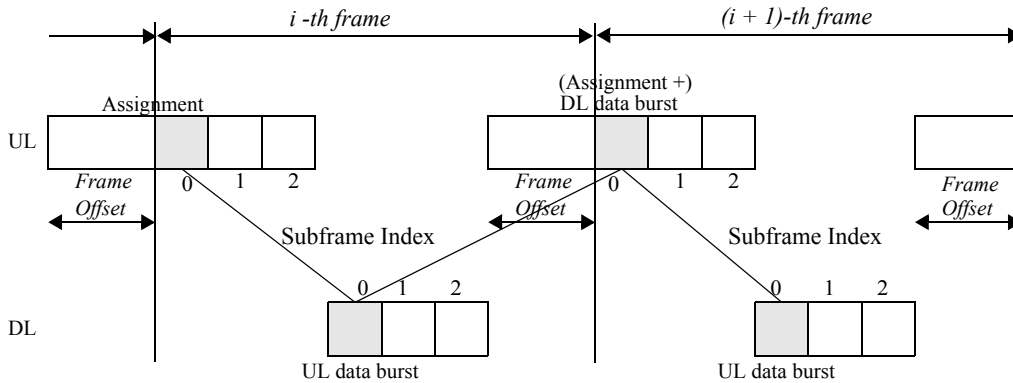


Figure 415—Example of TDD UL HARQ timing in frame structure supporting the Wireless-MAN-OFDMA frame

Figure 414— and Figure 415—show examples of the DL and UL timing relationships between a Assignment A-MAP IE with $N_{A-MAP} = 1$, 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 subframes to whole UL subframes, $D':U'$ is 5:3. In this example, $FRAME_OFFSET$ is 2, UL subframes of the Wireless-

MAN-OFDMA and the Advanced Air Interface are frequency-division multiplexed, the ratio of DL to UL subframes for the Advanced Air Interface, $D:U$ is 3:3, and T_{proc} is 3.

15.2.14.3 Group Resource Allocation HARQ signaling and timing

15.2.14.3.1 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 15.2.14.2.1.1. 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.

15.2.14.3.2 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 15.2.14.2.1.2. 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.

15.2.14.4 Persistent Allocation HARQ signaling and timing

15.2.14.4.1 Downlink

Upon receiving a DL persistent A-MAP IE, AMS attempts to decode the data burst at every periodic subframe specified in the DL persistent 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 15.2.14.2.1.1.

15.2.14.4.2 Uplink

Upon receiving a UL persistent A-MAP IE, AMS shall transmit the subpacket of HARQ data burst through the assigned resource at every periodic subframe specified in the UL persistent 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 15.2.14.2.1.2.

15.2.14.5 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.

1 If the HARQ entity in the transmitter determines that the HARQ process was terminated with an
2 unsuccessful outcome, the HARQ entity in the transmitter informs the ARQ entity in the transmitter about
3 the failure of the HARQ data burst. The ARQ entity in the transmitter can then initiate retransmission and
4 re-segmentation of the ARQ blocks that correlate to the failed HARQ data burst.
5

6 7 **15.2.15 Network Entry and Initialization**

8
9 Systems shall support the applicable procedures for entering and registering a new AMS or a new node to
10 the network. The procedure for initialization of an AMS shall be divided into the following phases:
11

- 12 a) Scan for DL channel and establish synchronization with the ABS
- 13 b) Obtain DL/UL parameters (from SuperFrameHeader)
- 14 c) Perform ranging
- 15 d) Negotiate Pre-authentication capability
- 16 e) Authorize AMS and perform key exchange
- 17 f) Perform Capability exchange and registration, and setup default service flow.

18 During network entry, ABS may allocate an UL bandwidth for transmission or retransmission of MAC
19 messages without a bandwidth request from AMS.
20

21 Each AMS contains the following information when shipped from the manufacturer:
22

- 23 • A 48-bit universal MAC address (per IEEE Std 802-2001) assigned during the manufacturing process.
24 This is used to identify the SS to the various provisioning servers during initialization.
- 25 • Security information as defined in Clause 7 (e.g., X.509 certificate) used to authenticate the AMS to the
26 security server and authenticate the responses from the security and provisioning servers.
27

28 29 **15.2.15.1 AMS synchronization.**

30 On initialization or after signal loss, the AMS shall acquire a A-PREAMBLE according to cell selection
31 rule. Once the PHY has achieved synchronization the MAC shall attempt to acquire the channel control
32 parameters for the DL and then the UL.
33

34 35 **15.2.15.2 AMS obtaining DL/UL parameters**

36 To establish the DL synchronization the AMS shall perform the following operations:
37

- 38 • Scan the air interface and synchronize to the ABS
- 39 • Acquire network parameters and select the network
- 40 • Acquire SFH information

41 On initialization or after signal loss, the AMS shall acquire the DL synchronization. The AMS shall have
42 nonvolatile storage in which the last operational parameters are stored and may first try to reacquire the
43 stored DL channel. If the aforementioned process fails, the AMS shall begin to scan the possible channels of
44 the DL frequency band of operation until it finds a valid DL signal.
45

46 The AMS shall synchronize at PHY level through the A-PREAMBLE. The detailed procedure for PHY
47 synchronization is reported in section 15.3.6.1. Once the AMS has achieved PHY synchronization, the AMS
48 shall attempt to decode P-SFH and the S-SFH to obtain necessary system information for initial network
49 entry. Based on the network information, the AMS shall decide whether to continue the network entry
50 process or to scan for another ABS.
51

52 After these steps the DL synchronization with the ABS is established.
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The procedure to maintain the DL synchronization is TBD.

The AMS shall wait for the remaining S-SFH SPs from the ABS in order to retrieve a set of transmission parameters for a possible UL channel as indicated in Section 15.3.5.1.

15.2.15.3 Initial ranging and automatic adjustments

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 receive frame, and received within the appropriate reception thresholds. The timing delays through the PHY shall be relatively constant. Any variation in the PHY delays shall be accounted for in the guard time of the UL PHY overhead.

15.2.15.3.1 Contention-based initial ranging and automatic adjustments.

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 Slot using the random backoff. The random backoff shall use a binary truncated exponent algorithm. After selecting the Ranging Slot, the AMS shall choose a ranging sequence (from the Initial Ranging domain) using a uniform random process. The selected ranging sequence is sent to the ABS in the selected Ranging Slot.
- The ABS should respond with an indication message including a Decoding Status Bitmap in a pre-defined, subsequent DL subframe. Each bit of Decoding Status Bitmap field corresponds to one initial ranging slot in a previous UL subframe. If the AMS finds in the status indication message that no initial ranging sequence has been successfully decoded in the ranging slot selected by the AMS, the AMS considers its ranging request is failed and restarts the initial ranging procedure.
- Upon successfully receiving a CDMA ranging sequence, the ABS broadcasts a AAI_RNG-RSP message. AAI_RNG-RSP message can be linked to the corresponding bit of the decoding status bitmap. The AAI_RNG-RSP message contains all the needed adjustment (e.g., time, power, and possibly frequency corrections) and a status notification.
- Upon receiving a AAI_RNG-RSP message with Continue status, the AMS shall continue the ranging process as done on the first entry (using random selection rather than random backoff) with ranging sequences randomly chosen from the initial ranging domain sent on the periodic ranging region.
- When the ABS receives an initial-ranging CDMA code that requires no corrections, the ABS shall provide BW allocation for the AMS to send the AAI_RNG-REQ message. Sending the AAI_RNG-RSP message with status "Success" is optional.
- Initial ranging process is over after receiving AAI_RNG-RSP message, which includes a TSTID (temporary station ID) to be used until STID is received at successful registration.(following a AAI_RNG-REQ transmission).
- The timeout required for AMS to wait for AAI_RNG-RSP, following or not following CDMA Allocation A-MAP IE, is defined by T3 (TBD).

15.2.15.4 Negotiate Pre-authentication capability.

Immediately after completion of ranging, the AMS informs the ABS of its pre-authentication capabilities by transmitting an AAI-SBC-REQ message with its capabilities set to "on". The ABS responds with an AAI-SBC-RSP message with the intersection of the AMS's and the ABS's pre-authentication capabilities set to "on". Among the parameters for pre-authentication capability from AMS, if AMS follows default value, the AMS may omit those parameters from AAI-SBC-REQ. If AMS omits some parameters, the ABS consider AMS follows the default value for those parameters and ABS may omits those parameters applying default value in its AAI-SBC-RSP.

15.2.15.5 AMS authorization and key exchange.

If PKM is enabled in pre-authentication capability negotiation, the ABS and AMS shall perform authorization and key exchange as described in 15.2.3. If this procedure completes successfully, all parameters for TEK generation are shared, and TEKs are derived at each side of AMS and ABS.

15.2.15.6 Capability exchange and registration.

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 capabilities except pre-authentication capabilities with its capabilities set to "on". In AAI-REG-RSP, the ABS responds with the intersection of the AMS's and the ABS's capabilities set to "on". Among the parameters for capability from AMS, if AMS follows default value, the AMS may omit those parameters from AAI-REG-REQ. If AMS omits some parameters, the ABS consider AMS follows the default value for those parameters and ABS may omits those parameters applying default value in its AAI-REG-RSP.

ABS shall allocate and transfer a STID to the AMS through AAI-REG-RSP message in secure manner and the temporary STID, which is allocated during initial ranging procedure, is discarded.

If the registration is successful, a flow ID for default service flow is assigned to MS.

15.2.16 Sleep Mode

Sleep Mode is a state in which an AMS conducts pre-negotiated periods of absence from the serving ABS air interface. Sleep Mode may be activated when an AMS is in the connected state. When Sleep Mode is active, 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 autonomously transmit 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 System Configuration Description Change Count are as expected. If the AMS detects a loss of connectivity with the serving ABS, then it shall exit Sleep mode and perform recovery procedures for loss of connectivity. 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. AMS may send and receive data and MAC control signaling without deactivating the Sleep Mode.

For each involved AMS, the ABS shall keep context known as Sleep Cycle setting which keeps track of all the parameters related to the AMS' current Sleep Cycle. 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).

15.2.16.1 Sleep Mode initiation

Sleep Mode activation/entry may be initiated either by an AMS or an ABS. When AMS is in active mode, parameters of the Sleep Cycle are negotiated between the AMS and 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 management messages AAI_SLP-REQ and AAI_SLP-RSP or Service Flow management messages. Sleep Cycle parameters can be included in the Service Flow management 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 AMS shall reply to the ABS with AAI_SLP-ACK message, only if HARQ is not enabled.

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.

15.2.16.2 Sleep Mode operation

15.2.16.2.1 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 does not contain a Listening Window.

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 subframes during each frame in the listening window.

For synchronization purposes, the AMS may receive the preamble symbol in the frame containing listening sub-frames or any other preamble in any of the frames during unavailability period. 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 15.2.x.x.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, the AMS and ABS shall update the length of the Sleep Cycle as follows:

$$\text{Current Sleep Cycle} = \min(2 \times \text{Previous Sleep Cycle}, \text{Final Sleep Cycle}) \dots \dots \dots (x)$$

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 Final Sleep Cycle is equal to or larger than 2 times the Initial Sleep Cycle, the length of Sleep Cycle exponentially enlarges 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 Sleep Cycle shall be reset to Initial Sleep Cycle. The Sleep Cycle could be the different length according to the New Initial Sleep Cycle Flag (NISCF). If the NISCF is set to 0 then the Initial Sleep Cycle is always the same as the first Initial one.

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.

15.2.16.2.2 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. If AMS has data or MAC control signaling to transmit to ABS during the Sleep Window, AMS may interrupt the Sleep Window and request bandwidth for UL transmission with or without deactivating sleep mode based on the sleep cycle setting.

The protocols and procedures relating to interruptions of normal Sleep Cycle operation are provided in sub-clause 15.2.x.x.2.5.

15.2.16.2.3 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. 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 control signal 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 control signal 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.

15.2.16.2.3.1 Traffic Indication

Traffic Indication is sent for one or a group of AMS using the AAI_TRF-IND message. AAI_TRF-IND is transmitted at a pre-determined location, i.e. in the continuous NTRFIND distributed LRUs right following the A-MAP region in the 1st subframe of a frame in the listening window.

AAI_TRF-IND message shall be transmitted at the first frame of Listening Window of each AMS.

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. 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 send a MAC management message (e.g. a signaling header) to ask the ABS what was the traffic indication for the AMS. The ABS shall respond to the AMS by unicasting a MAC management message containing the traffic indication for that AMS.

AAI_TRF-IND is segmented into two parts: AAI_TRF-IND_I and AAI_TRF-IND_II. AAI_TRF-IND_I is transmitted using fixed LRUs. If AAI_TRF-IND_II is transmitted, it follows the AAI_TRF-IND_I and its length will be indicated in AAI_TRF-IND_I.

15.2.16.2.3.2 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

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 the Listening Window has not been explicitly terminated, and if the T_AMS timer has not expired or a T_HARQ_Retx timer has not expired when the length of the Listening Window is already larger than the length of the default listening window.

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 it receives the UL assignment. If the maximum retransmissions of the HARQ burst are exhausted, the AMS can enter the sleep.
- 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 it has not sent explicit signaling to terminate the Listening Window, and if the T_ABS timer has not expired or a T_HARQ_Retx timer has not expired when the length of the Listening Window is already larger than the length of the default listening window.

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 (TBD) including the number of frame for extended listening window to indicate extension of Listening Window during the Listening Window.

The ABS may send an explicit indication (TBD) to terminate the current Listening Window. When an ABS has a last PDU in the DL buffer during the listening window, the ABS may transmit an explicit indication

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).

15.2.16.2.4 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 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 that start frame number the sleep cycle changes to the new sleep cycle settings. Alternatively, the ABS may initiate a Sleep Cycle parameter change by sending an unsolicited AAI_SLP-RSP message to the AMS.

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.

15.2.16.2.5 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.

15.2.16.2.5.1 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 subheader and any MAC management 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 in AAI_SLP_RSP message or sleep control subheader along with Resume Sleep Cycle Indication. A scheduled Sleep Cycle interruption shall be implicitly cancelled by the sending and reception of the expected response at the ABS and AMS, respectively, before the scheduled start time of the interruption is reached. 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.

15.2.16.2.5.2 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.

15.2.16.3 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 deactivate Sleep Mode. Sleep Mode shall be implicitly terminated when an AMS enters idle mode or performs handover 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.

15.2.17 Idle mode

An ABS may be a member of one or more paging groups that may have different cycle and offset. 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 idle mode AMS in the Lzone of a mixed mode ABS decides to move to the Mzone of the ABS, in which case the AMS shall perform location update. When an AMS is paged in the Lzone of a mixed mode ABS, the AMS shall perform the network re-entry in the LZone of the ABS and may switch to the MZone of the ABS.

An AMS may be assigned one or more paging groups. If an AMS has multiple paging groups, it may be assigned multiple paging offsets within a paging cycle. 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 MS's paging groups is called primary paging group and rest of the assigned paging group is called secondary paging group. When an AMS is assigned to one paging group, the paging group is considered as a primary paging group.

When multiple paging offsets are assigned to AMS, those paging offsets shall be associated with either the primary or secondary paging groups. AMS in the primary paging group shall monitor the paging message transmitted at the associated paging offset. If AMS leaves the primary paging group and enters a secondary paging group, AMS shall monitor the paging message at the paging offset associated with the secondary paging group.

15.2.17.1 Idle mode initiation

Idle mode for an AMS can be initiated either by the AMS or by its serving ABS.

15.2.17.1.1 AMS initiated

In case of AMS initiated idle mode entry, during normal operation with its serving ABS, an AMS may signal intent to begin idle mode by sending a 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 MS may request the paging controller to retain specific MS service and operational information for idle mode management purposes through inclusion of the Idle Mode Retain Information element in the DREG-REQ management message. When the ABS decides to reject AMS-initiated idle mode request, the ABS shall send a DREG-CMD with action code 0x06 in response to this DREG-REQ message. ABS may include REQ-Duration TLV in this DREG-CMD message. In this case, the AMS may retransmit the DREG-REQ message after the expiration of REQ_Duration. If the AMS does not receive the DREG-CMD message within T45 timer expiry after it sends the DREG-REQ message to the ABS, the AMS shall retransmit the DREG-REQ message as long as DREG Request Retry Count has not been exhausted. Otherwise, the AMS shall reinitialize MAC. Also, the ABS shall start Management_Resource_Holding_Timer to maintain connection information with the AMS as soon as it sends the DREG-CMD message 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 416— and Figure 417—.

AMS may include its mobility information in the DREG-REQ message.

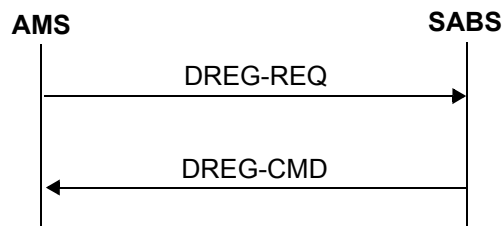
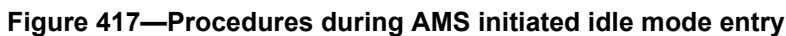


Figure 416—Call flow for AMS initiated idle mode entry



Using ABS initiated idle mode entry, a serving ABS may signal for an AMS to begin idle mode by sending a DREG-CMD message with action code 0x05 in unsolicited manner. This unsolicited DREG-CMD may include REQ-Duration TLV. When an AMS receives an unsolicited DREG-CMD without REQ-Duration TLV, the AMS shall immediately start the idle mode initiation procedures. In this case of ABS-initiated idle mode, 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 DREG-REQ message with the De-registration_Request_Code parameter = 0x02 from the AMS in response to the unsolicited DREG-CMD message with action code 0x05 within T46 timer expiry, the ABS shall retransmit the DREG-CMD message with action code 0x05 in unsolicited manner as long as DREG command retry count has not been exhausted. AMS shall enter idle mode after it sends DREG-REQ message with the De-registration_Request Code parameter = 0x02 in response to the unsolicited DREG-CMD message with action code 0x05. If the AMS has a pending UL data to transmit, it shall send DREG-REQ message with De-registration_Request Code parameter = 0x03 in response to the unsolicited DREG-CMD message with action code 0x05 by the ABS. These procedures are illustrated in Figure 418.

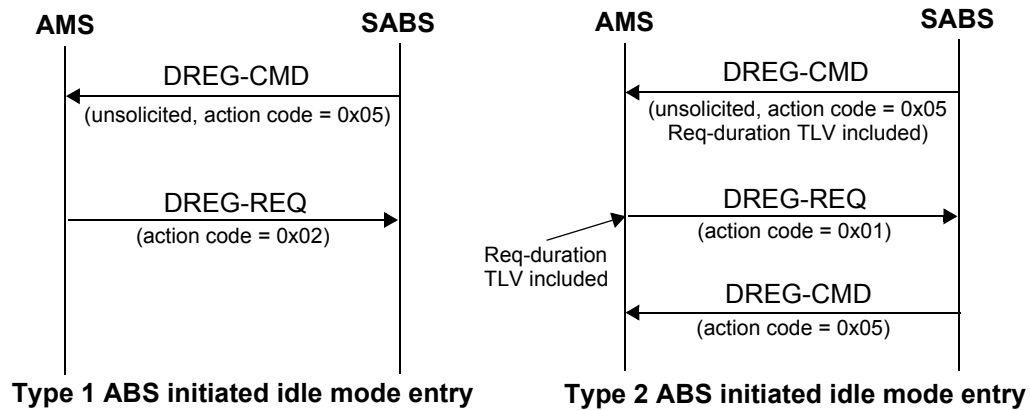


Figure 418—Call flow for ABS initiated idle mode entry

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 DREG-CMD, signaling for an AMS to initiate an Idle Mode request through a 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 DREG-REQ message with De-Registration_Request Code = 0x01 transmitted at the REQ-duration expiration. In this case, ABS shall transmit another DREG-CMD message with Action Code=0x05 including Idle Mode Retain Information TLV. These procedures are illustrated in Figure 419.

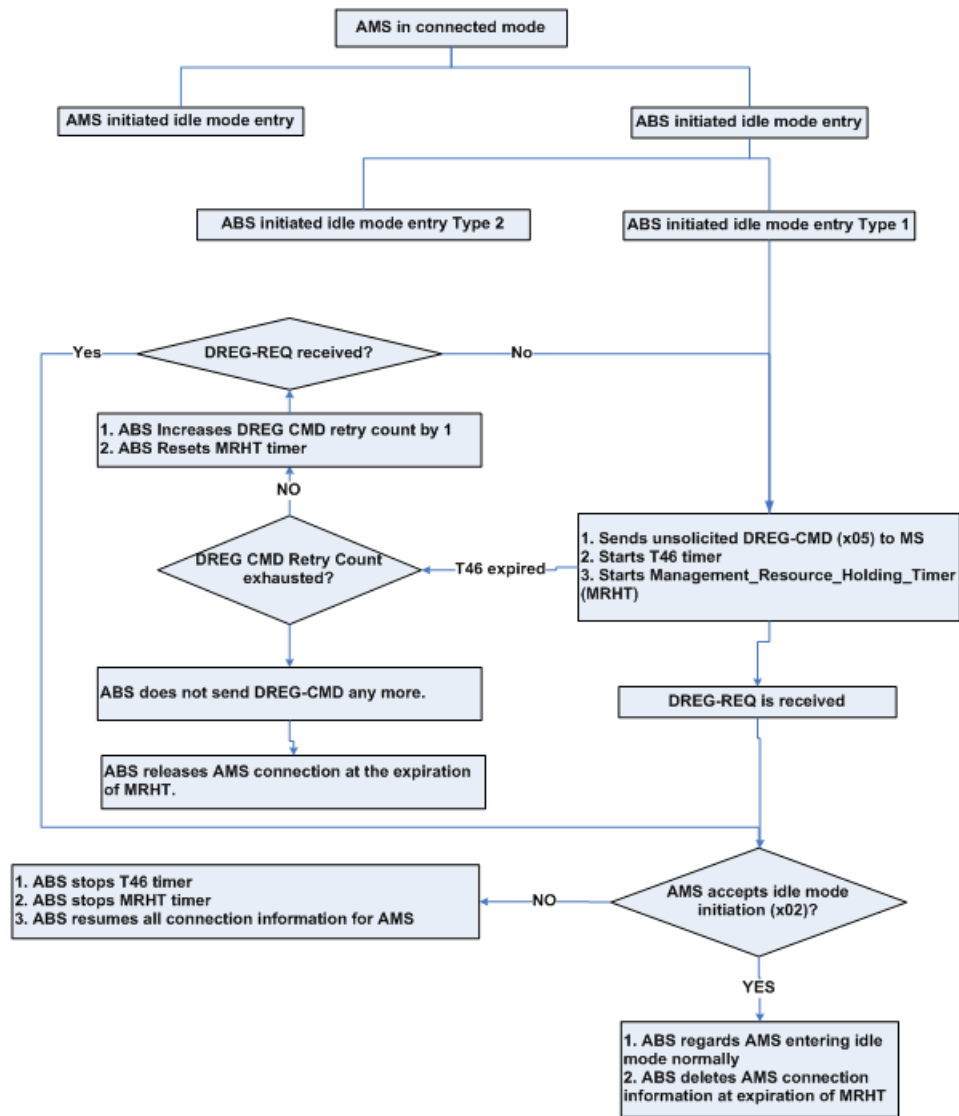


Figure 419—Procedures during Type 1 ABS initiated idle mode entry

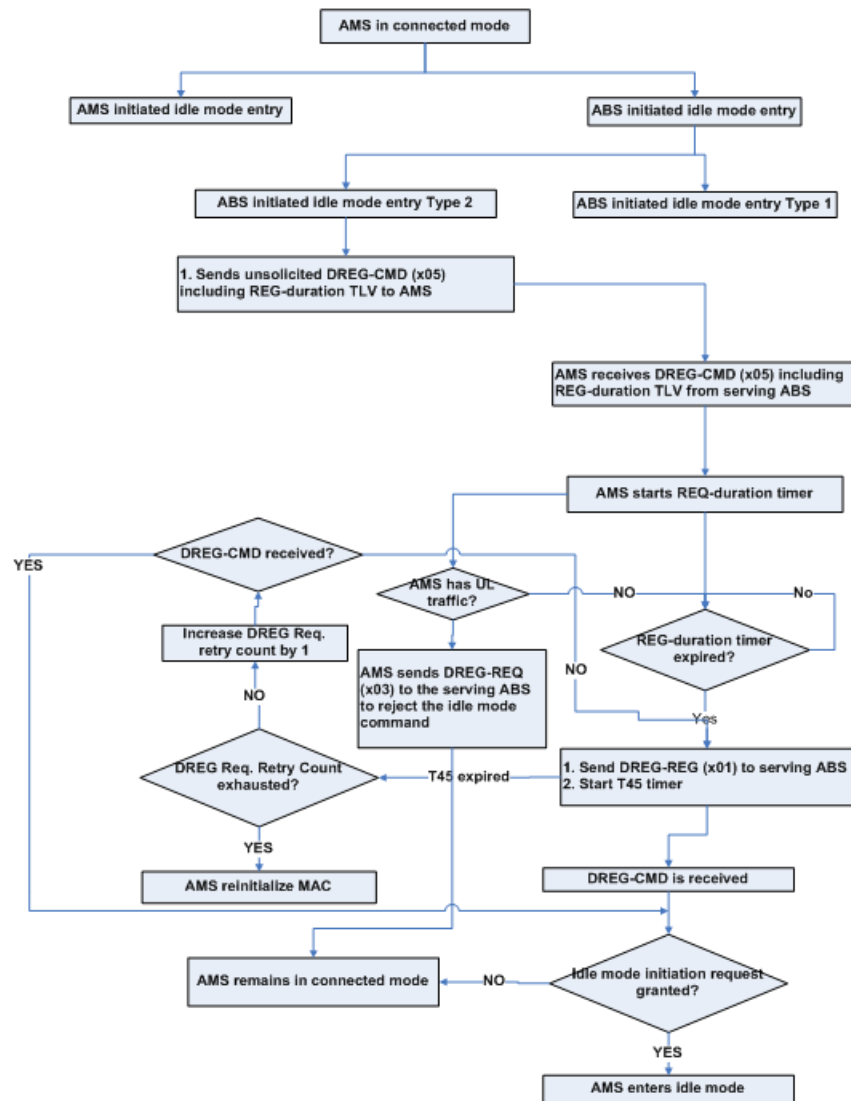


Figure 420—Procedures during Type 2 ABS initiated idle mode entry

15.2.17.2 Operation during Idle mode

15.2.17.2.1 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 or to request an AMS to perform LBS measurement.

A single Paging message may include the information for multiple AMSs.

Paging message includes identification of the AMSs (i.e. temporary identifier) to be notified of DL traffic pending or location update.

The Paging message also includes an action code directing each AMS notified via the inclusion of its identifier as appropriate:

- 0b00: Perform network re-entry
- 0b01: Perform ranging to establish location
- 0b10: Perform LBS measurement

An AMS shall terminate idle mode and reenter the network if it decodes a paging message that contains the AMS's temporary identifier and action code 0b00 (Re-enter Network). In the event that an AMS decodes a paging message that contains the AMS's temporary identifier and action code 0b01, it performs ranging for location update. When the AMS decodes a paging message that does not include its temporary identifier, 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. If the ABS cannot transmit the entire paging message in a predetermined paging transmission frame, the remaining part of the paging message is transmitted in the earliest subsequent 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 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.

15.2.17.2.2 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 (super-frame 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.

15.2.17.2.3 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.

$$N_{superframe} \text{ modulo } \text{PAGING_CYCLE} == \text{PAGING_OFFSET}$$

The length of the paging listening interval is one superframe.

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 PG ID information 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 information shall be transmitted by the ABS regardless of whether or not there any notifications for AMSs. The location of PGID(s) is TBD.

ABS transmits the paging information in the S-SFH SP5 during AMS's paging listening interval as shown in Figure 421—. S-SFH SP5 includes the PGID[s] that ABS belongs to and may also include the whether or

not paging indicator is used using the Paging indicator usage flag. When paging indicator usage flag is set to 1, ABS transmits associated [paging indicator flag] in the S-SFH SP5 indicating the presence of full paging messages for the corresponding PGIDs.

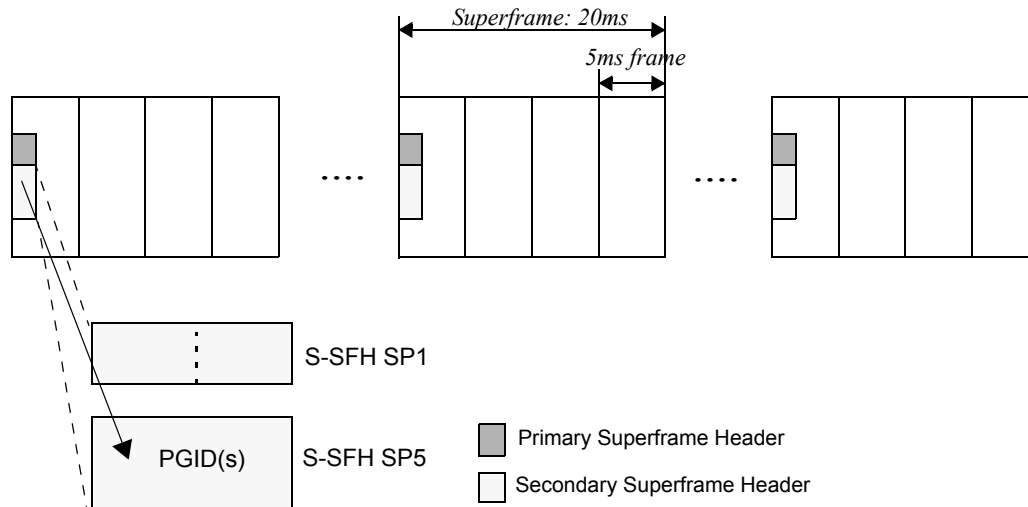


Figure 421—Transmission of PGID information

The AMS shall determine whether it exists in the same paging group at the preferred ABS as it has most recently belonged using PGID(s) information.

If the AMS determine that its paging group has changed, the AMS shall perform idle mode location update as described in section 15.2.x.4.1.1.

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. If AMS's temporary identifier is included in the paging message, the AMS shall perform network re-entry or location update depending on the notification in the paging message. Otherwise, the AMS may return to the paging unavailable interval.

15.2.17.3 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

An AMS may terminate idle mode at any time. For the termination of the idle mode, the AMS performs network re-entry with its preferred ABS as described in section 15.2.x.5.

15.2.17.4 Location update

Location update comprises condition evaluation and update processing.

15.2.17.4.1 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 temporary identifier, paging cycle and paging offset.

15.2.17.4.1.1 Paging group based update

An AMS shall perform Location Update process when an AMS detects a change in the paging groups. 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.

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. An AMS performs the paging group location update after PG_LU_TIMER 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.

15.2.17.4.1.2 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.

15.2.17.4.1.3 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.

15.2.17.4.2 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 RNG-REQ message, then the AMS shall conduct initial ranging with the ABS by sending a RNG-REQ message including Ranging Purpose Indication TLV 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 a RNG-RSP message including the Location Update Response TLV and CMAC Tuple completing the location update process. If paging group has changed, then the ABS shall include Paging Group ID in the 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 Re-Entry procedure from Idle Mode.

15.2.17.5 Network reentry from idle mode

For the network reentry from idle mode, the AMS shall initiate network reentry with the ABS by sending a RNG-REQ message including the Ranging Purpose Indication TLV 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 RNG-REQ message, then the AMS shall conduct initial ranging with the ABS by sending a RNG-REQ message including CMAC Tuple. 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.

15.2.17.6 Idle Mode Support for MBS

15.2.17.6.1 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.

15.2.17.7 Idle Mode Support for Multicarrier

15.2.17.8 Idle Mode Support for SON/Femto

15.2.18 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 45—. Support of all three types of CLC classes is mandatory for ABS, and optional for AMS.

Table 45—mapping from aGPS (without adaptation) to ertPS/rtPS

	CLC active cycle	CLC active interval	CLC start time
Type I	microsecond	subframe	subframe
Type II	frame	subframe	frame
Type III	not applicable	subframe	superframe

AMS shall determine CLC active interval and CLC active cycle based on the activities of its co-located non 802.16 radios. 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 REG-RSP. The higher value of a limit indicates better support for non-802.16m radio activities. The CLC limits, if set, shall be no less than the default values in Table X2. If not specified in REG-RSP, the CLC limits shall assume the values in Table 46—.

Table 46—Default Value of CLC limits

	N_i	R_i	T_i
Type I	1	5%	8 subframes (5ms)
Type II	1	30%	64 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. If the allocation spans over more than one subframe, ABS shall skip the subframe that overlaps with CLC active intervals, and not schedule any resource block in it.

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.

When a CLC active interval overlaps with the allocation of data or HARQ feedback due to synchronous HARQ retransmission and the CLC active interval is equal to or shorter than one frame, then ABS and AMS shall cancel the allocation locally and ABS shall reschedule it after the end of the CLC active interval. The allocation for future retransmission shall be synchronously scheduled according to the rescheduled allocation; if the CLC active interval is longer than one frame, the current allocation shall not be rescheduled.

- Figure 422— explains how it works. The pre-allocated 1st retransmission falls in a CLC active interval, and the serving ABS reschedules it to next available subframe. The static time relevance to the initial transmission is no longer valid, and the serving ABS sends A-MAP to notify AMS where the rescheduled allocation is. Then, the serving ABS synchronously schedules the 2nd retransmission according to the rescheduled 1st retransmission.

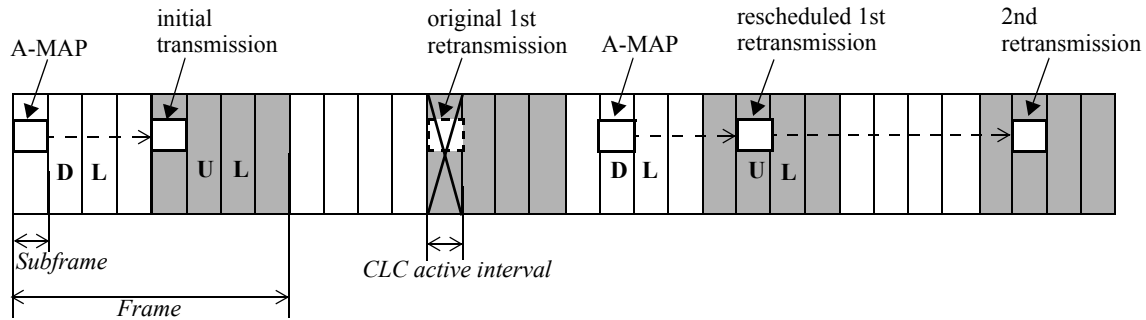


Figure 422—Rescheduling for Synchronous HARQ to Avoid CLC Active Interval

When a CLC active interval overlaps with the allocation of data or HARQ feedback for initial transmission due to group scheduling, and the CLC active interval is equal to or shorter than one frame, ABS shall reschedule it after the end of the CLC active interval. Otherwise, if the CLC active interval is longer than one frame, the current allocation shall not be rescheduled.

In case of persistent scheduling ABS shall not configure persistent allocation which overlaps with CLC active intervals.

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 15.2.x.1, 15.2.x.2, and 15.2.x.3, respectively.

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

X1. 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.

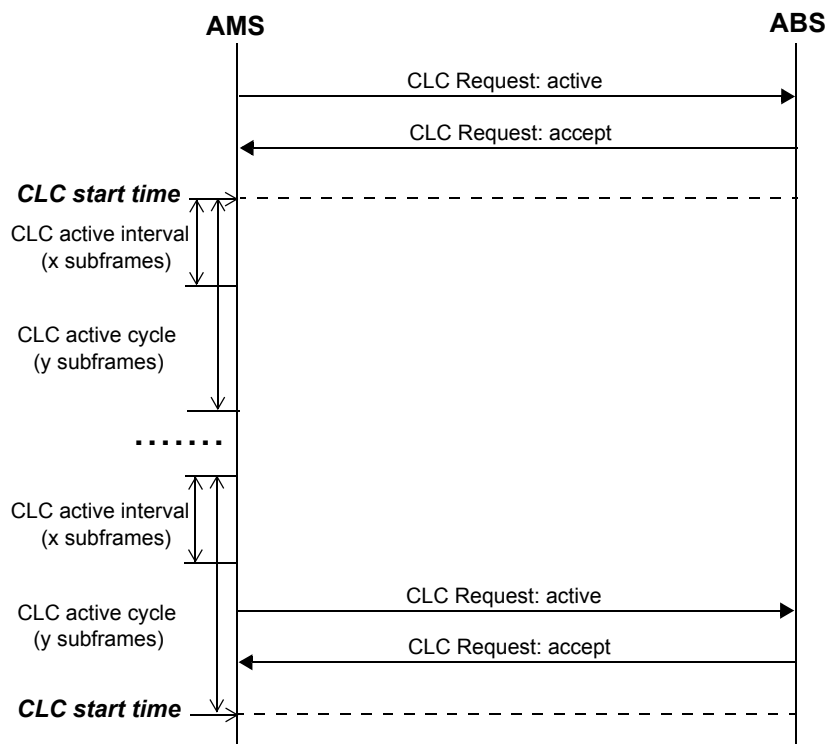


Figure 423—CLC Request / Response Exchange

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 AMS and the AMS shall consider the CLC class starting immediately and ending before 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 suspend all active CLC classes after receiving AAI-HO-CMD or sending AAI-HO-REQ, and reactivate them with the new serving ABS. The CLC active cycle and interval parameters shall remain the same, and the start time shall be set to the beginning of the next CLC cycle for Type I CLC class. For Type II CLC class, the new serving ABS shall set the Super Frame Number of the start time to the suggested value in CLC Request from the AMS, and the new serving ABS may set the Start Frame Index of the start time different from the suggested value in CLC Request from the AMS. The AMS and the serving ABS shall automatically reactivate the suspended CLC classes if the handover is cancelled.

The AMS may provide ABS information about the characteristics of its co-located non-802.16m radio activities.

The AMS shall wait for at least 100ms to send new CLC Request since its last successful transmission of CLC Request.

The AMS shall wait for at least 1 second to send new CLC Request since its last successful reception of CLC Response.

Figure 423— shows an example of CLC Request / Response exchange for activating and deactivating a Type II CLC class.

15.2.18.1 ype 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 subframe index
- a_1 : time duration of CLC active intervals in each cycle (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 subframe index further indicates in which 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 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:

- $a_1 \leq \min(T_1, (s - d)/5 \times m)$
- $n_1 < N_1$
- $a_1 / (m \times \text{floor}(b_1/5000)) \leq R_1$

Figure 424— shows an example of Type I CLC class.

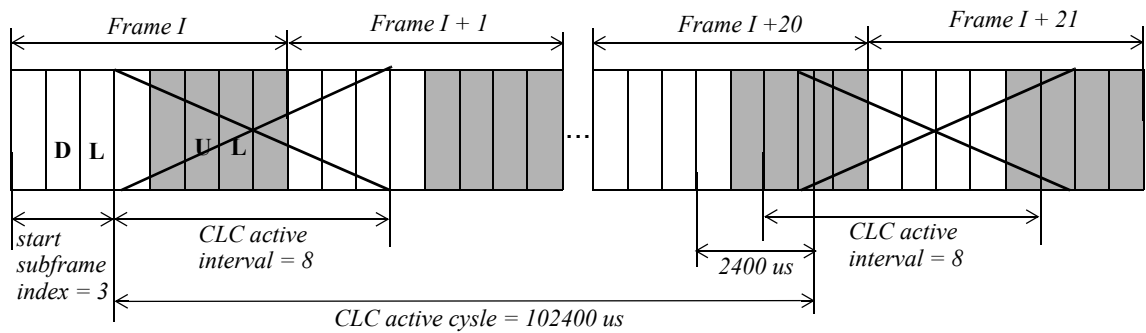


Figure 424—Type I CLC Class Example (a1=8, b1=102400)

15.2.18.2 Type II CLC Class

The parameters for Type I 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 (subframe)
- b_2 b2: 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 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 47—. Support of Extended CLC Active Bitmap is optional for ABS.

Table 47—Type II CLC Class Subtype

Subtype	CLC Active Cycle (frame)	Information Elements
1	1	<ul style="list-style-type: none">• CLC Active bitmap
2	>1	<ul style="list-style-type: none">• CLC Active interval• CLC Active Cycle
3	2, 3, or 4	<ul style="list-style-type: none">• Extended CLC Active bitmap

15.2.18.2.1 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 subframe is CLC active interval. The first LSB of CLC Active Bitmap corresponds to the last subframe of each frame. If a frame consists of m subframes, the AMS and the serving ABS shall consider the first $m-1$ LSBs of the field, and never configure the first 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:

- $n_2 < N_2$
- $a_2/m \leq R_2$

Wherein, a_2 is set to the total number of "1" bits in CLC Active Bitmap.

Figure 425— shows an example of Type II CLC class with Subtype 1.

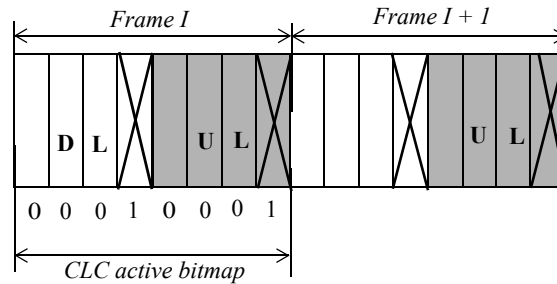


Figure 425—Example of Type II CLC Class Subtype 1 ($a_2=2$)

15.2.18.2.2 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:

- $a_2 \leq \min(T_2, (s-d)/5 \times m)$
- $n_2 < N_2$
- $a_2/(m \times b_2) \leq R_2$

Figure 426— shows an example of Type II CLC class with Subtype 2.

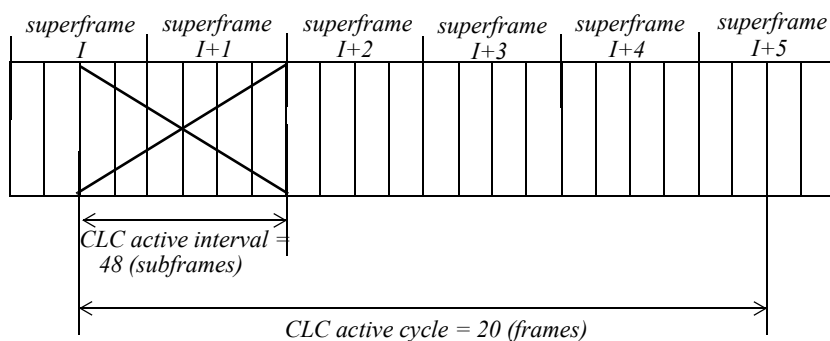


Figure 426—Example of Type II CLC Class Subtype 2 ($a_2=48$, $b_2=20$)

15.2.18.2.3 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 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 bit-map length in bytes.

Figure 427— shows an example of Type II CLC class with subtype 3.

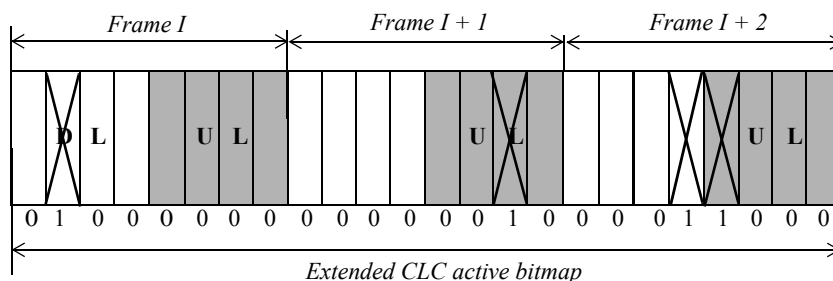


Figure 427—Example of Type II CLC Class Subtype 3 ($a_2=4$, $b_2=3$)

15.2.18.3 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:

- $a_3 \leq T_3$
- The AMS only has Best-Effort service flows activeInterference Mitigation Mechanism

15.2.18.4 DL FFR

15.2.18.5 UL FFR

15.2.18.6 DL Multi-BS MIMO

15.2.18.7 UL Multi-BS MIMO

15.2.18.8 Capability negotiation on interference mitigation

Each sub-section has the following content:

- DL/UL Signaling
 - 1) [PHY layer signaling is to be moved to corresponding chapters; make ref.]
 - 2) [MAC message and TLV is to be moved to 15.2.4.Y and 11.Z respectively]
- Operation procedure
 - 1) [The interact protocol between ABS and AMS]
 - 2) [The interact protocol between ABS and ABS]

15.2.19 MAC Management Reliability

802.16m shall provide fast and reliable delivery for MAC management messages. Large messages can be fragmented for transmission. Retransmission timers may be defined for MAC management messages. The transmitter may retransmit a complete message or a fragment of the message if the retransmission timer expires while waiting for acknowledgement of successful transmission. If HARQ is applied during the transmission of a MAC management message 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 message or the message fragment of the failed HARQ burst.

15.2.20 Power Management for the Connected Mode

Enhanced power savings when an AMS is in connected mode and is actively communicating with an ABS may be supported. In this mode, the ABS may allocate resources and set transmission parameters to optimize energy savings at the AMS.

An AMS may report its battery level when the AMS supports the power management in Connected Mode and its battery level goes below a certain threshold.

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 Connected Mode.

15.3 Physical layer

15.3.1 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 MS 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.

15.3.2 OFDMA symbol description, symbol parameters and transmitted signal

15.3.2.1 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 428 illustrates this structure.

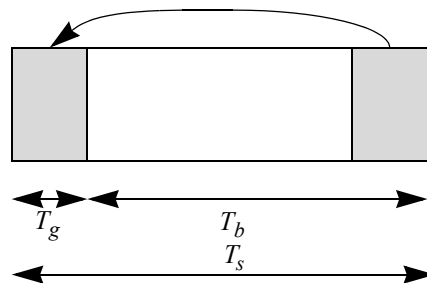


Figure 428—OFDMA symbol time structure

15.3.2.2 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.

15.3.2.3 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 647 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.

15.3.2.4 Derived parameters

The following parameters are defined in terms of the primitive parameters of 15.3.2.3:

- 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 647. Tone dropping based on 10 and 20 MHz systems can be used to support other various bandwidths.

Table 647—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 (μ s)			91.4	128	102.4	91.4	91.4
CP ratio, $G = 1/8$	OFDMA symbol time, T_s (μ s)		102.857	144	115.2	102.857	102.857
	FDD	Number of OFDMA symbols per 5ms frame	48	34	43	48	48
		Idle time (μ s)	62.857	104	46.40	62.857	62.857
	TDD	Number of OFDMA symbols per 5ms frame	47	33	42	47	47
		TTG + RTG (μ s)	165.714	248	161.6	165.714	165.714
CP ratio, $G = 1/16$	OFDMA symbol time, T_s (μ s)		97.143	136	108.8	97.143	97.143
	FDD	Number of OFDMA symbols per 5ms frame	51	36	45	51	51
		Idle time (μ s)	45.71	104	104	45.71	45.71
	TDD	Number of OFDMA symbols per 5ms frame	50	35	44	50	50
		TTG + RTG (μ s)	142.853	240	212.8	142.853	142.853

Table 647—OFDMA parameters

CP ratio, $G = 1/4$	OFDMA symbol time, T_s (μ s)		114.286	160	128	114.286	114.286
	FDD	Number of OFDMA symbols per 5ms frame	43	31	39	43	43
		Idle time (μ s)	85.694	40	8	85.694	85.694
	TDD	Number of OFDMA symbols per 5ms frame	42	30	38	42	42
		TTG + RTG (μ s)	199.98	200	136	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 sub-frame.			24	48	48	48	96

15.3.2.5 Transmitted signal

Equation (173) specifies the transmitted signal voltage to the antenna, as a function of time, during any OFDMA symbol.

$$s(t) = \text{Re} \left\{ e^{j2\pi f_c t} \sum_{\substack{k = -(N_{used}-1)/2 \\ k \neq 0}}^{(N_{used}-1)/2} c_k \cdot e^{j2\pi k \Delta f (t - T_g)} \right\} \quad (173)$$

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.

15.3.2.6 Definition of basic terms on the transmission chain

The basic terms related with the transmission chain are defined as illustrated in Figure 429.

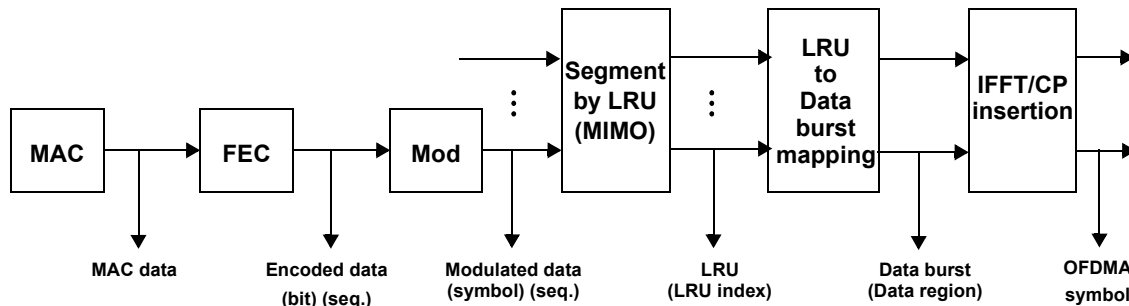


Figure 429—Definition of basic terms on the transmission chain

15.3.3 Frame structure

15.3.3.1 Basic frame structure

The advanced air interface basic frame structure is illustrated in Figure 430. Each 20 ms superframe is divided into four equally-sized 5 ms radio frames. When using the same OFDMA parameters as in Table 647 with the channel bandwidth of 5 MHz, 10 MHz, or 20 MHz, each 5 ms radio frame further consists of eight subframes for $G = 1/8$ and $1/16$. With the channel bandwidth of 8.75 and 7 MHz, each 5 ms radio frame further consists of seven and six subframes, respectively for $G = 1/8$ and $1/16$. In the case of $G = 1/4$, the number of subframes per frame is one less than that of other CP lengths for each bandwidth case. A subframe shall be assigned for either DL or UL transmission. There are four types of subframes:

- 1) the type-1 subframe consists of six OFDMA symbols,
- 2) the type-2 subframe consists of seven OFDMA symbols,
- 3) the type-3 subframe which consists of five OFDMA symbols, and
- 4) the type-4 subframe which consists of nine OFDMA symbols. This type shall be applied only to UL 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 MS 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 MSs are included in an FDD system, the frame structure from the point of view of the H-FDD MS 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 subframe (i.e. the default TTI transmission) or contiguous multiple subframes (i.e. the long TTI transmission). The long TTI in FDD shall be 4 subframes for both DL and UL. The long TTI in TDD shall be the whole DL (UL) subframes for DL (UL) in a frame.

Every superframe shall contain a superframe header (SFH). The SFH shall be located in the first DL subframe of the superframe, and shall include broadcast channels.

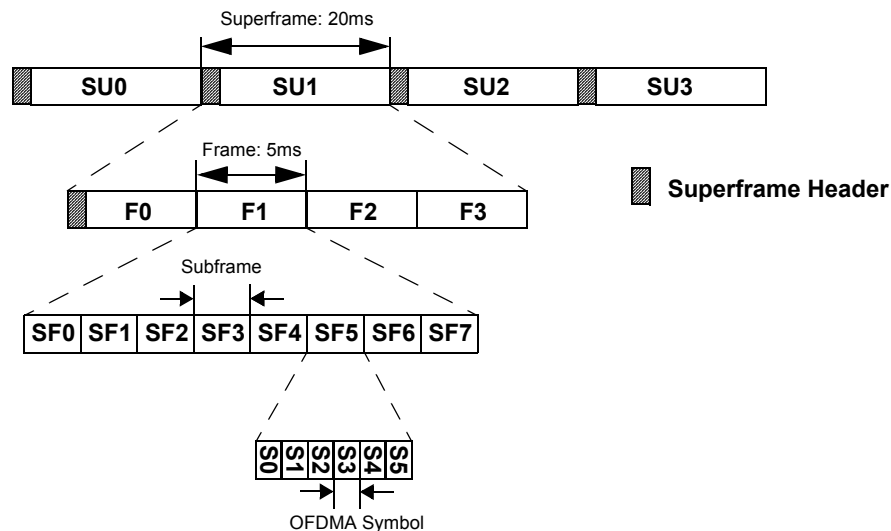


Figure 430—Basic frame structure for 5, 10 and 20 MHz channel bandwidths

15.3.3.2 Frame structure for $CP = 1/8 T_b$

15.3.3.2.1 FDD frame structure

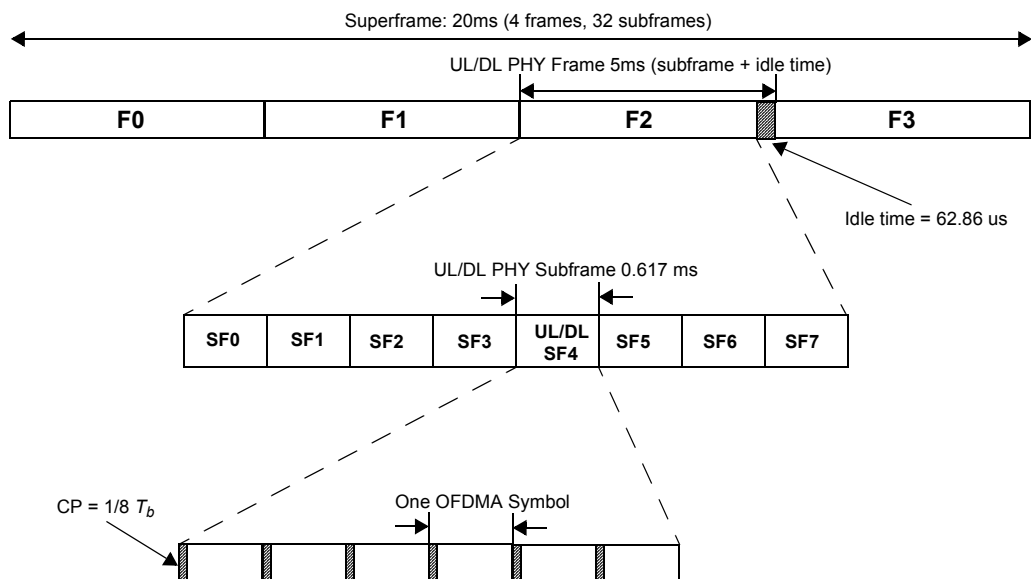
An ABS supporting FDD mode shall be able to simultaneously support half duplex and full duplex AMSs operating on the same RF carrier. The AMS supporting FDD mode shall use either H-FDD or FDD.

The FDD frame shall be constructed on the basis of the basic frame structure defined in 15.3.3.1. In each frame, all subframes are available for both DL and UL transmissions. The DL and UL transmissions are separated in the frequency domain.

FDD MS is able to receive data burst in any DL subframe while accessing UL subframe at the same time. For H-FDD MS, either transmission or reception, but not both, is allowed in each subframe.

The idle time specified in Table 647 shall be placed at the end of each FDD frame as shown in Figure 431.

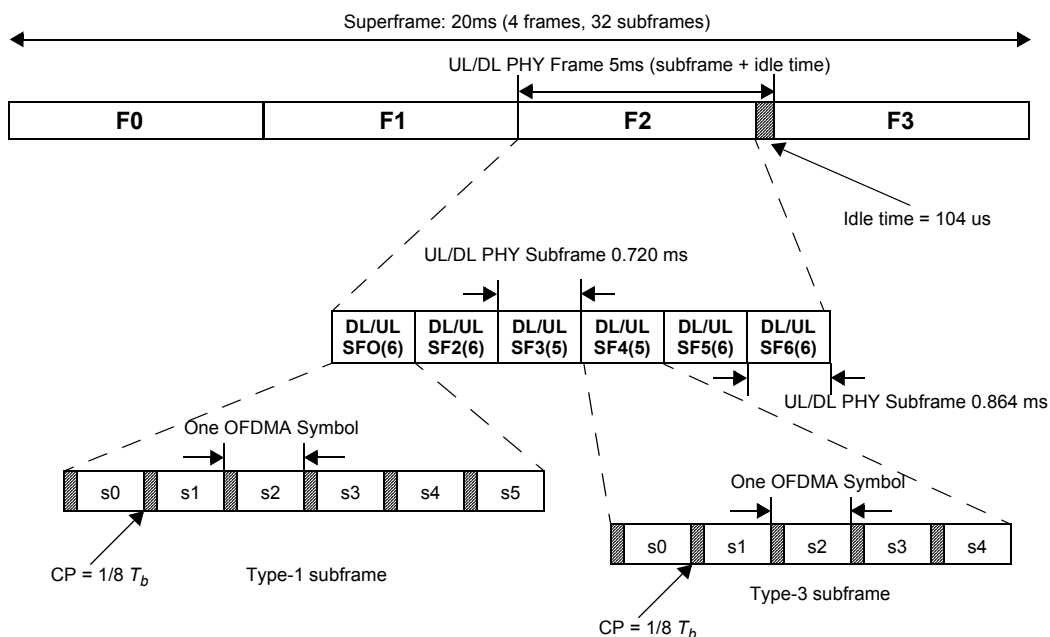
Figure 431 illustrates an example FDD frame structure, which is applicable to the nominal channel bandwidth of 5, 10, and 20 MHz with $G = 1/8$.



Frame structure with Type-1 subframe in FDD for 5, 10, and 20 MHz channel bandwidths (CP= $\frac{1}{8} T_b$)

Figure 431—Frame structure with Type-1 FDD subframe

Figure 432 illustrates an example FDD frame structure, which is applicable to the nominal channel bandwidth of 7 MHz with $G = \frac{1}{8}$. Four subframes among six subframes are the type-1 subframes, and the other two subframes are the type-3 subframe. The third and fourth subframes are the type-3 subframe.



Frame structure with Type-1 and Type-3 subframe in FDD for 5, 10, and 20 MHz channel bandwidths (CP= $\frac{1}{8} T_b$)

Figure 432—Frame structure with Type 1 and Type 3 subframe

Figure 433 illustrates an example FDD frame structure, which is applicable to the nominal channel bandwidth of 8.75 MHz with $G = 1/8$. In Figure 433 the fourth subframe is a type-2 subframe and the other subframes are type-1 subframes.

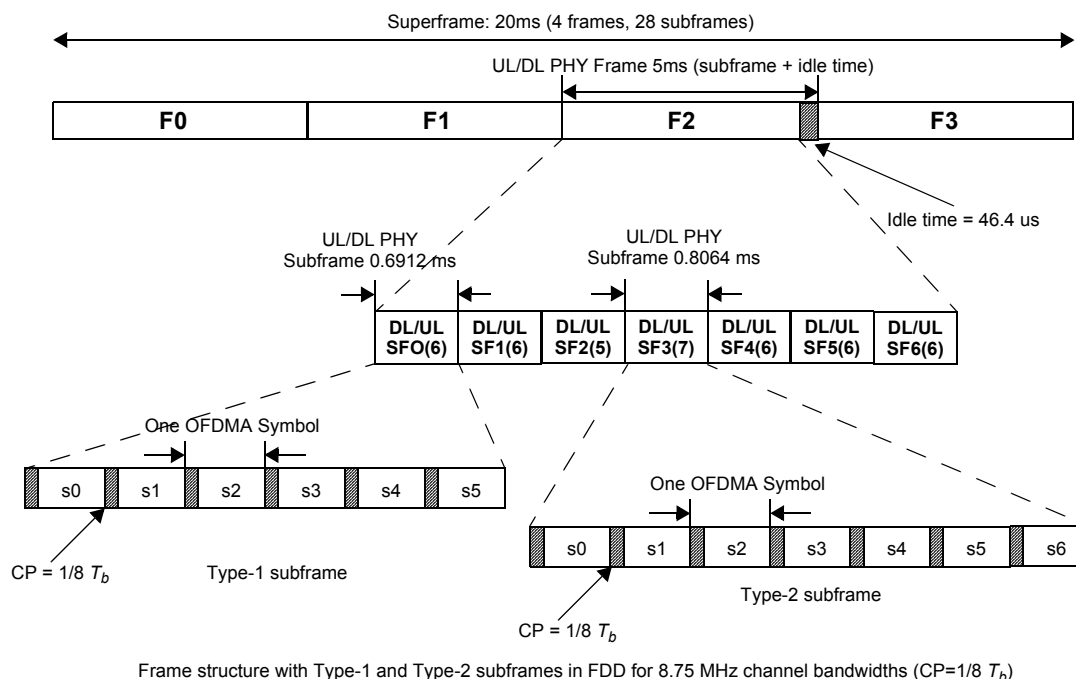


Figure 433—Frame structure for 8.75 MHz FDD

15.3.3.2.1.1 H-FDD frame structure

15.3.3.2.2 TDD frame structure

The TDD frame shall be constructed on the basis of the basic frame structure defined in 15.3.3.1.

In a TDD frame with DL to UL ratio of D:U, the 1st contiguous D subframes and the remaining U 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 $D + U = 6$ 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 [TBD] for 7 and 8.75 MHz channel bandwidths.

In each frame, the TTG and RTG shall be inserted between the DL and UL switching points.

Figure 434 illustrates an example 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 434 the last DL subframe, i.e. DL SF4, is a type-3 subframe and the other subframes are type-1 subframes. TTG and RTG are 105.714 μ s and 60 μ s, respectively.

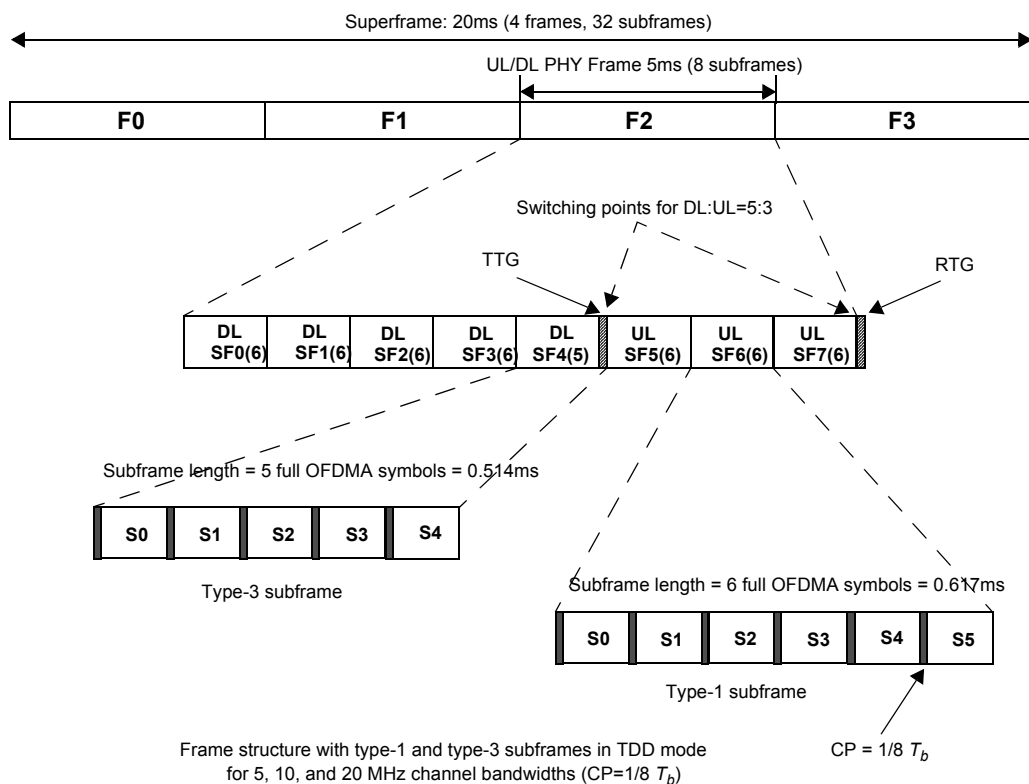


Figure 434—Frame structure with Type-1 TDD subframe

Figure 435 illustrates an example TDD frame structure with D:U = 4:2, which is applicable to the nominal channel bandwidths of 7 MHz with $G = 1/8$. Three subframes among six subframes are the type-1 subframes, and the other three subframes are the type-3. The second, third and fourth DL subframes are the type-3 subframe. TTG and RTG are 188 μ s and 60 μ s, respectively.

