IEEE Standard for WirelessMAN-Advanced Air Interface for Broadband Wireless Access Systems

IEEE Computer Society

and the

IEEE Microwave Theory and Techniques Society

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Abstract: The WirelessMAN-Advanced Air Interface, an enhanced air interface designated as "IMT-Advanced" by the International Telecommunication Union—Radiocommunication Sector (ITU-R), is specified in this standard.

Keywords: broadband wireless access, IEEE 802.16, IEEE 802.16.1, IMT-Advanced radio interface, mobile broadband, orthogonal frequency-division multiple access (OFDMA), WirelessMAN®-Advanced Air Interface, wireless metropolitan area networks

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Historical information regarding IEEE Std 802.16.1

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IEEE 802.16 Standards	Date approved by IEEE	Officers
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Introduction

This introduction is not part of IEEE Std 802.16.1-2012, IEEE Standard for WirelessMAN-Advanced Air Interface for Broadband Wireless Access Systems.

This standard specifies the WirelessMAN-Advanced Air Interface, an enhanced air interface designated as "IMT-Advanced" by the International Telecommunication Union—Radiocommunication Sector (ITU-R).

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IEEE Standard for WirelessMAN-Advanced Air Interface for Broadband Wireless Access Systems

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1. Overview

1.1 Scope

This standard specifies the WirelessMAN-Advanced Air Interface, including the medium access control layer (MAC) and physical layer (PHY), of a broadband wireless access (BWA) system supporting multiple services. The WirelessMAN-Advanced Air Interface supports the International Telecommunication Union (ITU)'s IMT-Advanced requirements.

1.2 Purpose

This standard enables rapid worldwide deployment of innovative, cost-effective, and interoperable multivendor broadband wireless access products, facilitates competition in broadband access by providing alternatives to wireline broadband access, encourages consistent worldwide spectrum allocation, and accelerates the commercialization of broadband wireless access systems. The standard serves as a basis for IMT-Advanced recommendations within the ITU.

1.3 Frequency bands

The primary bands of interest are described in 1.3.1.

1.3.1 Frequencies below 11 GHz

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, line-of-sight (LOS) is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.4 Reference models

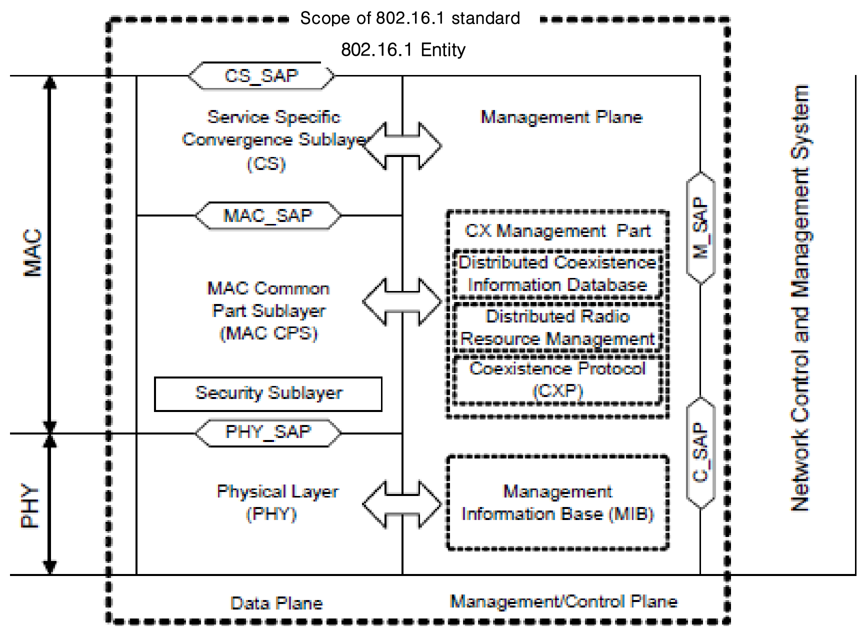

Figure 1-1—IEEE 802.16.1 protocol layering, showing service access points (SAPs)

The MAC common part sublayer (CPS) provides the core MAC functionality of system access, bandwidth allocation, connection establishment, and connection maintenance. It receives data from the various convergence sublayers (CSs), through the MAC SAP, classified to particular MAC connections. Quality of service (QoS) is applied to the transmission and scheduling of data over the PHY. The MAC also contains a separate security sublayer providing authentication, secure key exchange, and encryption. Data, PHY control, and statistics are transferred between the MAC CPS and the PHY via the PHY SAP (which is implementation specific). The PHY specifications supported is discussed in 6.3. All these parts are supported at the MAC level. The MAC comprises three sublayers. The service-specific CS provides any transformation or mapping of external network data, received through the CS SAP, into MAC service data units (SDUs) received by the MAC CPS through the MAC SAP. This includes classifying external network SDUs and associating them to the proper MAC service flow identifier (SFID) and, for an advanced base station (ABS) or advanced mobile station (AMS), a Station Identifier + Flow Identifier (STID + FID) combination. It may also include such functions as payload header suppression (PHS). Multiple CS specifications are provided for interfacing with various protocols. The internal format of the CS payload is unique to the CS, and the MAC CPS is not required to understand the format of or to parse any information from the CS payload.

1.4.1 IEEE 802.16.1 entity

An IEEE 802.16.1 entity is defined as the logical entity in an AMS or ABS that comprises the PHY and MAC layers of the Data Plane and the Management/Control Plane.

1.4.2 Network reference model

Figure 1-2 describes a simplified network reference model. Multiple AMS may be attached to an ABS. An AMS communicate to the ABS over the U interface using a Primary Management Connection, a Basic Connection, or a Secondary Management Connection.

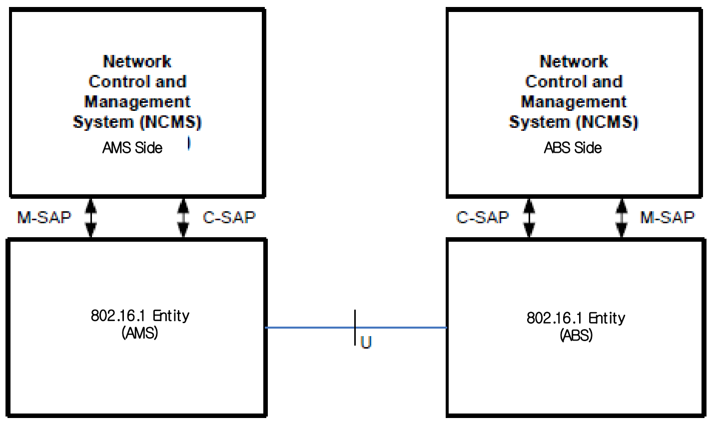

Figure 1-2—IEEE 802.16.1 Network reference model

1.4.2.1 AMS and ABS interface

This standard observes the following correlation:

— MAC control PDUs that are exchanged on the control connection trigger or are triggered by primitives that are exchanged over either the C-SAP or the M-SAP depending on the particular management or control operation.

1.4.2.2 IEEE 802.16 entity to NCMS interface

This interface is a set of SAP between an IEEE 802.16 entity and NCMS and is represented in Figure 1-2. It is decomposed into two parts: the Management SAP (M-SAP) is used for less time-sensitive Management plane primitives, and the Control SAP (C-SAP) is used for more time-sensitive Control plane primitives that support handovers, security context management, radio resource management, and low-power operations (such as idle mode and paging functions).

Architecturally, the base stations and their backbone connections form the access service network (ASN), defined as a complete set of network functions, are needed to provide radio access to the mobile stations. The ASN is outside the scope of this standard.

1.4.3 Management SAP (M-SAP)

The Management SAP may include, but is not limited to, primitives related to the following:
- System configuration
- Monitoring statistics
- Notifications/triggers
- Multimode interface management

The network control and management system (NCMS) interacts with the management information base (MIB) through the M-SAP in a method not defined in this standard.

1.4.4 Control SAP (C-SAP)

The Control SAP may include, but is not limited to primitives related to the following:
- Handovers [e.g., notification of handover (HO) request from AMS]
- Idle mode mobility management (e.g., Mobile entering idle mode)
- Subscriber and session management (e.g., Mobile requesting session setup)
- Radio resource management
- AAA server signaling [e.g., extensible authentication protocol (EAP) payloads]

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

FIPS 197, Advanced Encryption Standard (AES).[1]

IEEE Std 802®, IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture.[2, 3]

IEEE Std 802.16™, IEEE Standard for Air Interface for Broadband Wireless Access Systems.

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ITU-T Recommendation G.704—Synchronous Frame Structures Used at 1544, 6312, 2048, 8448 and 44 736 kbit/s Hierarchical Levels, Oct. 1998.[5]

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[4]IETF documents (i.e., RFCs) are available for download at http://www.rfc-archive.org/.

ITU-T Recommendation X.25—Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit, Oct. 1996.

NIST Special Publication 800-38A—Recommendation for Block Cipher Modes of Operation—Methods and Techniques.[6]

NIST Special Publication 800-38B—Recommendation for Block Cipher Modes of Operation: The CMAC Mode for Authentication.

NIST Special Publication 800-38C-Recommendation for Block Cipher Modes of Operation: The CCM Mode for Authentication and Confidentiality, May 2004.

[5]ITU-T publications are available from the International Telecommunications Union (http://www.itu.int/).
[6]NIST publications are available from the National Institute of Standards and Technology (http://www.nist.gov/).

3. Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[7]

AAI (DL/UL) Access Zone: An integer multiple of subframes located in the MZone of the ABS frame or ARS frame, where an ABS or ARS transmits to the AMSs or receives from the AMSs.

AAI (DL/UL) Relay Zone: An integer multiple of subframes located in the MZone of the ABS frame, where an ABS transmits to the ARSs and/or AMSs or receives from the ARSs and AMSs, or the ARS frame, where an ARS transmits to the ABS or receives from the ABS.

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

advanced base station (ABS): A base station that supports the WirelessMAN-Advanced Air Interface.

advanced mobile station (AMS): A subscriber station capable of performing the Wireless-MAN-OFDMA TDD Release 1 subset of mobile station (MS) features and functions and of implementing the WirelessMAN-Advanced Air Interface.

advanced network: An access network compliant with the WirelessMAN-Advanced Air Interface System.

advanced relay station (ARS): A relay station that supports the WirelessMAN-Advanced Air Interface.

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

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

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

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.

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

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

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

[7] *The IEEE Standards Dictionary Online* subscription is available at http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

default service flow: A service flow that is established automatically without DSA procedure after successful registration procedure. QoS parameters for the default service flow are predefined.

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.

dual-radio MS: A multimode MS/AMS that can have both radios (transmitting and receiving) active at the same time. A dual-radio MS/AMS can simultaneous transmit and receive on both radios. A dual-radio MS/AMS may behave as a single-radio MS by operating in single radio mode.

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

frame index: The frame order within a superframe (i.e., the first, second, third, or fourth frame of superframe).

frame number: In WirelessMAN-Advanced Air Interface, the frame number is obtained by concatenating the 12-bit superframe number (transmitted in every superframe) and the 2-bit frame index. Superframe numbers are synchronized across base stations.

horizontal encoding: Indicates transmitting multiple MIMO layers over multiple antennas. The number of MIMO layers is more than 1. The number of MIMO streams is the same as the number of MIMO layers in this case.

logical resource unit (LRU): The generic name of logical units for distributed and contiguous resource allocations.

LZone: A positive integer number of consecutive subframes during which an ABS communicates with RSs or R1 MSs, and where an ARS or an RS communicates with one or more R1 MSs.

Macro ABS: An ABS with high transmit power. A Macro ABS is directly connected to the service providers network.

Macro hot-zone ABS: An ABS with smaller transmission power/cell size than that of macro ABSs, typically deployed by service provider and operated on service provider backhaul.

MIMO layer: An information path fed to the MIMO encoder as an input. A MIMO layer represents one channel coding block.

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

mixed-mode ABS: An ABS with an operating LZone and operating MZone.

multilayer encoding: The number of MIMO streams is the same as the number of MIMO layers in this case.

multi-radio MS: A multimode MS/AMS that can have multiple radios (transmitting and receiving) active at the same time. A multi-radio MS/AMS can simultaneous transmit and receive on multiple radios. A multi-radio MS/AMS may behave as a single-radio MS by operating in single-radio mode.

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

MZone: A positive integer number of consecutive subframes during which an ABS communicates with one or more ARSs or AMSs, and where an ARS communicates with one or more ARSs or AMSs.

Operator ID: Operator ID is an identifier of the network provider. The Operator ID is contained in the Advanced Base Station ID (ABSID).

OSG Femto ABS: A Femto ABS accessible to any AMS.

partially configured carrier: A downlink-only carrier configured with control channels to support downlink transmission.

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

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

R1 BS: A base station compliant with the WirelessMAN-OFDMA R1 Reference System.

R1 MS: A mobile station compliant with the WirelessMAN-OFDMA R1 Reference System.

R1 network: An access network compliant with the WirelessMAN-OFDMA R1 Reference System.

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

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

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

secondary carrier: An OFDMA carrier that an AMS may use to exchange traffic with an ABS, based on allocation commands and rules received over the primary carrier of that ABS. The secondary carrier may also include control signaling to support multicarrier operation.

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

single-radio MS: A multimode MS/AMS that operates with only a single transmitting radio and with one or more receiving radios at any given time.

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

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

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

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

vertical encoding: Indicates transmitting a single MIMO layer over multiple antennas. The number of MIMO layers is always 1.

WirelessMAN-Advanced Air Interface Co-existing System: An ABS and/or AMS that also implements LZone functionality compliant with WirelessMAN-OFDMA TDD Release 1.

WirelessMAN-OFDMA R1 Reference System: A network compliant with the WirelessMAN-OFDMA capabilities as specified in WirelessMAN-OFDMA TDD Release 1.

4. Abbreviations and acronyms

AAI	Advanced Air Interface
ABS	advanced base station
ABSID	ABS identifier
AGMH	advanced generic MAC header
aGPS	adaptive grant polling service
A-MAP	advanced MAP
AMS	advanced mobile station
AOA	angle of arrival
A-Preamble	advanced preamble
ARQ	automatic repeat request
ARS	advanced relay station
ASN	access service network
ASN.1	abstract syntax notation
ATM	asynchronous transfer mode
BE	best effort
BR	bandwidth request
BS	base station
BWA	broadband wireless access
CDR	conjugate data repetition
CID	connection identifier
CL	closed-loop
CLRU	contiguous LRU
CMAC	cipher-based message authentication code
CMI	codebook matrix index
CoRe	constellation rearrangement
CPS	common part sublayer
CQI	channel quality information
CRID	context retention identifier
CRT	context retention timer
CRU	contiguous resource unit
CRV	CoRe version
CS	convergence sublayer
C-SAP	control service access point
CSG	closed subscriber group
CSM	collaborative spatial multiplexing
DCAS	downlink CRU allocation size
DCR	deregistration with context retention
DHCP	Dynamic Host Configuration Protocol
DID	deregistration identifier
DL	downlink
DLRU	distributed LRU
DRU	distributed resource unit

DSA	dynamic service addition
DSD	dynamic service deletion
DSAC	downlink subband allocation count
DSC	dynamic service change
EAP	extensible authentication protocol
EBB	established before break
EDI	Event Driven Indication
EH	extended header
E-MBS	multicast and broadcast service
FDD	frequency division duplex or duplexing
FFR	fractional frequency reuse
FID	flow identifier
FMT UL	feedback mini-tile
FP	frequency partition
FPC	frequency partition configuration
FPCT	frequency partition count
FPEH	fragmentation and packing extended header
FPS	frequency partition size
FPSC	frequency partition subband count
GMH	generic MAC header
GPI	grant polling interval
GRA	group resource allocation
HARQ	hybrid ARQ
HE	horizontal encoding
HMT	UL HARQ mini-tiles
HO	handover
ICV	integrity check value
IE	information element
IP	Internet Protocol
IR	incremental redundancy
ISL	interference sensitivity level
ITU	International Telecommunication Union
LDM	low-duty mode
LOS	line-of-sight
LRU	logical resource unit
MAC	medium access control layer
MAEH	MAC control ACK extended header
MC	multicarrier
MCEH	MAC control extended header
MCHO	MC handover
MEF	MIMO encoder format
MEH	multiplexing extended header
MIB	management information base

MIH	media independent handover
MIHF	MIH Function
MIMO	multiple-input/multiple-output
MLRU	minimum A-MAP logical resource unit
MS	mobile station
M-SAP	management service access point
MU	multi-user
N/A	not applicable
NCMS	network control and management system
NIP	normalized interference power
NLOS	non-LOS
NLRU	miniband LRU
NSCF	Next Sleep Cycle Flag
NS/EP	National Security/Emergency Preparedness
NS-RCH	non-synchronized ranging channel
OFDMA	orthogonal frequency-division multiple access
OL	open-loop
OSG	open subscriber group
PA	persistent allocation
PA-Preamble	primary advanced preamble
PFBCH	UL primary fast feedback channel
PGID	paging-group identifier
PHS	payload header suppression
PHSF	payload header suppression field
PHSI	payload header suppression index
PHSM	payload header suppression mask
PHSS	payload header suppression size
PHSV	payload header suppression valid
PHY	physical layer
PMI	preferred matrix index
PoA	point of attachment
PPRU	permuted physical resource unit
PRU	physical resource unit
P-SFH	primary superframe header
PSI	pilot stream index
QAM	quadrature amplitude modulation
QoS	quality of service
R1	Release 1
RA-ID	random access identifier
RAN	radio access network
RAP	radio access point
RAT	radio access technology
RCH	ranging channel

RCP	ranging cyclic prefix
RD	relative delay
RF	radio frequency
RFMT	reordered UL feedback mini-tile
RHMT	reordered UL HARQ mini-tile
ROHC	robust header compression
RP	ranging preamble
RS	relay station
RTD	round-trip delay
RU	resource unit
Rx	receive
SA	security association
S-ABS	serving ABS
SAC	subband allocation count
SAID	SA identifier
SAP	service access point
SA-Preamble	secondary advanced preamble
Sc	subcarrier
SDU	service data unit
SF	service flow
SFBC	space-frequency block code
SFBCH	UL secondary fast feedback channel
SFH	superframe header
SFID	service flow identifier
SLRU	subband LRU
SMS	short message service
SN	sequence number
SOHO	small office home office
SON	self-organizing networks
SP	S-SFH subpacket
SPID	subpacket ID
SPMH	short-packet MAC header
S-RCH	synchronized ranging channel
S-SFH	secondary superframe header
SSN	subblock SN
SSSCH	service-specific scheduling control header
STID	station identifier
SU	single user
T-ABS	target ABS
TDD	time division duplex or duplexing
TOA	time of arrival
TSTID	temporary STID
Tx	transmit

UCAS	uplink CRU allocation size
UFPC	uplink frequency partition configuration
UGS	unsolicited grant service
UL	uplink
USAC	uplink subband allocation count
VE	vertical encoding
VLAN	virtual local area network
VSIF	vendor-specific information field

5. Service-specific CS

The service-specific CS resides on top of the MAC CPS and utilizes, via the MAC SAP, the services provided by the MAC CPS (see Figure 1-1). The CS performs the following functions:

- Accepting higher layer protocol data units (PDUs) from the higher layer
- Performing classification of higher layer PDUs
- Processing (if required) the higher layer PDUs based on the classification
- Delivering CS PDUs to the appropriate MAC SAP
- Receiving CS PDUs from the peer entity

Currently, the packet CS specification is provided. Other CSs may be specified in the future.

5.1 ATM CS

The asynchronous transfer mode (ATM) CS is not supported by the AMS or the ABS.

5.2 Packet CS

The packet CS resides on top of the IEEE 802.16 MAC CPS. The CS performs the following functions, utilizing the services of the MAC:

a) Classification of the higher layer protocol PDU into the appropriate transport connection

b) Suppression of payload header information (optional)

c) Delivery of the resulting CS PDU to the MAC SAP associated with the service flow for transport to the peer MAC SAP

d) Receipt of the CS PDU from the peer MAC SAP

e) Rebuilding of any suppressed payload header information (optional)

The sending CS is responsible for delivering the MAC service data unit (MAC SDU) to the MAC SAP. The MAC is responsible for delivery of the MAC SDU to the peer MAC SAP in accordance with the QoS, fragmentation, concatenation, and other transport functions associated with a particular connection's service flow characteristics. The receiving CS is responsible for accepting the MAC SDU from the peer MAC SAP and for delivering it to a higher layer entity.

The packet CS is used for transport for all packet-based protocols as defined in 11.13.18.3 in IEEE Std 802.16.[8]

5.2.1 MAC SDU format

Once classified and associated with a specific MAC connection, the Convergence Sublayer SDUs (CS SDUs), i.e., higher layer PDUs, shall be encapsulated in the MAC SDU format as illustrated in Figure 5-1. The 8-bit PHSI (payload header suppression index) field shall be present when a PHS rule has been defined for the associated connection. PHS is described in 5.2.3. The 8-bit Type ID field shall be present when a Multiprotocol flow is defined for the associated connection. This is described in 5.2.6.

[8]Information on references can be found in Clause 2.

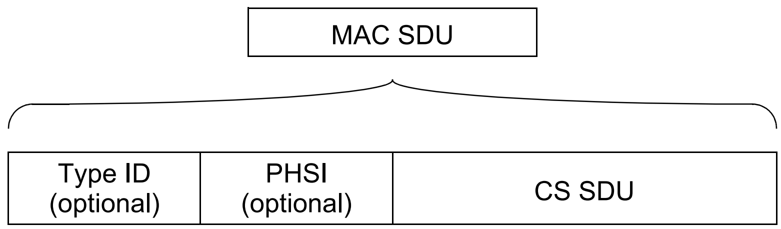


Figure 5-1—MAC SDU format

5.2.2 Classification

Classification is the process by which a MAC SDU is mapped onto a particular transport connection for transmission between MAC peers. The mapping process associates a MAC SDU with a transport connection, which also creates an association with the service flow characteristics of that connection. This process facilitates the delivery of MAC SDUs with the appropriate QoS constraints.

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

Several classification rules may each refer to the same service flow. The classification rule priority is used for ordering the application of classification rules to packets. Explicit ordering is necessary because the patterns used by classification rules may overlap. The priority need not be unique, but care shall be taken within a classification rule priority to prevent ambiguity in classification. DL classification rules are applied by the ABS to packets it is transmitting and UL classification rules are applied at the AMS. Figure 5-2 and Figure 5-3 illustrate the mappings discussed in the previous paragraph.

It is possible for a packet to fail to match the set of defined classification rules. In this case, the CS shall discard the packet.

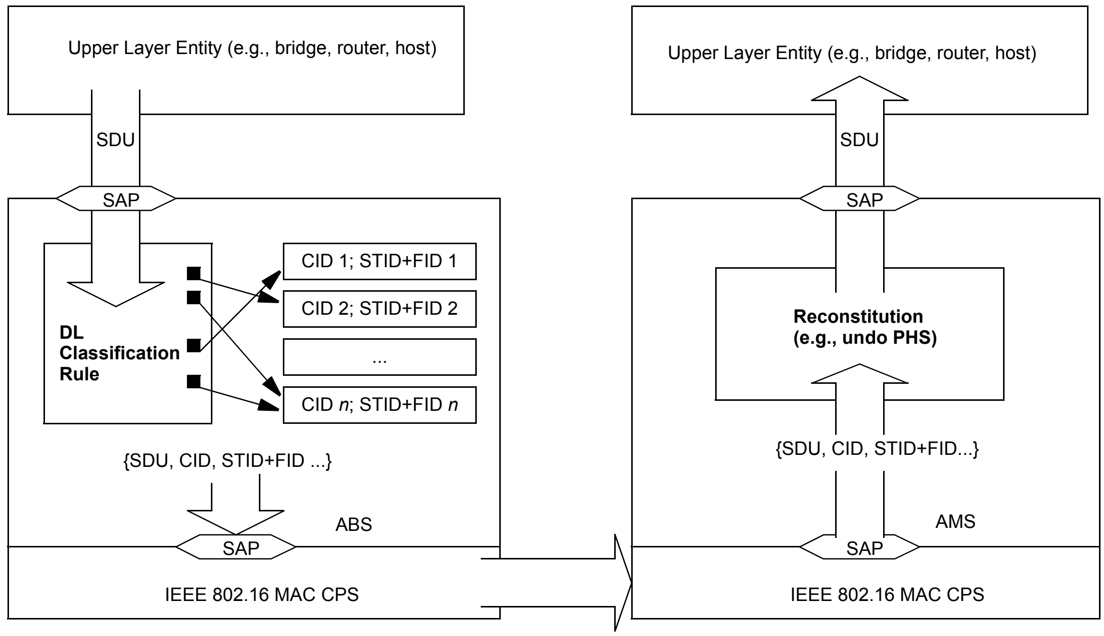


Figure 5-2—Classification and CID (or STID/FID) mapping (ABS to AMS)

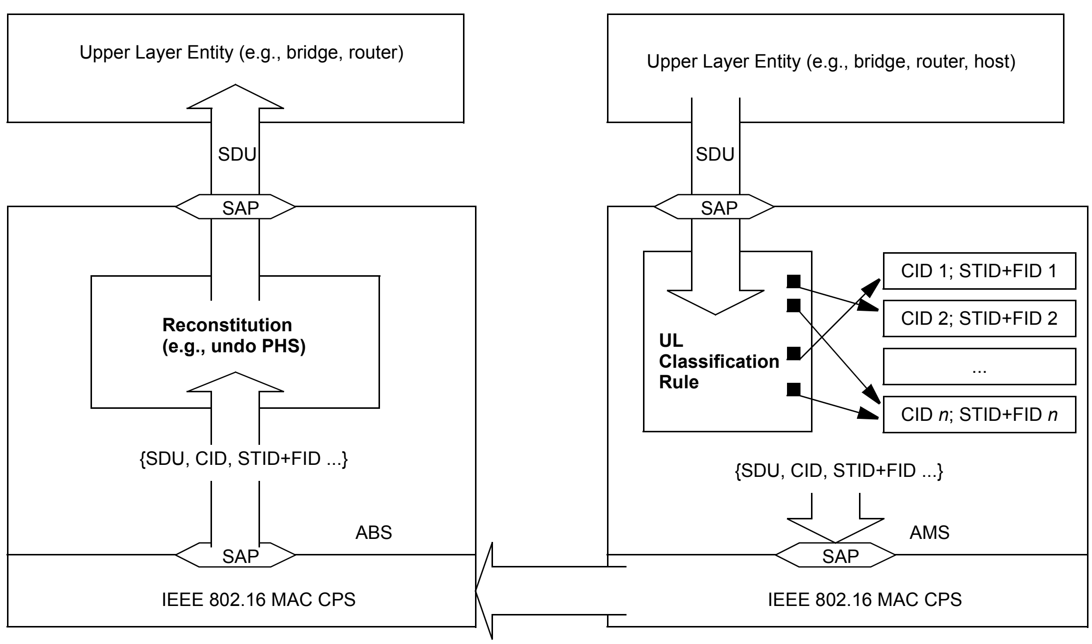


Figure 5-3—Classification and CID (or STID/FID) mapping (AMS to ABS)

5.2.3 Payload header suppression (PHS)

In PHS, a repetitive portion of the payload headers of the higher layer is suppressed in the MAC SDU by the sending entity and restored by the receiving entity. Implementation of PHS capability is optional. On the UL, the sending entity is the AMS and the receiving entity is the ABS. On the DL, the sending entity is the ABS and the receiving entity is the AMS. If PHS is enabled at MAC connection, each MAC SDU is prefixed with a PHSI, which references the Payload Header Suppression field (PHSF).

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

PHS has a payload header suppression valid (PHSV) option to verify or not verify the payload header before suppressing it. PHS has also a payload header suppression mask (PHSM) option to allow select bytes not to be suppressed. The PHSM facilitates suppression of header fields that remain static within a higher layer session (e.g., IP addresses), while enabling transmission of fields that change from packet to packet (e.g., IP Total Length).

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

It is the responsibility of the higher layer service entity to generate a PHS Rule that uniquely identifies the suppressed header within the service flow. It is also the responsibility of the higher layer service entity to guarantee that the byte strings that are being suppressed are constant from packet to packet for the duration of the active service flow.

5.2.3.1 PHS operation

AMS and ABS implementations are free to implement PHS in any manner as long as the protocol specified in this subclause is followed. Figure 5-4 illustrates the following procedure.

A packet is submitted to the packet CS. The AMS applies its list of classification rules. A match of the rule shall result in an UL service flow and CID or STID + FID and may result in a PHS Rule. The PHS Rule provides PHSF, PHSI, PHSM, PHSS, and PHSV. If PHSV is set to 0 or not present, the AMS shall compare the bytes in the packet header with the bytes in the PHSF that are to be suppressed as indicated by the PHSM. If they match, the AMS shall suppress all the bytes in the UL PHSF except the bytes masked by PHSM. The AMS shall then prefix the PDU with the PHSI and present the entire MAC SDU to the MAC SAP for transport on the UL.

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

A similar operation occurs on the DL. The ABS applies its list of Classifiers classification rules. A match of the classification shall result in a DL service flow and a PHS rule. The PHS rule provides PHSF, PHSI, PHSM, PHSS, and PHSV. If PHSV is set to 0 or not present, the BS shall verify the Downlink Suppression field in the packet with the PHSF. If they match, the ABS shall suppress all the bytes in the Downlink Suppression field except the bytes masked by PHSM. The ABS shall then prefix the PDU with the PHSI and present the entire MAC SDU to the MAC SAP for transport on the DL.

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

Figure 5-5 demonstrates packet header suppression and restoration when using PHS masking. Masking allows only bytes that do not change to be suppressed. Note that the PHSF and PHSS span the entire suppression field, including suppressed and unsuppressed bytes.

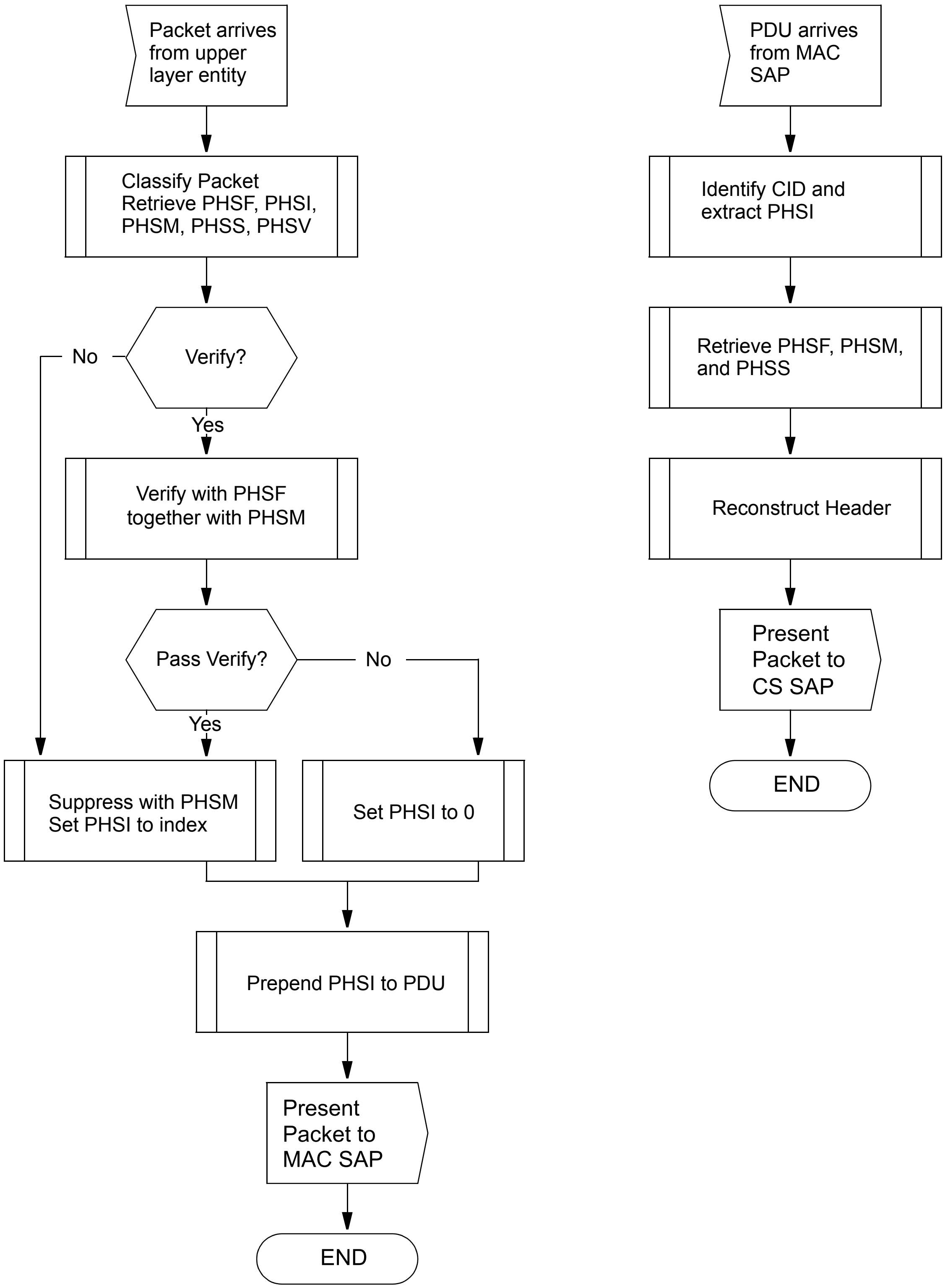


Figure 5-4—PHS operation

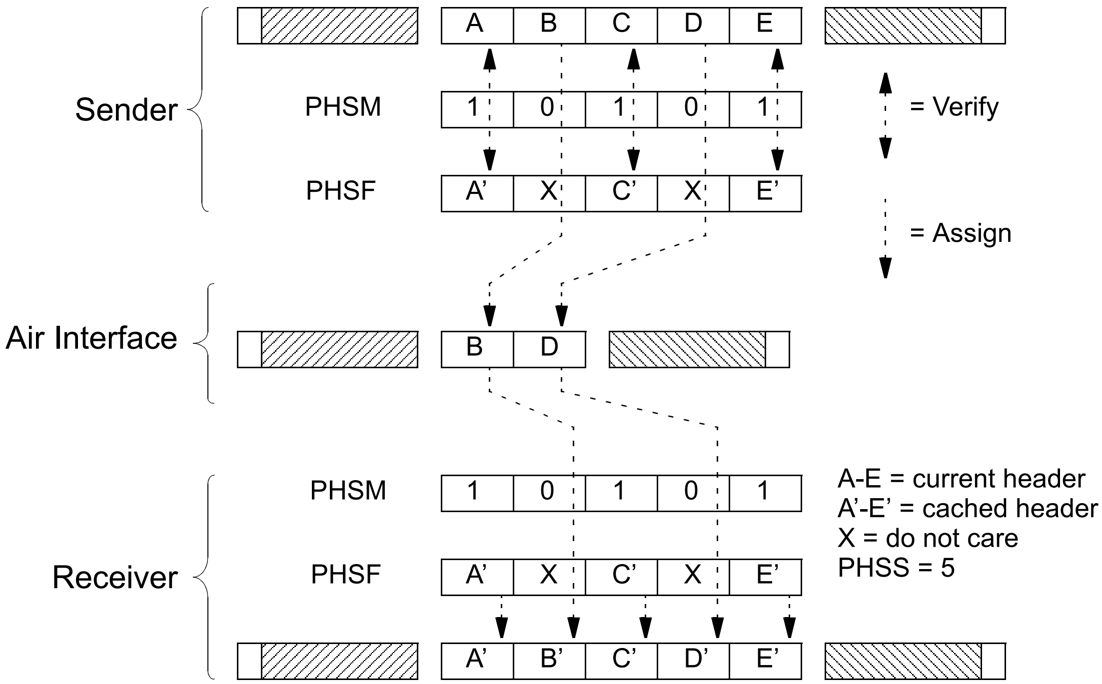


Figure 5-5—PHS with masking

5.2.3.2 PHS signaling

PHS requires the creation of the following three objects:

a) Service flow

b) Classification rule

c) PHS rule

These three objects may be created either simultaneously or in separate message flows.

PHS rules are created with dynamic service addition (DSA) or dynamic service change (DSC) messages. The ABS shall define the PHSI when the PHS rule is created. If the AMS includes more than one classification rule and at least one PHS rule in AAI-DSx-REQ message when initiating a dynamic service addition via AAI-DSA-REQ or change via AAI-DSC-REG, the MS shall include a temporary PHSI with each PHS rule in the AAI-DSx-REQ message. Temporary PHSI(s) shall only be used by the ABS to identify the association of the PHS rule to corresponding classification rule(s) included in the AAI-DSA-REQ or AAI-DSC-REQ from the AMS by inclusion of the Associated PHSI field (see Table 6-133) and shall have no further meaning beyond this. Temporary PHSI(s) included in AAI-DSx-REQ sent from the AMS shall not constrain the PHSI values assigned by the ABS. If the ABS cannot identify the association between PHS rule(s) and classification rule(s), the ABS shall reject the AAI-DSx-REQ message sent from the AMS. PHS rules are deleted with the DSC or dynamic service deletion (DSD) messages. The AMS or ABS may define the PHSS and PHSF. To change the value of a PHSF on a service flow, a new PHS rule shall be defined, the old rule is removed from the service flow, and the new rule is added.

Figure 5-6 shows the two ways to signal the creation of a PHS rule.

It is possible to partially specify a PHS rule (in particular the size of the rule) at the time a service flow is created. As an example, it is likely that when a service flow is first provisioned, the header fields to be suppressed will be known. The values of some of the fields [for example: IP addresses, User Datagram Protocol (UDP) port numbers, etc.] may be unknown and would be provided in a subsequent AAI-DSC as part of the activation of the service flow (using the “Set PHS Rule” DSC Action). If the PHS rule is being defined in more than one step, each step, whether it is a AAI-DSA or AAI-DSC message, shall contain both the SFID (or reference) and a PHS index to uniquely identify the PHS rule that is being defined.

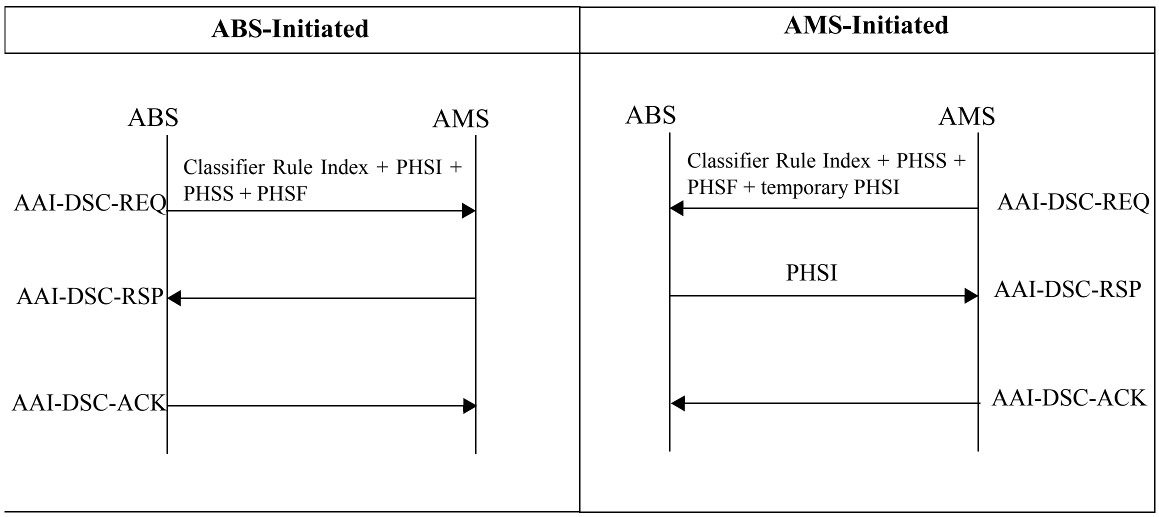


Figure 5-6—PHS signaling example

5.2.4 IEEE 802.3/Ethernet-specific part

5.2.4.1 IEEE 802.3/Ethernet CS PDU format

The IEEE 802.3/Ethernet PDUs are mapped to MAC SDUs according to Figure 5-7 (when header suppression is enabled at the connection but not applied to the CS PDU) or Figure 5-8 (with header suppression). In the case where PHS is not enabled, PHSI field shall be omitted.

The IEEE 802.3/Ethernet PDU shall not include the Ethernet FCS when transmitted over this CS.

PHSI = 0	IEEE 802.3/Ethernet PDU

Figure 5-7—IEEE 802.3/Ethernet CS PDU format without header suppression

PHSI $\neq$ 0	Header-Suppressed IEEE 802.3/Ethernet PDU

Figure 5-8—IEEE 802.3/Ethernet CS PDU format with header suppression

Robust header compression (ROHC) (refer to IETF RFC 3095) may be used in addition to PHS to compress the IP header portion of an IP packet over Ethernet frame. The AMS and the ABS shall set bit 7 of Request/Transmission Policy (see Table 6-133) to 0 to enable ROHC. When ROHC is enabled for a service flow, the service flow constitutes what in IETF RFC 3095 is referred to as a ROHC channel. Two service flows cannot share a ROHC channel, and two ROHC channels cannot share the same service flow. On a service flow for which ROHC has been enabled, all of the IP packet parts of IP over Ethernet frames shall pass through the ROHC compressor on the sender side and the decompressor on the receiver side.

ROHC compression and decompression operation shall be performed in accordance with IETF RFC 3095, IETF RFC 3759, IETF RFC 3243, IETF RFC 4995, IETF RFC 3843, and IETF RFC 4996. To enable ROHC, the following two steps are required:

1) Capability negotiation during REG-REQ/RSP message exchange to determine whether ROHC is supported. In the AAI system, capability negotiation during AAI-REG-REQ/RSP message exchange to determine whether ROHC is supported.
2) Indication in DSA-REQ/RSP messages to enable ROHC for the service flow. In the AAI system, indication in AAI-DSA-REQ/RSP messages to enable ROHC for the service flow.

5.2.4.2 IEEE 802.3/Ethernet CS classification rules

The following parameters are relevant for IEEE 802.3/Ethernet CS classification rules:

— IEEE 802.3/Ethernet header classification parameters—zero or more of the IEEE 802.3/Ethernet, VLAN, and IP headers may be included in the classification. In this case, only the IEEE 802.3/IEEE 802.1Q/IP (11.13.18.3.3.2 through 11.13.18.3.3.12 and 11.13.18.3.3.16 in IEEE Std 802.16) classification parameters are allowed.

— For IP over IEEE 802.3/Ethernet, Ethernet, and VLAN, IP headers may be included in classification. In this case, only the IP, IEEE 802.3, and IEEE 802.1Q (11.13.18.3.3.2 through 11.13.18.3.3.12 and 11.13.18.3.3.16 in IEEE Std 802.16) classification parameters are allowed.

— For IP-header compressed IP over IEEE 802.3/Ethernet, Ethernet and VLAN headers may be included in the classification. In this case, only the IEEE 802.3/IEEE 802.1Q (11.13.18.3.3.8 through 11.13.18.3.3.12 in IEEE Std 802.16) classification parameters are allowed.

5.2.5 IP specific part

This subclause applies when IP (IETF RFC 791 and IETF RFC 2460) is carried over the IEEE 802.16 network.

5.2.5.1 IP CS PDU format

The format of the IP CS PDU shall be as shown in Figure 5-9 (when header suppression is enabled at the connection, but not applied to the CS PDU) or Figure 5-10 (with header suppression). In the case where PHS is not enabled, the PHSI field shall be omitted.

PHSI = 0	IP Packet (including header)

Figure 5-9—IP CS PDU format without header suppression

PHSI ≠ 0	Header-Suppressed IP Packet

Figure 5-10—IP CS PDU format with header suppression

ROHC (refer to IETF RFC 3095) may be used instead of PHS to compress IP headers. The MS and the BS signal enabling of ROHC by setting bit 7 of Request/Transmission Policy (see 11.13.11 in IEEE Std 802.16) to 0. The AMS and the ABS signal enabling of ROHC by setting Bit 6 of Request/Transmission Policy to 0 in the AAI-DSA-REQ message. When ROHC is enabled for a service flow, the service flow constitutes what in IETF RFC 3095 is referred to as a ROHC channel.

Two service flows cannot share a ROHC channel, and two ROHC channels cannot share the same service flow. All IP packets that are classified onto a service flow for which ROHC has been enabled shall pass through the ROHC compressor on the sender side, and the decompressor on the receiver side.

ROHC compression and decompression operation shall be performed in accordance with IETF RFC 3095, IETF RFC 3759, IETF RFC 3243, IETF RFC 4995, IETF RFC 3843, and IETF RFC 4996. To enable ROHC, the following two steps are required:

a) Capability negotiation during REG-REQ/RSP message exchange to determine whether ROHC is supported. In the AAI system, capability negotiation during AAI-REG-REQ/RSP message exchange to determine whether ROHC is supported.
b) Indication in DSA-REQ/RSP messages to enable ROHC for the service flow. In the AAI system, indication in AAI-DSA-REQ/RSP messages to enable ROHC for the service flow.

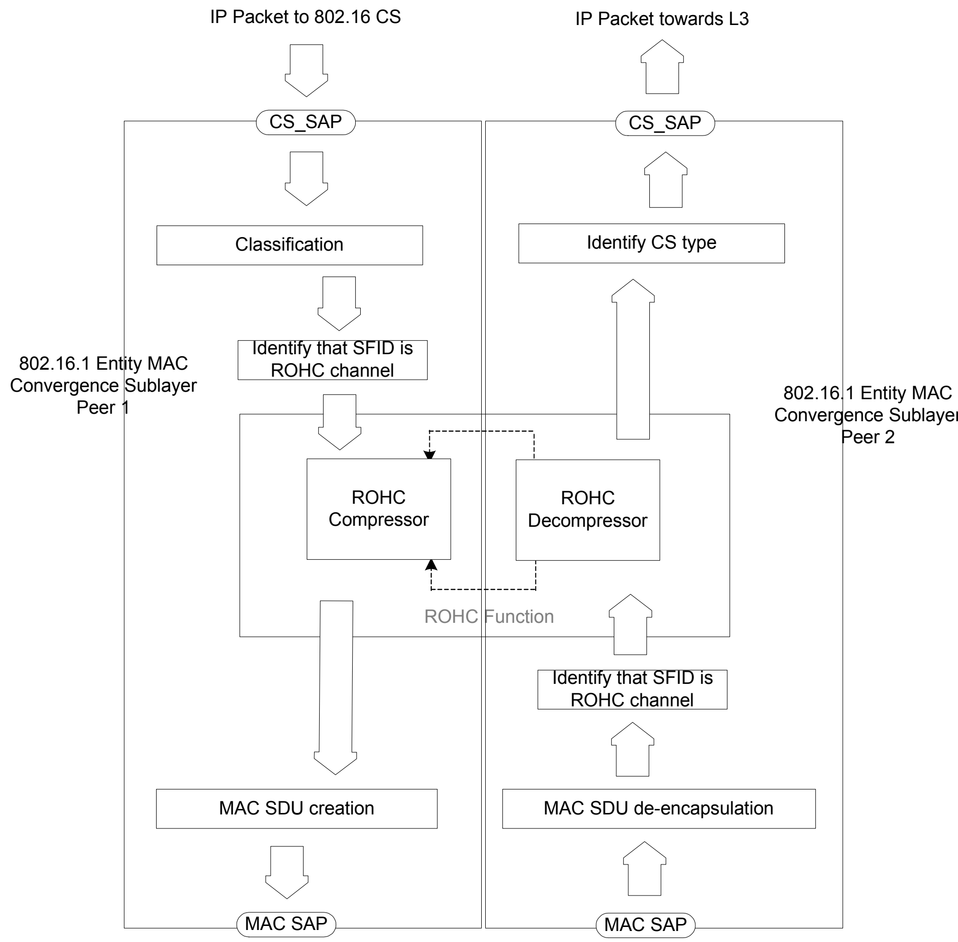


Figure 5-11—ROHC function

5.2.5.2 IP classification rules

IP classification rules operate on the fields of the IP header and the transport protocol. IP classification rules may operate on the fields of the inner IP header and/or outer IP header. For AMS and ABS, the Packet Classification Rule parameters (Table 6-88) may be used in IP classification.

5.2.6 Support for multiple protocols on the same flow

In order to transport several types of protocols over the same MAC connection, the Multi-protocol flow can be used. The receiver shall identify the protocol to correctly forward the SDU. For instance, if the information carried by the SDU is a ROHC packet, it should be forwarded to the ROHC decompressor. The receiver does this according to the Type ID field, which is the first byte of a Multi-protocol flow connection as depicted in Figure 5-12 and Figure 5-13. Type ID may vary from SDU to SDU on the same flow.

Multi-protocol CS classification rules operate on the fields of the Multi-protocol Type ID, and/or the Packet Classification Rule parameters in Table 6-133, for example, the header fields of the IEEE 802.3/Ethernet header, VLAN header, IP header, and the transport protocol.

Type ID	CS SDU

Figure 5-12—Multi-protocol flow PDU format without PHS

Type ID	PHSI	CS SDU

Figure 5-13—Multi-protocol flow PDU format with PHS

On the transmitter side, once the type of an incoming packet is determined, the appropriate classification rules are applied to the packet and the correct service flow is identified. It is then optionally forwarded to the header suppression mechanism (PHS or ROHC) and then mapped MAC SAP using the format described in this subclause. The Type ID content is set by the transmitter to the protocol identified by the classification and according to the Table 5-1.

Table 5-1—Type ID for Multi-protocol flow

Type ID	Meaning
0	Reserved
1	IP
2	IP with RoHC
3	IP with PHS
4	Ethernet
5	Ethernet with PHS
6..255	*Reserved*

6. WirelessMAN-Advanced Air Interface

6.1 Introduction

6.1.1 AMS operational states

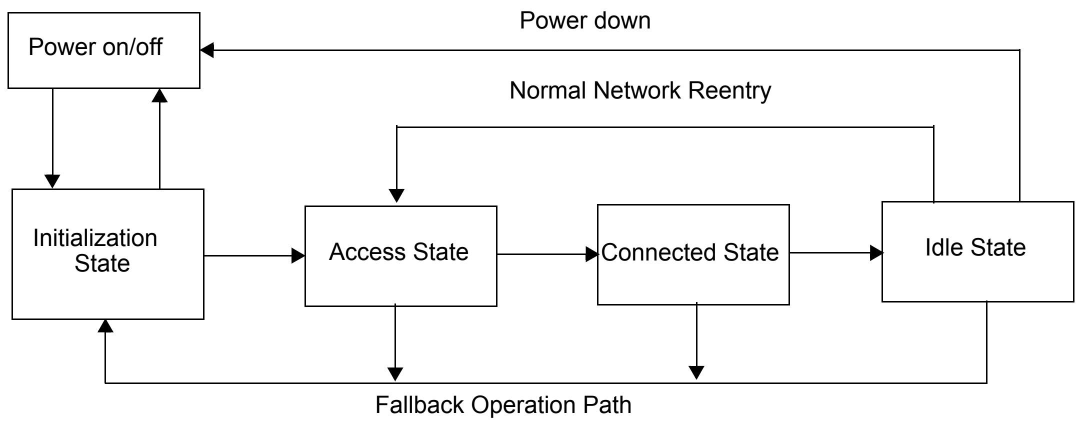


Figure 6-1—AMS state transition diagram

Initialization State

In the Initialization State, the AMS performs cell selection by scanning, synchronizing, and acquiring the system configuration information before entering the Access State.

During this state, if the AMS cannot properly perform the system configuration information decoding and cell selection, it falls back to perform scanning and DL synchronization. If the AMS successfully decodes the system configuration information and selects a target ABS (T-ABS), it transitions to the Access State.

Access State

The AMS performs network entry with the T-ABS while in the Access State. Network entry is a multistep process consisting of ranging, basic capability negotiation, authentication, authorization, key exchange, registration with the ABS, and service flow establishment. The AMS receives its Station ID and establishes at least one connection using and transitioning to the Connected State. Upon failing to complete any one of the steps of network entry, the AMS transitions to the Initialization State.

Connected State

When in the Connected State, an AMS operates in one of three modes: sleep mode, active mode, and scanning mode. During Connected State, the AMS maintains two connections established during Access State. Additionally, the AMS and the ABS may establish additional transport connections. The AMS may remain in Connected State during a handover. The AMS transitions from the Connected State to the Idle State based on a command from the ABS. Failure to maintain the connections prompts the AMS to transition to the Initialization State.

Active Mode

When the AMS is in active mode, the serving ABS (S-ABS) may schedule the AMS to transmit and receive at the earliest available opportunity provided by the protocol (i.e., the AMS is assumed to be '"available" to the ABS at all times). The AMS may request a transition to either sleep or scanning mode from active mode. Transition to sleep or scanning mode happens upon command from the S-ABS. The AMS may transition to the Idle State from the active mode of the Connected State.

Sleep Mode

When in sleep mode, the AMS and ABS agree on the division of the radio frame in time into sleep windows and listening windows. The AMS is only expected to be capable of receiving transmissions from the ABS during the listening windows, and any protocol exchange has to be initiated during that time. The AMS transition to active mode is prompted by control messages received from the ABS. The AMS may transition to the Idle State from the sleep mode of the Connected State during Listening Intervals.

Scanning Mode

When in scanning mode, the AMS performs measurements as instructed by the S-ABS. The AMS is unavailable to the S-ABS while in scanning mode. The AMS returns to active mode once the duration negotiated with the ABS for scanning expires.

Idle state

The Idle state consists of two separated modes, Idle mode and DCR mode, based on its operation and MAC message generation. During Idle mode, the AMS may perform power saving by switching between the paging listening interval and the paging unavailable interval as defined in 6.2.18.2. The AMS in DCR mode may also perform power saving, but a paging is not available during DCR Mode.

6.2 Medium access control

6.2.1 Addressing

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

6.2.1.1 Global address

6.2.1.1.1 MAC address

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

Each ABS shall have a 48-bit Advanced Base Station ID (ABSID or ABS MAC address or ABS MAC ID). The ABSID is a 48-bit long field identifying the ABS. The least significant 24 bits of the ABSID shall be programmable. The most significant 24 bits shall be used as the Operator ID. The Operator ID is a network management hook that is sent with the S-SFH SP2 message (see Table 6-185, MSB of 48-bit ABS MAC ID) for handling edge-of-sector and edge-of-cell situations. The 24-bit Operator ID shall be assigned as an IEEE 802.16 Operator ID by the IEEE Registration Authority.[9] The IEEE Registration Authority shall be the sole authorized number space administrator for this function.

[9]The IEEE Registration Authority is a committee of the IEEE Standards Association Board of Governors. General information as well as details on the allocation of IEEE 802.16 Operator ID can be obtained at http://standards.ieee.org/regauth.

6.2.1.2 Logical identifiers

The following logical identifiers are defined in 6.2.1.2.1 through 6.2.1.2.6.

6.2.1.2.1 Station identifier (STID)

A 12-bit value that uniquely identifies an AMS in the domain of the ABS. The ABS shall assign an STID to each AMS during network entry as described in 6.2.15.

6.2.1.2.1.1 Temporary station identifier (TSTID)

A TSTID is used temporarily to protect the mapping between the STID, which is used after network entry, and the AMS MAC Address. TSTID is allocated from the STID number space. The ABS assigns and transfers a TSTID to the AMS by AAI-RNG-RSP during the initial ranging procedure. During the registration procedure, the ABS assigns and transfers an STID to the AMS by encrypted AAI-REG-RSP. The ABS and AMS shall use TSTID in all instances in place of STID until STID has been successfully transmitted by ABS, and AMS has acknowledged STID installation and use as specified in 6.2.15.6. The ABS and the AMS shall release the TSTID when each IEEE 802.16 AAI entity identifies that the peer IEEE 802.16 AAI entity has successfully completed the registration procedure as identified in 6.2.15.6.

6.2.1.2.2 Flow identifier (FID)

Each AMS connection is assigned a 4-bit FID that uniquely identifies the connection within the AMS. FIDs identify control connection and unicast transport connections. The FID for E-MBS connection is used along with a 12-bit E-MBS ID to uniquely identify a specific E-MBS flow in the domain of an E-MBS zone (see 6.9.3.2). The FID for multicast connection is used along with a 12-bit Multicast Group ID to uniquely identify a specific multicast flow in the domain of an ABS. DL and UL Transport FIDs are allocated from the transport FID space as defined in Table 6-1. An FID that has been assigned to one DL transport connection shall not be assigned to another DL transport connection belonging to the same AMS. An FID that has been assigned to one UL transport connection shall not be assigned to another UL transport connection belonging to the same AMS. An FID that has been used for a DL transport connection can be assigned to another UL transport connection belonging to the same AMS, or vice versa. Some specific FIDs are preassigned. The values of 0000 and 0001 are used to indicate control FIDs. The values of 0010 and 0011 are used to indicate the FID for the signaling header and the FID for the default service flow, respectively. See Table 6-1 for the specific allocation of FIDs. An FID in combination with an STID uniquely identifies any connection in an ABS.

Table 6-1—Flow identifiers

Value	Description
0000	Control FID for unencrypted control connection payload in the MAC PDU (unicast control FID when PDU is allocated by unicast assignment A-MAP IE; broadcast control FID when PDU is allocated by broadcast assignment A-MAP IE)
0001	Unicast Control FID for encrypted control connection payload in the MAC PDU
0010	FID for Signaling header
0011	FID for transport connection associated with default service flow (UL and DL)
0100–1111	FID for transport connection

6.2.1.2.3 Deregistration identifier (DID)

A 24-bit hash value of the MAC address is used to identify Idle Mode AMSs in R1 network mode. DID is used to identify Idle Mode AMSs in advanced network mode.

The advanced network shall assign an 18-bit DID to each AMS during Idle Mode initiation. The advanced network may assign a new DID to an AMS during the location update procedure. The DID shall uniquely identify the Idle Mode AMS within the set of paging group ID, paging cycle, and paging offset. The AMS shall be assigned a randomly selected DID from the available DID space.

The R1 network uses a 48-bit MAC address for Idle Mode AMSs. The R1 network shall use a 24-bit hash value of the MAC address in AAI-PAG-ADV message when paging the AMS. An AMS in Idle Mode shall decode the MAC address hash value to determine whether or not it is being paged.