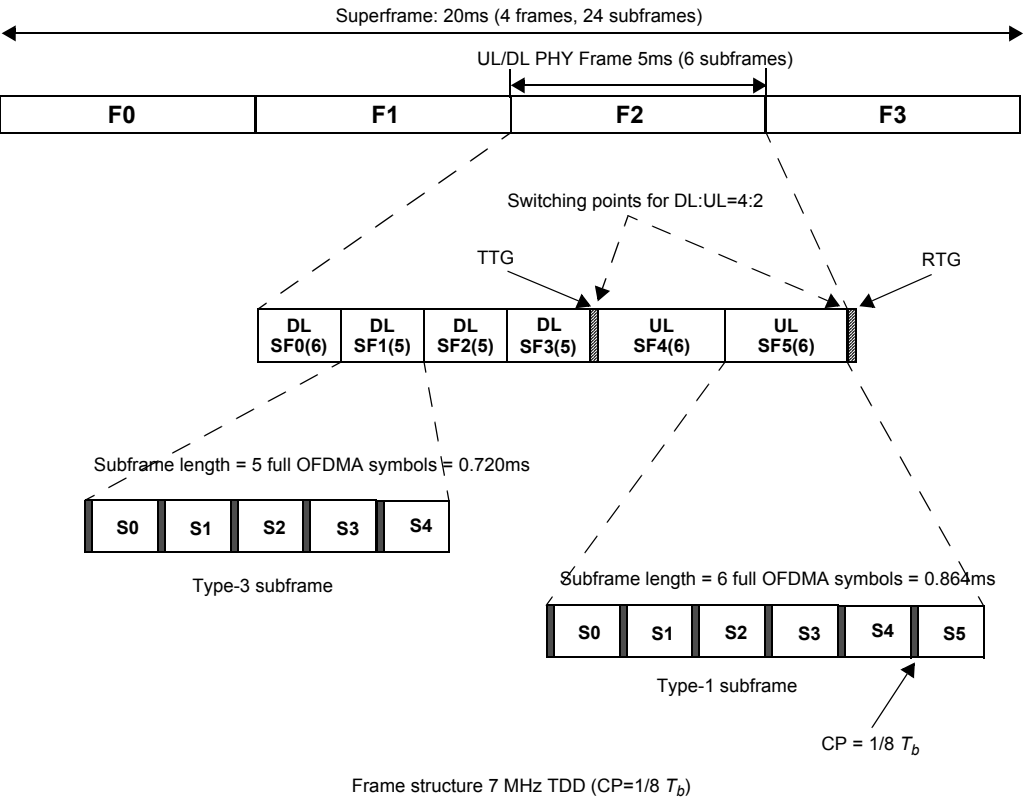


Figure 435—Frame structure for 7MHz TDD mode

Figure 436 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 436 all seven subframes in a frame are type-1 subframes. TTG and RTG are 87.2 μ s and 74.4 μ s, respectively.

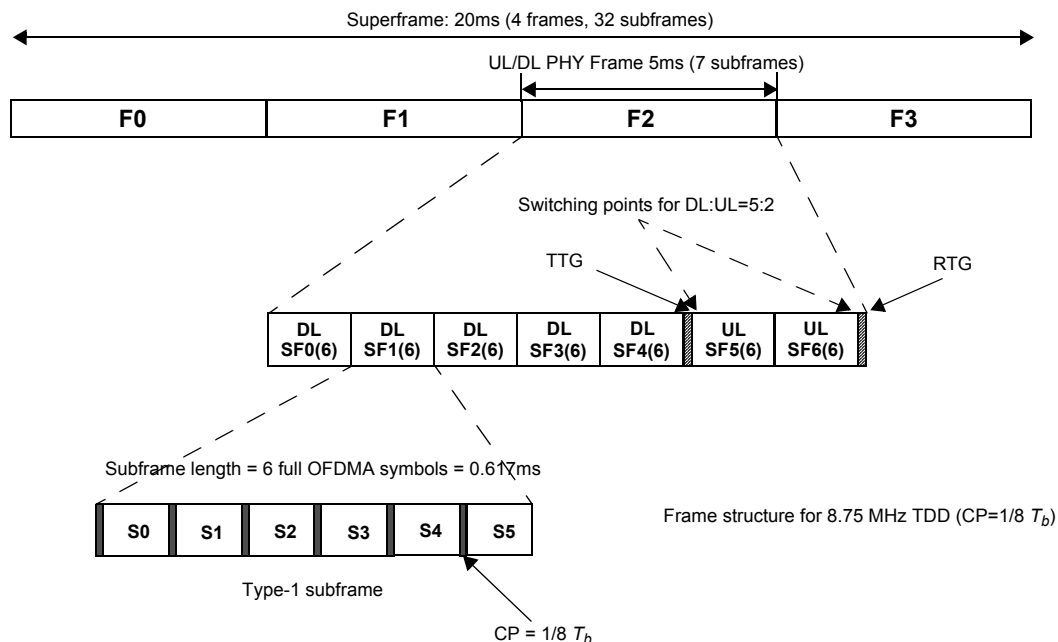


Figure 436—Frame structure for 8.75MHz TDD mode

15.3.3.3 Frame structure for $CP = 1/16 T_b$

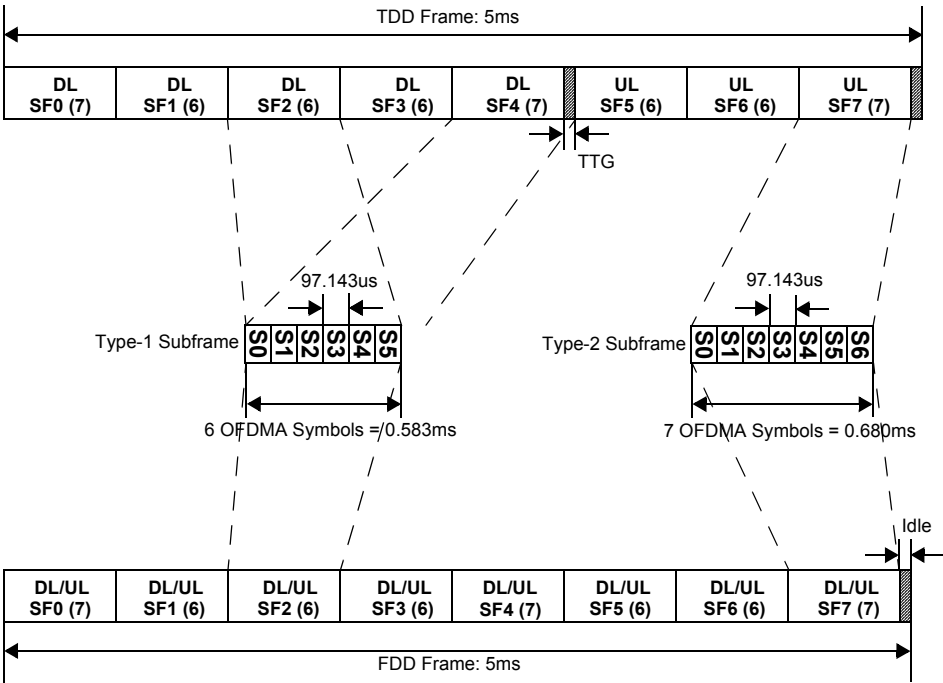
The frame structure for a CP length of $1/16 T_b$ shall consist of type-1 and type-2 subframes.

For channel bandwidths of 5, 10, and 20 MHz, an FDD frame shall have five type-1 subframes and three type-2 subframes, and a TDD frame shall have six type-1 subframes and two type-2 subframes. The subframe preceding a DL to UL switching point shall be a type-1 subframe.

In the TDD frame, the second and last subframes within each frame shall be type-2 subframes.

In the FDD frame, the second, fifth, and last subframes within each frame shall be type-2 subframes.

Figure 437 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 $97.143 \mu s$ and a CP length of $1/16 T_b$, the length of type-1 and type-2 subframes are 0.583 ms and 0.680 ms, respectively. TTG and RTG are $82.853 \mu s$ and $60 \mu s$, respectively.

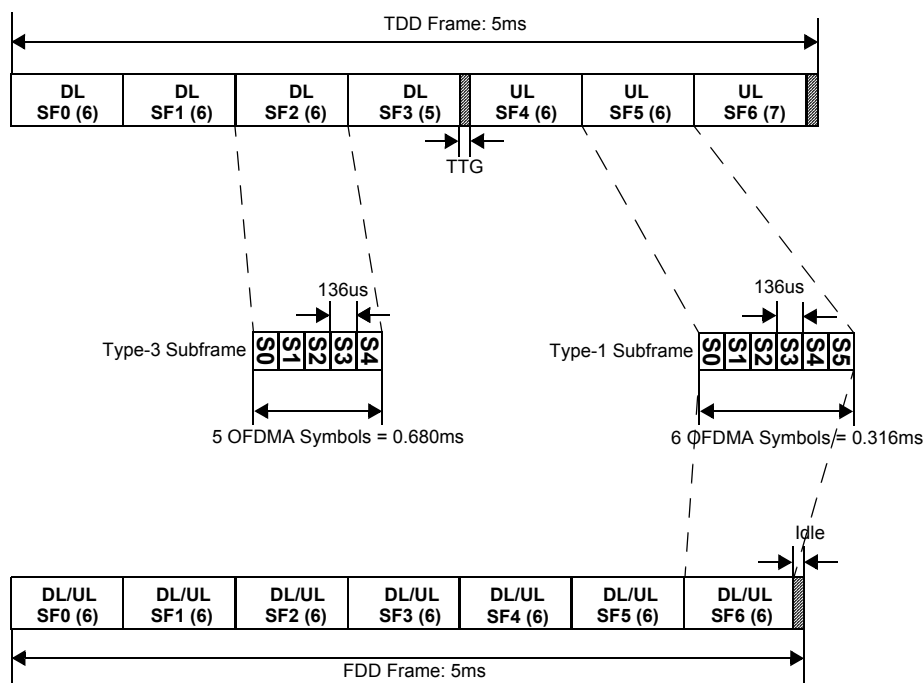


TDD and FDD frame structure with a CP of 1/16 T_b (DL to UL ratio of 5:3).

Figure 437—TDD and FDD frame structure

For a channel bandwidth of 7 MHz, a frame shall have six type-1 subframes for FDD, and five type-1 subframes and one type-3 subframes for TDD. In the TDD frame, the subframe preceding a DL to UL switching point is a type-3 subframe.

Figure 438 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 μ s and a CP length of 1/16 T_b , the length of type-1 and type-3 subframes are 0.816 ms and 0.680 ms, respectively. TTG and RTG are 180 μ s and 60 μ s, respectively.



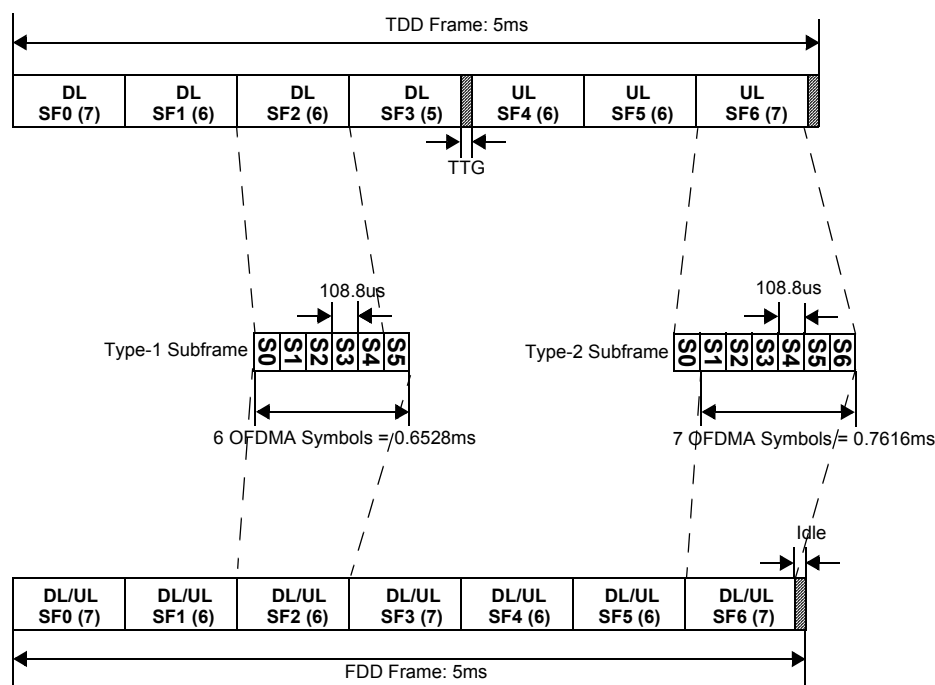
TDD and FDD frame structure for 7MHz channel with a CP of $1/16 T_b$ (DL to UL ratio of 4:3).

Figure 438—7 MHz TDD and FDD frame structure

For a channel bandwidth of 8.75 MHz, a frame shall have four type-1 subframes and three type-2 subframes for FDD, and five type-1 subframes and two type-2 subframes for TDD.

In the TDD frame, the first and last subframes within each frame shall be type-2 subframes. In the FDD frame, the first, forth, and last subframe within each frame shall be type-2 subframes.

Figure 439 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 $108.8 \mu s$ and a CP length of $1/16 T_b$, the length of type-1 and type-2 subframes are 0.6528 ms and 0.7616 ms, respectively. TTG and RTG are $138.4 \mu s$ and $74.4 \mu s$, 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 439—8.75 MHz TDD and FDD frame structure

15.3.3.4 Frame structure supporting the WirelessMAN-OFDMA frames

15.3.3.4.1 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 subframes. For normal channel bandwidth of 5, 10, or 20 MHz, a FDD frame shall have six type-1 subframes and one type-2 subframe. A TDD frame shall have seven type-1 subframes.

Figure 440 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 $114.286 \mu s$ and a CP length of $1/4 T_b$, the length of type-1 and type-2 subframes are 0.6857 ms and 0.80 ms, respectively. TTG and RTG are $139.988 \mu s$ and $60 \mu s$, respectively.

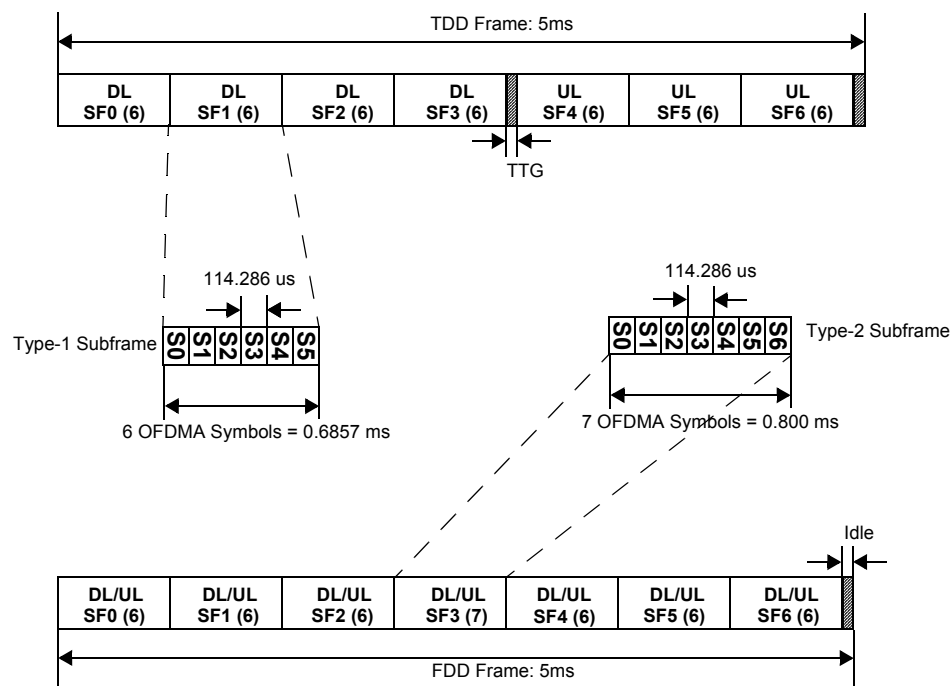


Figure 440—Frame structures for 5, 10, and 20 MHz of TDD and FDD modes (G=1/4)

For the coexistence scenarios with other CP lengths in the 5, 10, or 20 MHz channel bandwidths, another frame structure may be used.

Figure 441 illustrates an example of another TDD and FDD frame structure for the coexistence scenarios with other CP cases in 5, 10 and 20 MHz channel bandwidth. A TDD frame shall have six type-3 subframes and two type-1 subframes, and an FDD subframe shall have five type-3 subframes and three type-1 subframes. In the TDD frame, the first subframe in DL and the first subframe in UL within each frame shall be type-1 subframes. In the FDD frame, the first, fifth, and sixth subframes within each frame shall be type-1 subframes.

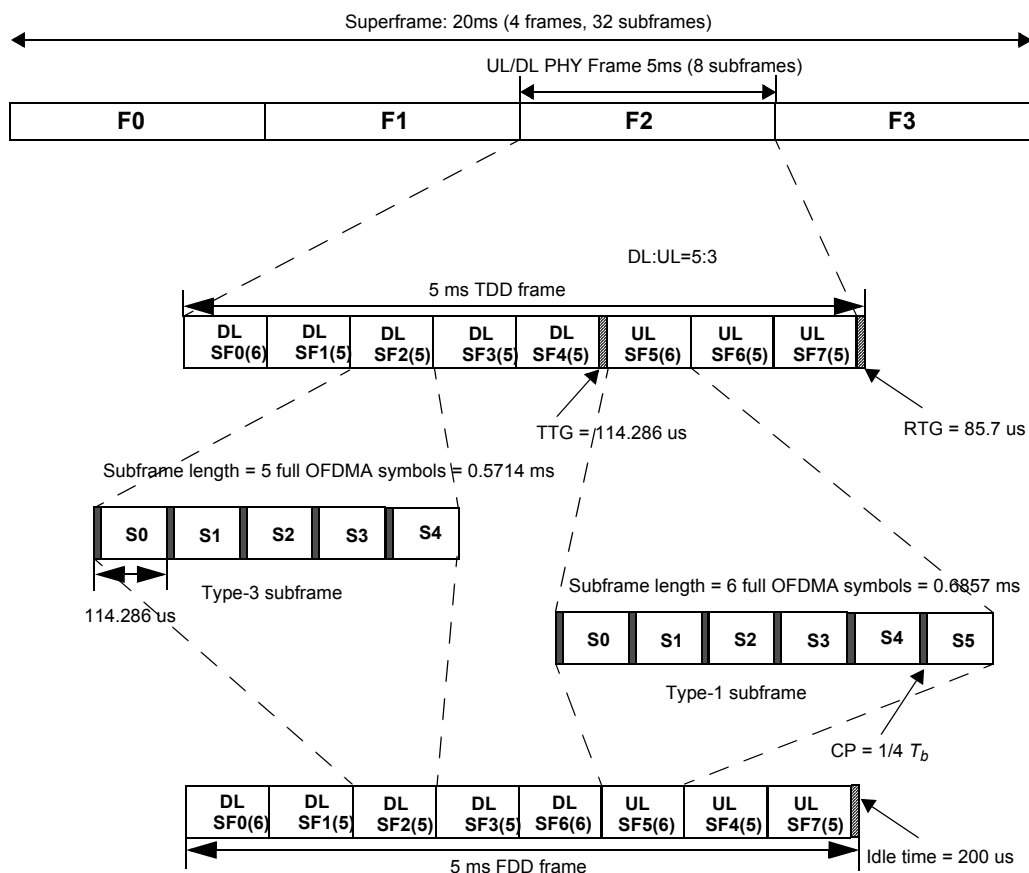


Figure 441—Frame structures for 5, 10, and 20 MHz when coexisting with other CP lengths

For a channel bandwidth of 7MHz, a FDD frame shall have four type-1 subframes and one type-2 subframes. And a TDD frame shall have five type-1 subframes.

Figure 442 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 $160 \mu s$ and a CP length of $1/4 T_b$ the length of type-1 and type-2 subframes are 0.960 ms and 1.120 ms, respectively. TTG and RTG are $140 \mu s$ and $60 \mu s$, respectively.

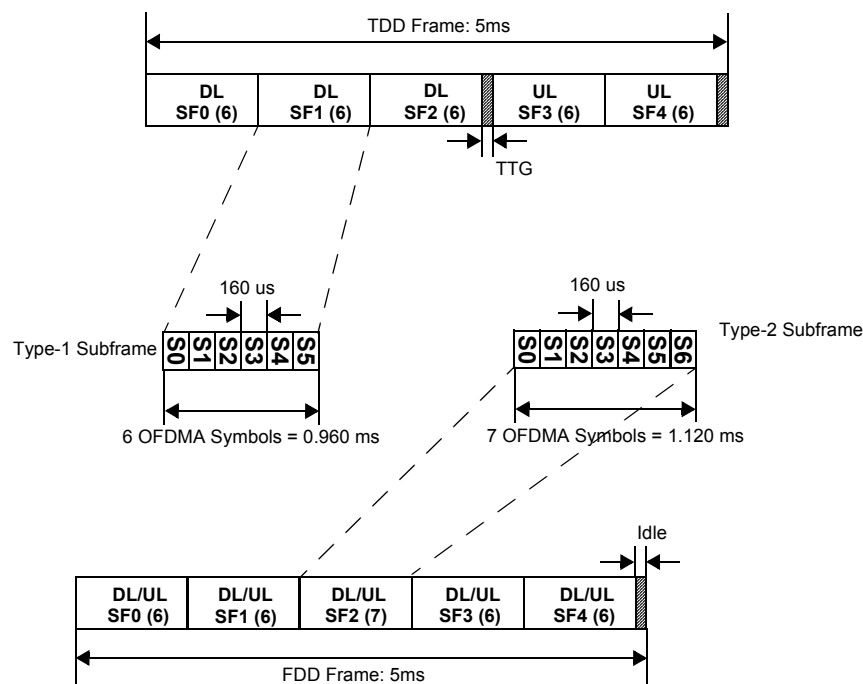


Figure 442—Frame structures for 7 MHz TDD and FDD modes ($G=1/4$)

For a channel bandwidth of 8.75MHz, a FDD frame shall have three type-1 subframes and three type-2 subframes. And a TDD frame shall have four type-1 subframes and two type-2 subframes. In TDD, the subframe preceding a DL to UL switching point shall be type-1 subframes.

Figure 443 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 μ s and a CP length of $1/4 T_b$ the length of type-1 and type-2 subframes are 0.768 ms and 0.896 ms, respectively.

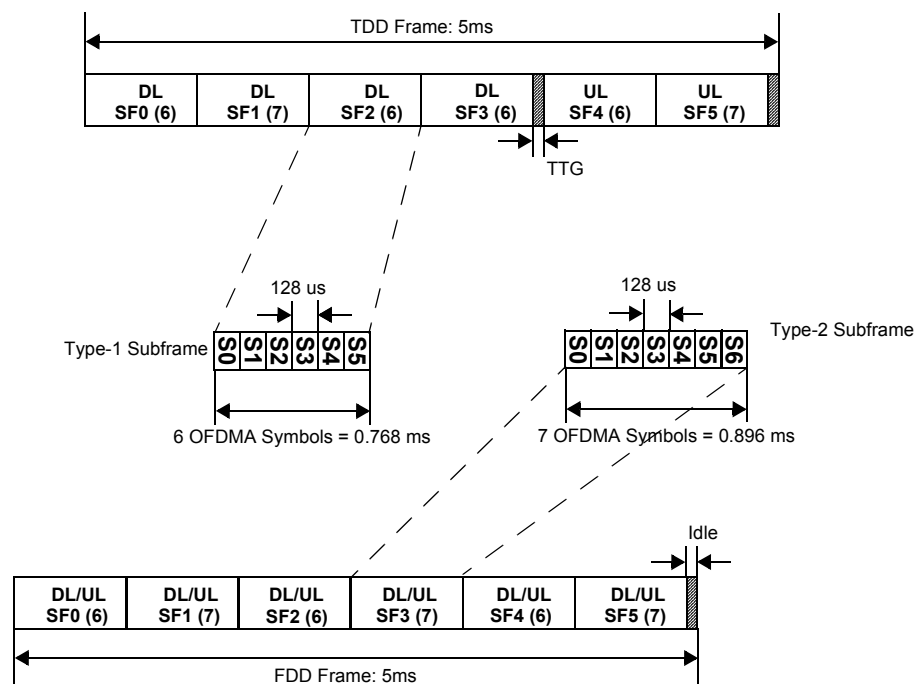


Figure 443—Frame structures for 8.75 MHz TDD and FDD modes (G=1/4)

15.3.3.4.2 TDD frame structure

The WirelessMAN-OFDMA and the Advanced Air Interface frames shall be offset by a fixed number of subframes, $\text{FRAME_OFFSET} = 1, 2, \dots, K$ as shown in Figure 444 and Figure 445. The FRAME_OFFSET of different BSs shall be the same within the same deployment region. When the Advanced Air Interface frames support the WirelessMAN-OFDMA for 5, 10, 20MHz channel bandwidths, all subframes in the Advanced Air Interface DL Zone are type-1 subframes. The number of symbols in the WirelessMAN-OFDMA DL Zone is $5 + 6 \cdot (\text{FRAME_OFFSET} - 1)$. 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 subframes in the Advanced Air Interface DL Zone are type-1 subframe. The number of symbols in the WirelessMAN-OFDMA DL Zone is $3 + 6 \cdot (\text{FRAME_OFFSET} - 1)$. The maximum value of parameter K is equal to the number of DL subframes minus two.

In the DL, a subset of DL subframes is dedicated to the WirelessMAN-OFDMA operation to enable one or more WirelessMAN-OFDMA DL time zones. The subset includes the 1st WirelessMAN-OFDMA DL time zone to support the transmission of the preamble, FCH and MAP, which are defined in 8.4.

Data bursts for the WirelessMAN-OFDMA MSs shall not be transmitted in the DL subframes for operation of the Advanced Air Interface. Those DL subframes shall be indicated as a DL time zone by transmitting an $\text{STC_DL_ZONE_IE}()$ with the Dedicated Pilots field set to 1, as defined in Table 328, in the DL-MAP messages.

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 subframes, are dedicated to the Advanced Air Interface operation. Figure 444 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 subframes are type-1 subframes. In the case of 8.75 MHz with 15 UL OFDM symbols, the [first] UL subframe is type-4 subframe and the [second] UL subframe is type-1 subframe.

Data bursts from the WirelessMAN-OFDMA MSs shall not be transmitted in the UL subchannels group for operation of the Advanced Air Interface. The UL subchannels group for operation of the WirelessMAN-OFDMA shall be indicated by the UL allocated subchannels bitmap TLV or the UL AMC Allocated physical bands bitmap TLV, defined in Table TBD, in the UCD message.

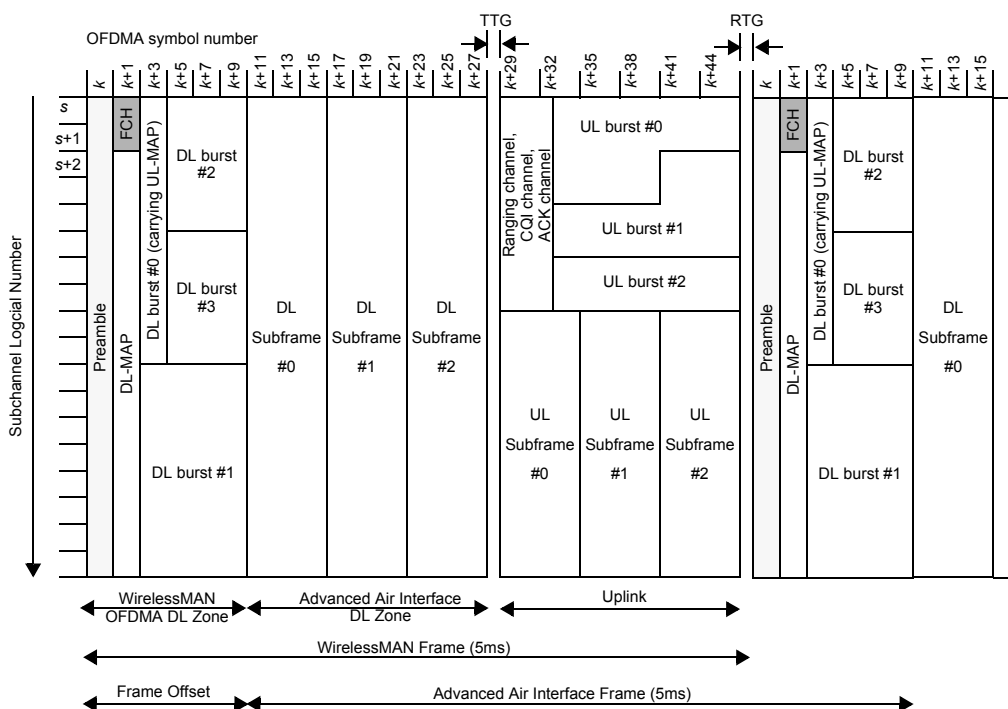


Figure 444—TDD frame configuration for supporting the WirelessMAN-OFDMA operation with UL FDM

- 2) TDM mode: A subset of UL subframes is dedicated to the WirelessMAN-OFDMA operation to enable one or more WirelessMAN-OFDMA UL time zones. The subset includes the 1st WirelessMAN-OFDMA UL time zone to support the transmission of the ranging channel, CQI channel and ACK channel, which are defined in 8.4. Figure 445 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 subframes in the Advanced Air Interface UL Zone are type-1 subframes.

Data bursts from the WirelessMAN-OFDMA MSs shall not be transmitted in the UL subframes for operation of the Advanced Air Interface. Those UL subframes shall be indicated as a UL time zone by transmitting an UL_ZONE_IE(), defined in Table TBD, in the UL-MAP message.

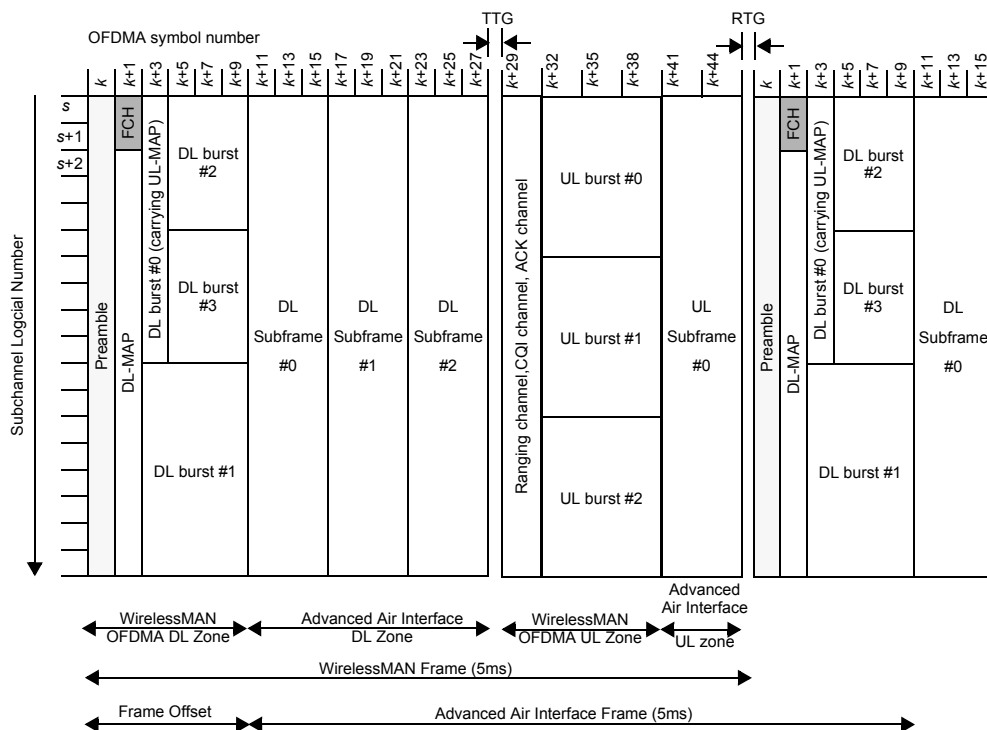


Figure 445—TDD frame configuration for supporting the WirelessMAN-OFDMA operation with UL TDM

15.3.3.4.3 FDD frame structure

15.3.3.5 Frame structure supporting wider bandwidth

The same frame structure (15.3.3.1, 15.3.3.2, 15.3.3.3) is used for each carrier in multi-carrier mode operation. Each carrier shall have its own superframe header. Some carriers may have only part of superframe header. Figure 446 illustrates the example of the frame structure to support multi-carrier operation. For FDD UL, the preamble and superframe headers are replaced with traffic OFDMA symbols.

The multiple carriers involved in multi-carrier 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 MS is controlled through an RF carrier which is the primary carrier. When multi-carrier 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 multi-carrier operation can be found in (ref TBD).

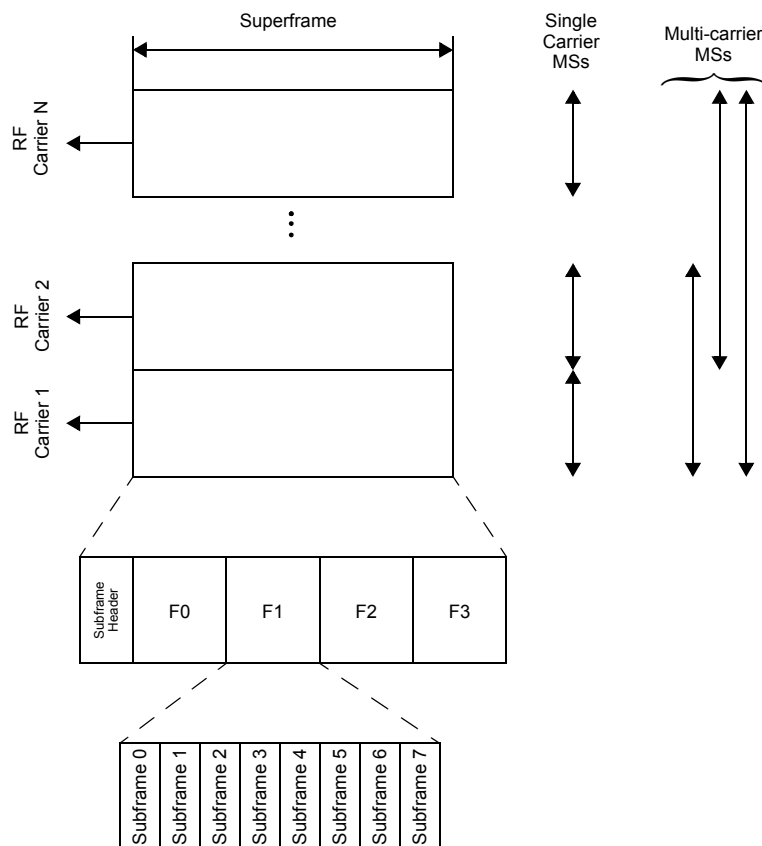


Figure 446—Example of the frame structure to support multi-carrier operation

15.3.3.5.1 Frame structure supporting multi-carrier operation in WirelessMAN-OFDMA support mode

In the multi-carrier mode supporting WirelessMAN-OFDMA, each carrier can have either a basic frame structure (15.3.3.1) or a basic frame structure configured to support the WirelessMAN-OFDMA (15.3.3.3). Figure 447 illustrates an example of the frame structure in the multi-carrier mode supporting WirelessMAN-OFDMA. In the multi-carrier mode, to support WirelessMAN-OFDMA, the uplink can be also configured as TDM as defined 15.3.3.3.

The multi-carrier operation (ref. TBD) is only performed between subframes where the Advanced Air Interface frame is defined. No multi-carrier operation is defined between the Advanced Air Interface frames and WirelessMAN-OFDMA frames.

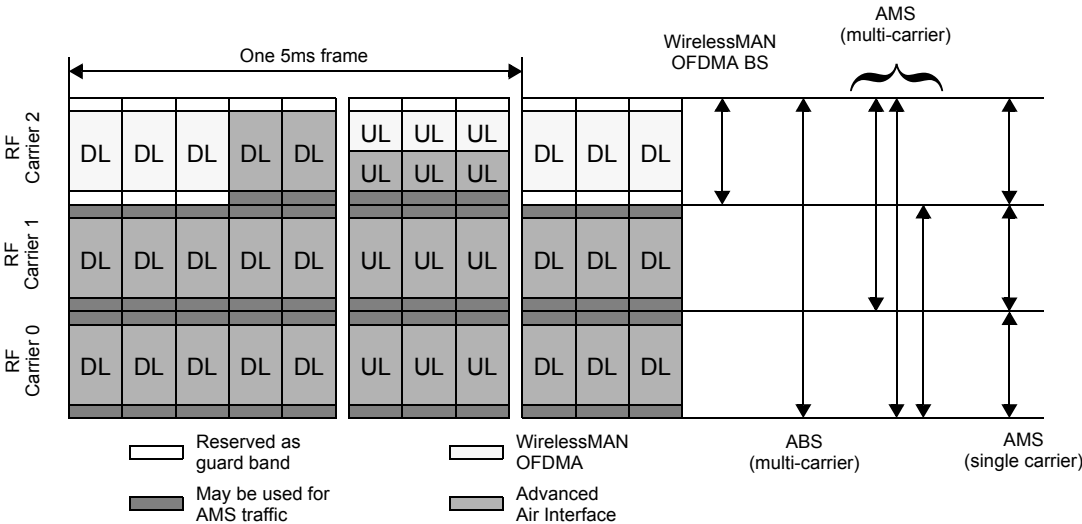


Figure 447—Example of the frame structure to support multi-carrier operation in WirelessMAN-OFDMA support mode

15.3.3.5.2 Subcarrier alignment for multi-carrier operation

When contiguous carriers are involved in multi-carrier operation, the overlapped guard 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 (Δf) will be applied over the original center frequency. The basic principle is shown by the example in Figure 448. The subcarrier alignment shall be achieved without affecting legacy support. In mixed mode operation, the legacy channel raster shall be maintained.

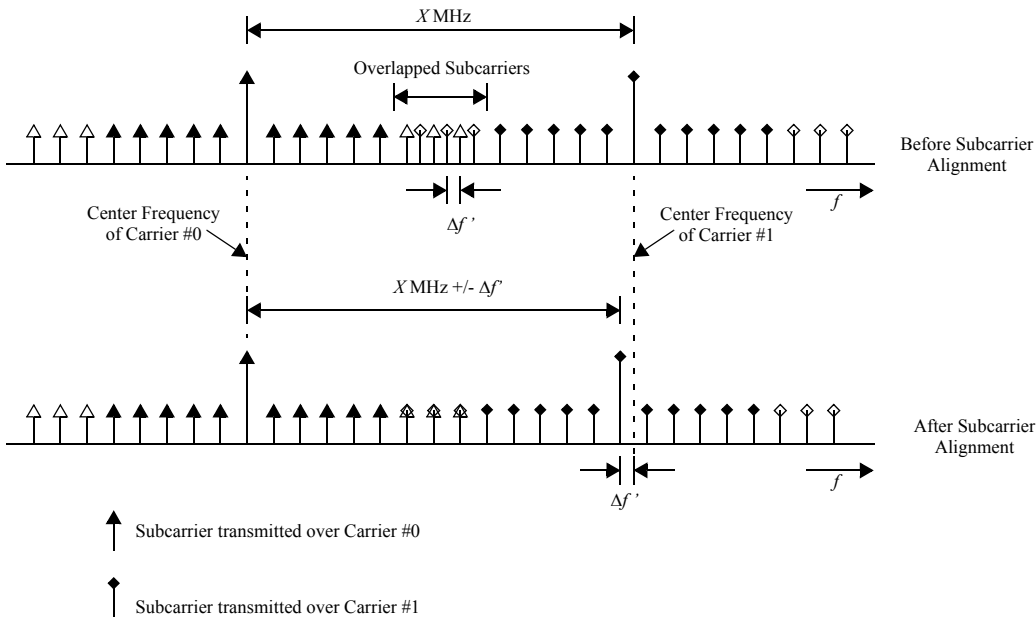


Figure 448—Example of subcarrier alignment of adjacent carriers

During the network entry procedure defined in [TBD], the ABS will notify the AMS of the frequency offset to be applied over each carrier for sub-carrier alignment. According to the multi-carrier configuration index and the reference carrier index broadcasted by ABS, AMS can derive the center frequency of the adjacent carriers and the associated frequency offset $\Delta f'$ using Table 648.

In Table 648, the multi-carrier 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 which carrier within the configuration information is the one where this information sent through.

Based on the center frequency of the carrier that AMS is currently receiving this information 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 $\Delta f'$ to be applied over each carrier based on the multi-carrier configuration index, the reference carrier index and Table 648. So that AMS can obtain the correct center frequency of each carrier including the sub-carrier alignment effect.

Table 648—Center frequency of adjacent carriers with subcarrier alignment

#	Multi-Carrier Configuration (MHz)	Reference Carrier Index	Frequency Offset ?f' (kHz)	Contiguous Channel Bandwidth (MHz)
(TBD)				

15.3.3.5.3 Data Transmission over guard subcarriers in multi-carrier operation

When contiguous carriers are involved in multi-carrier operation, the guard sub-carriers between contiguous frequency channels may be utilized for data transmission. During the network entry procedure defined in [TBD], the ABS will notify the information on available guard sub-carriers eligible for data transmission to the AMS.

15.3.3.6 Relay support in frame structure

15.3.4 Reserved

15.3.5 Downlink physical structure

Each downlink subframe is divided into 4 (TBD) or fewer frequency partitions; each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the 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) or multicast and broadcast services (MBS). Figure 449 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 subcarrier.

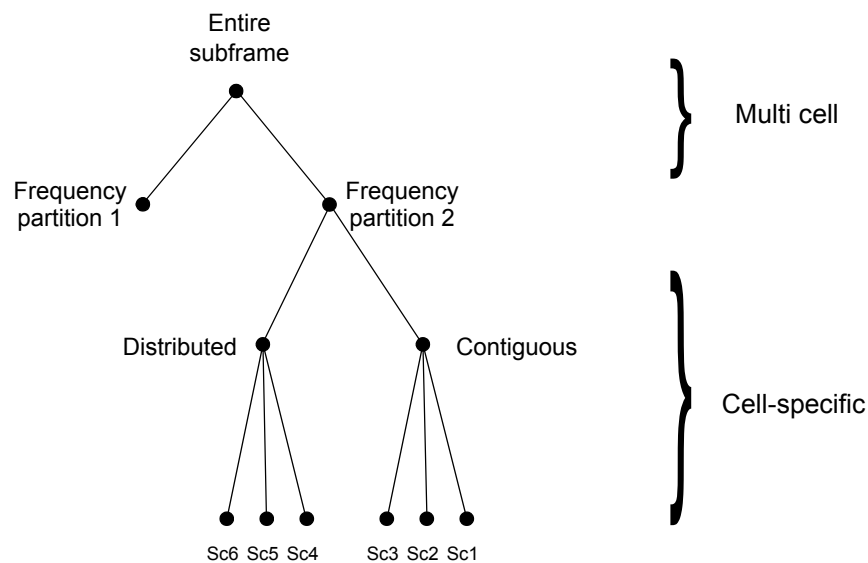


Figure 449—Example of downlink physical structure

15.3.5.1 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 OFDMA symbols for type-1 subframes, N_{sym} is 7 OFDM symbols for type-2 sub frames, and N_{sym} is 5 OFDMA symbols for type-3 subframes. 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 subframes, type-2 subframes, and type-3 subframes. The LRU includes the pilots (ref. TBD) that are used in a PRU. The effective number of subcarriers in an LRU depends on the number of allocated pilots.

15.3.5.1.1 Distributed resource unit

The distributed resource unit (DRU) contains a group of subcarriers which are spread across the distributed resource allocations within a frequency partition. The size of the DRU equals the size of PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The minimum unit for forming the DRU is equal to a pair of subcarriers, called tone-pair, as defined in (ref. TBD).

15.3.5.1.2 Contiguous resource unit

The localized resource unit, also known as contiguous resource unit (CRU) contains a group of subcarriers which are contiguous across the localized resource allocations. The size of the CRU equals the size of the PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols.

15.3.5.2 Multi-cell resource mapping

15.3.5.2.1 Subband partitioning

The PRUs are first subdivided into subbands and minibands where a subband comprises N_1 adjacent PRUs and a miniband comprises 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 maximum number of subbands that can be formed is denoted as N_{sub} where $N_{sub} = N_{PRU}/N_1$.

The number of subbands is denoted by K_{SB} . The number of PRUs allocated to subbands is denoted by L_{SB} , where $L_{SB} = N_1 \cdot K_{SB}$, depending on system bandwidth. A 5, 4 or 3-bit field called Downlink Subband Allocation Count (DSAC) field determines the value of K_{SB} depending on system bandwidth. The SAC is transmitted in the SFH. The remainder of the 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 $N_{PRU} = L_{SB} + L_{MB}$.

Table 649 and Table 650 show the mapping between SAC and K_{SB} for the 10 and 20MHz bands and the 5MHz band, respectively.

Table 649—Mapping between SAC and K_{SB} for 10MHz or 20MHz

SAC	# of subbands allocated (K_{SB})	SAC	# of subbands allocated (K_{SB})
0	0	8	10
1	1	9	12
2	2	10	14
3	3	11	16
4	4	12	18
5	5	13	20
6	6	14	22
7	8	15	24

Table 650—Mapping between SAC and K_{SB} for 5MHz

SAC	# of subbands allocated (K_{SB})	SAC	# of subbands allocated (K_{SB})
0	0	4	4
1	1	5	5
2	2	6	6
3	3	7	N.A

PRUs are partitioned and reordered into two groups subband PRUs and miniband PRUs, denoted 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 (174) defines the mapping of PRUs to PRU_{SB} s. Equation (176) defines the mapping of PRUs to PRU_{MB} s. Figure 450 illustrates the PRU to PRU_{SB} and PRU_{MB} mapping for a 5 MHz bandwidth with K_{SB} equal to 3.

$$PRU_{SB}[j] = PRU[i]; j = 0, 1, \dots, L_{SB} - 1 \quad (174)$$

where:

$$i = N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{j}{N_1} \right\rfloor + \left\lfloor \frac{j}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\} \bmod \{N_{sub}\} + \{j\} \cdot \bmod \{N_1\} \quad (175)$$

where $\{x\} \bmod \{y\}$ is modulus when dividing x by y , and $GCD(x,y)$ is the greatest common divisor of x and y .

$$PRU_{MB}[k] = PRU[i]; k = 0, 1, \dots, L_{MB} - 1 \quad (176)$$

where:

$$i = \begin{cases} N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{k+L_{SB}}{N_1} \right\rfloor + \left\lfloor \frac{k+L_{SB}}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\} \bmod \{N_{sub}\} + \{k+L_{SB}\} \cdot \bmod \{N_1\} & K_{SB} > 0 \\ k & K_{SB} = 0 \end{cases} \quad (177)$$

where $GCD(x,y)$ is the greatest common divisor of x and y .

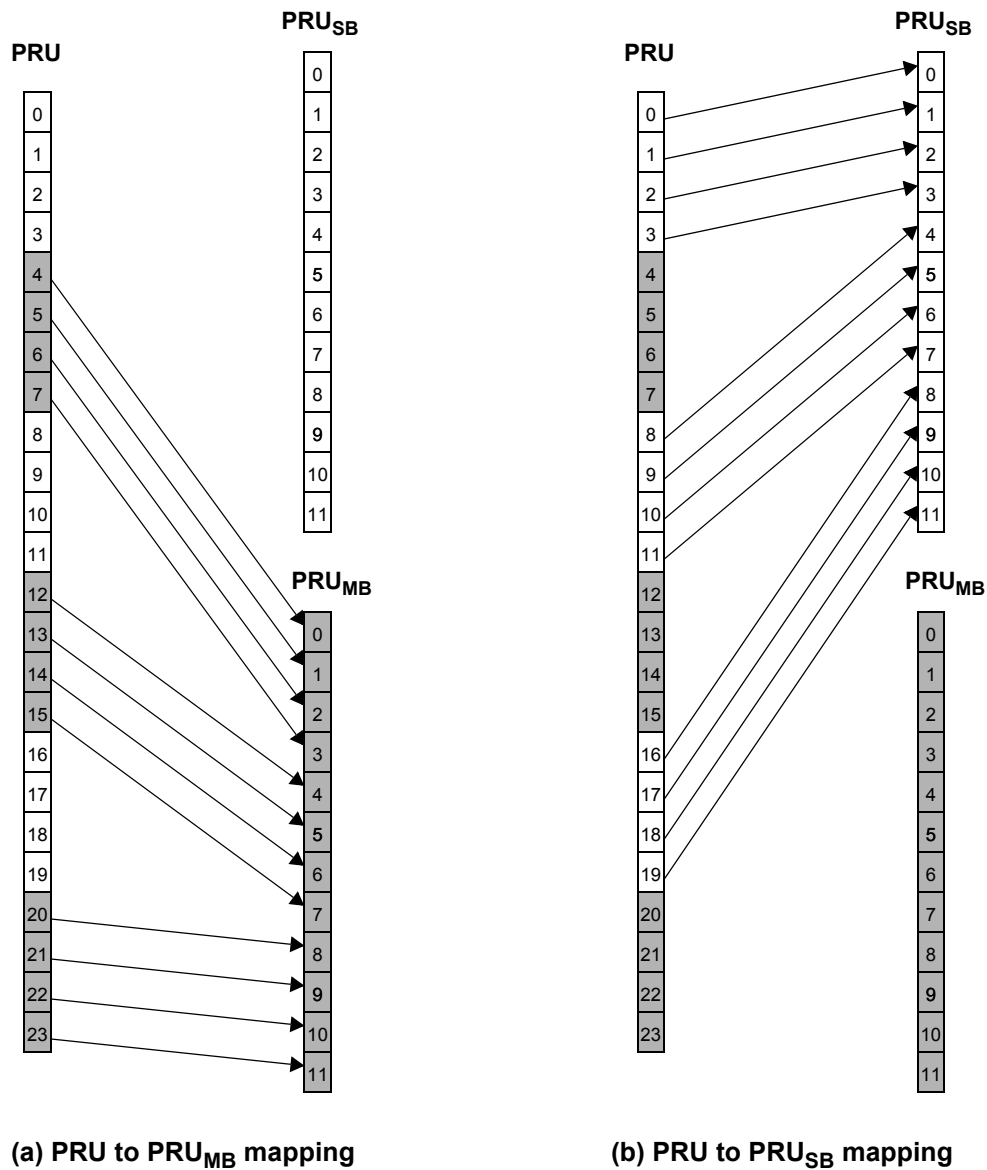


Figure 450—PRU to PRU_{SB} and PRU_{MB} mapping for BW=5 MHz, K_{SB}=3

15.3.5.2.2 Miniband permutation

The miniband permutation maps the PRU_{MB}s to Permuted PRU_{MB}s (PPRU_{MB}s) to insure frequency diverse PRUs are allocated to each frequency partition. Equation (178) provides a mapping from PRU_{MB} to PPRU_{MB}s:

$$PPRU_{MB}[j] = PRU_{MB}[i]; j = 0, 1, \dots, L_{MB} - 1 \quad (178)$$

where:

$$i = (q(j) \bmod(D)) \cdot P + \left\lfloor \frac{q(j)}{D} \right\rfloor \quad (179)$$

$$P = \min(K_{MB}, N_1 / N_2) \quad (180)$$

$$r(j) = \max(j - (K_{MB} \bmod(P) \cdot D), 0) \quad (181)$$

$$q(j) = j + \left\lfloor \frac{r(j)}{D-1} \right\rfloor, D = \left\lfloor \frac{K_{MB}}{P} + 1 \right\rfloor \quad (182)$$

Figure 451 depicts the mapping from PRUs to PRU_{SB} and PPRU_{MB}.

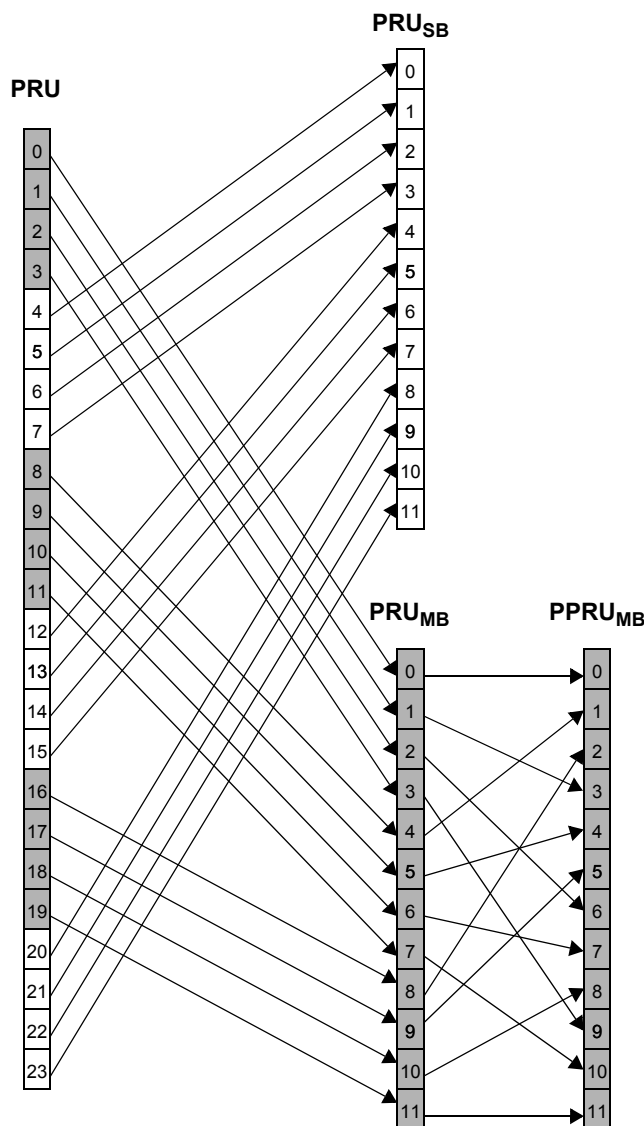


Figure 451—Mapping from PRUs to PRU_{SB} and PPRU_{MB} for BW=5 MHz, K_{SB}=3

15.3.5.2.3 Frequency partitioning

The PRU_{SB} and PPRU_{MB} 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 called the Downlink Frequency Partition Configuration (DFPC) depending on system bandwidth. Frequency Partition Count (FPCT) defines the number of frequency partitions. Frequency Partition Size (FPS_{*i*}) defines the number of PRUs allocated to FP_{*i*}. FPCT and FPS_{*i*} are determined from FPC as shown in Table 651 and Table 652. A 3, 2, or 1-bit called the Downlink Frequency Partition Subband Count (DFPSC) defines the number of subbands allocated to FP_{*i*}, *i*>0.

Table 651—Mapping between DFPC and frequency partitioning for 10MHz or 20MHz

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} * 1/3
2	1 : 1 : 1 : 1	4	N _{PRU} * 1/4	N _{PRU} * 1/4
3	3 : 1 : 1 : 1	4	N _{PRU} * 1/2	N _{PRU} * 1/6
4	5 : 1 : 1 : 1	4	N _{PRU} * 5/8	N _{PRU} * 1/8
5	9 : 1 : 1 : 1	4	N _{PRU} * 9/12	N _{PRU} * 1/12
6	9 : 5 : 5 : 5	4	N _{PRU} * 3/8	N _{PRU} * 5/12
7-15	<i>Reserved</i>			

Table 652—Mapping between DFPC and frequency partitioning for 5Mhz

FPC	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} * 1/3
2	1 : 1 : 1 : 1	4	N _{PRU} * 1/4	N _{PRU} * 1/4
3	3 : 1 : 1 : 1	4	N _{PRU} * 1/2	N _{PRU} * 1/6
4-7	<i>Reserved</i>			

The number of subbands in i^{th} frequency partition is denoted by K_{SB,FP_i} . The number of minibands is denoted by K_{MB,FP_i} , which is determined by FPS and FPSC fields. The number of subband PRUs in each frequency partition is denoted by L_{SB,FP_i} , which is given by $L_{SB,FP_i} = N_1 \cdot K_{SB,FP_i}$. The number of miniband PRUs in each frequency partition is denoted by L_{MB,FP_i} , which is given by $L_{MB,FP_i} = N_2 \cdot K_{MB,FP_i}$.

$$K_{SB,FP_i} = \begin{cases} K_{SB} - (FPCT - 1) \cdot FPSC & i = 0 \\ FPSC & i > 0 \end{cases} \quad (183)$$

$$K_{MB,FP_i} = (FPS_i - K_{SB,FP_i} \cdot N_1) / N_2 \quad 0 \leq i < FPCT \quad (184)$$

The mapping of subband PRUs and miniband PRUs to the frequency partition is given by Equation (185):

$$PRU_{FP_i}(j) = \begin{cases} PRU_{SB}(k_1) & \text{for } 0 \leq j < L_{SB,FP_i} \\ PPRU_{MB}(k_2) & \text{for } L_{SB,FP_i} \leq j < (L_{SB,FP_i} + L_{MB,FP_i}) \end{cases} \quad (185)$$

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 452 depicts the frequency partitioning BW=5 MHz, $K_{SB}=3$, FPCT=2, FPS=12, and FPSC=1.

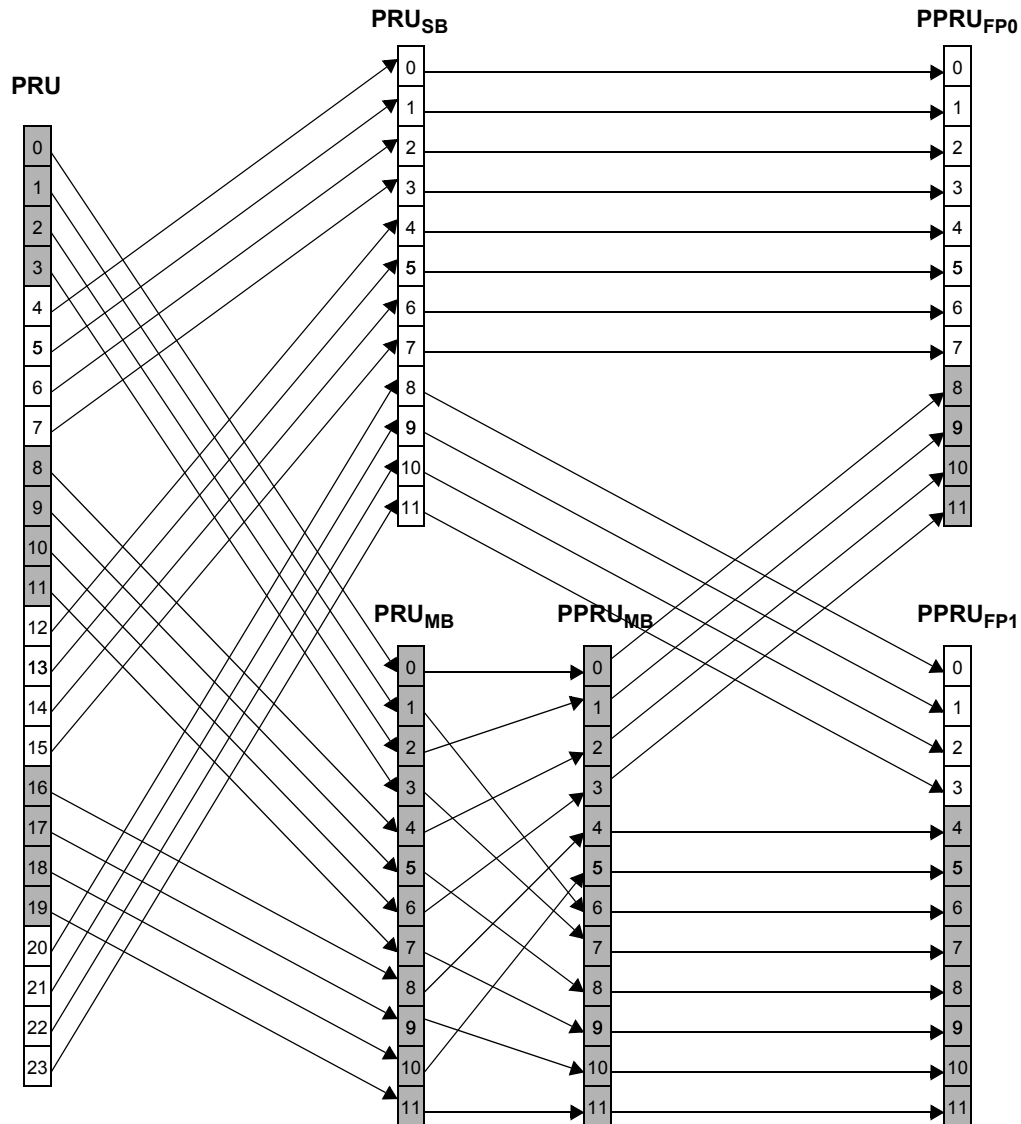


Figure 452—Frequency partitioning for BW=5 MHz, $K_{SB}=3$, FPCT=2, FPS=12, and FPSC=1

15.3.5.3 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.

15.3.5.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector specific basis. 4 or 3-bit Downlink subband-based CRU allocation size (DCAS_{SBi}) field is sent in the SFH for each allocated frequency partition. DCAS_{SBi} indicates the number of allocated CRUs for partition FPi in a unit of subband size. A 5, 4 or 3-bit Downlink miniband-based CRU allocation size (DCAS_{MB}) is sent in the SFH only for partition FP₀ depending on system bandwidth, which indicates the number of allocated miniband-based CRUs for partition FP₀.

The number of CRUs in each frequency partition is denoted by $L_{CRU,FPi}$, where

$$L_{CRU,FPi} = \begin{cases} CAS_{SB,i} \cdot N_1 + CAS_{MB} \cdot N_2 & i=0 \\ CAS_{SB,i} \cdot N_1 & 0 < i < FPCT \end{cases} \quad (186)$$

The number of DRUs in each frequency partition is denoted by $L_{DRU,FPi}$, where $L_{DRU,FPi} = FPS_i - L_{CRU,FPi}$ for $0 \leq i < FPCT$ and FPS_i is the number of PRUs allocated to FPi.

The mapping of PRU_{FPi} to CRU_{FPi} is given by:

$$CRU_{FPi}[j] = \begin{cases} PRU_{FPi}[j], & 0 \leq j < CAS_{SB,i} \cdot N_1 \\ PRU_{FPi}[k + CAS_{SB,i} \cdot N_1], & CAS_{SB,i} \cdot N_1 \leq j < L_{CRU,FPi} \end{cases} \quad 0 \leq i < FPCT \quad (187)$$

where $k = s[j - CAS_{SB,i} \cdot N_1] \cdot s[]$ is the CRU/DRU allocation sequence defined in Equation (188) and $0 \leq s[j] < FPS_i - CAS_{SB,i} \cdot N_1$.

$$s[j] = \{PermSeq(j) + DL_PermBase\} \bmod (FPS_i - CAS_{SB,i} \cdot N_1), \quad (188)$$

where $PermSeq()$ is the permutation sequence of length $(FPS_i - CAS_{SB,i} \cdot N_1)$ and is determined by $SEED = \{IDcell * 343\} \bmod 2$. The permutation sequence is generated by the random sequence generation algorithm specified in Section <<15.3.5.3.4>>. $DL_PermBase$ is an interger ranging from 0 to 31(TBD), which is set to preamble $IDcell$.

The mapping of PRU_{FPi} to DRU_{FPi} is given by:

$$DRU_{FPi}[j] = PRU_{FPi}[k + CAS_{SB,i} \cdot N_1], \quad 0 \leq j < L_{DRU,FPi} \quad (189)$$

where $k = s^c[j] \cdot s^c[]$ is the sequence which is obtained by renumbering the remainders of the PRUs which are not allocated for CRU from 0 to $L_{DRU,FPi} - 1$.

15.3.5.3.2 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 remainders of the 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 $L_{SC,l}/2$. A permutation sequence $PermSeq()$ is defined by (TBD) to perform the DL subcarrier permutation as follows:

For each l -th OFDMA symbol in the subframe:

- 1) Allocate the n_l pilots within each DRU as described in section (TBD). Denote the data subcarriers of $DRU_{FPi,l}$ in the l -th OFDMA symbol as $SC_{DRUj,l}^{FPi}[k]$, $0 \leq j < L_{DRU,FPi}$ and $0 \leq k < L_{SC,l}$.
- 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 $RSP_{FPi,l}$.

$$RSP_{FPi,l}[u] = \{ SC_{DRUj,l}^{FPi}[2v], SC_{DRUj,l}^{FPi}[2v+1] \}, \quad 0 \leq u < L_{DRU,FPi} L_{SP,l}$$

where $j = \lfloor u/L_{SP,l} \rfloor$ and $v = \{u\} \bmod (L_{SP,l})$.