6.2.1.2.4 Context retention identifier (CRID)

The network shall assign a unique 72-bit CRID to each AMS during network entry. The network may reassign a CRID to each AMS during network reentry. The AMS is identified by the CRID in coverage loss recovery and DCR mode, where the CRID allows the network to retrieve AMS context. The network may assign the AMS a new CRID if necessary.

6.2.1.2.5 E-MBS identifier

A 12-bit value that is used along with a 4-bit long FID (see 6.2.1.2.2) to uniquely identify a specific E-MBS flow in the domain of an E-MBS zone (see 6.9.3.2).

6.2.1.2.6 Multicast Group identifier

A 12-bit value that is used along with a 4-bit-long, multicast-specific FID to uniquely identify a multicast flow in the domain of the ABS.

6.2.2 MAC PDU formats

MAC PDUs shall be of the form illustrated in Figure 6-2. Each PDU shall begin with a MAC header. The MAC PDU may also contain payload. The header may be followed by one or more extended headers. Extended headers shall not be present in a MAC PDU without payload.

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

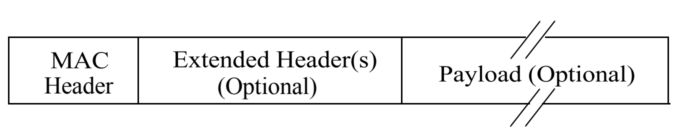


Figure 6-2—MAC PDU formats

6.2.2.1 MAC header formats

There are three defined MAC header formats: the advanced generic MAC header, the Short-Packet MAC header, and the MAC signaling header. At any connection, only one of the following formats shall be used: advanced generic MAC header, short-packet MAC header, and MAC signaling header.

6.2.2.1.1 Advanced generic MAC header (AGMH)

The AGMH format is defined in Table 6-2. For E-MBS services, the FID shall be ignored by the receiver. For multicast service, the multicast-specific FID associated with Multicast Group ID shall be used in the FID field of AGMH.

Table 6-2—AGMH format

Syntax	Size (bits)	Notes
Advanced Generic MAC header() {		
FID	4	Flow identifier.
EH	1	Extended header group presence indicator; When set to ‘1’, this field indicates that an Extended Header group is present following this AGMH.
Length	11	This field indicates the length in bytes of MAC PDU including the AGMH and extended header if present. If EH is set to ‘1’, this represents the 11 LSBs of 14-bit MAC PDU length; otherwise, it represents the 11-bit MAC PDU length.
}		

6.2.2.1.2 Short-packet MAC header (SPMH)

The SPMH is defined to support applications, such as Voice over IP (VoIP), that utilize small data packets and non-ARQ connections. The extended header group may be piggybacked on the SPMH, if allowed by its length field. The SPMH is identified by the specific FID that is provisioned statically, or created dynamically via AAI-DSA-REQ/RSP.

The SPMH format is defined in Table 6-3.

Table 6-3—SPMH format

Syntax	Size (bits)	Notes
Short-Packet MAC Header() {		
FID	4	Flow identifier.
EH	1	Extended header group presence indicator; When set to '1', this field indicates that an Extended Header group is present following this SPMH.
Length	7	This field indicates the length in bytes of MAC PDU including the SPMH and extended header if present.
SN	4	MAC PDU payload sequence number increments by one for each MAC PDU (modulo 16).
}		

6.2.2.1.3 MAC signaling header

The signaling header shall be sent standalone or concatenated with other MAC PDUs in either DL or UL. One FID is reserved for the MAC signaling header. The value of FID for the MAC signaling header is 0010.

All MAC signaling header formats follow the layout defined in Table 6-4.

Table 6-4—MAC signaling header format

Syntax	Size (bits)	Notes
MAC Signaling Header() {		
FID	4	Flow Identifier. Set to 0010.
Type	5	MAC signaling header type.
Length	3	Indicates the length of the signaling header (includes the FID, Type, Length, and contents): 0b000 and 0b001: *Reserved* 0b010: 2 bytes 0b011: 3 bytes 0b100: 4 bytes 0b101: 5 bytes 0b110: 6 bytes 0b111: *Reserved*
Contents	*variable;* ≤ 36	MAC signaling header contents, with the size indicated by the length field. The size in bits is Length $\times$ 8 – 12.
}		

Type field encodings are shown in Table 6-5.

Table 6-5—Type field encodings for MAC signaling header type

Type field (5-bits)	MAC signaling header type
00000	BR with STID
00001	BR without STID
00010	Service-specific scheduling control header
00011	Sleep control
00100	AMS battery level report
00101	Uplink power status report
00110	Correlation matrix feedback
00111	MIMO feedback
01000	Grant Management
01001–11111	*Reserved*

6.2.2.1.3.1 Bandwidth request (BR) with STID header

When an AMS requests bandwidth through a UL resource allocated by the CDMA Allocation A-MAP IE, it shall transmit BR with STID signaling header on the allocated UL resource. The BR format with STID header is defined in Table 6-6.

Table 6-6—BR with STID header format

Syntax	Size (bits)	Notes
BR with STID () {		
FID	4	Flow Identifier. Set to 0010.
Type	5	MAC signaling header type = 0b00000.
Length	3	Indicates the length of the signaling header in bytes.
BR Size	19	Aggregated bandwidth request size in bytes.
BR FID	4	The FID for which UL bandwidth is requested.
STID	12	STID of the AMS that requests UL bandwidth.
Reserved	1	*Reserved*. This field shall be filled by 0.
}		

6.2.2.1.3.2 Bandwidth request (BR) without STID header

BR without STID header is sent through adedicated UL resource assigned to the AMS. BR type shall be included to indicate whether BR type is incremental or aggregate. BR format without STID header is defined in Table 6-7.

Table 6-7—BR without STID header format

Syntax	Size (bits)	Notes
BR without STID header() {		
FID	4	Flow Identifier. Set to 0010.
Type	5	MAC signaling header type = 0b00001.
Length	3	Indicates the length of the signaling header in bytes.
BR Type	1	Indicates whether the requested bandwidth is incremental or aggregate: 0: aggregate 1: incremental
BR Size	19	Bandwidth request size in bytes.
BR FID	4	The FID for which UL bandwidth is requested.
Reserved	4	Shall be filled by 0.

6.2.2.1.3.3 Service-specific scheduling control header (SSSCH)

The service-specific scheduling control header is sent either by AMS through a dedicated UL resource or by ABS, which needs to change or acknowledge the scheduling parameters of its service flow. For aGP service, SSSCH Type indicates if it is an Adaptation Request, Adaptation ACK/NACK from AMS, or Adaptation Response from ABS. If the SCID change indicator is set to 1, the ABS shall send an SSSCH with SSSCH type = 0b01 (i.e., Adaptation Response) to confirm the change of sleep mode configuration.

Table 6-8—Service specific scheduling control header format

Syntax	Size (bits)	Notes
Service Specific Scheduling Control Header() {		
FID	4	Flow Identifier to indicate Signaling Header. Set to 0010.
Type	5	MAC signaling header type = 0b00010.
Length	3	Indicates the length of the signaling header in bytes.
Transport FID	4	The related transport FID for which this message is intended.
if (scheduling type == aGP Service) {		

Table 6-8—Service specific scheduling control header format *(continued)*

Syntax	Size (bits)	Notes
SSSCH type	2	Indicates the type of SSSCH: 0b00: Adaptation Request 0b01: Adaptation Response 0b10: Adaptation ACK 0b11: Adaptation NACK
If (SSSCH type == 0b00 or 0b01) {		
QoS parameter change indicator	1	QoS parameter change indicator 0: QoS parameter set selection 1: QoS parameter change
if (QoS parameter change indicator == 1){		
Running Grant Size	14	Indicating new grant size (bytes) to use for future allocation.
Running Grant Polling Interval (GPI)	6	Indicating new GPI (frames) to use for future allocation.
}else{		
QoS parameter set selection	1	0: primary QoS parameter set 1: secondary QoS parameter set
}		
SCID change indicator	1	If (SSSCH type == 0b00), this indicator means AMS's request to change SCID; Else if (SSSCH type == 0b01), this indicator means ABS's decision in response to AMS's previous request to change SCID (0: deny, 1: accept).
If(SCID change indicator == 1)		
{		
SCID	4	If (SSSCH type == 0b00), this means the new SCID requested by the AMS; Else if (SSSCH type == 0b01), this means the new SCID assigned by the ABS.
}		
}		
If (SSSCH type == 0b01) {		
If (Adaptation Method == ABS-initiated Adaptation) {		
UL Resource Allocation Frame	4	Frame number where UL resources for Adaptation ACK/NACK shall be allocated.
} else {		
Adaptation Start Frame	4	Least significant four bits of the frame number in which the changed QoS parameters or the switched QoS parameter set are to be applied. If (SCID change indicator == 1), this Adaptation Start Frame also serves as the start frame number for the new sleep cycle.

Table 6-8—Service specific scheduling control header format *(continued)*

Syntax	Size (bits)	Notes
}		
}		
}		
else if (scheduling type == BE) {		
BR Size	14	Aggregated bandwidth request size in bytes.
Minimum grant delay	6	Indicating minimum delay (frames) of the requested grant.
}		
Padding	*variable*	This field shall be filled by '0' so that the total length of this header is equal to 6 bytes.
}		

6.2.2.1.3.4 Sleep Control header (SCH)

The Sleep Control header shall be used to convey control signaling related to sleep cycle operation by an ABS or AMS. The specific control provided by SCH is given in Table 6-9.

In the case where a SCH is used for the response to the SCH, an AMS and an ABS shall set the Response indication in the SCH to 1 (i.e., indicating a response) and the same subtype upon reception of SCH with Response indication = 0 (i.e., indicating a request). If both an ABS-initiated request and an AMS-initiated request occur concurrently (i.e., if the AMS or the ABS receives SCH with Response Indication = 0 while waiting for the SCH with Response Indication = 1 after transmitting SCH with Response Indication = 0), the ABS-initiated request takes precedence over the AMS-initiated request.

When the AMS transmits SCH with Response Indication = 1 to the ABS, the parameters in the SCH shall be the same as the SCH that the ABS sent.

Table 6-9—Sleep Control header format

Syntax	Size (bits)	Notes
Sleep Control Header format {		—
FID	4	Flow Identifier. Set to 0010.
Type	5	MAC signaling header type = 0b00011.
Length	3	Indicates the length of the signaling header in bytes.
SCH subtype	3	0b000 = Listening window control 0b001 = Resume Sleep Cycle Indication 0b010 = Multicarrier listening window control 0b011~0b111 = *Reserved*
Response Indication	1	0: This indicates the request 1: This indicates the response (i.e., acknowledgment) to the request
if (SCH subtype == Listening Window Control) {	—	—
Listening Window End or Extension	1	0 = Listening Window End Indication 1 = Listening Window Extension Indication
if(Listening Window End or Extension==1){	—	—
Last frame of Extended Listening Window	7	LSB of frame sequence. Indicates the frame that extended listening window is terminated.
}	—	—
} else if (SCH subtype == Resume Sleep Cycle Indication) {	—	—
Scheduled Sleep Cycle Interruption included	1	0 = no scheduled Sleep Cycle interruption is included with the Resume Sleep Cycle Indication 1 = scheduled Sleep Cycle interruption is included with the Resume Sleep Cycle Indication
if (Scheduled Sleep Cycle Interruption included == 1) {	—	—
Start Frame Offset for Scheduled Sleep Cycle Interruption	7	Number of frames in the future from the frame containing this SCH at which the scheduled Sleep Cycle interruption will occur. Frame offset is value of this field plus one (i.e., range is 1 to 128).

Table 6-9—Sleep Control header format *(continued)*

Syntax	Size (bits)	Notes
}	—	—
}	—	—
else if (SCH subtype == multicarrier Listening Window control) {		
Num_Target Carrier	4	
for(*i* = 0; *i* < Num_Target Carrier; *i*++) {		
Target Carrier Index	4	Indicates that DL data transmission on the secondary carrier of physical carrier index ends.
}		
}		
Padding	*variable*	For byte alignment
}	—	—

6.2.2.1.3.5 AMS Battery Level Report header

The AMS Battery Level Report header should be used to convey AMS battery level information from the AMS to the ABS. Battery level is defined as the amount of energy remaining in the battery as a percentage of the rated capacity of the battery. The units and algorithm used by the AMS to determine the battery level are implementation specific. The format of the AMS Battery Level Report header is given in Table 6-10.

Table 6-10—AMS Battery Level Report Header format

Syntax	Size (bits)	Notes
AMS Battery Level Report header () {	—	—
FID	4	Flow Identifier. This field indicates MAC signaling header. Set to 0010.
Type	5	MAC signaling header type = 0b00100.
Length	3	Indicates the length of the signaling header in bytes.
AMS Battery Status	1	0b0: The AMS is plugged into a power source 0b1: The AMS is not plugged into a power source
Battery Level Indication	1	0b0: Detailed battery level report is not included 0b1: Detailed battery level report is included

Table 6-10—AMS Battery Level Report Header format *(continued)*

Syntax	Size (bits)	Notes
If (Battery Level Indication == 1) {		
AMS Battery Level	3	0b000: Battery level is >75% and ≤100% 0b001: Battery level is >50% and ≤75% 0b010: Battery level is >25% and ≤50% 0b011: Battery level is >5 % and ≤25% 0b100: Battery level is below 5% 0b101–0b111: *Reserved*
Reserved	7	Shall be filled by 0
}		
else {		
Reserved	2	Shall be filled by 0
}		
}		

6.2.2.1.3.6 Uplink Power Status Report header

The Uplink Power Status Report header should be used to convey AMS ULPC status from the AMS to the ABS. The control of the reporting is described in 6.3.8.4.7.

Table 6-11—Uplink Power Status Report header format

Syntax	Size (bits)	Notes
Uplink Power Status Report Header() {		
FID	4	Flow Identifier. Set to 0010.
Type	5	MAC signaling header type = 0b00101.
Length	3	Indicates the length of the signaling header in bytes: 0b110: 6 bytes
ULPC Parameters Updating Indicator	1	Indicates whether the AMS has updated its ULPC parameters from AAI-SCD: 0: No ULPC parameters have changed 1: The confirmation of new ULPC parameters from AAI-SCD applied
Configuration Change Count	4	Only valid if ULPC Parameters Updating Indicator == 0b1. The value is the same as “Configuration Change Count” in the latest AAI-SCD message.

Table 6-11—Uplink Power Status Report header format *(continued)*

Syntax	Size (bits)	Notes
txPowerPsdBase	8	txPowerPsdBase (*PSD(base)*) is coded using 8 bits in 0.5 dBm steps ranging from –74 dBm (coded 0x00) to 53.5 dBm (coded 0xFF).
txSirDownlink	10	txSirDownlink (SIR_{DL}) is coded using 10 bits in 1/16 dB steps ranging from –12 dB (coded 0x000) to 51.9375 dB (coded 0x3ff).
Physical Carrier Index	6	The relevant active carrier with which this signaling header is associated. The value shall be set to 0b111111 if AMS has not received AAI-Global-CFG message or AAI-MC-ADV message yet.
Reserved	7	Shall be filled by 0 for byte alignment.
}		

6.2.2.1.3.7 Correlation Matrix Feedback header (CMFH)

This Correlation Matrix Feedback header format is defined in Table 6-12. This signaling header is used by AMS as a response to a Feedback Polling A-MAP IE requesting only the quantized transmit correlation matrix when the ABS is equipped with two or four transmit antennas. N_t is the number of transmit antennas at the ABS, indicated in S-SFH SP3.

Table 6-12—Correlation Matrix Feedback header format

Syntax	Size (bits)	Notes
CMFH() {		
FID	4	Flow Identifier. Set to 0010.
Type	5	MAC signaling header type = 0b00110.
Length	3	Indicates the length of the signaling header.
For (i = 1; $i \le N_t$; i++){		
i-th diagonal entry of correlation matrix	1	As defined in Table 6-237.
For ($j = i + 1$; $j \le N_t$; j++){		
(i,j)-th entry of correlation matrix	4	As defined in Table 6-238.
}		
}		
Reserved	*variable*	For byte alignment.
}		

6.2.2.1.3.8 MIMO feedback header (MFH)

This MIMO feedback header format is defined in Table 6-13. This signaling header is used by AMS as a response to a Feedback Polling A-MAP IE to send only the wideband information for any combinations of MFM 0, 4, 7 with $q = 0$.

Table 6-13—MIMO feedback header format

Syntax	Size (bits)	Notes
MFH() {		
FID	4	Flow Identifier. Set to 0b0010.
Type	5	MAC signaling header type = 0b0111.
Length	3	Indicates the length of the signaling header.
MFM bitmap	3	Bitmap to indicate the MFMs for which the AMS is sending feedback. It shall be consistent with current feedback allocations corresponding to the MFM requested by Feedback Polling A-MAP IE. LSB #0: MFM 0 LSB #1: MFM 4 LSB #2: MFM 7
If (LSB#0 in MFM_bitmap == 1){		MFM 0
Wideband CQI	4	
Wideband STC rate	3	Indicates STC rate (*R*). 0b000: STC rate = 1 0b001: STC rate = 2 0b010: STC rate = 3 0b011: STC rate = 4 0b100 ~ 0b111: *Reserved*
}		
If (LSB#1 in MFM_bitmap == 1){		MFM 4

Table 6-13—MIMO feedback header format *(continued)*

Syntax	Size (bits)	Notes
Wideband CQI	4	
Wideband STC rate	3	Indicates STC rate (*R*). 0b000: STC rate = 1 0b001: STC rate = 2 0b010: STC rate = 3 0b011: STC rate = 4 0b100 ~ 0b111: *Reserved*
Wideband PMI	6	Wideband preferred matrix index (PMI), size of which is the number of PMI bits (‘NB’) used, mapped to NB LSB bits of this field, while the remaining MSB bit(s) set to zero(0).
}		
If (LSB#2 in MFM_bitmap == 1){		MFM 7
Wideband CQI	4	
Wideband PMI	6	Wideband preferred matrix index (PMI), size of which is the number of PMI bits (‘NB’) used, mapped to NB LSB bits of this field, while the remaining MSB bit(s) set to zero(0).
}		
Reserved	*variable*	For byte alignment
}		

6.2.2.1.3.9 Grant management header (GMH)

The GMH is used by the AMS to convey bandwidth management needs to the ABS. This header is encoded differently based on the type of UL scheduling service for the connection (as given by the FID). The GMH is shown in Table 6-14. Its fields are defined in Table 6-15.

Table 6-14—Grant Management header format

Syntax	Size (bits)	Notes
GMEGH {	—	—
FID	4	Flow Identifier. Set to 0010.
Type	5	MAC signaling header type = 0b01000.
Length	3	Indicates the length of the signaling header in bytes.
BR FID	4	The FID for which UL bandwidth is requested.
if (Uplink grant scheduling type == UGS) {	—	—
SLI	1	
PM	1	
FLI	1	—
FL	4	—
Reserved	9	Shall be set to zero.
} else if (Uplink grant scheduling type == Extended rtPS) {	—	—
Extended piggyback request	11	—
FLI	1	—
FL	4	—
} else {	—	—
PiggyBack Request	16	—
}		
Reserved	*variable*	For byte alignment.
}		

Table 6-15—GMH fields

Name	Lengthe (bit)	Description
FLI	1	Frame latency indication 0 = FL field disabled for this grant. 1 = FL field enabled for this grant.
FL	4	Frame latency. The number of frames previous to the current one in which the transmitted data was available. When the latency is greater than 15, then the FL field shall be set to 15.
Extended Piggyback Request	11	The number of bytes of UL bandwidth requested by the AMS. The request shall not include any PHY overhead. In case of Extended rtPS, the ABS changes its grant size to the size specified in this field.
PBR	16	Piggyback request. The number of bytes of UL bandwidth requested by the AMS. The request shall not include any PHY overhead. The request shall be incremental.
PM	1	Poll me 0 = No action. 1 = Used by the AMS to request a bandwidth poll.
Reserved	9	—
SLI	1	Slip indicator. 0 = No action. 1 = Used by the AMS to indicate a slip of UL grants relative to the UL queue depth.

6.2.2.2 Extended header group formats

The inclusion of Extended header group is indicated by EH bit in MAC header. The extended header group format is defined in Table 6-16. The extended header group, when used, shall always appear immediately after the MAC header. The extended header group shall not be encrypted.

Table 6-16—Extended header group format

Syntax	Size (bits)	Notes
Extended header Group() {		
MPDU length extension	3	MAC PDU with AGMH: This field is added to the 11-bit length field in AGMH to have 14-bit MAC PDU length. It represents the 3 MSBs of the 14-bit MAC PDU length value. MAC PDU with SPMH: This field is set to 0.
EHLI	1	Extended Headers Length Indicator This field is always set to 0 in a MAC PDU with SPMH. This field is also set to 0 if there is no extended header.
If (EHLI == 0) {		
EH Length	4	Indicate the length of Extended Header Group = the length of extended headers + 1. If there is no extended header, EH Length shall be set to 1.
}		
Else {		
EH Length	12	Indicate the length of Extended Header Group = the length of extended headers + 2.
}		
}		
For (EHL = EH Length–1 or EHL = EH length – 2; J = 0 ; EHL > 0 ; EHL = EHL – LEN(EH[J]), *j*++) {		If EHLI == 0, EHL = EH Length – 1. If EHLI == 1, EHL = EH Length – 2. LEN(EH[J]) is the length of the Extended Header J, and is determined by the Type of EH[J].
Type of EH[J]	4	EH type.
Body of EH [J]	*variable*	EH body.
}		
}		

Table 6-17—Description of Extended header types

Extended Header types	Names	Description
0b0000	MAC SDU Fragmentation Extended header	See 6.2.2.2.1
0b0001	MAC SDU Packing Extended header	See 6.2.2.2.2
0b0010	MAC Control Extended header	See 6.2.2.2.3
0b0011	Multiplexing Extended header	See 6.2.2.2.4
0b0100	Message ACK Extended header	See 6.2.2.2.5
0b0101	Piggybacked Bandwidth Request Extended header	See 6.2.2.2.6
0b0110	Rearrangement Fragmentation and Packing Extended header	See 6.2.2.2.7
0b0111	ARQ Feedback Polling Extended header	See 6.2.2.2.8
0b1000	Advanced Relay Forwarding Extended Header	See 6.2.2.2.9
0b1001–0b1111	*Reserved*	—

6.2.2.2.1 MAC SDU Fragmentation Extended header (FEH)

The FEH shall be included in the MAC PDU with SPMH/AGMH if the transport connection payload in the MAC PDU contains a fragment of MAC SDU. The FEH shall also be included in the MAC PDU with AGMH if the transport connection payload in the MAC PDU contains an unfragmented MAC SDU that requires a sequence number including either ARQ or MAC SDU in-order delivery for the transport connection. The FEH format is defined in Table 6-18.

Table 6-18—Fragmentation Extended header format

Syntax	Size (bits)	Notes
FEH () {		
Type	4	Extended header type = 0b0000 (FEH Type).
FC	2	Fragmentation Control bits (see Table 6-20).
If (MAC Header == AGMH) {		
SN	10	SN is maintained per connection. For a non-ARQ connection, ‘SN’ represents the MAC PDU payload Sequence Number and the ‘SN’ value increments by one (modulo 1024) for each MAC PDU. For an ARQ connection, ‘SN’ represents the ARQ block sequence number.
}		
Else {		
Reserved	2	
}		
}		

6.2.2.2.2 MAC SDU Packing Extended header (PEH)

The PEH shall be included in the MAC PDU with AGMH if the MAC SDUs or MAC SDU fragments or both are packed in the transport connection payload in the MAC PDU. The PEH format is defined in Table 6-19.

Table 6-19—Packing Extended header format

Syntax	Size (bits)	Notes
PEH() {		
Type	4	Extended header type = 0b0001 (PEH Type).
FC	2	Fragmentation Control bits (see Table 6-20).
SN	10	SN is maintained per connection. For a non-ARQ connection, 'SN' represents the MAC PDU payload Sequence Number and the 'SN' value increments by one (modulo 1024) for each MAC PDU. For an ARQ connection, 'SN' represents the ARQ block sequence number.
Do {		
Length	11	This field indicates the length of MAC SDU or MAC SDU fragment in a MAC PDU payload. If a MAC PDU payload consists of 'N' MAC SDU/MAC SDU fragments, N – 1 'Length' fields are present to represent the length of MAC SDU/MAC SDU fragment #1 to #N–1. No multiplexing: Length of last MAC SDU/MAC SDU fragment = Length of MAC PDU (given by length field in AGMH and MPDU Length Extension(if EH == 1)) – Length of AGMH – EH length in Extended header group (if EH==1) – Length of PN and EKS (3 bytes, if present) – Length of ICV (if present) – sum of length of MAC SDU/ MAC SDU fragments #1 to #N–1 With multiplexing: Length of last MAC SDU/MAC SDU fragment = Length of connection payload corresponding to this PEH (see Table 6-13) – sum of length of MAC SDU/MAC SDU fragments #1 to #N–1.
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.
} while (!End)		
Padding	*variable*	For byte alignment.
}		

Table 6-20—Encoding of FC field

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

6.2.2.2.3 MAC Control Extended header (MCEH)

The MAC PDU shall include MCEH when the control connection payload contains a fragmented message or an unfragmented message that requires acknowledgement. When message fragments belonging to two different control messages are being sent, the transmitter shall assign different Control Connection Channel ID (CCC ID)s to the MCEH of each MAC PDU. The MCEH format is defined in Table 6-21.

Table 6-21—MAC Control Extended header format

Syntax	Size (bits)	Notes
MCEH () {		
Type	4	Extended header type = 0b0010 (MCEH Type)
Control Connection Channel ID (CCC ID)	1	Channel ID to identify separate fragmentation/reassembly state machines 0: channel 1 1: channel 2
Polling	1	0 = no acknowledgment required 1 = acknowledgment required upon receiving the MAC message
FC	2	Fragmentation control (see Table 6-20)
SN	8	Payload sequence number, SN is maintained per CCC ID, the ‘SN’ value increments by one (modulo 256) sequentially
}		

6.2.2.2.4 Multiplexing Extended header (MEH)

The format of MEH is defined in Table 6-22. The MEH is used when multiple connection payloads associated with the same security association are present in the MAC PDU. The MEH shall not be added in a MAC PDU with SPMH. The AGMH carries the FID corresponding to the payload of the first connection payload. MEH carries the FIDs corresponding to remaining connection payloads. Payloads from the same or different connections may be multiplexed. Payloads from the same connection may be multiplexed if they cannot be packed using packing defined in 6.2.4.5. For each FID occurring in the AGMH and MEH, there may be at most one associated extended header within the group consisting of FEH, PEH, RFPEH, and MCEH. The presence of such a header is indicated by the EH bitmap field in the MEH. These headers shall follow the MEH in the order of their corresponding payloads.

Table 6-22—Multiplexing Extended header format

Syntax	Size (bits)	Notes
MEH () {		
Type	4	Extended header type = 0b0011 (MEH type).
N_FI	4	Number of Flow information present in the MEH. If 'n' connections are multiplexed, 'n – 1' FIDs and Lengths are present. (i.e., N_FI is set to 'n – 1').
for (i = 1; $i \le N\_FI$; i++) {		
FID	4	Flow Identifier. The i-th FID indicates the flow identifier of the i + 1-th connection.
LI	1	Length Indicator LI = 0 indicates that size of Length field is 11 bits LI = 1 indicates that size of Length field is 14 bits
If (LI == 0) {		
Length	11	Length of the connection payload. The i-th length field indicates the length of the payload of the i + 1-th connection. Length of first connection payload = Length of MAC PDU (given by length field in AGMH and MPDU Length Extension(if EH == 1) – Length of AGMH – EH length in Extended header group (if EH == 1) – Length of PN and EKS (3 bytes, if present) – Length of ICV (if present) – sum of 'n – 1' Length fields.
} else {		
Length	14	Length of the connection payload. The i-th length field indicates the length of the payload of the i + 1-th connection. Length of first connection payload = Length of MAC PDU (given by length field in AGMH and MPDU Length Extension (if EH == 1) – Length of AGMH – EH length in Extended header group (if EH == 1) – Length of PN and EKS (3 bytes, if present) – Length of ICV (if present) – sum of 'n – 1' Length fields.
Reserved	1	
}		

Table 6-22—Multiplexing Extended header format *(continued)*

Syntax	Size (bits)	Notes
}		
EH_indicator bitmap	*variable*	A bit in the EH_indicator bitmap indicates the presence or absence of FEH/PEH/RFPEH/MCEH in the EH group corresponding to a connection payload. For a connection payload, only one extended header from FEH, PEH, RFPEH and MCEH shall be present. The FEH/PEH/RFPEH/MCEH for the connection payloads (if present) shall be present after the MEH in the same order as that of connection payloads. The numbers of bits in EH_indicator bitmap is equal to the number of flows multiplexed in MAC PDU (i.e., N_FI + 1). The most significant bit corresponds to the first connection payload. The least significant bit corresponds to the last connection payload. A bit set to 1 in EH_indicator bitmap indicates the presence of FEH/PEH/RFPEH/MCEH. A bit set to 0 in EH_indicator bitmap indicates the absence of FEH/PEH/RFPEH/MCEH.
Reserved	*variable*	For byte alignment.
}		

6.2.2.2.5 MAC Control ACK Extended header (MAEH)

The MAEH format is defined in Table 6-23. This header may be used by ABS and AMS to indicate the reception of a specific, previously received MAC control message. When an ABS or AMS receives a MAC control message or MAC control message fragment with the Polling bit set to 1 in the MCEH, the ABS or AMS shall transmit an MAEH or AAI-MSG-ACK message as an acknowledgment after receiving the complete message with the SN of the MAC control message PDU or the SN of the last received fragment if fragmented.

Table 6-23—MAC Control ACK Extended header format

Syntax	Size (bits)	Notes
MAEH () {		
Type	4	Extended header type = 0b0100 (MAEH type)
ACK_SN	8	SN retrieved from the MCEH of the MAC PDU with the Polling bit set to 1
Control Connection Channel ID (CCC ID)	1	Control Connection Channel ID (CCC ID) that the MAC control message is received
Reserved	3	For byte alignment
}		

6.2.2.2.6 Piggybacked Bandwidth Request Extended header (PBREH)

The PBREH shall be used when an AMS performs piggybacked bandwidth request for one or more flows. Table 6-24 is the format of PBREH.

Table 6-24—Piggybacked Bandwidth Request Extended header format

Syntax	Size (bits)	Notes
PBREH() {		
Type	4	Extended header type = 0b0101 (PBREH type)
Num_Of_PBR	4	Number of piggybacked BW request
For (*i* = 0 ; *i* < Num_Of_PBR ; *i*++) {		
FID	4	Flow identifier
Request type	1	0: aggregate 1: incremental
BR size	19	Amount of bandwidth requested
}		
}		

6.2.2.2.7 Rearrangement Fragmentation and Packing Extended header (RFPEH)

The RFPEH shall be used for ARQ enabled transport connection. It shall be included in MAC PDU with AGMH if MAC PDU payload contains an ARQ subblock that is constructed from SDU(s) or SDU fragment(s) or both are packed. The RFPEH format is defined in Table 6-25.

Table 6-25—Rearrangement Fragmentation and Packing Extended header format

Syntax	Size (bits)	Notes
RFPEH (){		
Type	4	Extended header type = 0b0110 (RFPEH Type).
FC	2	Fragmentation Control bits (see Table 6-20).
SN	10	SN is maintained per connection. 'SN' represents the ARQ block sequence number and the 'SN' value increments by one (modulo 1024) for each MAC PDU.
SSN	11	SSN of the first ARQ subblock.

Table 6-25—Rearrangement Fragmentation and Packing Extended header format *(continued)*

Syntax	Size (bits)	Notes
LSI	1	Last ARQ subblock indicator 0 = indicating the last ARQ subblock from the single ARQ block is not included in this MAC PDU 1 = indicating the last ARQ subblock from the single ARQ block is included in this MAC PDU
PI	1	Packing Indicator 0 = packing information is not present in RFPEH 1 = packing information is present in RFPEH
Reserved	3	For byte alignment
If (PI == 1) {		
Do {		
Length	11	This field indicates the length of MAC SDU or MAC SDU fragment in a MAC PDU payload. If a MAC PDU payload consists of 'N' MAC SDU/ MAC SDU fragments, N – 1 'Length' fields are present to represent the length of MAC SDU/ MAC SDU fragment #1 to #N – 1. No multiplexing: Length of last MAC SDU/ MAC SDU fragment = Length of MAC PDU (given by length field in AGMH and MPDU Length Extension(if EH == 1) – Length of AGMH – EH length in Extended header group (if EH == 1) – Length of PN and EKS (3 bytes, if present) – Length of ICV (if present) – sum of length of MAC SDU/MAC SDU fragments #1 to #N – 1. With multiplexing: Length of last MAC SDU/ MAC SDU fragment = Length of connection payload corresponding to this RFPEH (see Table 6-13) – sum of length of MAC SDU/ MAC SDU fragments #1 to #N – 1.
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
}while (!End)		
}		
Padding	*variable*	For byte alignment
}		

6.2.2.2.8 ARQ Feedback Polling Extended header (APEH)

The format of ARQ feedback polling extended header is defined in Table 6-26. This header shall be used by an ARQ transmitter to poll ARQ feedback.

Table 6-26—ARQ Feedback Polling Extended header format

Syntax	Size (bits)	Notes
APEH (){		
Type	4	Extended header type = 0b0111 (APEH Type)
FID	4	Reference FID for ARQ feedback polling

6.2.2.2.9 Advanced Relay Forwarding Extended header (ARFEH)

The ARFEH may be used when the ASN data traffic between ABS and ARS is encapsulated into MAC PDU. The ARFEH format is defined in Table 6-27.

Table 6-27—Advanced Relay Forwarding Extended header format

Syntax	Size (bits)	Notes
ARFEH (){		
Type	4	Extended header type = 0b1000 (ARFEH Type)
DO {		
Forwarding ID	12	Identity of the ASN data forwarded between ABS and ARS.
End	1	0: One or more Forwarding ID follows 1: This Forwarding ID is the last Forwarding ID
} while (!End)		
}		

6.2.3 MAC Control messages

The peer-to-peer protocol of MAC layers in ABS and AMS communicate using the MAC control messages to perform the control plane functions. MAC control messages shall be carried in a MAC PDU to be transported in broadcast, unicast, or random access connections. There is a single unicast Control connection and two control connection channels. HARQ shall be enabled for MAC control messages sent on the unicast Control connection. Encryption may be enabled for unicast MAC control messages. MAC control messages may be fragmented, but they shall not be packed. MAC control messages are specified in 6.2.3 and Annex B using ASN.1 notation. MAC control messages are listed in Table 6-28. The indication to the receiver that the PDU is encrypted or not is indicated by the FID 0x1 and 0x0 in AGMH, respectively. Whether the encryption is applied on a MAC control message or not shall be determined by the message type and MAC procedure context, which is defined in Table 6-28. A message included in a PDU whose encryption status indicated by the FlowID in AGMH does not match the combined message type and corresponding context defined in the Table 6-28 shall be discarded. Encrypted and non-encrypted MAC control messages shall not be sent in the same PDU.

In the AAI message Field Description tables (Table 6-29 through Table 6-108), if a field's entry in the Condition column is left blank, then

a) If the field occurs inside an if-statement or for-statement, the condition for including the field in the MAC control message is determined by the enclosing if-statements or for-statements.
b) Otherwise, the field shall always be present in the MAC control message.

Table 6-28—MAC Control messages

No.	Functional areas	Message names	Message description	Security	Connection
1	System Information	AAI-SCD	System configuration descriptor	N/A	Broadcast
2	System Information	AAI-SII-ADV	Service Identity Information Advertisement	N/A	Broadcast
3	System Information	AAI-ULPC-NI	UL Noise and Interference Level Broadcast	N/A	Broadcast
4	Network Entry/ Reentry	AAI-RNG-REQ	Ranging Request	Null: during the ranging procedure when there is no SA already established or preupdated. CMAC: all other cases	Initial Ranging or Unicast
5	Network Entry/ Reentry	AAI-RNG-RSP	Ranging Response	Null: during the ranging procedure when there is no primary SA already established or preupdated. Encrypted/ICV: all other cases	Initial Ranging or Unicast
6	Network Entry/ Reentry	AAI-RNG-ACK	Aggregated CDMA Ranging Acknowledge	N/A: in broadcast null: in unicast when primary SA is not established. Encrypted/ICV: in unicast when primary SA is established	Broadcast/ Unicast
7	Network Entry/ Reentry	AAI-RNG-CFM	Ranging Confirmation	Encrypted/ICV	Unicast
8	Network Entry/ Reentry	AAI-REG-REQ	Registration Request	Encrypted/ICV	Unicast
9	Network Entry/ Reentry	AAI-REG-RSP	Registration Response	Encrypted/ICV	Unicast

Table 6-28—MAC Control messages *(continued)*

No.	Functional areas	Message names	Message description	Security	Connection
10	Network Entry/ Reentry	AAI-SBC-REQ	Basic Capability Request	Null: during capability negotiation when there is no primary SA already established or preupdated. Encrypted/ICV: all other cases	Unicast
11	Network Entry/ Reentry	AAI-SBC-RSP	Basic Capability Response	Null: during capability negotiation when there is no primary SA already established or preupdated. Encrypted/ICV: all other cases	Unicast
12	Network Exit	AAI-DREG-REQ	Deregistration Request	Encrypted/ICV	Unicast
13	Network Exit	AAI-DREG-RSP	Deregistration Response	Encrypted/ICV	Unicast
14	Connection Management	AAI-DSA-REQ	Dynamic Service Addition Request	Encrypted/ICV	Unicast
15	Connection Management	AAI-DSA-RSP	Dynamic Service Addition Response	Encrypted/ICV	Unicast
16	Connection Management	AAI-DSA-ACK	Dynamic Service Addition Acknowledge	Encrypted/ICV	Unicast
17	Connection Management	AAI-DSC-REQ	Dynamic Service Change Request	Encrypted/ICV	Unicast
18	Connection Management	AAI-DSC-RSP	Dynamic Service Change Response	Encrypted/ICV	Unicast
19	Connection Management	AAI-DSC-ACK	Dynamic Service Change Acknowledge	Encrypted/ICV	Unicast
20	Connection Management	AAI-DSD-REQ	Dynamic Service Deletion Request	Encrypted/ICV	Unicast
21	Connection Management	AAI-DSD-RSP	Dynamic Service Deletion Response	Encrypted/ICV	Unicast
22	Connection Management	AAI-GRP-CFG	Group Configuration	Encrypted/ICV	Unicast

Table 6-28—MAC Control messages *(continued)*

No.	Functional areas	Message names	Message description	Security	Connection
23	Security	AAI-PKM-REQ	Privacy Key Management Request	Before AK is derived at network entry: NULL after AK is derived at network entry and EAP-transfer message is enclosed: encryption/ICV after AK is derived at network entry and the other message is enclosed: CMAC	Unicast
24	Security	AAI-PKM-RSP	Privacy Key Management Response	Before AK is derived at network entry: NULL at network entry and EAP-transfer message is enclosed: encryption/ICV after AK is derived after AK is derived at network entry and the other message is enclosed: CMAC	Unicast
25	ARQ	AAI-ARQ-Feedback	Stand-alone ARQ Feedback	Encrypted/ICV	Unicast
26	ARQ	AAI-ARQ-Discard	ARQ Discard	Encrypted/ICV	Unicast
27	ARQ	AAI-ARQ-Reset	ARQ Reset	Encrypted/ICV	Unicast
28	Sleep Mode	AAI-SLP-REQ	Sleep Request	Encrypted/ICV	Unicast
29	Sleep Mode	AAI-SLP-RSP	Sleep Response	Encrypted/ICV	Unicast
30	Sleep Mode	AAI-TRF-IND	Traffic Indication	N/A	Broadcast
31	Sleep Mode	AAI-TRF-IND-REQ	Traffic indication request	Encrypted/ICV	Unicast
32	Sleep Mode	AAI-TRF-IND-RSP	Traffic indication response	Encrypted/ICV	Unicast
33	Handover	AAI-HO-REQ	AMS Handover Request	Encrypted/ICV	Unicast

Table 6-28—MAC Control messages *(continued)*

No.	Functional areas	Message names	Message description	Security	Connection
34	Handover	AAI-HO-CMD	ABS Handover Command	Encrypted/ICV	Unicast
35	Handover	AAI-HO-IND	AMS Handover Indication	Encrypted/ICV	Unicast
36	Handover	AAI-NBR-ADV	Neighbor Advertisement	Encrypted/ICV: in unicast N/A: in broadcast	Unicast or broadcast
37	Handover	AAI-SCN-REQ	Scanning Interval Allocation Request	Encrypted/ICV	Unicast
38	Handover	AAI-SCN-RSP	Scanning Interval Allocation Response	Encrypted/ICV	Unicast
39	Handover	AAI-SCN-REP	Scanning Result Report	Encrypted/ICV	Unicast
40	Idle Mode	AAI-PAG-ADV	BS Paging Advertisement	N/A	Broadcast
41	Idle Mode	PGID-Info	Paging Group Advertisement	N/A	Broadcast
42	Multicarrier	AAI-MC-ADV	Multicarrier Advertisement	N/A	Broadcast
43	Multicarrier	AAI-MC-REQ	Multicarrier Request	Encrypted/ICV	Unicast
44	Multicarrier	AAI-MC-RSP	Multicarrier Response	Encrypted/ICV	Unicast
45	Multicarrier	AAI-CM-CMD	Carrier Management Command	Encrypted/ICV	Unicast
46	Multicarrier	AAI-CM-IND	Carrier Management Indication	Encrypted/ICV	Unicast
47	Multicarrier	AAI-Global-CFG	Global Carrier Configuration	Encrypted/ICV	Unicast
48	Power Control	AAI-UL-POWER-ADJ	Uplink TX power adjustment	Null	Unicast
49	Power Control	AAI-UL-PSR-CFG	Uplink Power Status Reporting Configuration	Null	Unicast
50	Collocated Coexistence	AAI-CLC-REQ	Co-located coexistence request	Encrypted/ICV	Unicast
51	Collocated Coexistence	AAI-CLC-RSP	Co-located coexistence response	Encrypted/ICV	Unicast
52	MIMO	AAI-SBS-MIMO-FBK	Single-BS MIMO feedback	Null	Unicast
53	MIMO	AAI-MBS-MIMO-FBK	Multi-BS MIMO feedback	Null	Unicast
54	MIMO	AAI-DL-IM	Downlink interference mitigation parameter	N/A	Broadcast

Table 6-28—MAC Control messages *(continued)*

No.	Functional areas	Message names	Message description	Security	Connection
55	MIMO	AAI-MBS-MIMO-MIMO-REQ	Multi-BS MIMO Request	Null	Unicast
56	MIMO	AAI-MBS-MIMO-RSP	Multi-BS MIMO Response	Null	Unicast
57	MIMO	AAI-MBS-SBP	UL multi-BS MIMO for single BS precoding with multi-BS coordination	Null	Unicast
58	MIMO	AAI-MBS-SOUNDING-CAL	Multi-BS sounding calibration	Null	Unicast
59	FFR	AAI-FFR-CMD	FFR measurement report command	Null	Unicast
60	FFR	AAI-FFR-REP	FFR measurement report	Null	Unicast
61	SON	AAI-SON-ADV	SON Advertizement	N/A	Broadcast
62	E-MBS	AAI-E-MBS-REP	E-MBS Report	Encrypted/ICV	Unicast
63	E-MBS	AAI-E-MBS-RSP	E-MBS Response	Encrypted/ICV	Unicast
64	E-MBS	AAI-E-MBS-CFG	E-MBS Configuration	Null	Broadcast
65	MISC	AAI-L2-XFER	AAI L2 Transfer	Encrypted/ICV: in unicast. N/A: in broadcast	Unicast or Broadcast
66	MISC	AAI-MSG-ACK	MAC message acknowledgement	Encrypted/ICV	Unicast
67	MISC	AAI-RES-CMD	Reset command	Null: when primary SA is not established Encrypted/ICV: when primary SA is established.	Unicast
68	LBS	AAI-LBS-ADV	Initiate LBS measurement	N/A	Broadcast
69	LBS	AAI-LBS-IND	LBS indication	N/A	Unicast
70	RELAY	AAI-ARS-CONFIG-CMD	ARS configuration Command	N/A	Unicast

6.2.3.1 AAI-RNG-REQ

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

If the AMS does not have an active STID assignment and the AMS has been provided with allocation of insufficient size for transmitting the whole AAI-RNG-REQ message, the AMS shall use the provided allocation for transmitting a fragment of the AAI-RNG-REQ and request more UL bandwidth by sending either a BR without STID header (refer to 6.2.2.1.3.2) or a PBREH (refer to 6.2.2.2.6).

In response to the additional UL bandwidth request, the ABS shall allocate UL bandwidth by sending a CDMA Allocation A-MAP IE still masked with the RA-ID and masking prefix indicator for the ranging code (refer to Table 6-194).

When the AMS is attempting to perform Network Reentry, Secure Location Update, or HO if the AMS has an available security context (e.g., AK context) necessary to expedite security authentication, it shall transmit CMAC tuple following ASN.1 encoded AAI-RNG-REQ.

Table 6-29—AAI-RNG-REQ message field description

Field	Size (bits)	Value/Description	Condition
Ranging Purpose Indication	4	0b0000 = Initial network entry 0b0001 = HO reentry 0b0010 = Network reentry from idle mode 0b0011 = Idle mode location update 0b0100 = DCR mode extension 0b0101 = Emergency call setup (e.g., E911) 0b0110 = Location update for updating service flow management encodings of E-MBS flows 0b0111 = Location update for transition to DCR mode from idle mode 0b1000 = Reentry from DCR mode, coverage loss or detection of different ABS restart count 0b1001 = Network reentry from an R1 BS 0b1010 = Zone switch to MZone from LZone 0b1011 = Location update due to power down 0b1100 = Interference mitigation request to a CSG Femto ABS when experiencing interference from the CSG Femto ABS 0b1101 = NS/EP call setup 0b1110 = Network Reentry from idle mode of AMS which has entered Idle Mode in R1 BS 0b1111 = *Reserved*	
CMAC indicator	1	Indicate whether this message is protected by CMAC tuple 0b0: not protected 0b1: protected	Shall always be present.

Table 6-29—AAI-RNG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If (Ranging Purpose Indication == 0b0000) {		// Initial network entry	
If (S-SFH Network Configuration bit == 0b0 and AMSID privacy is enabled) {			
AMSID*	48	The AMSID hash value. Refer to 6.2.5.3.1.	
} else if (S-SFH Network Configuration bit == 0b1 or AMSID privacy is disabled){			
AMS MAC address	48	AMS's real MAC address	
}			
MAC version	8	See 11.1.3 in IEEE Std 802.16.	
Initial Offset for uplink power control (OffsetInitial)	5	The bit size represents power level ranging from –15 dB (0x00) to 16 dB (0x1F) with 1 dB step The value is determined by AMS after successful initial ranging process	

} else if (Ranging Purpose Indication == 0b0001) {		// HO reentry
		//a: STID is not preassigned
		//b: HO	

If (STID is not pre assigned) {			
Serving BSID	48	The BSID of the AMS's previous S-ABS before incurring a coverage loss, or the BSID of the S-ABS to which the AMS is currently connected (has completed the registration cycle and is in Connected State).	
Previous STID	12	The STID that the AMS uses in the previous S-ABS.	
} else{			
if (S-SFH Network Configuration bit == 0b1 or AMSID privacy is disabled){			
AMS MAC address	48	AMS's real MAC address	
} else{			
STID	12	The Station ID preassigned by the T-ABS.	
}			
}			
If (CMAC indicator == 0b1){			

Table 6-29—AAI-RNG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present if the AMS has a CMAC Tuple necessary to expedite security authentication.
}			
For (*i* = 0; *i* < N_FIDs; *i*++) {		N_FIDs is the number of transport FIDs that the AMS has. 1 ≤ N_FIDs ≤ 24	
FID	4	Flow identifier	
FID change count	4	FID change count	
DL/UL indicator	1	0b0: Downlink 0b1: Uplink	
}			
Initial Offset for uplink power control (OffsetInitial)	5	The bit size represents power level ranging from –15 dB (0x00) to 16 dB (0x1F) with 1 dB step The value is determined by AMS after successful handover ranging process. The value is calculated as the same way with initial ranging channel power control.	Optional. Present if code-based ranging is done.
} else if (Ranging Purpose Indication == 0b0010) {		// Network reentry from idle mode	
if (S-SFH Network Configuration bit == 0b1){			
AMS MAC address	48	AMS's real MAC address	
} else{			
Deregistration Identifier (DID)	18	The ID that the AMS is assigned for idle mode and currently maintains.	
}			
Paging Controller ID	48	The Paging Controller ID that the AMS currently maintains in idle mode.	
PGID	16	The identification of the paging group to which the AMS previously belonged.	
Paging Cycle	4	PAGING_CYCLE applied to the AMS	
Paging Offset	12	PAGING_OFFSET applied to the AMS	
If (CMAC indicator == 0b1){			

Table 6-29—AAI-RNG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present if the AMS has a CMAC Tuple necessary to expedite security authentication.
}			
For (*i* = 0; *i* < N_FIDs; *i*++) {		N_FIDs is the number of transport FIDs that the AMS has. 1 ≤ N_FIDs ≤ 24	
FID	4	Flow identifier	
FID change count	4	FID change count	
DL/UL indicator	1	0b0: Downlink 0b1: Uplink	
}			
} else if (Ranging Purpose Indication == 0b0011 |0b0110|0b0111| 0b1011) {		// Idle mode location update (and with other additional purposes)	
if (S-SFH Network Configuration bit == 0b1){			
AMS MAC address	48	AMS's real MAC address	
} else{			
Deregistration Identifier (DID)	18	The ID that the AMS is assigned for idle mode and currently maintains.	
}			
Paging Controller ID	48	The Paging Controller ID that the AMS currently maintains in idle mode.	
PGID	16	The identification of the paging group to which the AMS previously belonged.	
Paging Cycle	4	PAGING_CYCLE applied to the AMS	
Paging Offset	12	PAGING_OFFSET applied to the AMS	
Paging Cycle Change	4	PAGING_CYCLE requested by the AMS	Present if AMS wants to change Paging Cycle.
Paging Carrier update	6	Preferred Paging carrier index requested by the AMS	Present if AMS wants to change Paging Carrier.
If (CMAC indicator == 0b1){			

Table 6-29—AAI-RNG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present for secure Location Update.
}			
AMS Mobility Information	2	0b00 = Slow (0–10 km/h) 0b01 = Medium (10–120 km/h) 0b10 = Fast (above 120 km/h) 0b11 = *Reserved*	Optional.
SMS	variable	Short Message content up to 140 bytes	May be present when there is SMS content to be sent.
} else if (Ranging Purpose Indication == 0b0100) {		// DCR mode extension	
CRID	72	AMS identifier that the AMS has been assigned for coverage loss or DCR mode and are currently maintained.	
If (CMAC indicator == 0b1){			
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present if the AMS has a CMAC Tuple necessary to expedite security authentication.
}			
} else if (Ranging Purpose Indication == 0b0101) {		// Emergency call setup (e.g., E911).	
AMS MAC address	48	AMS's real MAC address.	
MAC version	8	See 11.1.3 in IEEE Std 802.16.	
Initial Offset for uplink power control (OffsetInitial)	5	The bit size represents power level ranging from –15 dB (0x00) to 16 dB (0x1F) with 1 dB step The value is determined by AMS after successful initial ranging process.	
} else if (Ranging Purpose Indication == 0b1000) {		// Reentry from DCR mode, coverage loss or detection of different ABS restart count.	
CRID	72	AMS identifier that the AMS has been assigned for coverage loss or DCR mode and are currently maintained.	

Table 6-29—AAI-RNG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Serving BSID	48	The BSID of the AMS's previous S-ABS before incurring a coverage loss.	Present when the AMS is recovering from coverage loss unless the AMS can determine that the ABS-Resource-Retain-Timer maintained by the previous S-ABS has expired.
Previous STID	12	The STID that the AMS uses in the previous S-ABS.	Present when the AMS is recovering from coverage loss unless the AMS can determine that the ABS-Resource-Retain-Timer maintained by the previous S-ABS has expired.
If (CMAC indicator == 0b1){			
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present if the AMS has a CMAC Tuple necessary to expedite security authentication.
}			
For (*i* = 0; *i*<N_FIDs; *i*++) {		N_FIDs is the number of transport FIDs that the AMS has. 1 ≤ N_FIDs ≤ 24	
FID	4	Flow identifier	
FID change count	4	FID change count	
DL/UL indicator	1	0b0: Downlink 0b1: Uplink	
}			
If (S-SFH Network Configuration bit == 0b0 and AMSID privacy is enabled) {			
AMSID*	48	The AMSID hash value. Refer to 6.2.5.3.1	
} else if (S-SFH Network Configuration bit == 0b1 or AMSID privacy is disabled){			
AMS MAC address	48	AMS's real MAC address	
}			
MAC version	8	See 11.1.3 in IEEE Std 802.16.	

Table 6-29—AAI-RNG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Initial Offset for uplink power control (OffsetInitial)	5	The bit size represents power level ranging from –15 dB (0x00) to 16 dB (0x1F) with 1 dB step The value is determined by AMS after successful initial ranging process	
} else if (Ranging Purpose Indication == 0b1001) {		// Network reentry from an R1 BS	
If (S-SFH Network Configuration bit == 0b0 and AMSID privacy is enabled) {			
AMSID*	48	The AMSID hash value. Refer to 6.2.5.3.1.	
}			
Serving BSID	48	The BSID of the previous serving BS.	
AMS MAC address	48	AMS's real MAC address.	
If (CMAC indicator == 0b1){			
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present if the AMS has a CMAC Tuple necessary to expedite security authentication.
}			
} else if (Ranging Purpose Indication == 0b1010) {		// Zone switch to MZone from LZone.	
If (AMS received TSTID through Zone Switch TLV in LZone) {			
TSTID	12		
If (AMSID privacy is enabled) {			
AMSID*	48	The AMSID hash value. Refer to 6.2.5.3.1.	
}			
} else {			
Serving BSID	48	The BSID of the previous serving BS.	
Previous Basic CID	16	The Basic CID that the AMS used in the previous serving BS.	
If (AMSID privacy is enabled) {			
AMSID*	48	The AMSID hash value. Refer to 6.2.5.3.1.	
}			

Table 6-29—AAI-RNG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
}			
If (CMAC indicator == 0b1){			
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present if the AMS has a CMAC Tuple necessary to expedite security authentication.
} else if (Ranging Purpose Indication == 0b1100) {		// Experiencing "Femto interference"	
If (CMAC indicator == 0b1){			
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present if the AMS has a CMAC Tuple necessary to expedite security authentication.
}			
} else if (Ranging Purpose Indication == 0b1101) {		// NS/EP call setup	
AMS MAC address	48	AMS's real MAC address	
MAC version	8	See 11.1.3 in IEEE Std 802.16.	
Initial Offset for uplink power control (OffsetInitial)	5	The bit size represents power level ranging from –15 dB (0x00) to 16 dB (0x1F) with 1 dB step The value is determined by AMS after successful initial ranging process.	
}else if (Ranging Purpose Indication == 0b1110) {		// Network Reentry from idle mode of AMS that has entered idle mode in R1 BS	
Paging Controller ID	48	The Paging Controller ID to which the AMS previously belonged in serving legacy BS	
if (S-SFH Network Configuration bit == 0b1 or AMSID privacy is disabled){			
AMS MAC address	48	AMS's real MAC address	
}			
If (CMAC indicator == 0b1){			

Table 6-29—AAI-RNG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
AK_COUNT	16	The AMS's current value of the AK_COUNT, which is used to update the security keys in the T-ABS.	Shall be present if the AMS has a CMAC Tuple necessary to expedite security authentication.
}			
}//end of Ranging Purpose Indication			
for (*i* = 0; *i* < N_CSG_ID_Infos; *i*++) {		N_CSG_ID_Infos is the number of CSG ID Information blocks. 1 ≤ N_CSG_ID_Infos ≤ 15	Optional for loop. May be included for quick CSG membership detection or ABS reselection assistance.
Operator ID of the CSG Femtocell	24	The Operator ID of the CSG Femtocell.	Present if the Operator ID is different from the one of the ABS.
for (*j* = 0; *j* < N_CSG_IDs; *j*++) {		N_CSG_IDs is the number of CSG IDs belongs to this Operator ID.	
CSGID	variable	The CSGID within the Operator ID. It may be part of the BS ID, with certain bits inside indicating its length. If the CSG has single BS, it may be of maximum length, which is the LSB-24-bits of the full BS ID.	
}			
}			

6.2.3.2 AAI-RNG-RSP

An AAI-RNG-RSP shall be transmitted by the ABS in response to a received AAI-RNG-REQ. HARQ operation is applied to the DL burst including the AAI-RNG-RSP message. In a contention-based random access ranging procedure, DL bandwidth to send the AAI-RNG-RSP message is allocated using CDMA Allocation A-MAP IE only when the ABS transmits the AAI-RNG-RSP message to an AMS that has neither STID nor TSTID assigned.

When an ABS sends the AMS an AAI-RNG-RSP message in response to an AAI-RNG-REQ message, if a network assigns a new CRID to the AMS, then the AAI-RNG-RSP message shall contain the new CRID. When a network assigns a new CRID to the AMS separately from NW reentry or location update procedure, the ABS sends the AMS an unsolicited encrypted AAI-RNG-RSP message containing the new CRID and should set polling bit by 1 in MCEH so that the AMS shall send an acknowledgment (i.e., AAI-MSG-ACK) to the AAI-RNG-RSP message.

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

This message may include a TSTID or a STID, but not both. When either the TSTID or the STID is included in this message, the AMS shall pair the MAPMask Seed value received in this message with the TSTID or STID received. When the AMS receives a A-A-MAP IE whose CRC Mask Masking Code is the TSTID, it shall initiate the randomizer with the MAPMask Seed value received in the same MAC control message as the TSTID, and when the AMS receives a A-A-MAP IE whose CRC Mask Masking Code is the STID, it shall initiate the randomizer with the MAPMask Seed value received in the same MAC control message as the STID. See 6.3.5.3.2.4 for more details.

In the case of the Zone Switch procedure from LZone to MZone, the AAI-RNG-RSP message, if specific FID(s) is to be re-mapped to SAID of AES-CTR, the ABS shall include the “SAID_update_bitmap” in the AAI-RNG-RSP message.

Table 6-30—AAI-RNG-RSP message field description

Field	Size (bits)	Value/Description	Condition
Ranging Abort	1	Set to 1 when an ABS rejects the AMS.	Present when an ABS rejects an AMS.
If (Ranging Abort == 1) {			
Ranging Abort Timer	16	Timer defined by an ABS to prohibit the AMS from attempting network entry at this ABS, for a specific time duration. Value: 0 (Do not try ranging again at the ABS.) Value: 1–65 534, in units of seconds Value: 65 535 (When the received CSGID(s) from the AMS does not match any of the CSGID(s) of the Femto ABS. This value indicates the Ranging Abort Timer is not to be used, and the AMS can range any time.)	
}else{			
if (Temporary STID){			
Temporary STID	12	Used for AMS identification until STID is assigned to the AMS during registration procedure.	Shall be included in response to the AAI-RNG-REQ message that is not CMAC protected and when the AMS has not been assigned its STID/DID.
}			
else {			

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
STID	12	AMS identification to be used in the T-ABS.	Shall be included for uncontrolled HO, NW reentry, or Zone switching in case this message is encrypted.
}			
MAPMask Seed	15	This parameter shall be used at the T-ABS to initiate the PRBS generator used to scramble the 40-bit A-A-MAP IE when the STID is used to mask the CRC. See 6.3.5.3.2.4.	Shall be present if STID or TSTID is present.
If (S-SFH Network Configuration bit == 0b0) {			
AMSID*	48		Shall be included in response to the AAI-RNG-REQ message that is not CMAC protected when the AMS has not been assigned its STID.
} else {			
AMS MAC address	48		Shall be included in response to the AAI-RNG-REQ message that is not CMAC protected when the AMS has not been assigned its STID.
}			
CRID	72	The AMS identifier newly assigned by the network for coverage loss or DCR mode.	Shall be included when the AMS is attempting to perform network reentry from coverage loss or DCR mode or to perform network reentry/location update/zone-switch with assigning a new CRID in response to AAI-RNG-REQ, or it shall be included when the network assigns a new CRID unsolicitedly to the AMS.
Emergency Service FID	4	A FID number assigned within the Transport FID numbers 0100–1111 according to Table 6-1.	Shall be included when this message is sent in response to an AAI-RNG-REQ with Ranging Purpose Indication set to code 0b0101.

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
NS/EP service FID	4	A FID number assigned within the Transport FID numbers 0100–1111 according to Table 6-1.	Shall be included when this message is sent in response to an AAI-RNG-REQ with Ranging Purpose Indication set to code 0b1101.
Location Update Response	4	0x0 = Success of Location Update 0x1 = Failure of Location Update 0x2 = *Reserved* 0x3 = Success of location update and DL traffic pending 0x4 = Allow AMS's DCR mode initiation request or DCR mode extension request 0x5 = Reject AMS's DCR mode initiation request or DCR mode extension request 0x6~0xF: *Reserved*	Shall be included when this message is sent in response to an AAI-RNG-REQ message used to perform location update or DCR mode initiation from Idle Mode or DCR mode extension.
If (Location Update Response == 0x0) {			
Paging Group ID update	32	Old PG ID, New PG ID The Paging Group ID update specifies a new PGID that replaces an old PGID.	Shall be included when the Paging Group ID is changed.
Paging Offset update	24	Old Paging Offset, New Paging Offset The Paging Offset update specifies a new Paging Offset that replaces an old Paging Offset.	Shall be included when the Paging Offset is changed.
New Paging Cycle	4	New Paging Cycle to be assigned to the AMS 0b0000–0b1111	Shall be included when the new Paging Cycle is assigned.
New Paging Group ID	16	New PGID of the AMS.	Shall be included when the new Paging Group ID is assigned.
New Paging Offset	12	New paging offset of AMS that determines the Superframe within the paging cycle from which the paging listening interval starts. Shall be smaller than the Paging Cycle value.	Shall be included when the new Paging Offset is assigned.
Deregistration Identifier (DID)	18	The new DID that the AMS shall maintain in idle mode.	Shall be included only when the S-SFH Network Configuration bit == 0b0 and DID is changed.

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
New Paging Controller ID	48	The new Paging Controller ID that the AMS shall maintain in idle mode.	Shall be included only if Paging Controller ID is changed.
for (*i* = 1; *i* ≤ N-E-MBS-Zone-IDs; *i*++) {		N-E-MBS-Zone-IDs is the number of E-MBS zone IDs to be updated in the T-ABS [1..8].	Present if it needs to be updated.
Service_flow_update_indicator	1	Indicator whether “bitmap + new service flow” or “current service flow + new service flow” is included. 0b0: “Service Flow Update Bitmap + New_E-MBS ID and FID” 0b1: “Current_ E-MBS ID and FID and New_ E-MBS ID and FID Mappings”	
E-MBS_Zone_ID	7	Indicates an E-MBS zone where the connection for associated service flow is valid.	
New E-MBS_Zone_ID	7	Indicates an E-MBS zone to update.	Present only if the E-MBS zone ID needs to update.
Physical Carrier Index	6	The physical carrier index that is support for the new E-MBS zone ID to update.	Present only if the New E-MBS zone ID to update is served on a different carrier from the previous one.
If (Service_flow_update_indicator == 0b0) {			
Service Flow Update Bitmap	16	E-MBS Service Flow update bitmap where the E-MBS ID+FID is sorted with increasing order between ABS and AMS. A bit = 1, means the corresponding service flow, identified by E-MBS ID and FID, is updated.	
For each 1-bit in the Service Flow Update Bitmap{			
New_E-MBS ID	12	New E-MBS identifier.	
FID	4	Flow ID.	
}			
} else if (Service_flow_update_indicator == 0b1) {			

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
for(*j* = 0; *j* < N_E-MBS_IDs; *j*++) {		N_E-MBS_IDs is the number of EMBS IDs listed here. Mapping of current E-MBS ID and FID and new E-MBS ID and FID to update the service flow.	
Current E-MBS ID	12		
Current FID	4		
New_E-MBS ID	12		
New FID	4		
}			
} // end of else if			
}//end of for (N-E-MBS-Zone-IDs)			
For (*i* = 0; *i* < M; *i*++) {		Number of Multicast Group ID and FID (M) to update in the T-ABS[1..16]. Mapping of current Multicast Group ID and FID and new Multicast Group ID and FID to be updated. Based on the value of Num of Multicast Group ID and FID to be updated.	Present if it needs to be updated.
Current Multicast Group ID	12		
Current FID	4		
New Multicast Group ID	12		
New FID	4		
}			
SMS	*variable*	Short Message content up to the size of 140 bytes.	May be included when SMS contents is sent in idle mode.
}//end of If (Location Update Response == 0x0)			

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Reentry Process Optimization	5	Reentry process optimization bitmap indicates which MAC control message transactions may be omitted during an attempted reentry (i.e., reentry during HO (including zone switching), and reentry from idle mode). A value of 1 in the bitmap indicates that the corresponding MAC control message transaction may be omitted, while a 0 indicates that the corresponding MAC control message transaction shall be completed. The AMS shall only commence Connected State with the T-ABS after completing all the required MAC control message transactions. Bit 0: Omit AAI-SBC-REQ and AAI-SBC-RSP MAC control messages during reentry processing Bit 1: Omit PKM Authentication phase Bit 2: Omit AAI-REG-REQ and AAI-REG-RSP message during reentry processing Bit 3: Omit higher layer protocol triggering for IP address refresh during reentry processing Bit 4: For the case of reentry during HO including zone switching, a 1 indicates to the AMS that the T-ABS has received the full service and operational states for static and dynamic context (including ARQ window parameters and state machines). For the case of reentry from Idle mode, a 1 indicates to the AMS that the T-ABS has received the static context of the AMS. The static context includes SFIDs and related description (QoS descriptors and CS classifier information) for all service flows that the AMS has currently established as well as any SAs with their related keying information	It shall be included when the AMS is attempting to perform network reentry (i.e., reentry during HO (including zone switching), and reentry from idle mode), and the T-ABS wishes to identify which MAC control message transactions may be omitted.
Activation Deadline	6	LSB bits of Superframe number after the AAI-RNG-RSP message to confirm the activation of preassigned secondary carrier by sending the AAI-CM-IND message.	Shall be included when the T-ABS has preassigned the secondary carriers through AAI-HO-CMD.
Neighbor station measurement report indicator	1	1: Perform Neighbor station measurement report	Optional. Identifies Neighbor station measurement report is required during current network entry for ARS.

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Resource Retain Time	16	The default duration in units of 100 ms to which the ABS set the ABS_Resource_Retain_Timer.	May be included if Reentry Process Optimization Bit 3 is set to 1.
For (*i* = 0; *i*<N_FIDs; *i*++) {		N_FIDs is the number of FIDs to be included here. The maximum number of N_FIDs is 24.	Shall be included if the ABS needs to update the AMS's existing flows. FIDs that are not present here shall be regarded as guaranteed by the ABS.
SFID	32	SFID of the existing flow to be updated.	
FID	4		
Update or delete	1	0: delete the flow 1: updated QoS Info exists	

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Updated QoS Info	*variable*	The following parameters shall be included if the parameter needs to be updated. The parameter that does not have to be updated is not included in this field. — Traffic Priority parameter — Maximum Sustained Traffic Rate parameter — Maximum Traffic Burst parameter — Minimum Reserved Traffic Rate parameter — Maximum Latency parameter — Paging Preference parameter — Tolerated Jitter parameter — UL scheduling type — Unsolicited Grant Interval parameter — Unsolicited Polling Interval parameter — Primary Grant Polling Interval parameter — Primary Grant Size parameter — Secondary Grant Polling Interval parameter — Secondary Grant Size parameter — Adaptation Method — Access Class — Differentiated BR Timer — Predefined BR index — BR action — BR size — Initial Backoff Window Size — Maximum Backoff Window Size — Backoff Scaling Factor — MAC in-order delivery indicator — Vendor ID	Present if needed.
ROHC support	1	0: not support 1: support	Present if needed.
PHS support	1	Indicates the level of PHS support. 0: *Reserved* 1: Packet PHS	Present if needed.
If (ARQ parameters are needed) {			
ARQ Enable	1	0 = ARQ Not Requested/Accepted 1 = ARQ Requested/Accepted	Present if needed.
ARQ_WINDOW_SIZE	16	>0 and ≤ (ARQ_BSN_MODULUS/2)	Present if needed.

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
ARQ_BLOCK_LIFETIME	16	0 = Infinite 1–6 553 500 µs (100 µs granularity)	Present if needed.
ARQ_SYNC_LOSS_TIMEOUT	16	0 = Infinite 1–6 553 500 µs (100 µs granularity)	Present if needed.
ARQ_RX_PURGE_TIMEOUT	16	0 = Infinite 1–6 553 500 µs (100 µs granularity)	Present if needed.
ARQ_SUB_BLOCK_SIZE	3	Bit 0–2: encoding for selected block size (P), where the selected block size is equal to $2^{(P+3)}$, $0 \leq P \leq 7$. ARQ sub-block size is byte unit.	Present if needed.
ARQ_ERROR_DETECTION_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)	Present if needed.
ARQ_FEEDBACK_POLL_RETRY_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)	Present if needed.
}			
}			
Unsolicited bandwidth grant indicator	1	1: indicates an unsolicited BW grant will be available for transmission of BR header without request from AMS during network entry	Shall be included when AMS is attempting network entry.
CLC Response	*variable*	The information of co-located coexistence response (as defined in Table 6-46).	Shall be included when the AMS is attempting network reentry after HO if the AMS has any Type I or II CLC class active before handover.
for (*i* = 0; *i* < N_CSG_IDs; *i*++) {		N_CSG_IDs is the number of CSGIDs belong to the Femto ABS.	Optional. If included, to help the AMS make the decision if the Femto ABS is accessible or not.
CSGID	*variable*	CSGID of the Femto ABS sending the AAI-RNG-RSP.	
}			
For (*i* = 0; *i* < N_Redirect_Info; *i*++) {		N_Redirect_Info is the number of redirection information included here. ABSID, preamble index, and center frequency for one or more neighbor ABSs of the S-ABS. N_Redirection_Info: 1..8.	Sent by S-ABS to aid cell reselection in case the S-ABS does not allow the AMS to perform entry (due to various reasons such as high S-ABS load, non existence of CSG membership, etc.).
ABSID for neighbor ABS	48		

Table 6-30—AAI-RNG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Preamble index for neighbor ABS	10		
Center frequency for neighbor ABS	32	Center frequency (in unit of Hz).	
}			
Ranging Request bit	1	1: AMS shall send the AAI-RNG-CFM message after a successful periodic ranging	Shall be included when S-ABS performs coverage loss detection procedure (6.2.26).
For (*i* = 0; *i*<N_Invalid_FIDs; *i*++) {		N_Invalid_FIDs is the number of invalid FIDs listed here. The maximum number of N_Invalid_FIDs is 24.	Shall be included if there is any invalid FID. Invalid FID is a FID whose FID change count in AAI-RNG-REQ is different from the FID change count stored at the ABS. ABS and AMS may exchange the AAI-DSx-messages for invalid FIDs.
FID	4		
DL/UL indicator	1	0b0: Downlink 0b1: Uplink	
}			
SAID update bitmap	16	Bitmap for indicating the specific FID(s) that are being updated to SAID of AES-CTR.	Shall be included if specific FID(s) are to be remapped to SAID of AES-CTR in case of Zone Switch from LZone to MZone.
If (it is under network reentry for HO){			
For (*i* = 0; *i*< M; *i*++) {		Number of Multicast Group ID and FID (M) to update in the T-ABS[1..16]. Mapping of current Multicast Group ID and FID and new Multicast Group ID and FID to be updated. Based on the value of Num of Multicast Group ID and FID to be updated.	Present if it needs to be updated.
Current Multicast Group ID	12		
Current FID	4		
New Multicast Group ID	12		
New FID	4		
}			

Table 6-30—AAI-RNG-RSP message field description *(continued)*

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

6.2.3.3 AAI-RNG-ACK

The AAI-RNG-ACK message is sent by the ABS in response to the CDMA ranging request during initial ranging, periodic ranging, and HO ranging in order to provide PHY-level adjustment (e.g., timing offset, power level, and frequency offset). In addition, it may also be transmitted asynchronously to send corrections based on measurements that have been made on other received data or MAC messages. As a result, the AMS shall be prepared to receive an AAI-RNG-ACK at any time, not just following a ranging preamble transmission. Upon reception of ranging preamble codes, the AAI-RNG-ACK message is transmitted by the ABS in a DL resource allocated by Broadcast assignment A-MAP IE. If ABS receives a dedicated ranging preamble code, the AAI-RNG-ACK message in response to the ranging preamble code may be allocated by DL basic assignment A-MAP IE with unicast STID. When the AAI-RNG-ACK message is sent unsolicitedly to a specific user, the AAI-RNG-ACK message is allocated by DL basic assignment A-MAP IE with unicast STID, and it shall not contain Number of frame identifiers, Frame identifier, RNG-ACK Bitmap, Number of received codes, and Ranging preamble code index. When the AMS receives an unsolicited AAI-RNG-ACK message, it shall reset the periodic ranging timer and adjust its PHY parameters as notified in the AAI-RNG-ACK message. Upon reception of ranging preamble codes, the broadcast AAI-RNG-ACK provides responses to all the successfully received and detected ranging preamble codes in all the ranging opportunities in a frame indicated by the frame identifier. If no ranging preamble code is detected in a ranging resource allocation for periodic ranging or initial/HO ranging, the AAI-RNG-ACK may be omitted. For initial ranging and HO ranging, if all the ranging statuses of the detected initial/HO ranging preambles are equal to “success” and no UL transmission parameter adjustments are needed, the AAI-RNG-ACK may be omitted by allocating UL resources with CDMA Allocation A-MAP IEs or basic assignment A-MAP IEs for all the detected initial/HO ranging preambles. RNG-ACK Bitmap (starting from LSB) is encoded in ascending order based on the opportunity index.

Table 6-31—AAI-RNG-ACK message field description

Field	Size (bits)	Value/Description	Condition
If (transmitted in a DL resource allocated by Broadcast assignment A-MAP IE) {			
For (i = 0; i < N_Frame_Identifiers; i++) {		The number of frame identifiers (i.e., N_Frame_Identifiers) [1..8] included in this RNG-ACK message	
Frame identifier	4	Frame that contains the ranging opportunities to which this message refers. The frame identifier is produced by concatenating the following two values: 1) The 2 least significant bits of the superframe number. 2) The frame index within the superframe (ranging from 0b00 to 0b11).	
RNG-ACK Bitmap	4	Each bit indicates the decoding status of the corresponding ranging opportunity. 0b0: No ranging code is detected 0b1: At least one code is detected	
For each 0b1-bit in the RNG-ACK Bitmap {			
For (j = 0; j < N_Received_Codes; j++) {		The number of ranging preamble code indices (i.e., N_Received_Codes) [1..64] detected in this corresponding ranging opportunity.	
Ranging preamble Code Index	6	Ranging preamble code index received in this ranging opportunity.	
Ranging Status	2	Indicate whether ranging preamble code is received within acceptable limits by ABS. 0b00 = success 0b01 = abort 0b10 = continue	
If (Ranging Status == 0b01) {			
Ranging Abort Timer	16	Timer defined by an ABS to prohibit the AMS from attempting network entry at this ABS, for a specific time duration. Value: 0 (Do not try ranging again at the ABS.) Value: 1–65 535, in units of seconds	
}else if (Ranging Status == 0b00|0b10) {			

Table 6-31—AAI-RNG-ACK message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Adjustment parameters indication (API)	3	Bit 0: Time offset adjustment indication Bit 1: Power level adjustment indication Bit 2: Frequency offset adjustment indication	
If(API Bit 0==0b1) {			
Timing offset adjustment	15	Amount of time required to adjust AMS transmission (in units of 1/Fs). MSB 1 bit represents the sign of the value. That is, the value is negative (–) if the MSB=0b1, and the value is positive (+) if the MSB=0b0. LSB 14 bits represent timing offset correction value of [1..16384] that corresponds to 0x0000 ~ 0x3FFF, respectively. The AMS shall advance its transmission time if the value is negative (i.e., MSB = 0b1) and delay its transmission time if the value is positive (i.e., MSB = 0b0).	
}			
If(API Bit 1==0b1) {			
Power level adjustment	4	Power level adjustment that expresses the change in power level (in multiples of 1 dB) that the AMS shall apply to its current transmission power for initial ranging. MSB 1 bit represents the sign of the value. That is, the value is negative(–) if the MSB=0b1, and the value is positive(+) if the MSB = 0b0. LSB 3 bits represent power level correction value of [1..8] that corresponds to 0b000 ~ 0b111, respectively.	
}			
If (API Bit 2==0b1) {			

Table 6-31—AAI-RNG-ACK message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Frequency offset adjustment	9	Frequency offset adjustment. Relative change in transmission frequency. The correction is 2% of the subcarrier spacing (f) multiplied by the 9-bit number interpreted as a signed integer. MSB 1 bit represents the sign of the value. That is, the value is negative(–) if the MSB=0b1, and the value is positive(+) if the MSB=0b0. LSB 8 bits represent a frequency offset correction value of [1..256] that corresponds to 0x00 ~ 0xFF, respectively.	
}			
}//end of (Ranging Status == 0b00|0b10)			
}//end of for			
}//end of for each			
}//end of for			
} else if (transmitted in a DL resource allocated by DL basic assignment A-MAP IE) {			
Ranging Status	2	Indicate whether ranging preamble code or UL burst is received within acceptable limits by ABS. 0b00 = success 0b01 = abort 0b10 = continue	
If (Ranging Status == 0b01) {			
Ranging Abort Timer	16	Timer defined by an ABS to prohibit the AMS from attempting network entry at this ABS, for a specific time duration. Value: 0 (Do not try ranging again at the ABS.) Value: 1–65 535, in units of seconds	
}else if (Ranging Status == 0b00|0b10) {			
Adjustment parameters indication (API)	3	Bit 0: Time offset adjustment indication Bit 1: Power level adjustment indication Bit 2: Frequency offset adjustment indication	

Table 6-31—AAI-RNG-ACK message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If(API Bit 0 == 0b1) {			
Timing offset adjustment	15	Amount of time required to adjust AMS transmission (in units of 1/Fs). MSB 1 bit represents the sign of the value. That is, the value is negative(–) if the MSB = 0b1, and the value is positive(+) if the MSB = 0b0. LSB 14 bits represent timing offset correction value of [1..16384] that corresponds to 0x0000 ~ 0x3FFF, respectively. The AMS shall advance its transmission time if the value is negative (i.e., MSB = 0b1) and delay its transmission time if the value is positive (i.e., MSB = 0b0).	
}			
If(API Bit 1 == 0b1) {			
Power level adjustment	4	Power level adjustment that expresses the change in power level (in multiples of 1 dB) that the AMS shall apply to its current transmission power for initial ranging. MSB 1 bit represents the sign of the value. That is, the value is negative(–) if the MSB = 0b1, and the value is positive(+) if the MSB = 0b0. LSB 3 bits represent power level correction value of [1..8] that corresponds to 0b000 ~ 0b111, respectively	
}			
If (API Bit 2 == 0b1) {			
Frequency offset adjustment	9	Frequency offset adjustment. Relative change in transmission frequency. The correction is 2% of the subcarrier spacing (f) multiplied by the 9-bit number interpreted as a signed integer. MSB 1 bit represents the sign of the value. That is, the value is negative(–) if the MSB = 0b1, and the value is positive(+) if the MSB = 0b0. LSB 8 bits represent frequency offset correction value of [1..256] that corresponds to 0x00 ~ 0xFF, respectively.	

Table 6-31—AAI-RNG-ACK message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
}			
}//end of (Ranging Status == 0b00|0b10)			
}			

6.2.3.4 AAI-RNG-CFM

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

— STID of the AMS

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

Table 6-32—AAI-RNG-CFM message field description

Field	Size (bits)	Value/Description	Condition
STID	12	STID of the AMS	N/A

6.2.3.5 AAI-SBC-REQ

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

Table 6-33—AAI-SBC-REQ message field description

Field	Size (bits)	Value/Description	Condition
If (AMS requests transmittal of NSP information) {			
SIQ (Service Information Query)	2	Bit 0: Indicates that the AMS requests transmittal of the NSP List for the list of NSP IDs supported by the Operator Network that includes the current ABS. Bit 1: Indicates that the AMS requests transmittal of the Verbose NSP Name List in addition to the NSP List; bit 1 shall not be set to a value of '1' unless bit 0 is set to 1.	
} else {			
CAPABILITY_INDEX	5	It refers to the "Capability Class" that the AMS can support. Value: 0~31.	
DEVICE_CLASS	5	It refers to the "Device Class" that the AMS can support. Value: 0~31.	
CLC Request	*variable*	See Table 6-45.	Present if AMS requests to activate one Type I or II CLC class for fast CLC class activation during initial network entry.
Long TTI for DL	1	If Bit 0 = 1, it supports.	Present as needed.
UL sounding	2	If Bit 0 = 1, decimation separation based sounding (FDM) supports. If Bit 1 = 1, cyclic shift separation based sounding (CDM) supports.	Present as needed.
OL Region	3	If Bit 0 = 1, OL Region type 0 supports. If Bit 1 = 1, OL Region type 1, CDR and CoFIP supports. If Bit 2 = 1, OL Region type 2 supports.	Present as needed.
DL resource metric for FFR	1	If Bit 0 = 1, it supports.	Present as needed.
Max. Number of streams for SU-MIMO in DL MIMO	3	The number in the range 1 through 8 that is higher by 1 than this field.	Present as needed.
Max. Number of streams for CL MU-MIMO (MIMO mode 4) in AMS point of view in DL MIMO	1	The number in the range 1 through 2 that is higher by 1 than this field.	Present as needed.

Table 6-33—AAI-SBC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
DL MIMO mode	6	If Bit 0 = 1, mode0 supports. If Bit 1 = 1, mode1 supports. If Bit 2 = 1, mode 2 supports. If Bit 3 = 1, mode 3 supports. If Bit 4 = 1, mode 4 supports. If Bit 5 = 1, mode 5 supports.	Present as needed.
feedback support for DL	11	If Bit 0 = 1, differential mode supports. If Bit 1 = 1, MIMO feedback mode 0 supports. If Bit 2 = 1, MIMO feedback mode 1 supports. If Bit 3 = 1, MIMO feedback mode 2 supports. If Bit 4 = 1, MIMO feedback mode 3 supports. If Bit 5 = 1, MIMO feedback mode 4 supports. If Bit 6 = 1, MIMO feedback mode 5 supports. If Bit 7 = 1, MIMO feedback mode 6 supports. If Bit 8 = 1, MIMO feedback mode 7 supports. If Bit 9 = 1, Long-term reporting disabling support for MFM 0,4,7. If Bit 10 = 1, Short-term reporting disabling support for MFM 2,3,5,6.	Present as needed.
Subband assignment A-MAP IE support	1	If Bit 0 = 1, DL/UL Subband assignment A-MAP IE supports.	Present as needed.
DL pilot pattern for MU MIMO	2	If Bit 0 = 1, DL 4 stream pilot pattern for DL MU MIMO supports. If Bit 1 = 1, DL 8 stream pilot pattern for DL MU MIMO supports.	Present as needed.
Number of Tx antenna of AMS	2	The number in the range {1, 2, 4} that is higher by 1 than this field.	Present as needed.
Max. Number of streams for SU-MIMO in UL MIMO(1/2/3/4)	2	The number in the range 1 through 4 that is higher by 1 than this field.	Present as needed.
Max. Number of streams for MU-MIMO in AMS point of view in UL MIMO(1/2/3/4)	2	The number in the range 1 through 4.	Present as needed.
UL pilot pattern for MU MIMO	3	If Bit 0 = 1, UL 2 stream pilot pattern supports. If Bit 1 = 1, UL 4 stream pilot pattern supports. If Bit 2 = 1, UL 8 stream pilot pattern supports.	Present as needed.

Table 6-33—AAI-SBC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
UL MIMO mode	5	If Bit 0 = 1, mode0 supports. If Bit 1 = 1, mode1 supports. If Bit 2 = 1, mode 2 supports. If Bit 3 = 1, mode 3 supports. If Bit 4 = 1, mode 4 supports.	Present as needed.
Modulation scheme	2	If Bit 0 = 1, DL 64 QAM supports. If Bit 1 = 1, UL 64 QAM supports.	Present as needed.
UL HARQ buffering capability	7	Bit 0–6: The number that is higher by 1 than this field is the amount of information bits in 4800 bytes units the AMS can buffer in the UL.	Present as needed.
DL HARQ buffering capability	7	Bit 0–6: The number that is higher by 1 than this field is the steady amount of aggregated DL HARQ information bits per frame in units of 4800 bytes, at which the aimed combining gain or better is obtained in the benchmark scenario, as defined in 6.2.14.2.1.3.	Present as needed.
AMS DL processing capability per subframe	7	Bit 0–6: The number that is higher by 1 than this field is the steady amount of aggregated DL data information bits per subframe in units of 600 bytes that the AMS can process.	Present as needed.
AMS UL processing capability per subframe	7	Bit 0–6: The number that is higher by 1 than this field is the steady amount of aggregated UL data information bits per subframe in units of 600 bytes that the AMS can process.	Present as needed.
FFT size(2048/1024/512)	3	If Bit 0 = 1, FFT 2048 supports. If Bit 1 = 1, FFT 1024 supports. If Bit 2 = 1, FFT 512 supports.	Present as needed.
Authorization policy support	1	If Bit 0 = 0, No authorization. If Bit 0 = 1, EAP-based authorization is supported.	Present as needed.
Inter-RAT Operation Mode	2	0b00: single radio mode operation for inter RAT handover. 0b01: multi radio mode operation for inter RAT handover. 0b10–0b11: *Reserved*.	Present as needed.
Supported Inter-RAT type	8	1 indicates support, 0 indicates not supported: Bit 0: IEEE 802.11. Bit 1: GERAN(GSM/GPRS/EGPRS). Bit 2: UTRAN. Bit 3: E-UTRAN. Bit 4: CDMA 2000. Bit 5–7: *Reserved*, set to zero.	Present as needed.
MIH Capability Supported	1	If Bit 0 = 1, the capability of IEEE 802.21 Media Independent Handover Services supports.	Present as needed.

Table 6-33—AAI-SBC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
MAX Tx Power	24	The maximum available power of the carrier for initial network entry. Bit 0–7: Maximum transmitted power for QPSK Bit 8–15: Maximum transmitted power for 16-QAM Bit 15–23: Maximum transmitted power for 64-QAM Each unsigned 8-bit integer specifies the maximum transmitted power value in dBm. The maximum transmitted power is quantized in 0.5 dBm steps ranging from –64 dBm (encoded 0x00) to 63.5 dBm (encoded 0xFF). Values outside this range shall be assigned the closest extreme. If AMS does not support 64-QAM, the AMS shall report the value of 0x00 for Bit 15–23	Shall be present.
If (ARS is a sender of AAI-SBC-REQ) {			//only available during ARS network entry phase.
Relay mode	1	0b0: TTR relay mode 0b1: STR relay mode	
if (Relay mode == 0b0){			
ARSTTG	6	ARSTTG value (µs). It shall be less than 50 µs.	
ARSRTG	6	ARSRTG value (µs). It shall be less than 50 µs.	
}			
}			
Visited NSP ID	24	NSP ID of the Network Service Provider the AMS intends to be the conduit for authentication to the AMS home network.	Present as needed.
}			

6.2.3.6 AAI-SBC-RSP

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

Table 6-34—AAI-SBC-RSP message field description

Field	Size (bits)	Value/Description	Condition
If (SIQ bit 0 in AAI-SBC-REQ is set and AAI-SII-ADV Message Pointer is not included) {			
for (*i* = 0; *i* < number of NSP IDs; *i*++) {		List of the Network Service Provider identifiers.	
NSP identifier	24	NSP identifier that ABS supports.	
}			
If (if SIQ bit 1 in AAI-SBC-REQ is set) {			
for (*i* = 0; i< number of NSP IDs; *i*++) {		List of the verbose names of the NSPs. The order of Verbose NSP Names presented shall be in the same order as the NSP IDs presented in the NSP List.	
verboseNspName	*variable* (1...128 × 8)	Verbose NSP name string.	
}			
}			
else if (SIQ bit 0 in AAI-SBC-REQ is set and if AAI-SII-ADV Message Pointer is included) {			
AAI-SII-ADV Message Pointer	14	The 14 least significant bits of the frame number of the frame in which the AAI-SII-ADV message with requested NSP information is transmitted.	
} else {			
CAPABILITY_INDEX	5	It refers to the “Capability Class” that the AMS can support. Value: 0~31.	
DEVICE_CLASS	5	It refers to the “Device Class” that the AMS can support. Value: 0~31.	
CLC Response	*variable*	See Table 6-46.	Present if CLC Request is included in the corresponding AAI-SBC-REQ.
Long TTI for DL	1	If Bit 0 = 1, it supports.	Present as needed.
UL sounding	2	If Bit 0 = 1, decimation separation based sounding (FDM) supports. If Bit 1 = 1, cyclic shift separation based sounding (CDM) supports.	Present as needed.

Table 6-34—AAI-SBC-RSP message field description *(continued)*

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

Table 6-34—AAI-SBC-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Max. Number of streams for SU-MIMO in UL MIMO(1/2/3/4)	2	The number in the range 1 through 4 that is higher by 1 than this field.	Present as needed.
Max. Number of streams for MU-MIMO in AMS point of view in UL MIMO(1/2/3/4)	2	The number in the range 1 through 4.	Present as needed.
UL pilot pattern for MU MIMO	3	If Bit 0 = 1, UL 2 stream pilot pattern supports. If Bit 1 = 1, UL 4 stream pilot pattern supports. If Bit 2 = 1, UL 8 stream pilot pattern supports.	Present as needed.
UL MIMO mode	5	If Bit 0 = 1, mode 0 supports. If Bit 1 = 1, mode 1 supports. If Bit 2 = 1, mode 2 supports. If Bit 3 = 1, mode 3 supports. If Bit 4 = 1, mode 4 supports.	Present as needed.
Modulation scheme	2	If Bit 0 = 1, DL 64 QAM supports. If Bit 1 = 1, UL 64 QAM supports.	Present as needed.
UL HARQ buffering capability	7	Bit 0–6: The number that is higher by 1 than this field is the amount of information bits in 4800 bytes units the AMS can buffer in the UL.	Present as needed.
DL HARQ buffering capability	7	Bit 0–6: The number that is higher by 1 than this field is the steady amount of aggregated DL HARQ information bits per frame in units of 4800 bytes, at which the aimed combining gain or better is obtained in the benchmark scenario, as defined in 6.2.14.2.1.3.	Present as needed.
AMS DL processing capability per subframe	7	Bit 0–6: The number that is higher by 1 than this field is the steady amount of aggregated DL data information bits per subframe in units of 600 bytes that the AMS can process.	Present as needed.
AMS UL processing capability per subframe	7	Bit 0–6: The number that is higher by 1 than this field is the steady amount of aggregated UL data information bits per subframe in units of 600 bytes that the AMS can process.	Present as needed.
FFT size (2048/1024/512)	3	If Bit 0 = 1, FFT 2048 supports. If Bit 1 = 1, FFT 1024 supports. If Bit 2 = 1, FFT 512 supports.	Present as needed.
Authorization policy support	1	If Bit 0 = 0, No authorization. If Bit 0 = 1, EAP-based authorization is supported.	Present as needed.

Table 6-34—AAI-SBC-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Inter-RAT Operation Mode	2	0b00: single-radio mode operation for inter-RAT handover 0b01: multi-radio mode operation for inter-RAT handover 0b10–0b11: *Reserved*	Present as needed.
Supported Inter-RAT type	8	1 indicates support, 0 indicates not support: Bit 0: IEEE 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	Present as needed.
MIH Capability Supported	1	If Bit 0 = 1, the capability of IEEE 802.21 Media Independent Handover Services supports.	Present as needed.
Visited NSP Realm	*variable* (1...128 × 8)	Visited NSP Realm.	Present if the Visited NSP ID is found in the AAI-SBC-REQ.
}			

6.2.3.7 AAI-SON-ADV message

This message is optional and used by an ABS connected to a core access network that supports SON (Self-Organizing and Optimizing Networks) to broadcast relevant SON information for action types as defined in Table 6-35.

Table 6-35—Parameters for the AAI-SON-ADV message

Field	Size (bits)	Value/Description	Condition
Action Type	3	Used to indicate the purpose of this message 0b000: ABS Reconfiguration 0b001: ABS Restart 0b010: ABS Scanning 0b011: ABS Reliability 0b100: LDM parameter change	Mandatory
If (Action Type == 0b000) {			
New IDcell	10	New IDcell that the ABS will use after the reconfiguration process	
Unavailable Start Time (UST)	8	Start of unavailable time in unit of frame	Mandatory
Unavailable Time Interval (UTI)	8	Interval of unavailable time in unit of superframe	Mandatory

Table 6-35—Parameters for the AAI-SON-ADV message *(continued)*

Field	Size (bits)	Value/Description	Condition
}			
else if (Action Type == 0b001){			
Unavailable Start Time (UST)	8	Start of unavailable time in unit of frame	Mandatory
Unavailable Time Interval (UTI)	8	Interval of unavailable time in unit of superframe	Mandatory
} else if (Action Type == 0b010) {			
Unavailable Start Time (UST)	8	Start of unavailable time in unit of frame	Mandatory
Unavailable Time Interval (UTI)	8	Interval of unavailable time in unit of superframe	Mandatory
}			
else if (Action Type == 0b011) {			
Reason	3	0b000: Power down 0b001: Power reduction 0b010: FA change 0b011: Backhaul link down 0b100: Disable subframes	Mandatory
If (Reason == 0b000) {			
Time of Power Down	8	Expected time when the Femto ABS will be powered down in units of frame	Mandatory
Expected uptime of BS	8	Expected uptime of BS in units of superframe	Optional
} else if (Reason == 0b001) {			
Tx Power Reduction	10	dB value of Tx power reduction	Mandatory
Expected time of power reduction	8	Expected resource adjustment time in units of frame	
} else if (Reason == 0b010) {			
FA index	8	FA index	Mandatory
Expected downtime of current FA	8	Expected current FA downtime in units of frame	
Expected uptime of new FA	8	Expected uptime of new FA in units of superframe	Optional
} else if (Reason == 0b100) {			

Table 6-35—Parameters for the AAI-SON-ADV message *(continued)*

Field	Size (bits)	Value/Description	Condition
Disabled subframes index	6	The status of DL subframes Bit 0: The status of the 1st DL subframe Bit 1: The status of the 2nd DL subframe Bit 2: The status of the 3rd DL subframe Bit 3: The status of the 4th DL subframe Bit 4: The status of the 5th DL subframe Bit 5: The status of the 6th DL subframe (0 means disabled or no such subframe; 1 means enabled)	Mandatory
}			
}			
else if (Acton Type == 0b100) {			
LDM parameter—AI	4	The new AI for LDM	Mandatory
LDM parameter—UAI	8	The new UAI for LDM	Mandatory
LDM parameter—SFO	9	The new SFO for LDM	Mandatory
}			
Recommended BSID list	*variable*	Recommended BSID list	It is optional to help AMS to HO

6.2.3.8 AAI-REG-REQ

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

Table 6-36—AAI-REG-REQ message field description

Field	Size (bits)	Value/Description	Condition
AMS MAC address	48	AMS's real MAC address.	
MAXIMUM_ARQ_BUFFER_SIZE	23	ARQ buffer size depending on AMS's memory. Buffer size is defined as 2^P ($0 \le P \le 23$). Unit is byte.	Present if needed.
MAXIMUM_NON_ARQ_BUFFER_SIZE	23	Non-ARQ buffer size depending on AMS's memory. Buffer size is defined as 2^P ($0 \le P \le 23$). Unit is byte.	Present if needed.

Table 6-36—AAI-REG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Multicarrier capabilities	3	0b000: No MC modes 0b001: Basic MC mode 0b010: Multicarrier Aggregation 0b011: Multicarrier Switching 0b100: Both Multicarrier Aggregation and Multicarrier Switching	Present if needed.
Zone Switch Mode Support	1	Indicates whether the AMS has a capability to maintain its data communication with the ABS in LZone while performing network reentry in MZone 0b0: Not supported 0b1: Supported	Present if needed.
If (LBS Capabilities are required to setup) {			
Capability for supporting A-GPS method	1	0b0: No support 0b1: Support	
}			
If (Interference mitigation is supported) {			
DL PMI coordination capability	1	0: AMS is not DL PMI coordination capable 1: AMS is DL PMI coordination capable	
DL collaborative multi-BS MIMO capability	1	0: AMS is not DL collaborative multi-BS MIMO capable 1: AMS is DL collaborative multi-BS MIMO capable	
DL closed-loop multi-BS macro-diversity capability	1	0: AMS is not DL closed-loop multi-BS macro-diversity capable 1: AMS is DL closed-loop multi-BS macro-diversity capable	
UL PMI combination capability	1	0: AMS is not UL PMI combination capable 1: AMS is UL PMI combination capable	
Multi_BS sounding calibration capability	1	0: AMS is not multi_BS sounding calibration capable 1: AMS is multi_BS sounding calibration capable	
}			

Table 6-36—AAI-REG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
E-MBS capabilities	3	If Bit 0 is set to 1, it indicates E-MBS in S-ABS only is supported If Bit 1 is set to 1, it indicates macro-diversity multi ABS E-MBS is supported If Bit 2 is set to 1, it indicates non-macro-diversity multi ABS E-MBS is supported If all Bit 0~Bit 2 are set to 0, it indicates no E-MBS is supported	Present if needed.
Channel BW and Cyclic prefix	15	If Bit 0 = 1, 5 MHz supports (1/16 CP) If Bit 1 = 1, 5 MHz supports (1/8 CP) If Bit 2 = 1, 5 MHz supports (1/4 CP) If Bit 3 = 1, 10 MHz supports (1/16 CP) If Bit 4 = 1, 10 MHz supports (1/8 CP) If Bit 5 = 1, 10 MHz supports (1/4 CP) If Bit 6 = 1, 20 MHz supports (1/16 CP) If Bit 7 = 1, 20 MHz supports (1/8 CP) If Bit 8 = 1, 20 MHz supports (1/4 CP) If Bit 9 = 1, 8.75 MHz supports (1/16 CP) If Bit 10 = 1, 8.75 MHz supports (1/8 CP) If Bit 11 = 1, 8.75 MHz supports (1/4 CP) If Bit 12 = 1, 7 MHz supports (1/16 CP) If Bit 13 = 1, 7 MHz supports (1/8 CP) If Bit 14 = 1, 7 MHz supports (1/4 CP)	Present if needed.
Frame configuration to support R1 R1.0	4	If Bit 0 = 1, R1 5 MHz is supported (TDD only) If Bit 1 = 1, R1 10 MHz is supported (TDD only) If Bit 2 = 1, R1 8.75 MHz is supported (TDD only) If Bit 3 = 1, R1 7 MHz is supported (TDD only)	Present if needed.
Persistent Allocation support	1	If Bit 0 = 1, it supports	Present if needed.
Group Resource Allocation support	1	If Bit 0 = 1, it supports	Present if needed.

Table 6-36—AAI-REG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Co-located coexistence capability support	5	If Bit 0 =1, Type I CLC class support If Bit 1 =1, Type II CLC class subtype 1 If Bit 2 =1, Type II CLC class subtype 2 If Bit 3 =1, Type II CLC class subtype 3 If Bit 4 =1, Type III CLC class	Present if needed.
HO trigger metric	4	If Bit 0 =1, BS CINR mean supports If Bit 1 =1, BS RSSI mean supports If Bit 2 =1, Relative delay supports If Bit 3 =1, BS RTD supports	Present if needed.
EBB Handover support	1	Indicates whether the AMS has a capability to support EBB operation during handover 0b0: Not supported 0b1: Supported	Present if needed.
If (EBB Handover support == 0b1) {			
Minimal HO Reentry Interleaving Interval	2	The minimal HO_Reentry_Interleaving_Interval measured in frames. For AMS capable of Carrier Aggregation (Multicarrier Capability = 0b010 or 0b100), this value shall be 0.	
}			
Capability for sounding antenna switching support	1	0b0: No support 0b1: Support	Present if needed.
If (Capability for sounding antenna switching support == 0b1) {			
Antenna configuration for sounding antenna switching	1	0b0: Among DL Rx antennas 0b1: Among UL Tx antennas	
}			

Table 6-36—AAI-REG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
CS type	16	A bit set to ‘1’ indicates which CS Type the AMS supports Bit 0: *Reserved* Bit 1: Packet, IPv4 Bit 2: Packet, IPv6 Bit 3: Packet, IEEE 802.3/Ethernet[a] Bit 4: *Reserved* Bit 5: *Reserved* Bit 6: *Reserved* Bit 7: *Reserved* Bit 8: *Reserved* Bit 9: *Reserved* Bit 10: *Reserved* Bit 11: *Reserved* Bit 12: *Reserved* Bit 13: *Reserved* Bit 14: Packet, IP[b] Bit 15: Multiprotocol flow, IPv4 or IPv6 Traffic (a: Classifiers for IEEE 802.1Q VLAN tags may be applied to service flows of this CS type) (b: SDUs for service flows of this CS type may carry either IPv4 or IPv6 in the payload)	Present if needed.
Maximum number of classification rules	16	Maximum number of simultaneous admitted classification rules that a service flow supports.	Present if needed.
ROHC support	1	0: No support 1: Support	Present if needed.
PHS support	1	Indicates the level of PHS support. 0: *Reserved* 1: Packet PHS	Present if needed.
Host-Configuration-Capability-Indicator IE	1	Indicates whether the AMS supports the capability of configuring host using the received parameters through the AAI-REG-RSP message. (One bit indicator) 0b0: Not supported 0b1: Support	Shall be present.
Requested-Host-Configurations IE	*variable*	Includes requested host configuration options in DHCP Options format.	Shall be present when Host-Configuration-Capability-Indicator IE is set by 0b1 and additional host configurations are required.
Global carrier configuration change count	3	Indicates the AMS’s last received value of Global carrier configuration change count of the network. If set to 0, it implies that AMS never received a Global carrier configuration information.	

Table 6-36—AAI-REG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
AMS-initiated aGP Service Adaptation Capability:	1	0b0: No support 0b1: Support	Present if needed.
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address.	Present to indicate the vendor ID of the AMS sending this message if vendor-specific information is used.
Mobility features supported	4	A bit set to ‘1’ indicates which Mobility feature the AMS supports Bit 0: Mobility (HO) support Bit 1: Sleep mode support Bit 2: DCR mode support Bit 3: Reserved, this bit shall be ‘0’	Present if the AMS supports at least one feature.

6.2.3.9 AAI-REG-RSP

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

Table 6-37—AAI-REG-RSP message field description

Field	Size (bits)	Value/Description	Condition
STID	12	AMS identifier that the ABS assigns to the AMS in place of the temporary STID that has been transferred by AAI-RNG-RSP message	Shall be included when an AMS is performing initial network entry or an AMS has no STID preassigned when it is performing network reentry procedure
MAPMask Seed	15	The value of this parameter is the seed used at the ABS to initiate the PRBS generator used to scramble the 40-bit A-A-MAP IE when the value of the STID included in this message is used as the CRC Mask Masking Code. See 6.3.5.3.2.4	Shall be present if STID is present
CRID	72	AMS identifier that the AMS has been assigned for coverage loss or DCR mode	Shall be included when AMS is attaching in the advanced network mode (i.e., network configuration bit in SFH = 0b0)

Table 6-37—AAI-REG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If (Femto ABS LDM parameters are required to setup) {			
Start_superframe_offset	9	The 9 LSB of the start superframe number	
Available_interval_length	4	Length of available interval in units of four frames	
Unavailable_interval_length	8	Length of unavailable intervals in units of four frames	
}			
If (LBS capabilities are required to setup) {			
Capability for supporting A-GPS method	1	0b0: No support 0b1: Support	
}			
If (Interference mitigation is supported) {			
DL PMI coordination capability	1	0: ABS is not DL PMI coordination capable 1: ABS is DL PMI coordination capable	
DL collaborative multi-BS MIMO capability	1	0: ABS is not DL collaborative multi-BS MIMO capable 1: ABS is DL collaborative multi-BS MIMO capable	
DL closed-loop multi-BS macro-diversity capability	1	0: ABS is not DL closed-loop multi-BS macro diversity capable 1: ABS is DL closed-loop multi-BS macro-diversity capable	
UL PMI combination capability	1	0: ABS is not UL PMI combination capable 1: ABS is UL PMI combination capable	
Multi_BS sounding calibration capability	1	0: ABS is not multi_BS sounding calibration capable 1: ABS is multi_BS sounding calibration capable	
}			
Antenna configuration for sounding antenna switching	1	0b0: Among DL Rx antennas This is only possible when Antenna configuration for sounding antenna switching in AAI-REG-REQ is 0b0. 0b1: Among UL Tx antennas	Present if needed

Table 6-37—AAI-REG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
E-MBS capabilities	3	If Bit 0 is set to 1, it indicates E-MBS in S-ABS only is supported If Bit 1 is set to 1, it indicates macro-diversity multi ABS E-MBS is supported If Bit 2 is set to 1, it indicates non-macro-diversity multi ABS E-MBS is supported If all Bit 0~Bit 2 are set to 0, it indicates no E-MBS is supported	Present if needed
Persistent Allocation support	1	If Bit 0 = 1, it supports	Present if needed
Group Resource Allocation support	1	If Bit 0 =1, it supports	Present if needed
HO trigger metric	4	If Bit 0 = 1, BS CINR mean supports If Bit 1 = 1, BS RSSI mean supports If Bit 2 = 1, Relative delay supports If Bit 3 = 1, BS RTD supports	Present if needed
CS type	16	A bit set to ‘1’ indicates which CS Type the ABS supports Bit 0: *Reserved* Bit 1: Packet, IPv4 Bit 2: Packet, IPv6 Bit 3: Packet, IEEE 802.3/Ethernet[a] Bit 4: *Reserved* Bit 5: *Reserved* Bit 6: *Reserved* Bit 7: *Reserved* Bit 8: *Reserved* Bit 9: *Reserved* Bit 10: *Reserved* Bit 11: *Reserved* Bit 12: *Reserved* Bit 13: *Reserved* Bit 14: Packet, IP[b] Bit 15: Multiprotocol flow, IPv4 or IPv6 Traffic (a: Classifiers for IEEE 802.1Q VLAN tags may be applied to service flows of this CS type) (b: SDUs for service flows of this CS type may carry either IPv4 or IPv6 in the payload)	Present if needed
Maximum number of classification rules	16	Maximum number of simultaneous admitted classification rules that a service flow supports	Present if needed
ROHC support	1	0: No support 1: Support	Present if needed
PHS support	1	Indicates the level of PHS support. 0: *Reserved* 1: Packet PHS	Present if needed

Table 6-37—AAI-REG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Resource_Retain_Time	16	The default duration in units of 100 ms to which the ABS set the ABS-Resource-Retain-Timer	Present if needed
IPv4-Host-Address IE	32	The allocated IPv4 Host Address for the AMS	May be included when AMS indicates its capability of configuring host parameters
IPv6-Home-Network-Prefix IE	64	The allocated IPv6 Home Network Prefix for the AMS	May be included when AMS indicates its capability of configuring host parameters
Additional-Host-Configurations IE	*variable*	Includes additional host configuration options in DHCP Options format	May be included when AMS sends Requested-Host-Configurations IE in AAI-REG-REQ or network decided to configure Additional-Host-Configuration parameters
For(i = 0; i < N_Redirect_Info; i++) {		Sent by S-ABS to aid cell reselection in the event the S-ABS is not able to allow the AMS to perform entry N_Redirect_Info [1..8] is the number of redirection information to be included here	Present if needed
ABSID	48	ABS ID of the neighbor	
Preamble index	10	Preamble index of the neighbor	
Center frequency	32	Center frequency (in unit of Hz) of the neighbor	
}			
CSGID Length	5	Length of CSGID	Since the CSGID can be of variable length (MAX up to 24 bits)
Global carrier configuration change count	3	Indicates the current value of Global carrier configuration change count of the network	
Multicarrier capabilities	3	0b000: No MC modes 0b001: Basic MC mode 0b010: Multicarrier Aggregation 0b011: Multicarrier Switching 0b100: Both Multicarrier Aggregation and Multicarrier Switching	Present if needed
CS specification for default service flow	8	Indicates the CS type selected for default service flow (refers to CS specification in the Table 6-133)	Shall be included if multiple CS types are enabled

Table 6-37—AAI-REG-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
if (ABS configures the CLC Limit parameters different from the default values in Table 6-142) {			
For(i = 0; i < N-CLC-Params; i++) {		N-CLC-Params [1..2] is the number of CLC Limit parameter sets to be included here	
Type I Indicator	1	Setting the bit to 1 indicates the CLC limit information are applicable to Type I CLC class	
Type II Indicator	1	Setting the bit to 1 indicates the CLC limit information are applicable to Type II CLC class	
Active Class Limit	3	0: The maximum number of active CLC classes is 8 x (x > 0): the maximum number of active CLC classes is x	
Active Ratio Limit	6	x: the maximum CLC active ratio is x / 100	
Active Interval Limit	5	x: The maximum CLC active interval is $x \times m$ AAI subframes, where m is the total number of AAI subframes in a AAI frame	
}			
}			
AMS-initiated aGP Service Adaptation Capability:	1	0b0: No support 0b1: Support	Present if needed
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address	Present to indicate the vendor ID of the AMS sending this message if vendor-specific information is used
Mobility features supported	4	A bit set to '1' indicates which Mobility feature the AMS supports Bit 0: Mobility (HO) support Bit 1: Sleep mode support Bit 2: DCR mode support Bit 3: Reserved, this bit shall be '0'	Present if the AMS supports at least one feature

6.2.3.10 AAI-HO-IND

The AMS may send the AAI-HO-IND MAC control message in HO preparation, HO execution, and HO cancellation. If Piggyback Extended Header is included in the AAI-HO-IND message, an aggregated bandwidth request size should be transferred to the T-ABS. If an incremental bandwidth request is piggybacked by the AMS, the Serving BS shall calculate the aggregated bandwidth request size and forward it to the T-ABS. The AAI-HO-IND message includes the information in Table 6-38.

Table 6-38—AAI-HO-IND message field description

Field	Size (bits)	Value/Description	Condition
HO Event Code	2	Used to distinguish AAI-HO-IND among different scenarios 0b00: T-ABS selection in case of multiple candidate T-ABSs in HO-CMD. The S-ABS does not meet the “ABS unreachable” triggers 0b01: All T-ABSs in AAI-HO-CMD are unreachable. The AMS includes a new T-ABS that was not included in AAI-HO-CMD. The S-ABS does not meet the “ABS unreachable” triggers 0b10: The S-ABS meets the “ABS unreachable” triggers. The AMS will attempt network reentry at the indicated T-ABS 0b11: HO cancel. The S-ABS does not meet the “ABS unreachable” triggers	
If (HO Event Code == 0b00 or 0b01 or 0b10) {			
T-ABS ID	48		
T-ABS Physical Carrier Index	6	Physical carrier index of the T-ABS where an AMS will perform network reentry procedure	May be included when the T-ABS is a multicarrier ABS
AMS Physical carrier index at the S-ABS	6	Recommended carrier index of the AMS that was used in the S-ABS, and to be used for network reentry to the T-ABS. All other AMS’s carriers that were used in the S-ABS can be used for data communication with the S-ABS	May be included when AMS’s multicarrier capability = 0b10, HO Reentry Mode = 1 and the target carrier is different from the serving carrier
}else if (HO Event Code == 0b11) {			
SFH mismatch indication	1	1: The AMS does not have the latest SFH for any of the T-ABSs included in the AAI-HO-CMD message; 0: Otherwise	
AK_COUNT	16	The AMS’s current value of the AK_COUNT	
}			

6.2.3.11 AAI-HO-REQ

In AMS-initiated HO, the AMS shall send the AAI-HO-REQ to the S-ABS to initiate the HO procedure. The parameters listed in Table 6-39 shall be included in the AAI-HO-REQ message.

Table 6-39—AAI-HO-REQ message field description

Field	Size (bits)	Value/Description	Condition
AAI-NBR-ADV Change count	3	AAI-NBR-ADV change count last received from the S-ABS	Shall be included if this message contains one or more recommended ABSs identified by using Neighbor_ABS_Index.
Carrier Preassignment Indication	1	Indicates whether AMS needs pre-assignment of secondary carriers at the T-ABS	May be included when AMS supports MC mode = 0b010 or 0b011 or 0b100.
for(i = 0; i < N_New_ABS_Index; i++) {		N_New_ABS_Index is the number of neighboring ABSs to be considered for HO, which are included in AAI-NBR-ADV message. Range: 0 ~ 256	
Neighbor_ABS_Index	8	ABS index corresponds to AAI-NBR-ADV	
ABS CINR mean	8	CINR mean of the new ABS	May be included if it is available at the AMS.
ABS RSSI mean	8	RSSI mean of the new ABS	May be included if it is available at the AMS.
Physical_Carrier_Index	6	Physical carrier index of the ABS	May be included for each ABS with ABS Index or ABS ID when the ABS is multicarrier ABS.
}			
for(i = 0; i < N_New_ABS_Full; i++) {		N_New_ABS_ID is the number of neighboring ABSs to be are identified by full considered for handover, which is 48-bit ABSID. Range: 0 ~ 256	
Neighbor_ABS_ID	48	The 48-bit neighbor ABSID	

Table 6-39—AAI-HO-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
ABS CINR mean	8	CINR mean of the new ABS	May be included if it is available at the AMS.
ABS RSSI mean	8	RSSI mean of the new ABS	May be included if it is available at the AMS.
Physical_Carrier_Index	6	Physical carrier index of the ABS	May be included for each ABS with ABS Index or ABS ID when the ABS is multicarrier ABS.
}			
for(*i* = 0; *i* < N_R1_BS_Index; *i*++) {		N_R1_ABS_Index is the number of neighboring R1 BS index to be considered for handover. Range: 0 ~ 255	
Change Count	3	AAI-NBR-ADV Change Count	
Neighbor BS Index	8	Indicates neighbor BS index index in AAI-NBR-ADV which contains the Change Count	
BS CINR mean	8	CINR mean of the new BS	May be included if it is available at the MS.
BS RSSI mean	6	RSSI mean of the new BS	May be included if it is available at the MS.

6.2.3.12 AAI-HO-CMD

The S-ABS shall send AAI-HO-CMD to initiate the HO procedure, or to acknowledge the AAI-HO-REQ sent by the AMS. The AAI-HO-CMD message shall include the parameters listed in Table 6-40.