- 3) Apply the subcarrier permutation formula Equation (190) to map $RSP_{FPi,l}$ into the s^{th} distributed LRUs $s = 0, 1, \dots, L_{DRU,FPi} - 1$. The subcarrier permutation formula is given by

$$SC_{LRUs,l}^{FPi}[m] = RSP_{FPi,l}[k] \quad 0 \leq m \leq L_{SP,l} \quad (190)$$

where

$$k = L_{DRU,FPi} \cdot f(m, s) + g(PermSeq(), s, m, l, t)$$

- $SP_{LRUs,l}^{FPi}[m]$ is the m^{th} subcarrier pair in the l^{th} OFDMA symbol in the s^{th} distributed LRU of the l^{th} 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 $L_{DRU,FPi} - 1$.
- t is the subframe index with respect to the frame.
- $PermSeq()$ is the permutation sequence of length $L_{DRU,FPi}$ and is determined by $SEED = \{ID_{cell} * 1367\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in Section 15.3.5.3.3.
- $g(PermSeq(), s, m, l, t)$ is a function with value from the set $[0, L_{DRU,FPi} - 1]$, which is defined according to Equation (191).

$$g(PermSeq(), s, m, l, t) = \{PermSeq[\{f(m, s) + s + l\} \bmod L_{DRU,FPi}] + DL_PermBase\} \bmod L_{DRU,FPi} \quad (191)$$

where $DL_PermBase$ is an integer ranging from 0 to 31(TBD), which is set to preamble ID_{cell} , and $f(m, s) = (m + 13 * s) \bmod L_{SP,l}$.

15.3.5.3.3 Random sequence generation

The permutation sequence generation algorithm with 10-bit SEED ($S_{n-10}, S_{n-9}, \dots, S_{n-1}$) shall generate a permutation sequence of size M by the following process:

- 1) Initialization
 - a) Initialize the variables of the first order polynomial equation with the 10-bit seed, SEED. Set $d_1 = \text{floor}(\text{SEED}/2^5) + 1$ and $d_2 = \text{SEED} \bmod 2^5$.
 - b) Initialize the maximum iteration number, $N=4$.
 - c) Initialize an array A with size M with the numbers $0, 1, \dots, M-1$ (i.e. $A[0]=0, A[1]=1, \dots, A[M-1]=M-1$).
 - d) Initialize the counter i to $M-1$.
 - e) Initialize x to -1 .
- 2) Repeat the following steps if $i > 0$
 - a) Initialize the counter j to 0 .
 - b) Repetition loop as follows,
 - c) Increment x and j by 1 .
 - d) Calculate the output variable of $y = \{(d_1 * x + d_2) \bmod 1031\} \bmod M$.
 - e) Repeat the above step a. and b., if $y \geq i$ and $j < N$.
 - f) If $y \geq i$, set $y = y \bmod i$.
 - g) Swap the i^{th} and the y^{th} elements in the array (i.e. perform the steps $\text{Temp} = A[i], A[i] = A[y], A[y] = \text{Temp}$).
 - h) Decrement i by 1 .
- 3) $\text{PermSeq}[i] = A[i]$, where $0 \leq i < M$.

15.3.5.3.4 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 $L_{AMAP} \cdot N_{sym} \cdot L_{SP} - 1$. L_{AMAP} is the number of LRU allocated to the A-MAP.
- 2) A distributed tone-pair, $SP_{LRUs,i}^{FPI}[m][m]$, is mapped to $RMP[u]$, where $u = s \cdot N_{sym} \cdot L_{SP} + m \cdot N_{sym} + 1$. $SP_{LRUs,i}^{FPI}[m][m]$ is the tone-pair index of the m^{th} tone-pair in the i^{th} OFDMA symbol in the s^{th} distributed LRU of frequency partition i as defined in Section 15.3.5.3.2.
- 3) Suppose $RMP[v]$ is the first tone-pair for allocation 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 MLRU.

15.3.5.3.5 Logical Resource Unit Mapping

Both contiguous and distributed LRUs are supported in the downlink. The CRUs are directly mapped into contiguous LRUs. The DRUs are permuted as described in <<15.3.5.3.3>> to form distributed LRUs.

15.3.5.4 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, IEEE 802.16m 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. Dedicated pilots can be used with both localized and distributed allocations. The dedicated pilots are associated with a specific resource allocation, can be only used by the MSs allocated to said specific resource allocation, and therefore 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 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 subframe. Further, within the same subframe there is equal number of pilots for each PRU of a data burst assigned to one MS.

15.3.5.4.1 Pilot patterns

Pilot patterns are specified within a PRU.

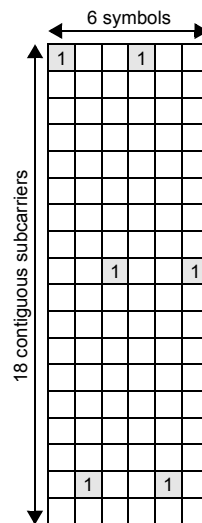


Figure 453—Pilot patterns used for 1 DL data stream

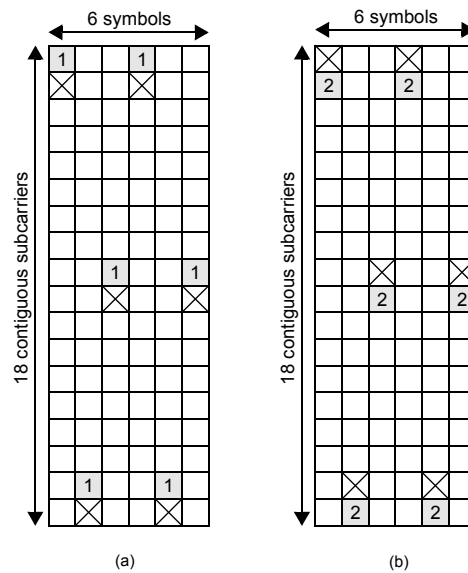


Figure 454—Pilot patterns used for 2 DL data streams

Base pilot patterns used for one and two DL data streams in dedicated and common pilot scenarios are shown in Figure 453 and Figure 454 respectively, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. The numbers on the pilot locations indicate the stream they correspond to. Subfigure (a) and Subfigure (b) in Figure 454 are used on DL data stream 1 and DL data stream 2, respectively, where 'X' stands for the null symbol, which means that no pilot or data is allocated on that time-frequency resource.

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 455 and interlaced pilot patterns on stream 0 and stream 1 for two streams are shown in Figure 456 and Figure 457, respectively. Each BS chooses one of the three pilot pattern sets (pilot pattern set 0, 1, and 2) as shown in Figure 455 and Figure 456. The index of the pilot pattern set used by a particular BS with Cell_ID = k is denoted by p_k . The index of the pilot pattern set is determined by the Cell_ID according to the following equation:

$$p_k = \text{mod}(k, 3) \quad (192)$$

For the subframe consisting of 5 symbols, the last OFDM symbol in each pilot pattern set shown in Figure 414 is deleted. For the subframe consisting of 7 symbols, the first OFDM symbol in each pilot pattern set shown in Figure 414 is added as 7th symbol.

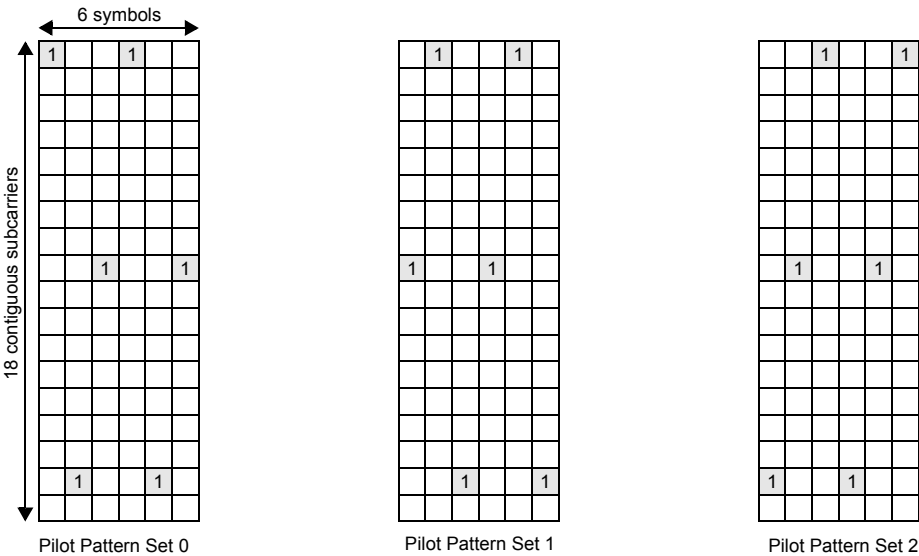


Figure 455—Interlaced pilot patterns for 1 pilot stream

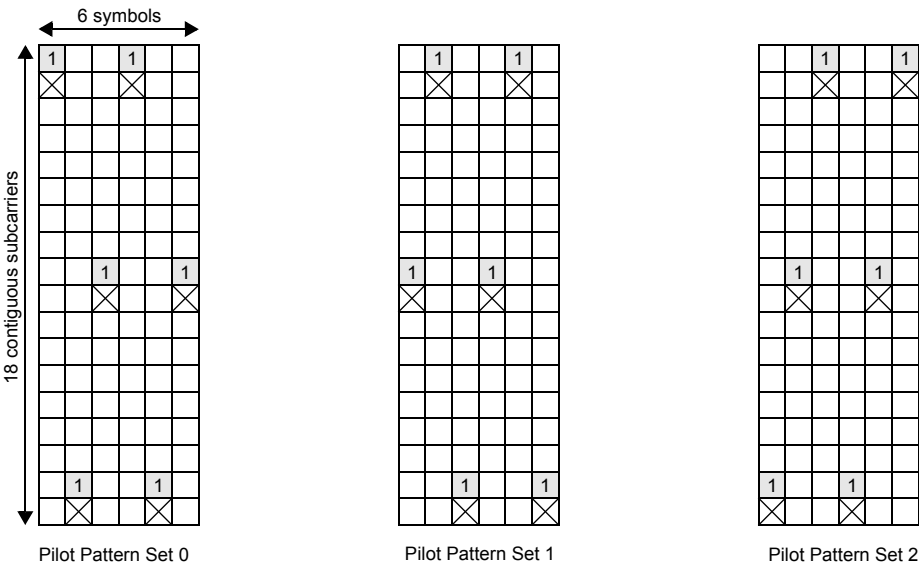


Figure 456—Interlaced pilot patterns on stream 0 for 2 data streams

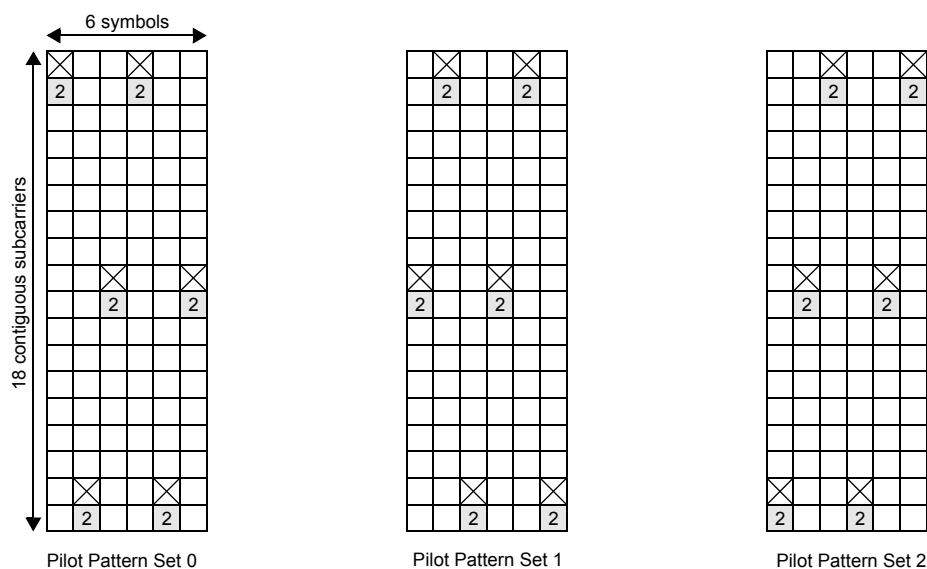


Figure 457—Interlaced pilot patterns on stream 1 for 2 data streams

The pilot patterns on stream 0 - stream 3 for four pilot streams are shown in Figure 458 through Figure 461— respectively, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) in Figure 458 through Figure 461— show the pilot pattern for four pilot streams in subframe with six OFDM symbols; Subfigure (b) in Figure 458 through Figure 461— show the pilot pattern for four pilot streams in subframe with five OFDM symbols; Subfigure (c) in Figure 458 through Figure 461— show the pilot pattern for four pilot streams in subframe with seven OFDM symbols.

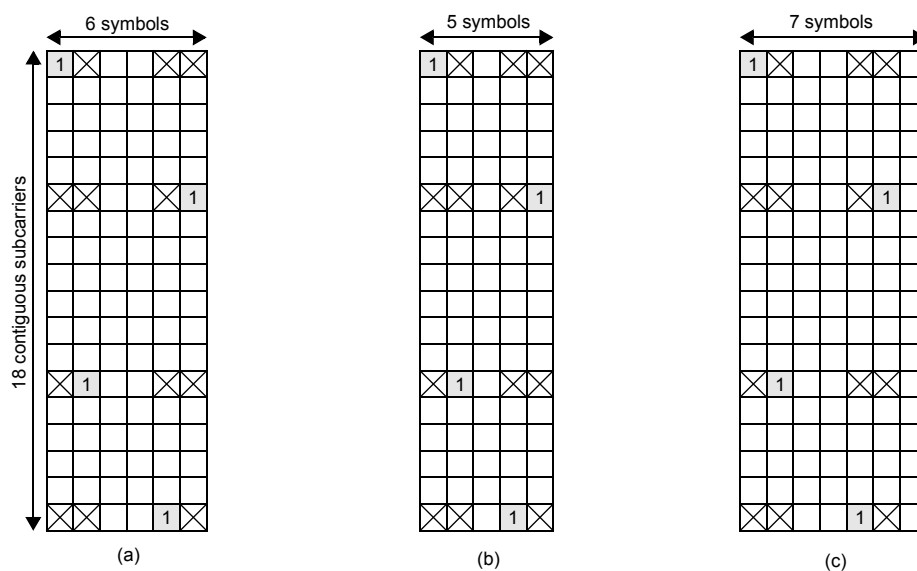


Figure 458—Pilot patterns on stream 0 for 4 data streams

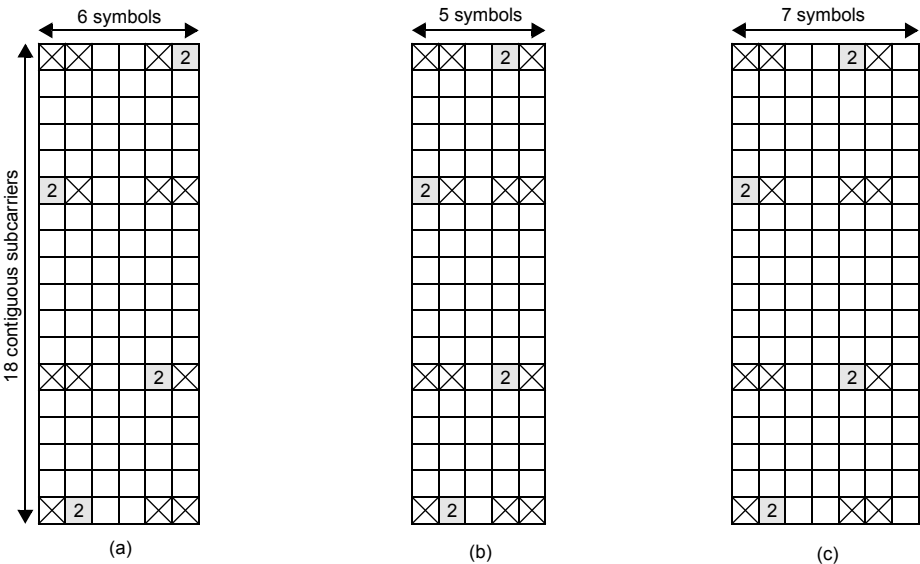


Figure 459—Pilot patterns on stream 1 for 4 data streams

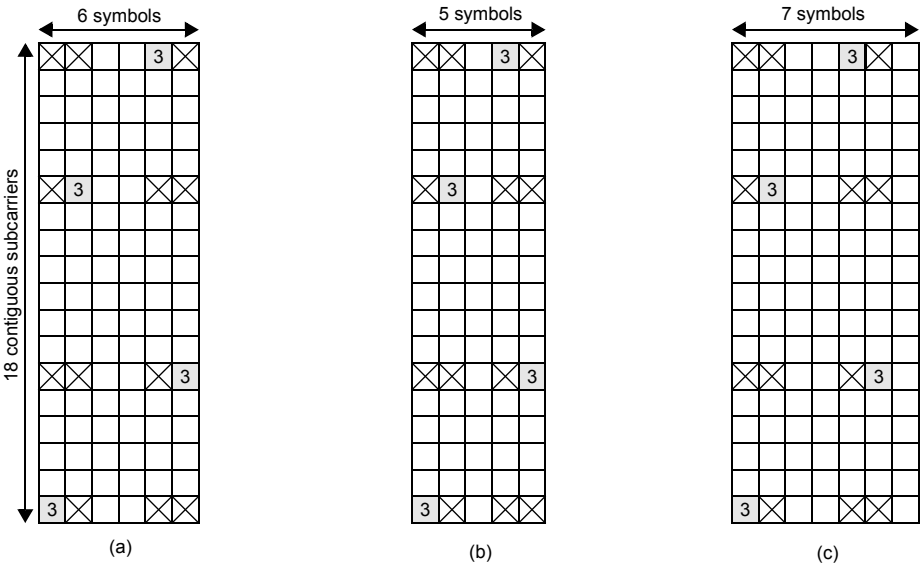


Figure 460—Pilot patterns on stream 2 for 4 data streams

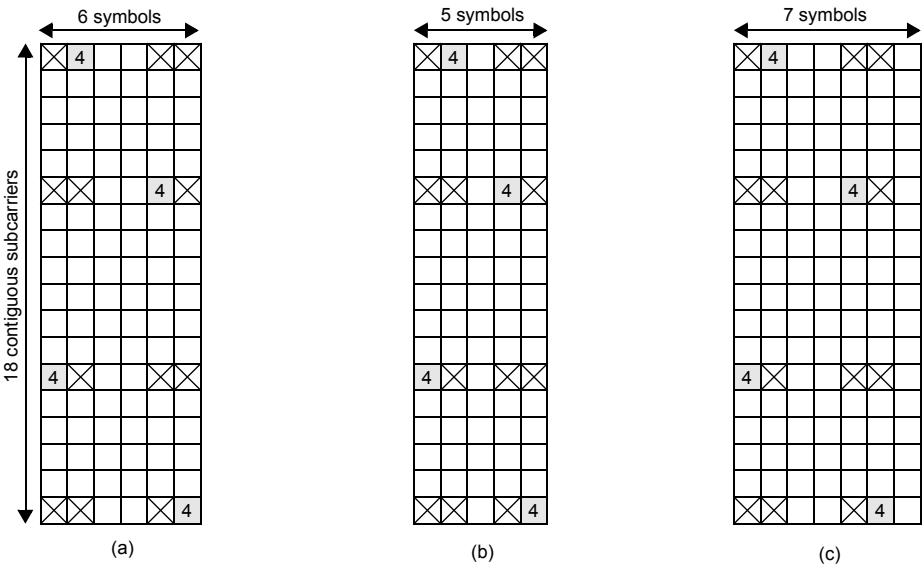


Figure 461—Pilot patterns on stream 3 for 4 data streams

The pilot patterns for eight pilot streams are shown in Figure 462— with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) in Figure 462— shows the pilot pattern for eight pilot streams in subframewith six OFDM symbols; Subfigure (b) in Figure xxx shows the pilot pattern foreight pilot streams in subframewith five OFDM symbols; Subfigure (c) in Figure xxx shows the pilot pattern for eight pilot streams in subframewith seven OFDM symbols.

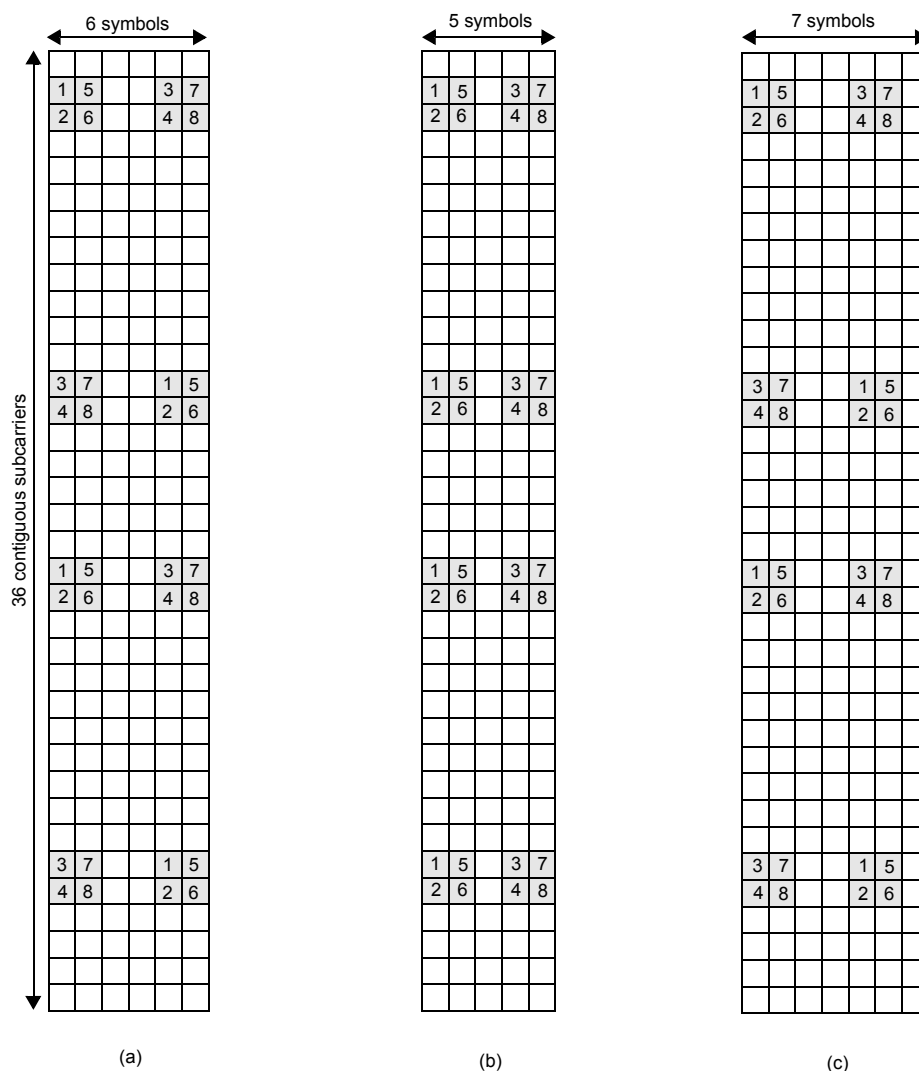


Figure 462—Pilot patterns for 8 data streams

15.3.5.4.2 MIMO midamble

MIMO midamble is used for PMI selection in closed loop MIMO. For OL MIMO, midamble can be used to calculate CQI. The midamble signal occupies the one OFDMA symbol in a DL sub-frame. For the type-1 subframe case, the remaining 5 consecutive symbols form a type-3 subframe. For the type-2 subframe case, the remaining 6 consecutive symbols form a type-1 subframe.

15.3.6 Downlink control structure

15.3.6.1 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 463 depicts the location of A-Preamble symbols.

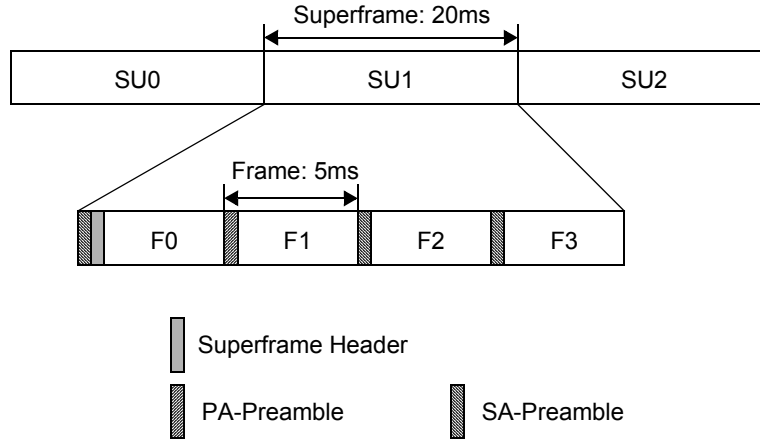


Figure 463—Location of the A-Preamble

15.3.6.1.1 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 ABS type, system bandwidth, and carrier configuration. When the subcarrier index 256 is reserved for DC, the allocation of subcarriers is accomplished by Equation (193):

$$PAPreambleCarrierSet = 2 \cdot k + 41 \quad (193)$$

where

$PAPreambleCarrierSet$ specifies all subcarriers allocated to the PA-Preamble, and

k is a running index 0 to 215.

Figure 464 depicts the symbol structure of the PA-Preamble in the frequency domain.

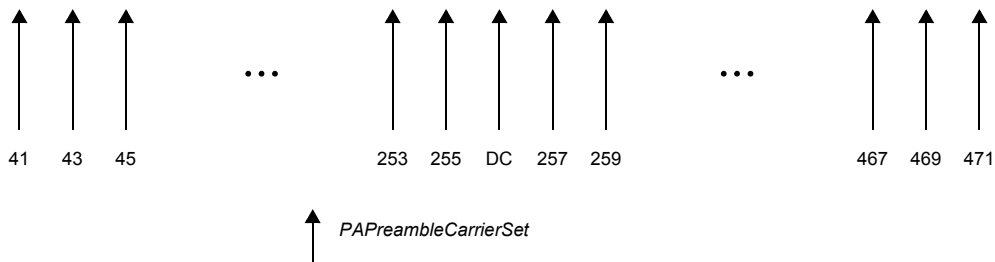


Figure 464—PA-Preamble symbol structure

In n Table 653 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 653—PA-Preamble series

Index	Carrier	BW	Series to modulate
0	Fully configured	5 MHz	6DB4F3B16BCE59166C9CEF7C3C8C A5EDFC16A9D1DC01F2AE6AA08F
1		10 MHz	1799628F3B9F8F3B22C1BA19EAF94 FEC4D37DEE97E027750D298AC
2		20 MHz	92161C7C19BB2FC0ADE5CEF3543A C1B6CE6BE1C8DCABDDDD319EAF7
3		<i>Reserved</i>	6DE116E665C395ADC70A8971690862 0868A60340BF35ED547F8281
4		<i>Reserved</i>	BCFDF60DFAD6B027E4C39DB20D78 3C9F467155179CBA31115E2D04
5		<i>Reserved</i>	7EF1379553F9641EE6ECDBF5F14428 7E329606C616292A3C77F928
6		<i>Reserved</i>	8A9CA262B8B3D37E3158A3B17BFA 4C9FCFF4D396D2A93DE65A0E7C
7		<i>Reserved</i>	DA8CE648727E4282780384AB53CEE BD1CBF79E0C5DA7BA85DD3749
8		<i>Reserved</i>	3A65D1E6042E8B8AADC701E210B5 B4B650B6AB31F7A918893FB04A
9		<i>Reserved</i>	D46CF86FE51B56B2CAA84F26F6F20 4428C1BD23F3D888737A0851C
10	Partially configured	N/A	640267A0C0DF11E475066F1610954B5 AE55E189EA7E72EFD57240F

The magnitude boosting levels for different FFT size are shown in Table 654.

Table 654—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 subframes, T_{OFFSET} as shown in Figure 465

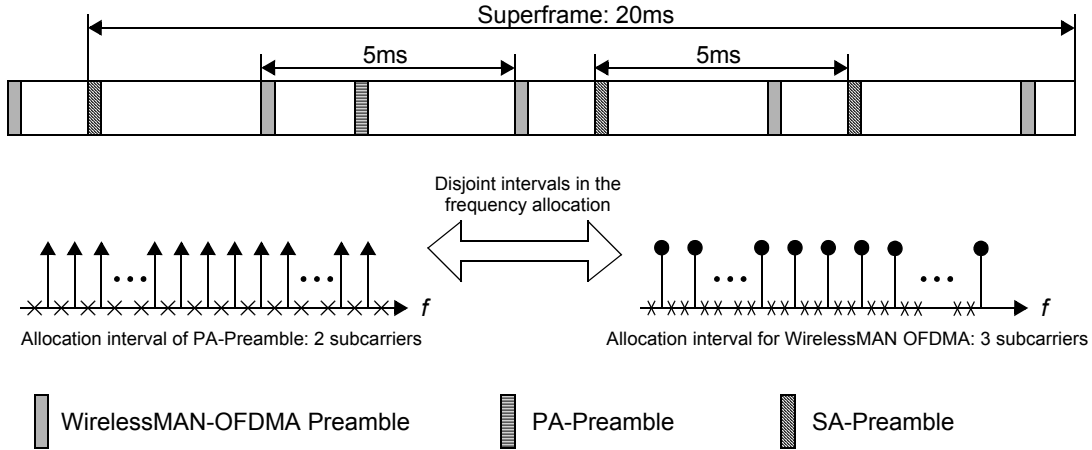


Figure 465—A-Preamble transmission structure supporting WirelessMAN-OFDMA

15.3.6.1.2 Secondary advanced preamble (SA-Preamble)

The N_{SAP} , the lengths of sequences 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 (194), when the subcarrier indexes 256, 512, and 1024 are reserved for DC for 512-FFT, 1024-FFT, and 2024-FFT, respectively.

$$SAPreambleCarrierSet_n = n + 3 \cdot k + 40 \cdot \frac{N_{SAP}}{144} + \left\lfloor \frac{2 \cdot k}{N_{SAP}} \right\rfloor \quad (194)$$

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 which will be defined later is assumed.

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 ID_{cell} from 0 to 767. The ID_{cell} is defined by segment index and an index per segment as follows:

$$ID_{cell} = 256n + Idx$$

where

n is the index of the SA-Preamble carrier-set 0, 1 and 2 representing segment ID,

Idx is a running index 0 to 255.

SA-Preamble sequences are partitioned and each partition is dedicated to specific base station type like Macro BS, Femto BS and etc. The partition information is broadcasted in the extended system information.

For the support of femtocell deployment, a femtocell BS should self-configure the segment or subcarrier set for SA-Preamble transmission based on the segment information of the overlay macrocell BS for minimized interference to macrocell if the femtocell BS is synchronized to macrocell BSs. The segment information of the overlay macrocell BS may be obtained by communications with macrocell BS through backbone network or active scanning of SA-Preamble transmitted by macrocell BS.

For 512-FFT size, the 144-bit SA-Preamble sequence is divided into 8 main blocks, namely, A, B, C, D, E, F, G, and H. The length of each block is 18 bits. Each segment ID has different sequence blocks. <<Table YYYY>> depicts the 8 blocks of each segment ID where LSB 18 bits are used to represent the binary sequence of each block. The binary sequence $\{0,1\}$ is mapped to real number $\{+1,-1\}$. For 512-FFT size, A, B, C, D, E, F, G, and H are modulated and mapped sequentially in ascending order onto the SA-Preamble subcarrier-set corresponding to segment ID, as shown in Figure 466. For higher FFT sizes, the basic 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 SA-Preamble subcarrier-set corresponding to segment ID.

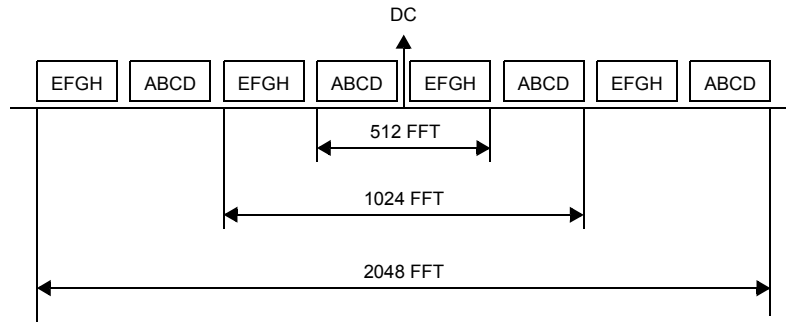


Figure 466—Allocation of sequence blocks for each FFT

A circular shift is applied to over 3 consecutive sub-carriers after applying subcarrier mapping based on Equation (194). Each subblock has common offset. The circular shift pattern for each subblock is:

$$[2,1,0,\dots,2,1,0,\dots,2,1,0,2,1,0, DC, 1,0,2,1,0,2,\dots,1,0,2,\dots,1,0,2],$$

where the shift is circularly right shift.

For 512-FFT size, the 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 467 depicts the symbol structure of SA-Preamble in the frequency domain for 512-FFT.

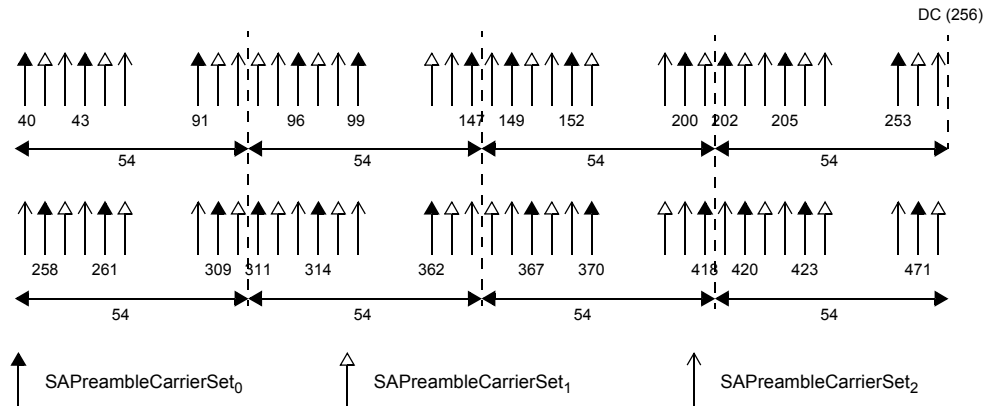


Figure 467—SA-Preamble symbol structure for 512-FFT

For multiple antenna systems, the SA-Preamble blocks are interleaved on the number of antennas as follows. For 512-FFT size, Figure 468 depicts the SA-Preamble allocation for 1, 2, and 4 antennas.

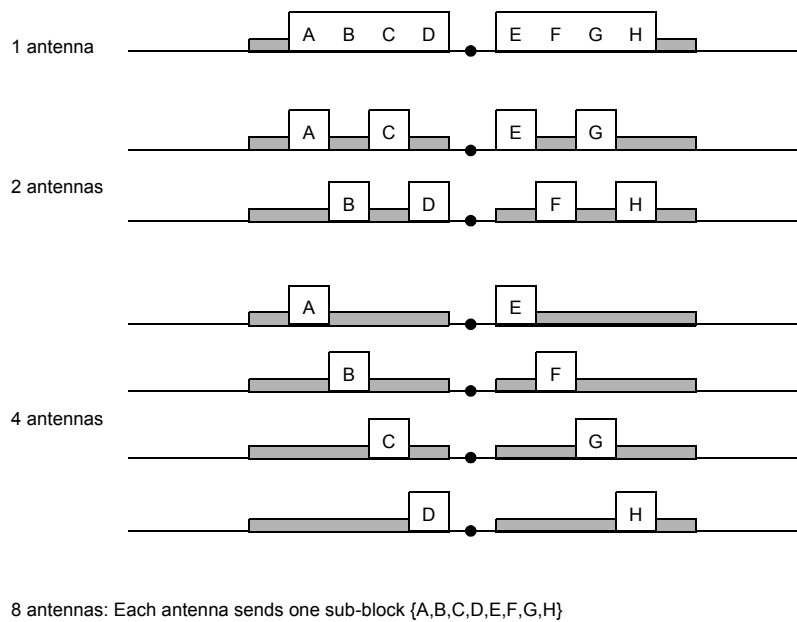
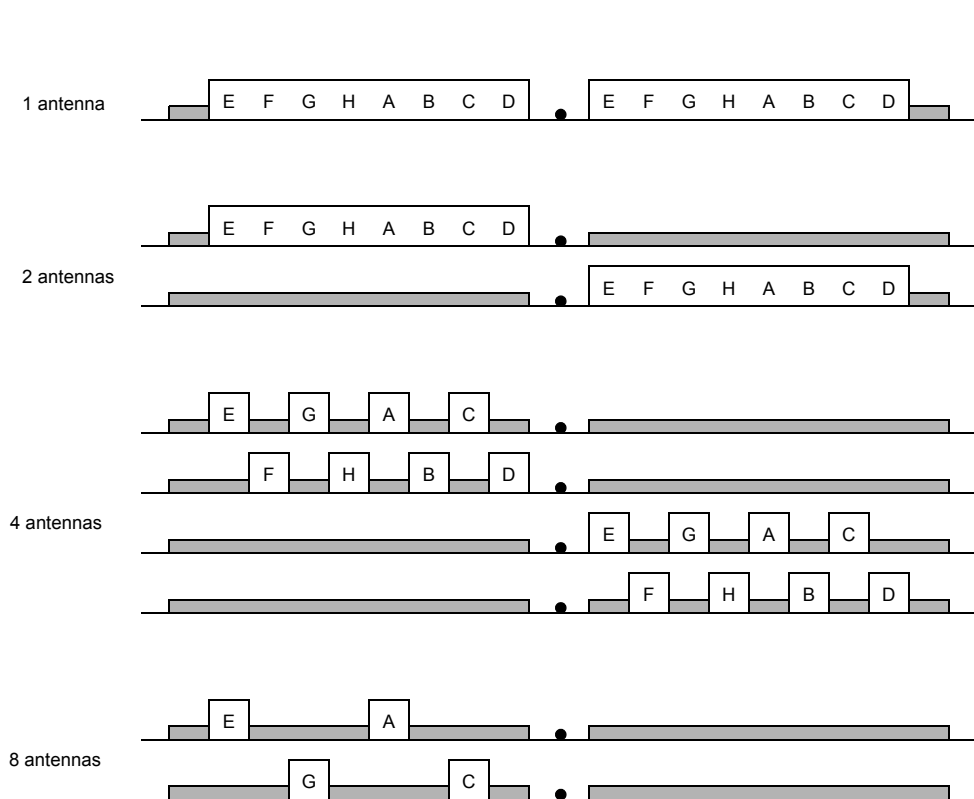


Figure 468—Multi antenna example for 512-FFT

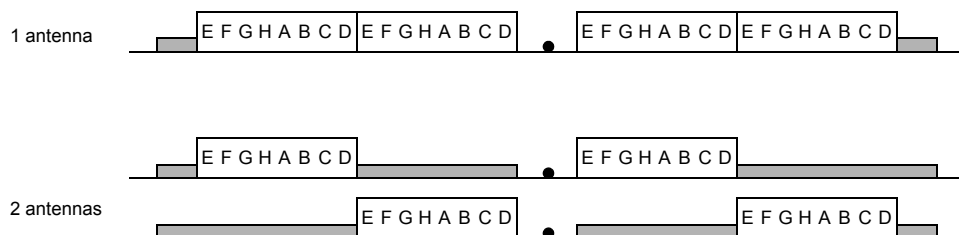
For 1024-FFT size, Figure 469 depicts the SA-Preamble allocation for 1, 2, 4, and 8 antennas.



Similarly, each four blocks of the 4-antenna case is transmitted using two antennas in the 8-antenna case using interleaved structure

Figure 469—Multi-antenna example for 1024-FFT

For the 2048-FFT, Figure 470 depicts the SA-Preamble allocation for 1, 2, and 4 antennas.



4 antennas: Each block {E,F,G,H,A,B,C,D} in the above 2-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 470—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 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 ($N_{bt} \geq 1$)
 Distribute consecutive blocks across the N_t antennas
 For a given antenna, a block is repeated with period N_t
 Block position of the $(t+1)^{th}$ antenna = $t + p * N_t$, where $t = 0, 1, \dots, N_t - 1$, $p = 0, 1, \dots, N_{bt} - 1$

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: $\text{floor}(i/4)$
 Block [0,0,G,0,0,0,C,0] is sent from antenna $i+1$ at block position: $\text{floor}((i+1)/4)$
 Block [0,F,0,0,0,B,0,0] is sent from antenna $i+2$ at block position: $\text{floor}((i+2)/4)$
 Block [0,0,0,H,0,0,0,D] is sent from antenna $i+3$ at block position: $\text{floor}((i+3)/4)$, where
 $i = 0, 4, 8, \dots, N_t$

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: $\text{floor}(i/2)$
 Block [0,F,0,H,0,B,0,D] is sent from antenna $i+1$ at block position: $\text{floor}((i+1)/2)$, where
 $i = 0, 2, 4, \dots, N_t$

Else
 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: $\text{floor}(i/8)$
 Block [0,F,0,0,0,0,0,0] is sent from antenna $i+1$ at block position: $\text{floor}((i+1)/8)$
 Block [0,0,G,0,0,0,0,0] is sent from antenna $i+2$ at block position: $\text{floor}((i+2)/8)$
 Block [0,0,0,H,0,0,0,0] is sent from antenna $i+3$ at block position: $\text{floor}((i+3)/8)$
 Block [0,0,0,0,A,0,0,0] is sent from antenna $i+4$ at block position: $\text{floor}((i+4)/8)$
 Block [0,0,0,0,0,B,0,0] is sent from antenna $i+5$ at block position: $\text{floor}((i+5)/8)$
 Block [0,0,0,0,0,0,C,0] is sent from antenna $i+6$ at block position: $\text{floor}((i+6)/8)$
 Block [0,0,0,0,0,0,0,D] is sent from antenna $i+7$ at block position: $\text{floor}((i+7)/8)$, where
 $i = 0, 8, \dots, N_t$

Each time frame, the transmitted structures are rotated across the transmit antennas. For example, we consider the 512-FFT system with 4 transmit antennas. At the j^{th} frame, the 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, at the $(j+1)^{th}$ frame, 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 for different FFT size and number of antennas shown in Table 655.

Table 655—SA-Preamble boosting levels

Ant\FFT	512	1k	2k
1	1.5928	1.9516	1.4748
2	2.1841	2.5474	2.0800
4	2.8489	3.1047	3.0915
8	3.5523	4.0273	4.3691

For single-antenna case, the SA-Preamble is transmitted with a magnitude boost of 1.5928. The boosted SA-Preamble at k-th subcarrier can be written as:

$$c_k = 1.5928 - b_k$$

where b_k represents SA-Preamble before the boosting (+1 or -1).

Block Cover Sequence $\{+1, -1\}$ for each sub-block in the structure (optimized for arbitrary number of transmit antennas and any bandwidth). The binary sequence $\{0, 1\}$ is mapped to real number $\{+1, -1\}$. The Block Cover Sequence of each case is shown in Table 656.

Table 656—SA-Preamble block cover sequence

(FFT,number of antennas)\Segment ID	0	1	2
(512,1)	DE	DE	0A
(512,2)	04	C0	28
(512,4)	20	00	90
(512,8)	00	00	00
(1024,1)	7CD6	7B2E	C66C
(1024,2)	1A1A	E2E2	0A0A
(1024,4)	1010	9090	2828
(1024,8)	2020	A0A0	8080
(2048,1)	68E7E631	FC8474DB	69C337F3
(2048,2)	2C210259	C2042058	7D160BC4
(2048,4)	6A5D2AF2	6476EDE6	56C6A39B
(2048,8)	E659356A	958047EE	1AD81B52

Table 657—SA Preamble for $n = 0$ (Segment 0)

Idx\blk	A	B	C	D	E	F	G	H
0	2A1FA	3DE76	2CCA0	15722	2A509	0E904	0C5D5	10774
1	23836	378C2	3BFDA	1A401	27FBD	1FA0E	02DA2	03949
2	211B7	2855B	25BCD	17F09	32910	090FB	07C8C	0CC20
3	3836C	22AD2	349DB	183CA	3B2CA	09CE3	12C6C	12282
4	26F2D	3DFF6	315B1	1234E	2A0AF	1BEAD	0CE1A	03B36
5	3D1C3	23AFF	22B8B	1A9DE	3E5A3	08235	1B7AF	136AD
6	30709	2FA42	31CBD	0F424	3E570	1D9A8	008AA	0F9D3
7	38E39	33279	2FF20	08825	3EBCB	1DCCD	15D61	0DECF
8	21779	264CB	3230D	0AE06	35140	1CA03	0E570	059BE
9	270A8	2ADE1	3B6B7	1A629	29B35	0C99D	0AC04	03C08
10	30F40	3363F	361F3	00A13	36A99	1CC91	0F8CB	1EDD2
11	28A18	2F6B4	20AE4	0BA1C	25EA6	063B1	1C5F4	1B85B
12	26821	3A5B3	3EE12	08B45	3C594	016FD	02A94	054F7
13	3AC52	33B19	3E9C6	1609E	2EB43	065DC	08E91	0B952
14	32B67	298C0	20ED5	1A699	343F1	1D965	17927	07EF0
15	3AC4D	35BBC	29713	06420	28132	0B1D1	16A5B	176B1
16	28B79	22EA0	341E6	088EF	23052	1944A	1452F	0176D
17	3F8D6	20E09	3791E	1762C	3E8DA	13B94	0D4DB	15807
18	2080F	2E4D0	291F6	153B4	368A2	1AD5C	161AD	06C1E
19	27DC1	21FEA	2B540	1F1BF	3C773	05585	11644	1A59A
20	34CAB	2FE84	3E702	02C06	3AEEC	0F583	0CD57	04AD1
21	24991	3CF91	2AEE1	0D6EB	32F0D	07E07	1BB88	0D321
22	30822	398DC	2F478	04B4D	3361B	156BE	0D5AC	11E4F
23	3C355	36EEE	35068	085B0	2FCBB	0855E	1466C	050CB
24	3ECC3	2A52B	3DFCC	03ADF	2DF1D	05C43	05A8A	19D9F
25	2FF61	2B725	37F3E	14092	3E129	16F47	0E8CC	1E8B8
26	235C9	275AC	22420	175DB	2118A	06177	0FB7A	00DF4
27	299F2	3D5DF	34668	12631	20E22	1BC59	049E8	1209C
28	2F3F4	34251	36429	0B0CF	2CCE6	109F4	0BA71	1D846
29	32816	25786	259F6	0CD01	3BA6A	1FC99	1DB12	1FED3

Table 657—SA Preamble for $n = 0$ (Segment 0)

30	3DF50	3EE78	2B708	19594	371DB	03C88	0794A	07B3C
31	3D053	3DF2C	273CC	165F6	2C436	09ED4	0C879	13571
32	3960E	26F45	33FBE	068B6	3C521	106C6	09C50	11A56
33	2B95B	385EE	3B804	03545	29D2E	01B2E	02F70	1C65A
34	3CC0F	201B2	28467	1D38A	258A4	0C37A	0F145	04C70
35	383EC	3A316	24A63	190FA	3AE63	0918B	1FE42	1DDD7
36	2C261	228F1	28B79	0D393	2DB97	1B131	105E9	1438A
37	2497F	292F3	2C371	12C8E	20A1D	14110	1A04F	0B028
38	372E6	304B6	2F16A	188E6	3688E	1D23F	0490A	1041F
39	34FFB	38DCD	25577	19DEF	251E4	00C71	01E27	15622
40	3D6FA	305DF	2AC73	1C8D6	3E5CA	00717	0851C	109B2
41	362C1	2723E	27046	134A2	3FCC3	0D635	0394C	02EE9
42	348E8	3972D	3D001	1315A	35EAE	1702C	11E63	0F600
43	2C7BB	2F28F	2015D	09325	24EE9	1F67B	1F377	1611E
44	2B3BE	27DA5	36FDF	0DD50	39C46	00D4E	1E49C	067C4
45	2614D	340BC	2B4F8	16369	31213	13F3F	0A130	1ECA1
46	26417	21306	33D64	130EF	39BC4	1751D	08580	13160
47	3F902	2A37D	361C8	19A54	3DB69	0C335	1171F	0F022
48	3AB24	3D551	3C977	1360A	3F0BC	021CF	14382	02E59
49	35E1E	26090	35738	158AF	3D8C2	1FAD3	01313	0868B
50	3AC9F	315BF	263B8	1C684	385D9	17DB0	0FDDD	1D8FF
51	2F482	3AC19	34498	0E65B	3D719	14DE7	17762	14F4D
52	2E248	348C5	35A9A	0D76F	3708E	1346E	1F653	1F281
53	2CFA2	28F3F	3A58F	15E30	3B0E7	1F67E	0187C	112E8
54	3DB3B	3D41B	3AC0A	0C7C3	2E71F	1946D	1C64B	06E3C
55	2C726	36DE4	252BF	1061D	25194	0FB2B	09B51	16744
56	229F2	32990	358C3	1BB30	2F008	0D0A2	051D3	17530
57	235C2	2EC63	2C3F8	16217	2183A	14406	0B8C8	10E19
58	25552	341AF	20810	073A1	2E1FB	1D58C	0F35C	0320E
59	39B09	209E8	35261	1D675	3A0DE	0A8A1	1EFF9	01F98
60	20A28	3792C	3F334	045D2	3D786	1A95C	08CB0	18DA1
61	29FE5	3E383	22DDB	14256	37B29	00FB1	10420	018A1
62	3F05B	30317	24779	1BB7B	269BC	0C785	04A86	118AA

Table 657—SA Preamble for $n = 0$ (Segment 0)

63	3739A	373CC	2C605	138A5	22112	00ABC	134D5	0FABE
64	339EC	3DA7E	2256C	10CFF	2593D	0DE36	032EC	1E199
65	3B3AD	264C2	3BDE5	11FDE	38AA1	1D1EF	1821E	0EE3E
66	3D528	38958	23331	0E8B9	26FCE	127B8	0DA80	1DCF8
67	3DA17	2AB6D	26ECE	0401A	3FBD8	17692	1E7F2	05FF2
68	21ED1	2F966	316F9	071F2	3ACF4	025A9	047E4	01DDC
69	2904C	3C712	2C41E	06801	2F9F2	076BA	112C6	09E1C
70	2726A	2F4B0	25E3D	15DE6	308B1	0D7FB	1196C	0BD53
71	289FD	3495C	2C772	0D1C6	2D855	1BA59	01297	00B23
72	2E936	37553	31EE9	1E026	27D7F	134DE	146D7	1FBB6
73	37A24	36101	34473	07695	2D6C2	1C05F	06FFB	1443E
74	3D1AF	29853	36B2C	0C23D	2B5BF	0647F	12084	09C1D
75	2964F	30824	236A0	11F14	3EF38	0342E	1F876	16A2F
76	351F8	32CA8	33583	141DC	26533	06DA9	0BD59	000BA
77	22160	2FDEA	33446	17661	23FA3	0D7FE	16C48	052E6
78	36995	36A68	336BB	0CE56	3FE11	12FFA	0BB3F	1B8E3
79	318E2	3E532	2FDA4	09CAE	3C3EF	0B3A7	0E451	0CA29
80	207EB	36723	2F1F5	0CCC9	3984A	0C153	1D629	1745B
81	3FE13	2CF97	2CA31	1B457	2BD86	06B5D	04999	066EC
82	3F9A3	22F77	3AB11	057AD	3E5EF	13D13	1F378	03B3F
83	2510E	248A3	341C6	06A43	27BC8	0842E	0C4A2	1413C
84	33B40	3EE48	28FF9	11ADD	3D7BC	0DD6F	10961	15406
85	3459E	3FC42	38114	166CA	34C25	01779	107E5	008E9
86	36C4F	309D7	390A8	18A58	24FD3	047F0	00AAD	132EF
87	39717	25556	28121	1266C	3BCB4	0C94B	16BD4	17B46
88	39AE3	37836	3D134	0E4C2	2FF8F	15803	1B9B2	0E48E
89	20F58	30F56	37826	0DBE9	25172	01A01	09AF7	0CF5D
90	364B3	2B0CA	2BE32	1AAE4	29D7D	05D93	1B9D3	021FD
91	35084	3E213	32EDB	0F527	20813	09A6A	1878A	15683
92	379C8	288ED	36C85	18C8D	31498	1C7B3	1E2E4	06ADF
93	22008	2CA3B	2B613	1D1E8	23142	1D141	1F1E3	1C8D1
94	20DFD	36D64	337D3	15C09	29B5A	1C75C	1FB06	0E75B
95	31671	231B5	26127	0A0E4	35797	00D1A	12AB4	187B8

Table 657—SA Preamble for $n = 0$ (Segment 0)

96	3EBB7	23D69	3D1F2	0EEFD	3AD47	1CC65	1C95B	03C78
97	25945	34B15	33E30	1127A	3B938	06A62	02D0D	1CB49
98	366BE	208F6	2DE7E	0713F	32D7A	1A0EC	06639	05F7F
99	31FF8	3A9D6	39DB2	1A1D9	3880C	011FE	1BE69	1F792
100	22535	3A2E2	298F0	0FE41	3E139	05858	101CA	1BC4D
101	3DDA5	23D87	32161	12156	2CA14	1F4E9	003D1	134CD
102	23F0D	231E8	316AD	147BF	21671	0AB19	141D3	130BA
103	3546F	251B4	33661	1B440	3827E	13FE7	0EAA5	1BCD6
104	39B3E	33A87	300B5	09DC0	2AC29	051E6	06706	179AA
105	372F2	3441D	34450	19F2C	22FF3	10C03	1A97E	16089
106	31287	394BD	329C7	0678B	2DE2E	0A8AF	1FD93	194E2
107	2AEC7	23388	293E7	0798F	27C06	0435B	1E169	11A0A
108	226E7	32E65	207B2	1DE2E	26B3D	178F7	15E56	16907
109	32A75	23B1C	35792	0FF8F	333D4	13399	0CD11	11C0D
110	21E53	3BF69	217F9	1E4CC	2FD44	0D3B4	08C04	17CFD
111	364A7	249A0	3273F	0B996	2FEBC	1ACEF	01EAB	0EDF3
112	34831	340E1	3C372	08432	253F5	1993C	0CA57	15BA3
113	3A7B8	2CFE0	31B37	0532D	2BD66	0B638	10C4F	02BA6
114	2CC36	33D15	354D3	0DCB9	34160	0E6A4	0A530	15AB7
115	36CD9	2B6B2	308A5	10C14	37DA2	14091	16635	09FC0
116	26390	3C089	20E90	198A0	3CF5A	0DA14	0B79E	00A81
117	35B16	2F4ED	329B7	0BABD	24957	071F8	1720B	00A51
118	21AEA	3CB09	3F850	1143F	26F6B	0B730	0A483	1C7B3
119	33300	2CDF0	23BE0	17190	33840	03912	1E470	07506
120	2CECA	2B8EE	227DA	1F9B9	3BE06	0F0C1	085D7	088DF
121	336A9	26C46	2A381	05AC3	3B3EF	1635F	02603	09A59
122	372BF	25ABE	3E1A1	02EBE	2797C	13647	14F10	056E9
123	2507B	269DD	393C9	14BC2	276FD	082A9	1E301	02204
124	2DAD4	233C2	24AE7	1A63E	3A4CD	19D27	00F38	1E632
125	3D94C	341EB	33B63	1E63F	20D60	0AA11	17730	040EC
126	314B1	21EEE	3A722	0D99D	2ADB6	1C749	0C11E	0300F
127	306CB	2D856	2B3E9	18998	3DCA7	00440	032D4	0AB14
128	2176F	2526A	2B8B8	03B7A	27F98	0C00A	15BC6	10BC4

Table 657—SA Preamble for $n = 0$ (Segment 0)

129	3502C	3381D	30162	0A91C	3723C	0BA48	13991	10007
130	205A9	20E77	236F0	1208E	333DB	1FD1D	0F663	1A2CD
131	29EFE	3165B	391FC	18A82	24FA5	13B49	0EA6A	1E7C5
132	3BC8F	35058	2B040	03175	21D63	080FD	10564	1943B
133	33856	31A6D	37FA5	10D6A	2778B	13BA8	17FCD	07D78
134	2462C	3126A	3DE29	0EFCE	2CE17	1F670	00A16	09992
135	31358	3A006	3D6C9	09C3F	2E42D	0757F	07DE5	13F2A
136	26FDC	25BF0	22AC3	0D92D	2CB72	17AF7	1761B	13F44
137	39282	3E781	2807B	055FE	316E0	16070	125E6	1595E
138	237D2	2FB31	3DFD9	03B7C	28F55	09601	09A26	1210C
139	3A13B	330D3	2C606	033B0	293B9	1D684	173DD	18858
140	27825	3A0FF	288D0	16B7E	31A53	1358C	03259	07CA5
141	246FE	35C69	32A82	14D6A	3CAFC	03A11	19D90	037DC
142	37170	2C096	22EB9	088D9	3F0AC	116D0	0AA84	07AAC
143	31081	30C8F	38264	0AF24	24325	15FE1	026C7	04115
144	234A3	28DB6	3A4CD	0545C	35272	19CBD	07F1F	009B7
145	21F32	3677D	35CFB	1D63F	293B0	1244F	00CDF	0D3CB
146	30318	2EDED	2F09A	15C54	329CC	0B24E	0D93A	0BC81
147	201CB	2DBD1	3E4A5	0E7A3	2C50A	0A4BC	15412	182CC
148	26E83	3E68F	3D675	031A9	2EDD8	1AA4F	02443	16BD9
149	38C83	3892F	3E237	10FC3	26F2E	1FADD	19F56	191B2
150	2181D	26EFC	240B6	1224B	3BD01	0AB64	080DA	1BEAE
151	39273	26387	3BF09	1AF9D	37D3D	1A42A	09DE7	05D2C
152	3ECE9	380EB	2DD42	0F762	3D03E	1A53C	0687D	002A2
153	2ABB7	2FC33	234C2	1E30C	2DE4E	0DF46	1B022	0F06E
154	33D0E	2861C	2F481	0D8E2	3B345	18AFF	142B3	13ECD
155	2A691	39F50	3907C	18306	2999E	0826F	0F5C2	1C1E8
156	3F10D	2E86C	35EAF	0C23D	30BBF	1C939	142A2	1D1AE
157	30888	334D8	2F54E	095C0	22591	0A2A9	03575	07E27
158	2C05B	3A3A2	2B9E1	043FD	26767	0B509	152FC	05B3A
159	3F536	363C2	39C31	0A348	3EC9C	074E0	1E6C9	0A359
160	34212	2B602	25538	1D949	3110B	09D01	17649	030E5
161	27DA4	25283	33CB0	00F26	2F77A	0428B	19C1F	03A2B

Table 657—SA Preamble for $n = 0$ (Segment 0)

162	29516	294A8	34D82	03B87	27025	03C98	13676	043DD
163	212A3	2BEB5	3A929	0EEB0	3C43E	18D49	013EE	07B2A
164	327A2	265B8	3E069	0615E	23B65	085AA	077FC	18161
165	26BC6	2D590	3213C	16691	20E7E	13460	1E439	079FB
166	353C0	26830	305A3	057BC	394DA	192E4	0F382	0867E
167	293AB	20EF0	22707	0816D	216A4	07B67	09B67	01B88
168	29915	2DEB9	3CE98	14D96	26F9B	15D4A	00853	1DE0C
169	36E40	3C7E1	3DE6B	0D335	39671	06EBA	18B85	07A81
170	36DBA	218AC	26D28	1BC51	37AF3	1635F	1B82C	0061A
171	33C22	3F96A	33645	05F3B	2AF82	16800	1630A	10F03
172	3EEEF	318D9	276E1	03FCD	34D35	05272	1B329	1D755
173	3D442	37142	3B3DC	1C93E	32C36	0DA72	05EE5	1D8BB
174	34B1B	2A7A5	2AA15	0CB44	3D239	08C8D	130BA	0BF9A
175	3E04B	3FF31	2B8B6	14832	2D5BA	01588	1F533	1FCF6
176	35613	2E44A	36AE7	186C8	2450D	00BAA	05F60	03973
177	2D44C	3C74B	21D8B	08900	21DB9	129AB	1C563	100D6
178	31176	2D23F	27D5C	11F23	23B1C	0803B	18D88	0EB94
179	3A4F7	3DC0C	3D797	0E67A	3281F	09BC7	03BF5	0F8B6
180	21F13	2DB72	2B9AD	10C4E	39523	1F841	07D9A	04F1B
181	26639	3613F	296F1	0B3F3	344F5	18059	175ED	0E5DE
182	3E770	2B61B	211C1	1AB8C	2BC76	1449F	09942	0F505
183	3548A	39519	3BC29	059E9	2AEDE	12581	0B2D0	0DC32
184	3177E	23D07	2440D	17B42	200DA	0C89E	16386	0B4D2
185	201A7	2797D	2A402	18C40	39516	042F6	1C339	0287C
186	37ED0	20BC2	20E2B	137F4	21262	19E9F	0A112	0C910
187	24EBC	2B01A	39C23	0A029	26819	02519	1694F	088A8
188	2EAED	3AFD0	364CB	1518B	2B3D2	1CA75	14337	1B365
189	2808C	3BAFC	2CDC2	0BFE2	20C06	193A3	1233B	14A7A
190	36EF7	37D4A	28F07	18BB0	2862F	09A95	0D154	1E3E6
191	33D1A	2C6B7	341BB	0CF28	2F438	154C3	0A2C7	15A5B
192	3F426	30FD5	2C7CE	07C50	2D1A0	06569	04B31	05FD0
193	303D5	27A8A	356D3	0FEF6	363EA	08562	0ED7A	175B4
194	3EC32	398EC	2CC89	0C404	3907C	1B759	1A587	03175

Table 657—SA Preamble for $n = 0$ (Segment 0)

195	39F93	30E4C	35A26	07AF9	3797B	0EB5E	1AFF5	1A672
196	2BAD0	2EEA0	21BBA	1B7CA	32264	0F0B9	131FA	0E97E
197	38127	31582	36BBE	1FE4F	25DF2	07EA9	0565A	1698D
198	3DC73	25F38	33B0F	04B20	3B4BE	0F73D	1D9DB	1029C
199	33FB6	2F281	3EB2E	0D90A	37AB9	1579A	1994A	1EFC4
200	3C0F6	3566A	3DFD7	14834	22577	04383	034D3	1D63E
201	32C8E	39FE9	25309	0E783	22ED6	14413	182D0	1D94D
202	36BA4	278F4	3E3FB	049F4	34B51	10EB3	0AF98	1A3BE
203	23E59	3AC99	221F4	0BC4F	31DD7	07190	01735	0CF52
204	227C2	2BED6	30C21	1CC8D	317EF	16B4C	1629F	16DC8
205	300C3	28EAF	2A68F	0E941	2C3DD	163A5	09BD6	05CCA
206	21159	3D839	2365D	0856C	20C00	1AFEC	0674B	0AF29
207	2DF8E	36078	3C37B	1F5B8	32D1A	1D705	02B88	13BF3
208	3A2EB	3CA5E	277CB	19169	37018	1221E	17283	06BFE
209	3663E	38132	3DDC6	0620F	331D3	1AD84	0B417	0A02A
210	3883A	3448E	221A9	0FB88	3D9BD	0B119	1F0DD	18264
211	296BE	28C22	309D2	0E577	384E5	0F074	04077	06E5D
212	39B37	36C83	3E5D5	10C02	3E880	18FE2	03D7A	1E433
213	392BC	282EA	237CF	08F89	35EBE	04733	0F765	0A2F5
214	2D434	3254C	2E816	1F529	20AD8	111DD	0B23C	0CEF0
215	27A5B	3630B	2FAD9	1DB40	2B485	1D5F4	0D95E	0CFEC
216	30B51	39851	2A1E3	0A6DB	28299	18837	06E57	10018
217	31FBC	2E171	3DD23	18189	29A2A	1F5BE	1027B	05C6B
218	3B7EE	3B4AA	3A6D1	1063A	25E5F	17B00	01626	0FA77
219	2EB6B	27CA2	2A739	108DF	2BC9F	0DC9D	18257	0E2C3
220	305AC	221B1	37F7F	0777C	20BE4	12BB5	12E57	0794D
221	32ED1	2E012	3C456	08DCC	28693	17865	11892	1F6D4
222	33A3E	3EF38	29619	12828	2F785	0D1D9	02A7C	19C4B
223	277CA	2BAC3	20F0B	0E3CF	3E30B	17CF2	0C66F	0670D
224	38EB9	2027C	3D0AF	19FAD	2D3DE	0FEE5	1C843	08902
225	21C7F	2029B	3BED4	1E1DE	36F6C	0DD85	165A7	13637
226	2A986	3EEAF	2E182	164AE	26B0E	0FE0F	1A485	0EB33
227	38177	2A44F	2B222	0CD6D	32C15	06B95	14D30	00E7A