Table 6-40—AAI-HO-CMD message field description

Field	Size (bits)	Value/Description	Condition
Mode	2	0b00: HO command 0b01: Zone switch command from MZone to LZone 0b10: AMS HO request rejected (ABS in list unavailable). In this case, AAI-HO-CMD message shall not include any T-ABS 0b11: *Reserved*	N/A
If (Mode == 0b00) {			

Table 6-40—AAI-HO-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
HO Reentry Mode	1	0b0: The AMS disconnects from the S-ABS before performing network reentry with the T-ABS 0b1: The AMS maintains communication with S-ABS while performing network reentry with the T-ABS	Shall not be set to 1 if the AMS does not support EBB (according to AAI-REG-REQ).
If (HO Reentry Mode == 0b1) {			
HO Reentry Interleaving Interval	8	If HO Reentry Interleaving Interval > 0, the AMS performs network reentry to the T-ABS within the HO Reentry Interval and continues data transmission with the S-ABS during HO Reentry Interleaving Interval. If HO Reentry Interleaving Interval = 0, the AMS performs multicarrier EBB (Entry Before Break) HO procedure per 6.2.8.2.9.2.2.	
If(HO Reentry Interleaving Interval > 0) {			
HO Reentry Interval	8	AMS performs network reentry at the T-ABS during HO Reentry Interval.	
HO Reentry Iteration	3	The requested number of iterating HO Reentry Intervals by an AMS.	
}			
AMS Physical carrier index at the S-ABS	6	Recommended carrier index of the AMS that was used in the S-ABS, and to be used for network reentry to the T-ABS. All other AMS's carriers that was used in the S-ABS can be used for data communication with the S-ABS.	May be included when the AMS's multicarrier capability = 0b010 or 0b100, and the target carrier is different from the serving carrier.
}//end of If (HO Reentry Mode == 0b1)			

Table 6-40—AAI-HO-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Disconnect time offset	8	Difference between Disconnect time and Action time in units of frames. The value of disconnect time shall be calculated for each T-ABS by adding/ subtracting this value with the value of Action time specified for this T-ABS. For HO_Reentry_Mode = 0, Disconnect time will be (Action time – Disconnect time offset); For HO_Reentry_Mode = 1, Disconnect time will be (Action time + Disconnect time offset).	
Resource_Retain_Time	16	The duration in units of 100 ms to which the T-ABS set the ABS-Resource-Retain-Timer.	Present if needed
for(*i* = 0; *i* < N_Target_BS; *i*++) {		N_Target_BS is the number of T-ABSs or target R1 BSs included in this message.	
targetBSID	48	BSID of the T-ABS or target R1 BS.	
SA-Preamble Index	10	Indicate the SA-Preamble index of the carrier.	Shall be included if the BS is T-ABS
Preamble Index	7	Indicate the preamble index of the neighbor BS.	Shall be included if the BS is target R1 BS
Center Frequency	32	Indicates center frequency (in unit of Hz) of the carrier.	Shall be included
Action Time	8	The 8 least significant bits of the absolute frame number at the T-ABS where the AMS starts to perform network reentry. When CDMA_RNG_FLAG is set to 1, it indicates the frame whereafter the AMS starts a CDMA ranging process. The action time should be set to a frame that includes either a non-dynamic ranging channel or a dynamic ranging channel. When CDMA_RNG_FLAG is set to 0, it indicates the frame where the AMS starts to expect the UL bandwidth allocation for transmission of RNG-REQ at target R1 BS or LZone (i.e., Fast ranging opportunity) or AAI-RNG-REQ at T-ABS.	

Table 6-40—AAI-HO-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
CDMA_RNG_FLAG	1	If CDMA_RNG_FLAG = 0, CDMA based ranging shall be skipped. Otherwise, if set to 1, it indicates that ranging shall be done.	
If(CDMA_RNG_FLAG == 0) {			
offsetData	7	It represents the value among –31.5 to 32 dB with 0.5 dB step.	Optional
offsetControl	7	It represents the value among –31.5 to 32 dB with 0.5 dB step.	Optional
Preassigned STID	12	STID assigned to the AMS by the T-ABS.	
}else {			
Dedicated CDMA ranging code	5	Indicates the dedicated ranging code.	Shall be present if Seamless HO = 1; otherwise optionally present
Ranging opportunity index	1	Indicates the index of the allocated ranging opportunity of the dynamic ranging channel used in the RA-ID. Ranging opportunity index shall be assigned by the T-ABS. The T-ABS shall assign unique ranging opportunity index that is not overlapped with other ranging channel in the allocated frame. 0b0: 0b01 0b1: 0b10	Optional
Ranging opportunity Subframe Index	3	Indicates the subframe index of the allocated ranging opportunity. The subband of a dynamic ranging channel is same as the ranging channel allocated by SFH.	Optional
Preassigned STID	12	STID assigned to the AMS by the T-ABS.	Optional
}			

Table 6-40—AAI-HO-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Reentry process optimization	5	For each bit location, a value of 0 indicates the associated reentry MAC control messages shall be required, a value of 1 indicates the reentry MAC control message may be omitted. Bit 0: Omit AAI-SBC-REQ/RSP MAC control messages during reentry processing Bit 1: Omit PKM Authentication phase Bit 2: Omit AAI-REG-REQ/RSP message during reentry processing Bit 3: Omit higher layer protocol triggering for IP address refresh during reentry processing Bit 4: If Bit 4 = 1, Full service and operational state transfer or sharing between Serving BS and Target BS (All static and dynamic context, e.g., ARQ windows, state machines.	
Seamless HO	1	Indicates whether seamless HO is supported.	
Ranging initiation deadline	8	An AMS shall send the AAI-RNG-REQ message during HO until Ranging initiation deadline.	Optional. Shall not be included if the BS is target R1 BS
Preassigned MAPMask Key	15	The value of this parameter is the seed used at the T-ABS to initiate the PRBS generator used to scramble the 40-bit A-A-MAP IE when the value of the STID included in this message is used as the CRC Mask Masking Code. See 6.3.5.3.2.4.	
Service level prediction	2	Indicates the level of service the AMS can expect from this ABS. The following encodings apply: 0b00: No service possible for this AMS 0b01: Some service is available for one or several service flows authorized for the AMS 0b10: For each authorized service flow, a MAC connection can be established with QoS specified by the AuthorizedQoSParamSet 0b11: No service level prediction available	

Table 6-40—AAI-HO-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
T-ABS Physical_Carrier_Index	6	Physical carrier index of the recommended T-ABS.	Shall be included when T-ABS is not included in the AAI-NBR-ADV message or is multicarrier ABS
Channel bandwidth	8	Channel bandwidth of recommended T-ABS in units of 125 KHz.	Shall be included when T-ABS is not included in the AAI-NBR-ADV message
CP length	2	CP length of the recommended T-ABS 0b00: 1/8 0b01: 1/16 0b10: 1/4 0b11: *Reserved*	Shall be included when T-ABS is not included in the AAI-NBR-ADV message
For(j = 0; j < N_Preassigned_Carriers; j++) {		N_Preassigned_Carrier is the number of preassigned carriers by the T-ABS.	Shall be included when one or more carriers of the AMS is preassigned by the T-ABS
Carrier Status Indication	1	Indicating whether this preassigned carrier will be activated immediately after HO procedure is done.	
Physical carrier index of the secondary carrier index	6	Physical carrier index of the preassigned secondary carrier.	
}			
Preallocated Basic CID	16	Used by the AMS to derive its own primary CID and transport CID in target R1 BS.	Optionally present only when HO to a R1 BS
SFH delta information	*variable*	Delta encoding with reference to the S-ABS.	May be included when SFH delta information is not included in the AAI-NBR-ADV message for the T-ABS
S-SFH change count	4	S-SFH change count of the reference for the included SFH delta information.	Shall be included when SFH delta information is included
S-SFH application indicator	1	Indicate if the SFH delta information at the T-ABS is applied at the Action Time 0b0: Not applied 0b1: Applied	Shall be included when SFH delta information is included
DCD Configuration Change Count	8	This represents the neighbor BS current DCD configuration change count.	May be included if target BS is R1 BS
UCD Configuration Change Count	8	This represents the neighbor BS current UCD configuration change count.	May be included if target BS is R1 BS

Table 6-40—AAI-HO-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
DCD_Info	Variable	The information from DCD message (Table 11-19 in IEEE Std 802.16) of target BS with the targetBSID	May be present if target BS is R1 BS. It is included only when AAI-NBR-ADV did not contain DCD_info for the targetB-SID or HO is issued by Serving ABS
UCD_Info	Variable	The information from UCD message (Table 11-12 in IEEE Std 802.16) of target BS with the targetBSID	May be present if target BS is R1 BS. It is included only when AAI-NBR-ADV did not contain UCD_info for the targetB-SID or HO is issued by Serving ABS
}//end of for(*i* = 0; *i* < N_Target_BS; *i*++)			
}else if (Mode == 0b01) {			
HO Reentry Mode	1	0b0: The AMS disconnects from the MZone before performing network reentry with the LZone 0b1: The AMS maintains communication with MZone while performing network reentry with LZone in the same frame or on another carrier	
Resource_Retain_Time	8	The time when the S-ABS discards AMS's context.	Optional. If not included, the value included in the AAI-RNG-RSP or AAI-REG-RSP shall be used.
FA index	8	Indicates the FA index.	Shall be included for target LZONE located in a different carrier.
Action Time	8	This value is defined as the frame number that AMS starts zone switch. Action Time included in this message is indicated by frame number.	
LZone Preamble Index	7	LZone Preamble Index for AMS to switch from MZone to LZone.	
Preallocated Basic CID	16	Used by the AMS to derive its own primary CID and transport CID in target LZONE.	Optional
}else if (Mode == 0b10) {			
}			

6.2.3.13 AAI-NBR-ADV

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

a) Cell type (macro, micro, macro hot-zone, Femto, relay)
b) Physical carrier index referring the AAI-Global-CFG message that provides carrier frequency, BW, TDD/FDD, and related definitions (expected to be the same given carrier frequency)
c) MAC version

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

To allow AAI-NBR-ADV fragmentation while providing flexibility for AMS HO operation without requiring acquisition of the whole AAI-NBR-ADV message, ABS always provides the total number of cell types, the total number of segments for each type, and the total number of neighbor ABS per segment. Each AAI-NBR-ADV fragment is indicated by the AAI-NBR-ADV Segment Index. Once an AAI-NBR-ADV segment is sent for a given cell type, the ABS should not start sending ABS for different cell types until all AAI-NBR-ADV segments for such given cell type are sent. ABSs with identical types are listed in the AAI-NBR-ADV message in descending order of their cell coverage.

Each AAI-NBR-ADV message carries the following:

— AAI-NBR-ADV change count
— Number of total cell types
— Segment information for this AAI-NBR-ADV message
— System information of ABSs of a specific cell type
— Starting ABS Index: Starting ABS Index of the AAI-NBR-ADV segment is the value of one incremented from the last ABS index of the previous AAI-NBR-ADV segment. The Starting ABS Index is the index of the first NBR ABS that is sent in a AAI-NBR-ADV segment. The index of the second NBR ABS is equal to Starting ABS Index +1, and so on, so that all ABSs in this AAI-NBR-ADV segment have consecutive indices that are in ascending order. If this is the first AAI-NBR-ADV segment or the AAI-NBR-ADV message is not segmented, the Starting ABS Index will be 0.

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

— Prefix of BSID
— SA-Preamble Index range
— Physical carrier range

The Prefix of BSID, SA-Preamble Index range, and Physical carrier range are optional fields, which can be used when the S-ABS chooses not to broadcast configuration information for each individual ABS within the cell type.

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

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

— MAC protocol versions (8 bits)

— Paging carrier indication (1 bit, refer to specify if a carrier is a paging carrier or not)

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

— SFH_encoding_format: Based on the present system information, the list of ABSs shall be categorized into three groups. The categorization is indicated by SFH_encoding_format parameter:

  — 0b00: full Subpacket information

  — 0b01: delta encoding with reference to the information of current carrier that transmits this AAI-NBR-ADV message

  — 0b10: no SFH included

  — 0b11: delta encoding with reference to the information of the preceding carrier

Dynamic SFH information such as the MSB of the superframe number shall not be transmitted in the AAI-NBR-ADV message.

The parameters NBR-ADV offset and NBR-ADV interval indicate the existence of neighbor R1 BS or LZone of ABS. The parameters shall be included in the AAI-NBR-ADV message when ABS indicates the existence of neighbor R1 BS or LZone of ABS.

NBR-ADV offset: The MOB_NBR-ADV to be scheduled after the frame n + NBR-ADV offset when the AAI-NBR-ADV message is sent in the frame n. Unit: Frame.

NBR-ADV interval: The interval of MOB_NBR-ADV is sent in LZone. Unit: Frame.

Table 6-41—AAI-NBR-ADV message field description

Field	Size (bits)	Value/Description	Condition
Change Count	3	AAI-NBR-ADV Change Count	
Total number of cell types	3	The total number of cell types	
Cell type	3	Cell type in this message 0b000: macro 0b001: micro 0b010: macro hot-zone 0b011: femto 0b100: TTR relay 0b101: R1 BS or LZone of ABS 0b110–0b111: *Reserved*	
Total Number of AAI-NBR-ADV Segments	4	Total number of segments of AAI-NBR-ADV	
AAI-NBR-ADV Segment Index	4	Indicates current segment index of this message in the specific cell type	

Table 6-41—AAI-NBR-ADV message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Starting ABS Index	8	Starting ABS Index is the index offset from the last ABS of the previous AAI-NBR-ADV segment. If this is the first AAI-NBR-ADV segment, the Starting ABS Index will be 0. Hence, each AAI-NBR-ADV segment has one Index that corresponds to the first ABS in that AAI-NBR-ADV segment. The order of the ABS within a segment serves as an offset from the 'Starting ABS index'. The sum of the offset and the 'Starting ABS index' serves as the ABS index that has the range of [1..256].	
For (i = 0; i < N-NBR-ABSs; i++) {		N-NBR-ABSs is the number of neighbor ABSs included in this message, and has the range of [1..64].	
BSID	48	Neighbor ABS ID	
MAC protocol version	8	MAC protocol version of the BS Consistent with IEEE Std 802.16 definition, with new MAC protocol version 10 defined for AAI.	
CP time	2	CP time of the BS 0b00: 1/8 0b01: 1/16 0b10: 1/4	
For(j = 0; j < N-Carrier-Info; j++) {		N-Carrier-Info is the number of carrier information listed here for the ABS_i	
SA-PREAMBLE index	10		
Physical carrier index	6	Refer to the physical carrier index in AAI-Global-CFG message	
Paging carrier indication	1	Indicates whether the carrier is a paging carrier in ABS or not 0: no paging carrier 1: paging carrier	May be present when multiple carrier operation is applied.
PGID	16	Indicates paging group identifier where the carrier belongs	
S-SFH change count	4	Indicates the value of S-SFH change count of this neighbor ABS	

Table 6-41—AAI-NBR-ADV message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
SFH encoding format	2	0b00: full Subpkt information 0b01: delta encoding with reference to the information of current carrier that transmits this AAI-NBR-ADV message 0b10: no SFH included 0b11: delta encoding with reference to the information of the preceding carrier For macrocell ABS, the SFH encoding format shall be either 0b00 or 0b01 or 0b11.	
If (SFH encoding format == 0b00) {			
SFH Subpkt 1	*variable*	See Table 6-184.	
SFH Subpkt 2	*variable*	See Table 6-185.	
SFH Subpkt 3	*variable*	See Table 6-186.	
}else if (SFH encoding format == 0b01‖0b11) {			
Delta information	*variable*	Indicates the delta encoding, between the reference carrier and the current carrier where this message is transmitted if SFH encoding format = 0b01, or between the reference carrier and the preceding carrier if SFH_encoding_format = 0b11. Delta information contains SFH SP1, SP2, and SP3 attributes as defined in Table 6-184, Table 6-185, and Table 6-186, respectively. Each delta information attribute is optional.	
}			
}			
Neighbor-specific trigger	*variable*	Optional neighbor-specific triggers with encoding defined in Table 6-120.	Optional
}//end of for N-NBR-ABSs			
For (*i* = 0; *i* < N-NBR-R1-BSs; *i*++) {		N-NBR-R1-BSs is the number of neighbor Release 1 BSs.	Shall be present if R1 NBR BS list is available
Neighbor BSID	48	Neighbor Base Station ID.	
Preamble index/Subchannel Index	8	Defines the PHY-specific preamble for each neighbor R1 BS. Bit 7: Indicates the reuse factor of the neighbor for purpose of CINR measurement for handoff. A value of '0' indicates a reuse factor of 1 and a value of '1' indicates reuse factor of 3 Bit 6 to Bit 0: Represent the preamble index of the neighbor R1 BS	

Table 6-41—AAI-NBR-ADV message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
PHY mode ID	16	Specifies the PHY parameters of each neighbor R1 BS, including channel bandwidth, FFT size, cyclic prefix, and frame duration, defined in 11.18.2 in IEEE Std 802.16.	
Channel bandwidth	2	Channel bandwidth of the neighbor R1 BS. R1 BS uses 5 ms frame duration, 1/8 CP 0b00: 5 MHz 0b01: 7 MHz 0b10: 8.75 MHz 0b11: 10 MHz	
R1 BS Center Frequency	32	Indicates center frequency (in unit of Hz) of the neighbor R1 BS.	Present when S-ABS carrier index is different from that of target R1 BS
DCD configuration change count	8	This represents the neighbor R1 BS' current DCD configuration change count.	May be present
UCD configuration change count	8	This represents the neighbor R1 BS' current UCD configuration change count.	May be present
if(*i* == 0) {			
DCD_Info	*variable*	The information from 1st neighbor R1 BS' DCD message (Table 11-19 in IEEE Std 802.16).	May be present. If this parameter present, it is only for 1st neighbor R1 BS
UCD_Info	*variable*	The information from 1st neighbor R1 BS' UCD message (Table 11-12 in IEEE Std 802.16).	May be present. If this parameter present, it is only for 1st neighbor R1 BS
} else {			
Delta_DCD	*variable*	Delta encoding of DCD information (Table 11-19 in IEEE Std 802.16) that is different from the 1st neighbor R1 BS.	Present if DCD information is different from that of 1st neighbor R1 BS
Delta_UCD	*variable*	Delta encoding of UCD information (Table 11-12 in IEEE Std 802.16) that is different from the 1st neighbor R1 BS.	Present if UCD information is different from that of 1st neighbor R1 BS
}			
}//end of for N-NBR-R1-BSs			
For(*i* = 1; *i* ≤ N-PHY-Carrier-Indices; *i*++) {		N-PHY-Carrier-Indices is the number of PHY Carrier Indices listed here. (1..64).	Optional. Present only for Cell type whose system info are not included in AAI-NBR-ADV

Table 6-41—AAI-NBR-ADV message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
PHY Carrier Index	6		
IDCell range start	10		Optional. Present only for Cell type whose system info are not included in AAI-NBR-ADV
IDCell range end	10		Optional. Present only for Cell type whose system info are not included in AAI-NBR-ADV
}			
NBR-ADV offset	4	The frame number offset the MOB_NBR-ADV is sent from the start point of frame counting, in unit of frames.	Optional. Present only if the S-ABS is a Wireless-MAN-Advanced Air Interface co-existing System
NBR-ADV interval	4	The interval of MOB_NBR-ADV being sent in LZone, in unit of frames.	Optional. Present only if the S-ABS is a Wireless-MAN-Advanced Air Interface co-existing System
S-ABS LZone Preamble Index	7	S-ABS LZone Preamble Index for AMS to synchronize with S-ABS LZone to receive MOB_NBR-ADV.	Optional. Present only if the S-ABS is a Wireless-MAN-Advanced Air Interface co-existing System

6.2.3.14 AAI-SCN-REQ

An AAI-SCN-REQ message is transmitted by an AMS to request a scanning interval for the purpose of seeking available ABSs and/or R1 BSs and determining their suitability as targets for HO. An AMS may request a scanning interval during the scan interleaving interval.

Table 6-42—AAI-SCN-REQ message field description

Field	Size (bits)	Value/Description	Condition
Scan duration	8	Duration (in units of AAI subframes) of the requested scanning period.	
Interleaving interval	8	The period of the AMS's active mode (in units of AAI subframes) that is interleaved between Scan Durations.	
Scan Iteration	6	The requested number of iterating scanning interval by an AMS.	
Recommended start super frame number	6	Represents the 6 least significant bits of the absolute super frame index for which the AMS recommends the first Scanning Interval to start. This field is set to 0 if an AMS has no preferred value.	Present if the AMS recommends a start super frame
Recommended start frame index	2	Recommended start frame index within a super frame. 0b00: The 1st frame in a super frame 0b01: The 2nd frame in a super frame 0b10: The 3rd frame in a super frame 0b11: The 4th frame in a super frame	Present if the AMS recommends a start super frame
N_Recommended_ABS		This is the number of neighboring ABS the AMS plans to scan, which are included in AAI-NBR-ADV message [0..63]. When an AMS receives AAI-SCN-RSP message from ABS in response to AAI-SCN-REQ message, the AMS shall check whether Configuration Change Count stored by the AMS is the same as one included in AAI-SCN-RSP message sent by the ABS. If an AMS detects mismatch of Configuration Change Counts, it may retransmit AAI-SCN-REQ message to the ABS.	
If(N_Recommended_ABS > 0) {			
Configuration Change Count of AAI-NBR-ADV	3	The value of Configuration Change Count in AAI-NBR-ADV message used for neighbor ABS index references.	
If (Nbr_Bitmap_Index is present) {			

Table 6-42—AAI-SCN-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Nbr_Bitmap_Index	*variable* [1..256]	Each bit position corresponds to a ABS Index of the corresponding AAI-NBR-ADV message, where the least significant bit corresponds to the first ABS Index, each next significant bit corresponds to the next ABS Index in sequential order, the most significant bit corresponds to the ABS Index of the last requested ABS, and ABSs with ABS Index greater than the last requested ABS are not requested and do not have a corresponding bit position in the bitmap. Bitmap position bit value: 0: The corresponding ABS is not requested. 1: The corresponding ABS is requested Maximum size of the bitmap is 256 bits Total number of '1's in the bitmap shall be equal to N_Recommended_ABS.	
} // End if (Nbr_Bitmap_Index is present)			
else if (ABS indexes are present) {			
For(*i* = 0; *i* < N_Recommended_ABS; *i*++) {			
Neighbor ABS index	8	ABS index corresponds to the position of ABS in AAI-NBR-ADV message.	
}			
} // End if (ABS indexes are present)			
else { // Full ABS ID is present			
For(*i* = 0; *i* < N_Recommended_ABS; *i*++) {			
Recommended ABS ID	48	Full ABS ID of the ABSs that are listed in AAI-NBR-ADV.	
}			
} // End else Full ABS ID is present			
For(*i* = 0; *i* < N_Recommended_ABS; *i*++) {			
N_Recommended_Carrier_Index		Number of carriers the AMS plans to scan at each neighbor ABS [0..63].	

Table 6-42—AAI-SCN-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For(*j* = 0; *j* < N_Recommended_Carrier_Index ; *j*++) {			Present when a neighbor ABS is a multicarrier ABS
Recommended Carrier Index	6	Requested physical carrier index for scan at each neighbor ABS.	Present when a neighbor ABS is a multicarrier ABS
}			
}			
}//end of If(N_Recommended_ABS > 0)			
N_Recommended_BS_Full		Number of neighbor R1 BS the AMS plans to scan that are using full 48-bit BSID [0..63].	
If(N_Recommended_BS_Full > 0) {			Present if the AMS decides to use full 48-bit BSID to identify a R1 BS
For(*i* = 0; *i* < N_Recommended_BS_Full; *i*++) {			
Recommended BS ID	48	BS ID of the R1 BSs the AMS plans to scan.	
}			
}//end of if(N_Recommended_BS_Full > 0)			
N_Recommended_FA_of_SA_Preamble_Index		Number of FAs the AMS plans to scan SA preambles [0..15].	
For(*j* = 0; *j* < N_Recommended_FA_of_SA_Preamble_Index; *j*++) {			Present if the AMS requests to scan SA preambles
Center Frequency	32	Indicates center frequency (in unit of Hz) of the carrier.	
N_Recommended_SA_Preamble_Index		Number of SA preambles the AMS plans to scan [0..15].	
For(*i* = 0; *i* < N_Recommended_SA_Preamble_Index; *i*++) {			Present if the AMS requests to scan SA preambles
SA Preamble Index	10	SA Preamble indices the AMS plans to scan.	Present if the AMS requests to scan SA preambles
}			

Table 6-42—AAI-SCN-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
} // End For(*j* = 0; *j* < N_Recommended_FA_of_SA_Preamble_Index			
N_Recommended_Carrier_Index_at_Serving_ABS		Number of carriers [0..63] the AMS plans to scan at each neighbor ABS.	Present if the AMS decides to scan other carriers of the S-ABS
For(*i* = 0; *i* < N_Recommended_Carrier_Index_at_Serving_ABS; *i*++) {			
Recommended Carrier index at S-ABS	6	Recommended physical carrier index of the S-ABS the AMS plans to scan.	Present if the AMS decides to scan other carriers of the S-ABS
}			
for (*i* = 0; *i* < N_CSG_ID_Infos; *i*++) {		N_CSG_ID_Infos is the number of CSG ID Information blocks [0..15].	Optional for loop. May be included for quick CSG membership detection or ABS reselection assistance
Operator ID of the CSG Femtocell	24	The Operator ID of the CSG Femtocell.	Present if the Operator ID is different from the one of the ABS
for (*j* = 0; *j* < N_CSG_IDs; *j*++) {		N_CSG_IDs is the number of CSG IDs belongs to this Operator ID.	
CSGID	*variable*	The CSGID within the Operator ID. It may be part of the BS ID, with certain bits inside indicating its length. If the CSG has single BS, it may be of maximum length that is the LSB-24 bits of the full BS ID.	
}			
}			

6.2.3.15 AAI-SCN-RSP

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

Table 6-43—AAI-SCN-RSP message field description

Field	Size (bits)	Value/Description	Condition
Scan duration	8	Duration (in units of AAI subframes) of the requested scanning period.	
Report mode	2	0b00:No report 0b01:Periodic report 0b10:Event-triggered report 0b11:One-time scan report	
Report metric	4	Bitmap indicator of trigger metrics that the S-ABS requests the AMS to report. The S-ABS shall indicate only the trigger metrics agreed during AAI-SBC-REQ/RSP negotiation. Each bit indicates whether reports will be initiated by trigger based on the corresponding metric: Bit 0: ABS CINR mean Bit 1: ABS RSSI mean Bit 2: Relative delay Bit 3: ABS RTD	
Report period	8	The period of the AMS's report of scanning result when the AMS is required to report the value periodically or one-time. The period is calculated from the start of the first scan duration. If the ABS sends an unsolicited AAI-SCN-RSP message without assignment of a scanning interval and the scan duration is set to zero, the period is calculated from the frame the AMS receives the AAI-SCN-RSP message. For AMS scanning request denied by AAI-SCN-RSP with scan duration set to zero, Report period is the number of frames that ABS suggests to AMS before transmitting next AAI-SCN-REQ.	
Duration for measurements signal location parameters on D-LBS zone	4	Duration (in units of 4 superframes) of the requested scanning.	Present if the ABS requests the AMS to scan the D-LBS zone for signal location parameters measurements
If(Scan Duration > 0) {			
Start superframe index	6	Represents the 6 least significant bits of the absolute superframe index in which the first scanning interval starts.	

Table 6-43—AAI-SCN-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Start frame index	2	Represents start frame number in the Start super frame number. 0b00: 1st frame in the super frame 0b01: 2nd frame in the super frame 0b10: 3rd frame in the super frame 0b11: 4th frame in the super frame	
Interleaving interval	8	The period of the AMS's active mode (in units of AAI subframes) that is interleaved between scan durations.	
Scan Iteration	6	The requested number of iterating scanning interval by an AMS.	
N_Recommended_ABS		Number of neighbor ABS [0..63] to be scanned, which are using full 48-bit BSID.	
If(N_Recommended_ABS > 0) {			Present only when this message is sent in response to AAI-SCN-REQ
Configuration Change Count of AAI-NBR-ADV	3	The value of Configuration Change Count in AAI-NBR-ADV message used for neighbor ABS index references.	
If (Req_Bitmap_Index is present) {			
Req_Bitmap_Index	*variable* [1..256]	Each bit position in this bitmap corresponds to a ABS Index of the corresponding AAI-SCN-REQ message, where the least significant bit corresponds to the first ABS Index, each next significant bit corresponds to the next ABS Index, the most significant bit corresponds to the ABS Index of the last recommended ABS, and ABSs with ABS Index greater than the last recommended BS are not recommended and do not have a corresponding bit position in the bitmap. Bitmap position bit value: 0: The corresponding ABS is not recommended 1: The corresponding ABS is recommended Maximum size of this bitmap is 256 Total number of '1's in the bitmap shall be equal to N_Recommended_ABS.	
} // End If (Req_Bitmap_Index is present)			
Else if (ABS indexes are present) {			

Table 6-43—AAI-SCN-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For(*i* = 0; *i* < N_Recommended_ABS; *i*++) {			
Neighbor ABS index	8	ABS index corresponds to the position of ABS in AAI-NBR-ADV message.	
}			
} // End if (ABS indexes are present)			
else { // Full ABS ID is present			
For(*i* = 0;*i* < N_Recommended_ABS; *i*++) {			
Recommended ABS ID	48	Full ABS ID of the ABSs that are listed in AAI-NBR-ADV.	
}			
} // else Full ABS ID is present			
For(*i* = 0; *i* < N_Recommended_ABS; *i*++) {			
N_Recommended_Carrier_Index		Number of carriers the AMS plans to scan at each neighbor ABS [0..63].	
For(*j* = 0; *j* < N_Recommended_Carrier_Index ; *j*++) {			Present when a neighbor ABS is a multicarrier ABS
Recommended Carrier Index	6	Requested physical carrier index for scan at each neighbor ABS.	Present when a neighbor ABS is a multicarrier ABS
SA Preamble Index	10	SA Preamble Index to be scanned.	
}//end of (*i* = 0; *i* < N_Recommended_ABS; *i*++)			
}//end of if(N_Recommended_ABS > 0)			
N_Recommded_ABS_Full		Full ABS ID of the ABSs that are not listed in AAI-NBR-ADV [0..63].	
For(*i* = 0; *i* < N_Recommended_ABS_Full; *i*++) {			Shall be included when neighbor ABS is not included in the AAI-NBR-ADV message and AAI-SCN-RSP is not sent as a response to AAI-SCNREQ that included this recommended carrier index
Recommended ABS ID	48	ABS ID of the ABSs to be scanned.	
N_Recommended_Carrier_Index		Number of carriers to be scanned at each neighbor ABS [0..63].	

Table 6-43—AAI-SCN-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For(*j* = 0; *j* < N_Recommended_Carrier_Index ; *j*++) {			
Recommended_Carrier_Index	6	Recommended physical carrier index for scan at each neighbor ABS. As defined in AAI-Global-CFG message.	
SA Preamble Index	10	SA Preamble Index to be scanned.	
Bandwidth	3	BW size of the recommended neighbor ABS 0b000: 10 MHz 0b001: 20 MHz 0b010: 5 MHz 0b011: 7 MHz 0b100: 8.75 MHz 0b101~0b111: *Reserved*	
CP length	2	CP length of the recommended T-ABS 00: 1/8 01: 1/16 10: 1/4	Shall be included when neighbor ABS is not included in the AAI-NBR-ADV message and AAI-SCN-RSP is not sent as a response to AAI-SCN-REQ that included this recommended carrier index
}//end of For(*j* = 0; *j* < N_Recommended_Carrier_Index)			
}//end of For(*i* = 0; *i* < N_Recommended_ABS_Full; *i*++)			
N_Recommended_BS_Full		Number of neighbor R1 BS the AMS plans to scan that are using full 48-bit BSID [0..63].	
If(N_Recommended_BS_Full > 0) {			Present if the AMS decides to use full 48-bit BSID to identify a R1 BS
For(*i* = 0; *i* < N_Recommended_BS_Full; *i*++) {			
Recommended BS ID	48	BS ID of the R1 BSs the AMS plans to scan.	
}			
}//end of if(N_Recommended_BS_Full > 0)			
N_Recommended_FA_of_SA_Preamble_Index		Number of FAs to be scanned for SA preambles [0..15].	

Table 6-43—AAI-SCN-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For(*j* = 0; *j* < N_Recommended_FA_of_SA_Preamble_Index; *j*++) {			Present if this message is sent in response to AAI-SCN-REQ with N_Recommended_FA_of_SA_Preamble_Index > 0
Center Frequency	32	Indicates center frequency (in unit of Hz) of the carrier.	
N_Recommended_SA_Preamble_Index		Number of SA preambles to be scanned [0..15].	
For(*i* = 0; *i* < N_Recommended_SA_Preamble_Index; *i*++) {			
SA Preamble Index	10	SA Preamble indices to be scanned.	
}			
}			
N_Recommended_Carrier_Index_at_Serving_ABS	6	Number of carriers to be scanned at the S-ABS.	Present if the AMS decides to scan other carriers of the S-ABS
For(*i* = 0; *i* < N_Recommended_Carrier_Index_at_Serving_ABS; *i*++) {			
Recommended Carrier index at S-ABS	6	Recommended physical carrier index of the S-ABS the AMS plans to scan.	Present if the AMS decides to scan other carriers of the S-ABS
}			
Scanning_Carrier_Index	6	Recommended physical carrier index of the AMS to be used for scanning.	Present if the AMS supports multicarrier scanning
} //End if (Scan Duration > 0)			

6.2.3.16 AAI-SCN-REP

When the report mode is 0b10 (i.e., event triggered) in the most recently received AAI-SCN-RSP, the MS shall transmit a AAI-SCN-REP message to report the scanning results to its S-ABS after each scanning period if the trigger condition is met. For a periodic report (i.e., Report Mode is 0b01) and for One-time Scan Report (Report Mode is 0b11), the AMS reports the scanning results to its S-ABS at the time indicated in the AAI-SCN-RSP message except when it is in the scanning interval. For a periodic report (i.e., Report Mode is 0b01), the AMS stops reporting after all scanning intervals in the AAI-SCN-RSP message. The AMS shall include all available scanning results for the requested ABSs specified in the said AAI-SCN-RSP message. The AMS may transmit an AAI-SCN-REP message to report the scanning results to its S-ABS at anytime or to get a unicast AAI-NBR-ADV with the system information for the requested cells (which are not already broadcasted by the ABS in the AAI-NBR-ADV message) and optionally the system information for other

Femto ABSs that are judged by the ABS to be in the vicinity of the AMS. The AMS may further indicate to the ABS for filtering the neighbor Femto ABS list based on the requested cell type by including "Neighbor_Request_BS_Type" indicator and/or the CSGIDs.

Table 6-44—AAI-SCN-REP message field description

Field	Size (bits)	Value/Description	Condition
Report mode	2	Action code for an AMS's scan report of its measurement 00: Event-triggered report 01: Periodic report according to Scan report period of AAI-SCN-RSP 10: One-time scan report	
For(*i* = 0; *i* < N-Carriers-SABS; *i*++) {		N-Carriers-SABS is the number of carriers at the S-ABS to be reported in this message.	Present if the AMS reports measurement results measured from carriers at the S-ABS
Carrier Index	6	Carrier Index of carrier at the S-ABS.	
S-ABS CINR mean	8	The S-ABS CINR Mean parameter indicates the CINR measured by the AMS from the S-ABS. The value shall be interpreted as a signed byte with units of 0.5 dB.	Present if the AMS is asked to report CINR
S-ABS RSSI mean	8	The S-ABS RSSI Mean parameter indicates the Received Signal Strength measured by the AMS from the S-ABS. The value shall be interpreted as an unsigned byte with units of 0.25 dB; e.g., 0x00 is interpreted as –103.75 dBm. An AMS shall be able to report values in the –103.75 dBm to –40 dBm range. An AMS with multiple receive antennas will report the linear sum of the RSSI values calculated over all the receive antennas.	Present if the AMS is asked to report RSSI
}			
S-ABS RTD	8	The S-ABS RTD parameter indicates the round-trip delay (RTD) measured by the AMS from the S-ABS. RTD can be given by the latest time advance taken by MS. The value shall be interpreted as an unsigned byte with units of 1/Fs.	Present if the AMS is asked to report RTD
N_Reported_ABS		Number of neighbor ABS reported in this message [0..63].	Present only when the scanning report includes ABSs referred by ABS index
If(N_Reported_ABS > 0) {			
Configuration Change Count of AAI-NBR-ADV	3	The value of Configuration Change Count in AAI-NBR-ADV message used for neighbor ABS index references.	

Table 6-44—AAI-SCN-REP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If (Rsp_Bitmap_Index is present) {			
Rsp_Bitmap_Index	8	Each bit position corresponds to a ABS Index of the corresponding AAI-SCN-RSP message, where the least significant bit corresponds to the first ABS Index, each next significant bit corresponds to the next ABS Index in sequential order, the most significant bit corresponds to the ABS Index of the last requested ABS, and ABSs with ABS Index greater than the last requested ABS are not requested and do not have a corresponding bit position in the bitmap. Bitmap position bit value: 0: The corresponding ABS is not requested 1: The corresponding ABS is requested Maximum size of the bitmap is 256 bits Total number of ‘1’s in the bitmap shall be equal to N_Reported_ABS.	
} // End If (Rsp _Bitmap_Index is present)			
Else if (ABS indexes are present) {			
For(*i* = 0; *i* < N_Reported_ABS; *i*++) {			
Neighbor ABS index	8	ABS index corresponds to the position of ABS in the AAI-NBR-ADV message.	
}			
} // End if (ABS indexes are present)			
else { // Full ABS ID is present			
For(*i* = 0; *i* < N_Reported_ABS; *i*++) {			
Reported ABS ID	48	Full ABS ID of the ABSs the AMS plans to report.	
}			
} // else Full ABS ID is present			
For(*i* = 0; *i* < N_Reported_ABS; *i*++) {			
N_Reported_Carrier_Index		Number of carriers the AMS reported at each neighbor ABS [0..63].	

Table 6-44—AAI-SCN-REP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For(*j* = 0; *j* < N_Reported_Carrier_Index; *j*++) {			Present when a neighbor ABS is a multicarrier ABS
Recommended Carrier Index	6	Reported physical carrier index at each neighbor ABS.	
CINR mean	8	The ABS CINR Mean parameter indicates the CINR measured by the AMS from this carrier. The value shall be interpreted as a signed byte with units of 0.5 dB.	Present if the AMS is asked to report CINR
RSSI mean	8	The ABS RSSI Mean parameter indicates the Received Signal Strength measured by the AMS from this carrier. The value shall be interpreted as an unsigned byte with units of 0.25 dB; e.g., 0x00 is interpreted as –103.75 dBm. An AMS shall be able to report values in the range –103.75 dBm to –40 dBm.	Present if the AMS is asked to report RSSI
}// End For(*j* = 0; *j* < N_Reported_Carrier_Index			
Relative delay	8	This parameter indicates the delay of the DL signals from the neighbor-ABS relative to the primary carrier of the S-ABS, as measured by the AMS. The value shall be interpreted as a signed integer in units of samples.	Present if the AMS is asked to report relative delay
}// End For(*i* = 0; *i* < N_Reported_ABS			
}//end of if(N_Reported_ABS > 0)			
N_Reported_BS_Full		Number of neighbor R1 BS [0..63] reported in this message, which are using full 48-bit BSID.	
If (N_Reported_BS_Full > 0) {			Present only when the scanning report includes R1 BSs referred by BS ID
For(*i* = 0; *i* < N_Reported_BS_Full; *i*++) {			
Reported BS ID	48	BS ID of the R1 BSs reported in this message.	Present if the AMS is asked to report CINR
CINR mean	8	The ABS CINR Mean parameter indicates the CINR measured by the AMS from this carrier. The value shall be interpreted as a signed byte with units of 0.5 dB.	Present if the AMS is asked to report RSSI

Table 6-44—AAI-SCN-REP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
RSSI mean	8	The ABS RSSI Mean parameter indicates the Received Signal Strength measured by the AMS from this carrier. The value shall be interpreted as an unsigned byte with units of 0.25 dB; e.g., 0x00 is interpreted as –103.75 dBm. An AMS shall be able to report values in the range –103.75 dBm to –40 dBm.	
}			
}//end of If (N_Reported_BS_Full > 0)			
N_Reported_FA_of_SA_Preamble_Index		Number of FAs reported in this message for SA preambles [0..15].	
For(*j* = 0; *j* < N_Reported_FA_of_SA_Preamble_Index; *j*++) {			Present only when the scanning report includes SA preamble reports
Center Frequency	32	Indicates center frequency (in unit of Hz) of the carrier.	
N_Reported_SA_Preamble_Index		Number of SA preambles reported in this message [0..15].	
For(*i* = 0; *i* < N_Reported_SA_Preamble_Index; *i*++) {			Present only when the scanning report includes SA preamble reports
SA Preamble Index	10	SA preamble indices reported in this message.	
CINR mean	8	Indicates the CINR measured by the AMS from this SA preamble. The value shall be interpreted as a signed byte with units of 0.5 dB.	Present if the AMS is asked to report CINR
RSSI mean	8	Indicates the Received Signal Strength measured by the AMS from this SA preamble. The value shall be interpreted as an unsigned byte with units of 0.25 dB; e.g., 0x00 is interpreted as –103.75 dBm. An AMS shall be able to report values in the range –103.75 dBm to –40 dBm.	Present if the AMS is asked to report RSSI
}			
Neighbor_Request_Indication	1	Request indication for system information and the list of the neighbor Femto ABSs.	Optional
If(Neighbor_Request_Indication == 1) {			

Table 6-44—AAI-SCN-REP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Neighbor_Request_BS_Type	3	Indicates type of neighbor Femto ABSs for which system information is requested. Bit 0: CSG-Closed Femto ABS Bit 1: CSG-Open Femto ABS Bit 2: OSG Femto ABS	Optional
for (*j* = 0; *j* < N_CSG_IDs; *j*++) {		N_CSG_IDs is the number of CSG IDs.	Optional. Sent by the AMS to aid in generation of optimized neighbor list by the ABS
CSGID	*variable*	The CSGID within the Operator ID. It may be part of the BS ID, with certain bits inside indicating its length. If the CSG has single BS, it may be of maximum length that is the LSB-24 bits of the full BS ID.	
}			
}			

6.2.3.17 AAI-CLC-REQ (Co-Located Coexistence Request)

The AMS sends the AAI-CLC-REQ message to activate, terminate, or reconfigure one or several Type I, Type II, and/or Type III CLC classes. The AAI-CLC-REQ message is sent from the AMS to the ABS on the AMS's Control FID. The AMS may include CLC Request and/or CLC Report parameter fields (see Table 6-45).

Table 6-45—AAI-CLC-REQ message field description

Field	Size (bits)	Value/Description	Condition
CLC request/report indicator	2	Indicate the inclusion of CLC request and/or CLC report: 0b00: *Reserved* 0b01: CLC request only 0b10: CLC report only 0b11: CLC request and report	
If (CLC request/report indicator == 0b10 || 0b11) {		CLC report	
CLC report type	8	0: Collocated interference level 1: Non-collocated interference level 2: Interference level (source unknown) Others: *Reserved*	
If (CLC report type == 0 || 1 || 2) {			

Table 6-45—AAI-CLC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Interference level	8	Signed integer: –127~127	
}			
}			
If (CLC request/report indicator == 0b01 || 0b11) {		CLC request	
Request Action	8	Bitmap, each bit of this parameter indicates whether the AMS requests to activate or deactivate the corresponding CLC class Bit *i* set to 0: indicates that the 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* set to 1: indicates that the AMS requests to activate the CLC class with CLC ID = I if it does not exist. For existing CLC ID, AMS may keep existing configuration, request to reconfigure, or replace existing CLC class.	
N	4	The number of new CLC classes and existing CLC classes that need to be reconfigured	
For (*i* = 0; *i* < N; *i*++) {			
CLC ID	3	0~7	
Start Superframe Number	3	The 3 LSB of the superframe number of CLC start time	
Start Frame Index	2	The frame index of CLC start time	
Scheduling Impact	2	0b00: Both DL and UL allocations are prohibited in the CLC active interval 0b01: Only DL allocations are prohibited in the CLC active interval 0b10: Only UL allocations are prohibited in the CLC active interval 0b11: *Reserved*	
Flag	3	0b000: Type I 0b001: Type II subtype 1 0b010: Type II subtype 2 0b011: Type II subtype 3 0b100: Type III Others: *Reserved*	
If (Flag == 0b000) {			
Start AAI Subframe Index	3	The subframe index of the first subframe of the CLC active interval	

Table 6-45—AAI-CLC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
CLC active interval of Type I CLC class	8	The number of AAI subframes of the CLC active interval	
CLC active cycle of Type I CLC class	21	The number of microseconds of the CLC active cycle	
}			
If (Flag == 0b001) {			
CLC active bitmap of Type II CLC class with subtype 1	8	Setting a bit of the field to "1" indicates the corresponding AAI subframe in each frame is in the CLC active interval	
}			
If (Flag == 0b010) {			
Start AAI Subframe Index	3	The subframe index of the first subframe of the CLC active interval	
CLC active interval of Type II CLC class with subtype 2	8	The number of AAI subframes of the CLC active interval	
CLC active cycle of Type II CLC class with subtype 2	8	The number of AAI frames of the CLC active cycle	
}			
If (Flag == 0b011) {			
CLC active cycle of Type II CLC class with subtype 3	2	x (0, 1 or 2): The length of Extended CLC active bitmap of Type II CLC class with subtype 3 is x + 2	
Extended CLC active bitmap of Type II CLC class with subtype 3	1..32	Setting a bit of the field to "1" indicates the corresponding AAI subframe in each CLC active cycle. The maximum value of the CLC active cycle of Type II CLC class with subtype 3 is 4 frames. There can be up to 6 subframes per frame. So, the maximum size of this bit map is 32.	
}			
If (Flag == 0b100) {			
CLC active interval of Type III CLC class	8	The number of superframes of the CLC active interval	
}			
}			
}			
Reserved	*variable*	For byte alignment	

Parameters shall be as follows:

Request Action

Bit *i* of the field set to “0” indicates that the 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 the AMS requests to activate the CLC class with CLC ID = *i* if it does not exist. For existing CLC ID, the AMS may keep existing configuration, request to reconfigure, or replace existing CLC class.

Scheduling Impact

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

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

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

0b11 = *Reserved*

Flag

0b000: Type I CLC class

0b001: Type II CLC class subtype 1

0b010: Type II CLC class subtype 2

0b011: Type II CLC class subtype 3

0b100: Type III CLC class

Others: *Reserved*

Start AAI subframe Index

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

CLC active interval of Type I CLC class

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

CLC active cycle of Type I CLC class

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

CLC active bitmap of Type II CLC class with subtype 1

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

CLC active interval of Type II CLC class with subtype 2

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

CLC active cycle of Type II CLC class with subtype 2

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

CLC active cycle of Type II CLC class with subtype 3

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

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

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

CLC active interval of Type III CLC class

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

CLC ID

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

Start Superframe Number

The 3 LSB of the superframe number of CLC start time.

Start Frame Index

The frame index of CLC start time.

Report Type

This field indicates which of the following fields are included.

Interference Level

This field is present if (Report Type == 0, 1, or 2).

If Report Type == 0, this level indicates the average power level over one OFDMA symbol in unit of 1 dBm with the range from –127 dBm to 127 dBm received at the AMS from its co-located, non–IEEE 802.16 radios when they are active.

If Report Type == 1, this level indicates the average power level over one OFDMA symbol in unit of 1 dBm with the range from –127 dBm to 127 dBm received at the AMS from its non–co-located, non–IEEE 802.16 radios when they are active.

If Report Type == 2, this level indicates the average power level over one OFDMA symbol in unit of 1 dBm with the range from –127 dBm to 127 dBm received at the AMS from non–IEEE 802.16 radios when they are active; however, it is not known whether these radios are collocated.

6.2.3.18 AAI-CLC-RSP (Co-Located Coexistence Response)

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

Table 6-46—AAI-CLC-RSP message field description

Field	Size (bits)	Value/Description	Condition
AAI-CLC-RSP Message () {			
Confirmed Action	8	Each bit of the parameter set to 0 or 1 indicates whether the corresponding CLC class is inactive or active.	
For (*i* = 0; *i* < 8; *i*++) {			
If ((Confirmed Action [i] == 1) and "CLC type is II or III" and "ABS configures different starting time") {			
CLC ID	3	0~7	
Start Superframe Number	3	The 3 LSB of the superframe number of CLC start time.	
Start Frame Index	2	The frame index of CLC start time.	
}			
}			
}			

In addition to presence in the AAI-CLC-RSP message, the CLC Response parameters listed in Table 6-46 may be present in AAI-SBC-RSP and AAI-RNG-RSP.

Confirmed Action

Bit *i* of the field set to "0" indicates that the 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 the ABS confirms the activation of the CLC class with CLC ID = *i*. For existing CLC ID, the ABS confirms the existing configuration, the reconfiguration, or the replacement if it is requested by the MS.

CLC Start Time parameters, CLC ID, Start Superframe Number, and Start Frame Index are included for each Type II or III CLC class that ABS configures its starting time differently from what is recommended by AMS.

6.2.3.19 AAI-FFR-CMD (FFR Command) message

An AAI-FFR-CMD message may be transmitted by the ABS to instruct the AMS to perform measurement over specific frequency partition(s). Table 6-47 lists the parameters to be included into the AAI-FFR-CMD message.

Table 6-47—AAI-FFR-CMD message field description

Field	Size (bits)	Value/Description	Condition
frequencyPartitionBitMap	4	Each bit indicates the interference statistics report status of corresponding frequency partition. 0b0: No report interference statistics 0b1: Report interference statistics Frequency Partition Bitmap shall contain at least one bit with value "1". The *i*-th bit starting from the LSB indicates the *i*-th FP.	
reportType	4	Each bit indicates if one type of report is required to be sent by the AMS. If one bit has value "1", it indicates the specific report type is required to be sent; otherwise, it indicates the specific report type is not required to be sent. At least 1 bit needs to be set to value "1". LSB 0: Interference-Mean LSB 1: Interference-Variance LSB 2: SINR-Mean LSB 3: SINR-Variance	
frameOffset	8	The offset (in units of frames) from the current frame in which the AAI-FFR-REP message shall be transmitted on the unsolicited UL resource.	
If (Carrier-specific PHY control mode == 0b0) {			
PhysicalCarrierIndex	6	The relevant active carrier with which this control message is associated.	Present if the Carrier-specific PHY control mode is disabled and an AMS has active secondary carrier(s).
}			

6.2.3.20 AAI-FFR-REP (FFR report) message

Once an AMS receives the AAI-FFR-CMD message, an AAI-FFR-REP message is sent by the AMS to report the downlink interference and/or SINR statistics of frequency partition(s) specified in the AAI-FFR-CMD message. Table 6-48 shows the parameters for the AAI-FFR-REP message.

Table 6-48—AAI-FFR-REP message field description

Field	Size (bits)	Value/Description	Condition
frequencyPartitionBitMap	4	Each bit indicates the interference statistics report status of corresponding frequency partition. 0b0: No report interference statistics 0b1: Report interference statistics Frequency Partition Bitmap shall contain at least one bit with value "1". The LSB indicates the lowest available FP, and the MSB indicates the highest available FP where the size of an available FP is bigger than zero.	
reportType	4	Each bit indicates if one type of report is required to be sent by the AMS. If one bit has value "1", it indicates the specific report type is being sent; otherwise it indicates the specific report type is not being sent. At least 1 bit needs to be set to value "1". LSB 0: Interference-Mean LSB 1: Interference-Variance LSB 2: SINR-Mean LSB 3: SINR-Variance	
If(0th LSB of frequencyPartitionBitMap == 0b1){		fp0report	
FFR-FeedbackIE	*variable*	See the definition below	
}			
If(1st LSB of frequencyPartitionBitMap == 0b1){		fp1report	
FFR-FeedbackIE	*variable*	See the definition below	
}			
If(2nd LSB of frequencyPartitionBitMap == 0b1){		fp2report	
FFR-FeedbackIE	*variable*	See the definition below	
}			
If(3rd LSB of frequencyPartitionBitMap == 0b1){		fp3report	
FFR-FeedbackIE	*variable*	See the definition below	
}			
FFR-FeedbackIE{	*variable*	FFR-FeedbackIE definition	
If(0th LSB of reportType == 0b1){			

Table 6-48—AAI-FFR-REP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
interferenceMean	8	Interference mean. This is noise plus inter-cell interference power level that is averaged over the frequency partition and divided by the number of subcarriers in the frequency partition. –134 dBm to –30 dBm in units of 1 dB. –134 dBm is encoded as 0x00, –30 dB is encoded as 0x68, 0x69 to 0xFF is *Reserved*.	
}			
If(1st LSB of reportType == 0b1){			
interferenceVariance	4	Interference variance 0 dB to 15 dB in units of 1 dB.	
}			
If(2nd LSB of reportType == 0b1){			
sinrMean	4	SINR mean –16 dB to 53 dB in units of 0.5 dB –16 dB is encoded as 0x00, 53 dB is encoded as 0x8A, 0x8B–0xFF are reserved	
}			
If(3rd LSB of reportType == 0b1){			
sinrVariance	8	SINR variance 0 dB to 15 dB in units of 1 dB	
}			
}			
If (Carrier-specific PHY control mode == 0b0) {			
PhysicalCarrierIndex	6	The relevant active carrier with which this control message is associated.	Present if the Carrier-specific PHY control mode is disabled and an AMS has active secondary carrier(s)
}			

6.2.3.21 AAI-DREG-REQ message

Table 6-49—AAI-DREG-REQ message field description

Field	Size (bits)	Value/Description	Condition
Deregistration_Request_Code	3	Used to indicate the purpose of this message 0x00: AMS deregistration request from ABS and network 0x01: request for AMS deregistration from S-ABS and initiation of AMS idle mode. 0x02: response for the unsolicited AAI-DREG-RSP message with action code 0x05 by the ABS. 0x03: reject for the unsolicited AAI-DREG-RSP message with action code 0x05 by the ABS. This code is applicable only when an AMS has a pending UL data to transmit. 0x04: request for AMS deregistration from S-ABS to enter DCR mode 0x05: response for the unsolicited AAI-DREG-RSP message with action code 0x00, 0x01, 0x02, or 0x03 0x06–0x07: *Reserved*	
If (Deregistration_Request_Code == 0x01) {			
Paging cycle request	4	Used to indicate Paging cycle recommended by the AMS 0b0000: 4 superframes 0b0001: 8 superframes 0b0010: 16 superframes 0b0011: 32 superframes 0b0100: 64 superframes 0b0101: 128 superframes 0b0110: 256 superframes 0b0111: 512 superframes 0b1000–0b1111: *Reserved*	

Table 6-49—AAI-DREG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Idle Mode Retain Information element	5	Provided as part of this message indicative only. Network reentry from idle mode process requirements may change at time of actual reentry. For each bit location, a value of 0 indicates the information for the associated reentry control messages shall not be retained and managed; a value of 1 indicates the information for the associated reentry control message shall be retained and managed. Bit 0: Retain MS service and operational information associated with AAI-SBC-REQ/RSP messages. Bit 1: Retain MS service and operational information associated with AAI-PKM-REQ/RSP messages. Bit 2: Retain MS service and operational information associated with AAI-REG-REQ/RSP messages. Bit 3: Retain MS service and operational information associated with network address. Bit 4: Retain MS state information. The information retained by setting bit 4 includes configuration of all Service Flows in the AMS as set by successful AAI-DSA and AAI-DSC transactions. In particular it includes FIDs and related description (QoS descriptors and CS classifier information).	
Mobility information	2	Used to indicate the AMS's mobility level 0b00 = Slow (0 km/h through 10 km/h) 0b01 = Medium (10 km/h through 120 km/h) 0b10 = Fast (above 120 km/h) 0b11 = *Reserved*	May be present if a system supports Mobility information
}			

Table 6-49—AAI-DREG-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If (Deregistration_Request_ Code == 0x04) {			
Idle Mode Retain Information element	5	Provided as part of this message indicative only. Network reentry from idle mode process requirements may change at time of actual reentry. For each bit location, a value of 0 indicates the information for the associated reentry control messages shall not be retained and managed; a value of 1 indicates the information for the associated reentry control message shall be retained and managed. Bit 0: Retain AMS service and operational information associated with AAI-SBC-REQ/RSP messages. Bit 1: Retain AMS service and operational information associated with AAI-PKM-REQ/RSP messages. Bit 2: Retain AMS service and operational information associated with AAI-REG-REQ/RSP messages. Bit 3: Retain AMS service and operational information associated with network address. Bit 4: Retain AMS state information. The information retained by setting bit 4 includes configuration of all Service Flows in the AMS as set by successful AAI-DSA and AAI-DSC transactions. In particular it includes FIDs and related description (QoS descriptors and CS classifier information).	
}			

6.2.3.22 AAI-DREG-RSP message

Table 6-50—AAI-DREG-RSP message format

Field	Size (bits)	Value/Description	Condition
Action code	4	Used to indicate the purpose of this message 0x00: AMS shall immediately terminate service with the ABS and should attempt network entry at another ABS. 0x01: AMS shall listen to the current ABS but shall not transmit until a RES-CMD message or AAI-DREG-RSP message with action code 0x02 or 0x03 is received. 0x02: AMS shall listen to the current ABS but only transmit on the control connection. 0x03: AMS shall return to normal operation and may transmit on any of its active connections. 0x04: This option is valid in response to a AAI-DREG-REQ message with Deregistration Request Code = 0x00. The AMS shall terminate current Connected State with the ABS. 0x05: AMS shall begin idle mode initiation: a) to signal AMS to begin idle mode in unsolicited manner or b) to allow AMS to transmit AMS-initiated idle mode request at the REQ-Duration expiration. 0x06: This option is valid only in response to an AAI-DREG-REQ message with Deregistration Code 0x01: a) to reject AMS-initiated idle mode request or b) to allow AMS to transmit AMS-initiated idle mode request at the REQ-Duration expiration. 0x07: This option is valid in response to an AAI-DREG-REQ message with Deregistration-request-code = 0x01 to allow AMS-initiated idle mode request. 0x08: This option is valid only in response to an AAI-DREG-REQ message with Deregistration Request Code 0x04 to allow retention of the AMS's connection information. 0x09: This option is valid only in response to an AAI-DREG-REQ message with Deregistration Request Code 0x04 to reject retention of the AMS's connection information. 0x10–0x15: *Reserved*	
If (Action code == 0x05) {			

Table 6-50—AAI-DREG-RSP message format *(continued)*

Field	Size (bits)	Value/Description	Condition
Paging cycle	4	Used to indicate Paging cycle for the AMS 0x00: 4 superframes 0x01: 8 superframes 0x02: 16 superframes 0x03: 32 superframes 0x04: 64 superframes 0x05: 128 superframes 0x06: 256 superframes 0x07: 512 superframes 0x08–0x15: *Reserved*	
Paging offset	12	Used to indicate Paging offset for the AMS. Determines the superframe within the paging cycle from which the paging listening interval starts. Shall be smaller than Paging cycle value.	
Paging controller ID	48	Used to indicate Paging controller that manages and retains the AMS's idle mode information $0..2^{48}-1$	
Paging group ID	16	Used to indicate Paging group that the AMS is located in $0..2^{16}-1$	
Deregistration ID	18	Used to indicate Deregistration ID used to identify the AMS in idle mode $0..2^{18}-1$	Present when the S-SFH Network Configuration bit == 0b0

Table 6-50—AAI-DREG-RSP message format *(continued)*

Field	Size (bits)	Value/Description	Condition
Idle Mode Retain Information element	5	Provided as part of this message indicative only. Network reentry from idle mode process requirements may change at time of actual reentry. For each bit location, a value of 0 indicates the information for the associated reentry control messages shall not be retained and managed; a value of 1 indicates the information for the associated reentry control message shall be retained and managed. Bit 0: Retain AMS service and operational information associated with AAI-SBC-REQ/RSP messages. Bit 1: Retain AMS service and operational information associated with AAI-PKM-REQ/RSP messages. Bit 2: Retain AMS service and operational information associated with AAI-REG-REQ/RSP messages. Bit 3: Retain AMS service and operational information associated with network address. Bit 4: Retain AMS state information. The information retained by setting bit 4 includes configuration of all Service Flows in the AMS as set by successful AAI-DSA and AAI-DSC transactions. In particular it includes FIDs and related description (QoS descriptors and CS classifier information).	
REQ-Duration	8	Used to indicate waiting value for the AAI-DREG-REQ message with DeregistrationDeregistration_Request_Code = 0x01 $0..2^8 - 1$: measured in frames	Present if needed
}			
If (Action code == 0x06) {			
REQ-Duration	8	Used to indicate waiting value for the AAI-DREG-REQ message with Deregistration_Request_Code = 0x01 $0..2^8 - 1$: measured in frames	Present if needed
}			
If (Action code == 0x07) {			

Table 6-50—AAI-DREG-RSP message format *(continued)*

Field	Size (bits)	Value/Description	Condition
Paging cycle	4	Used to indicate Paging cycle for the AMS 0x00: 4 superframes 0x01: 8 superframes 0x02: 16 superframes 0x03: 32 superframes 0x04: 64 superframes 0x05: 128 superframes 0x06: 256 superframes 0x07: 512 superframes 0x08–0x15: *Reserved*	
Paging offset	12	Used to indicate Paging offset for the AMS. Determines the superframe within the paging cycle from which the paging listening interval starts. Shall be smaller than Paging cycle value.	
Paging controller ID	48	Used to indicate Paging controller that manages and retains the AMS's idle mode information $0..2^{48}-1$	
Paging group ID	16	Used to indicate Paging group that the AMS is located in $0..2^{16}-1$	
Deregistration ID	18	Used to indicate Deregistration ID used to identify the AMS in idle mode $0..2^{18}-1$	Present when the S-SFH Network Configuration bit == 0b0

Table 6-50—AAI-DREG-RSP message format *(continued)*

Field	Size (bits)	Value/Description	Condition
Idle Mode Retain Information element	5	Provided as part of this message indicative only. Network reentry from idle mode process requirements may change at time of actual reentry. For each bit location, a value of 0 indicates the information for the associated reentry control messages shall not be retained and managed; a value of 1 indicates the information for the associated reentry control message shall be retained and managed. Bit 0: Retain MS service and operational information associated with AAI-SBC-REQ/RSP messages. Bit 1: Retain MS service and operational information associated with AAI-PKM-REQ/RSP messages. Bit 2: Retain MS service and operational information associated with AAI-REG-REQ/RSP messages. Bit 3: Retain MS service and operational information associated with network address. Bit 4: Retain MS state information. The information retained by setting bit 4 includes configuration of all Service Flows in the AMS as set by successful AAI-DSA and AAI-DSC transactions. In particular it includes FIDs and related description (QoS descriptors and CS classifier information).	
}			

6.2.3.23 AAI-PAG-ADV (paging advertisement) message

Table 6-51—AAI-PAG-ADV message field description

Field	Size (bits)	Value/Description	Condition
Paging_Group_IDs bitmap	L	Indicate that the paging information for the corresponding paging group is included in AAI-PAG-ADV message The length of Paging_Group_IDs bitmap is same as Num_PGIDs in PGID-Info message. 0: The paging information for the corresponding PGID is not included 1: The paging information for the corresponding PGID is included	L equals the Num_PGIDs in PGID-Info message

Table 6-51—AAI-PAG-ADV message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For (*i* = 0; *i* < M; *i*++) {			M equals the number of bits in Paging_Group_IDs bit-map whose bit is set to 1.
For (*j* = 0; *j* < Num_AMSs; *j*++) {		Num_AMSs indicates the number of paged AMSs in a corresponding paging group 1..32	
Deregistration Identifier	18	Used to indicate Deregistration ID for the AMS to be paged (Deregistration Identifier and Paging Cycle are used to identify each paged AMS) $0..2^{18}-1$	Present if the S-SFH Network Configuration bit == 0b0
MAC Address Hash	24	Used to identify the AMS to be paged	Present if the S-SFH Network Configuration bit == 0b1
Paging Cycle	4	Used to indicate Paging cycle for the AMS to be paged 0x00: 4 superframes 0x01: 8 superframes 0x02: 16 superframes 0x03: 32 superframes 0x04: 64 superframes 0x05: 128 superframes 0x06: 256 superframes 0x07: 512 superframes 0x08–0x15: *Reserved*	Present if the S-SFH Network Configuration bit == 0b0
Action code	1	Used to indicate the purpose of the AAI-PAG-ADV message 0b0: perform network reentry 0b1: perform ranging for location update	
}			
}			
Extension Flag	1	Used to indicate the remaining part of the AAI-PAG-ADV message exists 0b0: This is the last segment of the AAI-PAG-ADV message 0b1: This is not the last segment of the AAI-PAG-ADV message; the remaining segments of the message will be transmitted in the subsequent subframes or frames	
Emergency Alert Indication	1	Used to indicate the presence of emergency information 0b0: *Reserved* 0b1: There is emergency information	Optional Present if there is emergency information

6.2.3.24 PGID-Info (paging group information) message

Table 6-52—PGID-Info message field description

Field	Size (bits)	Value/Description	Condition
For(i = 0; i < Num_PGIDs; i++) {		Indicate the number of PGID included in PGID-Info message 1..4	
PGID	16	Indicate Paging group identifier where the ABS belongs $0..2^{16}-1$	Shall be present
}			
m	2	Time domain hash parameter (1~4) used to determine the frame index of a superframe for paging message transmission of an idle mode AMS. Indicate m in the equation $N_{paging\ frame}$ = AMS's deregistration identifier mod m to determine a predefined paging frame for the AMS 1..4	Shall be present
If (an ABS supports multiple carrier operation) {			
If (All PGs have same paging indication Bitmap) {			
Paging carrier indication bitmap	L	This bitmap is used to specify if carriers are a paging carrier in the ABS or not. The size of paging carrier indication bitmap (L) equals the total number of carriers in the AAI-Global-CFG message. The physical carrier index of each bit in bitmap corresponds to the ascending order of physical carrier index of the carriers in the AAI-Global-CFG message. The value N is the number of carrier indexes with its bit set to 1 in this bitmap. The paging carriers indicated in the PGID-Info message are chosen among the carriers on the same frequency band where the PGID-Info message is received.	
}			
Else {			
For(i = 0; i < Num_PGIDs; i++) {		Indicate the number of PGID included in the PGID-Info message 1..4	

Table 6-52—PGID-Info message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Paging carrier indication bitmap	L	This bitmap is used to specify if carriers are a paging carrier in the ABS or not. The size of paging carrier indication bitmap (L) equals the total number of carriers in the AAI-Global-CFG message. The physical carrier index of each bit in bitmap corresponds to the ascending order of physical carrier index of the carriers in the AAI-Global-CFG message. The value N is the number of carrier indexes with its bit set to 1 in this bitmap. The paging carriers indicated in the PGID-Info message are chosen among the carriers on the same frequency band where the PGID-Info message is received.	
}			
} //Else			
} // End If (an ABS supports multiple carrier operation)			

6.2.3.25 AAI-SLP-REQ

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

Table 6-53—AAI-SLP-REQ message field description

Field	Size (bits)	Value/Description	Condition
AAI-SLP-REQ message_format() {			
Operation	2	This indicates operation request type of the AAI-SLP-REQ message 0b00: Exit from sleep mode 0b01: Enter sleep mode 0b10: Change Sleep Cycle setting 0b11: Switch Sleep Cycle setting	
if(Operation != 00) {			
SCID	4	Sleep Cycle ID 0~15	

Table 6-53—AAI-SLP-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
FFBCH_Operation	2	0: The fast feedback channel assigned to the AMS is kept 1: The fast feedback channel is deallocated at the frame specified by Start_Frame_Number 2: The fast feedback channel is automatically deallocated at the beginning of the sleep window whenever the fast feedback channel is newly assigned to the AMS during the listening window 3: *Reserved*	
Start Frame Number	6	Least Significant 6 bits of Frame Number 0~63	
if(Operation == 0b01 || Operation == 0b10) {			
TIMF	1	Traffic Indication Message Flag 0: AAI-TRF-IND message is not sent for the AMS 1: AAI-TRF-IND message is sent to the AMS during every listening window 0~1	
LWEF	1	Listening Window Extension Flag 0: The Listening window is of fixed duration 1: The Listening window is extensible	
NSCF	2	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 × previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = *Reserved*	
Initial Sleep Cycle	4	This indicates an assigned duration for the Initial Sleep Cycle (measured in frames). Value: 0~15 Initial Sleep Cycle = Value + 1	
Final Sleep Cycle	10	This indicates an assigned duration for the Final Sleep Cycle (measured in frames). Value: 0~1023 Final Sleep Cycle = Value + 1	

Table 6-53—AAI-SLP-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Listening Window	6	Assigned duration of AMS's default listening window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. Value: 0~63 Listening window = Value + 1	
Listening subframe bitmap	8	The bitmap indicates the subframes in each frame where the AMS needs to remain in the Available state. The size of the bitmap equals the number of AAI subframes of a frame. Bit 0 is mapped to the first AAI sub-frame. Each bit in the bitmap indicates: 0: AMS does not transit to the Available state at the specific AAI sub-frame 1: AMS transits to the Available state at the specific AAI subframe	
if(NSCF == 0b10) {			
New Initial Sleep Cycle	5	When the current Sleep Cycle is reset, if this value is included, the current Sleep Cycle shall be reset to this value. Otherwise, the current Sleep Cycle may be reset to Initial Sleep Cycle or may be updated to min (2 × Previous Sleep Cycle, Final Sleep Cycle). Value: 0~31 New Initial Sleep Cycle = Value + 1	
}			
if(LWEF == 1) {			
T_AMS	6	This timer is for Listening Window Extension of AMS (measured in frames). 0~31	
}			
}// ENDIF (Operation == 0b01 || Operation == 0b10)			
}//ENDIF (Operation != 00)			
}			

Parameters shall be as follows:

Operation

This indicates the operation request type of the AAI-SLP-REQ message.

0b00 = AAI-SLP-REQ message is transmitted to exit from sleep mode.

0b01 = AAI-SLP-REQ message is transmitted to enter sleep mode.

0b10 = AAI-SLP-REQ message is transmitted to change the existing Sleep Cycle setting.

0b11 = AAI-SLP-REQ message is transmitted to switch the Sleep Cycle setting that has been negotiated since the AMS entered sleep mode.

SCID

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

LWEF

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

TIMF

1 = ABS is requested to transmit an AAI-TRF-IND message during the AMS's listening window.

0 = Traffic Indication via AAI-TRF-IND is not required.

NSCF

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

Start Frame Number

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

Initial Sleep Cycle

This indicates an assigned duration for the Initial Sleep Cycle (measured in frames). The length of the Initial Sleep Cycle shall be equal to or longer than the default listening window.

Final Sleep Cycle

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

Listening Window

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

Listening subframe bitmap

The bitmap indicates the subframes in each frame where the AMS needs to remain in the Available state. The most significant bit is mapped to the first AAI subframe.

If this value is set to 0xFF, the AMS shall remain in the Available state during entire subframes in each frame during the listening window.

New Initial Sleep Cycle

When the current sleep cycle is reset, if this value is included, the current sleep cycle shall be reset to this value. Otherwise, the current sleep cycle may be reset to the initial sleep cycle or may be updated to min (2 × Previous Sleep Cycle, Final Sleep Cycle).

T_AMS

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

6.2.3.26 AAI-SLP-RSP

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

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

Table 6-54—AAI-SLP-RSP message field description

Field	Size (bits)	Value/Description	Condition
AAI-SLP-RSP message_format() {			
Response_Code	2	This indicates response type of AAI-SLP-RSP message. 0b00: Request by ABS in Unsolicited manner 0b01: Approval of AAI-SLP-REQ 0b10: Rejection of AAI-SLP-REQ 0b11: *Reserved*	
if(Response_Code != 0b10) {			
Operation	2	This indicates operation request type of AAI-SLP-RSP message 0b00: Exit from sleep mode 0b01: Enter sleep mode 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	
if(Operation != 00) {			
SCID	4	Sleep Cycle ID 0~15	

Table 6-54—AAI-SLP-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
FFBCH_Operation	2	0: The fast feedback channel assigned to the AMS is kept 1: The fast feedback channel is deallocated at the frame specified by Start_Frame_Number 2: The fast feedback channel is automatically deallocated at the beginning of the sleep window whenever the fast feedback channel is newly assigned to the AMS during the listening window 3: *Reserved*	
Start Frame Number	6	Least Significant 6 bits of Frame Number 0~63	
if(Operation == 0b01 || Operation == 0b10) {			
TIMF	1	Traffic Indication Message Flag 0: AAI-TRF-IND message is not sent for the AMS 1: AAI-TRF-IND message is sent to the AMS during every listening window 0~1	
LWEF	1	Listening Window Extension Flag 0: The Listening window is of fixed duration 1: The Listening window is extensible	
NSCF	2	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 × previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = *Reserved*	
Initial Sleep Cycle	4	This indicates an assigned duration for the Initial Sleep Cycle (measured in frames). Value: 0~15 Initial Sleep Cycle = Value + 1	
Final Sleep Cycle	10	This indicates assigned duration for the Final Sleep Cycle (measured in frames). Value: 0~1023 Final Sleep Cycle = Value + 1	

Table 6-54—AAI-SLP-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Listening Window	6	Assigned duration of the AMS's default listening window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. Value: 0~63 Listening Window = Value + 1	
Listening subframe bitmap	8	The bitmap indicates the subframes in each frame where the AMS needs to remain in the Available state. The size of the bitmap equals the number of AAI subframes of a frame. Bit 0 is mapped to the first AAI subframe. Each bit in the bitmap indicates: 0: AMS does not transit to the Available state at the specific AAI subframe 1: AMS transits to the Available state at the specific AAI subframe	
if(TIMF == 1) {			
SLPID	10	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode 0~1023	
}			
if(NSCF == 0b10) {			
New Initial Sleep Cycle	5	When the current sleep cycle is reset, if this value is included, the current sleep cycle shall be reset to this value. Otherwise, the current sleep cycle may be reset to Initial Sleep Cycle or may be updated to min (2 × Previous Sleep Cycle, Final Sleep Cycle). Value: 0~31 New Initial Sleep Cycle = Value + 1	
}			
if(LWEF == 1) {			
T_AMS	6	This timer is for Listening Window Extension of AMS (measured in frames). 0~31	
}			

Table 6-54—AAI-SLP-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
}// ENDIF (Operation == 0b01 || Operation == 0b10)			
}// ENDIF (Operation != 0b00)			
} else {		// equivalent to if(Response_Code == 0b10)	
REQ_duration	8	Waiting value for the AAI-SLP-REQ message retransmission, which is the Least Significant 8 bits of Frame Number. If REQ_duration is missing in AAI-SLP-RSP when Response_Code == 0b10, it shall be regarded as REQ_duration = 0 0~255	Optional: This parameter may be omitted when (Response_Code == 0b10)
}			
}			

Response_Code

This indicates the response type of the AAI-SLP-RSP message.

0b00 = AAI-SLP-RSP message is transmitted in an unsolicited manner

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

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

0b11 = *Reserved*

Operation

This indicates the operation type of the AAI-SLP-RSP message.

0b00 = Approves/Requests the exit from sleep mode

0b01 = Approves/Requests the entrance to sleep mode

0b10 = Approves/Requests the change of an existing sleep cycle setting

0b11 = Approves/Requests the switch of a sleep cycle setting that has been negotiated since the AMS entered sleep mode

SCID

Assigned sleep cycle identifier. The ID shall be unique within the AMS. This ID may used in further AAI-SLP-REQ/RSP messages for changing/switching the sleep cycle setting.

LWEF

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

TIMF

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

0 = Traffic Indication via AAI-TRF-IND is disabled.

NSCF

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

Start Frame Number

Start frame number for first sleep window. This represents the 6 least significant bits of the frame number in which the AMS enters the sleep mode.

Initial Sleep Cycle

This indicates an assigned duration for the initial sleep cycle (measured in frames). The length of the initial sleep cycle shall be equal to or longer than the default listening window.

Final Sleep Cycle

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

Listening Window

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

Listening subframe bitmap

The bitmap indicates the subframes in each frame where the AMS needs to remain in the Available state. Most significant bit is mapped to the first AAI subframe.

If this value is set to 0xFF, the AMS shall remain in the Available state during entire subframes in each frame during the listening window.

SLPID

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

REQ-duration

Waiting value for the AAI-SLP-REQ message retransmission, which is the Least Significant 8 bits of Frame Number when AMS's request is rejected by ABS: the AMS may retransmit the AAI-SLP-REQ message after at least the frame designated by REQ-duration.

New Initial Sleep Cycle

When the current sleep cycle is reset, if this value is included, the current sleep cycle shall be reset to this value. Otherwise, the current sleep cycle may be reset to the initial sleep cycle or may be updated to min ($2 \times$ Previous Sleep Cycle, Final Sleep Cycle).

T_AMS

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

6.2.3.27 AAI-TRF-IND

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

There are two formats for the AAI-TRF-IND message, indicated by the FRMT field. When FRMT = 0, and if the AMS does not find its own SLPID-Group Indication bitmap or Traffic Indication bitmap, the AMS shall consider it as a negative indication and may transit to the Unavailable state. When FRMT = 1, and if the AMS does not find its own SLPID in the AAI-TRF-IND message, the AMS shall consider it as a negative indication and may transit to the Unavailable state.

Table 6-55—AAI-TRF-IND message field description

Field	Size (bits)	Value/Description	Condition
AAI-TRF-IND message_format() {			
FRMT	1	This indicates type of Traffic Indication in the AAI-TRF-IND message. 0: It indicates the SLPID bitmap-based traffic indication 1: It indicates the SLPID-based traffic indication	
Emergency Alert Indication	1	Used to indicate the presence of emergency information for supporting the Emergency Alert Service 0b0: There is no emergency information 0b1: There is emergency information	
if(FMT == 0) {			
SLPID Group Indication Bitmap	32	It indicates the existence of each SLPID group N-th bit of SLPID-Group Indication Bitmap [MSB corresponds to N = 0] is allocated to SLPID Group that includes AMS with SLPID values from N × 32 to N × 32 + 31 0: There is no traffic for any of the 32 AMSs that belong to the SLPID-Group 1: There is traffic for at least one AMS in the SLPID-Group	
Traffic Indication Bitmap	N×32	It indicates the traffic indication for 32 AMSs in each SLPID group Each Traffic Indication bitmap comprises multiples of 32-bit-long Traffic Indication units. A Traffic Indication unit for 32 SLPIDs is added to the AAI-TRF-IND message whenever its SLPID Group is set to 1 32-bits of Traffic Indication Unit (starting from MSB) are allocated to AMS in the ascending order of their SLPID values: 0: Negative indication 1: Positive indication N = The number of ‘1’ in SLPID Group Indication Bitmap (i.e., the number of SLPID Group that has positive traffic indication)	

Table 6-55—AAI-TRF-IND message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
} else {			
for (*i* = 0; *i* < Num_of_SLPIDs; *i*++) {			
SLPID	10	Each SLPID is used to indicate the positive traffic indication for an AMS 0~1023	
}			
Traffic Location Indicator Bitmap	L	The size L equals the number of AMSs for which positive traffic is indicated. The max value of L is 63. The bits (starting with MSB) correspond to the AMSs with a positive traffic indication in ascending order of their SLPID. Each bit in this bitmap is the Traffic Location Indicator of the corresponding AMS; see 6.2.17.2.3.1. 0b0: AMS shall remain in the Available state during the entire listening window 0b1: AMS may be in the Unavailable state in the first half of the listening window as the traffic is coming only in the second half of the listening window	Shall be included when there is at least one SLPID that has a positive traffic indication and its Traffic Location Indicator set to 1. Omission of this field signals that the Traffic Location Indicator is 0 for all SLPIDs that have a positive traffic indication.
}			
SLPID_Update	20×N	For each 20 bits, the first 10 bits indicate old SLPID and the second 10 bits indicate new SLPID N indicates the number of SLPID to be updated. The range of N is [1..1024]	Present when SLPID update is needed
}			

Parameters shall be as follows:

FRMT

The FRMT field indicates one of the SLPID bitmap based format and the SLPID based format.

SLPID-Group Indication Bitmap

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

SLPID-Group #*n*. In this case, the AMS in sleep mode belonging to SLPID-Group #*n* shall read its own Traffic Indication bitmap in the AAI-TRF-IND message.

Traffic Indication Bitmap

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

0: Negative indication

1: Positive indication

Num_of_SLPID

The number of SLPID with positive indication.

SLPID

The SLPID for AMS that has DL pending traffic.

Traffic Location Indicator Bitmap

Each bit corresponds to a SLPID that has a positive traffic indication and indicates whether the corresponding data is present only in the second half of the listening window.

The AAI-TRF-IND may include the following parameter.

SLPID_Update

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

6.2.3.28 AAI-TRF-IND-REQ

If the TIMF is set to 1, the ABS shall transmit the AAI-TRF-IND message in the first frame during the listening window. However, if the traffic indication message is lost or otherwise not detected by the AMS, the AMS shall stay awake for the rest of the listening window. If the AMS receives any unicast data during the listening window, then it shall assume that the traffic indication was positive. If the AMS receives neither the traffic indication message nor any unicast data in the listening window, the AMS shall send an AAI-TRF-IND-REQ message to the ABS after the listening window in order to ask the starting frame number and the size of the next scheduled sleep cycle. The ABS shall respond to the AMS by sending an AAI-TRF-IND-RSP. If the AMS does not receive the AAI-TRF-IND-RSP message until the T43 timer expires, the AMS shall retransmit the AAI-TRF-IND-REQ. This procedure shall be repeated until the AMS successfully receives the AAI-TRF-IND-RSP message from the ABS.

Table 6-56—AAI-TRF-IND-REQ message field description

Field	Size (bits)	Value/Description	Condition
AAI-TRF-IND-REQ message_format() {			

6.2.3.29 AAI-TRF-IND-RSP

When the ABS receives the AAI-TRF-IND-REQ message from an AMS, the ABS shall respond to the AMS by sending the AAI-TRF-IND-RSP message. When the AMS receives AAI-TRF-IND-RSP from the ABS, the AMS shall update the current sleep cycle based on the starting frame number and the size of next scheduled sleep cycle in the AAI-TRF-IND-RSP.

Table 6-57—AAI-TRF-IND-RSP message field description

Field	Size (bits)	Value/Description	Condition
AAI-TRF-IND-RSP message_format() {			
Emergency Alert Indication	1	Used to indicate the presence of emergency information for supporting the Emergency Alert Service 0b0: There is no emergency information 0b1: There is emergency information	
Frame_Number	10	The least significant 10 bits of the frame number in which incoming LW will start 0~1023	
Sleep Cycle Length	10	The length of the sleep cycle that contains the next scheduled listening window. If the AMS receives the negative traffic indication during the next scheduled listening window, the (current) sleep cycle shall be set to this value at that time. Value: 0~1023 Sleep Cycle Length = Value + 1	
SLPID	10	New SLPID with which to replace the AMS's old SLPID. When the ABS has sent the AAI-TRF-IND message including the SLPID update of the AMS and it receives AAI-TRF-IND-REQ from the AMS, the ABS shall include this parameter in AAI-TRF-IND-RSP.	Shall be included when the SLPID is updated.
}			

Parameters shall be as follows:

Frame_Number

This indicates the least significant 10 bits of the frame number in which the next scheduled listening window will start.

Sleep Cycle Length

This indicates the length of sleep cycle that contains the next scheduled listening window when the sleep cycle is doubled because of negative traffic indication during the next scheduled listening window.

6.2.3.30 L2 Transfer message (AAI-L2-XFER)

The AAI provides a generic MAC control message called AAI-L2-XFER. This message acts as a generic service carrier for various services including, but not limited to, the following:

- Device provisioning bootstrap message to AMS
- GPS assistance delivery to AMS
- ABS(es) geo-location unicast delivery to AMS
- IEEE 802.21 MIH transfer
- Messaging service

This container is also used for messages that are not processed by the ABS or ARS, but are rather processed by network entities beyond the ABS or ARS, including network elements belonging to other target RATs.

AAI-L2-XFER messages are very likely to bypass any firewalls or other security protection that may be implemented on terminal devices incorporating the AMS, firewalls that mostly, if not exclusively, monitor protocols on L3 and L4 and above layers. For this reason, use of the AAI-L2-XFER message poses a substantial security and access control risk to the terminal 1) unless the AAI-L2-XFER message is strictly used for very specific, identified purposes (SMS, etc.), by the designated applications only, and 2) unless the vendor implementation takes specific precaution to mitigate and minimize these risks. Vendor implementation and mitigation techniques are outside the scope of this specification. Any other use of the AAI-L2-XFER message may have unintended security and access control risks not contemplated in this specification.

The format of AAI-L2-XFER message is shown in Table 6-58.

Table 6-58—AAI-L2-XFER message field description

Field	Size (bits)	Value/Description	Condition
L2-Xfer Type	8	Transfer-Type = 1; GNSS assistance (DL) Transfer-Type = 2; LBS measurement [Terrestrial meas. and GNSS pseudo ranges] (UL) Transfer-Type = 3; Device Bootstrap (DL/UL) Transfer-Type = 4; WirelessMAN-Advanced Air Interface system network boundary indication (DL) Transfer-Type = 5; ORAT-MSG (DL/UL) Transfer-Type = 6: SMS Transfer-Type = 7: MIH Frame Transfer-Type = 8; ASN control messages for Relay support (DL/UL) Transfer-Type = 9; Emergency Alert Transfer-Type = 10–127; *Reserved* Transfer-Type = 128–255; vendor-specific types	
If (Transfer-Type == 5) {			

Table 6-58—AAI-L2-XFER message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
L2-Xfer Subtype	4	Subtype = 1: GERAN (GSM/GPRS/ EGPRS) Subtype = 2: UTRAN Subtype = 3: E-UTRAN Subtype = 4: TDSCDMA Subtype = 5: CDMA2000	
L2-Xfer payload			
} else if (Transfer-Type == 6) {			
L2-Xfer Subtype	4	Subtype = 1: SMS data Subtype = 2: SMS confirmation	
L2-Xfer payload			
} else if (Transfer-Type == 7) {			
L2-Xfer Subtype	4	Subtype = 1: Service Management Subtype = 2: Event Service Subtype = 3: Command Service Subtype = 4: Information Service	
L2-Xfer payload			
} else {			
L2-Xfer payload			
}			

The enumeration of Transfer-Type is as follows:

a) Transfer-Type = 1; GNSS assistance (DL)

b) Transfer-Type = 2; LBS measurement [Terrestrial measurement and GNSS pseudo-ranges] (UL)

c) Transfer-Type = 3; Device Bootstrap (DL/UL)

d) Transfer-Type = 4; WirelessMAN-Advanced Air Interface system network boundary indication (DL)

e) Transfer-Type = 5; ORAT-MSG (DL/UL)

   i Subtype = 1: GERAN (GSM/GPRS/EGPRS)

   ii) Subtype = 2: UTRAN

   iii) Subtype = 3: E-UTRAN

   iv) Subtype = 4: TDSCDMA

   v) Subtype = 5: CDMA2000

f) Transfer-Type = 6; SMS

   i) Subtype = SMS data

   ii) Subtype = SMS confirmation

g) Transfer-Type = 7; MIH Frame

   i) Subtype = 1: Service Management

   ii) Subtype = 2: Event Service

iii) Subtype = 3: Command Service
iv) Subtype = 4: Information Service

h) Transfer-Type = 8; ASN control messages for Relay support (DL/UL)
i) Transfer-Type = 9; Emergency Alert
j) Transfer-Type = 10–127; *Reserved*
k) Transfer-Type = 128–255; Vendor-specific types

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

6.2.3.31 AAI-System Configuration Descriptor (SCD) message

An AAI-SCD shall be transmitted by the ABS at a periodic interval to define a system configuration. Configuration Change Count in the AAI-SCD shall be incremented by 1 modulo 16 whenever the contents of this message are changed. The ABS shall indicate when the changed AAI-SCD is applied through the S-SFH applying offset in P-SFH and the SCD Count in S-SFH SP3. After sending an S-SFH SP3 that includes the same SCD Count with the Configuration Change Count in the AAI-SCD, the ABS shall apply the changed system configuration of the AAI-SCD associated with the SCD Count in the S-SFH SP3 when the update of the S-SFH SP3 is applied as described in 6.2.4. The AMS shall receive recent system configuration of the AAI-SCD message associated with current SCD Count. If an AAI-SCD change is caused by the update of S-SFH SPx, then the new AAI-SCD should be transmitted before the changed S-SFH SPx.

After the AMS receives the changed S-SFH SP3,

a) If SCD Count in the S-SFH SP3 is different from that saved lastly at the AMS and the changed S-SFH SP3 has not been applied yet, the AMS shall use system configuration of the AAI-SCD associated with the previous SCD Count (= (SCD Count in the S-SFH SP3 – 1) modulo 16).
b) Except in case a), the AMS shall use the system configuration of the AAI-SCD associated with the current SCD Count in the S-SFH SP3.
c) The AMS that failed to receive the updated AAI-SCD may apply the system configuration of the AAI-SCD associated with the previous SCD Count (= (SCD Count in the S-SFH SP3 – 1) modulo 16) except for the system configuration parameters for the periodic ranging (periodicityOfRngChSync, cntlStartCodeOfRngChSync, rangingPreambleCodeSync) and sounding channel (multiplexingType, decimationValueD, maxCyclicShiftIndexP, shiftValueUForSoundingSymbol).

Table 6-59—AAI-SCD message field description

Field	Size (bits)	Value/Description	Condition
Configuration Change Count	4	The value is increased whenever the contents of this message are changed. The value rolls over from 0 to 15	
BS_Restart_Count	4	The value is incremented by one whenever BS restarts. The value rolls over from 0 to 15	
SA_Preamble Partition for BS type	20	Indicates the SA-Preamble partition information. Each 4 bits represents a partition range for each cell type, as defined in 6.3.5.1.2 and Table 6-170	

Table 6-59—AAI-SCD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Trigger definitions	*variable*	Refer to Table 6-120	
Default Trigger Averaging Parameter for Intra-FA measurement	8	Indicates default alpha averaging parameter for intra-FA measurement. 0x0: 1 0x1: 1/2 0x2: 1/4 0x3: 1/8 0x4: 1/16 0x5: 1/32 0x6: 1/64 0x7: 1/128 0x8: 1/256 0x9: 1/512 0xA to 0xFF: *Reserved*	
Default Trigger Averaging Parameter for Inter-FA measurement	8	Indicates default alpha averaging parameter for inter-FA measurement. 0x0: 1 0x1: 1/2 0x2: 1/4 0x3: 1/8 0x4: 1/16 0x5: 1/32 0x6: 1/64 0x7: 1/128 0x8: 1/256 0x9: 1/512 0xA to 0xFF: *Reserved*	
If (OL MIMO parameters are needed) {			
OL-Region-Type0-ON	1	0 or 1	
OL-Region-Type1-NLRU-Size	4	0 to 15	
OL-Region-Type1-SLRU-Size	4	0 to 15	
OL-Region-Type2-SLRU-Size	4	0 to 15	
}			
If ((not a Femtocell) && (not a WirelessMAN-Advanced Air Interface co-existing System with FDM-based UL PUSC zone)) {			
periodicityOfRngChSync	2	The periodicity of the S-RCH allocation (Table 6-271)	
cntlStartCodeOfRngChSync	4	The parameter ks controlling the start root index of the RP codes for the S-RCH	
rangingPreambleCodeSync	2	The number of the RP codes for periodic ranging (Table 6-271)	
}			

Table 6-59—AAI-SCD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
periodOfPeriodicRngTimer	3	It is the period of Periodic Ranging timer that is broadcasted by the ABS. It has 3 bits to represent the value among {2, 4, 7, 10, 15, 20, 25, 35} seconds	
If(Frequency Partition 0 is used){			
gammaIotFp0	4	gammaIotFp (IoT) is the fairness and IoT control factor, broadcast by the ABS. It has 4 bits to represent the value among {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5}. It is different for each frequency partition (FP0, FP1, FP2, FP3)	
}			
If(Frequency Partition 1 is used){			
gammaIotFp1	4	gammaIotFp (IoT) is the fairness and IoT control factor, broadcast by the ABS. It has 4 bits to represent the value among {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5}. It is different for each frequency partition (FP0, FP1, FP2, FP3)	
}			
If(Frequency Partition 2 is used){			
gammaIotFp2	4	gammaIotFp (IoT) is the fairness and IoT control factor, broadcast by the ABS. It has 4 bits to represent the value among {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5}. It is different for each frequency partition (FP0, FP1, FP2, FP3)	
}			
If(Frequency Partition 3 is used){			
gammaIotFp3	4	gammaIotFp (IoT) is the fairness and IoT control factor, broadcast by the ABS. It has 4 bits to represent the value among {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5}. It is different for each frequency partition (FP0, FP1, FP2, FP3)	
}			

Table 6-59—AAI-SCD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Alpha	3	alpha (α) is the factor according to the number of receive antennas at the ABS. It has 3 bits to express {1, 1/2, 1/4, 1/8, 1/16, 0, reserved, reserved}	
Beta	1	It is used to indicate disable or enable of the power deboosting for uplink multi-stream transmission. 0: disable 1: enable	
dataSinrMin	4	dataSinrMin is the SINR requirement for the minimum data rate expected by ABS. SINRmin_Data has 4 bits to represent the value in dB among{–INF, –3, –2.5, –2, –1.5, –1, –0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4}	
dataSinrMax	4	dataSinrMax is the maximum SINR threshold defined by ABS. SINRmmax_Data has 4 bits to represent the value in dB among {10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40}	
targetHarqSinr	4	It is the HARQ feedback channel target SINR value broadcasted by the ABS. It has 4 bits to represent the value among {–3.5, –3, –2.5, –2, –1.5, –1, –0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4} dB	
targetSyncRangingSinr	4	It is the synchronized channel target SINR value broadcasted by the ABS. It has 4 bits to represent the value among {–9, –8.5, –8, –7.5, –7, –6.5, –6, –5.5, –5, –4.5, –4, –3.5, –3, –2.5, –2, –1.5} dB	
targetPfbchSinr	4	It is the P-FBCH target SINR value broadcasted by the ABS. It has 4 bits to represent the value among {–4.5, –4, –3.5, –3, –2.5, –2, –1.5, –1, –0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3} dB	
targetSfbchBaseSinr	4	It is defined as 4 bits to represent {0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5} dB	
targetSfbchDeltaSinr	3	It is defined as 3 bits to represent {0, 0.20, 0.21, 0.22, 0.23, 0.24, 0.25, 0.26} dB	

Table 6-59—AAI-SCD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
targetBwRequestSinr	4	It is the bandwidth request channel target SINR value broadcasted by the ABS. It has 4 bits to represent the value among {–4.5, –4, –3.5, –3, –2.5, –2, –1.5, –1, –0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3} dB	
gammaIotSounding	4	It is 4 bits to represent the value among {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5} dB	
soundingSinrMin	4	It is the minimum SINR requirement for sounding expected by ABS. It has 4 bits to represent the value among {–4, –3.5, –3, –2.5, –2, –1.5, –1, –0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5} dB	
soundingSinrMax	4	It is the maximum SINR requirement for sounding expected by ABS. It has 4 bits to represent the value among {5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20} dB	
T_ReTx_Interval	3	1–8 if DL_N_MAX_ReTx = 4; 1–4 if DL_N_MAX_ReTx = 8. The unit is a frame	
BR_Channel Configuration MIN Access Class of the (i + 0)-th frame	2	INTEGER (0..3)	Optional
BR_Channel Configuration MIN Access Class of the (i + 1)-th frame	2	INTEGER (0..3)	Optional
BR_Channel Configuration MIN Access Class of the (i + 2)-th frame	2	INTEGER (0..3)	Optional
BR_Channel Configuration MIN Access Class of the (i + 3)-th frame	2	INTEGER (0..3)	Optional
multiplexingType	1	0b0: Decimation separation 0b1: Cyclic shift separation	Present when Uplink AAI subframes for sounding in S-SFH SP1 is not set to 0b000
If (multiplexingType == 0b0) {			
decimationValueD	3	decValueD0 (4), decValueD1 (6), decValueD2 (8), decValueD3 (9), decValueD4 (12), decValueD5 (16), decValueD6 (18), decValueD7 (36)	
}else if (multiplexingType == 0b1) {			

Table 6-59—AAI-SCD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
maxCyclicShiftIndexP	3	csIndexP0 (4), csIndexP1 (6), csIndexP2 (8), csIndexP3 (9), csIndexP4 (12), csIndexP5 (16), csIndexP6(18), csIndexP7(36)	
}			
shiftValueUForSoundingSymbol	8	0–255	
If (ABS is the sender of AAI-SCD and ABS has TTR ARS in the cell) {			
AAI_Relay_zone_AMS_allocation_indicator	1	0b0: The ABS does not allocate resources to the AMS in the AAI DL Relay zone 0b1: The ABS may allocate resources to the AMS in the AAI DL Relay zone	Optional. Present when ABS is the sender of AAI-SCD and ABS has TTR ARS in the cell
}			
If (E-MBS is configured) {			
Zone_Allocation Bit-MAP	20 or 9 or 3	The number of bits in the bit map = the maximum number of sub-bands for a given FFT size (i.e., 2048 FFT, 1024 FFT, 512 FFT) – 1. 2048 FFT: b0–b19 1024 FFT: b0–b8 512 FFT: b0–b2 bi = 1 if resource is changed between subband *i* and subband *i* + 1 bi = 0 if resource is not changed between subband i and subband *i* + 1 See 6.9.3.1	
ZF	1	Zone Flag bit. Indicates the use of the last zone. 0b0: Unicast 0b1: E-MBS (see 6.9.3.1)	
MSI Length (N_{MSI})	2	The length of an MSI in units of the number of superframes 0b00: 4 superframes, 80 ms (N_{MSI} = 4) 0b01: 8 superframes, 160 ms (N_{MSI} = 8) 0b10: 16 superframes, 320 ms (N_{MSI} = 16) 0b11: 32 superframes, 640 ms (N_{MSI} = 32)	
E-MBS AAI frame offset	*variable*	The location of the AAI frame where the E-MBS data burst ends MSI length == 0b00: 4 bits MSI length == 0b01: 5 bits MSI length == 0b10: 6 bits MSI length == 0b11: 7 bits	
}			

Table 6-59—AAI-SCD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For(i = 0; i < N-UL-Feedback-Info; i++) {		N-UL-Feedback-Info is the number of UL feedback Information included here [1..8]	
If (multicarrier is configured in multicarrier Aggregation with DL-only secondary partially configured carriers) {			
physical PrimaryCarrierIndex	6	The physical carrier index for primary carrier	Present when all the AMSs do not support a single identical primary carrier
startDLRUIndex	7	The start DLRUs index for feedback channel	
dLRUNum	4	The number of DLRUs for feedback channel per UL AAI subframe (refer to 6.3.8.2.3.2)	
hARQChannelNum	2	The number of HARQ feedback channel per HARQ feedback region. This value is denoted by L_{HFB} in 6.3.7.3.3.2. Channel numbers represented by the two bits (0, 1, 2, 3) are as follows. For 512 FFT size, 6, 12, 18, 24 For 1024 FFT size, 6, 12, 24, 30 For 2048 FFT size, 12, 24, 48, 60	
}			
}			
If (FPS2 > 0) {		See Table 6-154 to Table 6-156	
resourceMetricFP2	4	Resource_Metric_FP2 Resource Metric of the first power deboosted frequency partition that is defined in Table 6-147. This parameter does not affect “Configuration Change Count”	
}			
If(FPS3 > 0) {		See Table 6-156 to Table 6-158	
resourceMetricFP3	4	Resource_Metric_FP3 Resource Metric of the second power deboosted frequency partition that is defined in Table 6-147. This parameter does not affect “Configuration Change Count”	
}			
Network synchronization indicator	1	Indicates whether the ABS achieves synchronization from backhaul network (0b01) or not (0b00)	Optional

6.2.3.32 AAI-UL Noise and Interference Level Broadcast message

An AAI-ULPC-NI broadcast NI values for the UL power control.

Table 6-60—AAI-ULPC-NI Field description

Field	Size (bits)	Value/Description	Condition
If (Sounding is used) {			
iotSounding	7	IoT value of sounding, quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB.	
}			
If(Frequency Partition 0 is used){			
gammaIotFp0	7	IoT value of Frequency Partition #0, quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB.	
}			
If(Frequency Partition 1 is used){			
gammaIotFp1	7	IoT value of Frequency Partition #1, quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB.	
}			
If(Frequency Partition 2 is used){			
gammaIotFp2	7	IoT value of Frequency Partition #2, quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB.	
}			
If(Frequency Partition 3 is used){			
gammaIotFp3	7	IoT value of Frequency Partition #3, quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB.	
}			

The UL noise and interference level shall be broadcast to AMSs in the given ABS coverage by the ABS. All the UL noise and interference noise level are quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB.

The absolute power level of NI is transformed from IoT level as shown in Equation (1).

$$NI = P_{TN} + IoT + 10\log 10(\Delta f) \tag{1}$$

where

P_{TN} is the thermal noise power density in 0 °C that has a value of –174.2352 dBm.

Δf is the subcarrier spacing (Hz).

6.2.3.33 AAI-UL-POWER-ADJ message

An AAI-UL-POWER-ADJ message shall be transmitted by the ABS to control the transmit power level of the AMS.

Table 6-61—AAI-UL-POWER-ADJ message field description

Field	Size (bits)	Value/Description	Condition
offsetData	6	offsetData is the transmit power adjustment value transmitted by the ABS. It represents the value among –15.5 dB to 16 dB with 0.5 dB steps.	N/A
offsetControl	6	offsetControl is the transmit power adjustment value transmitted by the ABS. It represents the value among –15.5 dB to 16 dB with 0.5 dB steps.	Present when the ABS wants to change the transmit power adjust value of the UL control channel. (More details can be found in 6.3.8.4.2.)
channelIndex	8	This value corresponds to “Channel Index” in Feedback Allocation A-MAP IE.	Present when the ABS wants to change Fast Feedback Control Channel Allocation by using the AAI-UL-POWER-ADJ message. (More details can be found in 6.3.5.5.2.4.5.)
shortTermFeedbackPeriod	3	This value corresponds to “Short-term feedback period (p)” in Feedback Allocation A-MAP IE.	Present when the ABS wants to change Fast Feedback Control Channel allocation by using the AAI-UL-POWER-ADJ message. (More details can be found in 6.3.5.5.2.4.5.)
longTermFeedbackPeriod	2	This value corresponds to “Long-term feedback period (q)” in Feedback Allocation A-MAP IE.	Present when the ABS wants to change Fast Feedback Control Channel allocation by using the AAI-UL-POWER-ADJ message. (More details can be found in 6.3.5.5.2.4.5.)

Table 6-61—AAI-UL-POWER-ADJ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
frameOffsetNumber	2	This corresponds to “Frame index” in Feedback Allocation A-MAP IE.	Present when the ABS wants to change Fast Feedback Control Channel allocation by using the AAI-UL-POWER-ADJ message. (More details can be found in 6.3.5.5.2.4.5.)
subframeIndex	3	This corresponds to “Subframe index” in Feedback Allocation A-MAP IE.	Present when the ABS wants to change Fast Feedback Control Channel allocation by using the AAI-UL-POWER-ADJ message. (More details can be found in 6.3.5.5.2.4.5.)
allocationDuration	3	This corresponds to “Allocation Duration (d)” in Feedback Allocation A-MAP IE.	Present when the ABS wants to change Fast Feedback Control Channel allocation by using the AAI-UL-POWER-ADJ message. (More details can be found in 6.3.5.5.2.4.5.)
If (Carrier-specific PHY control mode = 0b0) {			
PhysicalCarrierIndex	6	The relevant active carrier with which this control message is associated.	Present if the Carrier-specific PHY control mode is disabled and an AMS has active secondary carrier(s).
}			

6.2.3.34 AAI-Uplink Power Status Reporting Configuration (AAI-UL-PSR-CFG) message

An AAI-UL-PSR-CFG message is used to configure the AMS uplink power status reporting by unicasting. It is defined as in Table 6-62.

Table 6-62—AAI-UL-PSR-CFG message field description

Field	Size (bits)	Value/Description	Condition
uplinkPowerStatusReport	1	disable (0), enable (1)	N/A
If (uplinkPowerStatusReport = 0b 1) {			

Table 6-62—AAI-UL-PSR-CFG message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
txPowerReportThreshold	4	txPowerReportThreshold is a 4-bit unsigned integer value in 0.5 dB steps. txPowerReportThreshold = 0.5 × value And the specific value "0b1111" shall be interpreted as "infinite"	Present when uplink-PowerStatusReport is enabled
txPowerReportMinimumInterval	4	txPowerReportMinimumInterval (m) is coded by 4-bit unsigned integer values representing 2^m frames; the specific value m = 0b1111 shall be interpreted as "infinite"	
txPowerReportPeriodicalInterval	4	txPowerReportPeriodicalInterval (d) is coded by 4-bit unsigned integer values representing 2^d frames; the specific value d = 0b1111 shall be interpreted as "infinite"	
}			
If (Carrier-specific PHY control mode = 0b0) {			
PhysicalCarrierIndex	6	The relevant active carrier with which this control message is associated	Present if the Carrier-specific PHY control mode is disabled and an AMS has an active secondary carrier(s)
}			

6.2.3.35 AAI-DL-IM message

The AAI-DL-IM broadcast message may be transmitted by the ABS to define FFR and multi-BS MIMO parameters (see Table 6-63).

Table 6-63—AAI-DL-IM message field description

Field	Size (bits)	Value/Description	Condition
If (ABS needs to change FP2 power){			
fp2Power	5	FP2_power[dB] = 0b00000: –Inf Otherwise: –10 + (fp2Power-1) 0.5	
}			
If (ABS needs to change FP3 power){			

Table 6-63—AAI-DL-IM message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
fp3Power	5	FP3_power[dB] = 0b00000: –Inf Otherwise: –10 + (fp3Power-1) 0.5	
}			
If (N_t == 2){		N_t represents the number of transmit antenna, indicated in S-SFH SP3 as "# Tx Antenna".	
twoTxBCSI	8	BC_SI in case of two transmit antenna, refer to 6.3.6.2.5.5 If LSB#*n* is "1", the *n*-th codeword within the codebook or its subset is recommended; otherwise, the codeword is restricted	
}			
If ((N_t == 4) or (N_t == 8)){			
otherTxBCSI	16	BC_SI in case of four or eight transmit antenna, refer to 6.3.6.2.5.5 If LSB#*n* is "1", the *n*-th codeword within the codebook or its subset is recommended; otherwise, the codeword is restricted	
}			
If (multiBS MIMO is operated){			
nipTh1	4	NIP_th_1 The value shall be interpreted as unsigned 4 bits with units of 0.5 dB, 0b0000 is interpreted as –7.5 dB, and 0b1111 is interpreted as 0.0 dB NIP threshold for Single BS precoding with Multi-BS Coordination trigger	
nipTh2	4	NIP_th_2 The value shall be interpreted as unsigned 4 bits with units of 0.5 dB, 0b0000 is interpreted as –7.5 dB, and 0b1111 is interpreted as 0.0 dB Sum NIP threshold for DL Multi-BS Joint MIMO Processing trigger	
cinrTh	4	CINR_th The value shall be interpreted as signed 4 bits with units of 0.5 dB, 0b0000 is interpreted as –4.0 dB, and 0b1111 is interpreted as 3.5 dB. Used together with NIP_th_1 or NIP_th_2 for Multi-BS MIMO trigger	
diversitySetNum	4	The number of ABSs coordinating with the S-ABS for single BS precoding with multi-BS coordination	

Table 6-63—AAI-DL-IM message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If (diversitySetNum > 0){			
changeCount	8	Change count in AAI-NBR-ADV for the following BS_index	
for (i = 1; $i \leq$ diversitySetNum; i++){			
BS_index	8	Indicates diversity set members. Refers to the ABS index of the AAI-NBR-ADV. Temp_BSID is derived from this BS_index. The Temp_BSID is the order of the ABSs in respect to the BS_index. Temp_BSID = 0 represents the ABS that is referred by the first BS_index in the AAI-DL-IM message	
}			
}			
}			

6.2.3.36 AAI-MSG-ACK

The ABS and AMS may use AAI-MSG-ACK to indicate the reception of a MAC control message. When receiving a message over control connection with Polling bit set to 1 in MCEH, the ABS and AMS shall transmit AAI-MSG-ACK as an acknowledgment to the reception of the message (see Table 6-64).

Table 6-64—AAI-MSG-ACK message format

Attributes / Array of attributes	Size (bits)	Value / Note	Conditions
ACK_SN	8	SN retrieved from MCEH of the received MAC PDU.	Mandatory
CCC ID	1	Control Connection Channel ID (CCC ID) that the MAC management message is received.	Mandatory

6.2.3.37 AAI-SBS-MIMO-FBK

The AAI-SBS-MIMO-FBK message format is defined in Table 6-65. This message is used by the AMS as a response to a Feedback Polling A-MAP IE requesting to feedback one or multiple feedback contents. It is also used for the feedback of the transmit correlation matrix. Variables $MaxM_t$, Codebook_subset, Codebook_coordination, Num_best_subbands, long period q, and Measurement Method Indication are indicated in the Feedback Polling A-MAP IE. N_t is the number of transmit antennas at the ABS, indicated in S-SFH SP3. Best_subbands_index is encoded as described in 6.3.8.3.1.4. The feedback information reported in the AAI-SBS-MIMO-FBK message depends on currently assigned feedback processes and reporting times.

Table 6-65—AAI-SBS-MIMO-FBK message format

Field	Size (bits)	Value/Description	Condition
If (((MFM == 3) or (MFM == 4) or (MFM == 6) or (MFM == 7)) and (q > 0)){		MFM and long period q are indicated in Feedback Polling A-MAP IEs relevant to currently assigned feedback processes.	
For (i = 1; $i \le N_t$; i++){			
Diagonal	1	i-th diagonal entry of correlation matrix as defined in 6.3.6.2.5.5.1.	
For ($j = i + 1$; $j \le N_t$; j++){			
OffDiagonal	4	(i,j)-th entry of correlation matrix as defined in 6.3.6.2.5.5.1.	
}			
}			
}			
MfmBitmap	8	Bitmap to indicate the MFMs for which the AMS is sending feedback. It shall be consistent with current feedback allocations corresponding to the MFM requested by Feedback Polling A-MAP IE. LSB #0: MFM 0 LSB #1: MFM 1 LSB #2: MFM 2 LSB #3: MFM 3 LSB #4: MFM 4 LSB #5: MFM 5 LSB #6: MFM 6 LSB #7: MFM 7	
If (LSB #0 in MFM_bitmap == 1){		MFM 0	
wbstcRate	1-2	Wideband STC rate $MaxM_t$ = 2: 1 bit $MaxM_t$ = 3 or 4: 2 bits	Shall be omitted if $MaxM_t$ == 1
widebandCqi	4	Wideband CQI	
}			
If (LSB #1 in MFM_bitmap == 1){		MFM 1	
widebandCqi	4	Wideband CQI	
}			

Table 6-65—AAI-SBS-MIMO-FBK message format *(continued)*

Field	Size (bits)	Value/Description	Condition
If (LSB #2 in MFM_bitmap == 1){		MFM 2	
bestSubbandIndex	0–19	Best subband index 512 FFT(fiveM): 2 bit 1024 FFT(tenM): 4 bit for best 1, 8 bit for best 6 2048 FFT(twentyM): 5 bit for best 1, 16 bit for best 6, 19 bit for best 12	This field shall be omitted for full feedback (full)
stcRate	1–3	STC rate If Measurement Method Indication=0b0: $MaxM_t$ = 2: 1 bit $MaxM_t$ = 3 or 4: 2 bits $MaxM_t$ > 4: 3 bits	This field shall be omitted if Measurement Method Indication=0b1 or if $MaxM_t$ == 1
For (m = 0; m<Num_best_subbands; **m** ++){		The subbands CQIs are sorted in order of increasing logical index	
subbandCqi	4	MCS of m-th subband indicated by bestSubbandIndex	
}			
}			
If (LSB #3 in MFM_bitmap == 1){		MFM 3	
bestSubbandIndex	0–19	Best subband index 512 FFT(fiveM): 2 bit 1024 FFT(tenM): 4 bit for best 1, 8 bit for best 6 2048 FFT(twentyM): 5 bit for best 1, 16 bit for best 6, 19 bit for best 12	This field shall be omitted for full feedback (full)
stcRate	1–3	STC rate $MaxM_t$ = 2: 1 bit $MaxM_t$ = 3 or 4: 2 bits $MaxM_t$ > 4: 3 bits	Shall be omitted if $MaxM_t$ == 1
For (m = 0; m < Num_best_subbands; m ++){		The subbands CQIs are sorted in order of increasing logical index	
subbandCqi	4	MCS of m-th subband indicated by bestSubbandIndex	
subbandPmi	3–6	N_t = 2: 3 bits N_t = 4 and Codebook_subset = 0b0: 6 bits N_t = 4 and Codebook_subset = 0b1: 4 bits N_t = 8: 4 bits The subbands PMIs are sorted in order of increasing logical index. PMI of subbands indicated by BestSubbands	
}			
}			

Table 6-65—AAI-SBS-MIMO-FBK message format *(continued)*

Field	Size (bits)	Value/Description	Condition
If (LSB #4 in MFM_bitmap == 1){		MFM 4	
wbstcRate	1–2	Wideband STC rate $MaxM_t$ = 2: 1 bit $MaxM_t$ = 3 or 4: 2 bits	Shall be omitted if $MaxM_t$ == 1
widebandCqi	4	Wideband CQI	
widebandPmi	3–6	Wideband PMI N_t = 2: 3 bits N_t = 4 and Codebook_subset = 0b0: 6 bits N_t = 4 and Codebook_subset = 0b1: 4 bits N_t = 8: 4 bits	Presents when q == 0
}			
If (LSB #5 in MFM_bitmap == 1){		MFM 5	
bestSubbandIndex	0–19	Best subband index 512 FFT(fiveM): 2 bit 1024 FFT(tenM): 4 bit for best 1, 8 bit for best 6 2048 FFT(twentyM): 5 bit for best 1, 16 bit for best 6, 19 bit for best 12	This field shall be omitted for full feedback (full)
For (m = 0; m<Num_best_subbands; m ++){		The subbands CQIs are sorted in order of increasing logical index	
subbandCqi	4	MCS of m-th subband indicated by bestSubbandIndex	
Stream index	1–2	If Measurement Method Indication = 0b0: $MaxM_t$ = 2: 1 bit $MaxM_t$ = 3 or 4: 2 bits If Measurement Method Indication=0b1: 1 bit. The subbands Best stream indexes are sorted in order of increasing logical index. PMI of subbands indicated by BestSubbands	
}			
}			
If (LSB #6 in MFM_bitmap == 1){		MFM 6	

Table 6-65—AAI-SBS-MIMO-FBK message format *(continued)*

Field	Size (bits)	Value/Description	Condition
bestSubbandIndex	0–19	Best subband index 512 FFT(fiveM): 2 bit 1024 FFT(tenM): 4 bit for best 1, 8 bit for best 6 2048 FFT(twentyM): 5 bit for best 1, 16 bit for best 6, 19 bit for best 12	This field shall be omitted for full feedback (full)
For (m = 0; m < Num_best_subbands; m ++){		The subbands CQIs are sorted in order of increasing logical index	
subbandCqi	4	MCS of m-th subband indicated by bestSubbandIndex	
subbandPmi	3–6	N_t = 2: 3 bits N_t = 4 and Codebook_subset = 0b0: 6 bits N_t = 4 and Codebook_subset = 0b1: 4 bits N_t = 8: 4 bits The subbands PMIs are sorted in order of increasing logical index. PMI of subbands indicated by BestSubbands	
}			
}			
If (LSB #7 in MFM_bitmap == 1){		MFM 7	
widebandCqi	4	Wideband CQI	
widebandPmi	3–6	Wideband PMI N_t = 2: 3 bits N_t = 4 and Codebook_subset = 0b0: 6 bits N_t = 4 and Codebook_subset = 0b1: 4 bits N_t = 8: 4 bits	Presents when q == 0
}			

6.2.3.38 AAI-MBS-MIMO-FBK

The AAI-MBS-MIMO-FBK message format is defined in Table 6-66. This message is used by the AMS as a response to a Feedback Polling A-MAP IE requesting multi-BS MIMO feedback.