Table 657—SA Preamble for $n = 0$ (Segment 0)

228	263A7	2F3E6	25C44	0D315	2C3AD	02353	13F61	16CB3
229	2A956	36F67	21791	14004	222FC	1C91B	02ACD	1DB09
230	2683E	3C516	290C7	18FFB	3AFE5	0C2F0	1CE5E	19B14
231	3FC36	39DA0	3AA4B	1243F	34FBB	09428	1BD4A	01927
232	23B36	3BA46	3D433	126CA	2F152	116C0	1E5B8	0424D
233	36725	3CD2B	24DD6	1AE63	321E3	1B63C	11D51	1F7D6
234	2D676	2F5D9	20324	11DD6	385F5	102D3	1D57A	0B0FE
235	3BAE9	36BC6	3E739	1BC41	31F1C	1FA27	12283	15721
236	25694	38D83	32268	14404	22C82	02B1F	14CB4	083D2
237	3E56B	23886	3EA38	0E52B	222A9	1B3E9	0F81E	1D9FD
238	30C8D	363DC	2AC53	12A7A	3AE50	11773	10491	05FE3
239	256BC	2DE49	20E69	10B0F	34A04	00655	12081	02A03
240	32289	33BC0	2553F	1DB8B	2C5C6	006BA	13963	0A787
241	2802D	336F6	2071B	1721B	23280	06D85	1C75C	18167
242	3AE04	212E6	29BF9	09B13	307AF	187AE	04EAF	00B52
243	22A6D	2BBB4	36270	12ACD	32C83	1CA49	0E821	0961A
244	228D5	2CF29	27DDF	12B25	3E57F	1172C	033D8	04713
245	23A41	354F3	30484	18145	3B17E	1EB32	0DBD5	0BF01
246	294CB	26FD8	3B034	1463D	3073F	01A3D	0AFCE	17661
247	319D3	2352A	2430D	099C7	3F840	07E20	138EC	0AA70
248	3DBE9	39A18	358A1	16567	3E3F4	0580C	051CD	0C072
249	2A925	314AF	205D4	02BE1	23C2D	0D41C	11E20	116C2
250	247D0	25515	2C6C9	14805	2BF9E	10CDB	1E2EB	130FE
251	390A5	2C3BC	3CE8E	04720	28D78	04B30	08FF7	01079
252	29329	3F13E	30A30	010EB	263A8	1A23A	0178B	1D231
253	3B888	37156	2C7D2	10C79	3FF07	0E112	06A42	08313
254	3D8F4	3F7F2	24F25	1651C	24A73	09BBA	064D3	0EAE1
255	2A685	3DFFB	22546	194CC	3DEE3	05C53	115B6	1A57E

Table 658—SA Preamble for $n = 1$ (Segment 1)

Idx\blk	A	B	C	D	E	F	G	H
0	3DE61	1D68C	3F93E	284F8	1A7A2	0291F	32D3D	0C517

Table 658—SA Preamble for $n = 1$ (Segment 1)

1	1	36285	00A63	28CDF	25B91	1B188	15A9E	3FB6D	19C2D
2	2	26993	11BE0	3509E	2142D	159B3	05CD7	386F6	09B61
3	3	21514	14E4A	2E34D	35180	020DC	0F1DB	21E6F	10B6F
4	4	2587F	16929	275BF	2E1F6	164F8	08A48	2EAFD	14BFF
5	5	31A34	1D7D1	22D1B	2BFCD	16DE0	08590	27BF4	1B953
6	6	2E459	0E55D	2390F	388FA	19995	16995	28649	007A3
7	7	307E7	168A2	2F0D7	28918	00EFB	1A0CA	3CED1	0073D
8	8	3664A	1E9A1	35813	2893E	16B57	10D7E	323E4	0D7E1
9	9	33DA3	0DB4D	2F6B1	35DF7	0B179	14E40	358C9	15848
10	10	25BD2	0BD61	2E819	214E7	0A5A6	101C9	34986	00034
11	11	34700	1FDF4	2F2F4	22D49	1942E	06320	3ECF8	1C4DA
12	12	30313	0A962	2B0C2	3F3EF	01F6D	02A46	397B7	03D4D
13	13	256DA	0E6D2	341B2	30D48	03EED	19FF4	370A7	0C589
14	14	2FB71	1EB99	22873	2E59D	05BDE	1BD03	3CBEF	0379C
15	15	2AFD4	1E1B6	2213A	3BBFA	06ACE	00236	3E497	15EC9
16	16	330BB	1B8DB	39BA3	29535	15253	19EEF	296C8	1CE92
17	17	33C76	09601	287A0	2F666	1EFC6	05F51	3E6DB	1954B
18	18	2E54E	0F88A	3714F	3950E	02C6D	0E8D8	282BF	0DFC6
19	19	343CE	121FE	272D6	37D3C	15BA2	0B002	3545D	15D5A
20	20	311CB	0A807	29A20	376A3	02CE6	1C1CD	24395	1E43F
21	21	36736	1A9B1	30D8B	3DC72	1AD22	0600F	36EFF	0E2EC
22	22	3817B	1FDD6	361A7	34F1F	148C7	1C567	2FE84	1A4FB
23	23	2EB02	0248E	24720	3DB83	171C1	09614	22F4C	1FC6B
24	24	3FA4A	110F6	24436	3AD07	18881	0CBCC	2C1F5	1748A
25	25	23FF7	1BDB2	35550	23B7A	117E9	14B80	3B0CE	0DF95
26	26	2EF08	14FA1	3DC93	3DA90	06484	07462	3BCD3	076F4
27	27	37484	1375F	39488	23A1C	11133	0096F	29138	05B8D
28	28	35369	078AA	3A9FE	2AE4A	18CC3	18C01	29766	04CB3
29	29	30673	15DC6	39890	291DE	185B2	14ADB	22FCD	0D7C1
30	30	30B93	17301	30CE4	2C5FB	053C5	05386	3BAEB	0F78D
31	31	28BF8	1E6F9	2814F	29ABF	03EE6	0ADFD	3022F	1A107
32	32	2D1E8	15B08	378B2	2F90B	02D82	049E6	3402D	11543
33	33	24FBA	007F7	2E7FD	3153E	0A818	06A2A	25234	05A11

Table 658—SA Preamble for $n = 1$ (Segment 1)

34	3710C	0B68F	38105	215A7	1C6D0	0EE92	28545	054F0
35	28269	1DFB0	23CBA	23B3F	1A9EE	19CAA	241D9	12FBD
36	2798A	1AFBB	31DA8	28D32	04AA4	177EC	2B016	1F5D4
37	229DC	0A561	24989	2A118	01129	10F4D	3CC78	1E8A2
38	3371B	1DFCA	3EB98	304EE	0A295	0D2D2	357DE	1DBF3
39	2E40E	05BAD	3AD73	360A0	05A5A	015DD	3443B	0D524
40	24750	0BF9B	312ED	2E948	1826E	07B14	256A9	1AFF5
41	31BDC	05F21	3EA13	25B07	1C998	0E8E5	3D5D7	10395
42	2A1F2	046FE	33530	25276	10E6A	07CD6	39B27	0D826
43	20C09	13470	2D5F0	35A43	0D39D	16F71	3E86D	1B6E7
44	22E00	166A7	2FDAE	2A1AC	19108	0ACC6	2B9D3	00D9F
45	3606F	1BC39	3D038	25394	07DEA	06102	294E2	19357
46	245D0	06BCE	2073C	22B2F	128D2	12876	310E7	09FAB
47	3962A	142AB	20A26	26732	1B9FC	04DD3	35EF7	1A0B8
48	22964	0B693	39604	26111	1BB07	1D1AF	253FF	10BE1
49	34861	021ED	24CEC	254B2	1A260	0C50F	3A43E	09CE2
50	307E1	0965F	2B944	30378	060A3	16910	2A48D	09B22
51	314D6	1DEFF	249D3	36A44	08C5B	0A2F6	3D4FC	0B6C5
52	20902	09D13	2E07A	370CA	03ACF	0E3D0	219FA	1B103
53	26882	0F8CA	2514D	383B9	08213	11440	2E85C	0DF1B
54	3BFDD	14921	3AAFE	2BA0A	0F0EA	02629	2AC86	00E86
55	2602E	0E0F8	3CB25	2A941	0594E	0DBB4	2423D	1E335
56	2FB5B	1CE76	22CFD	21E72	1FDA5	0AA3F	2DD0C	0C70B
57	2CE04	1E2E9	2725F	2C50A	03500	0AC24	326B1	03663
58	3E92C	1185B	3694E	2A601	0C9EE	0B5B8	319AA	117F5
59	2C30C	1B95A	3DBF4	3DCA5	0AE4B	03219	31F90	0F3DE
60	32834	0103B	2E799	26133	11BD5	04B5C	31008	0A59F
61	3E532	061F7	2DC4B	22080	1F20E	12E0A	34451	0D861
62	39C85	1A67F	2A598	38A9F	1F6AC	1BA19	35732	1A451
63	27373	0CA57	37284	20A1F	1D368	178AC	31B8D	0F1F6
64	296EE	1D167	213FC	27FD6	09267	13D31	3FC1C	0DE3A
65	25B2B	0CFF8	24591	20ADA	085A8	04CF9	3728D	164EE
66	22A30	10901	3CD79	3E75E	10581	17FCC	3300D	0BE96

Table 658—SA Preamble for $n = 1$ (Segment 1)

67	28140	0E27E	39C66	2C3A6	02D0A	1316F	30D38	122BC
68	358C6	161FA	3FC97	2EAA7	02AD7	191DE	29C87	0176D
69	34701	0DB7F	3CD49	2C2F0	0DEAB	08F30	37756	18CF0
70	3EF22	04EA7	2DA56	268FD	133AD	022E8	323E1	0EBFE
71	3E9D3	08D7C	3E606	25F3F	1D86E	15980	2B37F	17556
72	346B9	13509	2E813	3ABB9	09DC1	1BBC7	2EAF5	13084
73	376EA	06883	3F515	23F91	098EB	014B7	3112D	1123D
74	3EFE0	01E3C	3E307	3DE98	1D8EA	0B2B4	39905	0FE98
75	365DA	1F855	273AC	33374	150CE	1FA9B	390AE	1EBEF
76	2D460	0DAD8	36D3F	2D6B0	0FA61	0AE1B	35450	11A3E
77	2F7BC	0C543	33470	286CE	0E64B	07CBD	2BBFC	06C45
78	3A99A	0CD00	2B682	3606A	0FEAC	0C3C0	393AD	09A8A
79	31D00	07820	3CFB0	29F90	0FF2B	0C9A9	259DA	123F9
80	312DF	04936	2E7B6	3AC02	10D13	078BE	2E4C7	0049D
81	39DD4	102B5	3E9F3	22C86	0EDA9	18D4C	306BA	02F98
82	2E776	03F2D	3BB13	39760	12CFF	16558	25B76	10CDB
83	24D16	108B0	3BF31	2A6D6	1CA87	0E7AE	368C5	106C7
84	3EFA1	06614	2FA51	26DCF	10D1C	149B4	2C60B	0E367
85	39DE9	0DE4A	234B9	20EBE	048B8	099FA	2ED09	1C23B
86	293A5	126A7	2009D	309B1	1E446	1A680	3C92B	08C0B
87	37E7C	16D7B	2AF4A	33FEB	09DAC	082ED	35A8F	08DE3
88	28B84	0422E	24553	30BD0	04E01	0424B	3B692	0515B
89	32615	17646	2EEEE	38005	0047A	078A4	265C8	06D23
90	2EB55	09A7E	3D35C	333D9	0B20E	1EA5C	3ED3E	12EEC
91	22F00	08260	26C2A	2658F	1279A	12E01	24075	1C8CE
92	3AF2D	0AE85	3E5AA	38126	1E444	06662	2ADCF	1CDE8
93	24B62	01D25	2EAF5	31E46	171AD	03E40	277ED	00CE9
94	31ACD	1A548	28093	2A1F0	14DEE	1C8A0	240FF	0DD89
95	3660D	07637	26385	3DD6A	08F2F	05776	3ED34	1CC67
96	3B6CF	14198	35C5F	373DB	00685	014F0	2F118	112C3
97	366F2	1FA53	2879E	24937	0C179	1D39C	2BC63	034A2
98	2F3E1	109DF	350EC	302E4	16F17	18A51	21193	0AE3B
99	3AF3D	196A0	32113	3504B	09C25	028F0	35AEF	19E8F

Table 658—SA Preamble for $n = 1$ (Segment 1)

100	3F4C4	19C69	24B08	255EF	03E6A	0255C	2D6E2	04241
101	21008	1077A	36450	2CFBD	09532	11622	3E92A	18BD9
102	240DD	03C50	27B25	38BC6	1AFD8	06D0D	38B2C	00450
103	369D3	161AA	2743E	20141	03792	00A71	3CB87	0A329
104	3E83A	03A44	375E0	3392F	16945	1B037	37D70	01DDC
105	3386D	1FAC3	28C44	3A4C2	197B1	07777	3E248	19EFF
106	3C21D	17E99	3D86C	302B3	184B9	03B38	3F8EB	0DA39
107	229B0	020D0	2227F	28C79	04679	1C6BB	27467	1D1FF
108	34413	1C4B3	3F94C	39231	19106	1FF99	2BA58	0F04D
109	352AD	0320B	248B8	2566C	1BF4E	05740	3BE78	1009B
110	2A628	07BC5	3C884	3D8A2	0E013	11687	384D0	1A104
111	3FB8F	07CDC	29ACD	3BA98	0F189	1FC9D	37345	07088
112	318E4	17C41	3B1CB	29D4A	07F98	0E7A2	3F5B8	115D9
113	3F797	0FB8D	3665B	2B679	1A431	0AEF5	244E2	12303
114	2CA35	0B287	21666	20122	0B4DA	1FBEC	2CF43	15726
115	2BE49	041EF	3ABA1	2862D	0D527	1E55C	23FC9	12981
116	3633D	1FD56	3C2D6	25FBB	0AD34	006BB	29D4C	0BA3F
117	34404	024E0	24BDB	22685	1CDBA	194C1	2BC8A	0771F
118	24DAE	11B42	260BC	266DF	060A9	0394C	2F742	1E584
119	33EB7	0233F	2E074	2EA35	0CF5A	09FE1	30419	1228C
120	378CA	02875	2C3DF	3311E	0CDC1	0CB5F	2FF43	192AB
121	2494D	13AD1	3923E	2A89C	02D83	1D898	2A8F6	158A6
122	28E88	1333B	306F7	24480	1838E	1EB20	3B6F7	0828A
123	282D1	1CC42	3E337	2FB36	003C0	14248	3DE5E	1CCFE
124	24920	099EB	2C675	26A44	13056	1FD7E	38B47	129D1
125	3A39D	10203	30208	29CA3	063B3	1A47A	3F2CF	02E47
126	3D536	19BCE	23E62	23191	16B3D	195E0	38679	1B239
127	2044A	18140	30469	258E8	06121	1022F	31FF9	0BB0D
128	35E30	16314	3DDBA	2D5DF	0BA1F	0A7AE	20669	0C796
129	3CA63	01756	3D4BF	22220	19314	142D0	2E4CC	03A70
130	38537	02FE4	2FE3F	2F5E1	0F37F	09109	33865	17DC8
131	21867	06958	2F8D4	2BC99	1EFAD	0A59A	36201	0EABB
132	22A36	0F7FC	384EA	26D3E	16BD9	1B616	25A51	02289

Table 658—SA Preamble for $n = 1$ (Segment 1)

133	3A076	06F56	39B85	3D25F	10C10	199E3	204CA	03620
134	3FEB8	13688	226E3	230F3	0A899	1E048	3094D	04883
135	2A0F4	05CC4	3ED27	31C35	1D6A0	137CB	208DD	18168
136	3AF47	1CC8A	3AC9C	34B44	0829A	00E9C	2840E	0F2CC
137	334F7	06AE9	2043B	32FCB	0E9EB	0CA81	35029	117A1
138	34C2A	132EA	2CE09	3E6F6	062D3	1DC79	368AF	10B82
139	2BAAA	0793F	23270	3250D	1C7DB	06C5A	29BFF	00EC5
140	30F0D	1C98D	36E94	2180D	07B5B	1D926	331CE	068BF
141	329E7	1BAC9	2B448	32DA1	174E4	1FB45	23FC4	16EE5
142	257E0	0069C	37B52	28E8A	109B3	12C4F	39340	0394E
143	205DE	1AD67	2077D	32D4D	0B5BE	180EC	20567	1F197
144	2E190	11CA5	335D4	21416	19B80	07568	3CD3A	01521
145	2ED27	07116	2CF0B	30129	0677C	1FA68	3984A	0B8DD
146	3B200	0BB19	2E3C0	2CC17	1838C	02BC2	2D213	1C369
147	2124B	0A53F	2776D	35406	19E4C	0390C	28E2E	0E6CB
148	20B57	1F98E	37E6D	3B07C	02788	14BB6	3E382	01369
149	38978	00F06	2FD86	27C39	13ADE	0D7FB	33632	166A2
150	3BB43	1EAEE	3A3DD	30A9F	187A2	1C45B	2DC21	10BD2
151	27653	07913	2176E	359A3	08912	167F3	39CD5	1D4C9
152	34711	1E35A	309F0	2139D	1A6CA	0C1A2	28076	1DF97
153	3256B	0EC3B	2B11D	2FDA5	11C87	1C1FB	210D9	128C3
154	24BF6	1D5C5	37865	2AFC0	113A0	13E44	394D5	08322
155	288FC	03FED	23860	29173	06772	15A1C	2525D	012C2
156	2FD29	13C5D	35BF9	341E1	07701	0D2D9	253FA	0CB5C
157	39E97	14437	26B4A	3731E	15045	120A5	29818	087DB
158	34597	0C9F2	255B2	35B9A	1622E	15B1A	2AC64	073D6
159	254D9	00377	21F37	2A77E	1F536	1CF18	32881	06728
160	2B985	0BA0C	3DB3F	257F4	02D67	00845	2BD42	09FDB
161	3E8F8	06ADF	24CB1	28F4A	18202	1206B	3C794	008BA
162	25082	02855	2596B	3C457	14DE4	098FC	21330	1A32F
163	271E2	000AC	39C51	2F6AC	14B30	0894C	3314D	1DAE5
164	3D944	07E90	38BC2	3F712	1585B	0AF76	2981F	1DE96
165	37832	16524	33AB9	2ADF9	0F89C	102AD	2A464	1243D

Table 658—SA Preamble for $n = 1$ (Segment 1)

166	253FB	1731D	31BE5	2B14D	02E12	16CBB	36C51	1A89C
167	3BE59	05D23	26D53	31EC2	15C14	0EA78	24138	1177B
168	21DC2	10C52	3F4AA	26077	0E53E	11843	36AEF	15B02
169	2517B	1A748	20E34	2732A	084AE	03FD9	22A1F	098C2
170	26DB3	04C63	2A4F0	383B2	0B55B	1C14F	3F808	07B0F
171	25EE4	0D1BE	36B8A	37135	1B633	1F10C	3A820	07015
172	2C73D	0E934	3BFCD	3188D	02F91	165D1	2F662	1929B
173	28A11	14882	279FA	291CC	1D01B	02C98	237A2	153EB
174	3C2B5	0554E	2C358	313D7	156F6	0AB48	3904C	06A1D
175	30C48	071F2	2A5BE	2CDF5	1A8EF	1BD15	3C530	05CE3
176	34D95	004EA	29D7D	3EA66	10564	0CD44	304FE	163C3
177	21E43	11A4B	34F42	2898A	1B395	125F6	24EA9	1E627
178	39063	18BC1	282A8	3FD9A	1A7C7	1808B	3AA6C	14735
179	30648	16687	2671A	254E5	0112D	0FF65	255A0	03C1B
180	21F55	03854	353EC	316A4	0133E	02079	22A73	0EC0E
181	23572	165CA	39533	2405B	1A114	1C3A4	2546A	1B18D
182	3D2AA	11FE8	2C7FD	200A8	02BB9	149A9	3CCF0	198B7
183	35E0B	14116	24963	37D87	07156	17AC2	28786	1B62A
184	3953E	1A39A	277B0	2BD93	09809	1F4A0	3F9A5	0401A
185	3DB95	1EAC8	343FC	2574F	05F70	04986	3767F	0A050
186	398DE	18D5D	2E3C4	2E9B6	14E7E	0EDFD	26C83	06056
187	33562	17906	253C1	3D8B4	02827	0CC80	22A9B	18F77
188	3A364	169D9	3C4D3	3EFFD	11C6B	08198	33246	0D0FB
189	24976	118D3	206E7	300C4	0E6CA	005F4	22919	0291A
190	299B4	02F7C	3393D	3AE75	06F60	04672	33535	0F7BE
191	30DE1	19869	210B3	2F70B	086B7	043B2	3CF9F	161BC
192	280A8	173CD	2303D	34A0F	1D6A4	134C8	25899	0021C
193	3EF59	12B45	30337	3F128	13841	08046	29D2C	055F1
194	27F7D	08BDE	20338	25DF3	190E9	0AD8C	2B156	16D05
195	39366	1745E	3043A	319EF	0B4D6	09B7A	261B0	0BCDA
196	3C271	1E26B	3D8C9	242B1	08C3F	09A1C	2BB76	17902
197	34D6C	07673	230F5	3F45B	1256A	18074	33FF5	00719
198	364CC	0DA4A	26F02	2AC5A	0F065	0FF14	3F474	0E1C6

Table 658—SA Preamble for $n = 1$ (Segment 1)

199	356CB	1DC95	3B8FD	27A1E	0FD5B	07CC0	395F8	0B359
200	2B9E9	03FBD	3B0C9	27A95	07A37	0C1B3	3055D	0A686
201	38156	1190C	27854	3BC4A	095B7	09F43	2E217	01A3F
202	22BA3	1FD50	3B843	3F722	0F5C3	1D8C5	3DB61	12039
203	371D8	0398F	25E2D	395AC	16478	09154	2595F	11488
204	2622C	123D6	3AA1D	3ECCE	0D810	06748	281B5	109BE
205	30979	0C55B	25003	2CDFE	19FA7	1681A	2D564	0F8F7
206	2E4DC	12A50	23BC8	36ACB	096AA	0A3C1	2F27D	10943
207	3B4B0	019A9	2AD95	225E1	0E26F	0C378	2E601	1DA58
208	2F4AE	1C3CC	36B26	2BB6C	0F630	164C6	38D70	08A9E
209	28147	0234B	2811B	2CB1C	05601	17C77	20748	06CEF
210	2F89C	17831	2F86D	22101	15A25	14940	357B6	0B3E4
211	3BDD8	04B3A	2D6BB	3F73F	00ABF	0D7CD	3657E	1AA5E
212	219A5	1DD04	35001	3CEDF	1B278	1B701	32143	13A8C
213	3B48B	03BAB	3394C	38DB9	02926	11E14	267EE	0ABE4
214	22F83	0B390	2277E	30DDE	046FD	02D8F	35E1D	05A31
215	2E3D5	1401D	26F7A	205CD	0FEA6	1939C	3C062	1E42C
216	22B4B	18824	2859C	2BAA8	1B8FF	05FA5	27766	1C5C8
217	3421D	08B0C	22107	231AE	13493	1001B	27B91	09620
218	322F1	196E0	20111	346FC	0325B	1D468	3300C	19E52
219	39D2C	056A7	27BC6	2DD02	18722	02C6C	3A61F	10368
220	32401	06AF3	269AF	2F3E4	0CCCB	02BC2	2C0BE	1D2B6
221	37406	02024	2E061	3BDF4	13AD1	1E6F1	314FE	18158
222	2247B	10D73	38D38	2CC0A	17CF0	124CA	26C0C	1490E
223	265CB	0DB51	2E1B0	32941	0CCAЕ	0717D	38E73	00759
224	385E5	15E19	36884	2FF8A	03F8F	02715	28E23	0A1AF
225	37C13	10D6F	39A39	2B8BC	10127	01BF7	2BAB6	0161F
226	20303	0B5AE	37630	26B00	1965E	12562	3E946	003B7
227	32F51	0FFC7	2D8DD	32354	12489	1B2F7	39A08	071AD
228	2650F	16C74	3FA21	27827	11667	04029	2A549	11446
229	37CFA	047D3	3F308	277EC	05948	11855	3769D	121A2
230	24970	0FF6D	22427	3E7C7	1D744	0A4FC	3B8C7	12F63
231	250AE	1F347	21476	2B5D8	085C7	1461A	26F8F	1CFA7

Table 658—SA Preamble for $n = 1$ (Segment 1)

232	2F669	0880F	34561	32D5F	1B8F4	16DAC	205EE	0A146
233	23A6E	03B8F	2D08A	34776	0AD38	1662D	233BF	151C3
234	2BC37	03F55	365D6	33FAE	17B48	1DEC4	2B37E	1A930
235	2E22C	0CF00	23825	3B2B0	137EC	134B9	3F94D	0DFC1
236	2F53B	0D023	33CDC	24C13	037FC	162C7	2F7C2	01248
237	389BC	1A160	38D44	2403C	1BFC1	08E7D	2E68A	1EFDB
238	24F2E	1CF17	3756D	2A4B8	0CA15	16A2E	3B10C	0D5DA
239	3EF75	0E914	32579	3EDC4	1AFB4	13672	21A11	1A31F
240	25A10	1093D	340CC	366A1	0F873	01352	30AC4	1D003
241	35D62	13B38	3A407	3B493	13517	0A8C5	2F445	07498
242	3FD13	1057E	29985	222E1	05849	0CAC1	33BE8	00531
243	23C5C	18E44	3EA36	22968	1E739	06109	3826B	09227
244	2E50E	1A629	357A4	2C9E0	1B31E	1FFC8	3461F	08A13
245	23A44	01E60	2D404	3BC99	10B43	07111	3255C	1A154
246	3E251	170F6	2AA9C	2E887	1A30A	01E7B	2A40D	0904C
247	3E463	0C53D	39020	38699	0E90B	1195F	315D9	153A8
248	26E19	1405D	34F78	2137A	050D8	06F04	3AA81	1E4F1
249	32F3A	0A200	3C505	26BEC	05704	15ECB	3D3E5	09CC5
250	3845D	0B06F	24DDE	396C3	07CE5	113E2	31380	01DDB
251	29B5E	19926	265DA	3A670	1A302	17DEE	25ABA	0F8C4
252	25A01	10ED0	2D09B	23516	19541	0D902	29DC8	05128
253	36079	163A2	33641	265FA	03405	08E98	2F21C	0C649
254	382C7	02E73	26C56	2E9B9	1E4AB	084B6	2CAF3	16E1B
255	391F6	0816D	2BE01	26786	039DD	1EE58	22B5C	04585

Table 659—SA Preamble for $n = 2$ (Segment 2)

Idx\blk	A	B	C	D	E	F	G	H
0	11048	24A62	36507	1CBE0	0C404	3F968	0AEFD	19F7B
1	1F1DF	23C78	3284F	1D5AE	1CA1F	24F41	1DF44	09AED
2	170F6	3EE4C	3D95C	08B2D	1C311	235C5	1E821	1C9DE
3	1ECAB	3D262	3EB3A	0517B	19970	30017	09A59	16830
4	0F18A	3061A	37A13	09655	09C24	26038	062D7	01385

Table 659—SA Preamble for $n = 2$ (Segment 2)

5	00987	29615	3F235	118AC	165AF	3A91A	0EA89	0C898
6	19787	2F080	32455	06BB5	03570	2D514	07FCC	071B2
7	19732	3ABB3	395A4	176B6	1D955	270B5	0274B	19387
8	03A43	2E4F4	292EF	111B0	0459B	302D3	022C0	13880
9	1A1A9	3D34C	2C538	0DE15	05BA6	2F163	131ED	00B7F
10	06772	275E0	3CF0B	0CDBB	1ACD3	3EDA1	0F8FB	08EC1
11	15AE7	28AE5	277CC	1A068	079FB	3F976	07C5A	122F6
12	1FC80	273E5	3E4E3	019B7	09A9A	38926	1AAC7	1F994
13	1FD66	3B014	3A5A5	0052D	1D998	21C22	02C16	13C33
14	145AA	2F906	2580C	162AD	0601B	37A34	0F877	1D023
15	13A1B	2F64D	3744B	0F151	1FA9E	39485	03B47	04C1A
16	19DF5	2454D	2793E	00F4D	18E12	25CF6	18A2F	02709
17	16A84	2EA7A	3F4BA	0E91C	1EBB0	20CBC	07064	17EF0
18	103D3	23C1C	31831	182FF	11A8C	3046E	038A6	0BEA6
19	1B1A6	2968D	358C9	082CE	08F0C	2FCFB	07FE8	0B227
20	0F69F	3B45B	243D3	1CCAA	0E616	38DDC	0E757	1D280
21	09A84	3304E	3484D	1BAED	0B411	234DA	129A2	0FEC0
22	0CB83	2E2F5	3D831	0A070	19D79	28B27	1DA1B	05D92
23	0EC60	3A34F	277C3	04186	1B347	3B365	02275	0735C
24	1B697	2C08A	3F321	1CC26	1227E	395B6	084F3	15BDE
25	0741E	2802B	2BC10	18853	11A0E	21458	137E6	17560
26	19699	344FE	28642	121CA	1594E	2F9EC	183F8	036A4
27	1E317	2D2C4	3A5CE	09D28	0BBB0	382E2	09749	09CA2
28	15CE5	339EB	21EF3	0EE52	1E828	330BA	19B90	1C186
29	16EB2	3EC56	2C5C8	0422C	0D9D2	3B04B	1F28A	1607A
30	056ED	33BD2	32880	07AF4	1FBB9	21E74	1B4B2	1F6F5
31	1C931	30A46	24E25	11E61	0D7E6	25133	12571	0DB80
32	19E2A	21B45	2D4CD	155C7	0879F	205E6	1CDCE	1E2A6
33	0DF04	293FB	26E2F	0ED2A	0BE1C	29315	157BE	1D829
34	03766	33BFE	34998	03E43	100BB	3C78B	05362	19777
35	113DE	2A53C	3DC44	1272C	06071	30DDA	1F114	1A2C1
36	0013B	33D94	34DC6	136B3	1FC17	3E813	1871C	14457
37	0E29E	3BFA7	24757	1C95F	1910B	29ED2	12E5C	18195

Table 659—SA Preamble for $n = 2$ (Segment 2)

38	15737	20ABB	3FB12	17A64	1FAD9	23CFD	1D309	0F242
39	0A618	299D1	2BF1D	0CF4E	1DF4C	382D2	0ED65	0A4C0
40	0DED1	271CB	32C02	1A41C	04543	2A88C	1CD46	12915
41	03BCC	2EFFF	21321	152DB	112C0	30F23	1F8E8	0B55F
42	0664E	364D3	3E0A0	0977B	0D71B	2F023	0C789	1DC85
43	043D4	3BCF7	245BF	1D861	1998D	3A107	178A1	06F35
44	11092	298A0	30BEA	18DBA	0FCCE	371EE	1175E	00898
45	1310F	3BB88	3C568	1C534	09630	2368C	0B106	03406
46	18B26	3FCAA	2A50D	0A656	09D40	3A1DB	1A029	17253
47	1D3BF	3E415	2C682	1D715	0BE9A	26049	1FDBB	0768E
48	1DC01	33852	3D1F2	1E24E	0320D	2E690	1771C	02723
49	17045	2F474	37739	09286	1EF82	325B7	00D7B	11645
50	038F7	26A2F	267AC	1B8BD	172E4	2C907	0BE97	12E7A
51	16136	2A4E1	2233B	07C61	16AC7	390DF	0FA7A	0602F
52	1F78A	24E96	3366B	132D3	11EF6	209CB	0DC4A	0F88C
53	179FD	206D7	34F66	01447	09C27	2DB5D	05A7C	13C09
54	066B0	35257	21C65	0C536	13891	2FC0C	100B1	0639A
55	18E59	28F18	24173	0EE5E	18626	2BE92	13A37	1AADE
56	0209A	3CB47	26D53	07183	169DD	3BCEF	01ECE	1149F
57	0832F	22B7B	3D7CC	186FE	0558B	3E160	14BDB	0B1EF
58	1C89A	3E50B	35DC3	1491D	057FD	2D86A	081C2	17EA3
59	1C137	30ECE	2AD5B	0776F	0E512	20898	133C0	0EDB7
60	1B94D	2FCEC	39021	10596	1538E	232B4	1F6B9	1BFF9
61	18D8D	3B8C0	347EC	01366	1A623	3EB7E	1641F	0AF2D
62	157CB	3E0DE	35E53	1D121	1BB04	234FE	09386	0E862
63	06A95	24995	206AE	0BFBB	1F94D	23748	171EB	1F27F
64	1FCA4	297A3	276CB	00DA0	14DDA	30D8F	1D45C	1D168
65	0C5BD	2C183	2A3F3	08C52	101DC	2BD0D	1A937	1D92D
66	1E382	2F05B	3C007	0699C	0EE34	21215	18B3F	1CEFA
67	1192C	22B08	32C21	00FD3	04FDD	33AD7	0FD84	11F7A
68	0C54C	2033D	3B24A	0840D	1A93F	20C21	14DAC	03EFF
69	1788A	27A53	22DF9	101C9	1E440	36F51	1FAB1	03367
70	1B07E	35C66	3AE1C	168E2	09D6D	27E4D	14104	1BEE9

Table 659—SA Preamble for $n = 2$ (Segment 2)

71	0D98B	233D7	21EE6	04C0D	0523F	25D19	1ED13	02DAB
72	156E9	3815B	31253	194E0	0280E	30B98	15038	0C322
73	04372	2BFA9	3231D	07979	07454	39F6D	178FE	109F6
74	14A87	246D5	33521	0A7EA	179BE	3D9C9	0D37B	1EE78
75	0A82F	20F96	33637	1BDD6	1C436	2BC28	00037	0451C
76	0F7AA	21059	29E90	0C8D0	11A01	3988E	0465B	1E5A7
77	17D8F	29976	3DE5C	1AA2B	0EA83	37327	1648E	12764
78	01597	35CE6	3848C	135EC	04F5B	3C98B	05781	0B1DD
79	0240E	253DF	37C93	0860B	1D887	38F8D	0A615	0F447
80	06B62	20EE8	2C93F	0E632	115E4	33DAB	02855	01611
81	06A7C	3BA96	36B28	1AC4D	079DA	31153	1D461	05107
82	07A69	2120B	3D362	01237	02B53	28FD0	05CC2	109CA
83	01EA3	3688F	3E197	1E83E	09A54	35ED4	19931	079AC
84	0E850	2E468	35925	1EE1E	14193	3BA41	01D46	15078
85	0B5CC	21FF2	2C90F	034BF	06C8A	267A5	0DEEB	140A6
86	12660	328A5	29BFE	07AE8	16A64	268CC	05D01	0D818
87	1E2CB	285C5	2150B	08AA4	0C730	2B1AB	093CF	108FD
88	08A84	281B5	238C0	1BC24	127D2	28441	14404	01F55
89	10E61	21D68	3FF0B	0A0B0	1A47F	255ED	1D2C5	0E636
90	051E0	2B82E	26D7F	03BA2	0A9FF	264A7	17023	0735A
91	1E141	2C6CC	39667	08061	125D0	263D1	0B75D	1E97C
92	06215	237EF	3574A	19E1A	19FC1	365DF	023F4	012E6
93	1C069	2BED7	3E914	1D5EC	0A30B	38112	14982	037D7
94	13969	2C2CB	31476	1AD71	03742	2FF03	06530	02F2A
95	1ED26	20588	23370	0EB18	1607C	309CB	1C7C6	140D0
96	0AC4A	355B0	3364E	14201	1DD8F	23E66	05C77	04216
97	040B3	39117	3ED45	13CF2	1951B	3E499	0C3D3	1B55D
98	0189D	30E7A	266BF	1A9BA	1F4B3	28486	04171	0F68A
99	07244	206FF	24F48	1353C	0898E	2EFD1	1174B	14FCC
100	13B6A	2CBC2	20940	0E077	1424F	3955A	02657	07EDA
101	05B25	28A31	2D861	1BB51	150EF	24CC8	05AF0	062EB
102	063C2	3093E	34CE3	02E24	0CAC9	35A6A	03EBB	146E5
103	1FA35	34739	265A9	0B386	1493B	3E167	0923D	15DEE

Table 659—SA Preamble for $n = 2$ (Segment 2)

104	01052	3805D	33C7F	03AF5	1FF71	2CE60	1B6BB	1D3A8
105	14175	20C29	204F8	0DA6B	0D2EE	3E0D8	1DF13	06DD1
106	07AA6	2D9AF	27548	1ECDE	1D2D3	3294E	00064	12771
107	03791	3B84B	247B5	132B4	068EE	2C374	10A24	14D0B
108	1B806	35593	31CA9	11FA6	0D4DD	29526	069FE	0DCC1
109	17D29	39A28	2B8FE	00B33	1075A	34D4D	164D1	041A7
110	08586	3B3F0	36CA9	1CAC6	0C0BF	3AFE9	1085A	0C9AE
111	02DA1	364FB	3D58F	14171	0C43F	35B53	193A0	0C26C
112	0AB83	37438	27EF7	15A0C	05FC1	2EED7	0DD89	1295E
113	067AC	33AC8	2E7F6	17641	1FAF8	2D4D8	07B32	181B3
114	1B066	26DDB	3D223	0734B	1B519	3E97A	10015	1FA43
115	0F743	3E35A	3F316	1DB26	09A96	2BE95	0E3D1	046DF
116	0C1E6	392BF	21419	18533	04906	328F1	14D4A	0174E
117	16103	3C42B	33FC4	02D65	1122C	38B91	05B8E	1691A
118	16B38	3C0B0	2761F	1FFDB	104B6	3AFD1	0B665	0C7B4
119	09774	2C9BC	210AB	08956	08E92	2C407	1C200	19E19
120	14BCE	2334B	2E02D	044D2	150BA	37A77	1CB8B	1287F
121	0D784	2ED81	33FCB	1CC8B	0D890	3C182	005A1	038B0
122	06D18	3F190	2EE5F	1B2EA	13FC5	2F374	14C09	09CD0
123	02FEB	3DCA4	2DC09	1BA31	01CCA	29CA8	0C8CF	16B89
124	0DF77	3B65D	38B1C	1507A	02C66	298FA	1CDE1	171C4
125	194B8	3E8BA	216C8	17C73	03BB5	2A2CF	003D9	17206
126	048B5	3959F	30E3B	055FC	1A7EF	3BD32	0D562	1836A
127	09EBF	31EB9	3CDC7	1B2C7	16F4D	33102	10F58	11DB8
128	036A6	3C0A8	3C372	0CFC6	03AAE	2D20A	12C9F	0DF13
129	049E4	2D1BC	2A708	1AD6D	0A69F	289BB	18C83	101C7
130	05B2C	23F00	22A89	0E5EB	1D730	34418	0C48E	10788
131	12319	21A1C	26014	13648	1B1B4	2C256	17AC2	13D3B
132	01A3C	399C7	35B3B	0B804	10286	2614A	13823	15928
133	16C55	33E87	30180	0BFC6	0C576	34526	0B073	16F00
134	15B72	26CB2	3D3B9	001A2	1A883	2679D	160D4	14EBC
135	0A0E9	23480	29E1F	17023	1482B	3FE1E	16983	0055D
136	1B9BA	27F59	29E0C	00961	03BDB	3364B	0AFFF	16585

Table 659—SA Preamble for $n = 2$ (Segment 2)

137	1BC05	33375	33124	1E592	19E54	3329F	14AE4	1CB7E
138	055F2	35A44	2CE25	08485	04CDD	35CF9	08C56	0452C
139	0BAFD	20C76	29E0D	117F1	033BA	2E290	18E9C	1A2C6
140	049CF	2C1C0	3D85C	1E368	036B6	2B011	0D1BB	171F6
141	0A840	38667	3E92B	0E68F	010D9	2910F	1E113	030CA
142	06892	3DD76	25D88	00F1D	0E2A1	2ECEE	008E6	13B1E
143	1CA4C	3CAFA	2C364	01853	05D53	387B6	058A5	0E07D
144	0ACD0	38315	3BEFB	1ECA7	0CF62	31392	063A2	14883
145	0E623	3EBA2	37047	189DA	01E2F	29036	04C08	1B443
146	136E2	37E46	31FF9	1C92E	0C33E	26294	04E63	177B2
147	15740	2B2F7	35831	13A94	10642	386ED	0733C	0C33E
148	0CF77	207A6	2FB91	156B3	1BFA5	22861	1A047	19051
149	1A731	2B6E7	224B2	13E89	0D898	3155B	0E9F2	1E29A
150	0A78F	3A367	242EC	1978C	1A063	21815	1765C	16DB5
151	11F5B	2FCAB	2BFB9	1F811	08CC2	24D27	03DCC	06849
152	1E4F5	2E330	39223	0CB20	1A9D7	36BF9	14B8F	187DB
153	1CCD2	2EE5A	23D7A	0FC67	11EDB	3D65D	03D67	03436
154	167F0	2B59B	24742	16B00	02B1C	3F371	158DF	06DB8
155	08E12	2C5CC	27084	1B2A4	038DF	2B30F	17B68	05AB2
156	17C49	2232B	34B22	05F06	01020	3D375	1A6AE	152AE
157	138D3	3A90A	28947	1BF1E	118F2	2E9BD	11EEC	0ABC0
158	0A11A	3EE17	3179E	0D40A	1CA63	34502	10A57	179A2
159	19F61	3B23A	25845	14FF7	100CC	2A274	05289	0819E
160	12938	2F3DB	20C74	10657	1210D	3750D	1518F	17200
161	11EB4	38A6B	20C17	0BA31	1481F	2D0F3	12563	1C88D
162	1C8BE	3014D	2CFEB	15D0A	180BD	25CC3	0FF59	1565F
163	1CE31	3A161	2BF22	1FC2D	16C9E	292CF	045F4	0A3DD
164	1F805	26FF1	27BF4	0AB2C	1846B	325A3	1CD73	13885
165	03430	3EB3E	2BB8D	17674	11A27	228A4	0738E	1DCBB
166	1E130	23F8B	32AD0	1C439	019FD	26C12	0AAB5	0E5AE
167	0A04D	2EB3F	2A139	02833	10BA5	3C458	1EE6B	0C6A1
168	1845E	35E78	2E6BF	0335E	16F88	3894C	1E856	06826
169	1AE4F	23AD1	3482F	1181B	0D562	245FF	07C2D	0830E

Table 659—SA Preamble for $n = 2$ (Segment 2)

170	1193D	3AF84	3A2F6	04AC0	1E076	3A530	022EB	03EB3
171	0FD44	2323A	354DA	10626	07338	3894B	031B0	18427
172	1E881	27819	3E067	01C42	1ED87	29A28	063CC	1AA81
173	12FC2	3375A	3861A	11E88	09FE2	2053D	0CCA0	113C1
174	11275	24A71	2CFA2	17050	0E06A	38483	055A7	007E2
175	1819D	3C3C8	241D8	038EF	11F14	33B74	1B4B1	037FD
176	165F7	32178	21C64	1DBA6	130F0	328D7	021D2	0A4D9
177	07AC0	3E56F	258BC	1E93D	081E3	20CB9	17F3E	037C4
178	1F393	2C52C	23E5D	02A46	0D25C	23D69	139F6	00EA6
179	0EEA1	24939	37827	05173	1D6F4	3C68D	199A0	1F1E5
180	08498	2078E	2CEBE	080B9	1AC81	38311	0F46E	08EB8
181	09A1C	23A0A	2997C	1ED43	008AB	31D02	191C0	0516A
182	1634D	2E19E	37052	12B85	1A438	3FD95	03A8B	0586E
183	09A3C	343A6	24D44	004F4	1B10A	22854	0D531	0E107
184	0289C	3CFCF	28E2D	1188D	15B29	3E544	0087F	122A8
185	15924	278BA	3E010	01CEB	036E3	386AE	140C0	03B62
186	1B2F0	2464D	2AADC	1CAF9	09590	313D4	05F04	0F9EB
187	0EF45	25629	260E5	0B4E1	13BA1	257A5	098C6	0917D
188	1FB4F	21366	2B3CE	10512	0D862	2EC44	096E4	1AF72
189	1514F	22922	285F6	0D7B4	07EAF	3F60E	030E2	1DDBC
190	12A5F	2DE3B	3A48E	1E2C4	12D9B	33093	0EAFD	0A868
191	03432	237DF	3E209	18F7C	0B470	22C88	0F439	07984
192	08284	2C436	2C42A	1D182	0D590	36839	0EF68	114CC
193	033F9	3CAB6	3F334	16E79	09869	2F815	0F270	0B7F3
194	0A044	25E0E	253D1	17689	18C7A	2CC88	17015	1A3C2
195	13A65	2FB30	32580	1EF1B	181DA	32645	1050C	11805
196	0064A	36FF4	30076	090A7	17B42	3242C	0FA71	030D8
197	06D4F	23070	29944	01BAD	07AFF	27C32	1A8CD	01DC1
198	128DA	2ADC0	30B22	0E76D	00CEE	351F6	1ED34	12F36
199	06360	3978A	36C51	0729C	149F1	2D5FF	1048E	0B8B7
200	18E16	27F45	24A57	05CB0	1EB68	3A6E3	19FE2	16F65
201	13CB0	2B227	296AA	04461	0C1FD	3DE20	0FF71	19164
202	01DDC	274D2	23552	01704	1BEB6	28C7D	06352	1E76E

Table 659—SA Preamble for $n = 2$ (Segment 2)

203	1D91A	2ABC1	241FC	156AD	1D40C	2D802	015EF	04A24
204	1A5CA	2C861	2DAD5	1256A	182A9	3C6FE	0D070	131DB
205	0EA7C	360F7	27D57	110BD	0CA56	3584D	03973	1E928
206	020FC	2F787	240A7	07460	03AED	29918	16194	0042A
207	08054	2AACC	34519	18464	11F88	38236	18BD2	1B7BC
208	1F101	37350	200B2	06E54	19C34	37638	15C8D	1959F
209	1F856	233FB	34AFF	0FFCB	0AFB0	21B1A	013DD	12105
210	0306F	325E8	34A77	182B5	03C1C	20CA7	1AD99	08A49
211	11C8F	3CB73	3B926	10529	0ACC7	318CB	063E4	16DBA
212	1A017	32567	21E19	131DA	11AF7	35622	1705B	01704
213	04FB1	2A352	2B92C	14A10	07276	2CF31	08F8D	163A6
214	07065	2AABB	2DFC2	16885	1EB75	2B4F2	0976A	00B6E
215	026F7	3F1B8	2DB70	064E0	12CE1	35804	01820	18239
216	17F68	24BA7	21A14	157C1	0F627	3864A	02677	1281E
217	1993D	375E5	2B489	0F630	153FA	3EC2E	1CFF9	1869C
218	131AB	36437	3FA4E	09D24	0D5BE	20CCA	036EE	0F7FA
219	02EAB	31C0B	3FBED	007B3	0B211	337C6	14E41	0C8ED
220	1C4B6	24BF8	3B5E0	06D2A	011FE	31BFE	06EE6	18A25
221	16876	221CD	3F835	1AC45	0365E	3D7C9	0D798	0C8D2
222	091B6	3452C	332C2	06397	1A1A8	31656	15ACF	10B1F
223	161F0	2DA74	377F9	0DC32	01498	33E91	038A2	12BF7
224	0D8F3	2BB69	39105	10391	06D31	35416	16E7D	17A08
225	16DF5	2B81A	3B90A	14F08	16CE5	2C083	10D09	00A7F
226	0E970	3590C	24CA1	152D7	17CCE	2810B	1594F	0DE07
227	08C6F	2C1B8	33C79	1E1E8	13696	36B96	00644	15F5D
228	1506F	39446	39072	06B7D	043F2	2CD44	174EB	053C3
229	046D1	35FD2	3B61A	17383	0974E	3BD71	1E69E	17B36
230	022A7	3CB54	3C7F6	0CA33	14DB3	3C104	0E594	08C06
231	010EE	26E5F	37F66	0794C	0948B	36311	17042	154FE
232	12E6D	245FD	3D3EC	0B454	07118	33D9B	05279	02E73
233	04835	3AE66	2A335	119FB	03321	303DD	02C11	1686A
234	16E28	33AF3	24D7D	0EC8A	1CB3F	29DBF	1CD5F	06AEF
235	065BE	2B74D	37417	07E54	1205E	32166	0E73A	0F18A

Table 659—SA Preamble for $n = 2$ (Segment 2)

236	0941E	3CC87	20CA9	0CEDF	06B3A	238B6	1DD66	1B983
237	15704	32B7A	2F879	02FC8	04284	39260	0CF20	0C6D9
238	0D543	346FC	22FBB	0D8D6	17D95	201B9	003A9	087A7
239	1F7C7	3622A	264CB	17935	0DDEF	31596	0FE28	19808
240	04A79	35732	3B527	0E613	12B62	371F5	0CAA3	1FC21
241	00DAD	33C6E	3F968	15595	11158	23325	0131C	00A29
242	1F591	37622	25762	1647C	1438F	2F4A5	0DE3C	0EDD6
243	06B42	37744	21D07	10F85	0AC45	208FD	16CA4	0A67C
244	17F1D	32F0A	3E0B3	1EE39	1A4EB	23876	101F5	0BC5D
245	10B2F	393FA	3419A	1441C	0A913	2E015	0D345	1AF1F
246	11AA2	3F5EB	3E95D	1F8B6	1C3DC	25952	1E37C	1666A
247	0F7BD	3D5DE	20FD3	1896B	1751C	2B2BA	124E9	1F9C0
248	19C8B	28CF8	3E949	04479	071AA	2E02A	0B49C	04D04
249	18123	3F12B	35B45	0825E	1DAB9	29229	1F5FF	11594
250	05BC8	2E4D8	2F3F7	15507	0BE99	2DB2C	1C510	15902
251	0CA30	33C05	2B7E8	1ECA5	03516	39549	03FB9	1BC1B
252	09C2D	2A8C5	3F328	1F6D5	02125	27A53	16A23	08681
253	1216D	2AB59	3DE01	03BBE	03822	2121F	09990	15DB7
254	0DA34	31014	28175	017CC	1C834	2942D	16875	1C51F
255	1218D	3ED6B	2416F	076F2	13F6A	23CD4	0A264	19BAC

15.3.6.2 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 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.

15.3.6.2.1 Superframe Header

The Superframe Header (SFH) carries essential system parameters and system configuration information. The SFH is located in the first subframe within a superframe. The SFH uses 5 OFDM symbols within the first subframe.

The SFH is TDM with A-Preamble.

The PHY structure for resource allocation of the SFH is described in Section <<15.3.5>>. The SFH is transmitted within a predefined frequency partition called the SFH frequency partition. The SFH frequency partition consists of $N_{PRU,SFH}$ PRUs within a 5 MHz physical bandwidth.

The PRUs in the SFH frequency partition uses the 2 stream pilot pattern defined in <<15.3.5>>. The PRUs in the SFH frequency partition are permuted to generate $N_{PRU,SFH}$ distributed LRUs.

The SFH is divided into two parts: Primary Superframe Header (P-SFH) and Secondary Superframe Header (S-SFH).

Table 660 includes the parameters and values for resource allocation of the SFH.

Table 660—Parameters and values for resource allocation of SFH

Parameters	Description	Value
$N_{DLRU,SFH}$	The number of distributed LRUs which are occupied by SFH. Note that $N_{DLRU,SFH} = N_{DLRU,P-SFH} + N_{DLRU,S-SFH}$	TBD (≤ 24 (i.e. 5 MHz))
$N_{DLRU,P-SFH}$	The number of distributed LRUs which are occupied by P-SFH	Fixed (value is TBD)
$N_{DLRU,S-SFH}$	The number of distributed LRUs which are occupied by S-SFH	Variable (maximum value is TBD)

If $N_{DLRU,SFH}$ is less than 24, the other DLRUs of the SFH frequency partition are allocated for data or other control transmission.

In the case of more than 5 MHz system bandwidth, the remaining frequency band in which SFH is not allocated is used for data and control transmission. This frequency band consists of $N_{LRU,remaining}$ LRUs, which is equal to $N_{LRU} - N_{DLRU,SFH}$. The resource of the remaining frequency band is configured as DRU by default and does not require extra configuration signaling. Configuring the resource as CRU is for further study. The PRUs in the remaining frequency band use the 2 stream pilot pattern defined in 15.3.5.

Figure 471 illustrates an example of the subcarrier to resource unit mapping in the SFH frequency partition when assuming a 10 MHz system bandwidth.

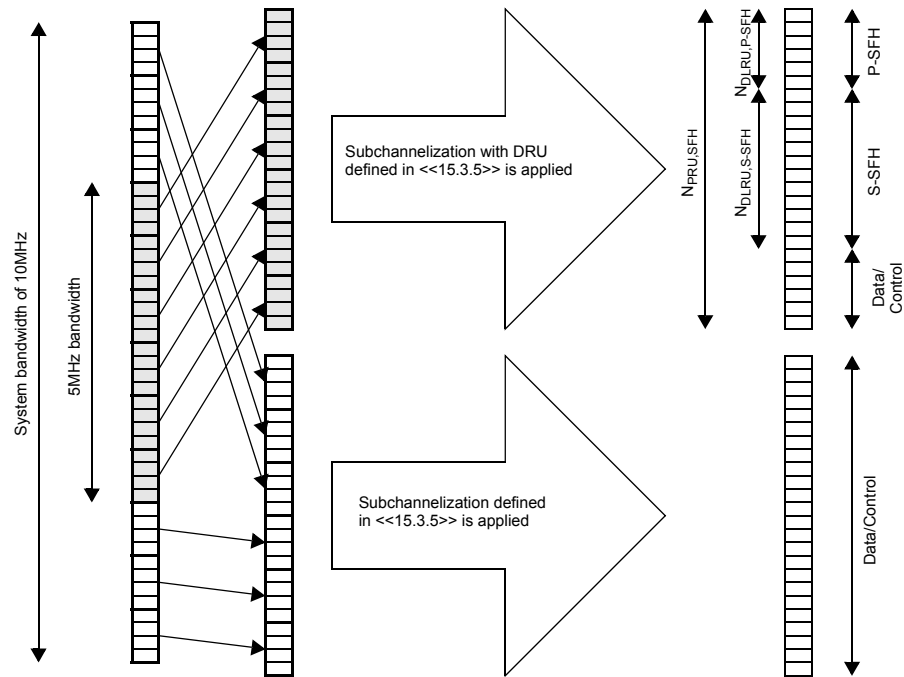


Figure 471—Example of SFH subcarrier to resource unit mapping

15.3.6.2.1.1 Primary Superframe Header

The Primary Superframe Header (P-SFH) shall be transmitted in every superframe.

The first $N_{DLRU,P-SFH}$ distributed LRUs of SFH frequency partition are allocated for P-SFH transmission. $N_{DLRU,P-SFH}$ is a fixed value.

15.3.6.2.1.2 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 $N_{DLRU,S-SFH}$ distributed LRUs following the $N_{DLRU,P-SFH}$ distributed LRUs. The value of $N_{DLRU,S-SFH}$ is indicated in P-SFH.

The S-SFH can be repeated over two consecutive superframes.

The information transmitted in S-SFH is divided into different sub-packets.

15.3.6.2.2 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 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 located $N_{\text{subframe}, \text{A-MAP}}$ subframes apart in a frame. If an A-MAP region is allocated in subframe i , the next A-MAP region shall be allocated in subframe $i + N_{\text{subframe}, \text{A-MAP}}$. In particular, for a frame with $N_{\text{subframe}, \text{DL}}$ DL subframes, A-MAP regions shall be present in subframe i , where $i = j \cdot N_{\text{subframe}, \text{A-MAP}}$ and j is any non-negative integer such that $j \cdot N_{\text{subframe}, \text{A-MAP}} < N_{\text{subframe}, \text{DL}}$. DL data allocations corresponding to the A-MAP region can correspond to resources in any subframes between successive A-MAP regions. The values of $N_{\text{subframe}, \text{A-MAP}}$ can be 1 or 2. Other values of $N_{\text{subframe}, \text{A-MAP}}$ (3 and 4) are FFS. For example, for $N_{\text{subframe}, \text{A-MAP}} = 2$, an A-MAP region in subframe i can point to resource allocation in subframe i or $i+1$ and the next A-MAP region is in subframe $i+2$.

Figure 472 illustrates the location of a MAP region for $N_{\text{subframe}, \text{A-MAP}} = 1$ and 2 cases in the TDD mode.



Figure 472—Example A-map region location in TDD with 4:4 subframe DL:UL split

In the DL subframes where the A-MAP regions can be allocated, each frequency partition may contain an A-MAP region. An A-MAP region, if present, shall occupy the first few distributed LRUs in a frequency partition. If frequency resource of a DL Subframe is composed of reuse 3 and reuse 1 frequency zone, the highest power level frequency partition in reuse 3 frequency zone may contain an A-MAP region.

The structure of an A-MAP region is illustrated in the example in Figure 473. The resource occupied by each A-MAP physical channel may vary depending on the system configuration and scheduler operation.

An A-MAP region consists of $L_{\text{A-MAP}}$ distributed LRUs and the LRUs are formed from PRUs with N_{sym} symbols.

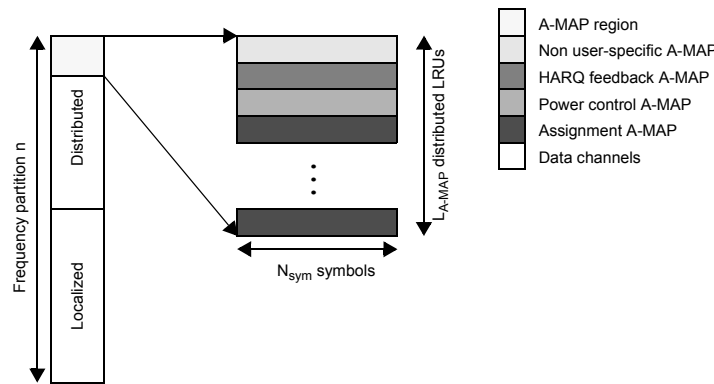


Figure 473—Structure of an A-MAP region

15.3.6.2.2.1 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. It includes information required to decode other A-MAPs.

The resource occupied by non-user specific information is of fixed size.

15.3.6.2.2.2 Assignment A-MAP

Assignment A-MAP contains resource assignment information which is categorized into multiple types of resource assignment IEs (assignment A-MAP IE). Each assignment A-MAP IE is coded separately and carries information for one or a group of users.

The size of the assignment A-MAP is indicated by non-user-specific A-MAP.

The minimum logical resource unit in the assignment A-MAP is called MLRU, consisting of $[N_{MLRU} = 48]$ 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 IE size and channel coding rate, where channel coding rate is selected based on AMS' link condition.

Assignment A-MAPs are grouped together based on MCS level and A-MAP IE sizes. Assignment A-MAPs in the same group are transmitted with the same MCS level and contain the same A-MAP IE size. Each assignment A-MAP group contains several logically contiguous MLRUs. The number of assignment A-MAPs in each assignment A-MAP group is signaled through non-user specific A-MAP.

15.3.6.2.2.3 HARQ Feedback A-MAP

HARQ feedback A-MAP carries HARQ ACK/NACK information for uplink data transmission.

15.3.6.2.2.4 Power Control A-MAP

Power Control A-MAP carries fast power control command to AMS.

15.3.6.3 Resource Mapping of DL Control Channels

15.3.6.3.1 Superframe Header

15.3.6.3.1.1 Primary Superframe Header

Figure 474 shows the physical processing block diagram for the P-SFH.

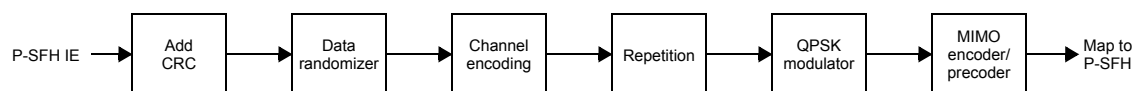


Figure 474—Physical processing block diagram for the P-SFH

The P-SFH IE shall be appended with $N_{CRC,P-SFH}$ bits CRC followed by scrambling with a cell-specific sequence. The cell-specific sequence is determined from the A-Preamble.

The resulting sequence of bits shall be encoded by the TBCC described in 15.3.6.3.3.

The encoded sequences shall be repeated $N_{Rep,P-SFH}$ times to effective code rate of $[1/16 \text{ or } 1/24]$.

The repeated bit sequences shall be modulated using QPSK.

The modulated symbols shall be mapped to two transmission streams using SFBC for two antennas. The two streams using SFBC may be precoded and mapped to more than two antennas described in section <<15.3.7.1.1>>.

Antenna specific symbols at the output of the MIMO encoder/precoder shall be mapped to the resource elements described in section <<15.3.6.2.1.1>>.

15.3.6.3.1.2 Secondary Superframe Header

Figure 475 shows the physical processing block diagram for the S-SFH.

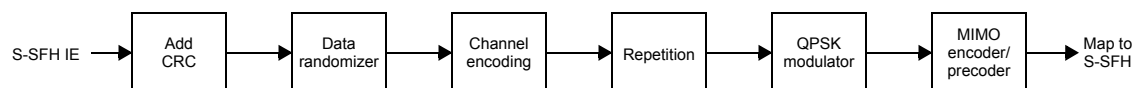


Figure 475—Physical processing block diagram for the S-SFH

The S-SFH IE shall be appended with a 16-bit CRC followed by scrambling with a cell-specific sequence. The cell-specific sequence is determined from the A-Preamble.

The resulting sequence of bits shall be encoded by the TBCC described in 15.3.6.3.3.

The encoded sequences shall be repeated $N_{\text{Rep,S-SFH}}$ times. The value of $N_{\text{Rep,S-SFH}}$ is indicated in P-SFH.

The repeated bit sequences shall be modulated using QPSK.

The modulated symbols shall be mapped to two transmission streams using SFBC for two antennas. The two streams using SFBC may be precoded and mapped to more than two antennas.

Antenna specific symbols at the output of the MIMO encoder/precoder shall be mapped to the resource elements described in section <<15.3.6.2.1>>.

15.3.6.3.2 Advanced MAP (A-MAP)

SFBC with precoding shall be used for the A-MAP region.

15.3.6.3.2.1 Non-user Specific A-MAP

The coding chain for non-user-specific A-MAP-IE to A-A-MAP symbols is shown in Figure 476.

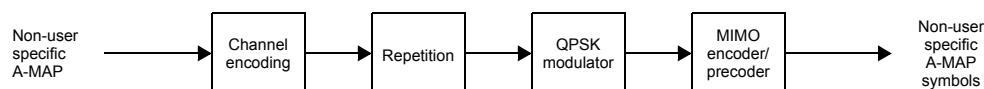


Figure 476—Chain of non-user specific A-MAP-IE to A-A-MAP symbols

The non-user specific A-MAP bit sequence shall be encoded with a fixed MCS.

The encoded sequences shall be repeated $N_{\text{Rep,NS-A-MAP}}$ times.

The repeated bit sequences shall be modulated using QPSK.

15.3.6.3.2.2 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 477 describes the procedure for constructing A-A-MAP symbols.