Table 6-66—AAI-MBS-MIMO-FBK message field description

Field	Size (bits)	Value/Description	Condition
If (ICT == 0b10){		ICT indicated in Feedback Polling A-MAP IE	
cqi	4	CQI for CL-MD	
}			
If (ICT == 0b11){			
cqi	4	CQI for Co-MIMO	
maxAmpBs	1	0b0: S-ABS has the maximum channel amplitude among collaborative ABS 0b1: S-ABS does not have the maximum channel amplitude among collaborative ABS	
If (maxAmpBsindex == 0b1){			
maxAmpBsindex	3	ABS index in adjAbsBitmapMultiBSMIMO in AAI-MBS-MIMO-RSP. 0b000 represents the ABS indicated by the first bit, and 0b111 represents the ABS indicated by the last bit. This index indicates the ABS with the largest channel amplitude	
relativeServingBs	3	Relative value of maximum amplitude ABS's amplitude compared to S-ABS's, which is representing 1 dB(0b000)~8 dB(0b111) with 1 dB steps	
}			
}			
for (i = 1; $i \leq$ N_multiBS_reports; i++){		N_multiBS_reports indicated in Feedback Polling A-MAP IE Range: 1–8	
pmi	3–4	PMI from the rank-1 base codebook or base codebook subset N_t = 2: 3 bits N_t = 4: 4 bits N_t = 8: 4 bits	
If (ICT == 0b00 or ICT == 0b01){			
tempBsid	4	Diversity set member ID, refer to 6.2.3.35	

Table 6-66—AAI-MBS-MIMO-FBK message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
measurementMetric	2	SINR gain assuming the reported PMI set is coordinated. This can be used for resolving conflict from multiple AMS. 0b00: 0.25 dB 0b01: 0.50 dB 0b10: 1.00 dB 0b11: above 1.50 dB	
pmiSubsetSize	1	Indication whether 1 PMI or a PMI set is feedback 0b0: 1 PMI 0b1: multiple PMIs	
If (pmiSubsetSize == 0b1){			
pmiCoordinationSubset	1	Set of PMIs from the rank-1 base codebook or base codebook subset 0b0: correlation level n1 (as defined in 6.5.1.2.1) 0b1: correlation level n2 (as defined in 6.5.1.2.1)	
}			
}			
If (ICT==0b10){			
cpmi	3	Concatenating PMI for neighboring cells	
}			
If (ICT == 0b11){			
cpmi	3	Concatenating PMI for neighboring cells	
RelativeAmp	4	Uniformly quantized relative channel amplitude (Normalized by the maximum channel amplitude among collaborative ABS) 0 dB (0b0000) to –15 dB(0b1111) with –1 dB steps	
}			
}			

For Co-MIMO, the AMS needs to feedback RelativeAmp of collaborative ABSs (including the ABSs indicated in AAI-MBS-MIMO-RSP). The *i*-th RelativeAmp feedback shall correspond to the *i*-th collaborative ABS in bitmap adjAbsBitmapMultiBSMIMO.

6.2.3.39 AAI-MBS-MIMO-REQ

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

The AMS shall perform the averaging of NIP measurements according to Equation (8-157) of 8.4.12.3 in IEEE Std 802.16.

Table 6-67—AAI-MBS-MIMO-REQ message field description

Field	Size (bits)	Value/Description	Condition
multiBsMimoRequest	1	0b0: Single-BS precoding with Multi-BS Coordination 0b1: Multi-BS Joint MIMO Processing	
If (multiBsMimoRequest == 0b0){			Single-BS precoding with Multi-BS Coordination
nipValueForSingleBS	2	NIP value encoded as difference to NIP_th_1 when multiBsMimoRequest = 0b0. The value shall be interpreted as unsigned 2 bits with units of 0.5 dB 0b00: NIP_th_1 dB 0b01: NIP_th_1+0.5 dB 0b10: NIP_th_1+1.0 dB 0b11: Above NIP_th_1+1.5 dB	
for (*i* = 1; *i* ≤ numbs; *i*++){		Numbs is the number of base station that exceeds threshold Range: 1–8	
tempBsid	4	This represents Temp_BSID. Temp_BSID is broadcasted through AAI-DL-IM message	
}			
}			
If (multiBsMimoRequest == 0b1){			Multi-BS Joint MIMO Processing
bitmapForRequestedAdjABSs	8	Each bit in this bitmap represents one ABS and the *i*-th bit (*i* = 1,...,8) represents the neighboring ABS (listed in AAI-DL-IM message) with the *i*-th strongest channel to the AMS. Please refer to 6.5.1.4	
nipValueForJoint	2	Sum NIP value encoded as difference to NIP_th_2 when multiBsMimoRequest = 0b1. The value shall be interpreted as unsigned 2 bits with units of 0.5 dB 0b00: NIP_th_2 dB 0b01: NIP_th_2+0.5 dB 0b10: NIP_th_2+1.0 dB 0b11: Above NIP_th_2+1.5 dB	
}			

6.2.3.40 AAI-MBS-MIMO-RSP

The AAI-MBS-MIMO-RSP message shall be transmitted by the ABS to the AMS indicating which of the adjacent ABSs listed in the previously broadcasted AAI-DL-IM message are involved in a multiBS MIMO joint processing operation (see Table 6-68).

Table 6-68—AAI-MBS-MIMO-RSP message field description

Field	Size (bits)	Value/Description	Condition
adjAbsBitmapMultiBSMIMO	8	0: ABS is not involved in multiBS MIMO 1: ABS is involved in multiBS MIMO Each bit in this bitmap represents one ABS, and the *i*-th bit (i = 1,...,8) represents the neighboring ABS (listed in the AAI-DL-IM message) with the *i*-th strongest channel to the AMS. Please refer to 6.5.1.4	

6.2.3.41 AAI-MBS-SOUNDING-CAL

The AAI-MBS-SOUNDING-CAL message shall be transmitted by the ABS to the AMS indicating how the AMS assists multi-BS calibration in TDD systems for sounding based multi-BS MIMO joint processing (see Table 6-69).

Table 6-69—AAI-MBS-SOUNDING-CAL message field description

Field	Size (bits)	Value/Description	Condition
calibrationMode	1	0: The calibration sounding mode that carries calibration phases of each involved ABS 1: The calibration sounding mode that carries differential values of calibration phases from involved adjacent ABSs to the S-ABS	
superframeNumber	2	The superframe number where multi-BS sounding calibration is scheduled If this message is transmitted in *i*-th superframe, then the sounding signal shall be transmitted in *i* + Superframe number superframe 0b00: 2 0b01: 4 0b10: 6 0b11: 8	
frameNumber	2	The frame number from which the multiBS sounding calibration is scheduled to start	
soundingAAISubframe	3	The AAI subframe from which multiBS sounding calibration is scheduled to start	
soundingSubbandBitmap	6–24	FFT size dependent 512 FFT: 6 bit 1024 FFT: 12 bit 2048 FFT: 24 bit	
decimationOffset d	5	Unique decimation offset	

Upon receiving AAI-MBS-SOUNDING-CAL, the AMS shall send the calibration sounding sequence defined in 6.5.1.3.1 at consecutive certain number (the number of ‘1’s in adjAbsBitmapMultiBSMIMO in AAI-MBS-MIMO-RSP plus 1 if calibration mode = 0, or the number of ‘1’s in adjAbsBitmapMultiBSMIMO in AAI-MBS-MIMO-RSP if calibration mode = 1) of sounding subframes. When the calibration mode = 0, the first calibration sounding subframe is mapped to the S-ABS and the remaining *i*-th calibration sounding subframe is mapped to the *i*-th involved adjacent ABS in adjAbsBitmapMultiBSMIMO. When the calibration mode = 1, the *i*-th calibration sounding subframe is mapped to the *i*-th involved adjacent ABS in adjAbsBitmapMultiBSMIMO.

6.2.3.42 AAI-MBS-SBP

The AAI-MBS-MIMO-SBP message format is defined in Table 6-70. This message is used by the ABS to indicate the PMI_{min}, interference sensitivity level (ISL) and PMI combination ratio (PCR) to the AMS for UL single BS precoding with multi-BS coordination.

Table 6-70—AAI-MBS-MIMO-SBP message field description

Field	Size (bits)	Value/Description	Condition
for (i = 1; $i \le N_{nbr}$; i++){		N_{nbr} is the number of neighboring ABSs. Range: 1–8 Refer to Table 6-320 for values of the following fields.	
PMI_{min}	4 or 6	PMIs from the rank-1 base codebook respectively generating minimum interference to each of the neighboring ABS.	
ISL(λ)	2	Interference sensitivity level (ISL) of each of the neighboring ABS.	
}			
PCR	2	PMI combination ratio.	

6.2.3.43 Privacy key MAC Control messages (AAI-PKM-REQ/AAI-PKM-RSP)

PKMv3 employs two MAC message types: AAI-PKM-REQ (PKM request) and AAI-PKM-RSP (PKM response), as described in Table 6-71 and Table 6-72, respectively.

Table 6-71—AAI-PKM-REQ message field description

Field	Size (bits)	Value/Description	Condition
PKM v3 message type code	4	—PKMv3 Reauth-Request; PKM v3 message code = 1 —PKMv3 EAP-Transfer; PKM v3 message code = 2 —PKMv3 Key_Agreement-MSG#2; PKM v3 message code = 4 —PKMv3 TEK-Request; PKM v3 message code = 6 —PKMv3 TEK-Invalid; PKM v3 message code = 8 9–16: *Reserved*	
PKM identifier	8	A value used to match an ABS response to the AMS requests or an AMS response to the ABS requests	
CMAC indicator	1	Indicates whether this message is protected by CMAC tuple 0: Not protected 1: Protected	Shall always be present

Table 6-71—AAI-PKM-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If(PKM v3 message code == 2) {			
EAP payload	*variable* (1..1400 × 8)	Contains the EAP authentication data, not interpreted in the MAC	
}			
If(PKM v3 message code == 4) {			
NONCE_ABS	64	A random number of 64 bits used for freshness	
NONCE_AMS	64	A random number of 64 bits used for freshness	
AK ID	64	AK ID = Dot16KDF(AK, 0b0000|PMK SN|AMSID* or MS MAC address|ABSID | "AKID", 64), where either AMSID* or MS MAC address is used depending on the used AK derivation formula This is used to verify sync of PMK SN and the corresponding AK	
size of ICV	1	0: size of ICV = 32 bits (default; Max Invalid value is 4096) 1: size of ICV = 64 bits (Max Invalid value is not used)	Present when it is used during network entry
PN window Size	16	The receiver shall track PNs within this window to prevent replay attacks	Present when it is used during network entry
}			
If(PKM v3 message code == 6) {			
SAID	8	Security association identifier	
TEK refresh flag	1	This flag is set to "1" in the signal when this request is for the first TEK after re-authentication completion when both TEKs need to be updated one after another and set to "0" when this request is for the second TEK update after the first TEK update is done.	Present when TEK update after reauthentication
}			
If(PKM v3 message code == 8) {			
SAID	8	Security association identifier	
}			

Table 6-72—AAI-PKM-RSP message field description

Field	Size (bits)	Value/Description	Condition
PKM v3 message type code	4	—PKMv3 EAP-Transfer; PKM v3 message code = 2 —PKMv3 Key_Agreement-MSG#1; PKM v3 message code = 3 —PKMv3 Key_Agreement-MSG#3; PKM v3 message code = 5 —PKMv3 TEK-Reply; PKM v3 message code = 7 —PKMv3 TEK-Invalid; PKM v3 message code = 8 9–16: *Reserved*	
PKM identifier	8	A value used to match an ABS response to the AMS requests or an AMS response to the ABS requests	
CMAC indicator	1	Indicates whether this message is protected by CMAC tuple 0: Not protected 1: Protected	Shall always be present
If(PKM v3 message code == 2) {			
EAP payload	*variable* (1..1400 × 8)	Contains the EAP authentication data, not interpreted in the MAC	
}			
If(PKM v3 message code == 3) {			
NONCE_ABS	64	A random number of 64 bits used for freshness	
AK ID	64	AK ID = Dot16KDF(AK, 0b0000|PMK SN|AMSID* or MS MAC address|ABSID | "AKID", 64), where either AMSID* or MS MAC address is used depending on the used AK derivation formula. This is used to verify sync of PMK SN and the corresponding AK	
Key lifetime	32	MSK lifetime; this attribute is included only in case of key agreement following EAP-based authorization or EAP-based reauthorization procedures	
}			
If(PKM v3 message code == 5) {			

Table 6-72—AAI-PKM-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
NONCE_ABS	64	A random number of 64 bits used for freshness	
NONCE_AMS	64	A random number of 64 bits used for freshness	
size of ICV	1	0: size of ICV = 32 bits (default; Max Invalid value is 4096) 1: size of ICV = 64 bits (Max Invalid value is not used)	Present when it is used during network entry
PN window Size	16	The receiver shall track PNs within this window to prevent replay attacks	Present when it is used during network entry
Supporting SAs	3	SAs are supported for transport connections as following bitmap; Bit 0: Null SA (SAID = 0x00) is supported if it is set to 1 Bit 1: SAID 0x01 is supported if it is set to 1 Bit 2: SAID 0x02 is supported if it is set to 1	Present when it is used during network entry
}			
If(PKM v3 message code == 7) {			
SAID	8	Security association identifier	
COUNTER_TEK	16	COUNTER_TEK used for deriving current uplink TEK	
EKS	2	Encryption key sequence number for current uplink TEK	
}			
If(PKM v3 message code == 8) {			
SAID	8	Security association identifier	
}			

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

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

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

— Code: The Code field identifies the type of PKM packet. When a packet is received with an invalid code, it shall be silently discarded. Table 6-73 describes the PKM message codes.

Table 6-73—PKM v3 message types

Code	PKM message type	MAC control message name
1	PKMv3 Reauth-Request	AAI-PKM-REQ
2	PKMv3 EAP-Transfer	AAI-PKM-REQ/ AAI-PKM-RSP
3	PKMv3 Key_Agreement-MSG#1	AAI-PKM-RSP
4	PKMv3 Key_Agreement-MSG#2	AAI-PKM-REQ
5	PKMv3 Key_Agreement-MSG#3	AAI-PKM-RSP
6	PKMv3 TEK-Request	AAI-PKM-REQ
7	PKMv3 TEK-Reply	AAI-PKM-RSP
8	PKMv3 TEK-Invalid	AAI-PKM-REQ/AAI-PKM-RSP
9–16	*Reserved*	—

— PKM Identifier: The PKM Identifier is used to match an ABS response to the AMS requests or an AMS response to the ABS requests.

AMS shall increment (modulo 256) the PKM Identifier field whenever it issues a new PKMv3 TEK-Request message, and ABS shall increment (modulo 256) the PKM Identifier field whenever it issues a new PKMv3 Key_Agreement-MSG#1.

For retransmissions, the Identifier field shall remain unchanged.

The Identifier field in PKMv3 EAP-Transfer, PKMv3 Reauth-Request, or PKMv3 TEK-Invalid messages that are redundant and do not affect any response messaging shall be set to zero. The Identifier field in an ABS's AAI-PKM-RSP message shall match the Identifier field of the AAI-PKM-REQ message to which the ABS is responding.

An ABS shall keep track of the PKM Identifier of its latest, pending PKMv3 Key_Agreement-MSG#1. The ABS shall discard PKMv3 Key_Agreement-MSG#2 messages with Identifier fields not matching that of the pending PKMv3 Key_Agreement-MSG#1. In addition, an AMS shall keep it, pending PKMv3 Key_Agreement-MSG#2. The AMS shall discard PKMv3 Key_Agreement-MSG#3 messages with Identifier fields not matching that of the pending PKMv3 Key_Agreement-MSG#2. An AMS shall keep track of the PKM Identifier of its latest, pending PKMv3 TEK-Request. The AMS shall discard the PKMv3 TEK-Reply message with Identifier fields not matching that of the pending PKMv3 TEK-Request.

6.2.3.43.1 PKMv3 Reauth-Request message

The Reauth-Request message may be used to request reauthentication by initiating an EAP session (e.g., in case that CMAC_PN_* or AK_COUNT is exhausted, reauthentication is required).

If ABS receives the Reauth-Request message, it should initiate the EAP reauthentication procedure.

CMAC Digest and Key Sequence Number attributes shall be included in the Reauth-Request message.

Code: 1

Attributes are shown in Table 6-74.

Table 6-74—PKMv3 Reauth Request message attributes

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

The CMAC Digest attribute (i.e., CMAC_PN_U and CMAC value) shall be transmitted for CMAC verification. The CMAC Digest attribute allows the ABS to authenticate the PKMv3 Reauth-Request message.

6.2.3.43.2 PKMv3 EAP-Transfer message

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

Code: 2

Attributes are shown in Table 6-75.

Table 6-75—PKMv3 EAP-Transfer message attributes

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

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

6.2.3.43.3 PKMv3 Key_Agreement-MSG#1 message

The ABS transmits the PKMv3 Key_Agreement-MSG#1 message as a first step in the 3-way key agreement handshake at initial network entry and at reauthorization. The ABS shall send this message to the AMS after finishing the authorization procedure(s) selected by the negotiated authorization policy support included in the basic capabilities negotiation.

It identifies an AK to be used and includes a random number challenge (i.e., NONCE_ABS) to be returned by the AMS in the PKMv3 Key_Agreement-MSG#2 message.

Code: 3

Attributes are shown in Table 6-76.

Table 6-76—PKMv3 Key_Agreement-MSG#1 message attributes

Attribute	Contents
NONCE_ABS	A freshly generated random number of 64 bits.
Key Sequence Number	New PMK sequence number.
AKID	Identifies the authorization key (this is the AKID of the new AK in the case of reauthentication). AK ID = Dot16KDF(AK, 0b0000|PMK SN|AMSID* or MS MAC address|ABSID | "AKID", 64), where either AMSID* or MS MAC address is used depending on the used AK derivation formula.
Key lifetime	PMK lifetime; this attribute shall be included only in case of key agreement following EAP-based authorization or EAP-based reauthorization procedures.
CMAC digest	Message digest calculated using the new AK.

The CMAC Digest attribute (i.e., CMAC_PN_D and CMAC value) shall be transmitted for CMAC verification, which is derived from new AK.

6.2.3.43.4 PKMv3 Key_Agreement-MSG#2 message

The AMS transmits the PKMv3 Key_Agreement-MSG#2 message after successful CMAC value verification of the PKMv3 Key_Agreement-MSG#1 message received from the ABS.

The PKMv3 Key_Agreement-MSG#2 message proves the liveliness of the AMS and its possession of the AK to the ABS.

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

Code: 4

Attributes are shown in Table 6-77.

Table 6-77—PKMv3 Key_Agreement-MSG#2 message attributes

Attribute	Contents
NONCE_ABS	A freshly generated random number of 64 bits contained in the PKMv3 Key_Agreement-MSG#1 message
NONCE_AMS	A freshly generated random number of 64 bits
AKID	Identifies the authorization key for protecting this message. AK ID = Dot16KDF(AK, 0b0000|PMK SN|AMSID* or MS MAC address|ABSID | "AKID", 64), where either AMSID* or MS MAC address is used depending on the used AK derivation formula
Key Sequence Number	New PMK sequence number
Security negotiation parameters	The requesting AMS's security capabilities (it should be included in case of key agreement during network entry only); i.e., — size of ICV part in the AES-CCM 0: 32 bits (default, Max Invalid value is 4096) 1: 64 bits (Max Invalid value is not used) — PN window Size: The receiver shall track PNs within this window to prevent replay attacks
CMAC digest	Message digest calculated using new AK

The CMAC Digest attribute (i.e., CMAC_PN_U and CMAC value) shall be transmitted for CMAC verification, which is derived from new AK.

6.2.3.43.5 PKMv3 Key_Agreement-MSG#3 message

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

Code: 5

Attributes are shown in Table 6-78.

Table 6-78—PKMv3 Key_Agreement-MSG#3 message attributes

Attribute	Contents
NONCE_ABS	A freshly generated random number of 64 bits contained in the PKMv3 Key_Agreement-MSG#1 message
NONCE_AMS	A freshly generated random number of 64 bits contained in the PKMv3 Key_Agreement-MSG#2 message
Key Sequence Number	New PMK sequence number
Supporting SAs	SAs are supported for transport connections as following bitmap; Bit 0: Null SA is supported if it is set to 1 Bit 1: SAID 0x01 is supported if it is set to 1 Bit 2: SAID 0x02 is supported if it is set to 1
Security negotiation parameters	The responding ABS's security capabilities (it should be included in case of key agreement during network entry only); i.e., —size of ICV part in the AES-CCM 0: 32 bits (default, Max Invalid value is 4096) 1: 64 bits (Max Invalid value is not used) —PN window Size: The receiver shall track PNs within this window to prevent replay attacks
CMAC digest	Message digest calculated using new AK

The CMAC Digest attribute (i.e., CMAC_PN_D and CMAC value) shall be transmitted for CMAC verification, which is derived from new AK.

6.2.3.43.6 PKMv3 TEK-Request message

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

Code: 6

Attributes are shown in Table 6-79.

Table 6-79—PKMv3 TEK-Request message attributes

Attribute	Contents
SAID	Security association identifier.
Key Sequence Number	Current PMK sequence number.
TEK refresh flag	This flag is set to “1” in the signal when this request is for the first TEK after key agreement when both TEKs need to be updated one after another and set to “0” when this request is for the second TEK update after the first TEK update is done. In case of normal TEK update, this flag is not included.
CMAC digest	Message digest calculated using AK.

The CMAC Digest attribute (i.e., CMAC_PN_U and CMAC value) shall be transmitted for CMAC verification.

6.2.3.43.7 PKMv3 TEK-Reply message

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

Code: 7

Attributes are shown in Table 6-80.

Table 6-80—PKMv3 TEK-Reply message attributes

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

The CMAC Digest attribute (i.e. CMAC_PN_D and CMAC value) shall be transmitted for CMAC verification.

6.2.3.43.8 PKMv3 TEK-Invalid message

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

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

Code: 8

Attributes are shown in Table 6-81.

Table 6-81—PKMv3 TEK-Invalid message attributes

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

The CMAC Digest attribute (i.e., CMAC_PN_D and CMAC value) shall be transmitted for CMAC verification.

6.2.3.44 AAI-ARQ-Feedback message

An AAI-ARQ-Feedback message is used for receiver to inform the reception status of a number of ARQ blocks or ARQ subblocks. ARQ feedback IE is included in the AAI-ARQ-Feedback message (see Table 6-82).

Table 6-82—AAI-ARQ-Feedback message field description

Field	Size (bits)	Value/Description	Condition
ARQ feedback IE{	*variable*	One or more ARQ feedback IEs may be present in the AAI-ARQ-Feedback message	Maximum number of ARQ feedback IEs is equal to maximum number of transport FIDs
FID	4	The FID of the connection corresponding to this ARQ feedback IE	
FLAG	1	0 = Cumulative ACK 1 = Selective ACK MAP existence	

Table 6-82—AAI-ARQ-Feedback message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
SN	10	Indicates the sequence number of an ARQ block. FLAG = 0, indicates ARQ blocks up to and including the sequence number in the SN field have been received successfully. FLAG = 1, indicates ARQ blocks less than the sequence number in the SN field have been received successfully. It also indicates the sequence number of the ARQ block whose ACK or NAK information is indicated by the MSB of Selective ACK MAP	
if(FLAG == 1){			
NSI	1	NACK Suspended Indicator 0 = Bit marked '0' in the following Selective ACK MAP represents an ARQ block NACK 1 = Bit marked '0' in the following Selective ACK MAP represents that ARQ block NACK decision is suspended (i.e., ARQ_ERROR_DETECTION_TIMER is running for corresponding ARQ block)	
EXT	1	Extension for ARQ subblock indication 0 = No ARQ subblock ACK/NACK indication 1 = ARQ subblock ACK/NACK indication follows	
Selective ACK MAP	*variable*	Each bit represents ACK or NACK or NACK Suspended of corresponding ARQ block. '0' is NACK if NSI equals zero '0' is NACK suspended if NSI equals one '1' is ACK MSB of the First Selective ACK MAP represents ACK or NAK information of an ARQ block identified by the sequence numbers in the SN field. Contiguous bits after MSB of the First Selective ACK MAP represents ACK or NACK information of contiguous ARQ blocks following the ARQ block identified by the sequence number in the SN field	Maximum size of Selective ACK MAP is equal to size of ARQ_WINODW_SIZE
if(EXT == 1){			

Table 6-82—AAI-ARQ-Feedback message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
SEM	L	Subblock-Existence Map The numbers of bits in Subblock-Existence Map is equal to the number of bits that indicates the NACKed ARQ blocks in the Selective ACK MAPs. Each bit represents the existence of partially NACKed ARQ blocks or completely NACKed ARQ blocks. The most significant bit corresponds to the first NACKed ARQ block in the Selective ACK MAP, and the least significant bit corresponds to the last NACKed ARQ block in the Selective ACK MAP. 1 = Partially NACKed ARQ block (the ARQ block has some subblocks that have received correctly) 0 = Completely NACKed ARQ blocks (the ARQ block has no subblocks that have received correctly)	L is equal to the number of bits that indicates the NACKed ARQ blocks in the Selective ACK MAPs
For(i = 0; i < Num_SN; i++){			Num_SN is the number of bits equal to '1' in SEM field
For(k = 0; k < Num_Sub_Block_Info; k++){			
SubBlockACKInfo {	*variable*	For each 'i', One or more SubBlockACKInfo can be present. If NSI bit set to '0', all ARQ subblocks that are not listed in the Start_SSN and Num_SSN in all the SubBlockACKInfos are considered as NACK. If NSI bit set to '1', for all the ARQ subblocks that are not listed in the Start_SSN and Num_SSN in all the SubBlockACKInfos, it is considered that NACK decision is suspended	The Maximum number of SubBlockACKInfo is equal to 1024
START_SSN	11	Start of ARQ subblock SN that was received correctly	
NUM_SSN	11	Number of consecutive ARQ subblocks that were received correctly from START_SSN onward	
}			
}			
}			
}			
}			
}			

6.2.3.45 AAI-ARQ-Discard message

The transmitter sends this message when it wants to skip a number of ARQ blocks. The procedure in the receiver after receiving an AAI-ARQ-Discard message is described in 6.2.3.45 (see Table 6-83).

Table 6-83—AAI-ARQ-Discard message field description

Field	Size (bits)	Value/Description	Condition
FID	4	Corresponding connection ID to perform ARQ block discard.	
SN	10	ARQ block SN of the last block in the transmission window that the transmitter wants to discard.	

6.2.3.46 AAI-ARQ-Reset message

The transmitter or receiver may send this message. The message is used in a dialog to reset the parent connection's ARQ transmitter and receiver state machines. The detail ARQ reset procedure is described in 6.2.13.5.4.

Table 6-84—AAI-ARQ-Reset message field description

Field	Size (bits)	Value/Description	Condition
DL/UL indicator	1	0b0 = Downlink 0b1 = Uplink	
FID	4	Corresponding connection ID to perform ARQ reset procedure	
Type	2	0b00 = Original message from Initiator 0b01 = Acknowledgment from Responder 0b10 = Confirmation from Initiator 0b11 = *Reserved*	
If (type == 0b00 || type == 0b01) {			
SN	10	ARQ transmitter sets this field to (ARQ_TX_WINDOW_START_SN + ARQ_WINDOW_SIZE) mod (ARQ_SN_MODULUS). (see 6.2.13.5.4 for details)	This field shall be included when the ARQ transmitter sends an ARQ reset message with type 0b00 or 0b01. This field is not included when the ARQ receiver sends an ARQ reset message.
}			

6.2.3.47 DSx MAC Control message

6.2.3.47.1 AAI-DSA-REQ

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

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

The following parameters may be included in the AAI-DSA-REQ message:

- Predefined BR index parameters: Predefined BR index parameters define the mapping from predefined BR index(es) to BR action and BR size, which is used in 3-step Bandwidth Request procedure, and are only included in ABS-initiated DSA-REQ. They are determined based on the QoS parameters of the service flow in the AAI-DSx messages. If BR Action is 0b00 or 0b01, the same BR Index shall not be assigned to different service flows. If BR action is 0b10 (BR), the ABS shall assign a different BR index to service flows whose UL Grant Scheduling Type is different and shall assign a different BR index to different service flows whose UL Scheduling Type is the same but BR size is different.

When an ABS commences E-MBS service flow, the following parameters shall be included in the AAI-DSA-REQ message:

- E-MBS Service: Indicates whether the E-MBS Service is being requested or provided for the connection that is being set up.
- E-MBS zone ID: Indicates an E-MBS zone where the connection for associated service flow is valid.
- E-MBS Service Flow Parameter: Mapping of E-MBS ID and FID are included.
- Physical Carrier Index: Target carrier that the AMS switches or is redirected by the ABS to, only included in ABS-initiated DSA-REQ.
- Carrier Switching Mode: Indicates if the carrier switching mode is based on a unicast available interval in the AAI-DSx message or E-MBS connection report in the AAI-E-MBS-REP message.
- Unicast Available Interval Bitmap: Indicates when the AMS should be available in the primary carrier.

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

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

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

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

— Multicast Group ID: Indicates multicast group for the connection that is associated with the service flow in AAI-DSA-REQ.

Table 6-85—AAI-DSA-REQ message field description

Field	Size (bits)	Value/Description	Conditions
FID Change Count	4	The change count of this transaction assigned by the sender. If a new transaction is started, FID Change Count is incremented by one (modulo 16) by the sender	Shall always be present
SFID	32	Service flow identifier	Present when an ABS initiates AAI-DSA-REQ
FID	4	Flow identifier	Present when an ABS initiates AAI-DSA-REQ
Uplink/Downlink Indicator	1	0: uplink; 1:downlink	
Service Class Name	16 to 1024	Null-terminated string of ASCII characters. The length of the string, including the null-terminator, may not exceed 128 bytes	Present when a predefined BS service configuration is used for this service flow
If (Global Service Class Name is included) {	84	Name of global service classes (see Table 6-128 in 6.2.12.8)	Present when a predefined BS service configuration to be used for this service flow is synchronized among all BS
I: Uplink/Downlink indicator	1	0: UL 1: DL	
S: Maximum sustained traffic rule	6	Extensible look-up Table 6-257 of 6.3.14.4.1 in IEEE Std 802.16	
B: Maximum traffic burst	6	Extensible look-up Table 6-257 of 6.3.14.4.1 in IEEE Std 802.16	
R: Maximum received traffic rate	6	Extensible look-up Table 6-257 of 6.3.14.4.1 in IEEE Std 802.16	
L: Maximum latency	6	Extensible look-up Table 6-257 of 6.3.14.4.1 in IEEE Std 802.16	
P: Paging preference	1	0 = No paging generation 1 = Paging generation	

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
S1: Request/Transmission policy	7	Bit 0: If this bit is set to 1, the service flow shall not use broadcast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 1: If this bit is set to 1, the service flow shall not use multicast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 2: If this bit is set to 1, the service flow shall not piggyback requests with data (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 3: If this bit is set to 1, the service flow shall not fragment data Bit 4: If this bit is set to 1, the service flow shall not suppress payload headers (CS parameter). If bit 4 is set to 0 and both the SS and the BS support PHS (according to 11.7.7.3 in IEEE Std 802.16), each SDU for this service flow shall be prefixed by a PHSI field, which may be set to 0 (see 5.2). If bit 4 is set to 1, none of the SDUs for this service flow shall have a PHSI field. This bit has no relevance for Multiprotocol CS Bit 5: If this bit is set to 1, the service flow shall not pack multiple SDUs (or fragments) into single MAC PDUs Bit 6: If this bit is set to 1, the service flow shall not compress payload headers using ROHC. If bit 6 is set to 0 and both the SS and the BS support ROHC (according to 11.7.7.4 in IEEE Std 802.16), each SDU for this service flow shall be compressed using ROHC. If bit 6 is set to 1, none of the SDUs shall be compressed. This bit has no relevance for Multiprotocol CS	
S2: Uplink grant scheduling type	3	0: *Reserved* 1: Undefined (BS implementation-dependent) 2: BE (default) 3: nrtPS 4: rtPS 5: Extended rtPS 6: UGS 7: aGP Service	
If (Uplink grant scheduling type == BE | nrtPS) {			
S3: Traffic priority	3	0 to 7: Higher numbers indicate higher priority Default: 0	
}else if (Uplink grant scheduling type == rtPS) {			

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
S3: Traffic priority	3	0 to 7: Higher numbers indicate higher priority Default: 0	
S5: Unsolicited polling interval	6	Extensible look-up Table 6-191 of 6.3.5.5.2.3.	
} else if (Uplink grant scheduling type == ertPS) {			
L1: Tolerated Jitter	6	Extensible look-up Table 6-190 of 6.3.5.5.2.3.	
S3: Traffic priority	3	0 to 7: Higher numbers indicate higher priority Default: 0	
S4: Unsolicited grant interval	6		
} else if (Uplink grant scheduling type == UGS) {			
L1: Tolerated Jitter	6	Extensible look-up Table 6-190 of 6.3.5.5.2.3	
S4: Unsolicited grant interval	6	Extensible look-up Table 6-191 of 6.3.5.5.2.3	
}			
} // End if (Global Service Class Name)			
QoS parameter set type	3	Bit 0: Provisioned Set Bit 1: Admitted Set Bit 2: Active Set	
If (QoS parameters are needed) {			
Traffic Priority parameter	3	0 to 7: Higher numbers indicate higher priority Default 0	Shall be present for BE flows on both UL and DL. Optionally present for other service flows (aGPS, ertPS, rtPS, nrtPS and UGS) on uplink) on UL
Maximum Sustained Traffic Rate parameter	32	Rate (in bits per second)	Present if needed
Maximum Traffic Burst parameter	32	Burst size (bytes)	Present if needed
Minimum Reserved Traffic Rate parameter	32	Rate (in bits per second)	Present if needed
Maximum Latency parameter	32	Milliseconds	Present if needed
Paging Preference parameter	1	0: No paging generation 1: Paging generation	Present if needed

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
Request/Transmission Policy parameter	7	Bit 0: If this bit is set to 1, the service flow shall not use broadcast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 1: If this bit is set to 1, the service flow shall not use multicast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 2: If this bit is set to 1, the service flow shall not piggyback requests with data (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 3: If this bit is set to 1, the service flow shall not fragment data Bit 4: If this bit is set to 1, the service flow shall not suppress payload headers (CS parameter). If bit 4 is set to 0 and both the SS and the BS support PHS (according to 11.7.7.3 in IEEE Std 802.16), each SDU for this service flow shall be prefixed by a PHSI field, which may be set to 0 (see 5.2). If bit 4 is set to 1, none of the SDUs for this service flow shall have a PHSI field. This bit has no relevance for Multiprotocol CS Bit 5: If this bit is set to 1, the service flow shall not pack multiple SDUs (or fragments) into single MAC PDUs Bit 6: If this bit is set to 1, the service flow shall not compress payload headers using ROHC. If bit 6 is set to 0 and both the SS and the BS support ROHC (according to 11.7.7.4 in IEEE Std 802.16), each SDU for this service flow shall be compressed using ROHC. If bit 6 is set to 1, none of the SDUs shall be compressed. This bit has no relevance for Multiprotocol CS	Present if needed
Tolerated Jitter parameter	32	Milliseconds	Present when needed
If(Uplink/Downlink Indicator == uplink) {			
UL Grant Scheduling Type	3	0: *Reserved* 1: Undefined (BS implementation-dependent) 2: BE (default) 3: nrtPS 4: rtPS 5: Extended rtPS 6: UGS 7: aGP Service	
If (UL Grant Scheduling Type == ertPS) {			
Unsolicited Grant Interval parameter	16	Milliseconds	

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
} else if (UL Grant Scheduling Type == UGS) {			
Unsolicited Grant Interval parameter	16	Milliseconds	
} else if (UL Grant Scheduling Type == rtPS) {			
Unsolicited Polling Interval parameter	16	Milliseconds	
} else if (UL Grant Scheduling Type == aGPS) {			
Primary Grant Polling Interval parameter	16	Milliseconds	Present if primary parameter set is needed
Primary Grant Size parameter	16	Number of bytes	Present if primary parameter set is needed
Secondary Grant Polling Interval parameter	16	Milliseconds	Present if secondary parameter set is needed
Secondary Grant Size parameter	16	Number of bytes	Present if secondary parameter set is needed
Adaptation Method	1	0:ABS-initiated adaptation 1:AMS-initiated adaptation	Shall be present when Uplink grant scheduling type is aGPS
}			
Access Class	2	This parameter specifies the priority assigned to a service flow. This priority is used in prioritizing access requests as described in 6.2.11.1.1	Present if needed
Differentiated BR Timer	6	Grant reception timeout before contention-based BR is attempted again for the service flow. Value of range 1 ~ 64 frame(s)	Present if needed, but shall be present when an ABS initiates AAI-DSA-REQ
For(i = 1; $i \le$ N-Predefined-BR-indices; i++) {		The mapping of a predefined BR index used in a quick access message to BR size and BR actions N-Predefined-BR-indices is the number of predefined BR indices [1..15]	
Predefined BR index	4	Predefined BR index	Present if N-Predefined-BR-indices is not zero
BR action	2	0b00: ertPS service flow requests to resume to maximum sustained rate 0b01: aGP service flow requests to switch to Primary QoS parameters 0b10: BR 0b11: *Reserved*	Present if N-Predefined-BR-indices is not zero
If(BR action == 0b10) {			

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
BR size	11	Number of bytes requested by the pre-defined BR index	
}			
}			
Initial Backoff Window Size	4	Window size expressed as a power of 2	Present if needed
Maximum Backoff Window Size	4	Window size expressed as a power of 2	Present if needed
Backoff Scaling Factor	4	“0010” for Binary Exponential Back-off	Present if needed
} // End If (Uplink/Downlink Indicator = uplink)			
MAC in-order delivery indicator	1	Indicate whether or not the order of delivery in the connection is preserved by the MAC. 0: Not preserved 1: Preserved For ARQ connections, it shall be always set to 1	Present if needed
If (MAC in-order delivery indicator == 1) {			
NON_ARQ_REORDERING_TIMEOUT	6	0 > and ≤ 32, Unit is PHY frame (5 ms)	
}			
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address	Present if needed
}// End If (QoS parameters are needed)			
Type of Data Delivery Services parameter	3	0: Unsolicited Grant Service 1: Real-Time Variable Rate Service 2: Non-Real-Time Variable Rate Service 3: Best Effort Service 4: Extended Real-Time Variable Rate Service 5: aGP service 6–7: *Reserved*	Present if needed
SDU Inter-Arrival Interval parameter	16	SDU inter-arrival interval in the resolution of 0.5 ms	Present if needed
Time Base parameter	16	Time base in milliseconds	Present if needed
SDU Size parameter	8	Number of bytes. Default = 49	Present if needed
Target SAID parameter	8	SAID onto which service flow is mapped	Present if needed

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
If (ARQ parameters are needed) {			
ARQ Enable	1	0 = ARQ Not Requested/Accepted 1 = ARQ Requested/Accepted	Present if needed
ARQ_WINDOW_SIZE	16	>0 and ≤(ARQ_BSN_MODULUS/2)	Present if needed
ARQ_BLOCK_LIFETIME	16	0 = Infinite 1–6 553 500 µs (100 µs granularity)	Present if needed
ARQ_SYNC_LOSS_TIMEOUT	16	0 = Infinite 1–6 553 500 µs (100 µs granularity)	Present if needed
ARQ_RX_PURGE_TIMEOUT	16	0 = Infinite 1-6 553 500 µs (100 µs granularity)	Present if needed
ARQ_SUB_BLOCK_SIZE	3	Bit 0–2: encoding for selected block size (P), where the selected block size is equal to $2^{(P+3)}$, $0 \le P \le 7$. ARQ sub-block size is byte unit	Present if needed
ARQ_ERROR_DETECTION_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)	Present if needed
ARQ_FEEDBACK_POLL_RETRY_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)	Present if needed
}			
CS Specification parameter	8	0: *Reserved* 1: Packet, IPv4 2: Packet, IPv6 3: Packet, IEEE 802.3/Ethernet[a] 4: *Reserved* 5: *Reserved* 6: *Reserved* 7: *Reserved* 8: *Reserved* 9: *Reserved* 10: *Reserved* 11: *Reserved* 12: *Reserved* 13: *Reserved* 14: Packet, IP[b] 15: Multiprotocol flow 16–255: *Reserved* (a: Classifiers for IEEE 802.1Q VLAN tags may be applied to service flows of this CS type) (b: SDUs for service flows of this CS type may carry either IPv4 or IPv6 in the payload)	Present if needed
If (Packet Classification Rule parameter is needed) {			
Classification Rule Priority field	8	0–255	Present if needed
Protocol field	8	Protocol	Present if needed

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
IP Masked Source Address parameter	32×2 (IPv4) or 128×2 (IPv6)	src, smask represent IP source and mask addresses that are 32 bits × 2 (Ipv4) or 128 bits × 2 (Ipv6) in size	Present if needed
IP Masked Destination Address parameter	32×2 (IPv4) or 128×2 (IPv6)	dst, dmask represent IP destination and mask addresses that are 32 bits × 2 (Ipv4) or 128 bits × 2 (Ipv6) in size	Present if needed
Protocol Source Port Range field	16×2	sportlow, sporthigh represent the lower bound and higher bound of the protocol source port range	Present if needed
Protocol Destination Port Range field	16×2	dportlow, dporthigh represent the lower bound and higher bound of the protocol destination port range	Present if needed
Associated PHSI field	8	Index value	Present if needed
Packet Classification Rule Index field	16	Packet Classification Rule Index	Present if needed
If (Vendor-specific classification parameters are needed) {		See 6.2.12.12.8.1	
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address	
Vendor-specific classification	*variable*	vendor-specific classification rule parameters	
}			
IPv6 Flow Label field	24	Flow Label	Present if needed
Classification Action Rule	1	0 = none. 1 = Discard packet	
IP Type of Service	7	DSCP value (0 to 127)	Present if needed
PHS DSC Action field	2	0: Add PHS Rule	Present if needed
If (PHS Rule field is added) {			
PHSI field	8	Index value	Present only ABS-initiated DSA
PHSF field	8	String of bytes suppressed	Present if needed

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
PHSM field	8	Bit 0: 0 = Do not suppress first byte of the suppression field 1 = Suppress first byte of the suppression field Bit 1: 0 = Do not suppress second byte of the suppression field 1 = Suppress second byte of the suppression field Bit x: 0 = Do not suppress (x + 1) byte of the suppression field 1 = Suppress (x + 1) byte of the suppression field	Present if needed
PHSS field	8	Number of bytes in the suppression string	Present if needed
PHSV field	1	0: Verify 1: Don't verify	Present if needed
If (Vendor-specific PHS parameters are needed) {		See 6.2.12.12.8.2	
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address	
Vendor-specific PHS	*variable*	Vendor-specific PHS parameters	
}			
}			
IEEE 802.3/Ethernet Destination MAC Address parameter	48×2	dst.msk represent Ethernet destination and mask addresses that are 48 bits × 2 in size	Present if needed
IEEE 802.3/Ethernet Source MAC Address parameter	48×2	src, msk represent Ethernet source and mask addresses that are 48 bits × 2 in size	Present if needed
Ethertype/IEEE 802.2 SAP	2/34/18	type, eprot1, eprot2 are the Layer 3 protocol ID. type = 0, eprot1, eprot2 are ignored type = 1, eprot1, and eprot2 give two 16-bit values of the Ethertype that the packet shall match in order to match the rule type = 2, eprot1, and eprot2 give two lower 8-bit values of the Ethertype that shall match the DSAP byte of the packet in order to match the rule	Present if needed
IEEE 802.1D User Priority field	3×2	pri-low, pri-high are the IEEE 802.1D user_priority bits Valid range: 0–7 for pri-low and pri-high	Present if needed

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
IEEE 802.1Q VLAN ID field	12	Specifies the matching value of the IEEE 802.1Q vlan_id bits	Present if needed
inner source IP	32	Source IP address of inner IP header	Present if needed
inner destination IP	32	Destination IP address of inner IP header	Present if needed
inner protocol field	8	Protocol field of inner IP header	Present if needed
inner TOS (Type of Service)	8	TOS field of inner IP header	Present if needed
inner IPv6 Flow Label	8	IPv6 Flow Label of inner IP header	Present if needed
} //End If (Packet Classification Rule)			
If (ROHC Parameter is needed) {			
ROHC Max Context ID	16	Non-negative integer	
Large Context IDs	8	0: FALSE (Small Context ID) 1: TRUE (Large Context ID) 2–255: *Reserved*	
ROHC MRRU	16	0: no segmentation 1..65 535: MRRU Maximum reconstructed reception unit	
ROHC Profiles	*variable*	A set of non-negative integers, where each integer indicates a 16-bit profile identifier of a ROHC profile supported by the decompressor.	
ROHC Feedback Channel	32	0: no associated ROHC feedback Otherwise: SFID for ROHC feedback.	
}			
Packet Error Rate (PER)	8	MSB (bit 7): 0–PER measured by the application, post-ARQ and post-HARQ process 1–PER measured on the airlink, before the application of ARQ and HARQ Bit 6: 0–Interpret bits 0–5 as an integer %; i.e., if bits 0–5 are the binary representation of the integer N, then the PER = N/100 (= N%) 1—Interpret bits 0–5 as 10 times a negative exponent of 10; i.e., if bits 0–5 are the binary representation of the integer N, then the PER = 10-N/10 LSB 6 bits (bits 0–5): PER value If bit 6 =0, [0 to 63%] PER If bit 6 = 1, [~5 × 10 – 7 to 1 × 10 – 0] PER	Present if needed
Emergency Indication parameter	1	Indicates the associated flow is used for emergency purposes. 0 = not an Emergency flow 1 = Emergency flow	Present if needed

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
NS/EP Service Indication parameter	1	Indicates the associated flow is used for NS/EP services 0 = not an NS/EP flow 1 = NS/EP flow	Present if needed
MAC Header Type	1	Indicates whether AGMH or SPMH is presented at the start of MAC PDUs of the service flow 0 = AGMH (Advanced Generic MAC Header) 1 = SPMH (Short-Packet MAC header) default value is 0.	Present if SPMH is used to transmit MAC PDUs from this service flow
E-MBS Service	3	Indicates whether the E-MBS service is being requested or provided for the connection that is being set up. 1 indicates support, 0 indicates not support. Bit 0: E-MBS in S-ABS Only Bit 1: E-MBS in a multi-ABS Zone supporting macro-diversity Bit 2: E-MBS in a multi-ABS Zone not supporting macro-diversity If all Bit 0~Bit 2 are set to 0, it indicates no E-MBS is supported.	Present when E-MBS service is provided
If(E-MBS is supported) {			
For (i = 0; i < N-E-MBS zone ID; i++) {		N-E-MBS zone ID is the number of E-MBS zone IDs [1..8]	
E-MBS_Zone_ID	7	Indicates an E-MBS zone where the connection for associated service flow is valid	
Physical Carrier Index	6	Target carrier that the AMS switches or is redirected by ABS to	Present only if the E-MBS zone ID is served on a different carrier from the current carrier
for (i = 0; i < N-E-MBS-ID; i++) {		N-E-MBS-ID is the number of E-MBS identifiers [1...15]	
E-MBS ID	12	E-MBS identifier	
FID	4	Flow ID	
}			
}			
} // End If (E-MBS is supported)			
Carrier Switching Mode	1	0b0: Carrier switching method based on the Unicast Available Interval in the AAI-DSA message 0b1: Carrier switching method using the AAI-E-MBS-REP/RSP message	Present when ABS-initiated DSA for carrier switching
If(Carrier Switching Mode == 0b0) {			

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
Unicast Available Interval Bitmap	*variable*	Indicates when the AMS should be available in the primary carrier using N bits $b_0b_1b_2...b_{N-1}$ If $b_i == 0$, then AMS is available for E-MBS data scheduling in secondary carrier If $b_i == 1$, then AMS is available for unicast scheduling in primary carrier $N_{MSI} = 4$ superframes: $N = 4$ bits $N_{MSI} = 8$ superframes: $N = 8$ bits $N_{MSI} = 16$ superframes: $N = 16$ bits $N_{MSI} = 32$ superframes: $N = 32$ bits Depending on the N_{MSI}, the number of bits per subframe changes, 4 frames per bit	
}			
If (Group Parameter Create/ Change is needed) {		Refer to 6.2.12.12.6	
Common for Group Create/ Change	*variable*	Common service flow encodings that are common to all service flows specified in Group Parameter Create/ Change. Service flow/convergence sublayer parameters in Table 6-133, except FID, SFID, E-MBS service related information, Group Parameter Create/ Change related information, and Coupled Group Create/Change related information, may be encapsulated in this field. Shall be included only once in a Group Parameter Create/Change as the first attribute	
Qty SFID request	5	The number of service flows to create	Shall only be sent by an AMS as the last attribute of Group Parameter Create/Change
For(i = 0; i < N-FIDs; i++) {		FIDs of service flows created with this Group Parameter Create/Change N-FIDs is the number of FIDs The maximum value of N-FIDs is 32	
FID	4		
}			
For(i = 0; i < N-FIDs-Noncommon; i++) {		N-FIDs-Noncommon is the number of non-common service flow IDs The maximum value of N-FIDs-Noncommon is 32	
FID	4		Shall be present if N-FIDs-Noncommon is not zero

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
Non-common for Group Create/ Change	*variable*	Non-common service flow encodings that are specific to individual service flows specified in N-FIDs-Noncommon FID List Service flow/convergence sublayer parameters in Table 6-133, except FID, SFID, E-MBS service-related information, Group Parameter Create/ Change related information, and Coupled Group Create/Change related information, may be encapsulated in this field.	Shall be present if N-FIDs-Noncommon is not zero
}			
}			
If (Coupled Group Create/ Change is needed) {		Refer to 6.2.12.12	
Common for Coupled Group	*variable*	Common service flow encodings that are common to all service flows specified in Coupled Group Create/Change parameter Service flow/convergence sublayer parameters in Table 6-133, except FID, SFID, E-MBS service-related information, Group Parameter Create/ Change related information, and Coupled Group Create/Change related information, may be encapsulated in this field This parameter shall be the first attribute of Coupled Group Create/ Change.	
Qty Coupled SFID request	5	The number of coupled DL service flow and UL service flow of the same common parameter set configuration to create This parameter is the last attribute of a Coupled Group Create/Change	Shall only be sent by an AMS
For(i = 0; i < N-FIDs-Coupled; i++) {		FIDs of DL and UL service flow (4 MSB for DL FID and 4 LSB for UL FID) N-FIDs-Coupled is the number of FIDs The maximum value of N-FIDs-Coupled is 16	
FID	8		
}			
For(i = 0; i < N-FIDs-Coupled-Noncommon; i++) {		N-FIDs-Coupled-Noncommon is the number of non-common coupled service flow IDs The maximum value of N-FIDs-Coupled-Noncommon is 32	

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
FID	4		Shall be present if N-FIDs-Coupled-Non-common is not zero
Non-common for Coupled Group	*variable*	Non-common service flow encodings that are specific to individual service flows specified in Coupled FID Parameter List Service flow/convergence sublayer parameters in Table 6-133, except FID, SFID, E-MBS service related information, Group Parameter Create/Change related information, and Coupled Group Create/Change related information, may be encapsulated in this field	Shall be present if N-FIDs-Coupled-Non-common is not zero
}			
}			
For (*i* = 0; *i* < Num of Multicast Group ID; *i*++) {		Num of Multicast Group ID is the number of Multicast Group IDs to add [1..16]	Present when ABS initiates AAI-DSA-REQ
Multicast Group ID	12	ID of a group to which the flow is added	Present only if Num of Multicast Group ID > 0
FID	4	Multicast specific FID that is associated with Multicast Group ID	Present only if Num of Multicast Group ID > 0
}			
if(Sleep Cycle Setting is included) {			May be present when sleep cycle setting needs to be changed or switched
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	
if(Operation == 0b10 || Operation == 0b11) {			
SCID	4	Sleep Cycle ID 0~15	
Start Frame Number	6	0–63	

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
FFBCH_Operation	2	0: The fast feedback channel assigned to the AMS is kept 1: The fast feedback channel is deallocated at the frame specified by Start_Frame_Number 2: The fast feedback channel is automatically deallocated at the beginning of the sleep window whenever the fast feedback channel is newly assigned to the AMS during the listening window 0~3	
if(Operation == 0b10)			
TIMF	1	Traffic Indication Message Flag 0: AAI-TRF-IND message is not sent for the AMS 1: AAI-TRF-IND message is sent to the AMS during every Listening window	
LWEF	1	Listening Window Extension Flag 0: The Listening window is of fixed duration 1: The Listening window is extensible	
NSCF	2	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 × previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = *Reserved* 0b00~0b11	
Initial Sleep Cycle	4	This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps the sleep state in sleep mode (measured in frames). Value: 0~15 Initial Sleep Cycle = Value + 1	
Final Sleep Cycle	10	This indicates assigned duration for the Final Sleep Cycle (measured in frames). Value: 0~1023 Final Sleep Cycle = Value + 1	
Listening Window	6	Assigned duration of AMS's default listening window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when the Listening Window Extension is enabled. Value: 0~63 Listening window = Value + 1	
if(TIMF == 1) {			

Table 6-85—AAI-DSA-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Conditions
SLPID	10	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. 0~1023	
}			
if(NSCF == 0b10) {			
New Initial Sleep Cycle	5	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. Value: 0~31 New_Initial_Sleep_Cyle = Value + 1	
}			
if(LWEF == 1) {			
T_AMS	5	This timer is for Listening Window Extension of AMS. 0~31	
}			
}//ENDIF (Operation == 0b10)			
}//ENDIF (Operation == 0b10 || Operation == 0b11)			
REQ_duration	8	Waiting value for the AAI-SLP-REQ message retransmission, which is the Least Significant 8 bits of Frame Number. If REQ_duration is missing when Response_Code == 0b10 in AAI-DSx-RSP message, the AMS shall consider REQ_duration = 0. 0~255	This parameter can be included only when BS transmits AAI-DSx-RSP message in response to AAI-DSx-REQ message sent by AMS
}// ENDIF (Sleep Cycle Setting is included)			
For (i = 0; i < Number of HARQ channels; i++){		Number of HARQ channels = 1..16	Present if needed
HARQ Channel Mapping	4	Indicates the index (ACID) of each HARQ channel	Shall be present when Number of HARQ channels > 0
}			

6.2.3.47.2 AAI-DSA-RSP

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

- Control Message Type: Type of AAI-DSA-RSP message.
- Confirmation Code: The appropriate confirmation code (CC) for the entire corresponding AAI-DSA-REQ.
- Service Flow parameters: Specification of the service flow's traffic characteristics and scheduling requirements if the transaction is successful. The complete specification of the service flow shall be included in the AAI-DSA-RSP if it includes an expanded service class name.
- Convergence Sublayer parameter encodings: Specification of the service flow's CS-specific parameters if the transaction is successful.

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

The ABS's AAI-DSA-RSP message for service flows that are successfully added shall contain a FID for the transport connection. The ABS's AAI-DSA-RSP message shall also include the Target SAID for the service flow. If the corresponding AAI-DSA-REQ message uses the service class name to request service addition, an AAI-DSA-RSP message shall contain the QoS parameter set associated with the named service class. If the service class name is used in conjunction with other QoS parameters in the AAI-DSA-REQ message, the ABS shall make its decision to accept or reject the AAI-DSA-REQ message based on the combined set of the implicit QoS parameters defined by the service class name and the explicit QoS parameters in the AAI-DSA-REQ message. If these explicit service flow encodings conflict with the implicit service class attributes, the ABS shall return in the AAI-DSA-RSP message the values used as overrides for those of the service class.

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

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

- E-MBS Service: Indicates whether the MBS service is being requested or provided for the connection that is being set up.
- E-MBS zone ID: Indicates an E-MBS zone where the connection for associated service flow is valid.
- E-MBS Service Flow parameter: Mapping of E-MBS ID and FID are included.
- Physical Carrier Index: Target carrier to which the AMS switches or is redirected by the ABS.
- Carrier Switching Mode: Indicates if the carrier switching mode is based on the unicast available interval in the AAI-DSx message or E-MBS connection report in the AAI-E-MBS-REP message.
- Unicast Available Interval Bitmap: Indicates when the AMS should be available in the primary carrier.

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

- Multicast Group ID: Indicates multicast group for the connection that is associated with the service flow in AAI-DSA-RSP.

Table 6-86—AAI-DSA-RSP message field description

Field	Size (bits)	Value / Description	Condition
FID Change Count	4	FID Change Count from corresponding the AAI-DSA-REQ message	Shall always be present
Confirmation Code	1	Zero indicates the request was successful. Nonzero indicates failure	Shall always be present
If (Confirmation Code == 0 && AMS-initiated AAI-DSA-REQ) {			
FID	4	An identifier of a service flow	
}			
If(received an AAI-DSA-REQ including Group Parameter Create/Change parameter) {			
For(*i* = 0; *i* < N-FIDs; *i*++) {		N-FIDs is the number of successfully created service flows	
FID	4	FIDs of service flows created successfully with this Group Parameter Create/Change	Shall be included when N-FIDs > 0
}			
}			
E-MBS Service	3	Indicates whether the E-MBS service is being requested or provided for the connection that is being successfully set up. 1 indicates support, 0 indicates not support. Bit 0: E-MBS in S-ABS Only Bit 1: E-MBS in a multi-ABS Zone supporting macro-diversity Bit 2: E-MBS in a multi-ABS Zone not supporting macro-diversity If all Bit 0~Bit 2 are set to 0, it indicates no E-MBS is supported	Present if needed
If(E-MBS is supported){			
For(*i* = 0; *i* < N-E-MBS zone ID; *i*++) {		N-E-MBS zone ID is the number of E-MBS zone IDs [1..8]	
E-MBS_Zone_ID	7	Indicates an E-MBS zone where the connection for associated service flow is valid	Shall be present if N-E-MBS zone ID >0
Physical Carrier Index	6	Target carrier to which the AMS switches or is redirected by ABS	Present only if the E-MBS zone ID is served on a different carrier from the current carrier
for (*j* = 0; *j* < N-E-MBS-ID; *j*++) {		N-E-MBS-ID is the number of E-MBS identifiers [1...15]	

Table 6-86—AAI-DSA-RSP message field description *(continued)*

Field	Size (bits)	Value / Description	Condition
E-MBS ID	12	E-MBS identifier	Shall be present if N-E-MBS-ID >0
FID	4	Flow ID	Shall be present if N-E-MBS-ID >0
}			
}			
}			
Carrier Switching Mode	1	0b0: carrier switching method based on the Unicast Available Interval in the AAI-DSA message 0b1: carrier switching method using the AAI-E-MBS-REP/RSP message	Present if the ABS indicates carrier switching when receiving AMS-initiated DSA
If(Carrier Switching Mode == 0b0) {			
Unicast Available Interval Bitmap	*variable*	Indicates when the AMS should be available in the primary carrier using N bits $b_0b_1b_2...b_{N-1}$ If b_i == 0, then the AMS is available for E-MBS data scheduling in the secondary carrier If b_i == 1, then the AMS is available for unicast scheduling in the primary carrier N_{MSI} = 4 superframes: N = 4 bits N_{MSI} = 8 superframes: N = 8 bits N_{MSI} = 16 superframes: N = 16 bits N_{MSI} = 32 superframes: N = 32 bits Depending on the N_{MSI}, the number of bits per subframe changes, 4 frames per bit	
}			
For (i = 0; i < Num of Multicast Group ID; i++) {		Num of Multicast Group ID is the number of Multicast Group ID to add [1..16]	
Multicast Group ID	12	ID of a group to which the flow is added	Present when Num of Multicast Group ID > 0
FID	4	Multicast specific FID that is associated with Multicast Group ID	Present when Num of Multicast Group ID > 0
}			
if(Sleep Cycle Setting is included) {			May be present when sleep cycle setting needs to be changed or switched

Table 6-86—AAI-DSA-RSP message field description *(continued)*

Field	Size (bits)	Value / Description	Condition
Response_Code	2	This indicates response type of AAI-SLP-RSP message 0b00: Request by ABS in Unsolicited manner 0b01: Approval of AAI-SLP-REQ 0b10: Rejection of AAI-SLP-REQ 0b11: *Reserved*	This parameter shall be included only when the ABS transmits this control message
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
if(Operation == 0b10 || Operation == 0b11) {			
SCID	4	Sleep Cycle ID 0~15	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Start Frame Number	6	0~63	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
FFBCH_Operation	2	0: The fast feedback channel assigned to the AMS is kept 1: The fast feedback channel is deallocated at the frame specified by Start_Frame_Number 2: The fast feedback channel is automatically deallocated at the beginning of the sleep window whenever the fast feedback channel is newly assigned to the AMS during the Listening window 0~3	This parameter shall be included only when one of the following conditions is met. —When ABS transmits this control message and (Response Code == 0b00 || Response Code == 0b01) —When AMS transmits this control message
if(Operation == 0b10)			
TIMF	1	Traffic Indication Message Flag 0: AAI-TRF-IND message is not sent for the AMS 1: AAI-TRF-IND message is sent to the AMS during every Listening window	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
LWEF	1	Listening Window Extension Flag 0: The Listening window is of a fixed duration 1: The Listening window is extensible	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10

Table 6-86—AAI-DSA-RSP message field description *(continued)*

Field	Size (bits)	Value / Description	Condition
NSCF	2	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 × previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = Reserved 0b00~0b11	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Initial Sleep Cycle	4	This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps sleep state in sleep mode (measured in frames). Value: 0~15 Initial Sleep Cycle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Final Sleep Cycle	10	This indicates assigned duration for the Final Sleep Cycle (measured in frames). Value: 0~1023 Final Sleep Cycle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Listening Window	6	Assigned duration of the AMS's default listening window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. Value: 0~63 Listening window = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
if(TIMF == 1) {			
SLPID	10	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. 0~1023	This parameter shall be included only when the ABS transmit this control message and (Response Code == 0b00 || Response Code == 0b01)
}			
if(NSCF == 0b10) {			
New Initial Sleep Cycle	5	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode Value: 0~31 New_Initial_Sleep_Cyle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
}			
if(LWEF == 1) {			

Table 6-86—AAI-DSA-RSP message field description *(continued)*

Field	Size (bits)	Value / Description	Condition
T_AMS	5	This timer is for Listening Window Extension of AMS. 0~31	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
}			
}//ENDIF (Operation == 0b10)			
}//ENDIF (Operation == 0b10 || Operation == 0b11)			
REQ_duration	8	Waiting value for the AAI-SLP-REQ message retransmission, which is the Least Significant 8 bits of Frame Number. If REQ_duration is missing when Response_Code == 0b10 in AAI-DSx-RSP message, the AMS shall consider REQ_duration = 0. 0~255	This parameter can be included only when the BS transmits the AAI-DSx-RSP message in response to the AAI-DSx-REQ message sent by the AMS
}// ENDIF (Sleep Cycle Setting is included)			
MAC Header type	1	Indicates whether AGMH or SPMH is presented at the start of MAC PDUs of the service flow 0 = AGMH (Advanced Generic MAC Header) 1 = SPMH (Short-Packet MAC header) default value is 0	Present if SPMH is used to transmit MAC PDUs from this service flow
For(i = 1; i ≤ N-Predefined-BR-indices; i++) {		The mapping of predefined BR index used in quick access message to BR size and BR actions N-Predefined-BR-indices is the number of predefined BR indices [1..15]	
Predefined BR index	4	Predefined BR index	Present if N-Predefined-BR-indices is not zero
BR action	2	0b00: ertPS service flow requests to resume to maximum sustained rate 0b01: aGP service flow requests to switch to Primary QoS parameters 0b10: BR 0b11: *Reserved*	Present if N-Predefined-BR-indices is not zero
If(BR action == 0b10) {			
BR size	11	Number of bytes requested by the predefined BR index	
}			

Table 6-86—AAI-DSA-RSP message field description *(continued)*

Field	Size (bits)	Value / Description	Condition
}			
If (ARQ parameters are needed) {			
ARQ Enable	1	0 = ARQ Not Requested/Accepted 1 = ARQ Requested/Accepted	Present if needed
ARQ_WINDOW_SIZE	16	>0 and (ARQ_BSN_MODULUS/2)	Present if needed
ARQ_BLOCK_LIFETIME	16	0 = Infinite 1–6 553 500 µs (100 µs granularity)	Present if needed
ARQ_SYNC_LOSS_TIMEOU T	16	0 = Infinite 1–6 553 500 µs (100 µs granularity)	Present if needed
ARQ_RX_PURGE_TIMEOUT	16	0 = Infinite 1–6 553 500 µs (100 µs granularity)	Present if needed
ARQ_SUB_BLOCK_SIZE	3	Bit 0–2: encoding for selected block size (P), where the selected block size is equal to $2^{(P+3)}$, $0 \le P \le 7$. ARQ subblock size is byte unit	Present if needed
ARQ_ERROR_DETECTION_ T IMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)	Present if needed
ARQ_FEEDBACK_POLL_RE T RY_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)	Present if needed
}			
}			

6.2.3.47.3 AAI-DSA-ACK

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

— Control Message Type: Type of AAI-DSA-ACK message.

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

Table 6-87—AAI-DSA-ACK message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	FID Change Count from corresponding the AAI-DSA-RSP message	
Confirmation Code	1	Zero indicates the request was successful. Nonzero indicates failure	

6.2.3.47.4 AAI-DSC-REQ

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

— Control Message Type: Type of AAI-DSC-REQ message.

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

The following parameters may be included in the AAI-DSC-REQ message:

— Predefined BR index parameters: Predefined BR index parameters define the mapping from predefined BR index(es) to BR action and BR size, which is used in the 3-step Bandwidth Request procedure, and are only included in ABS-initiated DSC-REQ. They are determined based on the QoS parameters of the service flow in the AAI-DSx messages. If BR action is 0b10 (BR), the ABS shall assign a different BR index to service flows whose UL Grant Scheduling Type is different and shall assign a different BR index to different service flows whose UL Scheduling Type is the same but BR size is different.

When an ABS updates E-MBS service flow, the following parameters may be included in the AAI-DSC-REQ message:

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

— E-MBS Service Flow Parameter: Mapping updates of E-MBS ID and FID.

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

— Carrier Switching Mode: Indicates if the carrier switching mode is based on the unicast available interval in the AAI-DSx message or E-MBS connection report in the AAI-E-MBS-REP message.

— Unicast Available Interval Bitmap: Indicates when the AMS should be available in the primary carrier.

When an ABS updates multicast service flow, the following parameters may be included in the AAI-DSC-REQ message:

— Multicast Service Flow Parameter: Mapping update of Multicast Group ID.

An AAI-DSC-REQ message shall not carry parameters for more than one service flow (see Table 6-88).

Table 6-88—AAI-DSC-REQ message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	The change count of this transaction assigned by the sender. If new transaction is started, FID Change Count is incremented by one (modulo 16) by the sender	Shall be always present
SFID	32	Service flow identifier	Shall be always present
Uplink/Downlink Indicator	1	0: uplink; 1:downlink	Shall be always present
Service Class Name	16 to 1024	Null-terminated string of ASCII characters. The length of the string, including the null-terminator, may not exceed 128 bytes	Present when a predefined BS service configuration is used for this service flow
Global Service Class Name field	84	Name of global service classes (see Table 6-128 in 6.2.12.8)	Present when a predefined BS service configuration to be used for this service flow is synchronized among all BS
QoS parameter set type	3	Bit 0: Provisioned Set Bit 1: Admitted Set Bit 2: Active Set	
If (QoS parameters are needed) {			
Traffic Priority parameter	3	0 to 7: Higher numbers indicate higher priority Default 0	Present when needed
Maximum Sustained Traffic Rate parameter	32	Rate (in bits per second)	Present when needed
Maximum Traffic Burst parameter	32	Burst size (bytes)	Present when needed
Minimum Reserved Traffic Rate parameter	32	Rate (in bits per second)	Present when needed
Maximum Latency parameter	32	Milliseconds	Present when needed
Paging Preference parameter	1	0: No paging generation 1: Paging generation	Present when needed
Tolerated Jitter parameter	32	Milliseconds	Present when needed
If (UL scheduling type == UGS | ertPS) {			
Unsolicited Grant Interval parameter	16	Milliseconds	Present if UL scheduling type is set to UGS or ertPS

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
}else if (UL scheduling type == rtPS) {			
Unsolicited Polling Interval parameter	16	Milliseconds	Present if UL scheduling type is set to rtPS
}else if (UL scheduling type == aGPS) {			
Primary Grant Polling Interval parameter	16	Milliseconds	Present when primary parameter set is needed
Primary Grant Size parameter	16	Number of bytes	Present when primary parameter set is needed
Secondary Grant Polling Interval parameter	16	Milliseconds	Present when secondary parameter set is needed
Secondary Grant Size parameter	16	Number of bytes	Present when secondary parameter set is needed
}			
If (Uplink/Downlink Indicator == 0) {			
Access Class	2	This parameter specifies the priority assigned to a service flow. This priority is used in prioritizing access requests as described in 6.2.11.1.1	Present if needed
Differentiated BR Timer	6	Grant reception timeout before contention-based BR is attempted again for the service flow. Value of range 1~64 frame(s)	Present if needed
For(*i* = 0; *i* < N-Predefined-BR-indices; *i*++) {		The mapping of predefined BR index used in quick access message to BR size and BR actions (see Table 6-136) N-Predefined-BR-indices is the number of predefined BR indices [1..15]	
Predefined BR index	4	Predefined BR index	Present when N-Predefined-BR-indices > 0
BR action	2	0b00: ertPS service flow requests to resume to maximum sustained rate 0b01: aGP service flow requests to switch to Primary QoS parameters 0b10: BR 0b11: *Reserved*	Present when N-Predefined-BR-indices > 0
If(BR action == 0b10) {			
BR size	11	Number of bytes requested by the predefined BR index	Present when BR action is set to 0b10
}			
}			

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Initial Backoff Window Size	4	Window size expressed as a power of 2	Present if needed
Maximum Backoff Window Size	4	Window size expressed as a power of 2	Present if needed
Backoff Scaling Factor	4	“0010” for Binary Exponential Back-off	Present if needed
} // End If (Uplink/Downlink Indicator == 0)			
MAC in-order delivery indicator	1	Indicate whether or not the order of delivery in the connection is preserved by the MAC. 0: Not preserved 1: Preserved For ARQ connections, it shall be always set to 1	Present if needed
If (vendor-specific classification parameters are needed) {		See 6.2.12.12.8.1	
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address	Present when vendor-specific classification parameters are included
Vendor-specific classification	*variable*	Vendor-specific classification rule parameters	Present when Vendor-specific classification parameters are included
}			
SDU Inter-Arrival Interval parameter	16	SDU inter-arrival interval in the resolution of 0.5 ms	Present when needed
Time Base parameter	16	Time base in milliseconds	Present when needed
Classifier DSC Action	8	0: DSC Add classifier 1: DSC Release classifier 2: DSC Delete classifier	Present when needed
If (Packet Classification Rule parameter is needed) {			
Classification Rule Priority field	8	0–255	Present when needed
Protocol field	8	protocol	Present when needed
IP Masked Source Address parameter	32×2 (IPv4) or 128×2 (IPv6)	src, smask represent IP source and mask addresses that are 32 bits × 2 (Ipv4) or 128 bits × 2 (Ipv6) in size	Present when needed
IP Masked Destination Address parameter	32×2 (IPv4) or 128×2 (IPv6)	dst, dmask represent IP destination and mask addresses that are 32 bits × 2 (Ipv4) or 128 bits × 2 (Ipv6) in size	Present when needed

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Protocol Source Port Range field	16×2	sportlow, sporthigh represent the lower bound and higher bound of the protocol source port range	Present when needed
Protocol Destination Port Range field	16×2	dportlow, dporthigh represent the lower bound and higher bound of the protocol destination port range	Present when needed
Associated PHSI field	8	Index value	Present when needed
Packet Classification Rule Index field	16	Packet Classification Rule Index	Present when needed
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address	Present when needed
IPv6 Flow Label field	24	Flow Label	Present when needed
Classification Action Rule	1	0 = none. 1 = Discard packet	Present when needed
IP Type of Service	7	DSCP value (0 to 127)	Present when needed
PHS DSC Action field	2	0: Add PHS Rule 1: Set PHS Rule 2: Delete PHS Rule 3: Delete all PHS Rules	Present when needed
If (PHS DSC Action field == Add PHS Rule || Set PHS Rule) {			
PHSI field	8	Index value	Shall be present if PHS DSC Action field is set to Add PHS Rule or Set PHS Rule when the ABS initiates AAI-DSC-REQ
PHSF field	8	String of bytes suppressed	Present when needed
PHSM field	8	Bit 0: 0 = Do not suppress first byte of the suppression field 1 = Suppress first byte of the suppression field Bit 1: 0 = Do not suppress second byte of the suppression field 1 = Suppress second byte of the suppression field Bit x: 0 = Do not suppress (x + 1) byte of the suppression field 1 = Suppress (x + 1) byte of the suppression field	Present when needed
PHSS field	8	Number of bytes in the suppression string	Present when needed

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
PHSV field	1	0: Verify 1: Don't verify	Present when needed
If (vendor-specific PHS parameters are needed) {		See 6.2.12.12.8.2	
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address	Present when vendor-specific PHS parameters are included
Vendor-specific PHS	*variable*	Vendor-specific PHS parameters	Present when vendor-specific PHS parameters are included
}			
}			
Else if (PHS DSC Action field = Delete PHS Rule) {			
PHSI field	8	Index value	Shall be present when PHS DSC Action field is set to Delete PHS Rule
}			
IEEE 802.3/Ethernet Destination MAC Address	48×2	dst, msk represent Ethernet destination and mask addresses that are 48 bits $\times$ 2 in size	Present if needed
IEEE 802.3/Ethernet Source MAC Address parameter	48×2	src, msk represent Ethernet source and mask addresses that are 48 bits $\times$ 2 in size	Present if needed
Ethertype/IEEE 802.2 SAP	2/34/18	type, eprot1, eprot2 are the Layer 3 protocol ID. type = 0, eprot1, eprot2 are ignored. type = 1, eprot1and eprot2 give two 16-bit values of the Ethertype that the packet shall match in order to match the rule. type = 2, eprot1and eprot2 give two lower 8-bit values of the Ethertype that shall match the DSAP byte of the packet in order to match the rule	Present if needed
IEEE 802.1D User Priority field	3×2	pri-low, pri-high are the IEEE 802.1D user_priority bits. Valid range: 0–7 for pri-low and pri-high	Present if needed
IEEE 802.1Q VLAN ID field	12	Specifies the matching value of the IEEE 802.1Q vlan_id bits	Present if needed
inner source IP	32	Source IP address of inner IP header	Present if needed
inner destination IP	32	Destination IP address of inner IP header	Present if needed

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
inner protocol field	8	Protocol field of inner IP header	Present if needed
inner TOS (Type of Service)	8	TOS field of inner IP header	Present if needed
inner IPv6 Flow Label	8	IPv6 Flow Label of inner IP header	Present if needed
}			
}// end if QoS			
If (ARQ parameters are needed) {			Present when an ABS initiates AAI-DSC transaction with an AMS that has performed network reentry with the ABS from direct HO or zone switch handover
ARQ_WINDOW_SIZE	16	>0 and ≤(ARQ_BSN_MODULUS/2)	Present if needed
ARQ_BLOCK_LIFETIME	16	0 = Infinite 1–6 553 500 μs (100 μs granularity)	Present if needed
ARQ_SYNC_LOSS_TIMEOUT	16	0 = Infinite 1–6 553 500 μs (100 μs granularity)	Present if needed
ARQ_RX_PURGE_TIMEOUT	16	0 = Infinite 1–6 553 500 μs (100 μs granularity)	Present if needed
ARQ_SUB_BLOCK_SIZE	3	Bit 0-2: encoding for selected block size (P), where the selected block size is equal to $2^{(P+3)}$, $0 \le P \le 7$. ARQ sub-block size is byte unit	Present if needed
ARQ_ERROR_DETECTION_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)	Present if needed
ARQ_FEEDBACK_POLL_RETRY_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)	Present if needed
}			
If (ROHC Parameter is needed) {			Present if needed
ROHC Max Context ID	16	Non-negative integer	
Large Context IDs	8	0: FALSE (Small Context ID) 1: TRUE (Large Context ID) 2–255: *Reserved*	
ROHC MRRU	16	0: no segmentation 1..65 535: MRRU Maximum reconstructed reception unit	
ROHC Profiles	*variable*	A set of nonnegative integers, where each integer indicates a 16-bit profile identifier of a ROHC profile supported by the decompressor	

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
ROHC Feedback Channel	32	0: no associated ROHC feedback Otherwise: SFID for ROHC feedback	
}			
Packet Error Rate (PER)	8	MSB (Bit 7): 0: PER measured by the application, post-ARQ and post-HARQ process 1: PER measured on the airlink, before the application of ARQ and HARQ Bit 6: 0: Interpret bits 0–5 as an integer %; i.e., if bits 0–5 are the binary representation of the integer N, then the PER = N/100 (= N%) 1: Interpret bits 0–5 as 10 times a negative exponent of 10; i.e., if bits 0–5 are the binary representation of the integer N, then the PER = 10-N/10 LSB 6 bits (bits 0–5): PER value If bit 6 = 0, [0% to 63%] PER If bit 6 = 1, [~5 × 10–7 to 1 × 10–0] PER	Present if needed
Emergency Indication parameter	1	Indicates the associated flow is used for emergency purposes. 0 = Not an Emergency flow 1 = Emergency flow	Present if needed
NS/EP Service Indication parameter	1	Indicates the associated flow is used for NS/EP services 0 = Not an NS/EP flow 1 = NS/EP flow	Present if needed
For (i = 0; i < Num of E-MBS zone ID; i++) {		Num of E-MBS zone ID [1..8] is the number of E-MBS ID to update	Present when the ABS initiates AAI-DSC-REQ Present only if Num of E-MBS zone ID > 0
Service_flow_update_indicator	1	Indicator whether "bitmap + new service flow" or "current service flow + new service flow" is included. 0b0: "Service Flow Update Bitmap + New_E-MBS ID and FID" 0b1: "Current_ E-MBS ID and FID and New_ E-MBS ID and FID Mappings"	Present only if Num of E-MBS zone ID > 0
E-MBS_Zone_ID	7	Indicates an E-MBS zone where the connection for associated service flow is valid	Present only if Num of E-MBS zone ID > 0
New E-MBS_Zone_ID	7	Indicates an E-MBS zone to update	Present only if the E-MBS zone ID needs to update

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Physical Carrier Index	6	The physical carrier index that is support for the new E-MBS zone ID to update	Present only if the New E-MBS zone ID to update is served on a different carrier from the previous one
If (Service_flow_update_indicator == 0b0) {			
Service Flow Update Bitmap	16	E-MBS Service Flow update bitmap where the E-MBS ID + FID is sorted with increasing order between the ABS and the AMS. A bit = 1, means the corresponding service flow, identified by E-MBS ID and FID, is updated	
for(*m* = 0; *m*<N_ServiceFlowUpdateBitmap; *m*++){		N_ServiceFlowUpdateBitmap is the number of bits to be set to 1 of Service Flow Update Bitmap. For each bit in the Service Flow Update Bitmap = 1 to indicate the corresponding service flow is updated Range: 0–15	Present only if the number of bits set to 1 in Service Flow Update Bitmap > 1
New_E-MBS ID	12	New E-MBS identifier	Present when N_ServiceFlowUpdateBitmap > 0
FID	4	Flow ID	Present when N_ServiceFlowUpdateBitmap > 0
}			
}else if (Service_flow_update_indicator == 0b1) {			
for(*k* = 0; *k* < N_E-MBS_FID_Mapping; *k*++) {		N_E-MBS_FID_Mapping is the number of mappings of current E-MBS ID and FID and new E-MBS ID and FID to update the service flow. N-E-MBS-IDs is the number of E-MBS IDs	
Current E-MBS ID	12	Current E-MBS identifier	Present when N_E-MBS_FID_Mapping > 0
Current FID	4	Current flow ID	Present when N_E-MBS_FID_Mapping > 0
New_E-MBS ID	12	New E-MBS identifier	Present when N_E-MBS_FID_Mapping > 0

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
New FID	4	New flow ID	Present when N_E-MBS_FID_Mapping > 0
}			
}			
} //end of for			
Carrier Switching Mode	1	0b0: carrier switching method based on Unicast Available Interval in the AAI-DSC message. 0b1: carrier switching method using the AAI-E-MBS-REP/RSP message	Shall be present when the Unicast Available Interval needs to be updated
If (Carrier switching Mode == 0b0) {			
Unicast Available Interval Bitmap	*variable*	Indicates when the AMS should be available in the primary carrier using N bits $b_0b_1b_2..b_{N-1}$ If b_i == 0, then the AMS is available for E-MBS data scheduling in the secondary carrier If b_i == 1, then the AMS is available for unicast scheduling in the primary carrier N_{MSI} = 4 superframes: N = 4 bits N_{MSI} = 8 superframes: N = 8 bits N_{MSI} = 16 superframes: N = 16 bits N_{MSI} = 32 superframes: N = 32 bits Depending on the N_{MSI}, the number of bits per subframe changes, 4 frames per bit	Present when Carrier Switching Mode is set to 0b0
}			
If (Group Parameter Create/Change is needed) {		Refer to 6.2.12.12.6	
Common for Group Create/Change	*variable*	Common service flow encodings that are common to all service flows specified in Group Parameter Create/Change. Service flow/convergence sublayer parameters in Table 6-133, except FID, SFID, E-MBS service related information, Group Parameter Create/Change related information, and Coupled Group Create/Change related information, may be encapsulated in this field. Shall be included only once in a Group Parameter Create/Change as the first attribute	Shall be present when Group Parameter Create/Change parameter is included

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Qty SFID request	5	The number of service flows to change. Shall be the last attribute of Group Parameter Create/Change	Shall only be sent by an AMS
For(*i* = 0; *i* < N-FIDs; *i*++) {		FIDs of service flows changed with this Group Parameter Create/Change. N-FIDs is the number of FIDs. The maximum value of N-FIDs is 32	
FID	4		Present when N-FIDs > 0
}			
For(*i* = 0; *i* < N-FIDs-Noncommon; *i*++) {		N-FIDs-Noncommon is the number of non-common service flow IDs. The maximum value of N-FIDs-Noncommon is 32	
FID	4		Present when N-FIDs-Noncommon > 0
Non-common for Group Create/ Change	*variable*	Non-common service flow encodings that are specific to individual service flows specified in the Group FID Parameter List. Service flow/convergence sublayer parameters in Table 6-133, except FID, SFID, E-MBS service-related information, Group Parameter Create/ Change related information, and Coupled Group Create/Change related information, may be encapsulated in this field	Present when N-FIDs-Noncommon > 0
}			
}			
If (Coupled Group Create/ Change is needed) {		Refer to 6.2.12.12	
Common for Coupled Group	*variable*	Common service flow encodings that are common to all service flows specified in the Coupled Group Create/ Change parameter. Service flow/convergence sublayer parameters in Table 6-133, except FID, SFID, E-MBS service-related information, Group Parameter Create/ Change related information, and Coupled Group Create/Change related information, may be encapsulated in this field. This parameter shall be the first attribute of the Coupled Group Create/ Change parameter	Present when Coupled Group Create/Change parameter is included

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Qty Coupled SFID request	5	The number of coupled DL service flow and UL service flow of the same common parameter set configuration to change This parameter is the last attribute of a Coupled Group Create/Change	Present when Coupled Group Create/Change parameter is included
For(*i* = 0; *i* < N-FIDs-Coupled; *i*++) {		FIDs of DL and UL service flow 4MSB for DL FID and 4LSB for UL FID. N-FIDs-Coupled is the number of FIDs. The maximum value of N-FIDs-Coupled is 16	
FID	8		Present when Coupled Group Create/Change parameter is included
}			
For(*i* = 0; *i* < N-FIDs-Coupled-Noncommon; *i*++) {		N-FIDs-Coupled-Noncommon is the number of non-common coupled service flow IDs. The maximum value of N-FIDs-Coupled-Noncommon is 32	
FID	4	Flow identifier	Present when N-FIDs-Coupled-Noncommon > 0
Non-common for Coupled Group	*variable*	Non-common service flow encodings that are specific to individual service flows specified in the Coupled FID Parameter List. Service flow/convergence sublayer parameters in Table 6-133, except FID, SFID, E-MBS service-related information, Group Parameter Create/Change related information, and Coupled Group Create/Change related information, may be encapsulated in this field	Present when N-FIDs-Coupled-Noncommon > 0
}			
}			
For (*i* = 0; *i* < Num of Multicast Group ID; *i*++) {		Num of Multicast Group ID is the number of Multicast Group IDs to add [1..16]	Present when the ABS initiates AAI-DSC-REQ Present only if Multicast Group ID to be added exists
Multicast Group ID to be added	12	Multicast Group ID to be added	Present only if Num of Multicast Group ID > 0
FID	4	Multicast specific FID that is associated with newly added Multicast Group ID	Present only if Num of Multicast Group ID > 0

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
}			
For (*i* = 0; *i* < Num of Multicast Group ID; *i*++) {		Num of Multicast Group ID is the number of Multicast Group IDs to delete [1..16]	Present when the ABS initiates AAI-DSC-REQ Present only if Multicast Group ID to be deleted exists
Multicast Group ID to be deleted	12	Multicast Group ID to be deleted	Present only if Num of Multicast Group ID > 0
}			
if(Sleep Cycle Setting is included) {			May be present when sleep cycle setting needs to be changed or switched
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	
if(Operation == 0b10 || Operation == 0b11) {			
SCID	4	Sleep Cycle ID 0~15	
Start Frame Number	6	0~63	
FFBCH_Operation	2	0: The fast feedback channel assigned to the AMS is kept. 1: The fast feedback channel is deallocated at the frame specified by Start_Frame_Number 2: The fast feedback channel is automatically deallocated at the beginning of the sleep window whenever the fast feedback channel is newly assigned to the AMS during the Listening window 0~3	
if(Operation == 0b10)			
TIMF	1	Traffic Indication Message Flag 0: AAI-TRF-IND message is not sent for the AMS 1: AAI-TRF-IND message is sent to the AMS during every Listening window	
LWEF	1	Listening Window Extension Flag 0: The Listening window is of a fixed duration 1: The Listening window is extensible	

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
NSCF	2	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 × previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = *Reserved* 0b00~0b11	
Initial Sleep Cycle	4	This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps the sleep state in sleep mode (measured in frames). Value: 0~15 Initial Sleep Cycle = Value + 1	
Final Sleep Cycle	10	This indicates an assigned duration for the Final Sleep Cycle (measured in frames). Value: 0~1023 Final Sleep Cycle = Value + 1	
Listening Window	6	Assigned duration of AMS's default Listening window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. Value: 0~63 Listening window = Value + 1	
if(TIMF == 1) {			
SLPID	10	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. 0~1023	
}			
if(NSCF == 0b10) {			
New Initial Sleep Cycle	5	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. Value: 0~31 New_Initial_Sleep_Cyle = Value + 1	
}			

Table 6-88—AAI-DSC-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
if(LWEF == 1) {			
T_AMS	5	This timer is for Listening Window Extension of AMS. 0~31	
}			
}//ENDIF (Operation == 0b10)			
}//ENDIF (Operation == 0b10 || Operation == 0b11)			
REQ_duration	8	Waiting value for the AAI-SLP-REQ message retransmission, which is the Least Significant 8 bits of Frame Number. If REQ_duration is missing when Response_Code == 0b10 in the AAI-DSx-RSP message, the AMS shall consider REQ_duration = 0. 0~255	This parameter can be included only when BS transmits the AAI-DSx-RSP message in response to the AAI-DSx-REQ message sent by the AMS
}// ENDIF (Sleep Cycle Setting is included)			
For (*i* = 0; Number of HARQ channels; *i*++){		Number of HARQ channels = 1..16	Present if needed
HARQ Channel Mapping	4	Indicates the index (ACID) of each HARQ channel	Shall be present when Number of HARQ channels > 0
}			

6.2.3.47.5 AAI-DSC-RSP

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

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

In response to the AAI-DSC-REQ message that contains “Predefined BR index,” the “Predefined BR index” may be included in the AAI-DSC-RSP message as approval to ABS or AMS’s request. If the AAI-DSC-RSP message does not include the “Predefined BR index,” the ABS or AMS shall regard its request as being failed.

Table 6-89—AAI-DSC-RSP message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	FID Change Count from corresponding the AAI-DSC-REQ message	Shall be always present
SFID	32	Service flow identifier	Present when an ABS initiates AAI-DSC-REQ
Confirmation Code	1	0 = Request was successful 1 = Request was failure	
If(received an AAI-DSA-REQ including Group Parameter Create/Change parameter) {			
For (i = 1; $i \le$ N-FIDs; i++) {		N-FIDs is the number of successfully created service flow. The range of N-FIDs is 1..16	
FID	4	FIDs of service flows created successfully with this Group Parameter Create/Change	Shall be included when N-FIDs > 0
}			
}			
if(Sleep Cycle Setting is included) {			May be present when sleep cycle setting needs to be changed or switched
Response_Code	2	This indicates the response type of the AAI-SLP-RSP message. 0b00: Request by ABS in Unsolicited manner 0b01: Approval of AAI-SLP-REQ 0b10: Rejection of AAI-SLP-REQ 0b11: *Reserved*	This parameter shall be included only when the ABS transmit this control message
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	In case of the ABS’s transmission: This parameter shall be omitted when Response_Code == 10
if(Operation == 0b10 || Operation == 0b11) {			
SCID	4	Sleep Cycle ID. 0~15	In case of the ABS’s transmission: This parameter shall be omitted when Response_Code == 10

Table 6-89—AAI-DSC-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Start Frame Number	6	0~63	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
FFBCH_Operation	2	0: The fast feedback channel assigned to the AMS is kept 1: The fast feedback channel is deallocated at the frame specified by Start_Frame_Number 2: The fast feedback channel is automatically deallocated at the beginning of the sleep window whenever the fast feedback channel is newly assigned to the AMS during the listening window 0~3	This parameter shall be included only when the one of the following conditions is met. —When the ABS transmits this control message and (Response Code == 0b00 || Response Code == 0b01) —When the AMS transmits this control message
if(Operation == 0b10)			
TIMF	1	Traffic Indication Message Flag 0: AAI-TRF-IND message is not sent for the AMS 1: AAI-TRF-IND message is sent to the AMS during every Listening window	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
LWEF	1	Listening Window Extension Flag 0: The Listening window is of a fixed duration 1: The Listening window is extensible	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
NSCF	2	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 × previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = *Reserved* 0b00~0b11	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Initial Sleep Cycle	4	This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps the sleep state in sleep mode (measured in frames). Value: 0~15 Initial Sleep Cycle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Final Sleep Cycle	10	This indicates an assigned duration for the Final Sleep Cycle (measured in frames). Value: 0~1023 Final Sleep Cycle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10

Table 6-89—AAI-DSC-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Listening Window	6	Assigned duration of the AMS's default Listening window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. Value: 0~63 Listening window = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
if(TIMF == 1) {			
SLPID	10	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode 0~1023	This parameter shall be included only when the ABS transmits this control message and (Response Code == 0b00 || Response Code == 0b01)
}			
if(NSCF == 0b10) {			
New Initial Sleep Cycle	5	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. Value: 0~31 New_Initial_Sleep_Cyle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
}			
if(LWEF == 1) {			
T_AMS	5	This timer is for Listening Window Extension of AMS. 0~31	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
}			
}//ENDIF (Operation == 0b10)			

Table 6-89—AAI-DSC-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
}//ENDIF (Operation == 0b10 || Operation == 0b11)			
REQ_duration	8	Waiting value for the AAI-SLP-REQ message retransmission, which is the Least Significant 8 bits of Frame Number. If REQ_duration is missing when Response_Code == 0b10 in the AAI-DSx-RSP message, the AMS shall consider REQ_duration = 0. 0~255	This parameter can be included only when the BS transmits the AAI-DSx-RSP message in response to the AAI-DSx-REQ message sent by the AMS
}// ENDIF (Sleep Cycle Setting is included)			

6.2.3.47.6 AAI-DSC-ACK

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

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

Table 6-90—AAI-DSC-ACK message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	FID Change Count from corresponding the AAI-DSC-RSP message	
Confirmation Code	1	0 = request was successful 1 = request was failure	

6.2.3.47.7 AAI-DSD-REQ

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

- FID: Flow identifier to be deleted.
- Control Message Type: Type of AAI-DSD-REQ message.

When An AAI-DSD-REQ message is sent by an AMS or ABS to delete an E-MBS service flow, the following parameters may be included in the AAI-DSD-REQ message:

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

— E-MBS ID and FID of the connection to be deleted.

Table 6-91—AAI-DSD-REQ message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	The change count of this transaction assigned by the sender. If a new transaction is started, FID Change Count is incremented by one (modulo 16) by the sender	Shall be always present
FID	4	Flow identifier to be deleted	Shall be always present when an existing service flow is deleted
If(E-MBS service flow to delete exists){			
E-MBS_Zone_ID	7	Indicates an E-MBS zone where the connection for associated service flow is valid	Shall be present when the E-MBS service flow to delete exists
N_E-MBS_ID_FID_Mapping	4	Indicates the number of mappings of E-MBS ID and FID in the E-MBS zone to delete Range: 0~15	
for(i = 1: $i \leq$ N_E-MBS_ID_FID_Mapping; i++) {			
E-MBS ID	12	E-MBS identifier	Shall be present when N_E-MBS_ID_FID_Mapping > 0
FID	4	Flow identifier	Shall be present when N_E-MBS_ID_FID_Mapping > 0
}			
}//ENDIF (E-MBS service flow deletion)			
if(Sleep Cycle Setting is included) {			May be present when the sleep cycle setting needs to be changed or switched
Response_Code	2	This indicates the response type of the AAI-SLP-RSP message. 0b00: Request by ABS in Unsolicited manner 0b01: Approval of AAI-SLP-REQ 0b10: Rejection of AAI-SLP-REQ 0b11: *Reserved*	This parameter shall be included only when the ABS transmits this control message
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10

Table 6-91—AAI-DSD-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
if(Operation == 0b10 || Operation == 0b11) {			
SCID	4	Sleep Cycle ID 0–15	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Start Frame Number	6	0–63	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
FFBCH_Operation	2	0: The fast feedback channel assigned to the AMS is kept 1: The fast feedback channel is deallocated at the frame specified by Start_Frame_Number 2: The fast feedback channel is automatically deallocated at the beginning of the sleep window whenever the fast feedback channel is newly assigned to the AMS during the Listening window 0~3	
if(Operation == 0b10)			
TIMF	1	Traffic Indication Message Flag 0: AAI-TRF-IND message is not sent for the AMS 1: AAI-TRF-IND message is sent to the AMS during every Listening window	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
LWEF	1	Listening Window Extension Flag 0: The Listening window is of a fixed duration 1: The Listening window is extensible	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
NSCF	2	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 × previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = *Reserved* 0b00~0b11	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Initial Sleep Cycle	4	This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps the sleep state in sleep mode (measured in frames). Value: 0~15 Initial Sleep Cycle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Final Sleep Cycle	10	This indicates assigned duration for the Final Sleep Cycle (measured in frames). Value: 0~1023 Final Sleep Cycle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10

Table 6-91—AAI-DSD-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Listening Window	6	Assigned duration of the AMS's default Listening window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. Value: 0~63 Listening window = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
if(TIMF == 1) {			
SLPID	10	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. 0~1023	This parameter shall be included only when the ABS transmits this control message and (Response Code == 0b00 || Response Code == 0b01)
}			
if(NSCF == 0b10) {			
New Initial Sleep Cycle	5	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. Value: 0~31 New_Initial_Sleep_Cyle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
}			
if(LWEF == 1) {			
T_AMS	5	This timer is for the Listening Window Extension of AMS. 0~31	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
}			
}//ENDIF (Operation == 0b10)			

Table 6-91—AAI-DSD-REQ message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
}//ENDIF (Operation == 0b10 || Operation == 0b11)			
REQ_duration	8	Waiting value for the AAI-SLP-REQ message retransmission, which is the Least Significant 8 bits of Frame Number. If REQ_duration is missing when Response_Code == 0b10 in the AAI-DSx-RSP message, the AMS shall consider REQ_duration = 0. 0~255	This parameter can be included only when the BS transmits the AAI-DSx-RSP message in response to the AAI-DSx-REQ message sent by the AMS
}// ENDIF (Sleep Cycle Setting is included)			

6.2.3.47.8 AAI-DSD-RSP

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

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

Table 6-92—AAI-DSD-RSP message field description

Field	Size (bits)	Value/Description	Condition
FID Change Count	4	FID Change Count from corresponding the AAI-DSD-REQ message	Shall be always present
FID	4	Flow identifier to be deleted	Present when an existing service flow is deleted
Confirmation Code	1	0 = Request was successful 1 = Request was failure	
if(Sleep Cycle Setting is included) {			May be present when the sleep cycle setting needs to be changed or switched

Table 6-92—AAI-DSD-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Response_Code	2	This indicates the response type of the AAI-SLP-RSP message. 0b00: Request by ABS in Unsolicited manner 0b01: Approval of AAI-SLP-REQ 0b10: Rejection of AAI-SLP-REQ 0b11: *Reserved*	This parameter shall be included only when the ABS transmits this control message
Operation	2	This indicates operation request type 0b00~0b01: *Reserved* 0b10: Change sleep cycle setting 0b11: Switch sleep cycle setting	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
if(Operation == 0b10 || Operation == 0b11) {			
SCID	4	Sleep Cycle ID. 0~15	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Start Frame Number	6	0–63	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
FFBCH_Operation	2	0: The fast feedback channel assigned to the AMS is kept 1: The fast feedback channel is deallocated at the frame specified by Start_Frame_Number 2: The fast feedback channel is automatically deallocated at the beginning of the sleep window whenever the fast feedback channel is newly assigned to the AMS during the Listening window 0~3	This parameter shall be included only when the one of the following conditions is met: —When the ABS transmits this control message and (Response Code == 0b00 || Response Code == 0b01) —When the AMS transmits this control message
if(Operation == 0b10)			
TIMF	1	Traffic Indication Message Flag 0: AAI-TRF-IND message is not sent for the AMS 1: AAI-TRF-IND message is sent to the AMS during every Listening window	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
LWEF	1	Listening Window Extension Flag 0: The Listening window is of a fixed duration 1: The Listening window is extensible	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10

Table 6-92—AAI-DSD-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
NSCF	2	Next sleep cycle indicator. 0b00 = Reset to Initial Sleep Cycle 0b01 = min (2 × previous sleep cycle, Final Sleep Cycle) 0b10 = Reset to another Initial Sleep Cycle value 0b11 = *Reserved* 0b00~0b11	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Initial Sleep Cycle	4	This indicates an assigned duration for the Initial Sleep Cycle during which an AMS keeps the sleep state in sleep mode (measured in frames). Value: 0~15 Initial Sleep Cycle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Final Sleep Cycle	10	This indicates assigned duration for the Final Sleep Cycle (measured in frames). Value: 0~1023 Final Sleep Cycle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
Listening Window	6	Assigned duration of the AMS's default Listening window (measured in frames). This Listening_Window may be extended as long as there is UL/DL data traffic between AMS and ABS when Listening Window Extension is enabled. Value: 0~63 Listening window = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
if(TIMF == 1) {			
SLPID	10	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. 0~1023	This parameter shall be included only when the ABS transmits this control message and (Response Code == 0b00 || Response Code == 0b01)
}			
if(NSCF == 0b10) {			
New Initial Sleep Cycle	5	This is an identifier assigned by the ABS when TIMF is set to 1. This ID shall be unique within an ABS. The other AMS shall not be assigned the same ID while the AMS is still in sleep mode. Value: 0~31 New_Initial_Sleep_Cyle = Value + 1	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
}			
if(LWEF == 1) {			

Table 6-92—AAI-DSD-RSP message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
T_AMS	5	This timer is for Listening Window Extension of AMS. 0~31	In case of the ABS's transmission: This parameter shall be omitted when Response_Code == 10
}			
}//ENDIF (Operation == 0b10)			
}//ENDIF (Operation == 0b10 || Operation==0b11)			
REQ_duration	8	Waiting value for the AAI-SLP-REQ message retransmission, which is the Least significant 8 bits of Frame Number. If REQ_duration is missing when Response_Code == 0b10 in the AAI-DSx-RSP message, the AMS shall consider REQ_duration = 0. 0~255	This parameter can be included only when BS transmits the AAI-DSx-RSP message in response to the AAI-DSx-REQ message sent by the AMS
}// ENDIF (Sleep Cycle Setting is included)			

6.2.3.48 Group Configuration MAC Control message (AAI-GRP-CFG)

The Group Configuration MAC Control message is used for group management when using Group Resource Allocation. This message is used to inform an AMS that one of its flows has been added to or deleted from a GRA group. Note that one or more AMS's flows can be added into the same group. A Group Configuration MAC control message should be sent per AMS flow addition to or deletion from a group (see Table 6-93).

Table 6-93—AAI-GRP-CFG message field description

Field	Size (bits)	Value/Description	Condition
Deletion Flag	1	Flag to signal whether this message includes addition or deletion information. 0: Flow is added to a group 1: Flow is explicitly deleted from a group	
dlUlIndicato	1	0: DL allocation 1: UL allocation	
FID	4	Identifies the flow that is added to or deleted from GRA group	

Table 6-93—AAI-GRP-CFG message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If(HARQ burst sizes are changed) {			Present if HARQ burst sizes are changed. Otherwise, burst sizes of the last GRA allocation are used
Burst size i	5	*i*-th burst size of the 4 burst sizes supported for the FID	
}			
If(Deletion Flag = 0) {			
groupId	12	ID of the group to which the flow is added	
Long TTI Indicator	1	Defines number of AAI subframes spanned by the allocated resource. 0: 1 AAI subframe (default) 1: 4 DL/UL AAI subframes for FDD or all DL/UL AAI subframe for TDD	
Periodicity	2	Periodicity of allocation of this group. This specifies the periodicity with which the corresponding GRA A-MAP IE will be transmitted. 0b00: 1 frame 0b01: 2 frames 0b10: 4 frames 0b11: 8 frames	
MIMO mode set	2	Signals the 2-bit MIMO mode set corresponding to this group. The MIMO mode set codes are specified in Table 6-127 and Table 6-128	
User Bitmap Size	2	The size of the user bitmap in bits. The size remains fixed for a group. The size determines the maximum number of flows that can be supported in one group. 0: 4 1: 8 2: 16 3: 32	
User Bitmap Index	5	Signals index of the flow in a group's user bitmap	
Initial_ACID	4	Signals the starting ACID of the range of ACIDs assigned to the GRA flow	
N_ACIDs	3	The number of ACIDs assigned to the GRA flow	

Table 6-93—AAI-GRP-CFG message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Resource size inclusion bitmap	16	Bitmap to signal which eight resource sizes are supported in the group out of the range of [1,16] LRUs supported for GRA. If *n*-th bit in the bitmap is set to 1, it signals that a resource size of *n* LRUs is supported in the group.	
}			

The Group Configuration MAC Control message signals all the information necessary for the AMS to receive allocations as part of a group via GRA (when the Deletion Flag is set to 0). The encoding of HARQ burst sizes and resource sizes supported in the group is determined as follows. The Group Configuration MAC control message signals four HARQ burst sizes. These burst sizes are assigned 2 bits of code in increasing order from 00 to 11 in the order in which they appear in the message.

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

6.2.3.49 AAI-RES-CMD (Reset command)

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

Table 6-94—AAI-RES-CMD

Attributes/Array of attributes	Size (bits)	Value/Note	Conditions
MAC control message type	8	AMS reset command	

6.2.3.50 AAI-SII-ADV (Service Identity information)

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

Table 6-95—AAI-SII-ADV message field description

Field	Size (bits)	Value/Description	Condition
Number of NSP IDs	4	Number of Network Service Providers	
for (*i* = 0; *i* < number of NSP IDs; *i*++) {		List of the Network Service Provider identifiers	

Table 6-95—AAI-SII-ADV message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
NSP identifier	24	NSP identifier that ABS supports	
}			
for (*i* = 0; *i* < number of NSP IDs; *i*++) {		List of the verbose names of the NSPs. The value of the Verbose NSP Name List is a compound list of verbose NSP name lengths and verbose NSP names. The order of the Verbose NSP Name Lengths and Verbose NSP Names presented shall be in the same order as the NSP IDs presented in the NSP List	
verbose NSP name length	7	Length of verbose NSP name (in byte)	
verboseNspName	*variable* (1..128 × 8)	Verbose NSP name string	
}			

6.2.3.51 AAI-MC-REQ (Multicarrier Request) message

The Multicarrier Request message (AAI-MC-REQ) is sent by an AMS to an ABS to request the list of Assigned Carriers. The AMS cannot send the AAI-MC-REQ message until it receives the AAI-Global-CFG message and AAI-MC-ADV message from its S-ABS. According to the multicarrier configuration supported by S-ABS, which is indicated in AAI-MC-ADV, the AMS shall determine the subset of carriers that it can simultaneously process under its hardware capability. Then AMS will send the AAI-MC-REQ message to the S-ABS and include sets of physical carrier index to inform ABS of this information.

The ASN.1 code of the AAI-MC-REQ message follows the format depicted in Table 6-96.

Table 6-96—AAI-MC-REQ message format

Field	Size (bits)	Notes	Condition
Global_Support	1	Indicates whether the AMS can simultaneously process all the carriers supported by the S-ABS 0b0: The AMS can only process a subset of the carriers supported by the S-ABS 0b1: The AMS can simultaneously process all carriers supported by the S-ABS	Mandatory
If (Global_Support == 0){			
Number of Candidate Combinations (N)	2		Shall be present if Global_Support is equal to zero
For (*i* = 0, *i* < N; *i*++) {			
Number of Candidate Assigned Carrier (Nc)	3		Shall be present if Global_Support is equal to zero. Note that N cannot be zero
For (*j* = 0, *j* < Nc; *j*++) {			
Physical Carrier Index	6	The carriers' AMS can simultaneously process	Shall be present if Global_Support is equal to zero. Note that Nc cannot be zero
}			
DL/UL indicator	1	Indicates whether the AMS supports the combination with UL transmission. 0b0: The combination can be applied to both DL and UL 0b1: The combination can be applied to DL only.	Shall be present if Global_Support is equal to zero
}			
}			
Support of data transmission over guard subcarrier in between two adjacent carriers that are subcarrier aligned	1	0b0 = Not supported 0b1 = Support	Mandatory
for(*i* = 0; *i* < Num of Power Sharing Groups; *i*++) {		Power Sharing Group is a set of carriers sharing uplink transmission power with a limitation (MAX Tx Power). Maximum value of "Num of Power Sharing Groups" is 16	

Table 6-96—AAI-MC-REQ message format *(continued)*

Field	Size (bits)	Notes	Condition
MAX Tx Power	24	The maximum available power of one power sharing group: Bit 0–7: Maximum transmitted power for QPSK Bit 8–15: Maximum transmitted power for 16-QAM Bit 15–23: Maximum transmitted power for 64-QAM Each unsigned 8-bit integer specifies the maximum transmitted power value in dBm. The maximum transmitted power is quantized in 0.5 dBm steps ranging from –64 dBm (encoded 0x00) to 63.5 dBm (encoded 0xFF). Values outside this range shall be assigned the closest extreme. If AMS does not support 64-QAM, the AMS shall report the value of 0x00 for Bit 15–23	Mandatory
for(*j* = 0; *j* < Num of Carriers in one Power Sharing Group; *j*++) {		Maximum value of “Num of Carriers in one Power Sharing Group” is 16	
Physical Carrier Index	6	The relevant carrier belongs to the Power Sharing Group	Mandatory
}			
}			

If the carriers within a candidate combination are a subset of carriers from one power sharing group, the MAX Tx Power of the power sharing group represents the total maximum transmission power over those carriers.

6.2.3.52 AAI-MC-RSP (Multicarrier Response) message

Based on information provided by the AMS in the AAI-MC-REQ message, the ABS shall respond to the AMS through the AAI-MC-RSP message to provide the AMS with information about its assigned carriers.

The ASN.1 code of AAI-MC-RSP message follows the format depicted in Table 6-97.

Table 6-97—AAI-MC-RSP message field description

Field	Size (bits)	Value/Description	Condition
Global_Assign	1	Indicates whether the ABS assigns all the carriers requested by the AMS through AAI-MC-REQ 0b0: The ABS assigns a subset of the carriers requested by AMS. 0b1: The ABS assigns all the carriers requested by the AMS.	Mandatory
If (Global_Assign == 0) {			
Number of Assigned Carriers (N)	3	Number of Assigned Secondary Carriers.	Shall be present if Global_Assign equals to zero.
For (i = 0; i < N; i++) {			
Physical carrier index	6	The index refers to a Physical carrier index in the AAI-MC-ADV message.	Shall be present if Global_Assign equals to zero. Note that N cannot be zero.
DL/UL indicator	1	Indicates whether the carrier is assigned for both DL and UL 0b0: The carrier is assigned for both DL and UL 0b1: The carrier is assigned for DL only.	Shall be present if Global_Assign equals to zero. Note that N cannot be zero.
Support of data transmission over guard subcarrier in between two adjacent carriers that are subcarrier aligned	1	0b0 = Not supported 0b1 = Support	Shall be present if Global_Assign equals to zero. Note that N cannot be zero.
}			
}			

6.2.3.53 Carrier Management Command (AAI-CM-CMD) MAC control message

An AAI-CM-CMD message shall be transmitted by an ABS to initiate a carrier management procedure when ABS and AMS both support carrier activation/deactivation or primary carrier change. In order to respond to a received AAI-CM-CMD MAC control message, the AMS shall transmit the AAI-CM-IND MAC control message.

The format of the AAI-CM-CMD MAC control message is shown in Table 6-98.

Table 6-98—AAI-CM-CMD message field description

Field	Size (bits)	Value/Description	Condition
Action code	1	Used to indicate the purpose of this message 0b0: Secondary carrier management 0b1: Primary carrier change	Mandatory
If (Action code == 0b0) {			
Indication Type	2	Indicates the corresponding secondary carrier is activated or deactivated 00: Deactivation only 01: Activation only 10: Both activation and deactivation 11: *Reserved*	Shall be present when Action code is set to 0b0
If (Indication Type == 00){			
Num of target carrier	3	Indicates the number of secondary carrier(s) to be deactivated 1..8	Shall be present when Indication Type is set to 00
For(*i* = 0; *i* < Num of target carrier; *i*++) {			
Target carrier index	6	Indicates the secondary carrier index to be deactivated 0..63	Shall be present when Indication Type is set to 00
Deactivation of DL/UL	1	Indicates the deactivation of DL or UL in the corresponding secondary carrier 0b0: Both DL/UL of the secondary carrier are deactivated 0b1: UL of the secondary carrier is deactivated but DL of the secondary carrier is kept active	Shall be present when Indication Type is set to 00
}			
}			
If (Indication Type == 01){			
Activation Deadline	6	LSB bits of frame number after the AAI-CM-CMD is sent for the AMS to confirm the activation of secondary carrier by sending the AAI-CM-IND message	Shall be present when Indication Type is set to 01
Num of target carrier	3	Indicate the number of secondary carrier(s) to be activated 1..8	Shall be present when Indication Type is set to 01

Table 6-98—AAI-CM-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For(i = 0; i < Num of target carrier; i++) {			
Target carrier index	6	Indicates the secondary carrier index to be activated 0..63	Shall be present when Indication Type is set to 01
Activation of DL/UL	1	Indicates the activation of DL or UL in the corresponding secondary carrier 0b0: Both DL/UL of the secondary carrier are activated 0b1: DL of the secondary carrier is activated but UL of the secondary carrier is not activated	Shall be present when Indication Type is set to 01
Ranging indicator	1	Indicates the periodic ranging is required for the carrier 0b0: No initial or periodic ranging is required for the carrier 0b1: Periodic ranging is required for the carrier	Shall be present when Indication Type is set to 01
}			
}			
If (Indication Type == 10){			
Activation Deadline	6	LSB bits of frame number after the AAI-CM-CMD is sent for the AMS to confirm the activation of the secondary carrier by sending the AAI-CM-IND message	Shall be present when Indication Type is set to 10
Num of activated target carrier	3	Indicates the number of secondary carrier(s) to be activated 1..8	Shall be present when Indication Type is set to 10
Num of deactivated target carrier	3	Indicates the number of secondary carrier(s) to be deactivated 1..8	Shall be present when Indication Type is set to 10
For(i = 0; i < Num of activated target carrier; i++) {			
Target carrier index	6	Indicates the secondary carrier index to be activated 0..63	Shall be present when Indication Type is set to 10 and Num of activated target carrier larger than zero

Table 6-98—AAI-CM-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Activation of DL/UL	1	Indicates the activation of DL or UL in the corresponding secondary carrier 0b0: Both DL/UL of the secondary carrier are activated 0b1: DL of the secondary carrier is activated but UL of the secondary carrier is not activated	Shall be present when Indication Type is set to 10 and Num of activated target carrier larger than zero
Ranging indicator	1	Indicates the periodic ranging is required for the carrier 0b0: no initial or periodic ranging is required for the carrier 0b1: periodic ranging is required for the carrier	Shall be present when Indication Type is set to 10 and Num of activated target carrier larger than zero
}			
For(i = 0; i < Num of deactivated target carrier; i++) {			
Target carrier index	6	Indicates the secondary carrier index to be deactivated 0..63	Shall be present when Indication Type is set to 10 and Num of deactivated target carrier larger than zero
Deactivation of DL/UL	1	Indicates the deactivation of DL or UL in the corresponding secondary carrier 0b0: Both DL/UL of the secondary carrier are deactivated 0b1: UL of the secondary carrier is deactivated but DL of the secondary carrier is kept active	Shall be present when Indication Type is set to 10 and Num of deactivated target carrier larger than zero
}			
}			
}			
If (Action code == 0b1) {			
Physical carrier index of Target carrier	6	Indicates the physical carrier index of a target carrier for primary carrier change. If the AMS supports multicarrier operation, the carrier shall be one of the assigned carriers 0..63	Shall be present if Action code equal to 0b1

Table 6-98—AAI-CM-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Ranging indicator	1	Indicates the periodic ranging is required for the carrier 0b0: No initial or periodic ranging is required for the carrier 0b1: Periodic ranging is required for the carrier	Shall be present if Action code equal to 0b1
Action Time	3	LSB bits of frame number at the time to switch to the target carrier.The value shall be set to the value more than the Message ACK timer for the AAI-CM-CMD message 0..7: LSB of frame	Shall be present if Action code equal to 0b1
Next state of serving primary carrier	1	Indicates the deactivation of serving the primary carrier after primary carrier change. 0b0: Serving the primary carrier will be deactivated after primary carrier change. If the AMS does not support carrier aggregation, this field shall be always set to 0b0. 0b1: Serving primary carrier is kept active after primary carrier change	Shall be present if Action code equal to 0b1
Activation Deadline	6	The time for the ABS to confirm the successful primary carrier change by receiving the AAI-CM-IND message before its expiration. The AMS shall send the AAI-CM-IND message to be received by the ABS before the expiration. LSB bits of frame number since Action Time	Present only when a target primary carrier is not one of the active secondary carriers of the AMS
}			

6.2.3.54 Carrier Management Indication (AAI-CM-IND) MAC control message

An AAI-CM-IND message shall be transmitted by an AMS to inform the ABS of the readiness of the target carrier when the AMS is instructed to newly activate the target carrier(s) in an AAI-CM-CMD message with action code = 0 or when the target carrier in an AAI-CM-CMD message with action code = 1 has not been an active carrier.

The format of the AAI-CM-IND MAC control message is shown in Table 6-99.

Table 6-99—AAI-CM-IND message field description

Field	Size (bits)	Value/Description	Condition
Action code	1	Used to indicate the purpose of this message 0b0: Secondary carrier management 0b1: Primary carrier change	Mandatory

6.2.3.55 AAI-MC-ADV (Multicarrier Advertisement) message

The ABS that supports multiple RF carriers shall periodically broadcast the AAI-MC-ADV message for the reception by all AMSs.

The AMS that does not have multicarrier capability or does not have active secondary carrier(s) shall ignore the field “Carrier-specific PHY control mode” in the AAI-MC-ADV message (see Table 6-100).