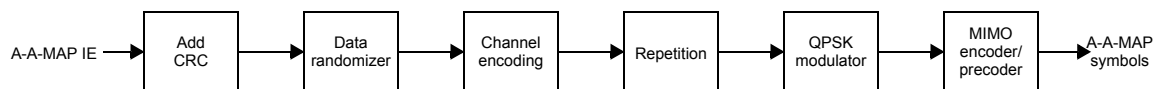


Figure 477—Chain of A-A-MAP-IE to A-A-MAP symbols

Each A-A-MAP IE shall be appended with 16-bit CRC.

The resulting sequence of bits shall be encoded by the TBCC described in 15.3.6.3.3.

Depending on the assignment IE size, a rate matching function may be applied.

Coded bits can be repeated to improve the robustness of an A-A-MAP channel based on the link condition of a particular AMS.

After rate matching and repetition, the encoded bit sequences shall be modulated using QPSK. 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 $(1/2, 1/8)$.

15.3.6.3.2.3 HARQ Feedback A-MAP

HARQ feedback A-MAP (HF-A-MAP) contains HARQ-feedback-IEs for ACK/NACK feedback information to uplink data transmission.

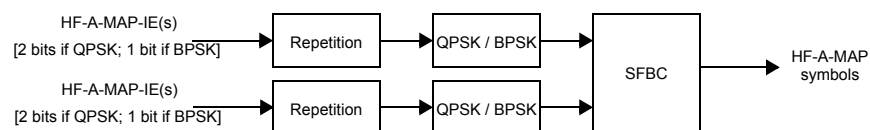


Figure 478—Chain of HF-A-MAP IE to HF-A-MAP symbols

Figure 478 shows the construction procedure of HF-A-MAP symbols from HF-A-MAP-IE.

Each HF-A-MAP IE carries 1 bit information. Depending on the channel conditions, the modulation can be QPSK or BPSK. If QPSK is used, 2 HF-A-MAP IEs are mapped to a point in the signal constellation. If BPSK is used, each HF-A-MAP IE is mapped to a point in the signal constellation. The repetition number is FFS.

15.3.6.3.2.4 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.

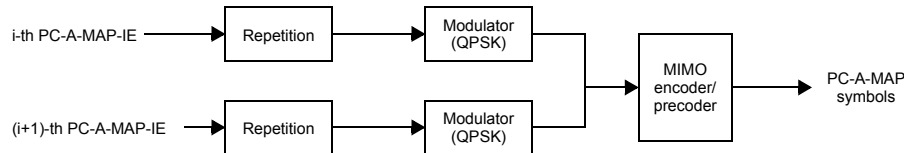


Figure 479—Chain of PC-A-MAP IE to PC-A-MAP symbols

Figure 479 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.

Repetition is then performed with $N_{rep, \text{PC-A-MAP-IE}}$, where $N_{rep, \text{PC-A-MAP-IE}}$ is the number of repetitions and explicitly signaled.

The repeated bit sequence shall be modulated as a QPSK symbol and scaled by $\sqrt{P_i}$, ($0 \leq i < N_{\text{PC-A-MAP-IE}}$), where $N_{\text{PC-A-MAP-IE}}$ is the number of PC-A-MAP-IEs and $\sqrt{P_i}$ is the value determined by the management entity to satisfy the link performance.

15.3.6.3.3 Tail-biting convolutional code for DL control channels

Figure 480 shows a block diagram of the rate 1/4 tail-biting convolutional codes for DL control channels. 1/4 TBCC encoded codewords are separated to four subblock and go through subblock interleaver. The length of coded block size is chosen according to the needed coding rate.

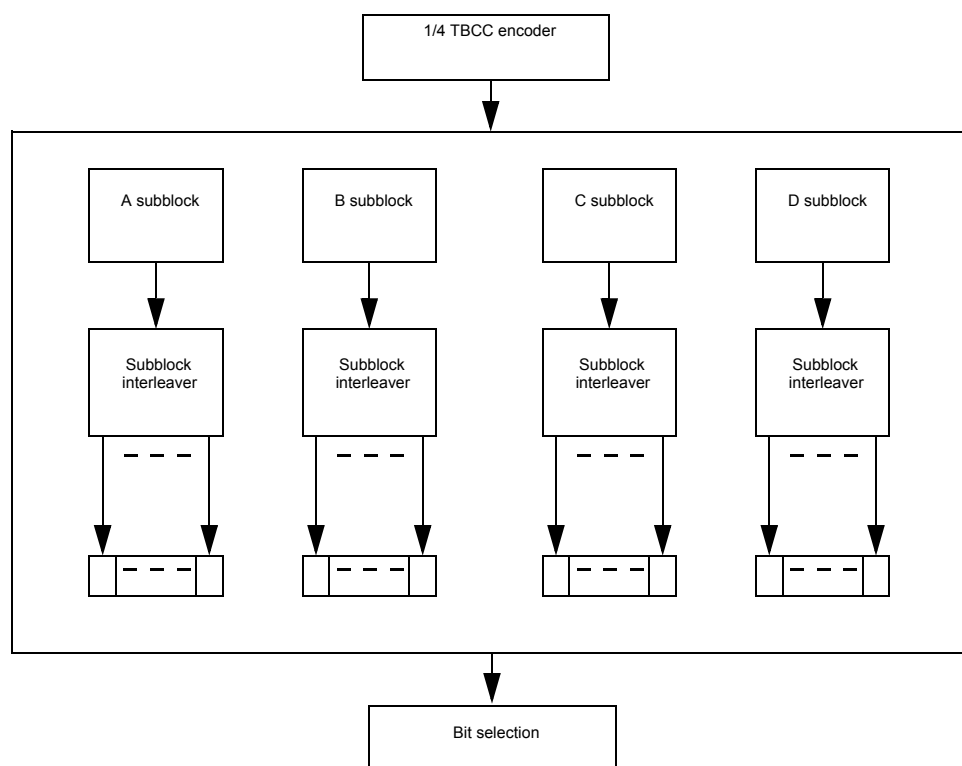


Figure 480—Block diagram of the tail-biting convolutional code for DL control channels

15.3.6.3.3.1 TBCC encoder with rate of 1/4

The binary TBCC shall have native rate of 1/4, a constraint length equal to $K=7$, and shall use the following generator polynomials codes to derive its five coded bits:

$$G_1 = 171_{\text{OCT}} \quad \text{FOR} \quad A \quad G_2 = 133_{\text{OCT}} \quad \text{FOR} \quad B$$

$$G_3 = 165_{\text{OCT}} \quad \text{FOR} \quad C \quad G_4 = 117_{\text{OCT}} \quad \text{FOR} \quad D$$

The generator is depicted in Figure 481.

15.3.6.3.3.2 Bit Separation

All of the encoded bits shall be demultiplexed into four subblocks denoted A, B, C, and D. Suppose L information bits are input to the encoder. The encoder output bits shall be sequentially distributed into four subblocks with the first L encoder output bits going to the A subblock, the second L encoder output going to the B subblock, the third L to the C subblock, the fourth L to the D subblock.

15.3.6.3.3.3 Subblock interleaver

First, the table for interleaving index with length of 128 entries was generated as follows.

$x = 1 : 128$

$\text{index} = (15x + 32x^2) \bmod 128 + 1$

when the number of information bits is less than 128, the corresponding index table can be generated by removing the entries whose values are larger than the number of information bits.

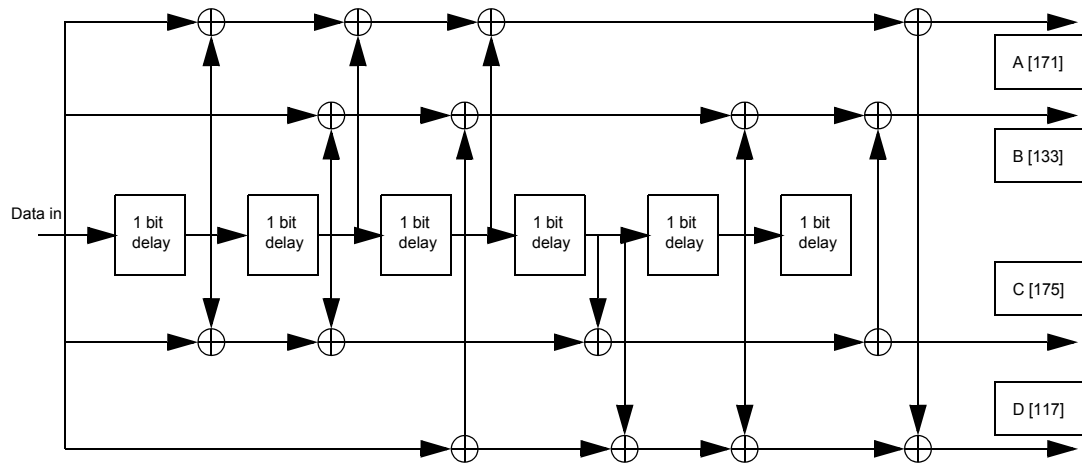


Figure 481—TBCC encoder of rate 1/4

15.3.6.3.3.4 Bit grouping

The channel interleaver output sequence shall consist of the interleaved A and B subblock sequences, followed by interleaved C, and D subblock sequences.

15.3.6.3.3.5 Bit selection

Suppose L information bits are input to the encoder. The output sequence of bit group consists of $4L$ bits denoted as $d_i, i = 0, 1, \dots, 4L$. Parameter $K_{bufsize}$ is used to indicate the size of buffer using for repetition. Its value is not larger than $4L$. If the output bits are M , the output sequence can be expressed as $c_j = d_{j \bmod K_{bufsize}}, j = 0, 1, \dots, M$.

15.3.6.4 Downlink power control

The ABS should be capable of controlling the transmit power per subframe and per user.

An ABS can exchange necessary information with neighbor ABS through backbone network to support downlink power control.

15.3.6.4.1 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.

15.3.6.5 DL Control Information Elements

15.3.6.5.1 Broadcast Control Information Elements

15.3.6.5.1.1 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 661.

Table 661—P-SFH IE format

Syntax	Size (bit)	Notes
P-SFH IE format () {		
LSB of Superframe number	4	Part of superframe number
System Configuration Description change count	4	
S-SFH Size	4	The units of LRU
S-SFH Transmission Format	2	Indicate the transmission format (repetition) used for S-SFH.
S-SFH Scheduling information bit-mat	3	0b000: no S-SFH If 1 st bit = 1, S-SFH includes SP1 otherwise no SP1 if 2 nd bit = 1, S-SFH includes SP2 otherwise no SP2 If 3 rd bit = 1, S-SFH includes SP3 otherwise no SP3
S-SFH SP change bitmap	3	
Reserved	TBD	Note the size of P-SFH should be fixed. The reserved bits are for future extension.
}		

SCD Count

Incremented by one (modulo TBD) by the BS whenever any of the values (except MSBs of superframe number in S-SFH SP1) of the S-SFH IEs changes. If the value of this count in a subsequent P-SFH IE remains the same, the AMS can quickly decide that the S-SFH IEs have not changed and may be able to disregard the S-SFH IEs.

15.3.6.5.1.2 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 multiple S-SFH subpacket IEs. The S-SFH IE format are shown in Table 655. The S-SFH IE includes the S-SFH subpacket IEs in different timing and periodicity.

Table 662—S-SFH IE format

Syntax	Size (bit)	Notes
S-SFH IE format () {		
If (1 st bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP1 IE ()		
}		
if (2 nd bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP2 IE ()		
}		
if (3 rd bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP3 IE ()		
}		
}		

S-SFH SP1 IE contains information for network re-entry, see Table 656

Table 663—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
LSB of BS ID	24	Specifies the 24 least bit of BS ID
Periodicity of A-MAP	1	0b0: every subframe 0b1: every 2 subframes
DL permutation configuration (CRU, DRU partitioning and signaling related to that)	[22]	DL_CAS_SBi(4), DL_CAS_MB0(6), DL_CAS_SBi (4x3) (Up to 22 bits, Need the decision from DL physical structure section)

Table 663—S-SFH SP1 IE format

Syntax	Size (bit)	Notes
UL permutation configuration (CRU, DRU partitioning and signaling related to that)	[22]	UL_CAS_SB0(4), UL_CAS_MB0(6), UL_CAS_SBi (4x3) (Up to 22 bits, Need the decision from UL physical structure section)
Initial ranging channel information (initial ranging region location)	TBD	(Need the decision from UL Ctrl section)
RNG codes information	12	Parameters for determining the root sequences and their cyclic shifts in the preamble set for the cell (Up to 12 bits, Need the decision from UL Ctrl section)
HO ranging codes	6	64 RNG codes (Need the decision from UL Ctrl section)
HO Ranging backoff start	4	Initial backoff window size for HO ranging contention, expressed as a power of 2. Values of n range 0-15 (the highest order bits shall be unused and set to 0) (Need the decision from UL Ctrl or MAC operation section)
HO Ranging backoff end	4	Final backoff window size for HO ranging contention, expressed as a power of 2. Values of n range 0-15 (the highest order bits shall be unused and set to 0) (Need the decision from UL Ctrl or MAC operation section)
BS EIRP	16	Signed in units of 1 dBm
Cell bar information	1	If Cell Bar bit = 1, this cell is not allowed for any new initial entry
Reserved	TBD	
}		

S-SFH SP2 IE contains information for initial network entry and network discovery, see Table 664.

Table 664—S-SFH SP2 IE format

Syntax	Size (bit)	Notes
S-SFH SP2 IE format () {		
Duplexing mode	1	
Sub-frame configuration (DL/UL ratio, duplexing mode)	6	
If (Duplexing mode == FDD) {		

Table 664—S-SFH SP2 IE format

Syntax	Size (bit)	Notes
UL carrier frequency	[12]	(Need more discussion)
UL bandwidth	[3]	(Need more discussion)
}		
MSB bytes of BSID	24	Specifies the Operator ID
FFR partitioning info for DL region	[11]	DL_SAC(4), DL_FPSC(3), DL_FPC(4) (Up to 11 bits, Need the decision from DL physical structure section)
FFR partitioning info for UL region	[11]	UL_SAC(4), UL_FPSC(3), UL_FPC(4) (up to 11 bits, Need the decision from UL physical structure section)
Initial ranging codes	6	64 RNG codes (Need the decision from UL Ctrl section)
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 (Need the decision from UL Ctrl or MAC operation section)
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) (Need the decision from UL Ctrl or MAC operation section)
Bandwidth request backoff end	4	Final backoff window size for contention BRs, expressed as a power of 2. Values of n range 0-15 (Need the decision from UL Ctrl or MAC operation section)
NSP ID	24	Network service provider ID
Additional broadcast information indicator (ABI)	TBD	
MS Transmit Power Limitation Level	8	Unsigned 8-bit integer. Specifies the maximum allowed MS transmit power. Values indicate power levels in 1 dB steps starting from 0 dBm
Minimum level of power offset adjustment	TBD	
Maximum level of power offset adjustment	TBD	
reserved		
}		

S-SFH SP3 IE contains remaining essential system information, see Table 665.

Table 665—S-SFH SP3 IE format

Syntax	Size (bit)	Notes
S-SFH SP3 IE format () {		
Periodic ranging channel information (periodic ranging region location)	TBD	Need the decision from UL Ctrl section
Periodic ranging codes	6	64 RNG codes (Need the decision from UL Ctrl section)
Periodic ranging backoff start	4	Initial backoff window size for periodic ranging contention, expressed as a power of 2. Values of n range 0-15 (Need the decision from UL Ctrl or MAC operation section)
Periodic ranging backoff end	4	Final backoff window size for periodic ranging contention, expressed as a power of 2. Values of n range 0-15 (Need the decision from UL Ctrl or MAC operation section)
UL FB Size	4	Specifies the size of UL feedback channel per a UL subframe (Need the decision from UL Ctrl section)
# Tx antenna	2	0b00: 2 antennas 0b01: 4 antennas 0b10: 8 antennas 0b11: reserved
Default RSSI and CINR averaging parameter	8	Bits 0-3: Default averaging parameter α_{avg} for physical CINR measurements, in multiple of 1/16 Bits 4-7: Default averaging parameter α_{avg} for RSSI measurements, in multiple of 1/16
Tx Power report	TBD	
SP scheduling periodicity information	TBD	
Reserved	TBD	
}		

15.3.6.5.2 Unicast Control Information Elements

A-MAP IE is defined as the basic element of unicast service control.

15.3.6.5.2.1 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. The detailed

information included in non-user specific information is TBD. The non-user specific A-MAP IE is shown in Table 666.

Table 666—Non-user specific A-MAP IE

Syntax	Size [bits]	Notes
Assignment A-MAP size	TBD	Indicate the number of assignment A-MAPs in each assignment A-MAP group as shown in Table 667.

Table 667 [Detailed entry is TBD] shows the number of the assignment A-MAPs in each assignment A-MAP group.

Table 667—The number of assignment A-MAPs in each assignment A-MAP group

Index	Assignment A-MAP group-1	Assignment A-MAP group-2	...
...	

15.3.6.5.2.2 DL basic assignment A-MAP IE

Table 668 describes the fields in a DL Basic Assignment A-MAP IE used for resource assignment in the DL.

Definitions of the fields in the DL Basic Assignment A-MAP IE are listed following Table 668.

Table 668—DL basic assignment A-MAP IE

Syntax	Size in bits	Description/Notes
DL-MAP() {		
A-MAP IE Type	4	DL Basic Assignment A-MAP IE
MCS	[4]	Depends on supported modes, 16 modes assumed as baseline
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Horizontal encoding 0b11: n/a
if (MEF == 0b01){		Parameters for vertical encoding
if($N_t == 2$){		
Mt	1	Number of streams in transmission for $N_t = 2$ ($M_t \leq N_t$) 0b0: 1 stream 0b1: 2 streams

Table 668—DL basic assignment A-MAP IE

Syntax	Size in bits	Description/Notes
<code>} else if($N_t == 4$) {</code>		
<code>Mt</code>	2	Number of streams in transmission for $N_t = 4$ ($M_t \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
<code>} else if($N_t == 8$) {</code>		
<code>Mt</code>	3	Number of streams in transmission for $N_t = 8$ ($M_t \leq N_t$) 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
<code>} else if(MEF == 0b10) {</code>		Parameters for horizontal encoding
<code>If($N_t == 2$) {</code>		
<code>PSI</code>	1	Allocated pilot stream index for $N_t = 2$ 0b0: #1 stream 0b1: #2 stream
<code>Mt</code>	1	Number of streams in transmission for $N_t = 2$ ($M_t \leq N_t$) 0b0: 1 stream 0b1: 2 streams
<code>} else</code>		
<code>PSI</code>	2	Allocated pilot stream index for $N_t = 4$ or 8 0b00: #1 stream 0b01: #2 stream 0b10: #3 stream 0b11: #4 stream
<code>Mt</code>	2	Number of streams in transmission for $N_t = 4$ or 8 ($M_t \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
<code>}</code>		

Table 668—DL basic assignment A-MAP IE

Syntax	Size in bits	Description/Notes
}		
Resource Allocation	Variable	Variable number of bits - depends on system bandwidth. Information may include: <ul style="list-style-type: none"> • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
if ($N_{\text{subframe, A-MAP}} == 2$) {		
Allocation Relevance	TBD	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) 0b0: Allocation in the first DL subframe relevant to an A-MAP region 0b1: Allocation in the second DL subframe relevant to an A-MAP region
}		
HFA	[4]	TBD HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
ACID	4	HARQ channel identifier
SPID/CoRe Version	[3]	HARQ subpacket identifier for IR and Constellation Rearrangement version
Reserved	TBD	Reserved bits
Padding	variable	Padding to reach byte boundary
MCRC	[16]	16 bit CRC masked by Station ID
}		

A-MAP IE Type: Defines the structure of the A-MAP IE for the bits in the A-MAP IE following the A-MAP IE type field. A-MAP IE Type distinguishes between UL/DL, basic/extended IE. Additional IE types are reserved for future use.

MEF: MIMO Encoder Format.

PSI: Allocated pilot stream index for horizontal encoding.

Mt: Number of streams in transmission. The DL pilot pattern with Mt streams shall be used in the allocated resource..

RA: Resource Allocation information is used to signal the type of resource unit allocated (DRU/CRU), the location (start/end) and allocation size.

Long TTI Indication: Indicator to signal allocations span multiple subframes in time.

Allocation Relevance: Subframe index corresponding to the A-MAP region in which the resource is allocated.

HFA: TBD allocation for HARQ feedback.

SPID/CoRe Version: Signaling for HARQ IR including HARQ subpacket identifier for IR and Constellation Rearrangement version.

MCRC: 16 bit CRC masked by Station ID/Flow ID.

Table 669 describes Assignment A-MAP IE Types.

Table 669—A-MAP IE Types

A-MAP IE Type	Usage
0b0000	DL Basic Assignment A-MAP IE
0b0001	UL Basic Assignment A-MAP IE
0b0010	Feedback Allocation A-MAP IE
0b0011	Reserved
0b0100	Reserved
0b0101	Reserved
0b0110	Reserved
0b0111	Reserved
0b1000	Reserved
0b1001	Reserved
0b1010	Reserved
0b1011	Reserved
0b1100	Reserved
0b1101	Reserved
0b1110	Reserved
0b1111	Reserved

15.3.6.5.2.3 UL basic assignment A-MAP IE

Table 670 describes the fields in a UL Basic Assignment A-MAP IE used for resource assignment in the UL.

Table 670—UL basic assignment A-MAP IE

Syntax	Size in bits	Description/Notes
UL-MAP_IE() {		
A-MAP IE Type	4	UL Basic Assignment A-MAP IE
MCS	[4]	Depends on supported modes, 16 modes assumed as baseline
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding
CSM	1	0b0: CSM enabled 0b1: No CSM enabled
If(MEF == 0b1){		Parameters for vertical encoding
Mt	2	Number of streams in transmission ($M_t \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
If(CSM == 0b1){		
TNS	2	Total number of streams in the LRU for CSM 0b00: reserved 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
if(TNS == 2){		
SI	1	First pilot index for CSM with TNS = 2
} else{		
SI	2	First pilot index for CSM with TNS = 3,4
}		
}		
PF	1	Precoding Flag 0b0: non adaptive precoding 0b1: adaptive codebook precoding
If(PF == 0b1){		
PMI Indicator	1	PMI Indicator 0b0: the MS shall use the precoder of rank M_t of its choice 0b1: the indicated PMI of rank M_t shall be used by the MS for precoding

Table 670—UL basic assignment A-MAP IE

Syntax	Size in bits	Description/Notes
if (PMI Indicator == 0b1){		
if($N_t = 2$){		
PMI	3	Precoding Matrix Index for $N_t = 2$
} else if ($N_t = 4$){		
PMI	6	Precoding Matrix Index for $N_t = 4$
}		
}		
}		
}		
Resource Allocation	<i>variable</i>	Variable number of bits - depends on system bandwidth. Information may include: <ul style="list-style-type: none"> • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 UL subframes for FDD or all UL subframes for TDD
if ($N_{\text{subframe, A-MAP}} = 2$){		
if (DL:UL != 3:5){		
Allocation Relevance	1	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) and DL:UL subframe ratio is 8:0, 6:2, 4:4 or 5:3 0b0: Allocation in the first UL subframe relevant to an A-MAP region 0b1: Allocation in the second UL subframe relevant to an A-MAP region
} else if (DL:UL == 3:5){		

Table 670—UL basic assignment A-MAP IE

Syntax	Size in bits	Description/Notes
Allocation Relevance	2	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}}=2$) and DL:UL subframe ratio is 3:5 i.e., the first A-MAP region is relevant to the first two UL subframes and the second A-MAP region is relevant to the last 3 UL subframes 0b00: Allocation in the first UL subframe relevant to an A-MAP region 0b01: Allocation in the second UL subframe relevant to an A-MAP region 0b10: Allocation in the third UL subframe relevant to an A-MAP region 0b11: reserved
}		
}		
else if ($N_{\text{subframe, A-MAP}} == 1$ and DL:UL == 3:5){		
Allocation Relevance	1	Subframe index when an A-MAP region occurs every subframes ($N_{\text{subframe, A-MAP}}=1$) and DL:UL subframe ratio is 3:5 i.e., the first A-MAP region is relevant to the first UL subframe and the next two A-MAP regions are relevant to two UL subframes each. 0b0: Allocation in the first UL subframe relevant to an A-MAP region 0b1: Allocation in the second UL subframe relevant to an A-MAP region
}		
HFA	[4]	TBD HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
ACID	3	HARQ channel identifier
Reserved	TBD	Reserved bits
Padding	variable	Padding to reach byte boundary
MCRC	[16]	16 bit CRC masked by Station ID
}		

TNS: Total number of streams in the LRU for CSM

SI: First pilot index for CSM.

PF: Precoding flag to indicate adaptive or non-adaptive precoding.

PMI: Precoding matrix index .

15.3.6.5.2.4 Group resource allocation A-MAP IE

Group control information is used to allocate resources and/or configure resources to one or multiple AMSs within a user group. The group resource allocation A-MAP IE is shown in Table 671.

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 A-MAP IE.
- 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 DL/UL Group Resource Allocation A-MAP IE. The DL/UL 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 resource assignment, MCS, MIMO mode and resource size.

Table 671—DL group resource allocation A-MAP IE

Syntax	Size in bits *	Description/Notes
A-MAP IE Type	4	DL Group Resource Allocation A-MAP IE
Resource Offset	[6][8]	Indicates starting LRU for resource assignment to this group
ACK Channel Offset	TBD	Indicates the start of ACK index used for scheduled allocations at this subframe in the group
NDA	[2][3]	Indicates the number of deleted AMSs in the group.
For(i=0,i++,i<NDA){		
User Bitmap Index	5	Indicates the User Bitmap Index of deleted AMSs.
}		
User Bitmap Size	[2][5]	Indicates the length of User Bitmap
User Bitmap	<i>Variable</i>	Bitmap to indicate scheduled AMSs in a group. The size of the bitmap is equal to the User Bitmap Size
If(Group MIMO mode set ==0b01 or 0b11){		
MIMO Bit-map	<i>Variable</i>	Bitmap to indicate MIMO mode for the scheduled AMSs.
}		
If(Group MIMO mode set == 0b11){		
PSI Bitmap	<i>Variable</i>	Bitmap to indicate PSI for MU-MIMO

Table 671—DL group resource allocation A-MAP IE

Syntax	Size in bits *	Description/Notes
Pairing Bit-map	<i>Variable</i>	Bitmap to indicate AMS pair sharing same resource for MU-MIMO
}		
Resource Assignment Bit-map	<i>Variable</i>	Bitmap to indicate MCS/resource size for each scheduled AMS
Padding	<i>Variable</i>	Padding to reach byte boundary
MCRC	[16]	16 bit masked CRC

Group configuration A-MAP IE: The group configuration A-MAP IE is used for initiating and maintaining a group for resource assignment.

Table 672—UL group resource allocation A-MAP IE

Syntax	Size in bits *	Description/Notes
A-MAP IE Type	4	UL Group Resource Allocation A-MAP IE
Resource Offset	[6][8]	Indicates starting LRU for resource assignment to this group
ACK Channel Offset	TBD	Indicates the start of ACK index used for scheduled allocations at this subframe in the group
NDA	[2][3]	Indicates the number of deleted AMSs in the group.
For(i=0,i++,i<NDA){		
User Bitmap Index	[5]	Indicates the User Bitmap Index of deleted AMSs.
}		
User Bitmap Size	[2][5]	Size of the user bitmap; may not be needed if user bitmap size is included in configuration message/A-MAP IE
User Bitmap	<i>Variable</i>	Bitmap to indicate scheduled AMSs in a group. The size of the bitmap is equal to the User Bitmap Size
If(Group MIMO mode set ==0b01 or 0b11){		
MIMO Bit-map	<i>Variable</i>	Bitmap to indicate MIMO mode for the scheduled AMSs.
}		
If(Group MIMO mode set == 0b10 of 0b11){		

Table 672—UL group resource allocation A-MAP IE

Syntax	Size in bits *	Description/Notes
PSI Bitmap	<i>Variable</i>	Bitmap to indicate PSI for MU-MIMO
Pairing Bit-map	<i>Variable</i>	Bitmap to indicate AMS pair sharing same resource for MU-MIMO
}		
Resource Assignment Bit-map	<i>Variable</i>	Bitmap to indicate MCS/resource size for each scheduled user
Padding	<i>Variable</i>	Padding to reach byte boundary
MCRC	[16]	16 bit masked CRC

15.3.6.5.2.5 Group Configuration A-MAP IE

The unicast group configuration A-MAP IE is used for initiating and maintaining a group for resource assignment. The broadcast group configuration A-MAP IE is TBD

Table 673—DL Group Configuration A-MAP IE

Syntax	Size in bits *	Description/Notes
A-MAP IE Type	4	DL Group Configuration A-MAP IE
Group ID	5	Indicates group index.
MCS Set ID	[3]	Indicates MCS set supported in the group that is selected from [the predefined MCS set candidates][the configured MCS set candidates in additional broadcast message].
HARQ Burst Size Set ID	[2]	Indicates HARQ data burst size set supported in the group that is selected from the configured HARQ data burst size set candidates in additional broadcast message.
GRA Periodicity	[2]	Indicate the period of transmitting GRA A-MAP IE 0b00: 1 frame 0b01: 2 frame 0b10: 4 frame 0b11: 8 frame
Long TTI Indicator	1	Defines number of subframe spanned by the allocated resource. 0b0: 1 subframe (Frequency first allocation) 0b1: 4 DL subframe for FDD or all DL frame subframe for TDD (Time first allocation)
Group MIMO Mode	2	Indicate Group MIMO mode set supported in the group. 0b00: SFBC 0b01: SFBC and Vertical encoding 0b10: CL SU-MIMO 0b11: CL SU-MIMO and CL MU-MIMO
if ($N_{\text{subframe, A-MAP}} \geq 2$) {		

Table 673—DL Group Configuration A-MAP IE

Syntax	Size in bits *	Description/Notes
Allocation Relevance	1	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}}=2$) 0b0: Allocation in the first DL subframe relevant to an A-MAP region 0b1: Allocation in the second DL subframe relevant to an A-MAP region
}		
User Bitmap Index	[5]	Indicates User Bitmap index to the AMS. An AMS may have multiple User Bitmap Indexes in a group.
Initial ACID	TBD	Indicates the start of ACID used for group resource allocation.
N_ACID	TBD	Indicates the number of ACIDs used for group resource allocation.
Padding	<i>Variable</i>	Padding to reach byte boundary
MCRC	[16]	16 bit masked CRC

Table 674—UL Group Configuration A-MAP IE

Syntax	Size in bits *	Description/Notes
A-MAP IE Type	4	UL Group Configuration A-MAP IE
Group ID	5	Indicates group index.
MCS Set ID	[3]	Indicates MCS set supported in the group that is selected from [the predefined MCS set candidates][the configured MCS set candidates in additional broadcast message].
HARQ Burst Size Set ID	[2]	Indicates HARQ data burst size set supported in the group that is selected from the configured HARQ data burst size set candidates in additional broadcast message.
GRA Periodicity	[2]	Indicate the period of transmitting GRA A-MAP IE 0b00: 1 frame 0b01: 2 frame 0b10: 4 frame 0b11: 8 frame
Long TTI Indicator	1	Defines number of subframe spanned by the allocated resource. 0b0: 1 subframe (Frequency first allocation) 0b1: 4 UL subframe for FDD or all UL frame subframe for TDD (Time first allocation)
Group MIMO Mode	2	Indicate Group MIMO mode set supported in the group. 0b00: SFBC 0b01: SFBC and Vertical encoding 0b10: OL MU-MIMO 0b11: CL SU-MIMO and CL MU-MIMO
if ($N_{\text{subframe, A-MAP}}=2$) {		

Table 674—UL Group Configuration A-MAP IE

Syntax	Size in bits *	Description/Notes
If(DL:UL !=3:5){		
Allocation Rel- evance	1	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}}=2$) 0b0: Allocation in the first DL subframe relevant to an A-MAP region 0b1: Allocation in the second DL subframe relevant to an A-MAP region
}else if (DL:UL !=3:5){		
Allocation Rel- evance	2	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}}=2$) and DL:UL subframe ratio is 8:0, 6:2, 4:4 or 5:3 0b0: Allocation in the first UL subframe relevant to an A-MAP region 0b1: Allocation in the second UL subframe relevant to an A-MAP region
}		
}		
User Bitmap Index	[5]	Indicates User Bitmap index to the AMS. An AMS may have multiple User Bitmap Indexes in a group.
Initial ACID	TBD	Indicates the start of ACID used for group resource allocation.
N_ACID	TBD	Indicates the number of ACIDs used for group resource allocation.
Padding	<i>Variable</i>	Padding to reach byte boundary
MCRC	[16]	16 bit masked CRC

15.3.6.5.2.6 DL PA A-MAP IE

The DL persistent A-MAP IE is specified in Table 675.

Table 675—DL persistent A-MAP IE

Syntax	Size in bits	Description/Notes
DL Persistent A-MAP_IE() {	--	--
A-MAP IE Type	4	DL Persistent A-MAP IE
if MCRC is masked with Station ID {		
DL Individual Persistent A-MAP_IE()		Refer to Table 676
} else if MCRC is masked with Composite ID {		
DL Composite Persistent A-MAP_IE()		Refer to Table 677

Table 675—DL persistent A-MAP IE

Syntax	Size in bits	Description/Notes
}		
MCRC	[16]	16 bit CRC masked by Station ID for individual PA and masked with composite ID (well-known ID specified in the system, TBD) for multi-user PA.
}		

15.3.6.4.2.6.1 - DL Individual PA A-MAP IE <<<need new Header Type for 7-levels -- must be created>>>

The DL individual persistent A-MAP IE is specified in Table 676.

Table 676—DL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
DL Persistent 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 Allocation	Variable	Variable number of bits - depends on system bandwidth. Information may include: • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
HFA	[4]	TBD HARQ Feedback Allocation
} else if (Allocation Period != 0b00){		
MCS	4	Depends on supported modes, 16 modes assumed as baseline
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Horizontal encoding 0b11: n/a
if (MEF == 0b01){		Parameters for vertical encoding
if(Nt == 2){		

Table 676—DL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Mt	1	Number of streams in transmission for $N_t = 2$ ($M_t \leq N_t$) 0b0: 1 stream 0b1: 2 streams
} else if($N_t == 4$) {		
Mt	2	Number of streams in transmission for $N_t = 4$ ($M_t \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
} else if($N_t == 8$) {		
Mt	3	Number of streams in transmission for $N_t = 8$ ($M_t \leq N_t$) 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
}		
} else if(MEF == 0b10) {		Parameters for horizontal encoding
if($N_t == 2$) {		
PSI	1	Allocated pilot stream index for $N_t = 2$ 0b0: #1 stream 0b1: #2 stream
Mt	1	Number of streams in transmission for $N_t = 2$ ($M_t \leq N_t$) 0b0: 1 stream 0b1: 2 streams
} else {		
PSI	2	Allocated pilot stream index for $N_t = 4$ or 8 0b00: #1 stream 0b01: #2 stream 0b10: #3 stream 0b11: #4 stream

Table 676—DL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Mt	2	Number of streams in transmission for $N_t = 4$ or 8 ($M_t \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
}		
}		
Resource Allocation	Variable	Variable number of bits - depends on system bandwidth. Information may include: • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
if ($N_{\text{subframe, A-MAP}} = 2$) {		
Allocation Relevance	1	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) 0b0: Allocation in the first DL subframe relevant to an A-MAP region 0b1: Allocation in the second DL subframe relevant to an A-MAP region
}		
HFA	[4]	TBD HARQ Feedback Allocation
ACID	4	HARQ channel identifier. The ACID field shall be set to the initial value of HARQ channel identifier for implicit cycling of HARQ channel identifiers.
N_ACID	2	Number of ACIDs for implicit cycling of HARQ channel identifier 0b00: 2 0b01: 3 0b10: 4 0b11: 5
}		
Reserved	TBD	Reserved bits

Table 676—DL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Padding	Variable	Padding to reach byte boundary
}	-	-

15.3.6.4.2.6.2 - DL Composite PA A-MAP IE <<<need new Header Type for 7-levels -- must be created>>>

The DL composite persistent A-MAP IE is specified in Table 677.

Table 677—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
DL Composite Persistent A-MAP_IE() {	-	-
Number of allocations	5	Number of allocation specified
RCID Type	2	0b00: Normal CID 0b01: RCID11 0b10: RCID7 0b11: RCID3
For (j=0;j<Number of allocations; j++) {		For loop where each loop element specifies information for one allocation.
Persistent Flag	1	0 = non-persistent 1 = persistent
RCID	variable	Specifies the station ID in RCID format, type defined by RCID Type
Allocation MCS indicator	1	If Allocation MCS Indicator is 1, it indicates that MCS is explicitly assigned for this allocation. Otherwise, this allocation will use the same MCS as the previous subburst. If j is 0 then this indicator shall be 1.
if (Allocation MCS indicator == 1) {		
MCS	4	Depends on supported modes, 16 modes assumed as baseline
}		
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Horizontal encoding 0b11: n/a
if (MEF == 0b01){		Parameters for vertical encoding
if(N _t == 2){		

Table 677—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Mt	1	Number of streams in transmission for $N_t = 2$ ($Mt \leq N_t$) 0b0: 1 stream 0b1: 2 streams
} else if($N_t == 4$) {		
Mt	2	Number of streams in transmission for $N_t = 4$ ($Mt \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
} else if($N_t == 8$) {		
Mt	3	Number of streams in transmission for $N_t = 8$ ($Mt \leq N_t$) 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
}		
} else if(MEF == 0b10) {		Parameters for horizontal encoding
if($N_t == 2$) {		
PSI	1	Allocated pilot stream index for $N_t = 2$ 0b0: #1 stream 0b1: #2 stream
Mt	1	Number of streams in transmission for $N_t = 2$ ($Mt \leq N_t$) 0b0: 1 stream 0b1: 2 streams
} else {		
PSI	2	Allocated pilot stream index for $N_t = 4$ or 8 0b00: #1 stream 0b01: #2 stream 0b10: #3 stream 0b11: #4 stream

Table 677—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Mt	2	Number of streams in transmission for $N_t = 4$ or 8 ($Mt \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
}		
}		
Resource Allocation Indicator	1	If Resource Allocation Indicator is 1, it indicates that Duration is explicitly assigned for this subburst (allocation or deallocation). Otherwise, this subburst (allocation or deallocation) will use the same Duration as the previous subburst. If j is 1 then this indicator shall be 1.
if (Resource Allocation Indicator == 1) {		
Resource Allocation	Variable	Variable number of bits - depends on system bandwidth. Information may include: • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
if ($N_{\text{subframe, A-MAP}} == 2$) {		
Allocation Relevance	1	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) 0b0: Allocation in the first DL subframe relevant to an A-MAP region 0b1: Allocation in the second DL subframe relevant to an A-MAP region
}		
}		
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	[4]	TBD HARQ Feedback Allocation
if (Persistent Flag == 1) {		

Table 677—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
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 Allocation	Variable	Variable number of bits – depends on system bandwidth. Information may include: • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
HFA	[4]	TBD HARQ Feedback Allocation
} else if (Allocation Period != 0b00){		
Allocation Period and ACID Indicator	1	If Allocation Period and ACID Indicator is 1, it indicates that allocation information (allocation period, Number of ACID (ACID)) is explicitly assigned for this allocation. Otherwise, this allocation will use the same allocation period as the previous allocation. If j is 0 then this indicator shall be 1.
if (Allocation Period and ACID Indicator == 1) {	-	-
Allocation Periodicity	2	Periodicity 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
Allocation Period (AP)	5	Period of the persistent allocation is this field value plus 1 (unit is sub-frame/frame TBD)
ACID	4	Number of HARQ channels associated with this persistent assignment is this field value plus 1
}		
}		
}		
}		
}		

15.3.6.5.2.7 UL PA A-MAP IE

The UL persistent A-MAP IE is specified in Table 678.

Table 678—UL Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
UL Persistent A-MAP_IE() {	--	--
A-MAP IE Type	4	UL Persistent A-MAP IE
if MCRC is masked with Station ID {		
UL Individual Persistent A-MAP_IE()		Refer to <<<this Table + 1>>>
} else if MCRC is masked with Composite ID {		
UL Composite Persistent A-MAP_IE()		Refer to <<<this Table + 2>>>
}		
MCRC	[16]	16 bit CRC masked by Station ID for individual PA and masked with composite ID (well-known ID specified in the system, TBD) for multi-user PA.
}		

15.3.6.4.2.7.1 UL Individual PA A-MAP IE <<<need new Header Type for 7-levels -- must be created>>>

The UL individual persistent A-MAP IE is specified in Table 679.

Table 679—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
UL Persistent A-MAP_IE() {	-	-
Allocation Period	2	Period of persistent allocation If (Allocation Period==0b00), it indicates the deallocation of persistent resource. 0b00: 0 frame 0b01: 2 frames 0b10: 4 frames 0b11: 6 frames
If (Allocation Period==0b00){		

Table 679—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Resource Allocation	Variable	Variable number of bits - depends on system bandwidth. Information may include: <ul style="list-style-type: none"> • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
HFA	[4]	TBD HARQ Feedback Allocation
} else if (Allocation Period != 0b00){		
MCS	4	MCS used for burst
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding
CSM	1	0b0: CSM enabled 0b1: No CSM enabled
If(MEF == 0b1){		Parameters for vertical encoding
Mt	2	Number of streams in transmission ($Mt \leq N_t$) 0b00: 1 stream 0b11: 2 streams 0b00: 3 stream 0b11: 4 streams
if(CSM == 0b1){		
TNS	2	Total number of streams in the LRU for CSM 0b00: reserved 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
if(TNS == 0b01){		
SI	1	First pilot index for CSM with TNS = 2
} else if(TNS == 0b10 or TNS==0b11){		
SI	2	First pilot index for CSM with TNS = 3,4
}		
}		
PF	1	Precoding Flag 0b0: non adaptive precoding 0b1: adaptive codebook precoding using the precoder of rank Mt of MS's choice
}		

Table 679—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Resource Allocation	Variable	Variable number of bits - depends on system bandwidth. Information may include: <ul style="list-style-type: none"> • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 UL subframes for FDD or all UL subframes for TDD
if ($N_{\text{subframe, A-MAP}} == 2$) {		
if ($DL:UL \neq 3:5$) {		
Allocation Relevance	1	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) and DL:UL subframe ratio is 8:0, 6:2, 4:4 or 5:3 0b0: Allocation in the first UL subframe relevant to an A-MAP region 0b1: Allocation in the second UL subframe relevant to an A-MAP region
} else if ($DL:UL == 3:5$) {		
Allocation Relevance	2	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) and DL:UL subframe ratio is 3:5 i.e., the first A-MAP region is relevant to the first two UL subframes and the second A-MAP region is relevant to the last 3 UL subframes 0b00: Allocation in the first UL subframe relevant to an A-MAP region 0b01: Allocation in the second UL subframe relevant to an A-MAP region 0b10: Allocation in the third UL subframe relevant to an A-MAP region 0b11: reserved
}		
}		
else if ($N_{\text{subframe, A-MAP}} == 1$ and $DL:UL == 3:5$) {		

Table 679—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Allocation Relevance	1	Subframe index when an A-MAP region occurs every subframes ($N_{\text{subframe, A-MAP}}=1$) and DL:UL subframe ratio is 3:5 i.e., the first A-MAP region is relevant to the first UL subframe and the next two A-MAP regions are relevant to two UL subframes each. 0b0: Allocation in the first UL subframe relevant to an A-MAP region 0b1: Allocation in the second UL subframe relevant to an A-MAP region
}		
HFA	[4]	TBD HARQ Feedback Allocation
ACID	3	HARQ channel identifier
N_ACID	2	Number of ACID for implicit cycling of HARQ channel identifier 0b00: 1 0b01: 2 0b10: 3 0b11: 4
}		
Reserved	TBD	Reserved bits
Padding	Variable	Padding to reach byte boundary
}	-	-

15.3.6.4.2.7.2 UL Composite PA A-MAP IE <<<need new Header Type for 7-levels -- must be created>>>

The UL composite persistent A-MAP IE is specified in Table 680.

Table 680—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
UL Composite Persistent A-MAP_IE() {	-	-
Number of allocations	5	Number of allocation specified
RCID Type	2	0b00: Normal CID 0b01: RCID11 0b10: RCID7 0b11: RCID3

Table 680—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
For (j=0;j<Number of allocations; j++) {		For loop where each loop element specifies information for one allocation.
Persistent Flag	1	0 = non-persistent 1 = persistent
RCID	variable	Specifies the station ID in RCID format, type defined by RCID Type
Allocation MCS indicator	1	If Allocation MCS Indicator is 1, it indicates that MCS is explicitly assigned for this allocation. Otherwise, this allocation will use the same MCS as the previous subburst. If j is 0 then this indicator shall be 1.
if (Allocation MCS indicator == 1) {		
MCS	4	Depends on supported modes, 16 modes assumed as baseline
}		
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding
CSM	1	0b0: CSM enabled 0b1: No CSM enabled
if(MEF == 0b1){		Parameters for vertical encoding
Mt	2	Number of streams in transmission ($M_t \leq N_t$) 0b00: 1 stream 0b11: 2 streams 0b00: 3 stream 0b11: 4 streams
if(CSM == 0b1){		
TNS	2	Total number of streams in the LRU for CSM 0b00: reserved 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
if(TNS == 0b01){		
SI	1	First pilot index for CSM with TNS = 2
} else if(TNS == 0b10 or TNS==0b11){		
SI	2	First pilot index for CSM with TNS = 3,4
}		
}		

Table 680—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
PF	1	Precoding Flag 0b0: non adaptive precoding 0b1: adaptive codebook precoding using the precoder of rank M_t of MS's choice
Resource Allocation Indicator	1	If Resource Allocation Indicator is 1, it indicates that Duration is explicitly assigned for this subburst (allocation or deallocation). Otherwise, this subburst (allocation or deallocation) will use the same Duration as the previous subburst. If j is 1 then this indicator shall be 1.
if (Resource Allocation Indicator == 1) {		
Resource Allocation	Variable	Variable number of bits - depends on system bandwidth. Information may include: • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
if ($N_{\text{subframe, A-MAP}} == 2$) {		
if (DL:UL != 3:5) {		
Allocation Relevance	1	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) and DL:UL subframe ratio is 8:0, 6:2, 4:4 or 5:3 0b0: Allocation in the first UL subframe relevant to an A-MAP region 0b1: Allocation in the second UL subframe relevant to an A-MAP region
}else if (DL:UL == 3:5) {		
Allocation Relevance	2	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) and DL:UL subframe ratio is 3:5 i.e., the first A-MAP region is relevant to the first two UL subframes and the second A-MAP region is relevant to the last 3 UL subframes 0b00: Allocation in the first UL subframe relevant to an A-MAP region 0b01: Allocation in the second UL subframe relevant to an A-MAP region 0b10: Allocation in the third UL subframe relevant to an A-MAP region 0b11: reserved
}		
}else if ($N_{\text{subframe, A-MAP}} == 1$ and DL:UL == 3:5) {		

Table 680—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Allocation Relevance	1	Subframe index when an A-MAP region occurs every subframes ($N_{\text{subframe, A-MAP}}=1$) and DL:UL subframe ratio is 3:5 i.e., the first A-MAP region is relevant to the first UL subframe and the next two A-MAP regions are relevant to two UL subframes each. 0b0: Allocation in the first UL subframe relevant to an A-MAP region 0b1: Allocation in the second UL subframe relevant to an A-MAP region
}		
}		
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	[4]	TBD HARQ Feedback Allocation
if (Persistent Flag == 1) {		
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 Allocation	Variable	Variable number of bits – depends on system bandwidth. Information may include: • Type of resource unit (DRU/CRU) • Location (start/end) • Allocation size
HFA	[4]	TBD HARQ Feedback Allocation
} else if (Allocation Period != 0b00){		
Allocation Period and ACID Indicator	1	If Allocation Period and ACID Indicator is 1, it indicates that allocation information (allocation period, Number of ACID (ACID)) is explicitly assigned for this allocation. Otherwise, this allocation will use the same allocation period as the previous allocation. If j is 0 then this indicator shall be 1.

Table 680—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
if (Allocation Period and ACID Indicator == 1) {	-	-
Allocation Periodicity	2	Periodicity 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
Allocation Period (AP)	5	Period of the persistent allocation is this field value plus 1 (unit is sub-frame/frame TBD)
ACID	4	Number of HARQ channels associated with this persistent assignment is this field value plus 1
}		
}		
}		
}		
}		

15.3.6.5.2.8 HARQ Feedback A-MAP IE

HARQ Feedback A-MAP IE includes one bit and corresponding value for HARQ ACK/NACK information is shown in Table 681. If HF-A-MAP IE has the 0b0 or 0b1, it shall be interpreted as ACK information or NACK information, respectively.

Table 681—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.
}		

15.3.6.5.2.9 Feedback Allocation A-MAP IE

Table 682 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.

Definitions of the fields in the Feedback Allocation A-MAP IE are listed below in Table 682.

Note: 1. Need to differentiate it is in OL region or not. In OL region, $MaxM_t$ is not required

Table 682—Feedback Allocation A-MAP IE

Syntax	Size (bit)	Notes
Feedback-Allocation-MAP_IE() {	-	-
A-MAP IE Type	[4]	Feedback Allocation A-MAP IE = 0b0010
Channel Index	<i>Variable</i>	Feedback channel index within the UL fast feedback control resource region (Dependent on L_{FB,FP_i} defined in 15.3.8.3.3.2)
Allocation Period (p)	[3]	A feedback is transmitted on the FBCH every 2^p frames
Long-term Allocation Period (TBD)		TBD
Frame offset (TBD)		Depends on the decision of A-MAP allocation IE
Allocation Duration(d)	[3]	
MaxMt	<i>Variable</i> [1-2]	Variable number of bits - depends on number of transmit antenna N_t If $N_t=2$: 0b0: 1 0b1: 2 If $N_t=4$: 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If $N_t=8$ (SU-MIMO) 0b000: 1 0b001: 2 0b011: 4 0b111: 8 If $N_t=8$: (MU-MIMO) 0b00: 1 0b01: 2 0b10: 3 0b11: 4

Table 682—Feedback Allocation A-MAP IE

Syntax	Size (bit)	Notes
MFM	[3]	MIMO Feedback Mode as defined in Table 671
Feedback Format	<i>Variable</i> [2-3]	Variable number of bits –depends on MIMO feedback mode
If(MFM=0,1,4,7){		(TBD depending on IM group decision on FFR)
Number of Reports (<i>n</i>)	[1]	0: Same Feedback reported on each FFB opportunity 1: Different Feedback reported in a time-interleaved fashion over the PFBC opportunities
If(Number of Reports>0) {		(TBD depending on IM group decision on FFR)
Long Allocation Period_multiple_reports (<i>q</i>)	[2]	Long Period Fast Feedback reports are transmitted on the FBCH channel every 2^{p+q+1} frames
}		
For (<i>i</i> =0 to <i>n</i>) {		For specified Number of Reports (<i>n</i>) (TBD depending on IM group decision on FFR)
FPS	[2]	Frequency Partition and Reuse Factor as follows: (Refer to section 20.1 for the frequency partition indexing definition.) 0b00: Frequency Partition 0 (Reuse 1) 0b01: Deboosted reuse 3 0b10: Boosted Reuse 3 0b11: Reserved.
}		
}		
If (MFM == 3,4,6,7) {		CL SU and MU MIMO

Table 682—Feedback Allocation A-MAP IE

Syntax	Size (bit)	Notes
CM	<i>Variable</i> [0, 2]	Codebook Feedback Mode and Codebook Coordination Enable 0b00: standard with CCE disabled 0b01: adaptive with CCE disabled 0b10: differential with CCE disabled 0b11: standard with CCE enabled If MFM = 2,5 CM is empty (0 bit)
CS	[1]	Codebook subset
}		
If(MFM==2,3,5,6) (TBD) {		Localized feedback mode
If (feedback_Format == 0) {		Specified CQI (used to report specified DLRU/subband CQI)
DLRU/subband index	<i>Variable</i> [3-4]	Variable number of bits – depends on system bandwidth. 0b000 - 0b110 (3bits): to index 6 subband when system bandwidth is 5MHz 0b0000-0b1100(4bits): to index 12 subband when system bandwidth is 10MHz
}		
}		
Padding	<i>Variable</i>	Padding to reach byte boundary
MCRC	[16]	16 bit CRC masked by Station ID
}	-	-

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. In case of multiple SFBC are allocated for an AMS, it is assumed that multiple SFBC are allocated contiguously and this field specifies the index of the first one.

MFM: MIMO feedback mode, defined in Table 691.

Feedback Format: This field specifies the feedback format index when reporting fast feedback information in FBCH. Feedback format definitions for different MIMO feedback modes are described in Error! Reference source not found.

Long-term Allocation Period: Long term period report punctures the normal report.

Number of Reports (n): Indicates whether the FFB channel allocated to the AMS carries 1 or 2 PFBC Reports.

Allocation Period (p):

Long Allocation Period multiple reports (q): Indicates the allocation period for Long-Period report and these puncture the Short-Period reports when MFM=0, 1, 4, 7.

FPS: Frequency Partition Selection & Reuse Factor Information. (Refer to <<<section 20.1>>> for the frequency partition indexing definition)

MaxMt: 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 BS if MFM=5,6,7 (which indicates a MU MIMO feedback mode)

CCE: Codebook Coordination Enable. When CCE is enabled, MS finds PMI within whole broadcasted codebook type entry; when this field is set to 0b1, it means MS finds rate-1 PMI within broadcasted codebook entries indicated by BC_SI and codebook subset indication (CS in DL A-MAP IE).

DLRU: This field specifies the index of a certain RU which needs AMS to estimate and report CQI/PMI feedback. When a certain RU is specified, AMS only report one CQI (may plus RI)/PMI for it.

CM: this field specifies codebook feedback mode, which is needed only for MFM 3 and 6.

15.3.6.5.2.10 Power Control A-MAP IE

The PC-A-MAP IE includes two bits and corresponding values for power correction is shown in Table 683, e.g., if the power correction value is 0b00, it shall be interpreted as tone power (power density) should be reduced by 0.5dB

Table 683—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
}		

15.3.6.5.2.11 UL Sounding Command A-MAP IE

Table 684—UL Sounding Command A-MAP IE

Syntax	Size (bit)	Notes
UL Sounding Command IE format() {	-	-
A-MAP IE type	4	
Sounding subframe	3	Indicates the sounding subframe [TBD]

Table 684—UL Sounding Command A-MAP IE

Syntax	Size (bit)	Notes
Sounding subband bitmap	Variable [max. 12]	[TBD] FFT size dependant TBD
If (Multiplexing type == 0) {		
Decimation offset d	4	Unique decimation offset
} else {		
Cyclic time shift n	4	Unique cyclic shift [TBD]
}		
Periodicity	3	0b000 = Single command, not periodic, or terminate the periodicity. Otherwise, repeat sounding once per $2^{(n-1)}$ frames, where n is decimal value of the periodicity field
Multi-antenna sounding	1	0b0: sounding with antenna switching 0b1: sounding from multiple antennas
MCRC	16	16 bit CRC masked by Station ID
}		

Table 684 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 subframe indicates the uplink subframe with sounding symbol. 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 further subdivided into sounding subbands, where each sounding subband compromises $N_1 * N_{\text{sc}}$ adjacent subcarriers with $N_{\text{sc}} = 18$. For multiplexing type equal to 0 the first subcarrier index of k^{th} transmit antenna within sounding allocation is determined from $g = F(d, k, \text{Frame Index})$, where function $F()$ is TBD. The three periodicity bits are used to indicate the MS 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. For multi-antenna flag equals to 0 the MS sounds with antenna switching, while for multi-antenna flag equals to 1 the MS sounds all transmit antennas.

15.3.7 Downlink MIMO

15.3.7.1 Downlink MIMO architecture and data processing

The architecture of downlink MIMO at the transmitter side is shown in Figure 482.

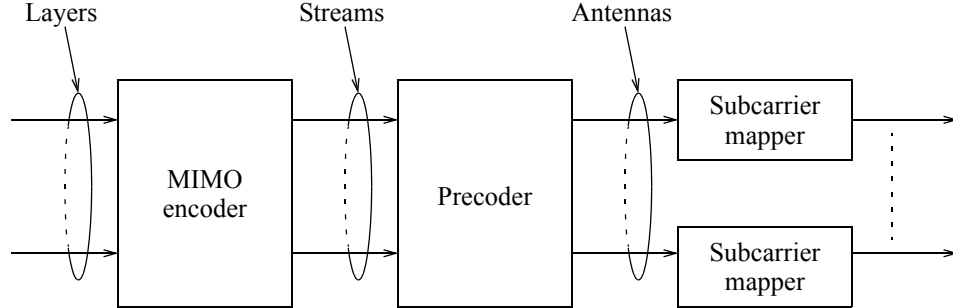


Figure 482—DL MIMO architecture

The MIMO encoder block maps L layers ($L \geq 1$) onto M_t streams ($M_t \geq L$), which are fed to the Precoder block. A layer is defined as a coding and modulation path fed to the MIMO encoder as an input. A stream is defined as an output of the MIMO encoder which is passed to the precoder.

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 at transmit side).

The Precoder block maps 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

15.3.7.1.1 Layer to stream mapping

Layer to 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 $M \times 1$ vector as specified in Equation (195)

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_M \end{bmatrix} \quad (195)$$

Where s_i is the i -th input symbol within a batch.

Layer to 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 (196), which serves as the input to the precoder.

$$\mathbf{x} = \mathbf{S}(s) \quad (196)$$

Where,

M_t is the number of streams

N_F is the number of subcarriers occupied by one MIMO block

\mathbf{x} is the output of the MIMO encoder

s is the input layer vector

$\mathbf{S}(s)$ is an STC matrix

And,

$$\mathbf{x} = \begin{bmatrix} x_{1,1} & x_{1,2} & \dots & x_{1,N_r} \\ x_{2,1} & x_{2,2} & \dots & x_{2,N_r} \\ \dots & \dots & \dots & \dots \\ x_{M_r,1} & x_{M_r,2} & \dots & x_{M_r,N_r} \end{bmatrix} \quad (197)$$

The three MIMO encoder formats (MEF) are SFBC, vertical encoding (VE), and horizontal encoding (HE). For SU-MIMO transmissions, the STC rate is defined as in Equation (198)

$$R = \frac{M}{N_F} \quad (198)$$

For MU-MIMO transmissions, the STC rate per layer (R) is equal to 1.

15.3.7.1.1.1 SFBC encoding

The input to the MIMO encoder is represented by a 2×1 vector.

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \quad (199)$$

The MIMO encoder generates the SFBC matrix.

$$\mathbf{x} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix} \quad (200)$$

Where \mathbf{x} is a 2x2 matrix.

The SFBC matrix, \mathbf{x} , occupies two consecutive subcarriers.

15.3.7.1.1.2 Vertical encoding

The input and the output of MIMO encoder is represented by an $M \times 1$ vector.

$$\mathbf{x} = \mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_M \end{bmatrix} . \quad (201)$$

Where s_i is the i -th input symbol within a batch.

For vertical encoding, $s_i \dots s_M$ belong to the same layer.

15.3.7.1.1.3 Horizontal encoding

The input and output of the MIMO encoder is represented by an $M \times 1$ vector.

$$\mathbf{x} = \mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_M \end{bmatrix} \quad (202)$$

Where s_i is the i -th input symbol within a batch.

For horizontal encoding, $s_i \dots s_M$ belong to different layers.

Horizontal encoding is only used for MU-MIMO mode.

15.3.7.1.2 Stream to antenna mapping

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, \mathbf{W} . The output of the precoder is denoted by an $N_t \times N_F$ matrix, \mathbf{z} . The mapping can be defined in Equation (203).

$$\mathbf{z} = \mathbf{W}\mathbf{x} = \begin{bmatrix} z_{1,1} & z_{1,2} & \dots & z_{1,N_F} \\ z_{2,1} & z_{2,2} & \dots & z_{2,N_F} \\ \dots & \dots & \dots & \dots \\ z_{N_t,1} & z_{N_t,2} & \dots & z_{N_t,N_F} \end{bmatrix} \quad (203)$$

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.

15.3.7.1.2.1 Non-adaptive precoding

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 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 <<<15.3.7.2.6.6.2.4.1>>>, according to the type of allocation, MEF, N_t and M_t , as specified in Table 685 and Table 686.

Table 685—Codebook subsets used for non-adaptive precoding in DL diversity allocations (DRU and distributed minibands)

MEF	RU with M_t pilot streams outside OL region	RU in OL region with $MaxM_t$ streams
SFBC	$C_{DL\text{OLSU}}(N_p, M_p, N_w), M_t = 2$	$C_{DL\text{OLSU}}(N_p, 2, N_w), MaxM_t = 2$
VE	$C_{DL\text{OLSU}}(N_p, M_p, N_w), M_t = 1, \dots, MaxM_t$	$C_{DL\text{OLSU}}(N_p, 2, N_w), MaxM_t = 2$
HE	na	na

Table 686—Codebook subsets used for non-adaptive precoding in DL localized allocations

MEF	RU with M_t pilot streams outside OL region	RU in OL region with $MaxM_t$ streams
SFBC	na	na
VE	$N_t=2$: $C(2, M_p, 3), M_t = 1, \dots, MaxM_t$ $N_t=4$: $C(4, M_p, 4), M_t = 1, \dots, MaxM_t$ $N_t=8$: $C(8, M_p, 4), M_t = 1, \dots, MaxM_t$	$N_t=2$: $C(2, MaxM_p, 3), MaxM_t = 1$ or 2 $N_t=4$: $C(4, MaxM_p, 4), MaxM_t = 1$ or 2 $N_t=8$: $C(8, MaxM_p, 4), MaxM_t = 1$ or 2
HE	$N_t=2$: $C(2, MaxM_p, 3), M_t = 1, \dots, MaxM_t$ $N_t=4$: $C(4, MaxM_p, 4), M_t = 1, \dots, MaxM_t$ $N_t=8$: $C(8, MaxM_p, 3), M_t = 1, \dots, MaxM_t$	$N_t=2$: $C(2, 2, 3), MaxM_t = 2$ $N_t=4$: $C(4, 2, 4), MaxM_t = 2$ $N_t=8$: $C(8, 2, 4), MaxM_t = 2$

Non-adaptive precoding outside the OL region

In a RU allocated outside the OL region, with MEF = 0b00 or 0b01 and non-adaptive precoding, the matrix \mathbf{W} changes every $N_1 P_{SC}$ contiguous physical subcarriers according to equation (10), and it does not depend on the 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_p , where i is given by

$$i = s \bmod N_w, \quad s = 0 \dots N_{sub} - 1 \quad (204)$$

In a RU allocated outside the OL region, with MEF = 0b10 and non-adaptive precoding, the matrix \mathbf{W} changes every $N_1 P_{SC}$ contiguous physical subcarriers according to Equation (205), and it does not depend on the 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 open-loop codebook subset of rank $MaxM_t$, where i is given by Equation (204).

Non-adaptive precoding inside the OL region

In a RU allocated in the $MaxM_t$ -streams OL Region, with MEF = 0b00, 0b01 or 0b10 and non-adaptive precoding, the matrix \mathbf{W} changes every $N P_{sc}$ contiguous physical subcarriers. The default value of N is N_1 . N_2 is optional [TBD].

When $N = N_1$, 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 open-loop codebook subset of rank $MaxM_p$, where i is given by

$$i = s \bmod N_w, \quad s = 0 \dots N_{sub} - 1 \quad (205)$$

When $N = N_2$, The $N_t \times 1$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in PRU s in subframe number t is selected as the codeword of index i in the open-loop codebook subset of rank 1, where i is given by

$$i = (s + t) \bmod N_W, \quad s = 0 \dots N_{PRU} - 1 \quad (206)$$

15.3.7.1.2.2 Adaptive precoding

With adaptive precoding, the precoder \mathbf{W} is derived from the feedback of the MS.

For codebook-based precoding (codebook feedback), there are 3 feedback modes: Base mode, transformation mode and differential mode, which are described in 15.3.7.2.6.6.1.

For TDD sounding-based precoding, the value of \mathbf{W} is derived from the MS sounding feedback. The sounding channel is defined in “Unquantized MIMO feedback for closed-loop transmit precoding” on page 264.

15.3.7.1.3 Downlink MIMO modes

There are five MIMO transmission modes for unicast DL MIMO transmission as listed in Table 687.

Table 687—Downlink 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 MU-MIMO (SM)	HE	non-adaptive
Mode 4	CL MU-MIMO (SM)	HE	adaptive

The allowed values of the parameters for each DL MIMO mode are shown in Table 688.

Table 688—DL MIMO parameters

	Number of transmit antennas	STC rate per layer	Number of streams	Number of subcarriers	Number of layers
	N_t	Rate	M_t	N_F	L
MIMO mode 0	2	1	2	2	1
	4	1	2	2	1
	8	1	2	2	1

Table 688—DL MIMO parameters

	Number of transmit antennas	STC rate per layer	Number of streams	Number of subcarriers	Number of layers
	N_t	$Rate$	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	n.a.	2	1	2
	4	n.a.	2	1	2
	4	n.a.	3	1	3
	4	n.a.	4	1	4
	8	n.a.	2	1	2
	8	n.a.	3	1	3
	8	n.a.	4	1	4

M_t refers to the number of streams transmitted to one MS with MIMO modes 0, 1, and 2.

M_t refers to the total number of streams transmitted to multiple MS on the same RU with MIMO modes 3 and 4.

15.3.7.2 Transmission schemes for data channels

15.3.7.2.1 Encoding, precoding and mapping of SU-MIMO

15.3.7.2.1.1 Encoding of MIMO modes

15.3.7.2.1.1.1 MIMO mode 0

SFBC encoding of section “SFBC encoding” on page 231 shall be used with MIMO mode 0.

15.3.7.2.1.1.1 MIMO mode 1

Vertical encoding of section “Vertical encoding” on page 231 shall be used with MIMO mode 1. The number of streams is , $M_t \leq \min(N_r, N_p)$ where N_r is the number of receive antennas and M_t is no more than 8.

15.3.7.2.1.1.1 MIMO mode 2

Vertical encoding of section “Vertical encoding” on page 231 shall be used with MIMO mode 2. The number of streams is , $M_t \leq \min(N_r, N_p)$ where M_t is no more than 8.

15.3.7.2.1.2 Precoding of MIMO modes

15.3.7.2.1.2.1 MIMO mode 0

Non-adaptive precoding of section “Non-adaptive precoding” on page 232 with $M_t=2$ streams shall be used with MIMO mode 0.

15.3.7.2.1.2.1 MIMO mode 1

Non-adaptive precoding of section “Non-adaptive precoding” on page 232 with M_t streams shall be used with MIMO mode 1.

15.3.7.2.1.2.1 MIMO mode 2

Adaptive precoding of section “Adaptive precoding” on page 234 shall be used with MIMO mode 2.

15.3.7.2.2 Encoding, precoding and mapping of MU-MIMO

Multi-user MIMO schemes are used to enable a resource allocation to communicate data to two or more MSs. Multi-user transmission with one stream per user is supported for MU-MIMO.

MU-MIMO includes the MIMO configuration of 2Tx antennas to support up to 2 MSs, and 4Tx or 8Tx antennas to support up to 4 MSs, with 1 stream per MS.

Both OL MU-MIMO (mode 3) and CL MU-MIMO (mode 4) are supported

15.3.7.2.2.1 Encoding of MIMO mode 3

Horizontal encoding of section “Horizontal encoding” on page 232 shall be used with MIMO mode 3.

15.3.7.2.2.2 Encoding of MIMO mode 4

Horizontal encoding of section “Horizontal encoding” on page 232 shall be used with MIMO mode 4

15.3.7.2.2.3 Precoding of MIMO modes

15.3.7.2.2.3.1 MIMO mode 3

Non-adaptive precoding of section 15.3.7.1.2.1 shall be used with MIMO mode 3.

Inside the OL region with OL MU MIMO, the precoder \mathbf{W} with 2 streams is predefined and fixed over time.

Outside the OL region with OL MU MIMO, the precoder \mathbf{W} is an $N_t \times M_t$ sub-matrix of a predefined $N_t \times \text{Max}M_t$ matrix.

The precoding matrix \mathbf{W} used by the BS is represented in Equation (207).

$$\mathbf{W}(k) = [v_1(k) \quad v_2(k) \quad \dots \quad v_M(k)] \quad (207)$$

Where $v_i(k)$ is the precoding vector for the i -th MS on the k -th subcarrier.

$v_i(k)$ shall be used for precoding the pilot symbols on the i -th pilot stream on the k -th subcarrier.

15.3.7.2.2.3.2 MIMO mode 4

In CL MU MIMO, the precoder \mathbf{W} is an $N_t \times M$ matrix for each subcarrier. It is used to communicate to M MSs simultaneously. The form and derivation of the precoding matrix does not need to be known at the MS. The BS determines the precoding matrix based on the feedback received from the MS.

The BS shall construct the precoding matrix \mathbf{W} as represented in Equation (208).

$$\mathbf{W}(k) = [v_1(k) \quad v_2(k) \quad \Lambda \quad v_M(k)] \quad (208)$$

Where, $v_i(k)$ is the precoding vector for the i -th MS on the k -th subcarrier.

15.3.7.2.3 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, 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.

15.3.7.2.3.1 MIMO mode 0

15.3.7.2.3.2 MIMO mode 1, 2

15.3.7.2.3.3 MIMO mode 3, 4

15.3.7.2.4 Usage of MIMO modes

Table 689 shows permutations supported for each MIMO mode. The definitions of DRU, mini-band based CRU, and subband based CRU are in subclause [TBD].

Table 689—Supported Permutation for each DL MIMO mode

	DRU	Mini-band based CRU (diversity allocation)	Mini-band and Subband based CRU (localized allocation)
MIMO mode 0	Yes	Yes	No
MIMO mode 1	Yes, with $M_t=2$	Yes	Yes
MIMO mode 2	No	Yes, with $M_t=1$	Yes
MIMO mode 3	No	No	Yes
MIMO mode 4	No	Yes	Yes

Mini band based CRU diversity allocation represents a resource allocation composed of non-contiguous minibands.

All pilots are precoded regardless of number of transmit antennas and allocation type.

15.3.7.2.4.1 Broadcast information

Some parameters necessary for DL MIMO operation shall be broadcast by the ABS. The broadcast information is carried by SFH or in DCD/UCD.

15.3.7.2.4.2 Unicast information

Some parameters necessary for DL MIMO operation shall be unicast by the BS to a specific MS. The unicast information is carried by A-MAP IEs or feedback allocation IEs

15.3.7.2.5 Feedback mechanisms and operation

15.3.7.2.5.1 Downlink post-processing CINR measurement feedback

The reported channel quality indicator has two types: wideband CQI, subband CQI.

The wideband CQI is one average CQI over the whole band.

The subband CQI is one average CQI over the subband.

For MU-MIMO feedback modes, the CQI is calculated at the MS assuming that the interfering users are scheduled by the serving BS using rank-1 precoders orthogonal to each other and orthogonal to the rank-1 precoder represented by the reported PMI.

15.3.7.2.5.2 MIMO mode feedback selection

An MS may send an unsolicited event-driven report to indicate its preferred MIMO mode to the BS. 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 15.3.10.3.

15.3.7.2.5.3 MIMO feedback information

Table 690 specifies the feedback information required for MIMO operation.

Table 690—MIMO feedback information

	Feedback information type	Description
Long period feed-back		
	STC rate	For MIMO modes 0, 1 and 2
	Subband selection	For CRU allocations, indicating which subbands are preferred
	Stream index	For MIMO mode 3, indicating which streams are preferred.
	Quantized Correlation matrix	For transformation codebook feedback mode and long term wideband beamforming
	PMI report for serving cell [TBD]	For long-term wideband beamforming
	PMI report for neighboring cell	For PMI coordination among multiple BSs
Short period feed-back	CQI	For link adaptation (MCS selection)
	PMI report for serving cell	For short-term beamforming with MIMO modes 2 and 4
Event-driven feed-back	Preferred MIMO feedback mode	For MS reporting of its preferred MIMO mode in unsolicited manner

15.3.7.2.5.4 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 MS, and the MS will feedback information accordingly.

The description of MIMO feedback modes and corresponding supported MIMO transmission modes is shown in Table 691. The detailed description of feedback and MS processing are in the following subsections.

The feedback of the quantized wideband correlation matrix shall be requested by the BS for operation with adaptive codebook-based feedback mode. The BS may request the feedback of the quantized wideband correlation matrix independently of the MIMO feedback mode requested in the FBCH_Alloc_IE. The quantized wideband correlation matrix may be used for wideband beamforming.

<<<15.3.7.2.5.4.1>>> MIMO feedback 0 <<<need 7-level header defined>>>

Table 691—MIMO feedback modes

Feedback Mode	Description	Feedback content	Type of RU	Supported MIMO transmission mode
Mode 0	OL SU MIMO SFBC/SM (Diversity)	1. STC Rate 2. Wideband CQI	Diversity (DRU, Mini-band based CRU)	MIMO mode 0 and MIMO mode 1. Flexible adaptation between the two modes STC Rate = 1: SFBC CQI STC Rate = 2: SM CQI In DRU: $M_t=2$ for SM. In Miniband based CRU: $M_t \geq 2$ for SM
Mode 1	OL SU MIMO SM (Diversity)	1. STC Rate 2. Wideband CQI	Diversity (Mini-band based CRU)	MIMO mode 1
Mode 2	OL SU MIMO SM (localized)	1. STC Rate 2. Subband CQI 3. Subband Selection	Localized (Subband based CRU, Mini-band based CRU)	MIMO mode 1
Mode 3	CL SU MIMO (localized)	1. STC Rate 2. Subband CQI 3. Subband PMI 4. Subband selection [5. Wideband PMI] 6. Wideband correlation matrix	Localized (Subband based CRU, Mini-band based CRU)	MIMO mode 2
Mode 4	CL SU MIMO (Diversity)	1. Wideband CQI [2. Wideband PMI] 3. Wideband correlation matrix	Diversity (Mini-band based CRU)	MIMO mode 2 ($M_t=1$)
Mode 5	OL MU MIMO (localized)	1. Subband CQI 2. Subband Selection 3. Stream indicator	Localized (Subband based CRU, Mini-band based CRU)	MIMO mode 3
Mode 6	CL MU MIMO (localized)	1. Subband CQI 2. Subband PMI 3. Subband Selection [4. Wideband PMI] 5. Wideband correlation matrix	Localized (Subband based CRU, Mini-band based CRU)	MIMO mode 4
Mode 7	CL MU MIMO (Diversity)	1. Wideband CQI [2. Wideband PMI] 3. Wideband correlation matrix	Diversity (Mini-band based CRU)	MIMO mode 4

MIMO feedback mode 0 is used for the OL-SU SFBC and SM adaptation in diversity permutation. The MS estimates the wideband CQI for both SFBC and SM, and reports the CQI and STC Rate. STC Rate 1 means SFBC with rank-2 SM with precoding.

<<<15.3.7.2.5.4.2>>> MIMO feedback 1<<<need 7-level header defined>>>

MIMO feedback mode 1 is used for the OL-SU SM with rank adaptation in diversity permutation. The transmission rank is determined by the STC Rate. STC Rate 1 means the rank-1 precoding.

<<<15.3.7.2.5.4.3>>> MIMO feedback 2<<<need 7-level header defined>>>

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 streams for SM. The subband CQI shall correspond to the selected rank.

<<<15.3.7.2.5.4.4>>> MIMO feedback 3<<<need 7-level header defined>>>

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 streams for SM. The subband CQI shall correspond to the selected rank.

<<<15.3.7.2.5.4.5>>> MIMO feedback 4<<<need 7-level header defined>>>

The MIMO feedback mode 4 is used for the CL SU MIMO using long-term beamforming with rank 1. In this mode, MS shall feedback the wideband CQI. The wideband CQI shall be estimated at the MS assuming long-term precoding at the BS. The channel state information may be obtained at the BS via the feedback of the correlation matrix. The feedback of a wideband PMI is TBD.

<<<15.3.7.2.5.4.6>>> MIMO feedback 5<<<need 7-level header defined>>>

The MIMO feedback mode 5 is used for OL MU MIMO in localized permutation with frequency selective scheduling. In the mode, MS shall feedback the subband selection, stream indicator and the corresponding CQI.

<<<15.3.7.2.5.4.7>>> MIMO feedback 6<<<need 7-level header defined>>>

The MIMO feedback mode 6 is used for CL MU MIMO in localized permutation with frequency selective scheduling. In the mode, MS 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.

<<<15.3.7.2.5.4.8>>> MIMO feedback 7<<<need 7-level header defined>>>

The MIMO feedback mode 7 is used for CL MU MIMO in diversity permutation (long-term beamforming MU MIMO). In this mode, MS shall feedback the wideband CQI. The wideband CQI shall be estimated at the MS assuming long-term precoding at the BS. The channel state information may be obtained at the BS via the feedback of the correlation matrix. The feedback of a wideband PMI is TBD.

15.3.7.2.5.5 Downlink signaling support of DL-MIMO modes

15.3.7.2.5.6 Quantized MIMO feedback for closed-loop transmit precoding

Table 692—DL MIMO control parameters

Parameters	Description	Value	Control Channel (IE)	Notes
<i>Broadcast Information</i>				
N_t	Number of transmit antennas at the BS	0b00: 2 0b01: 4 0b10: 8	SFH (system information)	N_t must be known before decoding the DL A-MAP IE
$OL_Region[TBD]$	OL MIMO region, which signaling is used to indicate MS where is the pre-defined OL MIMO region and number of streams (1 or 2)	TBD	Broadcast information	
SU_CT	SU base codebook type		Broadcast information	SU base codebook subset indication
$MU_CT(TBD)$	MU base codebook type		Broadcast information	MU base codebook subset indication
BC_SI	Rank-1 base codebook subset indication	BitMAP (Same size as rate-1 codebook for each number of transmit antenna)	Broadcast information	Rate-1 codebook element restriction/recommendation information It shall be ignored if CCE = 0b0
$MaxMt(TBD)$	Maximum number of streams	0b00: 2 0b01: 3 0b10: 4 0b11: reserved	Broadcast information	If MFM indicates a MU feedback mode: the maximum number of users scheduled on each RU
<i>Unicast Information</i>				

Table 692—DL MIMO control parameters

Parameters	Description	Value	Control Channel (IE)	Notes
<i>MEF</i>	MIMO encoder format	0b00: SFBC 0b01: Vertical encoding 0b10: Horizontal encoding 0b11: n/a	A-MAP IE (unicast)	MIMO encoder format [MEF bitfield may not be explicitly indicated in DL A-MAP IE].
M_t	Number of streams in transmission	0b000: 1 0b001: 2 0b010: 3 0b011: 4 0b100: 5 0b101: 6 0b110: 7 0b111: 8 ($M_t \leq N_t$)	A-MAP IE (unicast)	Number of streams in the transmission. When $MEF=0b00$: $M_t = 2$ $MEF=0b10$, $M_t \leq 4$. [Bit-field length is variable, depending on the number of Tx at BS]
<i>RU allocation (TBD)</i>	RU [and stream] indicator for the burst of data	TBD	A-MAP IE (unicast)	Refer to DL control group.
<i>SI(TBD)</i>	<i>Index of pilot stream allocation</i>	0b00: 1 0b01: 2 0b10: 3 0b11: 4	A-MAP IE (unicast)	SI shall be indicated if $MEF = 0b010$ [Bit-field length is variable, depending on the number of Tx at BS] RU allocation and SI can be merged together depending on other DG's decision
<i>Feedback Allocation IE</i>				
<i>MF</i>	MIMO feedback mode	Refer to Table 691	Feedback allocation IE (unicast)	To decide the feedback content and related MS processing
<i>DLRU (TBD)</i>	Downlink RU, indicating which RUs or which type of RU (DRU or miniband-based CRU) to work on for feedback	TBD (Tree structure, bit map etc)	Feedback allocation IE (unicast)	To process CQI (PMI) estimation for the indicated RUs. Refer to other DG
<i>FT</i>	MIMO feedback type	0b00:codebook 0b01:sounding	Feedback allocation IE (unicast)	
<i>CM</i>	Codebook feedback mode	0b00:standard 0b01:transformation 0b10:differential	Feedback allocation IE (unicast)	Enabled when $FT = 0b00$
<i>CCE</i>	Codebook Coordination Enable	0b0:disable 0b1:enable		$CCE = 0b0$: MS finds PMI within whole broadcasted codebook type entry. $CCE = 0b1$: When MS finds rate-1 PMI, it finds within broadcasted codebook entries indicated by BC_ST, [SU_CT and MU_CT]

15.3.7.2.6.6.1 Quantized feedback modes

An MS 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:

- 3) **The base mode:** the PMI feedback from a MS shall represent an entry of the base codebook. It shall be sufficient for the BS to determine a new precoder.
- 4) **The transformation mode:** the PMI feedback from a MS shall represent an entry of the transformed base codebook according to long term channel information.
- 5) **The differential mode:** the PMI feedback from a MS shall represent an entry of the differential codebook or an entry of the base codebook at PMI reset times. The feedback from a MS 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 BS 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.

15.3.7.2.6.6.2 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 MS selects its preferred matrix from the base codebook based on the channel measurements. The MS feedbacks the index of the preferred codeword, and the BS computes the precoder \mathbf{W} according to the index. Both BS and MS 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 BS.

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 streams.

The notation $C(N_t, M_t, NB, i)$ denotes the i -th codebook entry of $C(N_t, M_t, NB)$.

15.3.7.2.6.6.2.1 Base codebook for two transmit antennas

[Editors note: need to create higher level Headers]

15.3.7.2.6.6.2.1.1 SU-MIMO base codebook

[Editor's note: this section needs text]

Table 693—C(2,1,3)

Index	m	$C(2,1,3,m) = [c_1; c_2]$	
		c_1	c_2
000	0	0.7171	-0.7171
001	1	0.7171	-0.5000 - 0.5000i
010	2	0.7171	-0.7171i
011	3	0.7171	0.5000 - 0.5000i
100	4	0.7171	-0.7171
101	5	0.7171	0.5000 + 0.5000i
110	6	0.7171	-0.7171i
111	+	0.7171	-0.5000 + 0.5000i

Table 694—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_1	c_2
000	0	0.7171 0.7171	0.7171 0.7171
001	1	0.7171 0.7171	-0.5000 - 0.5000i 0.5000 + 0.5000i
010	2	0.7171 0.7171	0.7171 0.7171
011	3	0.7171 0.7171	0.5000 - 0.5000i -0.5000 + 0.5000i
100~111	4~7	-	-

15.3.7.2.6.6.2.1.2 MU-MIMO base codebook

The base codebook for MU-MIMO is the same as the rank 1 base codebook for SU-MIMO, defined in 15.3.7.2.6.6.2.1.1

15.3.7.2.6.6.2.2 Base codebook for four transmit antennas**15.3.7.2.6.6.2.2.1 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(4,4,3). Table 695, Table 696, Table 697 and Table 698 are included to illustrate the rank-1,2,3,4 base codebooks.

Table 695—C(4,1,6)

Binary Index	m	$C(4,1,6,m)$			
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
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	$-0.0793 + 0.4260i$	$-0.1995 - 0.6025i$	$0.4906 - 0.2674i$

Table 695—C(4,1,6)

Binary Index	m	$C(4,1,6,m)$			
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
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

Table 695—C(4,1,6)

Binary Index	<i>m</i>	<i>C</i> (4,1,6, <i>m</i>)			
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 696—C(4,2,6)

Index	<i>m</i>	$C(4, 2, 6, m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \end{bmatrix}^T$			
		$\begin{matrix} c_{11} \\ c_{21} \end{matrix}$	$\begin{matrix} c_{12} \\ c_{22} \end{matrix}$	$\begin{matrix} c_{13} \\ c_{23} \end{matrix}$	$\begin{matrix} c_{14} \\ c_{24} \end{matrix}$
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

Table 696—C(4,2,6)

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
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

Table 696—C(4,2,6)

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
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

Table 696—C(4,2,6)

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
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 697—C(4,3,4)

$C(4, 3, 4, m) = \begin{bmatrix} C(4, 1, 6, i) \\ C(4, 1, 6, j) \\ C(4, 1, 6, k) \end{bmatrix}$											
Binary index	m	i,j,k	Binary index	m	i,j,k	Binary index	m	i,j,k	Binary index	m	i,j,k
000000	0	6,0,1	000100	4	7,3,4	001000	8	6,0,4	001100	12	8,9,10
000001	1	6,0,2	000101	5	7,3,5	001001	9	6,4,5	001101	13	8,10,11
000010	2	6,1,2	000110	6	7,4,5	001010	10	7,3,1	001110	14	12,13,15
000011	3	0,1,2	000111	7	3,4,5	001011	11	7,1,2	001111	15	13,14,15

Table 698—C(4,4,3)

$C(4, 4, 3, m) = \begin{bmatrix} C(4, 1, 6, i) \\ C(4, 1, 6, j) \\ C(4, 1, 6, k) \\ C(4, 1, 6, p) \end{bmatrix}$								
Binary index	m	i,j,k,p	Binary index	m	i,j,k,p	Binary index	m	i,j,k,p
000000	0	6,0,1,2	000010	2	6,0,4,5	000100	4	8,9,10,11
000001	1	7,3,4,5	000011	3	7,3,1,2	000101	5	12,13,14,15

In terms of the chordal distance, the hierarchical structure of C(4,1,6) is depicted in Figure 483. In this hierarchical structure, it is shown that C(4,1,6) consists of 16 codeword clusters. Each codeword cluster has four codewords, of which one codeword is from Layer 1 and the three other codewords are from Layer 2. For any

given Layer 2 codeword, its chordal distance to all other Layer 1 codewords of different clusters is always much larger than that distance to the Layer 1 codeword of its same cluster

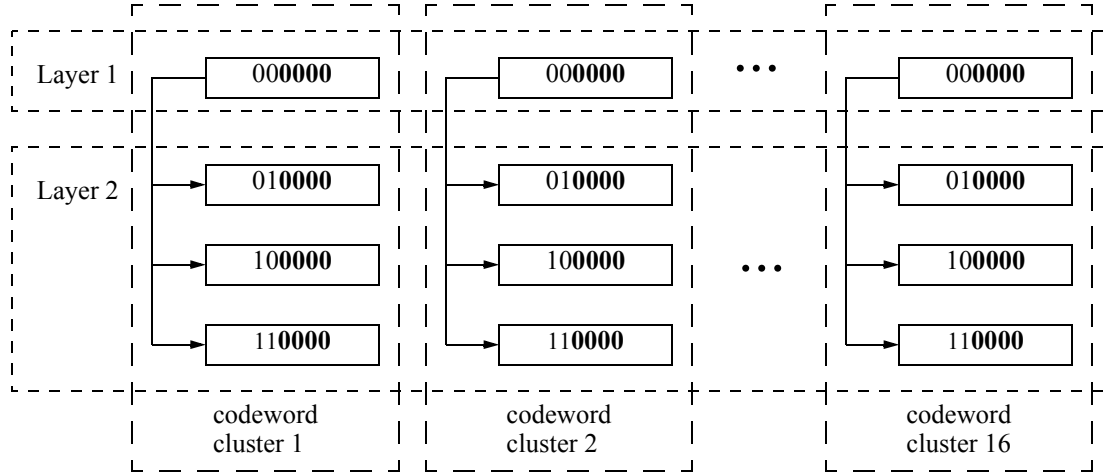


Figure 483—Chordal distance map of C(4,1,6)

As a potential benefit, this hierarchical structure can facilitate codeword searching. More specifically, codeword searching in C(4,1,6) can start from all Layer 1 codewords. Only when a Layer 1 codeword satisfies a certain criterion, associated Layer 2 codewords within the same cluster need to be searched.

The binary indices of the codewords in cluster, $i, i \in [0, \dots, 15]$ is given by Table 699.

Table 699—Binary indices of the codewords in cluster i

Codeword in cluster i	Layer 1 codeword	Layer 2 codewords		
		Codeword 1	Codeword 2	Codeword 3
Binary index	$00x_{i3}x_{i2}x_{i1}x_{i0}$	$01x_{i3}x_{i2}x_{i1}x_{i0}$	$10x_{i3}x_{i2}x_{i1}x_{i0}$	$11x_{i3}x_{i2}x_{i1}x_{i0}$
$i = x_{i3} \times 2^3 + x_{i2} \times 2^2 + x_{i1} \times 2 + x_{i0}, x_{ij} \in [0, 1], i \in [0, \dots, 15], j \in [0, 1, 2, 3]$				

15.3.7.2.6.6.2.2.2 MU-MIMO base codebook

The base codebook for MU-MIMO is same as the rank 1 base codebook for SU-MIMO, defined in 15.3.7.2.6.6.2.2.1.

15.3.7.2.6.6.2.3 Base codebook for eight transmit antennas

15.3.7.2.6.6.2.3.1 SU-MIMO base codebook

The base codebook is constructed from two matrices $V8(:, :, 1)$ and $V8(:, :, 2)$, which are constructed as described below

$$T_1 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$T_2 = \begin{bmatrix} 1 & 1 \\ \frac{1+j}{\sqrt{2}} & -\frac{1+j}{\sqrt{2}} \end{bmatrix}$$

$$T_3 = \begin{bmatrix} 1 & 1 \\ j & -j \end{bmatrix}$$

$$T_4 = \begin{bmatrix} 1 & 1 \\ -\frac{1+j}{\sqrt{2}} & -\frac{1+j}{\sqrt{2}} \end{bmatrix}$$

Define

$$\begin{aligned} \mathbf{H}_i(m1, m2) &\equiv \mathbf{H}_i(\mathbf{T}_{m1}, \mathbf{T}_{m2}) \\ &= [\mathbf{T}_i(:,1) \otimes \mathbf{T}_{m1}, \mathbf{T}_i(:,2) \otimes \mathbf{T}_{m2}] \end{aligned} \quad (209)$$

$$\begin{aligned} H_{i,k,l}(\mathbf{T}_{m1}, \mathbf{T}_{m2}, \mathbf{T}_{m3}, \mathbf{T}_{m4}) &\equiv H_{i,k,l}(m1, m2, m3, m4) \\ &= (\mathbf{T}_i(:,1) \otimes [\mathbf{H}_k(m1, m2)], \mathbf{T}_i(:,2) \otimes [\mathbf{H}_l(m3, m4)]) \\ &= H_i(\mathbf{H}_k(m1, m2), \mathbf{H}_l(m3, m4)) \end{aligned} \quad (210)$$

The two rank-8 matrices used for rank-2 to rank-8 transmission for SU-MIMO are:

$$V8(:, :, 1) = \frac{1}{\sqrt{8}} H_{1,1,3}(1, 3, 2, 4) = \frac{1}{\sqrt{8}} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & j & -j & \frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} & \frac{(-1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} \\ 1 & 1 & -1 & -1 & j & j & -j & -j \\ 1 & -1 & -j & j & \frac{(-1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & -1 & j & -j & -\frac{(1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} & \frac{(-1+j)}{\sqrt{2}} \\ 1 & 1 & -1 & -1 & -j & -j & j & j \\ 1 & -1 & -j & j & -\frac{(-1+j)}{\sqrt{2}} & \frac{(-1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} \end{bmatrix} \quad (211)$$

$$V_8(:,2) = \frac{1}{\sqrt{8}} H_{3,2,4}(1,3,2,4) = \frac{1}{\sqrt{8}} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & j & -j & \frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} & \frac{(-1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} \\ \frac{(1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} & \frac{(-1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} & \frac{(-1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} \\ \frac{(1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} & -1 & 1 & j & -j \\ j & j & j & j & -j & -j & -j & -j \\ j & -j & -1 & 1 & -\frac{(-1+j)}{\sqrt{2}} & \frac{(-1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} \\ \frac{(-1+j)}{\sqrt{2}} & \frac{(-1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} \\ \frac{(-1+j)}{\sqrt{2}} & -\frac{(-1+j)}{\sqrt{2}} & \frac{(1+j)}{\sqrt{2}} & -\frac{(1+j)}{\sqrt{2}} & j & -j & 1 & -1 \end{bmatrix} \quad (212)$$

The third base matrix, $V_8(:,3)$, is used for rank-1 transmission for MU-MIMO. The j -th column vector of the base matrix $V_8(:,3)$ is given by

$$V_8(:,j,3) = \frac{1}{\sqrt{8}} \begin{bmatrix} 1 \\ e^{j\pi \sin(\theta_j)} \\ e^{j2\pi \sin(\theta_j)} \\ e^{j3\pi \sin(\theta_j)} \\ e^{j4\pi \sin(\theta_j)} \\ e^{j5\pi \sin(\theta_j)} \\ e^{j6\pi \sin(\theta_j)} \\ e^{j7\pi \sin(\theta_j)} \end{bmatrix} \quad (213)$$

where the set $\theta_j, j = 1, \dots, 16$ is given by:

$$\theta_j = ((j-1) + 1/2) \times \frac{\pi}{24} - \frac{\pi}{3} \quad (214)$$

The 4bits 8Tx base codebook is constructed from the three 8×8 base matrices and is specified in Table 700 and Table 701. Note that only the column indices of the corresponding base matrices are shown in Table 701 for brevity.

Table 700—Rank 1 of SU MIMO 4bit 8Tx base codebook

Codebook Matrix Index (CMI)	Base Matrix	C(8,1,4)
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Table 700—Rank 1 of SU MIMO 4bit 8Tx base codebook

1	V8(:,3)	V8(:,1,3)
2		V8(:,2,3)
3		V8(:,3,3)
4		V8(:,4,3)
5		V8(:,5,3)
6		V8(:,6,3)
7		V8(:,7,3)
8		V8(:,8,3)
9		V8(:,9,3)
10		V8(:,10,3)
11		V8(:,11,3)
12		V8(:,12,3)
13		V8(:,13,3)
14		V8(:,14,3)
15		V8(:,15,3)
16		V8(:,16,3)

Table 701—Ranks 2 to 8 of SU MIMO 4 bit 8Tx base codebook

Codebook Matrix Index (CMI)	Base Matrix	C(8,2,4)	C(8,3,4)	C(8,4,4)	C(8,5,4)	C(8,6,4)	C(8,7,4)	C(8,8,4)
1	V8(:,1)	15	1 3 5	1537	12357	123567	1234567	12345678
2		2 6	2 4 6	2648	12468	124568	1234568	n/a
3		3 7	2 3 7	3726	23467	234678	1234678	n/a
4		4 8	1 4 8	4815	13458	134578	1234578	n/a
5		5 3	3 5 7	5372	23567	234567	2345678	n/a
6		4 6	4 6 8	6481	14568	134568	1345678	n/a
7		2 7	2 6 7	7264	24678	124678	1245678	n/a
8		8 1	1 5 8	8153	13578	123578	1235678	n/a
9								
		1 2 3	1234	12345	123456	1234567	12345678	
10		2 4	1 2 4	1246	12456	124567	1245678	n/a
11		2 3	2 3 4	2437	23478	123478	1234578	n/a
12		1 4	1 3 4	1348	13478	134678	1234678	n/a
13		5 8	5 7 8	3578	23578	235678	1235678	n/a
14		6 7	6 7 8	4678	14678	145678	1345678	n/a
15		5 7	5 7 6	5678	35678	345678	2345678	n/a
16		6 8	5 6 8	1568	13568	123568	1234568	n/a

15.3.7.2.6.6.2.3.2 MU-MIMO base codebook

The base codebook for MU-MIMO is same as the rank 1 base codebook for SU-MIMO, defined in 15.3.7.2.6.6.2.3.1

15.3.7.2.6.6.2.4 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, SU_CT.

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 CM is not set to 0b11. CM is transmitted in FBCH_Alloc_IE.

15.3.7.2.6.6.2.5 Codebook subsets <<<need to create higher level Headers>>>

15.3.7.2.6.6.2.5.1 OL MIMO subset<<<need to create higher level Headers>>>

The OL SU-MIMO codebook subset shall be used for non-adaptive precoding with MIMO mode 0 and MIMO mode 1.

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 streams. The notation $C_{DL,OL,SU}(N_t, M_t, N_w, i)$ denotes the i -th codebook entry of $C_{DL,OL,SU}(N_t, M_t, N_w)$.

15.3.7.2.6.6.2.5.1.1 OL SU-MIMO subset for two transmit antennas<<<need to create higher level Headers>>>

Table 702 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 2Tx.

Table 702—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 703 for each rank. The corresponding codewords of the DL base codebook for two transmit antennas are also given in Table 703.

Table 703— $C_{DL,OL,SU}(2,1,2)$ 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	PMI m in DL base codebook of rank 1	n	PMI m in DL base codebook of rank 2
0	2	0	2
1	6		

The PMI m in the base codebook of rank M_t with $N_t = 2$ is given by v_{m+1} as in <<Equation (203)>>.

[Editor's note: equation 203 was deleted by comment 286 at Session 61]>>>.

15.3.7.2.6.6.2.5.1.2 OL SU-MIMO subset for four transmit antennas<<<need to create higher level Headers>>>

Table 704 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 4Tx.

Table 704—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 705 for each rank. The corresponding codewords of the DL base codebook for four transmit antennas are given in Table 705.

Table 705— $C_{DL,OL,SU}(4,1,4)$, $C_{DL,OL,SU}(4,2,4)$, $C_{DL,OL,SU}(4,3,2)$ 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(4,3,4,12)	0	C(4,4,3,4)
1	C(4,1,6,10)	1	C(4,2,6,29)	1	C(4,3,4,13)		
2	C(4,1,6,9)	2	C(4,2,6,27)				
3	C(4,1,6,11)	3	C(4,2,6,25)				

15.3.7.2.6.6.2.5.1.3 OL SU-MIMO subset for eight transmit antennas<<<need to create higher level Headers>>>

Table 706 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 8Tx.

Table 706—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 707 and Table 708 for each rank. The corresponding codewords of the DL base codebook for eight transmit antennas are given in Table 707 and Table 708.

Table 707— $C_{DL,OL,SU}(8,1,8)$, $C_{DL,OL,SU}(8,2,4)$, $C_{DL,OL,SU}(8,3,4)$ 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)

Table 707— $C_{DL,OL,SU}(8,1,8)$, $C_{DL,OL,SU}(8,2,4)$, $C_{DL,OL,SU}(8,3,4)$ 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
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 708— $C_{DL,OL,SU}(8,5,2)$, $C_{DL,OL,SU}(8,6,2)$, $C_{DL,OL,SU}(8,7,2)$ 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	$C(8,7,4,1)$		

15.3.7.2.6.6.2.5.2 CL SU-MIMO subset**15.3.7.2.6.6.2.5.2.1 CL SU-MIMO subset for four transmit antennas**

Codebook subset selection for four transmit antennas is specified in Table 709.

Table 709—Subset selection of the base codebook for four transmit antennas

Rank	One	Two	Three	Four
Subset selection	$C(4,1,6,m)$ $m = 0$ to 15	$C(4,2,6,m)$ $m = 0$ to 15	$C(4,3,4,m)$ $m = 0$ to 15	$C(4,4,3,m)$ $m = 0$ to 5

15.3.7.2.6.6.2.5.3 CL MU-MIMO subset**15.3.7.2.6.6.2.5.3.2. 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 709.

15.3.7.2.6.6.3 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 BS transmit correlation matrix. A quantized representation of the BS transmit correlation matrix shall be fed back by the MS as instructed by the BS

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 BS and MS 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 (215)

$$\tilde{\mathbf{V}}_i = \frac{\mathbf{R}\mathbf{v}_i}{\|\mathbf{R}\mathbf{v}_i\|} \quad (215)$$

\mathbf{V}_i is the i -th codeword of the base codebook,

$\tilde{\mathbf{V}}_i$ 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 MS and BS 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 MS is operating with transformation codebook-based feedback mode.

The correlation matrix \mathbf{R} shall be fed back to support transformation mode of codebook-based precoding.

\mathbf{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

$$\mathbf{R} = \mathbf{E}(\mathbf{H}_{ij}^H \mathbf{H}_{ij}) \quad (216)$$

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

$$\mathbf{R} = \begin{pmatrix} r_{11} & r_{12} \\ \text{conj}(r_{12}) & r_{22} \end{pmatrix} \quad (N_T = 2) \quad (217)$$

$$\mathbf{R} = \begin{pmatrix} r_{11} & r_{12} & r_{13} & r_{14} \\ \text{conj}(r_{12}) & r_{22} & r_{23} & r_{24} \\ \text{conj}(r_{13}) & \text{conj}(r_{23}) & r_{33} & r_{34} \\ \text{conj}(r_{14}) & \text{conj}(r_{24}) & \text{conj}(r_{34}) & r_{44} \end{pmatrix} \quad (N_T = 4) \quad (218)$$

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.

R matrix is normalized by the maximum element amplitude, and then quantized to reduce the feedback overhead.

The equation of normalization is

$$\bar{R} = \frac{R}{\max(\text{abs}(r_{ij}))} \quad (i, j = 1, \dots, N_T) \quad (219)$$

The normalized diagonal elements are quantized by 1 bit, and the normalized complex elements are quantized by 4 bits.

The equation for quantization is

$$q = a \cdot e^{(j \cdot b \cdot 2\pi)} \quad (220)$$

$a=[0.6 \ 0.9]$ and $b=0$ for diagonal entries

Table 710—

Diagonal Entries	a	b	q
q_1	0.6	0	0.6000
q_2	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 triangular entries

Table 711—

non-Diagonal Entries	a	b	q
q_1	0.1	0	0.1000
q_2	0.1	1/8	$0.0707 + 0.0707i$
q_3	0.1	1/4	$0.0000 + 0.1000i$
q_4	0.1	3/8	$-0.0707 + 0.0707i$

Table 711—

non-Diagonal Entries	a	b	q
q_5	0.1	1/2	-0.1000 + 0.0000i
q_6	0.1	5/8	-0.0707 - 0.0707i
q_7	0.1	3/4	-0.0000 - 0.1000i
q_8	0.1	7/8	0.0707 - 0.0707i
q_9	0.5	0	0.5000
q_{10}	0.5	1/8	0.3536 + 0.3536i
q_{11}	0.5	1/4	0.0000 + 0.5000i
q_{12}	0.5	3/8	-0.3536 + 0.3536i
q_{13}	0.5	1/2	-0.5000 + 0.0000i
q_{14}	0.5	5/8	-0.3536 - 0.3536i
q_{15}	0.5	3/4	-0.0000 - 0.5000i
q_{16}	0.5	7/8	0.3536 - 0.3536i

The total number of bits of feedback is 6 bits for 2 transmit antennas and 28 bits for 4 transmit antenna. The MS and BS shall use the same transformation based on the correlation matrix fed back by the MS.

15.3.7.2.6.4 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. The codebook for the one-shot feedback is defined for the base mode.

Denote the feedback index, the correspondingly fed back matrix, and the corresponding precoder by t , $\mathbf{D}(t)$, and $\mathbf{V}(t)$, respectively. The sequential index is reset to 0 at $T_{max} + 1$. The index for the initial or the restart feedback is 0 and $\mathbf{V}(0) = \mathbf{D}(0)$. The indexes of the subsequent differential feedback are 1, 2, ..., T_{max} and the corresponding precoders are $\mathbf{V}(t) = \mathbf{Q}_{\mathbf{V}(t-1)} \mathbf{D}(t)$, where $\mathbf{Q}_{\mathbf{V}(t-1)}$ is a unitary $N_t \times N_t$ matrix computed from the previous precoder $\mathbf{V}(t-1)$; N_t is the number of transmit antennas. The dimension of the fed back matrix $\mathbf{D}(t)$ is $N_t \times N_s$ for $t = 0, 1, 2, \dots, T_{max}$, where N_s is the number of spatial streams.

The rotation matrix $\mathbf{Q}_{\mathbf{V}(t-1)}$ of $\mathbf{V}(t-1)$ has the form $\mathbf{Q}_{\mathbf{V}(t-1)} = [\mathbf{V}(t-1) \mathbf{V}^\perp(t-1)]$, where $\mathbf{V}^\perp(t-1)$ consists of columns each of which has a unit norm and is orthogonal to the other columns of $\mathbf{Q}_{\mathbf{V}(t-1)}$. Define the Householder matrix Ω_x of unit vector \mathbf{x} as:

$$\Omega_x = \begin{cases} \mathbf{I} - \frac{2}{\|\mathbf{w}\|^2} \mathbf{w} \mathbf{w}^H & \text{for } \|\mathbf{w}\|, \|\mathbf{x}\| > 0 \\ \mathbf{I} & \text{otherwise} \end{cases}$$

where $\|\mathbf{x}\| = 1$ and $\mathbf{w} = e^{-j\theta} \mathbf{x} - \mathbf{e}_1$; θ is the phase of the first entry of \mathbf{x} ; $\mathbf{e}_1 = [1 \ 0 \ \dots \ 0]$. For $N_s = 1$, $\mathbf{V}(t-1)$ is an $N_t \times 1$ vector and $\mathbf{Q}_{\mathbf{V}(t-1)} = \Omega_{\mathbf{V}(t-1)}$. For $N_s = 2$ and $N_t = 4$, $\mathbf{V}(t-1)$ is 4×2 . Denote $\mathbf{V}(t-1)$ as $\mathbf{B} = [\mathbf{b}_1 \ \mathbf{b}_2]$. Two columns are appended to \mathbf{B} as $\mathbf{M} = [\mathbf{B} \ \mathbf{e}_i \ \mathbf{e}_j]$, where \mathbf{e}_i and \mathbf{e}_j are vectors with all zeros except that the i^{th} and j^{th} entries are ones, respectively. The index i and j are selected. Let the i^{th} and j^{th} entries of $\mathbf{g} = (|Re(\mathbf{B})| + |Im(\mathbf{B})|) \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ be the smallest and the second smallest, respectively, where $|A|$ converts A 's entries

to their absolute values; $|Re(\mathbf{B})|$ and $|Im(\mathbf{B})|$ are the real and imaginary parts of \mathbf{B} , respectively. Gram-Schmidt orthogonalization is applied on \mathbf{e}_i as $\mathbf{m}_3 = \mathbf{e}_i - b_{i,1}^* \mathbf{b}_1 - b_{i,2}^* \mathbf{b}_2$, where $b_{k,l}^*$ is the conjugate of \mathbf{B} 's entry of on the k^{th} row and l^{th} column. Normalization follows the orthogonalization as $\mathbf{b}_3 = \frac{\mathbf{m}_3}{\|\mathbf{m}_3\|}$. The matrix \mathbf{B} is extended by one column as $\mathbf{B} = [\mathbf{b}_1 \ \mathbf{b}_2 \ \mathbf{b}_3]$. The Gram-Schmidt process on \mathbf{e}_j is $\mathbf{m}_4 = \mathbf{e}_j - b_{j,1}^* \mathbf{b}_1 - b_{j,2}^* \mathbf{b}_2 - b_{j,3}^* \mathbf{b}_3$. The followed normalization is $\mathbf{b}_4 = \frac{\mathbf{m}_4}{\|\mathbf{m}_4\|}$. Finally, $\mathbf{Q}_{\mathbf{V}(t-1)} = [\mathbf{V}(t-1) \ \mathbf{b}_3 \ \mathbf{b}_4]$. The Gram-Schmidt orthogonalization is the same as the one applied in the transformed codebook. An illustration of the computation of $\mathbf{Q}_{\mathbf{V}(t-1)}$ is shown in <<Figure xxx>>. Let \mathbf{A} be a vector or a matrix with two columns. Denote $\mathbf{Q}_{\mathbf{A}}$ the rotation matrix of \mathbf{A} .

The feedback matrix $\mathbf{D}(t)$ is selected from a differential codebook. Denote the codebook by $D(N_t, N_s, N_w)$, where N_w is the number of codewords in the codebook. The codebooks $D(2,1,4)$, $D(2,2,4)$, $D(4,1,16)$, and $D(4,2,16)$ are listed in Table 712, Table 713<<Table xxx, xxx, xxx, xxx>>. Denote $\mathbf{D}_i(N_t, N_s, N_w)$ the i^{th} codeword of $D(N_t, N_s, N_w)$. The rotation matrices $\mathbf{Q}_{\mathbf{D}_i}$ s of the $\mathbf{D}_i(N_t, N_s, N_w)$ s comprises a set of N_t by N_t matrixes that is denoted by $\mathcal{Q}_{D(N_t, N_s, N_w)}$.

The differential codebook $D(4,3,N_w)$ is computed from $\mathcal{Q}_{D(4,1,N_w)}$. The i^{th} codeword of $D(4,3,N_w)$ denoted by $\mathbf{D}_i(4,3,N_w)$ is computed as

$$\mathbf{D}_i(4, 3, N_w) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} \tilde{\mathbf{Q}}_i(4, 1, N_w),$$

where $\tilde{\mathbf{Q}}_i(4, 1, N_w)$ consists of the last three columns of the i^{th} matrix in $\mathcal{Q}_{D(4,1,N_w)}$. The differential codebook $D(4,4,N_w)$ is computed from $\mathcal{Q}_{D(4,2,N_w)}$. The i^{th} codeword of $D(4,4,N_w)$ is the i^{th} matrix in $\mathcal{Q}_{D(4,2,N_w)}$. Two sets of differential codebooks are defined. One has a large step size for fast tracking capability and the other has a small step size for high tracking accuracy. For $t = 1$, the codebook with large step size shall be used. A 1-bit indicator may be fed back for the step size used for $t = 2, \dots, T_{\text{max}}$.

Table 712— $D(2,1,4)$ codebook

	Index	Codeword	Index	Codeword
Codebook of large step size	1	$\begin{bmatrix} 1 & 0 \end{bmatrix}^T$	3	$\begin{bmatrix} \cos(15) & \sin(15)e^{j120} \end{bmatrix}^T$
	2	$\begin{bmatrix} \cos(15) & \sin(15) \end{bmatrix}^T$	4	$\begin{bmatrix} \cos(15) & \sin(15)e^{-j120} \end{bmatrix}^T$

Table 713— $D(2,2,4)$ codebook

	Index	Codeword	Index	Codeword
Codebook of large step size	1	$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$	3	$\begin{bmatrix} \cos(15) & \sin(15)e^{j120} \\ \sin(15)e^{j120} & -\cos(15) \end{bmatrix}$
	2	$\begin{bmatrix} \cos(15) & \sin(15) \\ \sin(15) & -\cos(15) \end{bmatrix}$	4	$\begin{bmatrix} \cos(15) & \sin(15)e^{-j120} \\ \sin(15)e^{-j120} & -\cos(15) \end{bmatrix}$

15.3.7.2.5.7 Unquantized MIMO feedback for closed-loop transmit precoding

15.3.7.2.6.7.1 UL sounding

To assist the BS in determining the precoding matrix to use for SU-MIMO or MU-MIMO, the BS may request the MS transmit a sounding signal in an UL sounding channel. The BS may translate the measured UL channel response to an estimated DL channel response. The transmitter and receiver hardware of BS and MS shall be calibrated.

The UL sounding channel defined in subclause [TBD] is used in MIMO transmission

15.3.7.2.6.7.2 Analog feedback

15.3.7.3 Transmission schemes for control channels

15.3.7.3.1 Superframe header (SFH)

For two BS transmit antennas, the P-SFH and the S-SFH shall be transmitted using SFBC.

The input to the MIMO encoder is represented by a 2×1 vector.

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \quad (221)$$

The MIMO encoder generates the SFBC matrix.

$$\mathbf{x} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix} \quad (222)$$

The two-stream pilot pattern defined in 15.3.5.x is used for SFH transmission.

15.3.7.3.2 Advanced MAP (A-MAP)

MIMO mode 0 shall be used for transmission of the A-MAP.

Two stream pilot pattern defined in 15.3.5.x shall be used for A-MAP transmission.

15.3.7.4 MIMO transmission schemes for E-MBS

15.3.8 Uplink physical structure

Each uplink 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 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 484 illustrates the uplink physical structure in the example of two frequency partitions with frequency partition 2 including both contiguous and distributed resource allocations, where S_c stands for Sub-carrier.

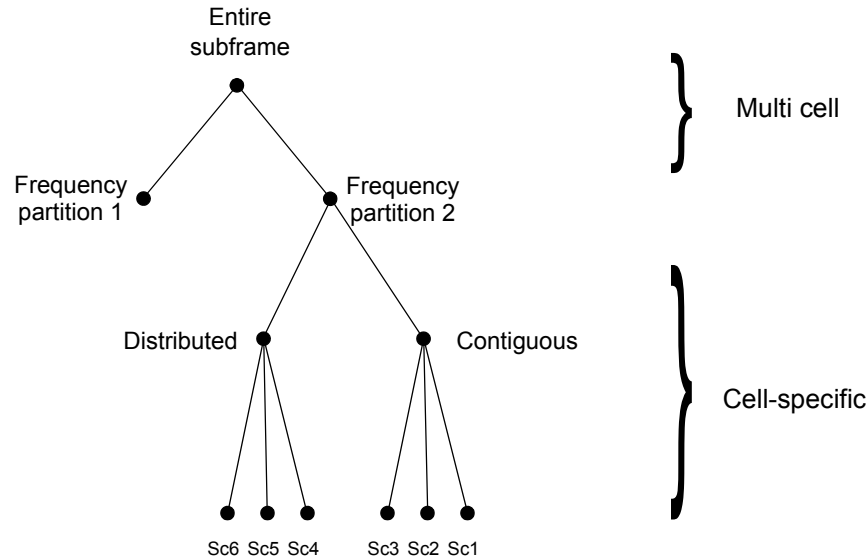


Figure 484—Example of uplink physical structure

15.3.8.1 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 and N_{sym} is 6 for type-1 subframes, 7 for type-2 subframes, 5 for type-3 subframes, and 9 for type-4 subframes. A logical resource unit (LRU) is the basic logical unit for distributed and localized resource allocations. An LRU has $P_{sc} \times N_{sym}$ 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.

15.3.8.1.1 Distributed resource unit

The distributed resource unit (DRU) contains a group of subcarriers which are spread across the distributed resource allocations within a frequency partition. The size of the DRU equals the size of a PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The minimum unit for forming the DRU is a tile. The uplink tile size is $6 \times N_{sym}$, where the value of N_{sym} depends on the subframe type.

15.3.8.1.2 Contiguous resource unit

The localized resource unit, also known as contiguous resource unit (CRU) contains a group of subcarriers which are contiguous across the resource allocations. The size of the CRU equals the size of a PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols.

15.3.8.2 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 subclauses.

15.3.8.2.1 Subband Partitioning

The PRUs are first divided into subbands and minibands; a subband comprises N_1 adjacent PRUs and a miniband 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 $L_{SB} = N_1 * K_{SB}$. A 5, 4 or 3-bit (TBD) field called *Uplink Subband Allocation Count* (USAC) determines the value of K_{SB} depending on system bandwidth. 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 $L_{MB} = N_2 * K_{MB}$. The total number of PRUs is $N_{PRU} = L_{SB} + L_{MB}$. Mappings between USAC and K_{SB} are shown in Table 714 and Table 715.

Table 714—Mapping between USAC and K_{SB} for 10 or 20MHz

USAC	# of subbands allocated (K_{SB})	USAC	# of subbands allocated (K_{SB})
0	0	8	10
1	1	9	12
2	2	10	14
3	3	11	16
4	4	12	18
5	5	13	20
6	6	14	22
7	8	15	24

Table 715—Mapping between USAC and K_{SB} for 5MHz

USAC	# of subbands allocated (K_{SB})	USAC	# of subbands allocated (K_{SB})
0	0	4	4
1	1	5	5
2	2	6	6
3	3	7	N.A

The PRUs are partitioned and reordered into two groups of 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 (223) defines the mapping of PRUs into PRU_{SB} s. Equation (225) defines the mapping of PRUs to PRU_{MB} s. Figure 485 illustrates the PRU to PRU_{SB} s and PRU_{MB} s mapping for a 5 MHz bandwidth with K_{SB} equal to 3.

$$PRU_{SB}[j] = PRU[i]; \quad 0 \leq j \leq L_{SB} - 1 \quad (223)$$

where

$$i = N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{j}{N_1} \right\rfloor + \left\lfloor \frac{j}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\} \bmod \{N_{sub}\} + \{j\} \bmod \{N_1\} \quad (224)$$

$$PRU_{MB}[k] = PRU[i]; \quad k = 0, 1, \dots, L_{MB} - 1 \quad (225)$$

where

$$i = \begin{cases} N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{k + L_{SB}}{N_1} \right\rfloor + \left\lfloor \frac{k + L_{SB}}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\} \bmod \{N_{sub}\} + \{k + L_{SB}\} \bmod \{N_1\} & K_{SB} > 0 \\ k & K_{SB} = 0 \end{cases} \quad (226)$$

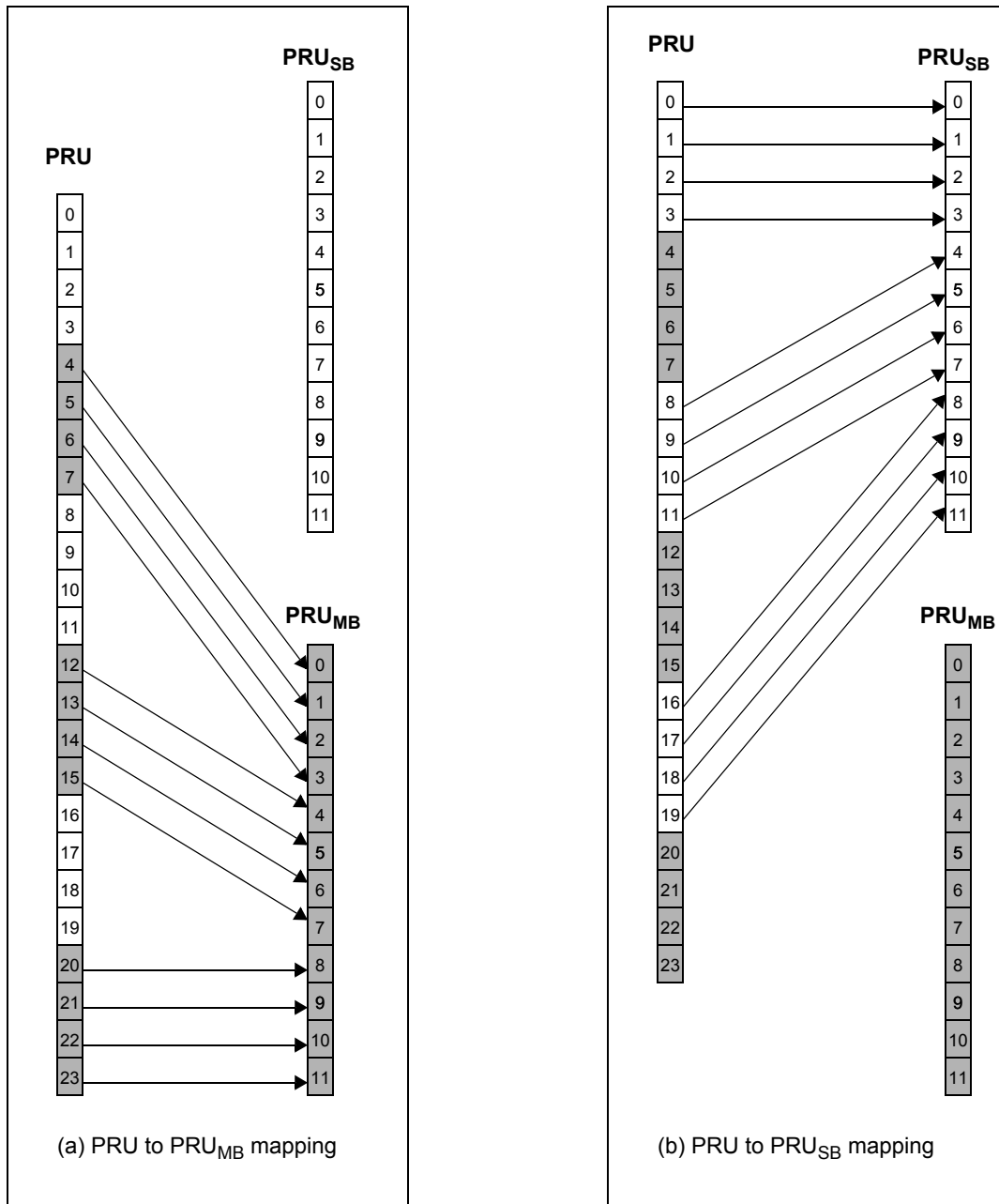


Figure 485—PRU to PRU_{SB} and PRU_{MB} mapping for BW of 5 MHz and $K_{SB}=3$

15.3.8.2.2 Miniband permutation

The miniband permutation maps the PRU_{MB}s to permuted-PRU_{MB}s (PPRU_{MB}s) to insure allocation of frequency diverse PRUs to each frequency partition. Equation (227) provides a mapping from PRU_{MB}s to PPRU_{MB}s.

$$PPRU_{MB}[j] = PRU_{MB}[i]; \quad 0 \leq j \leq L_{MB} - 1 \quad (227)$$

where:

$$i = (q(j) \bmod D) \cdot P + \left\lfloor \frac{q(j)}{D} \right\rfloor$$

$$P = \min(K_{MB}, N_1/N_2)$$

$$r(j) = \max\{j - ((K_{MB} \bmod P) \cdot D), 0\}$$

$$q(j) = j + \left\lfloor \frac{r(j)}{D-1} \right\rfloor$$

$$D = \left\lfloor \frac{K_{MB}}{P} + 1 \right\rfloor$$

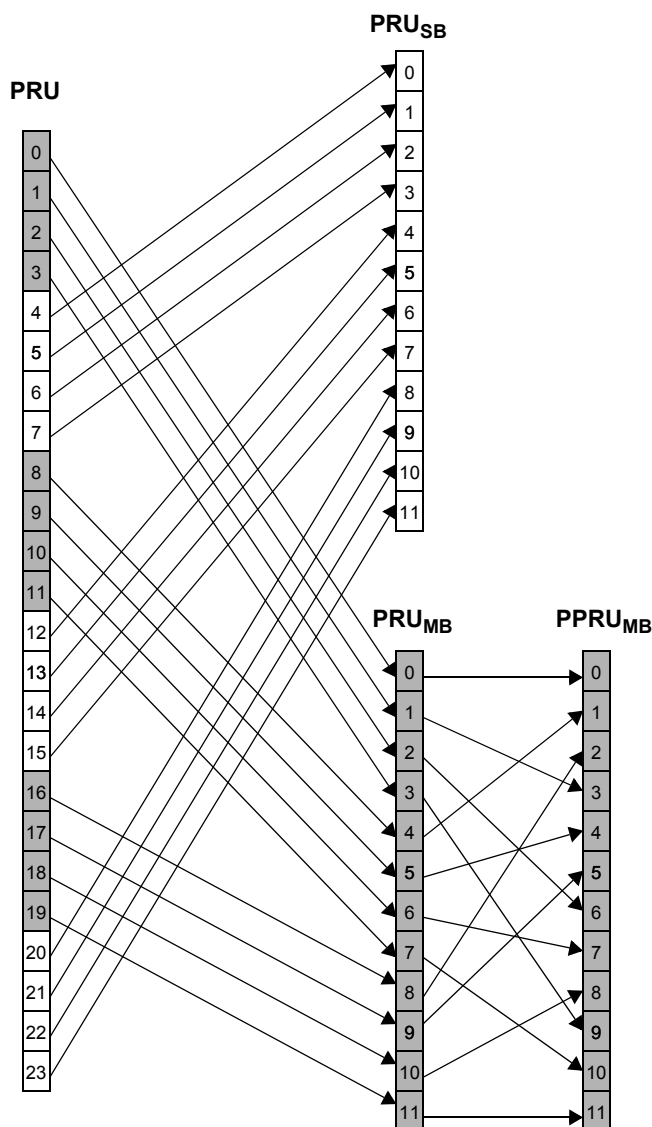


Figure 486—Mapping of PRU_{SB} to PRU_{SB} and PPRU_{MB} for BW=5MHz, K_{SB}=3

15.3.8.2.3 Frequency partitioning

The PRU_{SB} and PPRU_{MB} are allocated to one or more frequency partitions. By default, only one partition is present. The maximum number of frequency partitions is 4 (TBD). The frequency partition configuration is transmitted in the SFH in a 4, 3-bit composite field called the *Uplink Frequency Partition Configuration* (UFPC), depending on system bandwidth. Frequency Partition Count (FPCT) defines the number of frequency partitions. Frequency Partition Size (FPSi) defines the number of PRUs allocated to FPi. FPCT and FPSi are determined from UFPC as shown in Table 716 and Table 717.

A 3, 2, or 1-bit called the Uplink Frequency Partition Subband Count (UFPSC) defines the number of subbands allocated to FPi for i>0.

Table 716—Mapping between UFPC and frequency partitioning for 10 or 20MHz

UFPC	Freq. Partitioning (FP ₀ :FP ₁ :FP ₂ : FP ₃)	FPCT	FPSi (i=0)	FPSi (i>0)
0	1 : 0 : 0 : 0	1	N _{PRU}	0
1	0 : 1 : 1 : 1	3	0	N _{PRU} * 1/3
2	1 : 1 : 1 : 1	4	N _{PRU} * 1/4	N _{PRU} * 1/4
3	3 : 1 : 1 : 1	4	N _{PRU} * 1/2	N _{PRU} * 1/6
4	5 : 1 : 1 : 1	4	N _{PRU} * 5/8	N _{PRU} * 1/8
5	9 : 1 : 1 : 1	4	N _{PRU} * 9/12	N _{PRU} * 1/12
6	9 : 5 : 5 : 5	4	N _{PRU} * 3/8	N _{PRU} * 5/24
7-15	Reserved			

Table 717—Mapping between UFPC and frequency partitioning for 5MHz

UFPC	Freq. Partitioning (FP ₀ :FP ₁ :FP ₂ : FP ₃)	FPCT	FPSi (i=0)	FPSi (i>0)
0	1 : 0 : 0 : 0	1	N _{PRU}	0
1	0 : 1 : 1 : 1	3	0	N _{PRU} * 1/3
2	1 : 1 : 1 : 1	4	N _{PRU} * 1/4	N _{PRU} * 1/4
3	3 : 1 : 1 : 1	4	N _{PRU} * 1/2	N _{PRU} * 1/6
4-7	Reserved			

The number of subbands and minibands in the i^{th} frequency partition are denoted by $K_{SB,FPi}$ and $K_{MB,FPi}$ respectively, as shown in Equation (228) and Equation (229).

$$K_{SB,FPi} = (FPS_i - K_{SB,FPi} \cdot N_1) / N_2, \quad 0 \leq i < FPCT \quad (228)$$

$$K_{MB,FPi} = (FPS_i - K_{SB,FPi} \cdot N_1) / N_2 \quad 0 \leq i < FPCT \quad (229)$$

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 in the following equations:

$$PRU_{FPi}(j) = \begin{cases} PRU_{SB}(k_1) & 0 \leq j < L_{SB,FPi} \\ PPRU_{MB}(k_2) & L_{SB,FPi} \leq j < (L_{SB,FPi} + L_{MB,FPi}) \end{cases} \quad (230)$$

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 487 depicts the frequency partitioning for BW of 5 MHz, $K_{SB} = 3$, $FPCT = 2$, $FPS = 12$, and $FPSC = 1$.

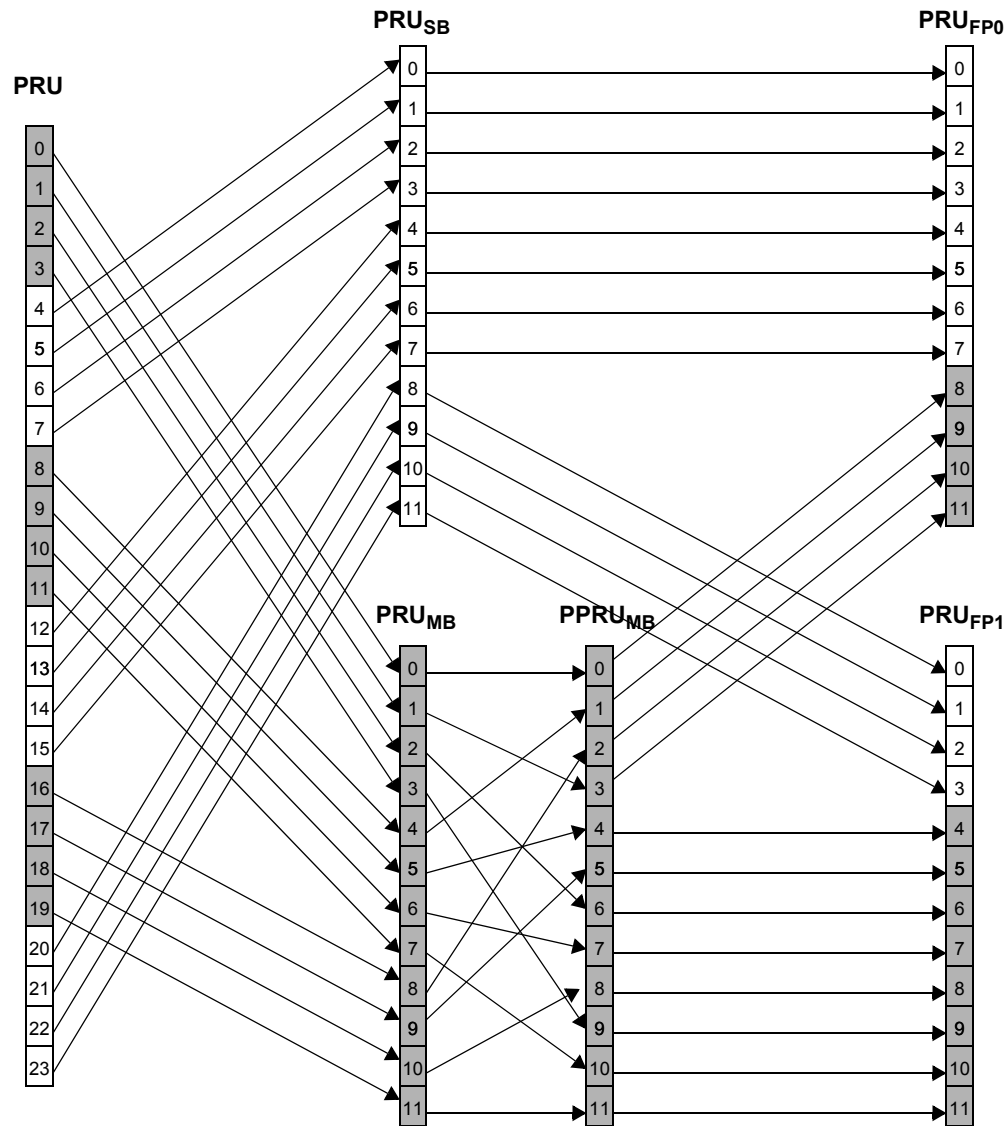


Figure 487—Frequency partitioning: BW=5MHz, K_{SB}=3, FPCT=2, FPS₀=12, FPSC=1

15.3.8.3 Cell-specific resource mapping

PRU_{FPi}s are mapped to LRUs. All further PRUs and tile permutations are constrained to the PRUs within the frequency partition.

15.3.8.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector specific basis. 4 or 3-bit uplink subband-based CRU allocation size ($UCAS_{SB,i}$) field is sent in the SFH for each allocated frequency partition depending on system bandwidth. $UCAS_{SB,i}$ indicates the number of allocated subband-based CRUs for partition FP_i in the unit of subband size. And 5, 4, or 3-bit uplink miniband-based CRU allocation size ($UCAS_{MB}$) is sent in the SFH only for partition FP_0 depending on system bandwidth, which indicates the number of allocated miniband-based CRUs for partition FP_0 .

The number of CRUs in each frequency partition is denoted by L_{CRU,FP_i} calculated as shown in Equation (231)

$$L_{DRU,FP_i} = \begin{cases} UCAS_{SB,i} \cdot N_1 + UCAS_{MB} \cdot N_2 & \text{for } i=0 \\ UCAS_{SB,i} \cdot N_1 & \text{for } 0 < i < UFPCT \end{cases} \quad (231)$$

The number of DRUs in each frequency partition is denoted by L_{DRU,FP_i} , calculated as shown in Equation (232)

$$L_{DRU,FP_i} = UFPS_i - L_{CRU,FP_i} \quad \text{for } 0 \leq i < UFPCT \quad (232)$$

The mapping of PRU_{FP_i} to CRU_{FP_i} is given by Equation (233):

$$CRU_{FP_i}[j] = \begin{cases} PRU_{FP_i}[j] & 0 \leq j \leq UCAS_{SB,i} \cdot N_1 \\ PRU_{FP_i}[k + UCAS_{SB,i} \cdot N_1] & UCAS_{SB,i} \cdot N_1 \leq j < L_{CRU,FP_i} \end{cases}, 0 \leq i < UFPCT \quad (233)$$

where $k = s[j - UCAS_{SB,i} \cdot N_1]$. $s[]$ is the CRU/DRU-allocation sequence defined below and

$$0 \leq s[j] < UFPS_i - UCAS_{SB,i} \cdot N_1.$$

$$s[j] = \{ \text{PermSeq}(i) + \text{UL_PermBase} \} \bmod (UFPS_i - UCAS_{SB,i} \cdot N_1)$$

where $\text{PermSeq}()$ is the permutation sequence of length $(UFPS_i - UCAS_{SB,i} \cdot N_1)$ and is determined by $\text{SEED} = \{\text{IDcell} * 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in 15.3.5.3.3. UL_PermBase is an interger ranging from 0 to 31(TBD), which is set to preamble IDcell.

The mapping of PRU_{FP_i} to DRU_{FP_i} is given by Equation (234):

$$DRU_{FP_i}[j] = PRU_{FP_i}[k + UCAS_{SB,i} \cdot N_1] \quad 0 \leq j < L_{DRU,FP_i} \quad (234)$$

where $k = s^c[j]$. $s^c[]$ is the sequence which is obtained by renumbering the remainders of the PRUs, which are not allocated for CRU, from 0 to $L_{DRU,FP_i} - 1$.

15.3.8.3.2 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:

$$Tile(s, n, t) = L_{DRU, FPI} \cdot n + g(PermSeq(), s, n, t) \quad (235)$$

where:

$Tiles(s, n, t)$ is the tile index of the n^{th} tile in the s^{th} distributed LRU of the t^{th} subframe.

n is the tile index, 0 to 2, in a distributed LRU.

t is the 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 $SEED = \{ID_{cell} * 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in Section <<15.3.5.3.4>>.

$$g(PermSeq(), s, n, t) = \{PermSeq[(n + 107 * s + t) \bmod L_{DRU, FPI}] + UL_PermBase\} \bmod L_{DRU, FPI}$$

where $UL_PermBase$ is an integer ranging from 0 to 31 (TBD), which is set to preamble ID_{cell} .

15.3.8.3.3 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 feedback channels, and analog feedback channels. The feedback channels can be used for both HARQ ACK/NAK and fast feedback. The analog feedback channels are specifically for transmitting unquantized eigenvector feedback for supporting MU-MIMO transmission. The allocation order of data channels and UL control channels are TBD.

15.3.8.3.3.1 Bandwidth request channels

The number of bandwidth request channels in frequency partition FP_i , $L_{BWR, FPI}$, is indicated by the (TBD)-bit field UL_BWREQ_SIZE in the S-SFH (TBD) in the unit of LRUs.

$$L_{BWR, FPI} = N_{bwr} \cdot UL_BWREQ_SIZE \quad (236)$$

Where N_{bwr} is 1 in MZone and 2 in LZone with PUSC.

Bandwidth request channels are not necessarily present in all subframes and the allocation can differ from subframe to next.

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 15.3.8.3.2.

15.3.8.3.3.2 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 $L_{FB, FPI}$.

$$L_{FB, FPI} = N_{fb} \cdot UL_FEEDBACK_SIZE \quad (237)$$

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 and illustrated in <<Figure UL- 1>>.

- 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 $3 \cdot L_{FB,FPi} - 1$.
- 2) A mini-tile reordering is applied to the available 2-by-6 FMTs as specified by Equation (238) and Equation (239) to obtain the reordered FMTs (RFMTs).
- 3) 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 (238) in MZone and Equation (239) in the LZone with PUSC:

$$MiniTile(s, n) = 9 \cdot floor\left(\frac{s}{3}\right) + mod(s, 3) + 3 \cdot n \quad (238)$$

$$MiniTile(s, n) = 6 \cdot floor\left(\frac{s}{2}\right) + mod(s, 2) + 2 \cdot n \quad (239)$$

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 $L_{FB,FPi} - 1$.

15.3.8.3.3.2.1 HARQ feedback channels <<<need level 7 header>>>

Each feedback channel constructed according to 15.3.8.3.3.2 can be used to transmit six HARQ feedback channels. The number of HARQ feedback channels is denoted by $L_{HFB,FPi}$.

A HARQ feedback channel is formed by three reordered 2-by-2 HARQ mini-tiles (RHMT). The HMTs reordering process and the construction of HARQ feedback channel are described below and illustrated in Figure 488.

- 1) Each 2x6 RFMT is divided into three consequitively indexed 2-by-2 HMTs. The HMTs so obtained are numbered from 0 to $3 \cdot L_{HFB,FPi} - 1$.
- 2) A HMT reordering is applied to the HMTs as specified by Equation (240) to obtain the reordered HMTs (RHMTs).
- 3) Each group of three consecutive RHMTs forms a HARQ feedback channel.

The closed form expression for the HMT reordering function used in step 2 above is as Equation (240).

$$HMT(k, m) = 9 \cdot floor\left(\frac{k'}{3}\right) + mod(k' + m, 3) + 3 \cdot m \quad (240)$$

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 $L_{HFB,FPi} - 1$.

$$k' = \lfloor k/2 \rfloor$$

15.3.8.3.3.2.2 Fast Feedback Channels <<<need level 7 header>>>

A fast feedback channel consists of one feedback channel.

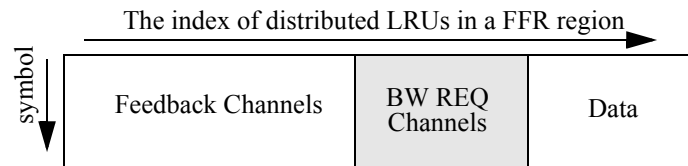


Figure 488—The allocation of UL control channels and data channels in the distributed

15.3.8.3.3.3 Analog Feedback Channels

The number of analog feedback channels in frequency partition FP_i , $L_{AFB,FPi}$, is indicated by the (TBD)-bit field UL_AFB_SIZE in the S-SFH (TBD) in the unit of LRUs.

$$L_{AFB,FPi} = UL_AFB_SIZE \quad (241)$$

Analog Feedback (AFB) Channels may be present in some subframes, and the AFB allocation can differ from subframe to subframe.

In MZone, the analog feedback channels are of same size as LRUs, i.e. three 6-by-6 tiles. In LZone with PUSC, the analog feedback channels consist of three 4-by-6 tiles. The analog feedback channels use LRUs constructed from the tile permutation specified in Section <<15.3.8.3.2>>.

15.3.8.3.4 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 15.3.8.3.2 to form distributed LRUs.

15.3.8.3.5 WirelessMAN-OFDMA Systems Support

When frame structure is supporting the WirelessMAN-OFDMA MSs in PUSC zone by FDM manner as defined in 15.3.3.4, a new symbol structure and subchannelization defined in the subclause are used.

15.3.8.3.5.1 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 718, Table 719, and Table 720.

Table 718—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

Table 718—512 FFT OFDMA UL subcarrier allocations for DRU

Parameters	Value	Comments
$N_{g,right}$	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 719—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

Table 720—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

15.3.8.3.5.2 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 y-1>>.

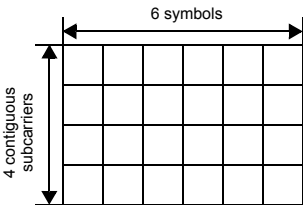


Figure 489—Resource block for FDM based UL PUSC zone support

15.3.8.3.5.3 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 718, Table 719, and Table 720 are divided into PUSC tiles.
- 2) UL PUSC subchannelization is performed as described in section <<8.4.6.2.2>>.
- 3) Available subchannels for Advanced Air Interface MS shall be specified through subchannel bitmap broadcasted by [system descriptor, TBD].
- 4) All PUSC tiles of specified subchannels from step 3 are extended in time domain from 3 OFDM symbols to N_{sym} OFDM symbols, where N_{sym} is dependent of subframe type.
- 5) Based on specified subchannels of step 3 with symbol extension tiles of step 4, DRUs for Advanced Air Interface are made up.
- 6) Repeat step 4 and step 5 for remained OFDMA symbols of every uplink subframe.

Overall process of subcarrier to subchannel mapping is shown in Figure 490.

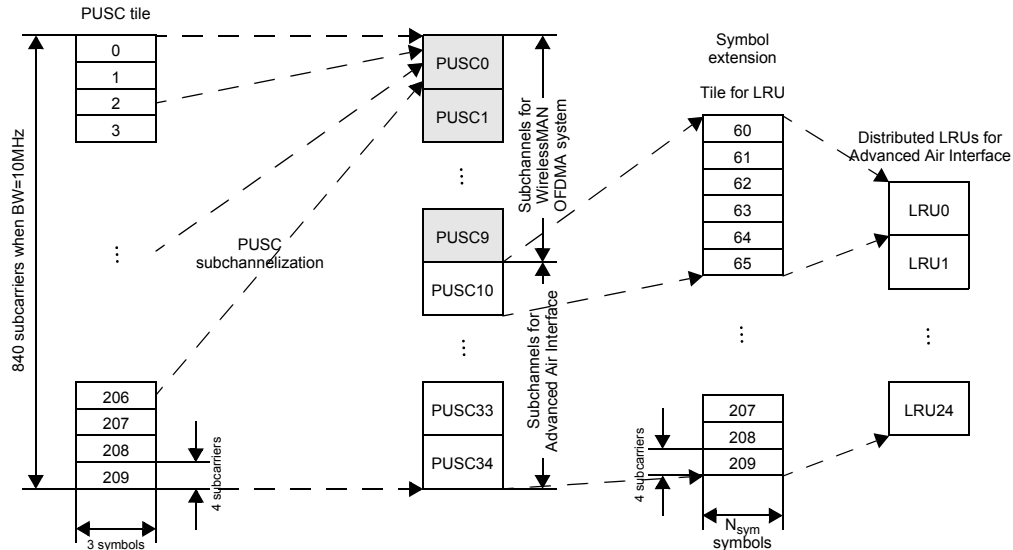


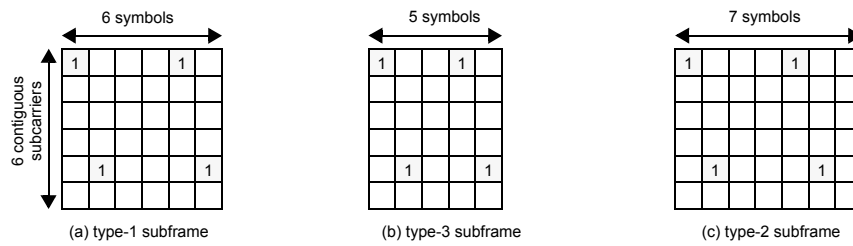
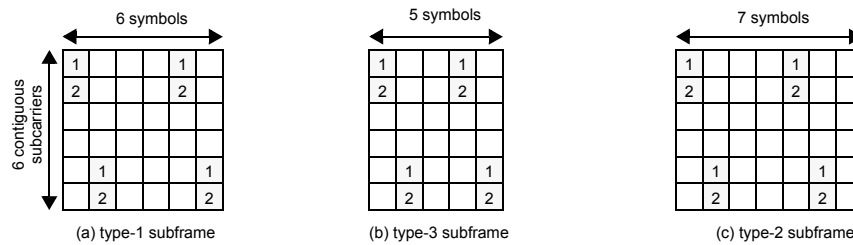
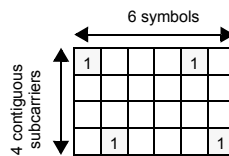
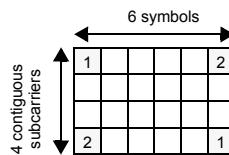
Figure 490—Example of subchannelization for FDM base UL PUSC zone support

15.3.8.4 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. The boosting values are TBD.

Figure 495 shows 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 491 and Figure 492 show the pilot structure for distributed LRUs where the number of streams is one or two, respectively. Figure 493 and Figure 494 contain the one and two-stream pilot patterns for the distributed PUSC LRU.

**Figure 491—Pilot patterns of 1-Tx stream for distributed LRUs****Figure 492—Pilot patterns of 2-Tx streams for distributed LRUs****Figure 493—Pilot pattern of 1-Tx stream for distributed PUSC LRUs****Figure 494—Pilot pattern of 2-Tx stream for distributed PUSC LRUs**

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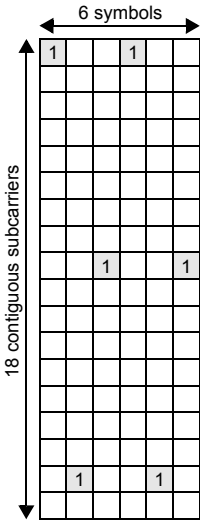


Figure 495—Pilot patterns for contiguous LRUs for 1 Tx stream

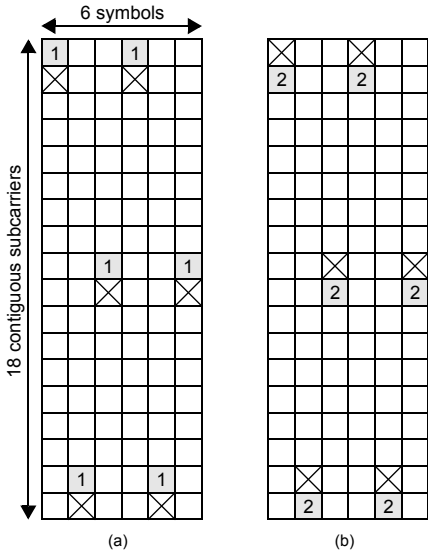


Figure 496—Pilot patterns for contiguous LRUs for 2 Tx streams

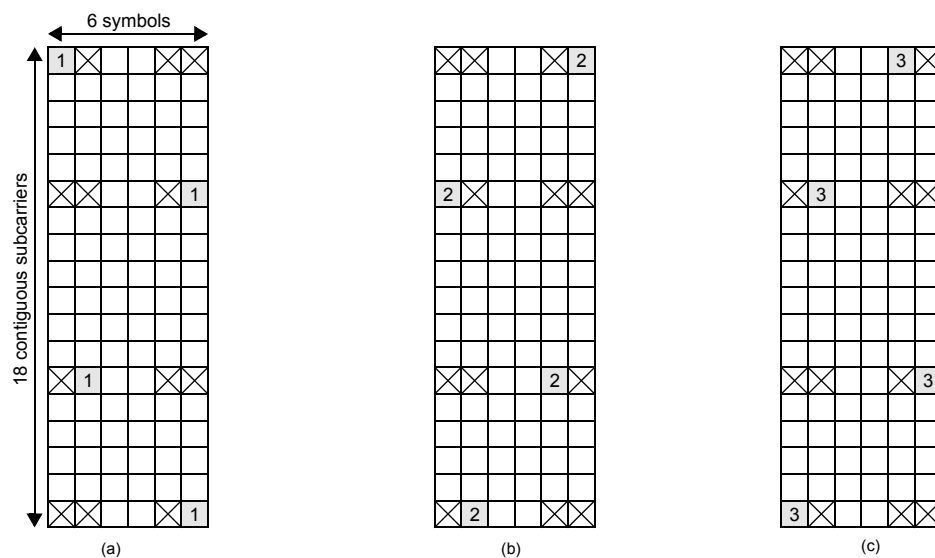


Figure 497—Pilot patterns for contiguous LRUs for 3 Tx streams

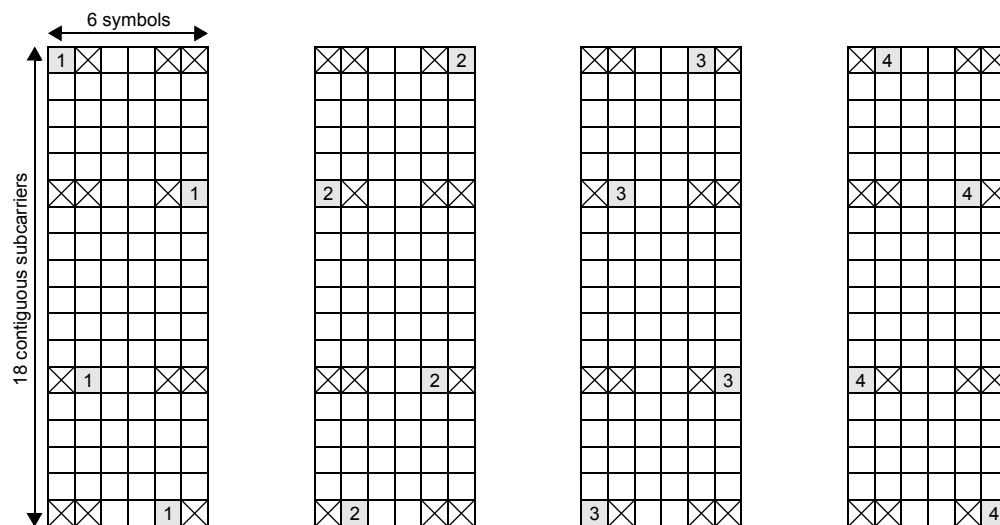


Figure 498—Pilot patterns for contiguous LRUs for 4 Tx streams

15.3.9 Uplink control channel

15.3.9.1 Physical uplink control channel

15.3.9.1.1 Fast feedback control channel

The DRUs are permuted by UL tile permutation as described in Section <<15.3.5.4>> 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 section <<15.3.8.3.4.2>>.

15.3.9.1.1.1 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 section <<15.3.8.3.4.2>>.

15.3.9.1.1.2 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 section <<15.3.8.3.4.2>>.

15.3.9.1.2 HARQ feedback control channel

Each UL HARQ feedback resource consists of three distributed UL reordered feedback mini-tiles (RFMTs), where the UL FMT is defined as 2 contiguous subcarriers by 6 OFDM symbols. The procedures for allocation of resources for transmission of UL control information and the formation of control channels for such transmission are described in section <<15.3.8.3.4.2>>. 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.

15.3.9.1.3 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 and AMS are appropriately calibrated.

15.3.9.1.3.1 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 subframe, the sounding signal shall not be transmitted in the LRU which contains other control channels. For type-2 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 x(a). 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 x(b). Multiple UL 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.

The UL subframes containing the sounding symbol shall be configured by Uplink subframe bitmap, which is transmitted in S-SFH Sub-packet 4.

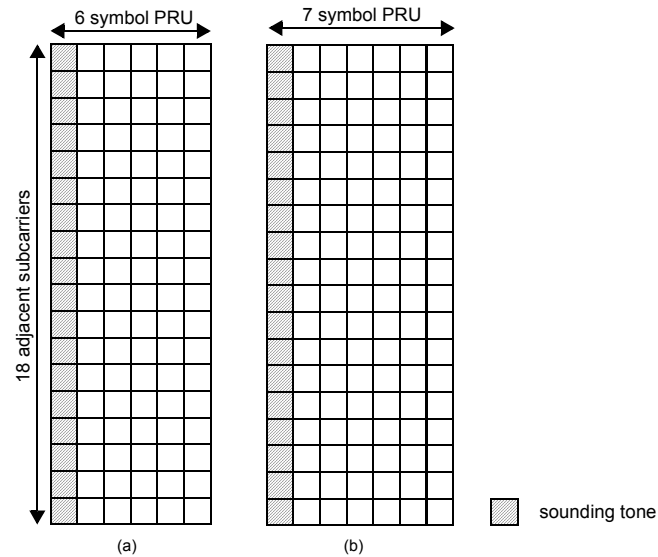


Figure 499—Sounding PHY structures for (a) 6-symbol PRU and (b) 7-symbol PRU cases.

15.3.9.1.4 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.

15.3.9.1.4.1 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 the 1 subband.

Power control operation described in subclause [TBD] applies to ranging signal transmission.

Figure 500 illustrates the ranging channel structures in the time domain.

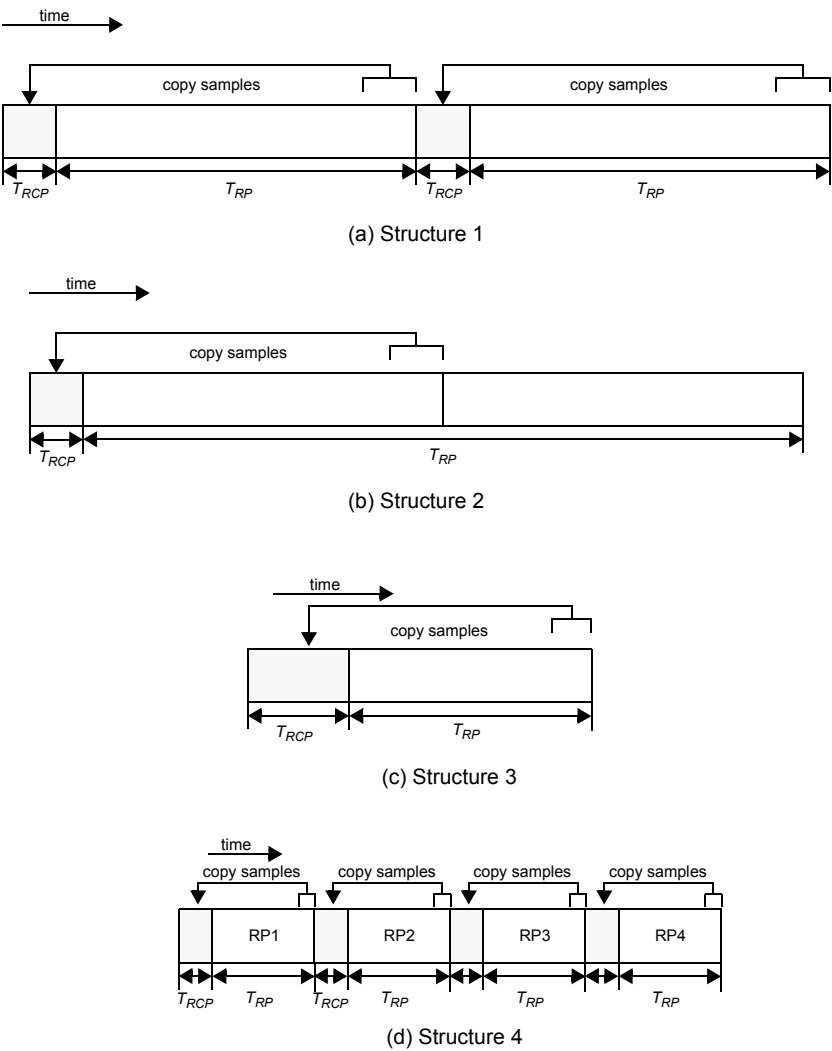


Figure 500—Ranging channel structures in the time domain

Table 721 contains ranging channel formats and parameters.

Table 721—Ranging channel formats and parameters

Format No.	Ranging Channel Structure	T_{RCP}	T_{RP}	Δf_{RP}
0	Structure 1	$T_g + k \times T_b^{(a)}$	$2 \times T_b$	$\Delta f/2$
1	Structure 3			
2	Structure 2	$m \times T_g + n \times T_b^{(b)}$	$2 \times 2 \times T_b^{(c)}$	$\Delta f/8$
3	Structure 3	$7 \times T_g + T_b$	$8 \times T_b$	
4	Structure 4	T_g	T_b	Δf

where T_s , T_b , T_g and Δf are defined in 15.3.2.4.

(a): The T_{RCP} for Formats 0 and 1 depends on OFDMA parameters, subframe types as follows:

$$k = \lceil \{ [N_{sym} \cdot T_s - 2 \cdot (T_{RP} + T_g)] / 3 \} \cdot F_s \rceil / N_{FFT}$$

N_{sym} is the number of OFDMA symbols in a subframe as defined in 15.3.8.1. F_s and N_{FFT} are defined in 15.3.2.4.

(b): The T_{RCP} for Format 2 depends on OFDMA parameters, subframe types as follows:

$$m = (N_{sym} + 1) / 2$$

$$n = (N_{sym} - 4) / 2$$

N_{sym} is the number of OFDMA symbols in a subframe as defined in 15.3.8.1.

(c): T_{RP} for Format 2 denotes the total length of repeated ranging preamble.

In the ranging channel Format 0, the repeated RCPs and RPs are used as a single time ranging opportunity within a subframe in Figure 500 (a). Format 2 consists of a single RCP and repeated RPs within a subframe. Format 1 consists of a single RCP and RP which is a part of the Format 0. When Format 1 is used, there are two time opportunities within a subframe. Format 3 has the same structure with Format 1 but its length is different. RP1, RP2, RP3, and RP4 in Format 4 are constructed by the first portion, second portion, third portion, and the last portion of the ranging sequences [the detail is TBD depending on the ranging sequences], respectively.

When the ranging channel format is configured as Format 0, 2, 3, 4, or Format 1 using the first time-opportunity in the time domain, the transmission start time of the ranging channel is aligned with the UL subframe start time at the AMS. For the Format 1 using the second time-opportunity, the transmission of the ranging channel starts at $T_{RCP} + T_{RP}$ in Format 1 after the start time of first time-opportunity.

15.3.9.1.4.2 Ranging channel for synchronized AMSs

The ranging channel for synchronized AMSs is used for periodic ranging. Only the AMSs that are already synchronized to the target ABS are allowed to transmit the periodic ranging signal.

Power control operation described in subclause [TBD] applies to ranging signal transmission.

15.3.9.1.5 Bandwidth request channel

In the LZone with PUSC, a BW REQ tile is defined as four contiguous subcarriers by six OFDM symbols. The number of BW REQ tiles per BW REQ channel is three or six. Each BW REQ tile carries a BW REQ access sequence only.

In the Mzone, a BW REQ tile is defined as six contiguous subcarriers by six OFDM symbols. Each BW REQ channel consists of three distributed BW-REQ tiles. Each BW REQ tile carries a BW REQ access sequence and a BW REQ message. The AMS may transmit the access sequence only and leave the resources for the quick access message unused.

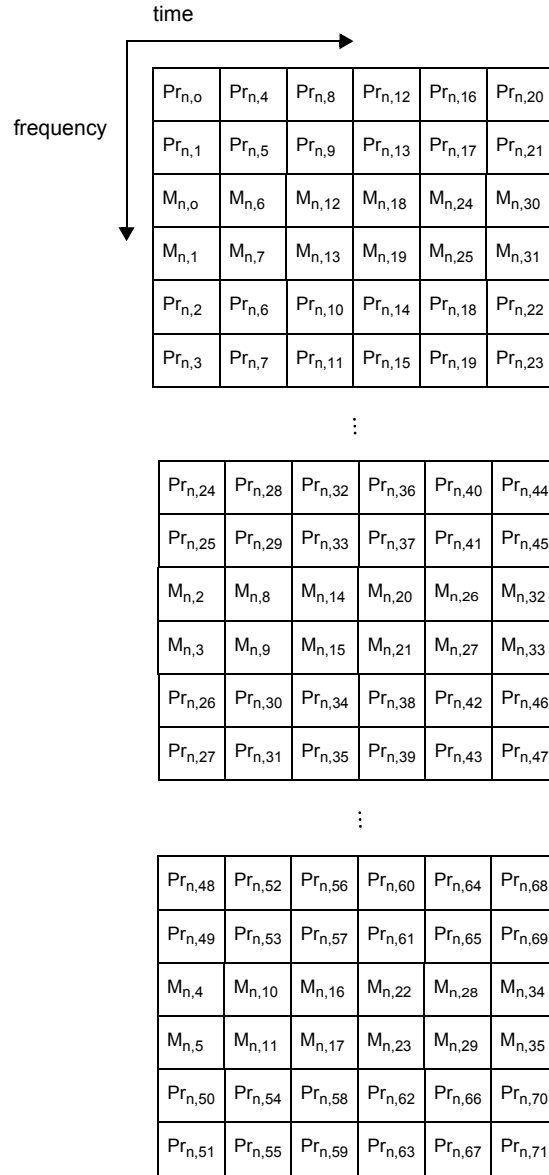


Figure 501—6x6 BW REQ Tile Structure in the Advance Air Interface

A BW REQ tile in the Advanced Air Interface specifications is defined as 6 contiguous subcarriers by 6 OFDM symbols. As shown in Figure 501, the BW REQ preamble shall be transmitted on a resource that spans 4 subcarriers by 6 OFDM symbols. Additionally, a quick access BW REQ message shall be carried in the data portion of the tile that spans 2 contiguous subcarriers by 6 OFDM symbols. Each BW REQ channel shall comprise of 3 distributed BW REQ tiles for frequency diversity. The procedure for allocation of resources for transmission of UL control information and the formation of DRUs for such transmission is TBD.

Let $b_0, b_1, b_2, \dots, b_{15}$ denote a total of 16 bits of information to be carried as the quick access message. 4 bits of the 16 information bits shall be carried in the BW REQ preamble using the preamble index. The combined

resource in the data portions of the three tiles that form the BW REQ channel shall be used to transmit the remaining 12 bits of information,. The construction of the BW REQ preamble for a 6x6 tile structure is TBD.

The 12 bits of information in the quick access message transmitted in the BW REQ channel shall be encoded into 72 bits $c_0, c_1, c_2, \dots, c_{71}$ using the 1/6 TBCC code described in <<<section 15.3.9.2.1.2.1(channel coding for secondary fast feedback control channel)>>> with parameters $L = 12$, $K_{bufsize} = 60$ and $M = 72$. The 72 coded bits shall then be QPSK modulated as described in Section TBD and scrambled to generate 36 data symbols, $v_0, v_1, v_2, \dots, v_{35}$. The combined data portions of the three distributed BW REQ tiles that form the BW REQ channel shall be used to transmit these data symbols.

In order to support operation in the legacy mode, a BW REQ tile shall be defined as 4 contiguous subcarriers by 6 OFDM symbols. As shown in Figure 502, only the BW REQ access sequence or BW REQ preamble shall be transmitted in all 24 subcarriers that form the BW REQ tile. In this case, the *BWREQ_PREAMBLE_INDEX* shall be randomly selected from all available logical preamble sequences.

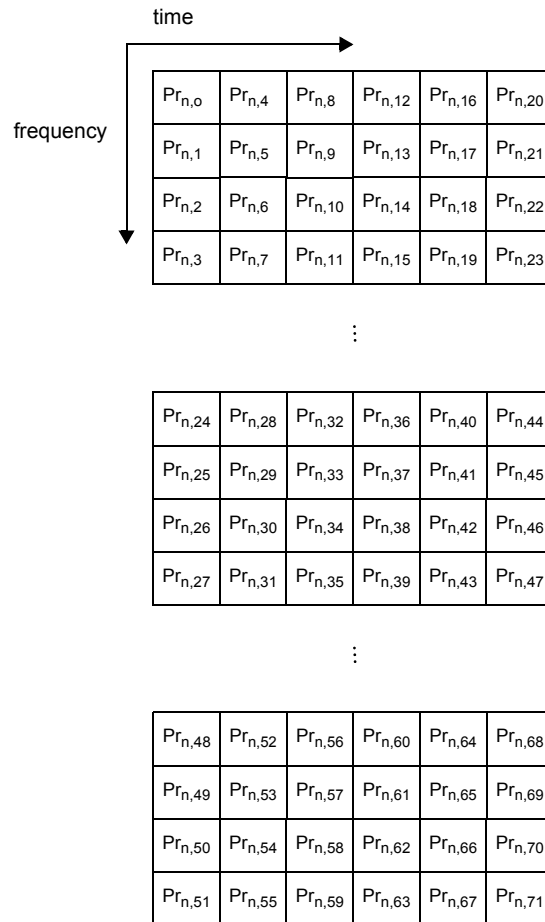


Figure 502—6x6 4x6 BW REQ tile structure

15.3.9.1.6 Analog Feedback channel

In the LZone with PUSC, an AFB tile is defined as 4 contiguous subcarriers by 6 OFDM symbols. The number of AFB tiles per AFB channel is 3. For 2- and 4- transmit-antenna base stations, each AFB channel can

1 multiplex analog eigenvector feedback from up to 4 mobile stations. For 8 transmit antennas, each AFB
 2 channel can multiplex analog eigenvector feedback from up to 3 mobile stations.
 3

4
 5 In the MZone, an AFB tile is defined as 6 contiguous subcarriers by 6 OFDM symbols. Each AFB channel
 6 consists of 3 distributed AFB tiles. For 2- and 4- transmit-antenna base stations, each AFB channel can mul-
 7 tiplex analog eigenvector feedback from up to 6 mobile stations. For 8- transmit-antenna base stations, each
 8 AFB channel can multiplex analog eigenvector feedback from up to 4 mobile stations.
 9

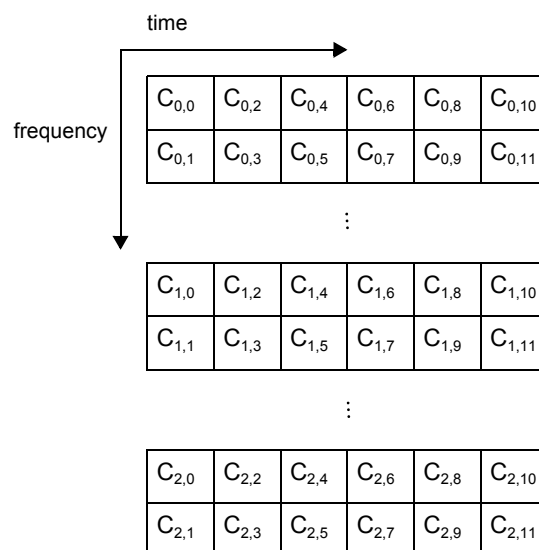
10 15.3.9.2 Uplink control channels physical resource mapping

11 15.3.9.2.1 Fast feedback control channel

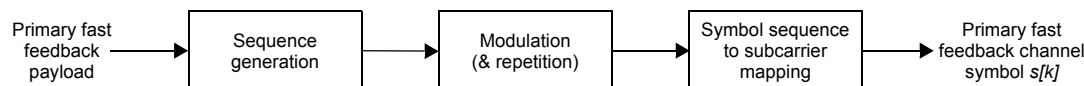
12
 13
 14
 15 There are two types of UL fast feedback control channels: primary fast feedback channel (PFBC) and sec-
 16 ondary fast feedback channels (SFBC).
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19 15.3.9.2.1.1 Primary fast feedback control channel

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 22 The primary fast feedback channels are comprised of three distributed FMTs. Figure 503 illustrates the map-
 23 ping of the PFBC.
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Figure 503—PFBC comprised of three distributed 2x6 UL FMTs



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Figure 504—Mapping of information in the PFBC

The process of composing the PF BCH is illustrated in Figure 504. The / PF BCH payload bits are used to generate PF BCH sequence according to Table 722. The resulting bit sequence is modulated, repeated and mapped to uplink PF BCH symbol $s[k]$. The mapping of primary fast feedback channel symbol $s[k]$ to the UL FMTs is given by Table 242. This set of sequences can carry up to six information bits.

$$C_{i,j} = s[K_i[j]], \text{ for } i = 0, 1, 2, 0 \leq j \leq 11 \quad (242)$$

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 722—Sequences for PF BCH

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 722—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

15.3.9.2.1.2 Secondary fast feedback control channel

The SFBCCH is comprised of 3 distributed FMTs with 2 pilots allocated in each FMT. Pilot sequence is TBD.

The SFBCCH symbol generation procedure is as follows. First, the SFBCCH payload information bits $a_0 a_1 a_2 \dots a_{l-1}$ are encoded to M bits $b_0 b_1 b_2 \dots b_{M-1}$ using the TBCC encoder described in <<Section 15.3.9.2.1.2.1>>.

For $l \leq 12$, information bits $a_0 a_1 a_2 \dots a_{l-1}$ are encoded using the linear block code $(N, 1)$.

For $12 < l \leq 24$, information bits $a_0 a_1 a_2 \dots a_{l-1}$ are split into 2 parts:

Part A consists of $a_0 a_1 a_2 \dots a_{\lfloor \frac{l}{2} \rfloor - 1}$

Part B consists of $a_{\lfloor \frac{l}{2} \rfloor} a_{\lfloor \frac{l}{2} \rfloor + 1} a_{\lfloor \frac{l}{2} \rfloor + 2} \dots a_{l-1}$.

Part A is encoded to $N/2$ bits $b_0 b_1 b_2 \dots b_{\frac{N}{2}-1}$ using linear block code $\left(\frac{N}{2}, \left\lfloor \frac{l}{2} \right\rfloor\right)$ and Part B is encoded to $N/2$ bits

$b_{\frac{N}{2}} b_{\frac{N}{2}+1} b_{\frac{N}{2}+2} \dots b_{N-1}$ using a linear block code $\left(\frac{N}{2}, l - \left\lfloor \frac{l}{2} \right\rfloor\right)$. The coded sequence $b_0 b_1 b_2 \dots b_N$ is then modulated

to $N/2$ symbols $c_0 c_1 c_2 \dots c_{\frac{N}{2}-1}$ using QPSK. The value of N is TBD. The modulated symbols $c_0 c_1 c_2 \dots c_{\frac{N}{2}-1}$

and pilot sequence (TBD) are combined to form sequence $d_0 d_1 d_2 \dots d_{35}$ and are mapped to the data subcarriers

of the SFBCCH FMTs as shown in Figure 506.

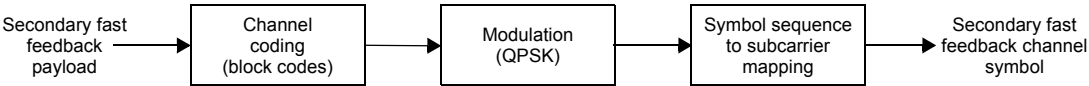


Figure 505—Mapping of information in the SF BCH

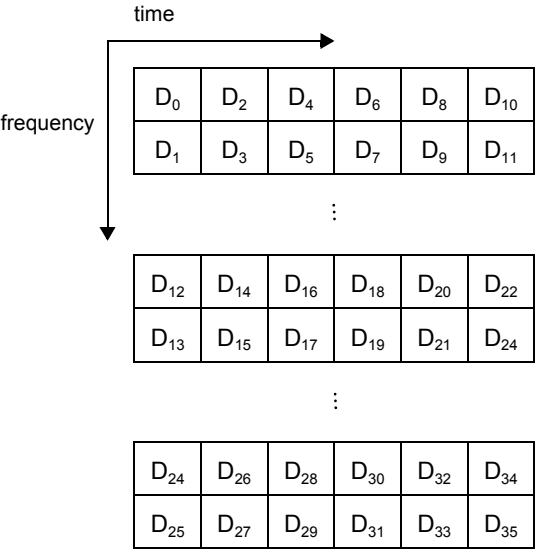


Figure 506—SF BCH comprising of three distributed 2x UL FMTs

Channel coding for secondary fast feedback control channel

The $k(7 \leq K \leq 12)$ information bits in the SF BCH shall be encoded using linear block codes with codeword length N . Let the K information bits be denoted by $a_0 a_1 a_2 \dots a_{K-1}$ and the N bits codeword is denoted by $b_0 b_1 b_2 \dots b_{N-1}$. The codeword is obtained as a linear combination of the N basis sequences denoted as $v_{i,n}$ where $n = 0, 1, 2, \dots, N-1$ in Table 723.

Table 723—Basis sequences

i	vi,0	vi,1	vi,2	vi,3	vi,4	vi,5	vi,6	vi,7	vi,8	vi,9	vi,10	vi,11
0												
1												
2												
...												
N-1												

15.3.9.2.2 HARQ feedback control channel

The HARQ feedback control channel resource of three distributed FMTs shall be further divided into nine HARQ mini-tiles (HMTs), each having a structure of two subcarriers by two OFDM symbols. Each pair of HARQ feedback channels are allocated three HMTs, identified by similar patterns in the structure shown in Figure 507. 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 724 is mapped to each HMT to form HARQ feedback channels, where 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, 1st and 2nd HARQ feedback channel. The support and details of two-bit HARQ feedback scenarios are TBD. The sequence and mapping of the HARQ feedback are show in Table 724.

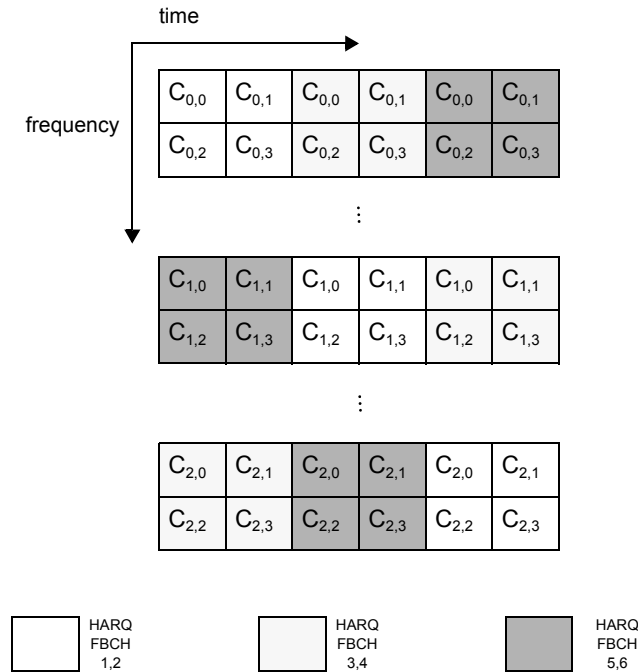


Figure 507—2x2 HMT structure

Table 724—Orthogonal sequences for UL HARQ feedback channel

Sequence index	Orthogonal sequence	1-bit Feedabck	2-bit Feedback (per HMT channel)
0	[+1 +1 +1 +1]	Even numbered channel ACK	ACK/ACK
1	[+1 -1 +1 -1]	Even numbered channel NACK	ACK/NACK
2	[+1 +1 -1 -1]	Odd numbered channel ACK	NACK/ACK
3	[+1 -1 -1 +1]	Odd numbered channel NACK	NACK/NACK

15.3.9.2.3 Sounding channel

15.3.9.2.3.1 Sounding sequence

15.3.9.2.3.2 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 subframes for sounding, time division separation can be applied by assigning different AMS to different UL 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 ($0, 1, \dots, N_T-1$) on frames $n = j \cdot T + i$, where $n = 0$ corresponds to the frame where UL sounding command A-MAP IE is received, T is periodicity in UL sounding command A-MAP IE, and j is a running index ($j = 0, 1, 2, \dots$ for $T \neq 0$ and $j = 0$ for $T = 0$). For sounding with antenna switching and periodical sounding allocation ($T \neq 0$), the assigned periodicity T shall be larger or equal to the number of AMS transmit antennas N_T .

15.3.9.2.4 Ranging channel

15.3.9.2.4.1 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.

Ranging channel configurations

Ranging signal transmission

<<Eqn. UL- 7>> specifies the transmitted signal voltage to the antenna, as a function of time, during ranging channel format 0, 1, 2 or 3.

$$s(t) = \text{Re} \left\{ e^{j2\pi f_c t} \sum_{k=-(N_{RP}-1)/2}^{(N_{RP}-1)/2} x_p(k + (N_{RP}-1)/2) \cdot e^{j2\pi(k + K_{offset})\Delta f_{RP}(t - T_{offset})} \right\} \quad (243)$$

where

t is the elapsed time since the beginning of the subject ranging channel.

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

1	$K_{offset} = -\{(N_{used} - 1)/2 - 2 \cdot P_{SC} \cdot (2 \cdot k_0 - 1) + \lfloor 8 \cdot k_0 / N_{PRU} \rfloor\} \cdot \Delta f / \Delta f_{RP}$
2	
3	
4	N_{PRU} is the total number of PRUs as defined in 15.3.8.2.1.
5	
6	k_0 is a logical ranging channel parameter in the frequency domain as units of N_I , where N_I is
7	the number of the adjacent PRUs within a subband as defined in 15.3.8.2.1.
8	
9	
10	P_{sc} is the number of the consecutive subcarriers within a PRU in frequency domain as defined
11	in 15.3.8.1.
12	
13	Δf_{RP} is the ranging subcarrier spacing.
14	
15	
16	T_{offset} is the parameter related to the length of ranging cyclic prefix and is defined by
17	
18	$T_{offset} = \begin{cases} T_{RCP} & , 0 \leq t < T_{RCP} + R_{RP} \text{ for Format 0, 1, 2, or 3} \\ T_{RP} + 2 \cdot T_{RCP} & , T_{RCP} + R_{RP} \leq t < 2 \cdot (T_{RCP} + R_{RP}) \text{ for Format 0} \end{cases}$
19	
20	

The transmitted signal voltage to the antenna in Format 4 is generated by the Equation (173).

15.3.9.2.5 Bandwidth request channel

Contention based random access is used to transmit bandwidth request information on this control channel. The bandwidth request (BW REQ) channel contains resources for the AMS to send a BW REQ access sequence and an optional quick access message. Prioritized bandwidth requests are supported on this channel. The mechanism for such prioritization is TBD. For AMS with multiple transmission antennas, the multi-antenna transmission of BW REQ shall be limited to 1-stream mode 1 uplink MIMO scheme defined in 15.3.10.

15.3.9.2.6 Analog Feedback Channels

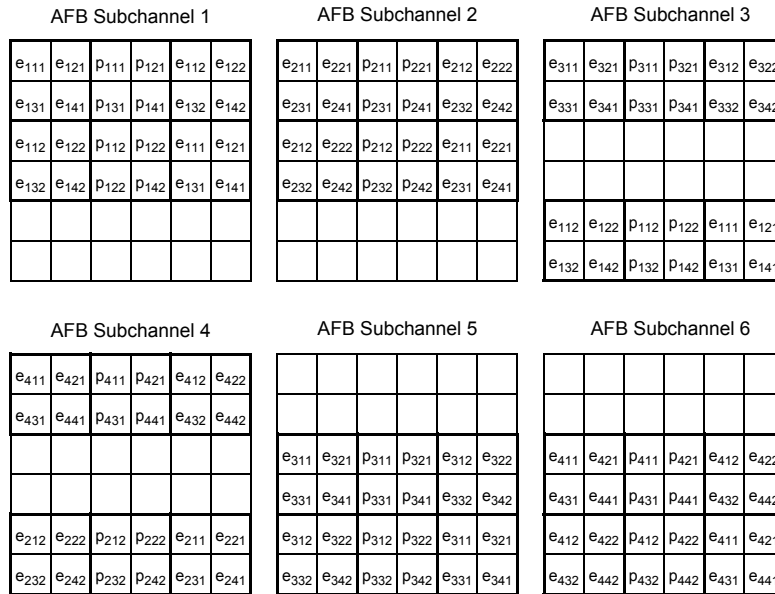
For the MZone and the LZone, the structure of the analog feedback channels is defined for the number of base station antennas equaling 2, 4, and 8.

For the MZone, the structure for 2 transmit antennas is shown in Figure UL- 12. The analog feedback (AFB) channel for 2Tx antennas contains 6 analog feedback subchannels for enabling up to 6 AMSs to send analog eigenvector feedback with a CDM factor of 4. In <<Figure UL- 12>>, the structure is shown for the first tile of all six AFB subchannels. The structure on the 2nd and 3rd tiles are identical to the structure of the first tile. A blank symbol means the AMS does not transmit on that subcarrier/OFDM symbol. The construction of the information symbols e_{ijk} and pilot symbols P_{ijk} that are transmitted in the AFB subchannels is described in <<Section 15.3.9.3.4>>.

For the MZone, the structure for 4 transmit antennas is shown in <<Figure UL- 13>>. The analog feedback channel for 4Tx antennas contains 6 analog feedback subchannels for enabling up to 6 AMSs to send analog eigenvector feedback with a CDM factor of 4. In <<Figure UL- 13>>, the structure is shown for the first and second tiles of all six analog feedback subchannels. The structure of the 3rd tile is identical to the structure of the first tile. A blank symbol means the AMS does not transmit on that subcarrier/OFDM symbol. The construction of the information symbols e_{ijk} and pilot symbols P_{ijk} that are transmitted in the AFB subchannels is described in Section <<15.3.9.3.4>>.

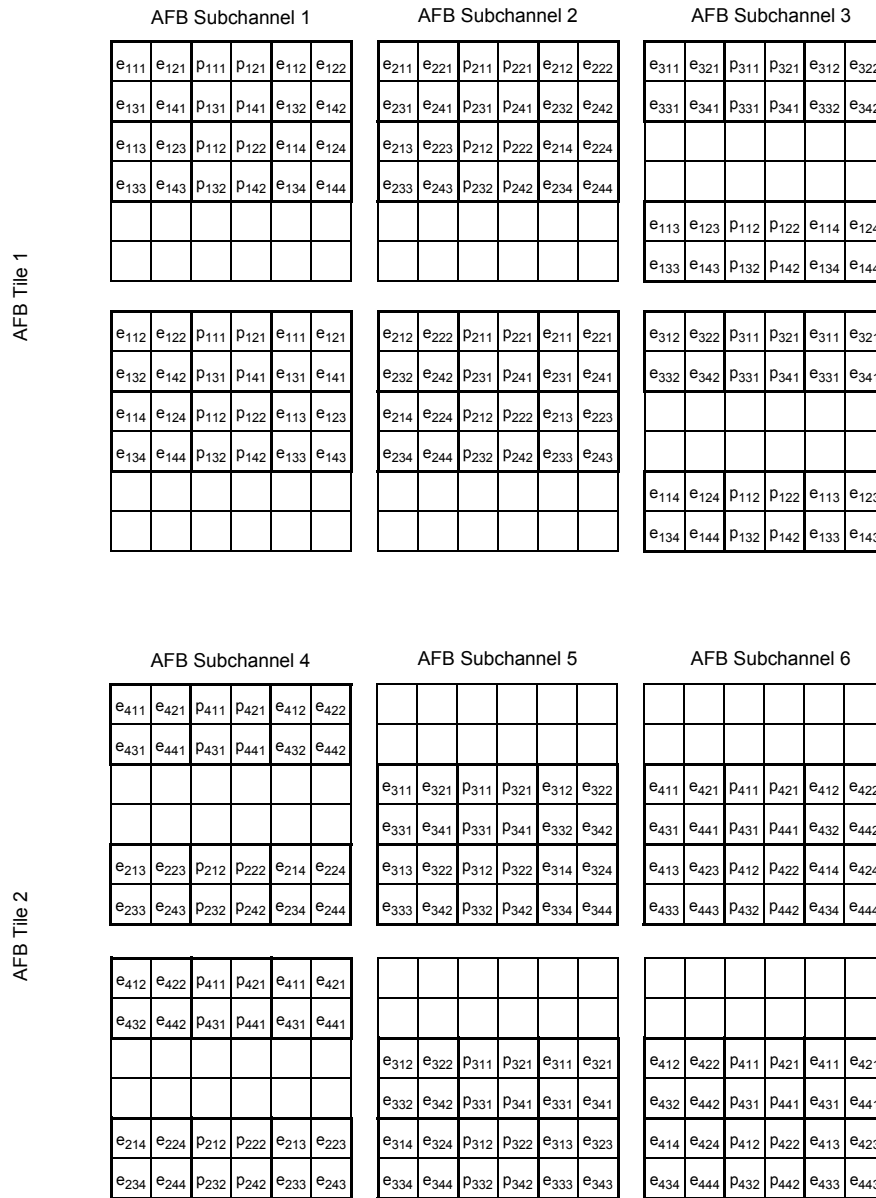
For the MZone, the structure for 8 transmit antennas is shown in Figure UL- 14. The analog feedback channel for 8Tx antennas contains 4 analog feedback subchannels for enabling up to 4 AMSs to send analog eigenvector feedback with a CDM factor of 4. In <<Figure UL- 14>>, the structure is shown for all three tiles of all six analog feedback subchannels. A blank symbol means the AMS does not transmit on that subcarrier/OFDM symbol.

The construction of the information symbols e_{ijk} and pilot symbols p_{ijk} that are transmitted in the AFB sub-channels is described in <<Section 15.3.9.3.4>>.



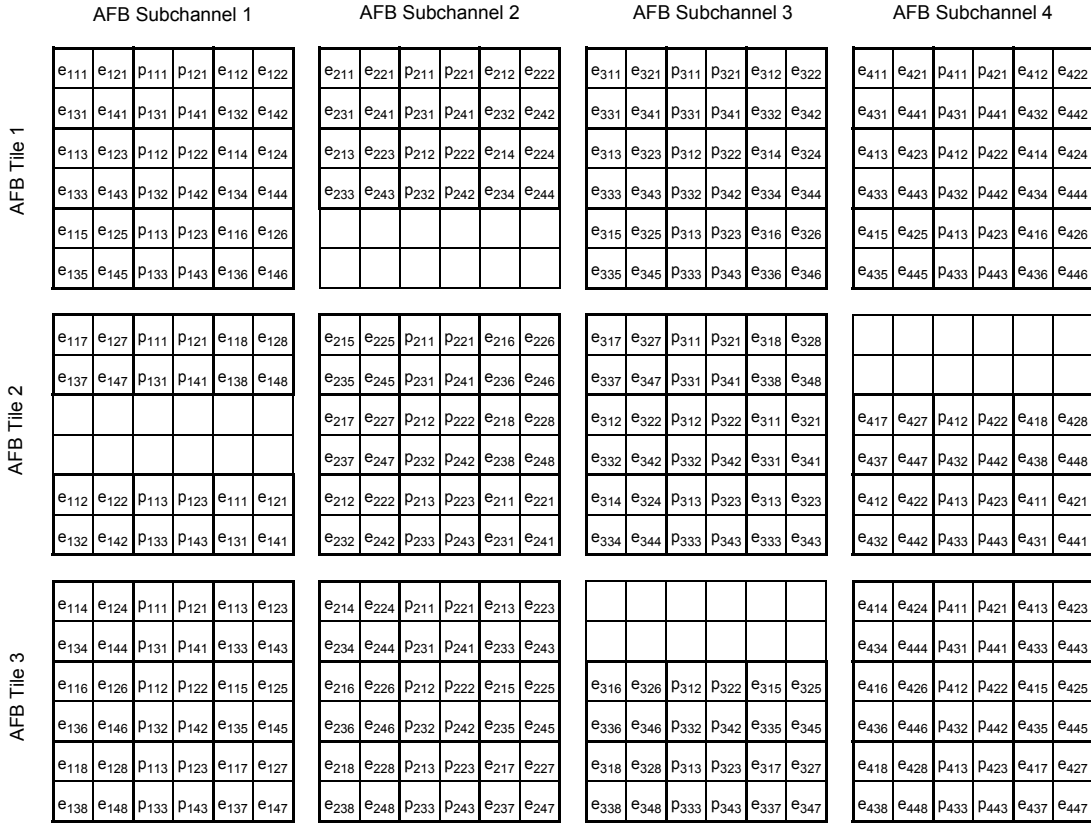
Analog feedback channel structure for 2 transmit antenna base stations (MZone). Six analog feedback subchannels for multiplexing up to 6 AMSs with a CDM factor of 4. Only Tile 1 is shown for the six analog feedback subchannels. Tiles 2 and 3 are identical to Tile 1.

Figure 508—Analog Feedback Channel Structure for 2 Tx MZone



Analog feedback channel structure for 4 transmit antenna base stations (MZone). Six analog feedback subchannels for multiplexing up to 6 AMSS with a CDM factor of 4. Only Tiles 1 and 2 are shown. Tile 3 is identical to Tile 1.

Figure 509—Analog Feedback Channel Structure for 2 Tx MZone



Analog feedback channel structure for 8 transmit antenna base stations (MZone).
Four analog feedback subchannels for multiplexing up to 4 AMSs with a CDM factor of 4.

Figure 510—Analog Feedback Channel Structure for 8 Tx MZone

For the LZone, the structure for 2 transmit antennas is shown in <<Figure UL- 14>>. The analog feedback channel for 2 Tx antennas supports up to 4 AMSs sending analog eigenvector feedback with a CDM factor of 4. In <<Figure UL- 14>>, the structure is shown for the first tile of all four users. The structure on the 2nd and 3rd tiles are identical to the structure of the first tile. A blank symbol means the AMS does not transmit on that subcarrier/OFDM symbol. The construction of the information symbols e_{ijk} and pilot symbols p_{ijk} that are transmitted in the AFB subchannels is described in Section <<15.3.9.3.4>>.

For the LZone, the structure for 4 transmit antennas is shown in <<Figure UL- 15>>. The analog feedback channel for 4 Tx antennas supports up to 4 AMSs sending analog eigenvector feedback with a CDM factor of 4. In <<Figure UL- 15>>, the structure is shown for the first and second tile of all four AMSs. The structure on the 3rd tile is identical to the structure of the first tile. A blank symbol means the AMS does not transmit on that subcarrier/OFDM symbol. The construction of the information symbols e_{ijk} and pilot symbols p_{ijk} that are transmitted in the AFB subchannels is described in Section <<15.3.9.3.4>>.

For the LZone, the structure for 8 transmit antennas is shown in <<Figure UL- 16>>. The analog feedback channel for 8 Tx antennas supports up to 3 AMSs sending analog eigenvector feedback with a CDM factor of 2. A blank symbol means the AMS does not transmit on that subcarrier/OFDM symbol. The construction

of the information symbols e_{ijk} and pilot symbols p_{ijk} that are transmitted in the AFB subchannels is described in Section <<15.3.9.3.4>>.

AFB Subchannel 1						AFB Subchannel 2						AFB Subchannel 3						AFB Subchannel 4					
e_{111}	e_{121}	p_{111}	p_{121}	e_{112}	e_{122}	e_{211}	e_{221}	p_{211}	p_{221}	e_{212}	e_{222}	e_{311}	e_{321}	p_{311}	p_{321}	e_{312}	e_{322}	e_{411}	e_{421}	p_{411}	p_{421}	e_{412}	e_{422}
e_{131}	e_{141}	p_{131}	p_{141}	e_{132}	e_{142}	e_{231}	e_{241}	p_{231}	p_{241}	e_{232}	e_{242}	e_{331}	e_{341}	p_{331}	p_{341}	e_{332}	e_{342}	e_{431}	e_{441}	p_{431}	p_{441}	e_{432}	e_{442}
e_{112}	e_{122}	p_{112}	p_{122}	e_{111}	e_{121}	e_{212}	e_{222}	p_{212}	p_{222}	e_{211}	e_{221}	e_{312}	e_{322}	p_{312}	p_{322}	e_{311}	e_{321}	e_{412}	e_{422}	p_{412}	p_{422}	e_{411}	e_{421}
e_{132}	e_{142}	p_{132}	p_{142}	e_{131}	e_{141}	e_{232}	e_{242}	p_{232}	p_{242}	e_{231}	e_{241}	e_{332}	e_{342}	p_{332}	p_{342}	e_{331}	e_{341}	e_{432}	e_{442}	p_{432}	p_{442}	e_{431}	e_{441}

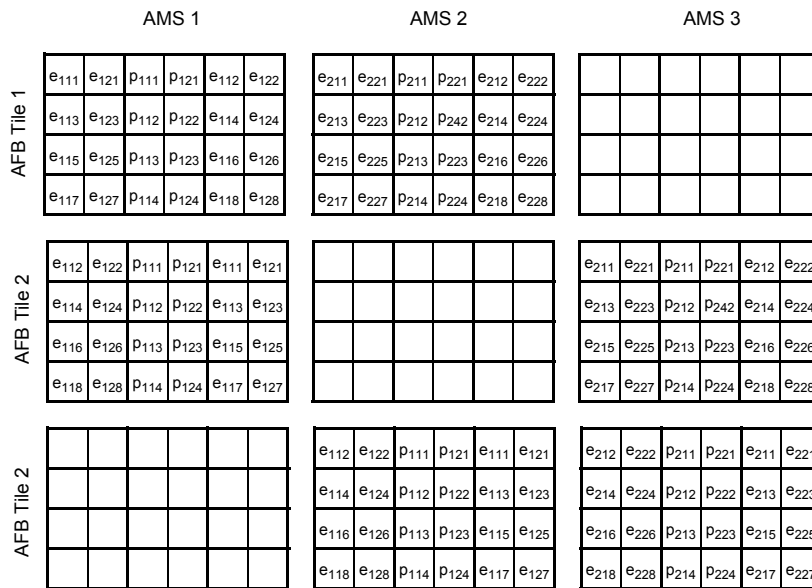
Analog feedback channel structure for 2 transmit antenna base stations (LZone).
Four AMSS multiplexed with a CDM factor of 4. Only one tile is shown for the four AMSSs. Tiles 2 and 3 are identical to Tile 1.

Figure 511—Analog Feedback Channel Structure for 2 Tx LZone

AFB Subchannel 1						AFB Subchannel 2						AFB Subchannel 3						AFB Subchannel 4						
AFB Tile 1	e_{111}	e_{121}	p_{111}	p_{121}	e_{112}	e_{122}	e_{211}	e_{221}	p_{211}	p_{221}	e_{212}	e_{222}	e_{311}	e_{321}	p_{311}	p_{321}	e_{312}	e_{322}	e_{411}	e_{421}	p_{411}	p_{421}	e_{412}	e_{422}
	e_{131}	e_{141}	p_{131}	p_{141}	e_{132}	e_{142}	e_{231}	e_{241}	p_{231}	p_{241}	e_{232}	e_{242}	e_{331}	e_{341}	p_{331}	p_{341}	e_{332}	e_{342}	e_{431}	e_{441}	p_{431}	p_{441}	e_{432}	e_{442}
	e_{113}	e_{123}	p_{112}	p_{122}	e_{114}	e_{124}	e_{213}	e_{223}	p_{212}	p_{222}	e_{214}	e_{224}	e_{313}	e_{323}	p_{312}	p_{322}	e_{314}	e_{324}	e_{413}	e_{423}	p_{412}	p_{422}	e_{414}	e_{424}
	e_{133}	e_{143}	p_{132}	p_{142}	e_{134}	e_{144}	e_{233}	e_{243}	p_{232}	p_{242}	e_{234}	e_{244}	e_{333}	e_{343}	p_{332}	p_{342}	e_{334}	e_{344}	e_{433}	e_{443}	p_{432}	p_{442}	e_{434}	e_{444}
AFB Tile 2	e_{112}	e_{122}	p_{111}	p_{121}	e_{111}	e_{121}	e_{212}	e_{222}	p_{211}	p_{221}	e_{211}	e_{221}	e_{312}	e_{322}	p_{311}	p_{321}	e_{311}	e_{321}	e_{412}	e_{422}	p_{411}	p_{421}	e_{411}	e_{421}
	e_{132}	e_{142}	p_{131}	p_{141}	e_{131}	e_{141}	e_{232}	e_{242}	p_{231}	p_{241}	e_{231}	e_{241}	e_{332}	e_{342}	p_{331}	p_{341}	e_{331}	e_{341}	e_{432}	e_{442}	p_{431}	p_{441}	e_{431}	e_{441}
	e_{114}	e_{122}	p_{112}	p_{122}	e_{113}	e_{123}	e_{214}	e_{224}	p_{212}	p_{222}	e_{213}	e_{223}	e_{314}	e_{324}	p_{312}	p_{322}	e_{313}	e_{323}	e_{414}	e_{424}	p_{412}	p_{422}	e_{413}	e_{423}
	e_{134}	e_{142}	p_{132}	p_{142}	e_{133}	e_{143}	e_{234}	e_{244}	p_{232}	p_{242}	e_{233}	e_{243}	e_{334}	e_{344}	p_{332}	p_{342}	e_{333}	e_{343}	e_{434}	e_{444}	p_{432}	p_{442}	e_{433}	e_{443}

Analog feedback channel structure for 4 transmit antenna base stations (LZone).
Four AMSS multiplexed with a CDM factor of 4. Only Tiles 1 and 2 are shown for the 4 AMSSs. Tile 3 is identical to Tile 1.

Figure 512—Analog Feedback Channel Structure for 4 Tx LZone



Analog feedback channel structure for 8 transmit antenna base stations (LZone).
Three AMSs multiplexed with a CDM factor of 2.

Figure 513—Analog Feedback Channel Structure for 8Tx LZone

15.3.9.3 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) E-MBS feedback.
- 7) Frequency partition selection (for DRU only) (TBD)

15.3.9.3.1 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 (PFBC) and secondary fast feedback channels (SFBC). 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.

15.3.9.3.1.1 Primary fast feedback control channel

The UL PFBC carries 4 to 6 bits of information, providing wideband channel quality feedback and MIMO feedback.

Table 725—PFBCH Feedback Content

PFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
CQI		1) Wideband CQI 2) Subband CQI for Best -1 subband (TBD) 3) Average CQI over resource units indicated by BS (TBD)
STC Rate Indicator		Number of streams
BSI (Band Selection Info for best-1 subband) (TBD)		
PMI (TBD)		1) wideband PMI 2) subband PMI for best-1
Event-driven Indicator (EDI) for CQICH de-allocation (TBD)	N/A	MS to indicate channel variation event
Event-driven for confirmation of CQICH de-allocation. (TBD)		
Event-driven Indicator (EDI) for Preferred MIMO operation (TBD)		Sequences: Option 1: 1) OL distributed 2) OL localized 3) CL distributed 4) CL localized Option 2: 1) OL 2) CL 3) SU 4) MU MaxMt =2 5) MU MaxMt = 3 6) MU MaxMt = 4 Option 3: 1) two steps method

Table 725—PFBCH Feedback Content

PFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
Event-driven Indicator (EDI) for Multi-cell MIMO Initiation (TBD)		Sequence based
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) (TBD)	N/A	Inform BS the frequency partition of the reported CQI (DL diversity mode only)
Event-driven Indicator (EDI) for Buffer management (TBD)	N/A	Indicates occupancy status of HARQ soft buffer

15.3.9.3.1.2 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 726—SFBCH Feedback Content

PFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
Subband CQI		Reporting of average and differential CQI of selected sub-bands. Reporting of transformed coefficients is TBD
Band selection information		Selected band position. Index to indicate sub-band selection If transformed coefficients method is used, band selection is not necessary.

Table 726—SFBCH Feedback Content

PFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
Subband PMI		Precoding Matrix Indicator of one sub-band for CL MIMO
Wideband PMI (TBD)		Wideband PMI with subband CQI
Stream Indicator		It is needed for OL MU MIMO only and used to indicate which spatial stream to estimate CQI
STC Rate Indicator		Number of streams
Event-Driven (TBD)		

15.3.9.3.1.3 Channel quality indicator(CQI) definition

Jointly encoding of CQI and STC rate is TBD, which specifies the spectrum efficiency.

Wideband CQI

Wideband CQI is one average CQI over whole band corresponding to the MIMO mode. In case of FFR , the wideband CQI TBD.

Subband CQI

Subband CQI is represented by one base CQI (ave_CQI) over the selected M subbands (or whole bandwidth TBD) plus a differential CQI, which is used for best-M feedback.

For best-M feedback, the subband selection and Ave_CQI and Diff_CQI may be reported at different intervals, and share the same FBCH with TDM manner. Subband selection and Ave_CQI will puncture the Diff_CQI at every [4th TBD] report if TDM is enabled.

[All subband CQIs across the whole bandwidth may be organized in hierarchical tree (TBD)]

[Reporting of transformed coefficients is TBD, where MS linearly transforms all the subband CQIs (whole band) into a series of progressively insignificant coefficients, and quantize the coefficients to few bits for feedback. The transformed values are sent over one or several reports]

Specified CQI (TBD)

Specified CQI is the CQI specified for a certain RU indicated by DLRU parameters in feedback allocation A-MAP IE.

15.3.9.3.1.4 Feedback format

Feedback format for MFM 0,1,4,7

Feedback format for MFM 2

The detailed format is listed in Table 727. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report in every [4n-th TBD] reporting period.

Table 727—Feedback formats for MIMO feedback mode 2

Feedback Format	FBCH	Number of reports	Feedback Fields		Size in bits	Description / Notes
0						
1 (M=1)						
2 (M=2)						
3						
4						

Feedback format for MFM 3 and 6

The detailed format is listed in Table 728. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report in every [4n-th TBD] reporting period.

Table 728—Feedback formats for MIMO feedback mode 3 and 6

Feedback Format	FBCH	Number of reports	Feedback Fields		Size in bits	Description / Notes
0						
1 (M=1)						
2 (M=2)						
3						

Feedback format for MFM 5

The detailed format is listed in Table 729. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report in every [4n-th TBD] reporting period.

Table 729—Feedback formats for MIMO feedback mode 5

Feedback Format	FBCH	Number of reports	Feedback Fields		Size in bits	Description / Notes
0						
1 (M=1)						
2 (M=2)						
3						

15.3.9.3.2 HARQ feedback control channel**15.3.9.3.3 Bandwidth request channel****15.3.9.3.4 Analog feedback channel**

The analog feedback LRUs are used by the AMSs to transmit analog eigenvector feedback for enabling the ABS to compute high precision MU-MIMO transmit precoding weights. In analog eigenvector feedback, the AMS first computes an estimate of the downlink transmit spatial covariance matrix R given by:

$$R = \frac{1}{N_K} \cdot \sum_{k \in S(k)} H^H(k)H(k) \quad (244)$$

where $H(k)$ is the downlink matrix channel response (dimensioned as the number of AMS receive antennas by the number of ABS transmit antennas) at subcarrier k . The AMS may estimate $H(k)$ from downlink measurement pilots. The $S(k)$ denotes the set of subcarriers that the transmit covariance matrix is computed over. N_K is the number of subcarriers in the set $S(k)$.

Two modes of analog eigenvector feedback are supported: wideband eigenvector feedback and narrowband eigenvector feedback. In wideband mode, the set of subcarriers $S(k)$ used to compute R consist of all used subcarriers. In narrowband mode, the set of subcarriers used to compute R consist of all subcarriers in the sub-band requested by the ABS in the [TBD] DL Control signaling. The ABS will indicate which mode (wideband or narrowband) the AMS is to use.

After computing R over the appropriate subcarriers, the AMS computes the eigenvector corresponding to the largest eigenvalue of R , where the largest eigenvector is denoted:

$$E = \begin{bmatrix} c_1 \\ c_2 \\ \dots \\ c_N \end{bmatrix}$$

where N is the number of transmit antennas at the ABS. The coefficients to be mapped to the analog feedback channels are denoted by e_i where elements $e_i = \alpha c_i$. The scale factor α is chosen by the MS to appropriately normalize the overall average transmit power to the value needed to achieve the per-subcarrier power control target for analog feedback. The ABS will indicate the per-subcarrier power control target for each user in a [TBD] DL control message.

The ABS will indicate to the AMS which form (wideband or narrowband) is to be transmitted and on which analog feedback subchannel to transmit the elements e_i . For narrowband mode, the ABS will indicate over which sub-band the covariance matrix R is to be computed.

The mapping from the elements e_i to the information symbols e_{ijk} that are transmitted in the AFB subchannels shown in Section <<15.3.9.2.6>> is as follows. First, the entries of the unquantized eigenvector are denoted e_k , for $k = 1 \dots N$, where N is the number of BS transmit antennas. The symbol transmitted in the analog feedback subchannel is denoted as e_{ijk} , where $e_{ijk} = m_{ij} \times e_k$, and m_{ij} is the $(j,i)^{\text{th}}$ entry of the particular spreading matrix being used by the base station sector, where j is the row index and i is the column index of the spreading matrix. There are four choices for the spreading matrix to be used within a sector for spreading the analog feedback and those choices are denoted A, B, C, or D:

$$A = \left(\frac{1}{2}\right) \cdot \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 1 & 1 \\ 1 & -1 & -1 & -1 \end{bmatrix}, B = \left(\frac{1}{2}\right) \cdot \begin{bmatrix} 1 & 1 & 1 & 1 \\ -1 & -1 & 1 & 1 \\ -i & i & i & -i \\ -i & i & -i & i \end{bmatrix}, C = \left(\frac{1}{2}\right) \cdot \begin{bmatrix} 1 & 1 & 1 & 1 \\ -i & -i & i & i \\ -i & i & i & -i \\ -1 & 1 & -1 & 1 \end{bmatrix}, D = \left(\frac{1}{2}\right) \cdot \begin{bmatrix} 1 & 1 & 1 & 1 \\ i & i & -i & -i \\ 1 & -1 & -1 & 1 \\ -i & i & -i & i \end{bmatrix}$$

The BS will indicate to the MS which spreading matrix is being used by the sector to which the MS belongs via [TBD] signaling/methodology. The pilot symbols P_{ijk} are similarly constructed: $P_{ijk} = m_{ij} \times P_k$, where P_k is the [TBD] pilot value to be transmitted by the MS assigned to the AFB subchannel and m_{ij} is given above.

15.3.9.4 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 same 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, without additional power control messages. 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. The AMS shall interpret power control messages as the required changes to the transmitted power density.

For interference level control, current IoT level of each cell may be shared among ABSs.

15.3.9.4.1 UL Open-Loop Power Control

When the open-loop power control is used, the power per subcarrier and per transmission antenna shall be maintained for the UL transmission as indicated in Equation (245).

$$P(\text{dBm}) = L + \text{SINR}_{\text{Target}} + NI + \text{Offset}_{\text{AMS}_{\text{perAMS}}} + \text{Offset}_{\text{ABS}_{\text{perAMS}}} \quad (245)$$

Where:

$\text{SINR}_{\text{Target}}$ is the target uplink SINR received by the ABS. The mode used to calculate this value is signaled through a power control message.

P is the TX power level (dBm) per subcarrier for the current transmission.

L is the estimated average current UL propagation loss. 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, not including ABS's Rx antenna gain.

$\text{Offset}_{\text{AMS}_{\text{perAMS}}}$ is a correction term for AMS-specific power offset. It is controlled by the AMS. Its initial value is zero.

$\text{Offset}_{\text{ABS}_{\text{perAMS}}}$ is a correction term for AMS-specific power offset. It is controlled by the ABS through power control messages.

The estimated average current UL propagation loss, L , shall be calculated based on the total power received on the active subcarriers of the frame preamble.

When the user connects to network, it can negotiate the parameters using Equation (246):

$$\text{SINR}_{\text{Target}} = \begin{cases} \text{SINR}_{\text{OPT}}, & \text{OLPC Mode 1} \\ (C/N - 10\log 10(R)), & \text{OLPC Mode 2} \end{cases} \quad (246)$$

Where

C/N is the normalized C/N of the modulation/FEC rate for the current transmission, as appearing in <<Table 1>>.

R is the number of repetitions for the modulation/FEC rate

SINR_{OPT} is the target SINR value for IoT control and tradeoff between overall system throughput and cell edge performance, decided by the control parameter $[\gamma \text{ or } \Delta_{\text{IoT}}]$ and SINR_{MIN} :

$$\begin{aligned} \text{SINR}_{\text{OPT}} = & 10\log 10 \left(\max \left(10^{\frac{\text{SINR}_{\text{MIN}}}{10}}, \gamma \cdot \text{SIR}_{\text{DL}} - \frac{1}{N_r} \right) \right), \text{ or} \\ & \max(\text{SINR}_{\text{MIN}}, \min(C/N - 10\log 10(R), \Delta_{\text{IoT}} + 10\log 10(\text{SIR}_{\text{DL}}))), \end{aligned}$$

Where

SINR_{MIN} is the SINR requirement for the minimum rate expected by ABS which is set by a unicast power control message. SINR_{MIN} has 4 bits to represent the value in dB among $\{-3, -2.5, -2, -1.5, -1, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5\}$ (TBD).

γ is the fairness and IoT control factor, broadcast by the ABS. It has 4 bits to represent the value among $\{0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5\}$

Δ_{IoT} is the parameter for IoT control and broadcast by the ABS. It has 3 or 4 bits and the exact values in dB are TBD. It can also be different for each frequency partition.

N_r is the number of receive antennas at the ABS.

SIR_{DL} is the ratio of the downlink signal vs. interference power, measured by the AMS.

Table 730—Normalized C/N per modulation

Modulation/FEC rate	Required C/N
ACK/NAK	-3.0
CQI	0
MAP ACK/NAK	0
Ranging code	3
QPSK 1/3	0.5
QPSK 1/2	6
QPSK 2/3	7.5
QPSK 3/4	9
16-QAM-1/2	12
16-QAM-2/3	14.5
16-QAM-3/4	15
16-QAM-5/6	17.5
64-QAM-1/2	18
64-QAM-2/3	20
64-QAM-3/4	21
64-QAM-5/6	23

15.3.9.4.2 UL Closed-Loop Power Control

To maintain at the ABS a power density consistent with the modulation and FEC rate used by each AMS, the ABS may change the AMS's TX power through direct power adjustment signaling such as PC-A-MAP. Closed loop power control is defined in Equation (247).

$$P_{tx} = P_{last} + \Delta_{SINR} + \Delta_{PowerAdjust} \quad (247)$$

where:

P_{tx} is transmit power level per subcarrier.

P_{last} is the latest transmitted maximum power level among different uplink physical channels transmitted concurrently.

Δ_{SINR} is the difference of the desired SINRs between the previous and new MCS levels for a uplink physical channel. Desired SINR for each MCS level is TBD.

$\Delta_{PowerAdjust}$ is the value indicated by PC-A-MAP.

Power correction values are defined in Table 731.

Table 731—Power correction offset values

Power Correction Value	Offset (dB)
0b00	-0.5
0b01	0.0
0b10	0.5
0b11	1.0

15.3.9.4.3 Ranging Channel Power Control

For initial ranging, AMS sends initial ranging code at a random selected ranging channel. The initial transmission power is decided according to measured RSS. If AMS does not receive a response, AMS may send a new initial ranging code and increase its power level by . AMS could further increase the power until maximum transmit power reached.

The initial transmission power of MS is calculated as:

$P_{TX_IR_MIN} = EIRxP_{IR,min} + BS_EIRP - RSS$, where $EIRxP_{IR,min}$ is the minimum targeting receiving power.

The maximum transmit power for initial ranging is calculated as:

$P_{TX_IR_MAX} = EIRxP_{IR,max} + BS_EIRP - RSS$, where $EIRxP_{IR,max}$ and BS_EIRP are obtained from ABS through decoding of the S-SFH IE SP3, see <<table 1>>.

$EIRxP_{IR,max}$ is the maximal targeting receiving power for initial ranging code.

BS_EIRP is the transmission power of the BS.

In the case that the Rx and Tx gain of the AMS antenna are different, the AMS shall use Equation (248):

$$P_{TX_IR_MAX} = EIRxP_{IR,max} + BS_EIRP - RSS + (G_{Rx_MS} - G_{Tx_MS}) \quad (248)$$

Where

G_{Rx_MS} is the antenna gain of AMS RX.

G_{Tx_MS} is the antenna gain of AMS TX.

RSS is the measured receiving signaling strength by AMS.

For periodic ranging, once an AMS sends a periodic ranging code and fails to receive RNG-RSP, the AMS may adjust its transmit power for the subsequent periodic ranging codes transmission, step-by-step, up to $P_{Tx_IR_MAX}$.

15.3.9.4.4 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 CINR value. The power per subcarrier shall be maintained for the UL sounding transmission as shown in Equation (249):

$$P_{tx}(dBm) = PL + CINR_{target} + NI_{sounding} + OffsetAMS_{perAMS} + OffsetABS_{perAMS} \quad (249)$$

where:

$P_{tx}(dBm)$ is the transmit power per subcarrier and per transmit antenna power level.

PL is the estimated average pathloss.

$CINR_{target}$ is the target sounding CINR required at ABS.

$NI_{sounding}$ is the estimated average power level (dBm) of the noise and interference per subcarrier at ABS.

$OffsetAMS_{perAMS}$ is the correction term for AMS-specific power offset controlled by AMS.

$OffsetABS_{perAMS}$ is the correction term for AMS-specific power offset controlled by ABS.

In Equation (249), $CINR_{target}$ is the sounding channel target CINR, which is set according to the DL CINR of AMS. In order to maintain the UL sounding quality, the different target CINR values are assigned according to DL CINR of each AMS; the AMS with high DL CINR applies relatively high target CINR and the AMS with low DL CINR applies relatively low target CINR.

15.3.10 Uplink MIMO transmission schemes

15.3.10.1 Uplink MIMO architecture and data processing

The architecture of uplink MIMO at the transmitter side is shown in Figure 514.

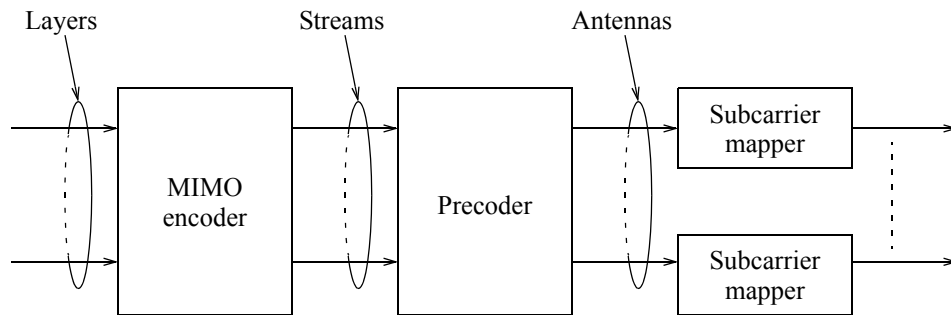


Figure 514—UL MIMO architecture

The MIMO encoder block maps a single layer ($L = 1$) onto M_t ($M_t \geq L$) streams, which are fed to the Precoder block. A layer is defined as a coding and modulation path fed to the MIMO encoder as an input. A stream is defined as an output of the MIMO encoder which is passed to the precoder.

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 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 MS has one transmit antenna.

The subcarrier mapping blocks map antenna-specific data to the OFDM symbol.

15.3.10.1.1 Layer to stream mapping

Layer to stream mapping is performed by the MIMO encoder. The uplink MIMO encoder is identical to the downlink MIMO encoder described in section “Layer to stream mapping” on page 230.

Horizontal encoding (MEF = 0b10) is not supported for uplink transmissions.

A MS with 1 transmit antenna shall use vertical encoding (MEF = 0b01) for uplink transmissions.

15.3.10.1.1.1 SFBC encoding

Uplink SFBC encoding is identical to the downlink SFBC encoding described in section “SFBC encoding” on page 231.

SFBC encoding format shall not be allocated to an MS with 1 transmit antenna.

15.3.10.1.1.2 Vertical encoding

Uplink vertical encoding is identical to the downlink vertical encoding described in section “Vertical encoding” on page 231.

Vertical encoding with 1 stream ($M_t = 1$) format shall be allocated to an MS with 1 transmit antenna.

15.3.10.1.2 Stream to antenna mapping

Stream to antenna mapping is performed by the precoder. The uplink mapping is identical to the downlink mapping described in section “Stream to antenna mapping” on page 232.

15.3.10.1.2.1 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 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_H precoders of the base codebook for a given rank. \mathbf{W} belongs to one of the subsets of the base codebook specified in <<<Section 15.3.7.2.6.6.2.4.1>>>, according to the type of allocation, MEF, N_t and M_t , as specified in Table 732 and <<<Table Y>>>.

Table 732—Codebook subsets used for non-adaptive precoding in UL diversity allocations (DRU and distributed minibands)

MEF	RU with M_t pilot streams
SFBC	$C_{ULOLSU}(N_t, M_t, N_w), M_t = 2$
VE	$C_{ULOLSU}(N_t, M_t, N_w), M_t = 1, \dots, 4$

Table 732—Codebook subsets used for non-adaptive precoding in UL diversity allocations (DRU and distributed minibands)

HE	Not allowed on UL
----	-------------------

Table 733—Codebook subsets used for non-adaptive precoding in UL localized allocations (minibands and subbands CRU)

MEF	RU with M_t pilot streams
SFBC	na
VE	$C(N_p, M_p, N_w), N_w = 2^{NB}, M_t = 1, \dots, 4$
HE	Not allowed on UL

In a RU allocated in a subframe with MEF = 0b00 or 0b01 and non-adaptive precoding, the matrix \mathbf{W} changes every $N_I P_{SC}$ contiguous physical subcarriers according to Equation (250), and it does not depend on the 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

$$i = s \bmod N_w, \quad s = 1 \dots N_{sub} - 1 \quad (250)$$

15.3.10.1.2.2 Adaptive precoding

There is no precoding if there is only one transmit antenna at the MS.

With adaptive precoding, the precoder \mathbf{W} is derived at the BS or at the MS, as instructed by the BS.

With 2Tx or 4Tx at the MS in FDD and TDD systems, unitary codebook based adaptive precoding is supported. In this mode, a MS transmits a sounding signal on the uplink to assist the precoder selection at the BS. The BS shall signal the uplink precoding matrix index to be used by the MS in the UL A-MAP IE.

With 2Tx or 4Tx at the MS in TDD systems, adaptive precoding based on the measurements of downlink reference signals is supported. The MS chooses the precoder based on the downlink measurements. The form and derivation of the precoding matrix does not need to be known at the BS.

15.3.10.1.3 Uplink MIMO transmission modes

There are five MIMO transmission modes for UL MIMO transmission as listed in Table 734.

Table 734—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

Table 734—Uplink MIMO modes

Mode Index	Description	MIMO encoding format (MEF)	MIMO Precoding
Mode 3	OL Collaborative spatial multiplexing (MU-MIMO)	VE	non-adaptive
Mode 4	CL Collaborative spatial multiplexing (MU-MIMO)	VE	adaptive

The allowed values of the parameters for each UL MIMO mode are shown in Table 735.

Table 735—DL MIMO parameters

	Number of transmit antennas	STC rate per layer	Number of streams	Number of subcarriers	Number of 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
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

Table 735—DL MIMO parameters

	Number of transmit antennas	STC rate per layer	Number of streams	Number of subcarriers	Number of layers
	N_t	R	M_t	N_F	L
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

M_t refers to the number of streams transmitted to one MS with MIMO modes 0, 1, and 2.

M_t refers to the total number of streams transmitted to multiple MS on the same RU with MIMO modes 3 and 4.

15.3.10.2 Transmission schemes for data channels

15.3.10.2.1 Encoding, precoding and mapping of SU-MIMO

15.3.10.2.1.1 Encoding of MIMO modes

15.3.10.2.1.1.1 MIMO mode 0

SFBC encoding of section “SFBC encoding” on page 311 shall be used with MIMO mode 0.

15.3.10.2.1.1.2 MIMO mode 1

Vertical encoding of section “Vertical encoding” on page 311 shall be used with MIMO mode 1. The number of streams is $M_t \leq \min(N_T, N_R)$, where M_t is no more than 4.

15.3.10.2.1.1.3 MIMO mode 2

Vertical encoding of section “Vertical encoding” on page 311 shall be used with MIMO mode 2. The number of streams is $M_t \leq \min(N_T, N_R)$, where M_t is no more than 4.

15.3.10.2.1.2 Precoding of MIMO modes

15.3.10.2.1.2.1 MIMO mode 0

Non-adaptive precoding with $M_t=2$ streams of section “Non-adaptive precoding” on page 311 shall be used with MIMO mode 0.

15.3.10.2.1.2.2 MIMO mode 1

Non-adaptive precoding of section 15.3.10.1.2.1 shall be used with MIMO mode 1.

15.3.10.2.1.2.3 MIMO mode 2

Adaptive precoding of section 15.3.10.1.2.2 shall be used with MIMO mode 2.

15.3.10.2.2 Encoding, precoding and mapping of collaborative spatial multiplexing (MU-MIMO)

MSs can perform collaborative spatial multiplexing onto the same RU. In this case, the BS assigns different pilot patterns for each MS

15.3.10.2.2.1 Encoding of MIMO mode 3

Vertical encoding of section “Vertical encoding” on page 311 shall be used with MIMO mode 3.

15.3.10.2.2.2 Encoding of MIMO mode 4

Vertical encoding of section 15.3.10.1.1.2 shall be used with MIMO mode 4.

15.3.10.2.2.3 Precoding of MIMO modes

15.3.10.2.2.3.1 MIMO mode 3

Non-adaptive precoding of section “Non-adaptive precoding” on page 311 shall be used with MIMO mode 3.

15.3.10.2.2.3.2 MIMO mode 4

Adaptive precoding of section “Adaptive precoding” on page 312 shall be used with MIMO mode 4.

15.3.10.2.3 Mapping of data subcarriers

15.3.10.2.3.1 MIMO mode 0

15.3.10.2.3.2 MIMO mode 1 and mode 2

15.3.10.2.3.3 MIMO mode 3 and mode 4

15.3.10.2.4 Mapping of pilot subcarriers

15.3.10.2.5 Usage of MIMO modes

The following table shows the permutations supported for each MIMO mode. The definition of tile based DRU, mini-band based CRU, and subband based CRU are in 15.3.8.

Table 736—Supported permutation for each UL MIMO mode

	Tile based DRU	Mini-band based CRU (diversity allocation)	Mini-band based CRU Sub-band based CRU (localized allocation)
MIMO mode 0	Yes	Yes	No
MIMO mode 1	Yes, with $M_t \leq 2$	Yes	Yes
MIMO mode 2	Yes, with $M_t \leq 2$	Yes	Yes
MIMO mode 3	Yes, with $M_t = 1$	Yes	Yes
MIMO mode 4	Yes, with $M_t = 1$	Yes	Yes

15.3.10.2.6 Downlink signaling support of UL-MIMO modes**15.3.10.2.6.1 Broadcast information**

The BS 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 A-MAP IE, in the FBCH Alloc IE, on the Sounding_IE.

Table 737 specifies the DL control parameters required for UL MIMO operation.

Table 737—UL MIMO control parameters

Parameter	Description	Value	Control channel (IE)	Notes
MEF	MIMO Encoding Format	SFBC Vertical encoding	A-MAP IE	MIMO encoding format
CSM	Collaborative Spatial Multiplexing	Disabled or enabled	A-MAP IE	SU MIMO if CSM is disabled MU MIMO if CSM is enabled
M_t	Number of streams	1 to 4	A-MAP IE	Number of streams in the MS transmission.
TNS	Total number of streams in the LRU	1 to 4	A-MAP IE	Enabled when CSM is enabled. Indication of the total number of streams in the LRU
SI	First pilot index	1 to 4	A-MAP IE	Enabled when CSM is enabled. 1 bit for 2Tx, 2 bit for 4Tx
PF	Precoding flag	non adaptive precoding or adaptive codebook precoding	A-MAP IE	Cannot be applied to MS with 1 transmit antenna

Table 737—UL MIMO control parameters

Parameter	Description	Value	Control channel (IE)	Notes
PMI Indicator	PMI indicator	0b0: the MS shall use the precoder of rank M_t of its choice 0b1: the indicated PMI of rank M_t shall be used by the MS for precoding	A-MAP IE	This field is relevant only when PF indicates adaptive codebook precoding. PMI indication = 0b0 may be used in TDD. When PMI indication = 0b1, the BS selects the precoder to use at the MS.
PMI	Precoding matrix index in the UL base codebook	0 to 7 when $N_t = 2$ 0 to 63 when $N_t = 4$	A-MAP IE (unicast)	Enabled when PF = 0b1 [Bit-field length is variable, depending on the number of code matrices]

15.3.10.3 Codebook for closed-loop transmit precoding**15.3.10.3.1 Base codebook for two transmit antenna****15.3.10.3.1.1 SU-MIMO base codebook**

The base codebook of uplink 2 Tx is the same as the downlink 2 Tx base codebook (SU MIMO base codebook), defined in 15.3.7.2.6.6.2.1.1.

15.3.10.3.1.2 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 “SU-MIMO base codebook” on page 317.

15.3.10.3.2 Base codebook for four transmit antennas**15.3.10.3.2.1 SU-MIMO base codebook**

The codebooks for UL MIMO with four transmit antenna MS are constructed using the methodology described in section 15.3.7.2.6.6.2.1.1, for two transmit antenna case.

The parameters for the generation of codebooks for four transmit antenna $N_t = 4$ and number of streams $M_t = 1, 2, 3, 4$ are listed in Table 738.

Table 738—Generating parameters for four transmit antenna codebook

Nt	Mt	NB	L	$u = \lfloor u_1, u_2, \dots, u_{N_t} \rfloor$ in $Q^L(u)$	s in $H(s)$
4	1	6	6	[18, 55, 22, 6]	[1, 0, 0, 0]
4	2	6	6		
4	3	6	6		
4	4	6	6		

15.3.10.3.2.2 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 “SU-MIMO base codebook” on page 317.

15.3.10.4 Transmission schemes for control channels

15.3.10.5 Codebook subsets for open-loop non-adaptive transmit precoding

15.3.10.5.1 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 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 streams with MIMO mode 0 and MIMO mode 1.

15.3.10.5.1.1 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 streams with MIMO mode 0 and MIMO mode 1.

15.3.10.5.1.2 OL SU-MIMO subset for four transmit antennas

Table 739 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 4Tx.

Table 739—Size of the DL 4Tx OL SU-MIMO codebook subset

Rank	1	2	3	4
N_w	4	4	4	4

The codewords of the OL SU-MIMO codebook subset for four transmit antennas are given in Table 740 for each rank. The corresponding codewords of the uplink base codebook for four transmit antennas are given in Table 740.

Table 740— $C_{UL,OL,SU}(4,1,4)$, $C_{UL,OL,SU}(4,2,4)$, $C_{UL,OL,SU}(4,3,4)$ 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	PMI m in UL base codebook of rank 1	n	PMI m in UL base codebook of rank 2	n	PMI m in UL base codebook of rank 3	n	PMI m in UL base codebook of rank 3
0	9	0	9	0	9	0	9
1	15	1	15	1	15	1	15

Table 740— $C_{UL,OL,SU}(4,1,4)$, $C_{UL,OL,SU}(4,2,4)$, $C_{UL,OL,SU}(4,3,4)$ 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	PMI m in UL base codebook of rank 1	n	PMI m in UL base codebook of rank 2	n	PMI m in UL base codebook of rank 3	n	PMI m in UL base codebook of rank 3
2	49	2	49	2	49	2	49
3	55	3	55	3	55	3	55

The PMI m in the base codebook of rank M_t with $N_t = 4$ is given by v_{m+1} as in <<equation (203)>>.

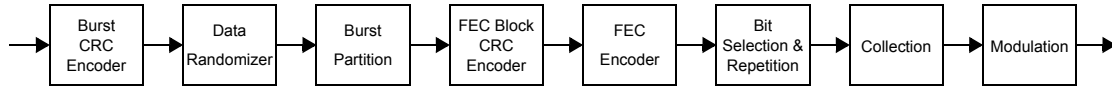
[Editor's note: equation 203 was deleted by comment 286 at Session 61.]

15.3.11 Multi-BS MIMO

15.3.12 Channel coding and HARQ

15.3.12.1 Channel coding

Channel coding procedures for downlink and uplink data channels are shown in Figure 515.

**Figure 515—Channel coding procedure**

15.3.12.1.1 Burst CRC encoding

Cyclic Redundancy Code (CRC) bits are used to detect errors in the received packets. A 16-bit burst CRC is appended to the data burst using the cyclic generator polynomial in Equation (251):

$$g_{DB-CRC}(D) = D^{16} + D^{12} + D^5 + 1 \quad (251)$$

Denote the bits of the input data burst by $d_1, d_2, d_3, \dots, d_{N_{PL}}$ 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 $p_1, p_2, p_3, \dots, p_{16}$. The burst CRC encoding is performed in a systematic form, which means that in GF(2), the polynomial in Equation (252):

$$d_1 D^{N_{PL}+15} + d_2 D^{N_{PL}+14} + \dots + d_n D^{16} + p_1 D^{15} + p_2 D^{14} + \dots + p_{15} D^1 + p_{16} \quad (252)$$

yields a remainder equal to 0 when divided by $g_{DB-CRC}(D)$.

The data burst, including the CRC, is further processed by the data randomizer as described in section 15.3.12.1.2.

15.3.12.1.2 Randomization

Data randomization shall be performed on the downlink and uplink data channel.

The randomization bits are generated using a PRBS generator as shown in Figure 516. The generator polynomial of the PRBS generator is $1 + x^{14} + x^{15}$. For each data burst, the beginning state of the PRBS is initialized to $[s_1 \ s_2 \ \dots \ s_{15}] = [0 \ 1 \ 1 \ 0 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 1 \ 0 \ 1 \ 0 \ 1]$ where s_1 is the LSB and s_{15} is the MSB. The data burst to be transmitted shall enter sequentially into the randomizer, 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.

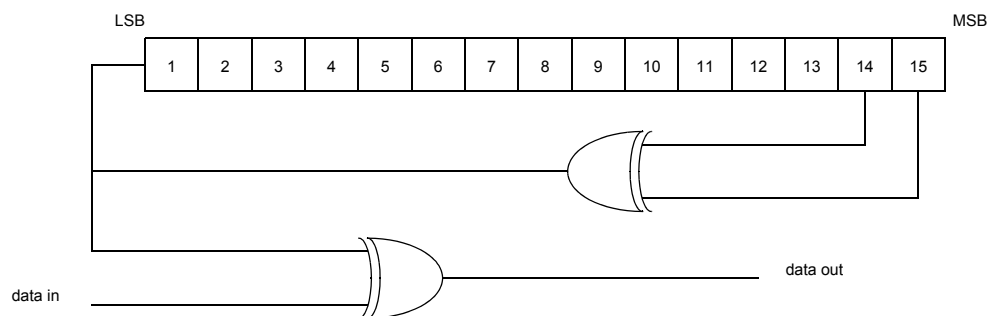


Figure 516—Data randomizer with a PRBS generator

The output of the data randomizer is further processed by burst partition as described in section 15.3.12.1.3.

15.3.12.1.3 Burst partition

When the burst size including 16 burst CRC bits exceeds the maximum FEC block size, N_{FB_MAX} , the burst is partitioned into K_{FB} FEC blocks. The modulation order, the nominal code rate, the number of resource elements allocated for data transmission, the spatial multiplexing order, and the maximum FEC block size are denoted by N_{mod} , R_{FEC} , N_{RE} , N_{SM} , N_{FB_MAX} , respectively.

N_{mod} is the modulation order of the burst transmission, which is specified by MCS index

R_{FEC} is the nominal code rate of the burst transmission, which is specified by MCS index

N_{RE} is the number of resource elements allocated for burst transmission. The calculation of N_{RE} shall exclude the resource elements used by pilot channels

N_{SM} is the spatial multiplexing order of the resource elements allocated for burst transmission. The value of N_{SM} depends on the MIMO transmission mode and is defined in section <<x.x.x.x>>.

N_{FB_MAX} is the maximum FEC block size, which equals to 4800 bits.

Table 741—Burst size

idx	N_{DB}	K_{FB}	idx	N_{DB}	K_{FB}	idx	N_{DB} (bytes)	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	145	1	49	1888	4
6	12	1	28	164	1	50	2112	4

Table 741—Burst size

7	13	1	29	181	1	51	2400	4
8	15	1	30	205	1	52	2640	5
9	17	1	31	233	1	53	3000	5
10	19	1	32	262	1	54	3600	6
11	22	1	33	291	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

$$idx = I_{MinimalSize} + I_{SizeOffset}, \text{ where}$$

$I_{SizeOffset} \in \{0, 1, \dots, 31\}$ is a 5 bits index in A-MAP IE, and $I_{MinimalSize}$ is calculated based on Table 742 and the allocation size, The allocation size is defined as the number of LRUs multiplied by the MIMO rank that are allocated for the burst .

Table 742—Minimal size index as a function of the number of allocated LRUs

Allo c. size	$I_{Minimal}$ Size	Allo c. size	$I_{Minimal}$ Size	Allo c. size	$I_{Minimal}$ Size	Allo c. size	$I_{Minimal}$ Size	Allo c. size	$I_{Minimal}$ Size	Allo c. size	$I_{Minimal}$ Size
1	1	33	21	65	27	97	30	129	32	161	34
2	1	34	21	66	27	98	30	130	32	162	34
3	1	35	21	67	27	99	30	131	32	163	34
4	2	36	22	68	27	100	30	132	33	164	34
5	4	37	22	69	27	101	30	133	33	165	35
6	6	38	22	70	27	102	30	134	33	166	35
7	8	39	22	71	27	103	31	135	33	167	35
8	9	40	22	72	27	104	31	136	33	168	35
9	10	41	23	73	28	105	31	137	33	169	35
10	11	42	23	74	28	106	31	138	33	170	35
11	11	43	23	75	28	107	31	139	33	171	35
12	12	44	23	76	28	108	31	140	33	172	35
13	13	45	23	77	28	109	31	141	33	173	35
14	14	46	24	78	28	110	31	142	33	174	35
15	14	47	24	79	28	111	31	143	33	175	35
16	15	48	24	80	28	112	31	144	33	176	35
17	15	49	24	81	28	113	31	145	33	177	35
18	15	50	24	82	28	114	31	146	34	178	35
19	16	51	25	83	29	115	31	147	34	179	35
20	16	52	25	84	29	116	31	148	34	180	35
21	17	53	25	85	29	117	32	149	34	181	35
22	17	54	25	86	29	118	32	150	34	182	35
23	18	55	25	87	29	119	32	151	34	183	35
24	18	56	25	88	29	120	32	152	34	184	35
25	18	57	25	89	29	121	32	153	34	185	36
26	19	58	26	90	29	122	32	154	34	186	36
27	19	59	26	91	30	123	32	155	34	187	36
28	19	60	26	92	30	124	32	156	34	188	36
29	20	61	26	93	30	125	32	157	34	189	36

Table 742—Minimal size index as a function of the number of allocated LRUs

30	20	62	26	94	30	126	32	158	34	190	36
31	20	63	26	95	30	127	32	159	34	191	36
32	20	64	26	96	30	128	32	160	34	192	36

The modulation order N_{mod} (2 for QPSK, 4 for 16-QAM and 6 for 64-QAM) depends on the parameter $I_{\text{SizeOffset}}$ according to Table 743. 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 $I_{\text{SizeOffset}}$.

Table 743—Rules for modulation order

$I_{\text{SizeOffset}}$	N_{mod} (allocation size = 3)	N_{mod} (allocation size = 2)	N_{mod} (allocation size = 1)	$I_{\text{SizeOffset}}$	N_{mod} (allocation size = 3)	N_{mod} (allocation size = 2)	N_{mod} (allocation size = 1)
0	2	2	2	16	2	4	6
1	2	2	2	17	2	4	6
2	2	2	2	18	2	4	6
3	2	2	2	19	4	4	6
4	2	2	2	20	4	4	6
5	2	2	2	21	4	4	6
6	2	2	2	22	4	6	6
7	2	2	2	23	4	6	6
8	2	2	2	24	6	6	6
9	2	2	2	25	6	6	6
10	2	2	4	26	6	6	6
11	2	2	4	27	6	6	6
12	2	2	4	28	6	6	6
13	2	2	4	29	6	6	6
14	2	2	4	30	6	6	6
15	2	2	4	31	6	6	6

The nominal MCS used rank-1 CQI feedback shall be selected from Table 744.

Table 744—MCS table for rank-1 CQI

MCS Index	Modulation	Code Rate
0000	QPSK	31/256
0001	QPSK	48/256

Table 744—MCS table for rank-1 CQI

MCS Index	Modulation	Code Rate
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	185/256
1010	64QAM	135/256
1011	64QAM	157/256
1100	64QAM	181/256
1101	64QAM	205/256
1110	64QAM	225/256
1111	64QAM	237/256

The size of the k^{th} FEC block is denoted by $N_{\text{FB},k}$, $k = 0, 1, \dots, K_{\text{FB}}-1$. The set of supported FEC block sizes is shown in Table 745.

Table 745—FEC block size table for downlink and uplink data channels

Index	N_{FB}	Index	N_{FB}	Index	N_{FB}	Index	N_{FB}	Index	N_{FB}
0	48	30	328	60	720	90	1424	120	2752
1	64	31	344	61	736	91	1448	121	2816
2	72	32	352	62	752	92	1480	122	2880
3	80	33	360	63	768	93	1504	123	2944
4	88	34	368	64	776	94	1536	124	3008
5	96	35	376	65	800	95	1560	125	3072
6	104	36	384	66	824	96	1600	126	3200
7	120	37	400	67	848	97	1640	127	3264
8	128	38	416	68	872	98	1672	128	3328
9	136	39	432	69	888	99	1712	129	3392
10	144	40	440	70	912	100	1752	130	3456
11	152	41	456	71	936	101	1784	131	3520

Table 745—FEC block size table for downlink and uplink data channels

Index	N _{FB}	Index	N _{FB}	Index	N _{FB}	Index	N _{FB}	Index	N _{FB}
12	160	42	472	72	960	102	1824	132	3648
13	176	43	480	73	984	103	1864	133	3712
14	184	44	496	74	1000	104	1896	134	3776
15	192	45	512	75	1024	105	1920	135	3840
16	200	46	528	76	1048	106	1952	136	3904
17	208	47	544	77	1072	107	2000	137	3968
18	216	48	552	78	1096	108	2048	138	4096
19	232	49	568	79	1112	109	2096	139	4160
20	240	50	584	80	1136	110	2144	140	4224
21	248	51	600	81	1160	111	2192	141	4288
22	256	52	608	82	1184	112	2232	142	4352
23	264	53	624	83	1216	113	2280	143	4416
24	272	54	640	84	1248	114	2328	144	4544
25	288	55	656	85	1280	115	2368	145	4608
26	296	56	664	86	1312	116	2432	146	4672
27	304	57	680	87	1336	117	2496	147	4736
28	312	58	696	88	1368	118	2560	148	4800
29	320	59	712	89	1392	119	2624		

The burst size N_{DB} including burst CRC and FEC block CRC is defined by Equation (253):

$$N_{DB} = \sum_{k=0}^{K_{FB}-1} N_{FB,k} \quad (253)$$

The payload size excluding burst CRC and FEC block CRC is defined by Equation (254):

$$N_{PL} = N_{DB} - N_{DB-CRC} - I_{MFB} \cdot K_{FB} \cdot N_{FB-CRC} \quad (254)$$

where:

I_{MFB} equals 0 when $K_{FB} = 1$, 1 when $K_{FB} > 1$

N_{FB-CRC} equals 16, which is the size of the FEC block CRC

N_{DB-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 FEC block CRC encoding block as described in 15.3.12.1.4.

15.3.12.1.4 FEC block CRC encoding

The burst partition procedure generates K_{FB} FEC blocks for each burst. If $K_{FB} > 1$, the FEC block CRC generator appends a 16-bit FEC block CRC for each FEC block. The cyclic generator for FEC block CRC encoding is shown in Equation (255):

$$g_{FB-CRC}(D) = D^{16} + D^{15} + D^2 + 1 \quad (255)$$

Denote the bits of the k -th input FEC block by $d_1, d_2, \dots, d_{N_{FB,k}}$ with d_1 being the MSB and $N_{FB,k}$ being the size of the k -th input FEC block, including the 16-bit FEC block CRC. Denote the parity bits produced by the burst CRC generator by p_1, p_2, \dots, p_{16} . The burst CRC encoding is performed in a systematic form, which means that in GF(2), the polynomial in Equation (256):

$$d_1 D^{N_{FB,k}-1} + d_2 D^{N_{FB,k}-2} + \dots + d_{N_{FB,k}-16} D^{16} + p_1 D^{15} + p_2 D^{14} + \dots + p_{15} D^1 + p_{16} \quad (256)$$

yields a remainder equal to 0 when divided by $g_{FB-CRC}(D)$.

15.3.12.1.5 FEC encoding

Each FEC block shall be encoded using the convolutional turbo codes specified in section 15.3.12.1.5.1.

15.3.12.1.5.1 Convolutional turbo codes

CTC encoder

The CTC encoder, including its constituent encoder, is depicted in Figure 517.

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_{EP} bits ($N_{FB} = 2N$ 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 $1 + D^3$

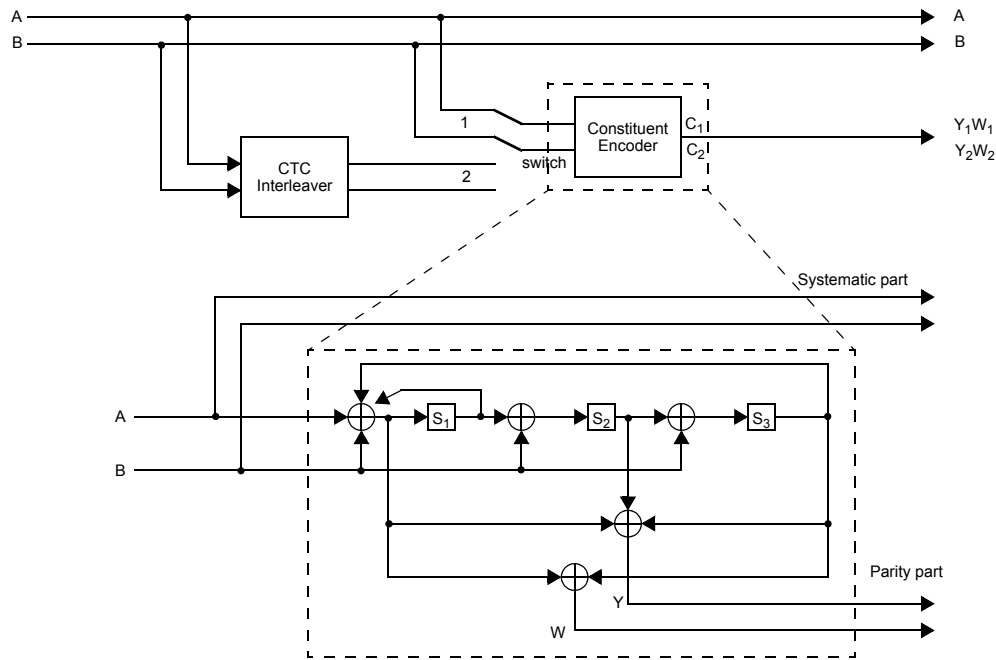


Figure 517—CTC encoder

First, the encoder (after initialization by the circulation state s_{c1} , see <<15.13.1.6.1.3>>) is fed the sequence in the natural order (switch 1 in Figure 517) with incremental address $i = 1, 2, \dots, N$. This first encoding is called C_1 encoding.

Next, the encoder (after initialization by the circulation state s_{c2} , see <<15.13.1.6.1.3>>) is fed by the interleaved sequence (switch 2 in Figure 517) with incremental address $i = 1, 2, \dots, N$. This second encoding is called C_2 encoding.

The order in which the encoded bits shall be fed into the bit separation block <<(15.x.1.6.1.4)>> is:

$$A, B, Y_1, Y_2, W_1, W_2 =$$

$$A_0, A_1, A_2, \dots, A_{N-1}, B_0, B_1, B_2, \dots, B_{N-1}, Y_{1,0}, Y_{1,1}, Y_{1,2}, \dots, Y_{1,N-1},$$

$$Y_{2,0}, Y_{2,1}, Y_{2,2}, \dots, Y_{2,N-1}, W_{1,0}, W_{1,1}, W_{1,2}, \dots, W_{1,N-1}, W_{2,0}, W_{2,1}, W_{2,2}, \dots, W_{2,N-1}.$$

CTC interleaver

The CTC interleaver requires the parameters $P0$, $P1$, $P2$, and $P3$ shown in Table 746 of which N_{EP} set corresponds to that in Table 745.

The detailed interleaver structures except table for interleaver parameters correspond to <<8.4.9.2.3.2>>.

Table 746—Interleaver Parameters

Inde x	N _{EP}	P0	P1	P2	P3	Inde x	N _{EP}	P0	P1	P2	P3	Inde x	N _{EP}	P0	P1	P2	P3
0	48	5	0	0	0	50	584	21	74	20	214	100	1752	31	314	656	666
1	64	11	12	0	12	51	600	31	12	272	28	101	1784	33	886	888	518
2	72	11	18	0	18	52	608	23	288	244	140	102	1824	41	774	548	898
3	80	7	4	32	36	53	624	23	286	220	70	103	1864	33	504	444	664
4	88	13	36	36	32	54	640	23	84	296	236	104	1896	35	936	940	832
5	96	13	24	0	24	55	656	23	24	300	52	105	1920	43	318	556	778
6	104	7	4	8	48	56	664	23	272	220	60	106	1952	35	94	144	686
7	120	11	30	0	34	57	680	19	48	240	144	107	2000	37	290	692	638
8	128	13	46	44	30	58	696	31	252	216	48	108	2048	31	2	332	622
9	136	13	58	4	58	59	712	25	214	180	286	109	2096	39	400	688	68
10	144	11	6	0	6	60	720	23	130	156	238	110	2144	29	298	252	610
11	152	11	38	12	74	61	736	29	126	208	270	111	2192	39	1074	148	710
12	160	13	68	76	64	62	752	23	26	24	230	112	2232	29	240	496	1100
13	176	17	52	68	32	63	768	29	252	0	88	113	2280	41	474	376	814
14	184	13	2	0	2	64	776	29	100	196	140	114	2328	41	254	884	1054
15	192	7	58	48	10	65	800	23	150	216	150	115	2368	47	228	440	724
16	200	11	76	0	24	66	824	29	130	332	42	116	2432	43	452	888	96
17	208	11	10	32	42	67	848	29	234	388	82	117	2496	43	0	208	528
18	216	11	54	56	2	68	872	29	408	300	316	118	2560	53	264	488	824
19	232	11	70	60	58	69	888	25	414	84	414	119	2624	47	378	1092	1250
20	240	13	60	0	60	70	912	29	14	264	94	120	2752	37	430	880	970
21	248	13	6	84	46	71	936	25	272	168	400	121	2816	31	624	704	400
22	256	11	64	8	8	72	960	53	62	12	2	122	2880	43	720	360	540
23	264	13	72	68	8	73	984	31	142	40	342	123	2944	41	338	660	646
24	272	13	82	44	38	74	1000	29	290	148	446	124	3008	43	916	1136	912
25	288	17	74	72	2	75	1024	29	320	236	324	125	3072	53	184	824	1368
26	296	13	0	84	64	76	1048	27	424	212	416	126	3200	43	1382	632	1086
27	304	13	130	112	46	77	1072	35	290	228	390	127	3264	49	142	828	1354
28	312	11	32	124	108	78	1096	23	178	392	430	128	3328	37	258	28	1522
29	320	17	84	108	132	79	1112	33	38	244	550	129	3392	51	460	56	1608
30	328	17	148	160	76	80	1136	37	170	276	134	130	3456	43	170	920	1518
31	344	17	160	116	52	81	1160	31	314	348	222	131	3520	57	776	1232	1012
32	352	17	106	56	50	82	1184	31	2	568	94	132	3648	49	132	720	276
33	360	17	40	132	128	83	1216	31	368	584	524	133	3712	41	1328	772	1036
34	368	19	88	0	172	84	1248	31	88	404	608	134	3776	53	772	256	408
35	376	13	110	92	14	85	1280	29	152	8	24	135	3840	53	92	1124	476

Table 746—Interleaver Parameters

Inde x	N _{EP}	P0	P1	P2	P3	Inde x	N _{EP}	P0	P1	P2	P3	Inde x	N _{EP}	P0	P1	P2	P3
36	384	11	96	48	144	86	1312	31	214	160	506	136	3904	51	664	200	64
37	400	19	142	0	142	87	1336	39	2	168	646	137	3968	57	1296	760	1360
38	416	17	102	132	178	88	1368	29	570	348	574	138	4096	55	148	808	308
39	432	17	126	92	74	89	1392	31	218	484	446	139	4160	79	214	308	262
40	440	19	48	20	144	90	1424	31	676	124	184	140	4224	59	14	668	1474
41	456	17	184	0	48	91	1448	33	254	372	158	141	4288	57	662	1516	42
42	472	19	40	104	28	92	1480	31	32	716	736	142	4352	59	2052	712	1804
43	480	13	120	60	180	93	1504	31	254	416	474	143	4416	59	1342	1968	1562
44	496	17	194	0	58	94	1536	31	34	564	710	144	4544	65	1380	1068	1036
45	512	19	64	52	124	95	1560	29	300	248	568	145	4608	67	954	1140	1566
46	528	17	36	196	100	96	1600	31	454	216	234	146	4672	67	410	1020	114
47	544	19	222	248	134	97	1640	33	164	432	748	147	4736	59	2	956	458
48	552	13	198	180	190	98	1672	35	164	368	700	148	4800	53	66	24	2
49	568	19	102	140	226	99	1712	41	4	848	332						

Determination of CTC cirulation 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 747 of which N_{EP} set corresponds to that in Table 745.

The detailed subblock interleaver structures except table for subblock interleaver parameters correspond to <<8.4.9.2.3.4.2>>.

Table 747—Parameters for the subblock interleavers

Index	N _{EP}	m	J	Index	N _{EP}	m	J	Index	N _{EP}	m	J	Index	N _{EP}	m	J	Index	N _{EP}	m	J
0	48	3	3	30	328	6	3	60	720	7	3	90	1424	8	3	120	2752	9	3
1	64	4	2	31	344	6	3	61	736	7	3	91	1448	8	3	121	2816	9	3
2	72	4	3	32	352	6	3	62	752	7	3	92	1480	8	3	122	2880	9	3
3	80	4	3	33	360	6	3	63	768	7	3	93	1504	8	3	123	2944	9	3
4	88	4	3	34	368	6	3	64	776	7	4	94	1536	8	3	124	3008	9	3
5	96	4	3	35	376	6	3	65	800	7	4	95	1560	8	4	125	3072	9	3
6	104	4	4	36	384	6	3	66	824	7	4	96	1600	8	4	126	3200	9	4

Table 747—Parameters for the subblock interleavers

Index	N _{EP}	m	J	Index	N _{EP}	m	J	Index	N _{EP}	m	J	Index	N _{EP}	m	J	Index	N _{EP}	m	J
7	120	5	2	37	400	6	4	67	848	7	4	97	1640	8	4	127	3264	9	4
8	128	5	2	38	416	6	4	68	872	7	4	98	1672	8	4	128	3328	9	4
9	136	5	3	39	432	6	4	69	888	7	4	99	1712	8	4	129	3392	9	4
10	144	5	3	40	440	6	4	70	912	8	2	100	1752	8	4	130	3456	9	4
11	152	5	3	41	456	7	2	71	936	8	2	101	1784	8	4	131	3520	9	4
12	160	5	3	42	472	7	2	72	960	8	2	102	1824	9	2	132	3648	10	2
13	176	5	3	43	480	7	2	73	984	8	2	103	1864	9	2	133	3712	10	2
14	184	5	3	44	496	7	2	74	1000	8	2	104	1896	9	2	134	3776	10	2
15	192	5	3	45	512	7	2	75	1024	8	2	105	1920	9	2	135	3840	10	2
16	200	5	4	46	528	7	3	76	1048	8	3	106	1952	9	2	136	3904	10	2
17	208	5	4	47	544	7	3	77	1072	8	3	107	2000	9	2	137	3968	10	2
18	216	5	4	48	552	7	3	78	1096	8	3	108	2048	9	2	138	4096	10	2
19	232	6	2	49	568	7	3	79	1112	8	3	109	2096	9	3	139	4160	10	3
20	240	6	2	50	584	7	3	80	1136	8	3	110	2144	9	3	140	4224	10	3
21	248	6	2	51	600	7	3	81	1160	8	3	111	2192	9	3	141	4288	10	3
22	256	6	2	52	608	7	3	82	1184	8	3	112	2232	9	3	142	4352	10	3
23	264	6	3	53	624	7	3	83	1216	8	3	113	2280	9	3	143	4416	10	3
24	272	6	3	54	640	7	3	84	1248	8	3	114	2328	9	3	144	4544	10	3
25	288	6	3	55	656	7	3	85	1280	8	3	115	2368	9	3	145	4608	10	3
26	296	6	3	56	664	7	3	86	1312	8	3	116	2432	9	3	146	4672	10	3
27	304	6	3	57	680	7	3	87	1336	8	3	117	2496	9	3	147	4736	10	3
28	312	6	3	58	696	7	3	88	1368	8	3	118	2560	9	3	148	4800	10	3
29	320	6	3	59	712	7	3	89	1392	8	3	119	2624	9	3				

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_{EP} is equal to multiple of the modulation order, k is set as 1. Otherwise, let k be 0. Figure 518 shows interleaving scheme as explained above.

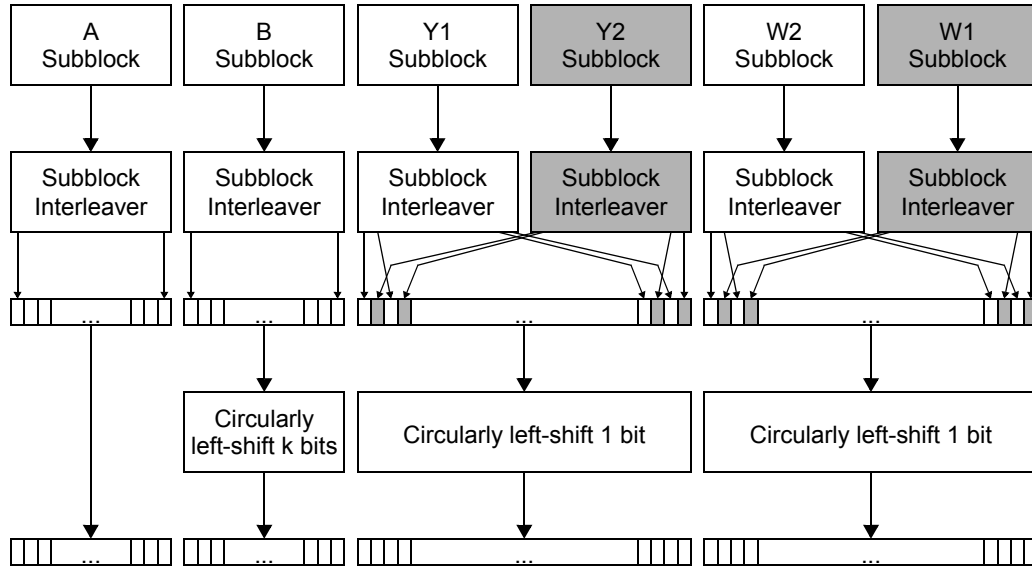


Figure 518—Block diagram of interleaving scheme

Resource segmentation

If $K_{FB} > 1$, the N_{RE} data resource elements allocated for the subpacket are segmented into K_{FB} blocks, one for each FEC block. The number of data resource elements for the k^{th} FEC block is defined by Equation (257).

$$N_{RE,k} = 2 \cdot \left\lfloor \frac{\frac{N_{RE}}{2} + (K_{FB} - k - 1)}{K_{FB}} \right\rfloor, 0 \leq k \leq K_{FB} \quad (257)$$

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 (258):

$$N_{CTC,k} = N_{RE,k} \cdot N_{SM} \cdot N_{mod} \quad (258)$$

The index in the HARQ buffer for the j^{th} bit transmitted for the k^{th} FEC block $u_{k,j,i}$ shall be:

$$N_{shift,i} = i \cdot N_{mod};$$

$$; index_{k,j,k} = (N_{CTC,k} - N_{shift,i} + j) \bmod (N_{CTC,k})$$

$$u_{k,j} = (P_{i,k} + index_{k,j,k}) \bmod N_{FB_Buffer,k};$$

for $k = 0, \dots, K_{FB} - 1$, and $j = 0, 1, \dots, N_{CTC,k} - 1$, 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 15.3.12.2.1, and $N_{FB_Buffer,k}$ is the buffer size for the k^{th} FEC block.

Bit collection

The selected bits from each FEC block are collected in the order of FEC block for the HARQ transmission.

Modulation

Correspond to <<8.4.9.4.2>>.

15.3.12.2 HARQ

15.3.12.2.1 IR HARQ

HARQ IR 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 section 15.3.12.1.5.1 is determined as a function of SPID using Table 748.

Table 748—Starting position determination for downlink HARQ

SPID	Starting position $P_{i,k}$
0	0
1	$(-N_{CTC,k}) \bmod N_{FB_Buffer,k}$
2	$(N_{FB_Buffer,k}/2 - N_{CTC,k}/2) \bmod (N_{FB_Buffer,k})$
3	$(N_{FB_Buffer,k} - N_{CTC,k}/2) \bmod (N_{FB_Buffer,k})$

For uplink HARQ, the starting position for the bit selection algorithm as described in section 15.3.12.1.5.1 is determined as a function of SPID for Equation (259).

$$P_{i,k} = (i \cdot N_{CTC,k}) \bmod N_{FB_Buffer,k} \quad (259)$$

For uplink HARQ, subpackets shall be transmitted in sequential order. In other words, for the t^{th} transmission, the subpacket ID shall be set to SPID = $t \bmod 4$.

15.3.12.2.1.1 Constellation rearrangement

Two constellation re-arrangement versions shall be supported. Constellation rearrangement only applies to 16QAM and 64QAM. In case of QPSK, it is transparent.

<<table>> describes the operations that produce different CoRe versions for 16QAM and 64QAM 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 749—Constellation rearrangement version (rank = 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 750—Constellation rearrangement version (rank = 2)

Constellation	Ncbps	CRV	Mapping rule											
			First symbol						Second 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

15.3.13 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.

15.3.13.1 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 shall 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.

15.3.13.2 UL Link Adaptation

Adaptive modulation and channel coding scheme for UL transmission shall be supported.

The serving ABS shall adapt the modulation and coding scheme (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.