Table 6-100—AAI-MC-ADV message field description

Field	Size (bits)	Description	Condition
Multicarrier configuration change count	4	The value is incremented by 1 upon each update	
Serving BS Carrier Number	3	Indicates the number of carriers supported by the S-ABS	
MAC Protocol version	8	Indicates the MAC protocol version that the current carrier supports: it is consistent with the REV.2 definition with new MAC protocol version 9 defined for AAI	
Number of neighbor ABS’s carriers for ABS-specific MC trigger	1	Indicates the threshold value for number of neighbor ABS’s carriers if ABS-specific MC trigger is applied. 0b0: N = 2 0b1: N = 3	Present when ABS-specific MC trigger is applied
Carrier-specific PHY control mode	1	Restrict transmission of PHY related control messages/headers on relevant carrier only, as defined in 6.2.8.2.8. 0b0: This mode is disabled 0b1: This mode is enabled	Present only when an ABS operates in multicarrier aggregation mode
For(i = 1; $i \leq$ Serving BS Carrier Number-1; i++){			
PGID	16	Indicate Paging group identifier where the carrier belongs	

Table 6-100—AAI-MC-ADV message field description *(continued)*

Field	Size (bits)	Description	Condition
Physical carrier index	6	Indicates the carrier index that the ABS carries except current carrier: the physical carrier index refers to the AAI-Global-CFG message	
SA-Preamble Index	10	Indicates the SA-Preamble index of the carrier	
Paging carrier indicator	1	Indicates whether this carrier is a paging carrier or not 0: No paging carrier 1: Paging carrier	Optional
Reference Carrier	6	Indicates the physical carrier index of the carrier that works as a reference carrier representing a group of carriers with a similar property and used for the CA specific trigger. The group of carriers represented by the Reference Carrier use the same CA-specific Trigger definitions as this reference carrier. If this value is present, CA-specific Trigger definitions for the corresponding carrier shall be omitted	Optional Present for the carriers that belong to the carrier group represented by the Reference Carrier. Shall be omitted for the physical carrier index that is the Reference Carrier
CA-specific Trigger definitions	*variable*	Carrier Activation-specific triggers with encoding defined in Table 6-122	Optional Present for the Reference Carrier when the corresponding carrier is required to be scanned for carrier activation. Shall be present only for the Reference Carrier (that is, inclusion of this parameter is mutually exclusive with the parameter of Reference Carrier)
PCC-specific Trigger definitions	*variable*	Primary Carrier Change-specific triggers with encoding defined in Table 6-120	Optional Present when the corresponding carrier is required to apply a different trigger condition from definitions of the AAI-SCD message

Table 6-100—AAI-MC-ADV message field description *(continued)*

Field	Size (bits)	Description	Condition
SFH encoding format	2	0b00: full SFH subpacket and AAI-SCD information 0b01: delta encoding of SFH_Info (SFH subpacket and AAI-SCD) with reference to the information of current carrier that transmits this AAI-MC-ADV message 0b10: delta encoding of SFH_Info (SFH subpacket and AAI-SCD) with reference to the information of the preceding carrier 0b11: *Reserved*	
S-SFH change count	4	Change count of S-SFH SP IE(s)	
Change count for AAI-SCD	4	Change configuration count of AAI-SCD	
If (SFH_encoding_format == 0b00) {			
SFHSubpkt 1	*variable*	SFH subpacket 1 is included; length depends on FFT size	
SFHSubpkt 2	*variable*	SFH subpacket 2 is included; length depends on FFT size	
SFHSubpkt 3	*variable*	SFH subpacket 3 is included	
AAI-SCD_Info	*variable*	Information from AAI-SCD is included	
}			
If (SFH_encoding_format == 0b01 or 0b10) {			

Table 6-100—AAI-MC-ADV message field description *(continued)*

Field	Size (bits)	Description	Condition
Delta information	*variable*	Indicates delta encoding between the reference carrier and the current carrier where this message is transmitted if SFH_encoding_format = 0b01, or between the reference carrier and the preceding carrier if SFH_encoding_format = 0b10 Delta information may contain SFH SP1, SP2, and SP3 attributes as defined in Table 6-185, Table 6-186, and Table 6-186, respectively. It may contain the following AAI-SCD attributes: — BS_Restart_Count — SA_PreamblePartitionforBStype — Trigger definitions — olRegionType0On — olRegionType1NLRUSize — olRegionType1SLRUSize — olRegionType2SLRUSize — periodicityOfRngChSync — cntlStartCodeOfRngChSync — rangingPreambleCodeSync — periodOfPeriodicRngTimer 1) gammaIotFp0 2) gammaIotFp1 3) gammaIotFp2 4) gammaIotFp3 5) Alpha 6) Beta 7) dataSinrMin 8) dataSinrMax 9) targetHarqSinr 10) targetSyncRangingSinr 11) targetPfbchSinr 12) targetSfbchBaseSinr 13) targetSfbchDeltaSinr 14) targetBwRequestSinr 15) gammaIotSounding 16) soundingSinrMin 17) soundingSinrMax — T_ReTx_Interval — BR_Channel Configuration MIN Access Class of the (i+0)-th frame — BR_Channel Configuration MIN Access Class of the (i+1)-th frame — BR_Channel Configuration MIN Access Class of the (*i*+2)-th frame — BR_Channel Configuration MIN Access Class of the (*i*+3)-th frame 1) decimationValueD 2) maxCyclicShiftIndexP — shiftValueUForSoundingSymbol — AAI_Relay_zone_AMS_allocation_indicator — Zone_Allocation Bit-MAP — ZF — MSI Length (N_{MSI}) — E-MBS AAI frame offset — resourceMetricFP2 — resourceMetricFP3 Each delta information attribute is optional.	

Table 6-100—AAI-MC-ADV message field description *(continued)*

Field	Size (bits)	Description	Condition
}			
}			

6.2.3.56 AAI-Global-CFG (global carrier configuration) message

The AAI-Global-CFG message provides the carrier information for all available carriers in the network. The ABS transmits the AAI-Global-CFG message to an AMS after transmitting the AAI-REG-RSP message.

The ASN.1 code of the AAI-Global-CFG message follows the format depicted in Table 6-101.

Table 6-101—AAI-Global-CFG message field description

Field	Size (bits)	Description	Condition
Global carrier configuration change count	3	Indicates the value of Global carrier configuration change count of the network, will be incremented each time the contents of this message change. Value range is 0–7	
Number of Carrier Groups	4	Groups of contiguous carriers whose subcarriers are aligned with a frequency offset. In case of FDD, only DL carrier groups are included. Value Range is 1(0x0)~16 (0xF)	Note that the Number of Carrier Groups cannot be zero
For (*i* = 0; *i* < Number of Carrier Groups; *i*++){			
Duplexing Mode	1	“0” for TDD “1” for FDD	
Number of Carriers	4	Number of carriers in this configuration. Value Range is 1(0x0)~16 (0xF)	
Multicarrier Configuration Index	6	Index refers to the multicarrier configuration depicted in Table 6-150	
If(Number of Carriers == 0x0){			
Center Frequency	18	Center frequency (in unit of 50 kHz) of the carrier in the *i*-th carrier group	Shall be present when Number of Carriers equal to one
Physical Carrier Index	6	Index of the physical carrier The range of value is 0b000000–0b111110. The value (0b111111) shall not be used	Shall be present when Number of Carriers equal to one
If(Duplexing_Mode== 1){			

Table 6-101—AAI-Global-CFG message field description *(continued)*

Field	Size (bits)	Description	Condition
Carrier Type	1	Indicates the type of this physical carrier. 0b0: Fully configured carrier 0b1: Partially configured carrier	Shall be present when Number of Carriers equal to one and Duplexing_Mode equal to one
}			
}else {			
Start Frequency	18	Center frequency (in unit of 50 kHz) of the carrier located at lowest frequency position in the *i*-th carrier group	Shall be present when Number of Carriers larger than one
For($j = 0$; j < Number of Carriers; j++) {			
Physical Carrier Index	6	Index of the physical carrier The range of value is 0b000000–0b111110. The value (0b111111) shall not be used	Shall be present when Number of Carriers larger than one
If(Duplexing_Mode == 1){			
Carrier Type	1	Indicates the type of this physical carrier. 0b0: Fully configured carrier 0b1: Partially configured carrier	Shall be present when Number of Carriers larger than one and Duplexing_Mode equal to one
}			
}			
}			

6.2.3.57 AAI-ARS-CONFIG-CMD message format

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

Table 6-102—AAI-ARS-CONFIG-CMD message field description

Field	Size (bits)	Value/Description	Condition
AAI_Relay_zone_AMS_allocation_indicator	1	0b0: The ABS does not allocate resources to the AMS in the AAI DL Relay zone 0b1: The ABS may allocate resources to the AMS in the AAI DL Relay zone	Always present

Table 6-102—AAI-ARS-CONFIG-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
MIMO Midamble indication in AAI DL Relay zone	1	0b0: MIMO midamble is not transmitted in the AAI DL Relay zone 0b1: MIMO midamble is transmitted in the AAI DL Relay zone If AAI_Relay_zone_AMS_allocation_indicator == 0b0, this field is set to 0b1	Always present
Superframe Number Action	4	LSBs of the superframe number when the ARS starts the ARS operation and applies the PHY operational parameters	Always present
R_IdleTime	11	Unit is 0.1 µs	Always present
If(ABS allocates resource for periodic ranging in AAI UL Relay zone) {			
Allocation periodicity of the S-RCH	2	Indicates the periodicity of the S-RCH allocation. 0b00: Every frame 0b01: The second frame in every superframe 0b10: The second frame in every 4th superframe, i.e., mod(superframe number, 4) = 0 0b11: The second frame in every 8th superframe, i.e., mod(superframe number, 8) = 0	Present when the ABS allocates resource for periodic ranging in the AAI UL Relay zone
Subframe offset of the S-RCH	2	Indicates the subframe offset (O_{SF}) of the S-RCH allocation. The range of values is $0 \le O_{SF} \le 3$. S-RCH is allocated in the (O_{SF} + UAZ) subframe	Present when the ABS allocates resource for periodic ranging in the AAI UL Relay zone
Start RP code information of the S-RCH	4	Indicates the ks that is the parameter controlling the start root index of the RP codes (r_{s0}). $r_{s0} = 6 \times k_s + 1$ The range of values is $0 \le k_s \le 15$	Present when the ABS allocates resource for periodic ranging in the AAI UL Relay zone
N_{PE}	2	Indicates the number of periodic code (N_{PE}) according to the Table 6-262	Present when the ABS allocates resource for periodic ranging in the AAI UL Relay zone
}			
If(ABS allocates resource for BR channel in AAI UL Relay zone) {			

Table 6-102—AAI-ARS-CONFIG-CMD message field description *(continued)*

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

Table 6-102—AAI-ARS-CONFIG-CMD message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
R_DCAS_i	3/2/1	Indicates the number of total allocated CRUs, in a unit of a subband, for FPi (*i* > 0) for AAI DL Relay zone. See 6.6.3.3.2 Cell-specific resource mapping For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bit	Present when AAI _Relay_zone_AMS_allocation_indicator == 0b0
R_UCAS_{SB0}	5/4/3	Indicates the number of total allocated CRUs, in a unit of a subband, for FPi (*i* > 0) for AAI DL Relay zone. See 6.6.3.5.1 Cell-specific resource mapping For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits	Present when AAI _Relay_zone_AMS_allocation_indicator == 0b0
R_UCAS_{MB0}	5/4/3	Indicates the number of miniband-based CRUs in FP0 for AAI UL Relay zone. See 6.6.3.5.1 Cell-specific resource mapping For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits	Present when AAI _Relay_zone_AMS_allocation_indicator == 0b0
R_UCAS_i	3/2/1	Indicates the number of total allocated CRUs, in a unit of a subbands, for FPi (*i* > 0) for AAI UL Relay zone. See 6.6.3.5.1 Cell-specific resource mapping For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bit	Present when AAI _Relay_zone_AMS_allocation_indicator == 0b0
}			

6.2.3.58 AAI-ARS-ESI message

When the essential system information in SFH is changed, an ABS shall send the information through a AAI-ARS-ESI control message in the AAI DL Relay zone.

Table 6-103—AAI-ARS-ESI message field description

Field	Size (bits)	Value/Description	Condition
S-SFH change count	4	Change count of S-SFH transmitted in this message	Always present
S-SFH information bitmap	3	If Bit 0 is 0b1, S-SFH SP 1 is included If Bit 1 is 0b1, S-SFH SP 2 is included If Bit 2 is 0b1, S-SFH SP 3 is included	Always present
Superframe Number Action	4	LSBs of the superframe number when the S-SFH information is applied	Always present

Table 6-103—AAI-ARS-ESI message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
If (S-SFH information bitmap Bit #0 == 0b1) {			
S-SFH SP1 IE ()	*variable*	Includes S-SFH SP1 IE in Table 6-184. The size of S-SFH SP1 IE depends on FFT size. For 2048 FFT, $Size_{SP1,\ default}$ = 96 For 1024 FFT, $Size_{SP1,\ default}$ = 90 For 512 FFT, $Size_{SP1,\ default}$ = 84	Optional
}			
If (S-SFH information bitmap Bit #1 == 0b1) {			
S-SFH SP2 IE ()	*variable*	Includes S-SFH SP2 IE in Table 6-185. The size of S-SFH SP2 IE depends on FFT size. For 2048 FFT, $Size_{SP2,\ default}$ = 96 For 1024 FFT, $Size_{SP2,\ default}$ = 90 For 512 FFT, $Size_{SP2,\ default}$ = 86	Optional
}			
If (S-SFH information bitmap Bit #2 == 0b1) {			
S-SFH SP3 IE ()	*variable*	Includes S-SFH SP3 IE in Table 6-186. $Size_{SP3,\ default}$ = 77	Optional
}			

6.2.3.59 AAI-E-MBS-REP

An AMS shall transmit the AAI-E-MBS-REP message to inform the ABS when one of the following conditions are met:

a) To request a start time from the ABS at which the AMS can switch to the E-MBS carrier after DSx transaction.

b) To update the indication regarding the E-MBS stream(s), the AMS is currently receiving when the carrier switching mode is set to 0b1 in the AAI-DSA-REQ/RSP message. This interval indication is carried in the E-MBS connection bitmap. The ABS uses the connection bitmap to compute the interval during which the AMS is available at the primary carrier for unicast scheduling.

c) To indicate that the AMS stops E-MBS carrier switching without releasing the E-MBS connection allocated via AAI-DSA-REQ/RSP.

The AAI-E-MBS-REP message also carries the E-MBS zone ID of the E-MBS zone from which the AMS is currently receiving E-MBS data.

Table 6-104—AAI-E-MBS-REP message field description

Field	Size (bits)	Value/Description	Condition
E-MBS zone ID	7	Indicates the E-MBS zone from which the AMS is currently receiving E-MBS data	
Report Mode	2	Indicates the AMS starts/changes/ ends E-MBS 0b00: AMS requests the ABS to assign a carrier switching start time 0b01: AMS updates the E-MBS connection Bitmap and requests the ABS to assign a carrier switching start time 0b10: AMS ends E-MBS carrier switching 0b11: *Reserved*	
E-MBS Connection Bitmap	16	Each bit of the bitmap represents an E-MBS connection for which service flows have been established using AAI-DSx transactions in one E-MBS zone. The E-MBS service(s) are mapped in ascending order of their E-MBS ID + FID value from LSB to MSB of the bitmap. For each bit: Value 0: The AMS does not intend to receive the E-MBS service Value 1: The AMS currently receives E-MBS or the AMS may switch to this service in the near future	Shall be included if the value of Report Mode is 0b01

6.2.3.60 AAI-E-MBS-RSP

The AAI-E-MBS-RSP message shall be transmitted by the ABS in response to an AAI-EMBS-REP message sent by the AMS. It shall include the following parameters.

— Carrier Switching Start Time: 4 LSBs of superframe number at which carrier switching happens.

— Unicast Available Interval Bitmap: Indicates when the AMS should be available in the primary carrier for unicast scheduling. The ABS uses the connection bitmap in the AAI-E-MBS-REP message to compute the unicast available interval bitmap.

Table 6-105—AAI-E-MBS-RSP message field description

Field	Size (bits)	Value/Description	Condition
Carrier Switching Start time	4	4 LSBs of superframe number at which the AMS starts the carrier switching operation when the report mode is 0b00 or 0b01	Present when the report mode in the AAI-E-MBS-REP message is 0b00 or 0b01
Unicast Available Interval Bit-map	*variable* (maximum: 32)	Indicates when the AMS should be available in the primary carrier using N bits $b_0b_1b_2...b_{N-1}$ If b_i == 0, then the AMS is available for E-MBS data scheduling in secondary carrier. If b_i == 1, then the AMS is available for unicast scheduling in primary carrier. N_{MSI} = 4 superframes: N = 4 bits N_{MSI} = 8 superframes: N = 8 bits N_{MSI} = 16 superframes: N = 16 bits N_{MSI} = 32 superframes: N = 32 bits Depending on the N_{MSI}, the number of bits per subframe changes, 4 frames per bit	Present when the report mode in the AAI-E-MBS-REP message is 0b01

6.2.3.61 AAI-E-MBS-CFG message

The E-MBS configuration information necessary for E-MBS operation include E-MBS-Zone_IDs of serving and neighboring ABSs, E-MBS MAP time offset (frequency offset), E-MBS MAP resource allocation, E-MBS MAP $I_{\text{size-offset}}$, and E-MBS ID and FID mappings between the serving E-MBS zone and the neighboring E-MBS zone for the same content. AAI-E-MBS-CFG shall be advertised at the superframe whose number ($N_{\text{superframe}}$) from SFH meets the following condition:

$N_{\text{superframe}}$ modulo 32 = 31

In the case of an AAI-SCD update that includes any updated E-MBS configuration parameter, the updated E-MBS resource configuration parameters shall be applied at the beginning of the first MSI in the next AAI-E-MBS-CFG life time cycle.

An AMS moving across the cell boundary is expected to update the AAI-E-MBS-CFG message from the T-ABS.

Table 6-106—AAI-E-MBS-CFG message field description

Field	Size (bits)	Value/Description	Condition
E-MBS_CFG_LIFETIME (m)	4	A value that indicates when the AMS shall decode the next instance of the E-MBS configuration message. It is the duration during which the contents of the AAI-E-MBS-CFG message of the zone do not change. The next E-MBS configuration message that the AMS shall decode is at the superframe whose superframe number, $N_{superframe}$, satisfies the following condition. $N_{superframe}$ modulo 32(m + 1) == 32(m + 1) – 1 At the end of the lifetime, the ABS resets the E-MBS_CFG_LIFETIME to a value between 1111 and 0000	
For (*i* = 0; *i* < Num_E-MBS_Zone; *i*++) {		Num_E-MBS_Zone is the number of E-MBS zones included in this message. Range: 1~8	
E-MBS_Zone_ID	7	The E-MBS_Zone_ID to which this E-MBS MAP applies	
E-MBS MAP Resource Index	11	Resource index includes location and allocation size	
E-MBS MAP $I_{SizeOffset}$	5	Offset used to compute burst size of E-MBS MAP	
AAI-NBR-ADV Change Count	3	Indicates the value of AAI-NBR-ADV change count	
For (*j* = 0; *j* < Num_Neighbor_E-MBS_Zones; *j*++) {		Num_Neighbor_E-MBS_Zones is the number of neighbor E-MBS zone of an E-MBS zone. Range: 0~7	Present when the S-ABS is located at the zone boundary and inter-zone service continuity is supported
Neighbor E-MBS zone ID	7	Neighbor E-MBS zone ID	
Physical Carrier Index	6	Target Carrier to which the AMS switches or to which it is redirected by the ABS	Present only if the current neighbor E-MBS zone is served on a different carrier from the previous one at the neighbor E-MBS zone
For (*k* = 0; *k* < Num_Neighbor_ABS; *k*++) {		Num_Neighbor_ABS is the number of neighbor ABSs which belong to the current neighbor E-MBS zone. Range: 1~256	
ABS Index	8	Index of Neighbor ABS	
}			

Table 6-106—AAI-E-MBS-CFG message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
For (m = 0; m < N_E-MBS_FID_Mapping; m++) {		N_ E-MBS_FID_Mapping is the number of mappings of current E-MBS ID and FID and new E-MBS ID and FID between serving E-MBS zone and neighbor E-MBS zone. Range: 0~15	Present when the list of E-MBS ID and FID supported by serving E-MBS zone is not the same as the one supported by neighbor E-MBS zone
Current_E-MBS ID and FID and New_E-MBS_ID and FID	32	Mapping of current E-MBS ID and FID and new E-MBS ID and FID between serving E-MBS zone and neighbor E-MBS zone. 16 MSBs is the current E-MBS ID and FID, and 16 LSBs is the new E-MBS ID and FID	
}			
}			
}			

Zone_Allocation Bit-MAP: Zone_Allocation Bit-MAP consists of subband indices reserved for all E-MBS zones the ABS belongs to. The Zone_Allocation Bit-MAP in the AAI-SCD message identifies the use of the resource comprising a set of contiguous subbands in a DL AAI subframe. The Bit-MAP determines the size (S) of each E-MBS zone in number of contiguous SLRUs in the frequency domain within the subframe, the index (L) of each E-MBS zone from where the allocated zone begins, and the total number (*Num_E-MBS_Zones*) of allocated zones.

The Zone_Allocation Bit-MAP is constructed using the following rules:

— If the use of the resource is changed between one subband and the next subband, the bit '1' is set in the location the same as the index of the subband in the Bit-MAP.

— Otherwise, the bit '0' is set in the Bit-MAP.

For a given FFT size with maximum number of subbands, $DSAC_{max}$ = 21, 10, 4 for 2048, 1024, and 512 FFT size, respectively, the size of the Zone_Allocation Bit-MAP is ($DSAC_{max}$ – 1). Let the total number of the bit '1' in the Bit-MAP be denoted as K and the index in which the bit '1' in the Bit-MAP is located be denoted as J_i, where i is the E-MBS zone index that is from 1 to *Num_E-MBS_Zones*. J_0 is fixed to 0.

$$\text{Num\_E-MBS\_Zones} = \begin{cases} K+1, & \text{if ZF} = \text{0b1} \\ K, & \text{if ZF} = \text{0b0} \end{cases}$$

$$L_i = J_{i-1} + 1$$

$$S_i = \begin{cases} J_i - J_{i-1} & ,1 \le i \le K \\ DSAC_{max} - J_K & ,i = K+1 \end{cases}$$

For example, consider the case where the Zone_Allocation Bit-MAP field = 000010010. The system bandwidth is 10 MHz and $DSAC_{max}$ is 10. This is illustrated pictorially in Figure 6-3. In this case, ZF = 0b0 because the last zone is the unicast zone. *Num_E-MBS_Zones* = 2, L_i = {1, 6}, S_i = {5, 3} from K = 2, J_i = {0, 5, 8}. Hence, the number of zones is 2. Each index of two zones is 1, 6, respectively, and each size of two zones is 5, 3, respectively.

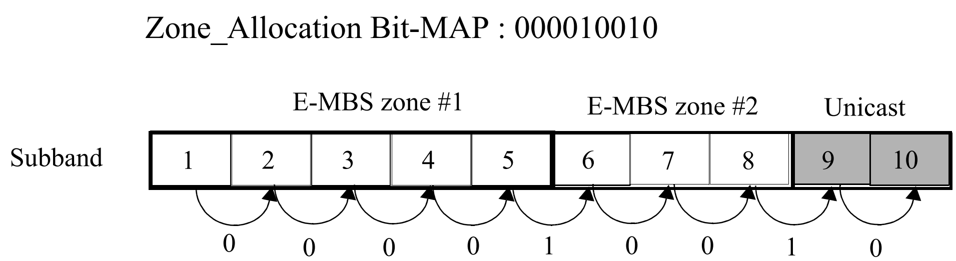


Figure 6-3—Zone_Allocation Bit-MAP for 10 MHz

E-MBS MAP Resource Index: Resource Index indicating the starting SLRUE-MBS index and size of a single allocation spanning contiguous SLRUE-MBSs of the E-MBS MAP.

For each neighbor E-MBS_Zone, the E-MBS ID and FID Mappings List between serving and neighbor E-MBS zones shall be included if the serving and neighbor ABSs belong to different E-MBS zones that provide service continuity.

The mappings list includes the following:

Num_Neighbor_E-MBS_Zones (3 bits)

AAI-NBR-ADV Change Count (3 bits)

for (*i* = 0; *i* < Num_Neighbor_E-MBS_Zones; *i*++) {
    Neighbor_E-MBS_Zone_ID (7 bits)
    Physical Carrier Index (6 bits)
    Number_Neighbor_ABS (8 bits)
    for (*j* = 0; *j* < Number_Neighbor_ABS; *j*++) {
        Index of BS (8 bits)
    }
    Num_E-MBS ID_FID Mappings (4 bits)
    for (*k* = 0; *k* < Num_E-MBS ID_FID Mappings; *k*++) {
        Current_E-MBS ID and FID (*k*),
        New_E-MBS ID and FID (*k*),
    }

}

If a Current_E-MBS ID and FID is not available in the E-MBS zone of the neighbor ABS, the mapping for the Current_E-MBS ID and FID shall not be included in the mapping list.

6.2.3.62 AAI-LBS-ADV message

An ABS that supports LBS shall use the AAI-LBS-ADV message to broadcast the LBS related configuration information. The message may be broadcast periodically without solicitation by the AMS (see Table 6-107).

Table 6-107—AAI-LBS-ADV message field description

Field	Size (bits)	Value/Description	Condition
Format Indication for the transmitting BS's coordinates	1	Represent absolute position whether using long format or short format. The value indicates: 0x0: long format is used 0x1: short format is used	
If (Format Indication for the transmitting BS's coordinates == 0x0) {			
Longitude	40	Bit 0–5: Longitude resolution 1–34: Number of valid bits in fixed-point value of longitude value 35: LBS not supported Other: *Reserved* Bit 6–14: Longitude integer Bit 15–39: Longitude fraction	
Latitude	40	Bit 0–5: Latitude resolution 1–34: Number of valid bits in fixed-point value of latitude value 35: LBS not supported Other: *Reserved* Bit 6–14: Latitude integer Bit 15–39: Latitude fraction	
Altitude	40	Bit 0–3: Altitude type 1: Meter 2: Floor Other: *Reserved* Bit 4–9: Altitude resolution 1–30: Number of valid bits in fixed-point value of altitude value 31: LBS not supported Other: *Reserved* Bit 10–31: Altitude integer Bit 32–39: Altitude fraction	
}			
If (Format Indication for the transmitting BS's coordinates == 0x1) {			
Type indication of short format	1	0x0: Short format including altitude is used 0x1: Short format excluding altitude is used	

Table 6-107—AAI-LBS-ADV message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Longitude	24	Longitude expressed in 2^{-15} parts of a degree	
Latitude	24	Latitude expressed in 2^{-16} parts of a degree	
If (Type indication of short format == 0x0) {			
Altitude	16	Bit 0–15: altitude in meters above sea level	
}			
}			
GPS time in units of frame duration	22	Refer to 11.21.4 in IEEE Std 802.16	
GPS frame transmission time offset	10		
GPS time accuracy	5		
Frequency accuracy	8	Information about the frequency accuracy. It is included once in the message. Refer to 11.21.5 in IEEE Std 802.16	
Number of ABS	8	Number of neighbor BSs included in this message that are identified using the BSID	
For (*i* = 0; *i* <Number of ABS; *i* ++){			
BSID	16	16-bit LSB of unique 48-bit identifier of the Neighbor ABS for number of BS	
Type indication of relative position format	1	0x0: Relative position format including altitude is used 0x1: Relative position format excluding altitude is used	
Longitude	16	Distance east of reference point in meters	
Latitude	16	Distance north of reference point in meters	
If (Type indication of relative position format == 0x0) {			
Altitude	16	Bit 0–15: altitude in meters above sea level	
}			
}			

Table 6-107—AAI-LBS-ADV message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Number of ABS Index	8	Number of neighbor ABSs included in this message that are identified using an index to their position in the AAI-NBR-ADV message	
if(Number of ABS Index != 0){			
Configuration change count for AAI-NBR-ADV	3		
}			
For (*i* = 0; *i* < Number of ABS Index; *i*++){			
Type indication of relative position format	1	0x0: Relative position format including altitude is used 0x1: Relative position format excluding altitude is used	
Neighbor ABS Index	8	Index that corresponds to the position of the ABS in the AAI-NBR-ADV message	
Longitude	16	Distance east of reference point in meters	
Latitude	16	Distance north of reference point in meters	
If (Type indication of relative position format == 0x0) {			
Altitude	16	Bit 0–15: altitude in meters above sea level	
}			
}			

The geographical coordinates refer to the WGS 84 datum, as defined in IETF RFC 3825. Other datums are not supported.

6.2.3.63 AAI-LBS-IND message

The AAI defines the AAI-LBS-IND message for U-TDOA.

Table 6-108—AAI-LBS-IND message field description

Field	Size (bits)	Value/Description	Condition
Action code	1	0x0: Special U-TDOA 0x1: General U-TDOA	
Frame identifier	4	Frame which contains the ranging. The frame identifier is the 4 least significant bits of the frame number	
Dedicated CDMA ranging code for the S-ABS	5	Indicates the dedicated ranging code	
Ranging opportunity index for the S-ABS	1	Indicates the index of the allocated ranging opportunity of the dynamic ranging channel used in the RA-ID for serving ABS. Ranging opportunity index shall be assigned by the serving ABS. The serving ABS shall assign a unique ranging opportunity index that is not overlapped with other ranging channels in the allocated frame. 0b0: 0b01 0b1: 0b10	
Subframe Index for the S-ABS	3	Indicates the subframe index of the allocated ranging opportunity	
If (Action code == 0x1) {			
Neighbor_ABS_Info_Array	8	List of neighbor ABS Info	Present when Action code == 0x1
For (i = 0; i < Neighbor_ABS_Info_Array; i ++){			
Neighbor ABS index	8	ABS index corresponds to the AAI-NBR-ADV message	Present when Action code == 0x1
Action time	8	Action Time included in this message is the absolute frame number at the S-ABS	Present when Action code == 0x1
Dedicated CDMA ranging code of neighbor ABS	5	Indicates the dedicated ranging code	Present when Action code == 0x1

Table 6-108—AAI-LBS-IND message field description *(continued)*

Field	Size (bits)	Value/Description	Condition
Ranging opportunity index of neighbor ABS	1	Indicates the index of the allocated ranging opportunity of the dynamic ranging channel used in the RA-ID for neighbor ABS. Ranging opportunity index shall be assigned by the neighbor ABS. The neighbor ABS shall assign a unique ranging opportunity index that is not overlapped with other ranging channels in the allocated frame. 0b0: 0b01 0b1: 0b10	Present when Action code == 0x1
Subframe Index of neighbor ABS	3	Indicates the subframe index of the allocated ranging opportunity	Present when Action code == 0x1
}			
}			

6.2.4 Construction and transmission of MAC PDUs

Figure 6-4 illustrates the various functional blocks involved in the construction of MAC PDU, input and output of each functional block, and sequence in which these functions are applied during the construction of MAC PDUs of various types of connections, i.e., ARQ connection, non–ARQ connection, and control connection. The construction of a MAC PDU is illustrated in Figure 6-5.

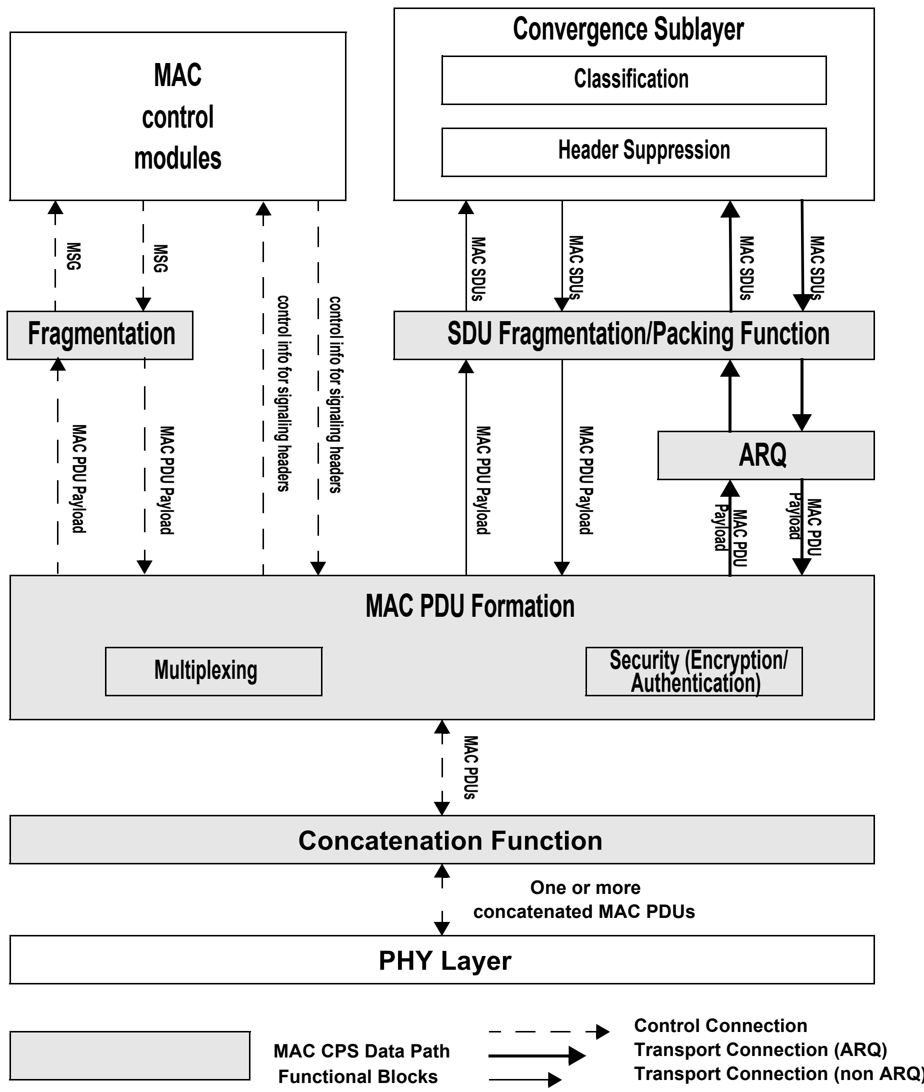


Figure 6-4—Data path functional blocks involved in construction of MAC PDUs

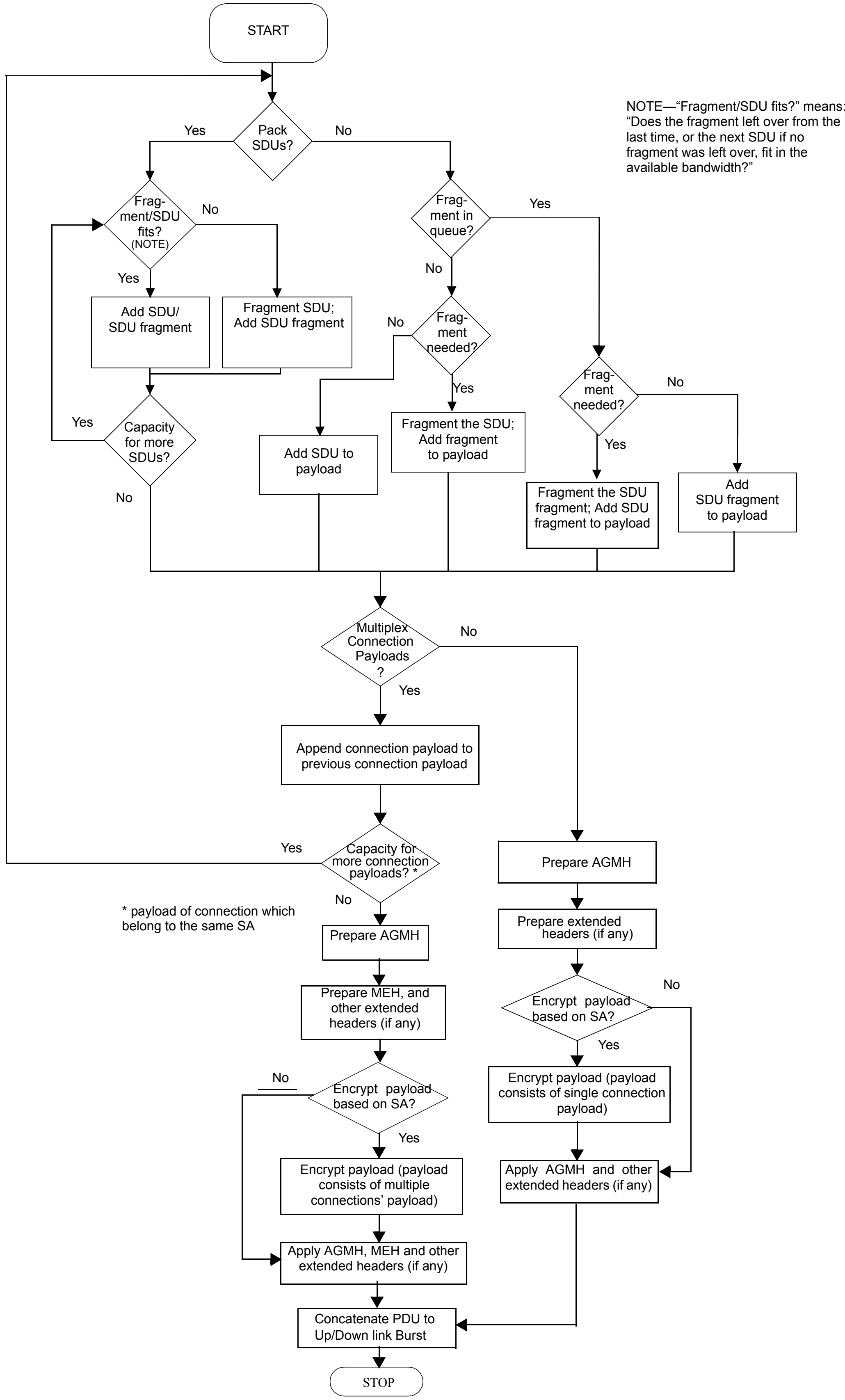


Figure 6-5—Example Construction of a MAC PDU for transport connections

6.2.4.1 Convention

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

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

b) Fields of MAC messages, which are specified in this standard as binary numbers, are transmitted as a sequence of their binary digits, starting from MSB. Bit masks (for example, in ARQ) are considered numerical fields. Negative numbers are represented in binary using two's complement.

c) Each SDU or SDU fragment within the payload is transmitted in the same byte order as received from upper layers.

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

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

6.2.4.2 Multiplexing

Multiple connections' payload associated with same security association can be multiplexed and encrypted together in a MAC PDU. If 'n' connections' payload are multiplexed, one MEH shall be present in a MAC PDU and up to one extended header from FEH, PEH, RFPEH, and MCEH per connection payload shall be present in a MAC PDU. The AGMH (as defined in 6.2.2.1.1) and the MEH (as defined in 6.2.2.2.4) carries the information about the Flow Ids and Lengths of the connection payloads. The FEH, PEH, and RFPEH carry information about the transport connection payload, and the MCEH carries information about the control connection payload. The EH_indicator bitmap field in MEH indicates the presence or absence of FEH/PEH/RFPEH/MCEH in the EH group corresponding to a connection payload.The FEH/PEH/RFPEH/MCEH for the connection payloads (if present) shall be present after the MEH in the same order as that of connection payloads. For example, multiple connections' payloads that are encrypted using AES CCM can be multiplexed and encrypted together in a MAC PDU. Figure 6-6 illustrates the multiplexing of two transport connection payloads that are associated with same security association (i.e., AES CCM). FEH/PEH/RFPEHx and FEH/PEH/RFPEHy in Figure 6-6 carry the information about the SDU/SDU fragments in the Payload-X and Payload-Y, respectively. Figure 6-7 illustrates the usage of FEH/PEH/RFPEH and MCEH together with MEH in a MAC PDU.

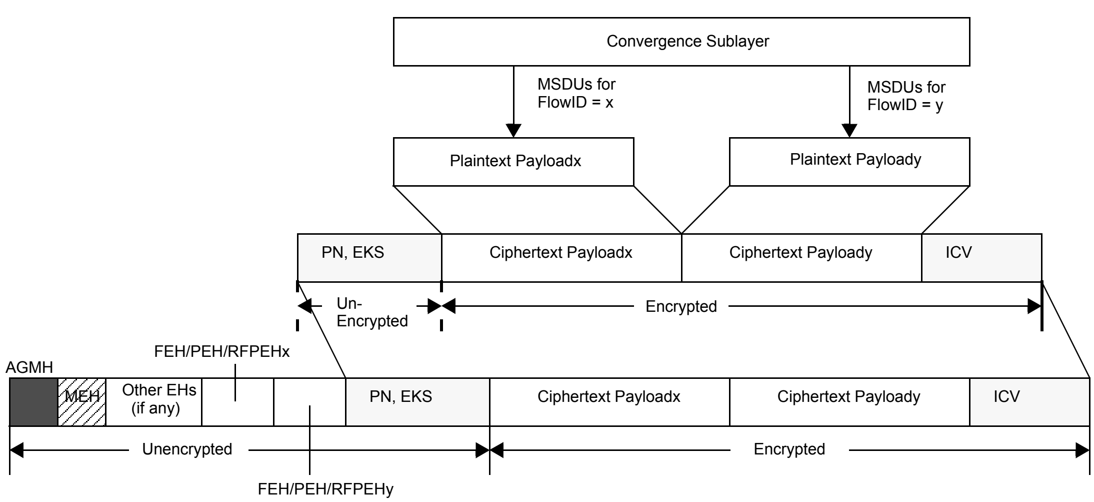


Figure 6-6—Multiplexing of connection payload associated with same SA

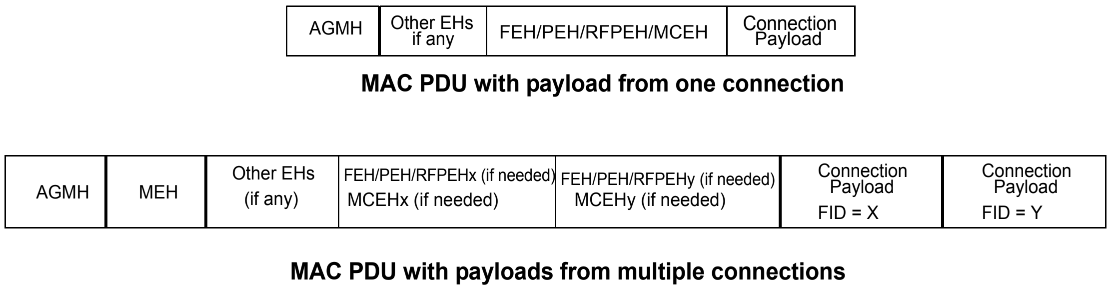


Figure 6-7—Usage of FEH/PEH/RFPEH/MCEH and MEH in MAC PDU

6.2.4.3 Concatenation

Multiple MAC PDUs from the same or different connections may be concatenated into a single transmission in either the UL or DL directions. MAC PDUs from the same connection may be concatenated only if the MAC SDUs cannot be packed in a single MAC PDU. For AMS attached to ABS, each MAC PDU in UL/DL burst is uniquely identified by FID.

Figure 6-8 illustrates the concept for a UL burst transmission. Since the MAC SDUs in MAC PDU are identified by the FID in the AGMH and MEH (in case of multiplexing), the receiving MAC entity is able to present the MAC SDU (after reassembling the MAC SDU from one or more received MAC PDUs) to the correct instance of the MAC SAP. MAC control messages, user data (from one or more connections), and signaling headers may be concatenated into the same transmission.

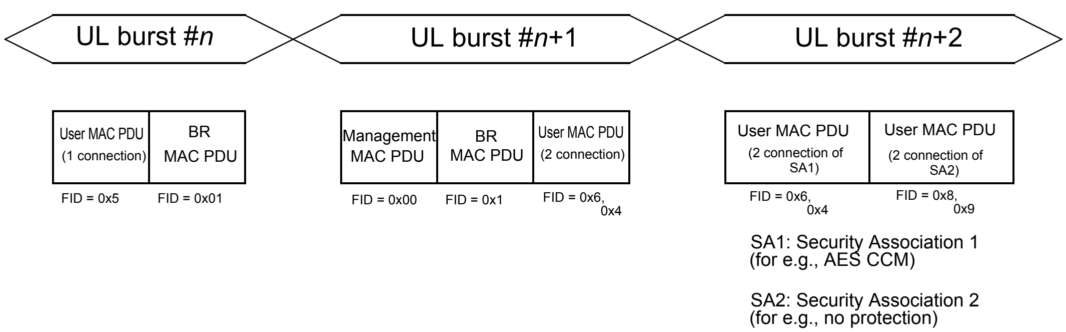


Figure 6-8— MAC PDU concatenation showing example FIDs

6.2.4.4 Fragmentation

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

6.2.4.4.1 Transport connections

For transport connections, the FEH (as defined in 6.2.2.2.1) shall be present in the MAC PDU with MAC SDU fragments. The FEH provides the information about the SDU fragment. SN in FEH is used for sequencing the SDU fragments, and Fragmentation control (FC) bits in FEH are used to tag the SDU fragments with respect to their position in the parent SDU.

6.2.4.4.1.1 Non-ARQ transport connections

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

During setup of a non–ARQ connection, the initiating part communicates to the peer the suggested value of NON_ARQ_REORDERING_TIMEOUT in AAI-DSA-REQ. The peer responds with the same or lesser value that becomes the agreed value for the timer.

NON_ARQ_REORDERING_TIMEOUT is the value used at the receiver side. This is the maximum time an SDU successfully received would be delayed in the reordering buffer.

MAXIMUM_NON_ARQ_BUFFER_SIZE, reordering buffer size of all non–ARQ connections, is defined in AAI-REG-REQ. The transmitter shall send SDUs of all non–ARQ connections not exceeding MAXIMUM_NON_ARQ_BUFFER_SIZE during the interval of NON_ARQ_REORDERING_TIMEOUT.

6.2.4.4.1.2 ARQ-enabled transport connections

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

6.2.4.4.2 Control connections

For control connections, the MCEH (as defined in 6.2.2.2.3) shall be present in the MAC PDU with a MAC control message fragment. The MCEH provides the information about the control message fragment. SN and Control Connection Channel ID (CCC ID) in MCEH are used for sequencing the control message fragments, and Fragmentation Control (FC) bits in MCEH are used by the receiver to identify the control message fragments of a control message. A sequence number shall be maintained independently for each Control Connection Channel ID (CCC ID).

The Control Connection Channel ID (CCC ID) identifies the fragmentation context for control messages. There are up to two contexts at a time.

The SN and CCC ID assigned to each control connection PDU carrying control message fragment allow the receiver to recreate the original payload and to detect the loss of any fragments. Upon loss of a control message fragment with certain CCC ID, the receiver shall wait for the lost control message fragments with the same CCC ID until a new first control message fragment is detected or a new nonfragmented control message is detected on the same Control Connection Channel ID (CCC ID).

6.2.4.5 Packing

MAC may pack multiple MAC SDUs and fragments of MAC SDUs of the same connection into a single MAC PDU. The transmitting side has full discretion whether to pack a group of MAC SDUs in a single

MAC PDU. The capability of unpacking is mandatory. The packing and fragmentation mechanisms for both the non–ARQ and ARQ connections are specified in 6.2.4.5.1 and 6.2.4.5.2, respectively.

6.2.4.5.1 Packing for non-ARQ connections

A MAC PDU containing a packed sequence of variable-length MAC SDUs is constructed as shown in Figure 6-9. Note that nonfragmented MAC SDUs and MAC SDU fragments may both be present in the same MAC PDU. The MAC attaches a PEH (defined in 6.2.2.2.2) in the MAC PDU.

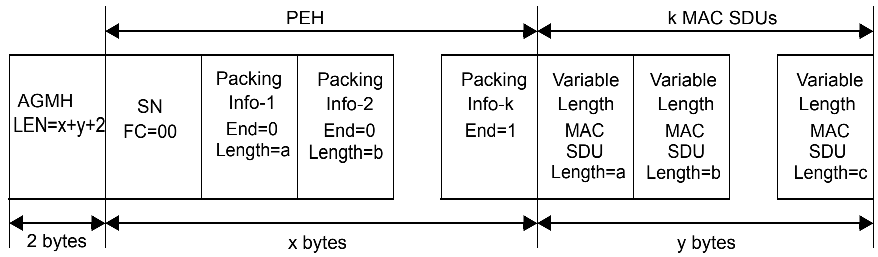
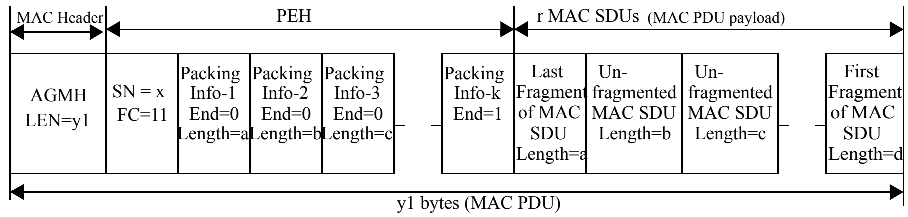
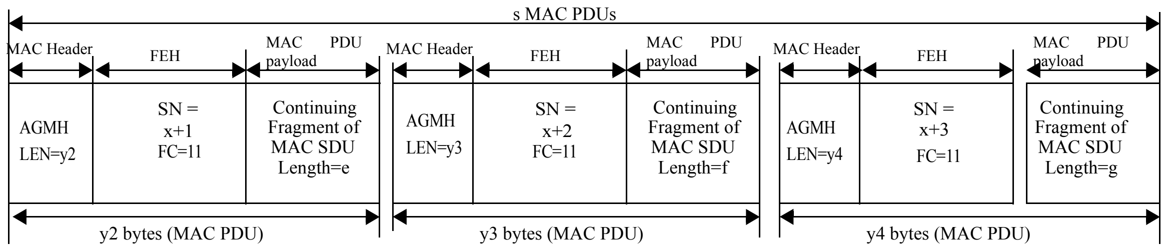


Figure 6-9— Packing variable-length MAC SDUs into a single MAC PDU

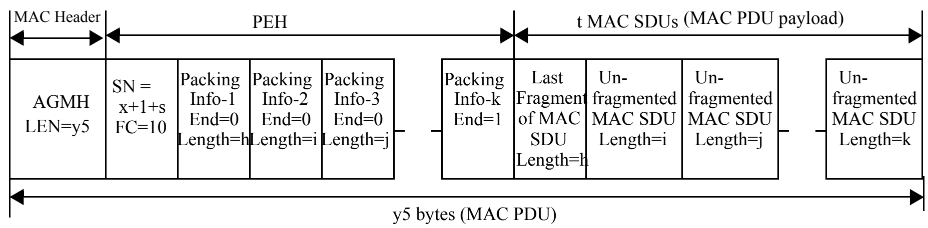
The fragmentation control bits shall be set according to the rules defined in Table 6-18. Packing with fragmentation is illustrated in Figure 6-10.



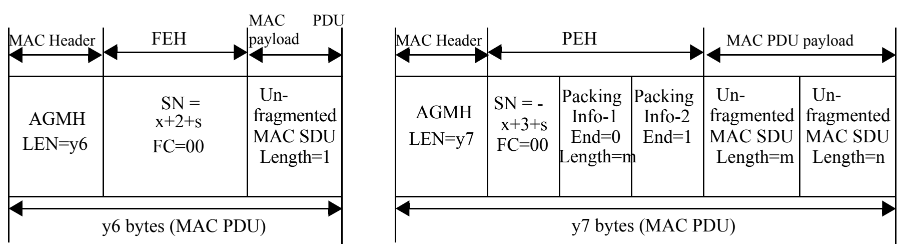
(a) Packing of Last MAC SDU Fragment, Unfragmented MAC SDUs, and First MAC SDU Fragment in a MAC PDU



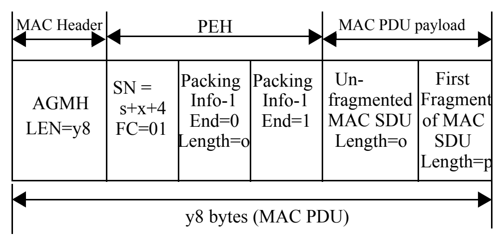
(b) MAC PDUs with middle MAC SDU Fragments



(c) Packing of Last MAC PDU Fragment, Unfragmented MAC SDUs in a MAC PDU



(d) Packing of unfragmented MAC SDUs in a MAC PDU



(e) Packing of unfragmented MAC SDU and first MAC SDU fragment in a MAC PDU

Figure 6-10—Packing with fragmentation

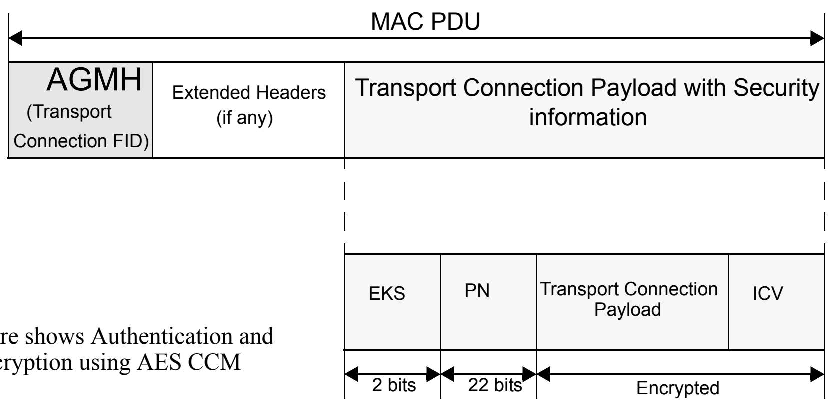
6.2.4.5.2 Packing for ARQ connections

The use of PEH for ARQ-enabled connections is similar to that for non–ARQ connections as described 6.2.4.5.1. The transmitting side has full discretion whether to pack a group of MAC SDUs and/or fragments in a single MAC PDU. The SN of the PEH shall be used by the ARQ protocol to identify and retransmit ARQ blocks.

6.2.4.6 Encryption of MAC PDUs

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

The Advanced Generic MAC header and extended headers shall not be encrypted. The receiver determines whether the payload in the MAC PDU is encrypted or not from the FID in the AGMH or SPMH. In case of control connection MAC PDU, control connection payload in the MAC PDU is encrypted if the Flow ID in AGMH is set to 0x1. Control connection payload in the MAC PDU is not encrypted if the Flow ID in AGMH is set to 0x0. The encryption information needed to decrypt a payload at the receiving station is present at the beginning and at the end of the connection payload. For example, in case of AES CCM, PN and EKS are present at the beginning of the connection payload and ICV is appended at the end of the connection payload in MAC PDU as shown in Figure 6-11.



This figure shows Authentication and Encryption using AES CCM

Figure 6-11—MAC PDU with transport connection payload

If multiple connection payloads are transmitted in the same burst and the connections are mapped to the same SA, then multiple connection payload may be multiplexed before encryption and multiplexed payload is encrypted together. The receiver shall perform the decryption and data authentication on the multiplexed payload, as specified by the SA. The receiver determines whether the payloads in the MAC PDU are encrypted or not from the FID in the AGMH. The encryption information needed to decrypt the multiplexed payload at the receiving station is present at the beginning of the first connection payload and at the end of the last connection payload. For example, in the case of AES CCM, PN and EKS are present at the beginning of connection payload 1 and ICV is appended at the end of the connection payload *n* in MAC PDU as shown in Figure 6-12.

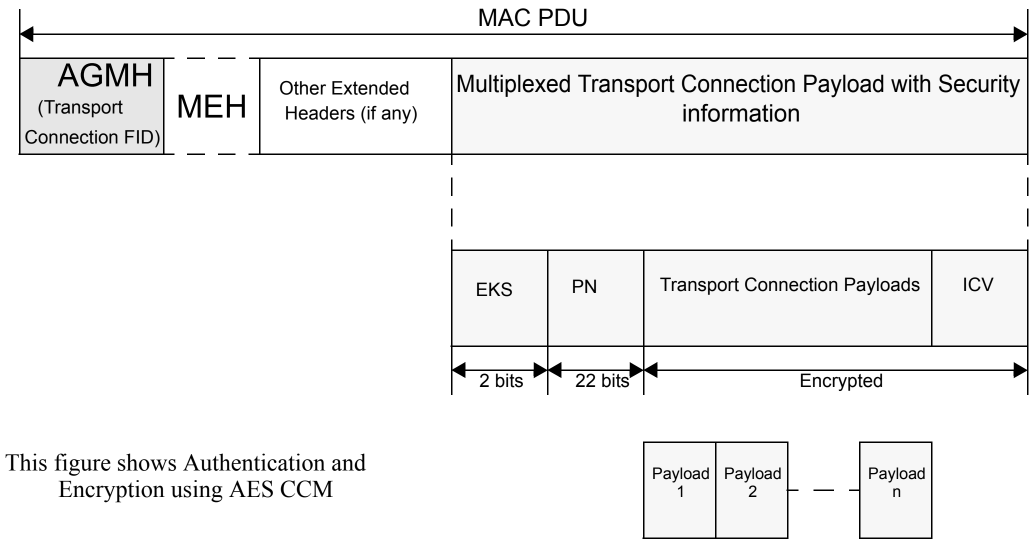


Figure 6-12—MAC PDU with multiple transport connection payload

6.2.4.7 Padding

Within the data burst, the unused portion shall be initialized to a known state. If the size of the unused portion is only 1 byte, then the unused byte is set to 0xF0. If the size of the unused portion is greater than or equal to 2 bytes, then the unused first byte is set to 0xF0 and the remaining unused bytes are set to 0x00.

If the ABS grants UL bandwidth to the AMS and the AMS has no pending UL MAC PDU to transmit, the AMS shall transmit padding bytes through the allocated UL burst.

6.2.4.8 MAC control messages with CMAC protection

A 12-byte CMAC tuple is included in some MAC control messages to enable the receiver to check the authenticity and the integrity of the messages. The CMAC tuple consists of the following fields:

— PMK_SN (4 bits): The sequence number of PMK used to derive AK.
— Reserved (4 bits): Added for byte alignment.
— CMAC_PN (24 bits): Current CMAC_PN_U for uplink or current CMAC_PN_D for downlink, where CMAC_PN_U represents the current CMAC serial number for Uplink control messages and CMAC_PN_D the current CMAC serial number of Downlink control messages, respectively.
— CMAC value (64 bits): The most significant 64 bits of the 128-bit CMAC value.

The CMAC protected MAC control message consists of MAC control message content data followed by the CMAC tuple. MAC control message content represents the MAC control message in the binary data format that is generated by the PER encoder. A CMACI (CMAC Indicator) flag is defined in the MAC control message to indicate whether the MAC control message is protected using CMAC or not. CMACI set to “1”indicates that the MAC control message is protected using CMAC and CMAC tuple is present after the ASN.1 binary data in the MAC control message. CMACI set to “0” or absence of CMACI in the MAC control message indicates that the MAC control message is not protected using CMAC.

Figure 6-13 illustrates the construction of a MAC PDU carrying a CMAC protected MAC control message. If a MAC control message has CMACI set to "0" or does not have CMACI, its MAC control message content data and padding bit (if needed for byte alignment) shall be the MAC PDU payload that has the size $M = N$ bytes, where N is the number of bytes of the MAC control message content data plus padding when needed. If a MAC control message has CMAC set to "1", its MAC control message content data and padding bits are sent to the AES-CMAC algorithm to generate the CMAC value. The CMAC protected MAC control message consists of MAC control message content data followed by the CMAC tuple.

The MAC PDU payload shall contain the MAC control message content data, padding bits (if any), and CMAC tuple, and have the size $M = N + 12$ bytes, where N is the number of bytes of the MAC control message content data plus padding when needed.

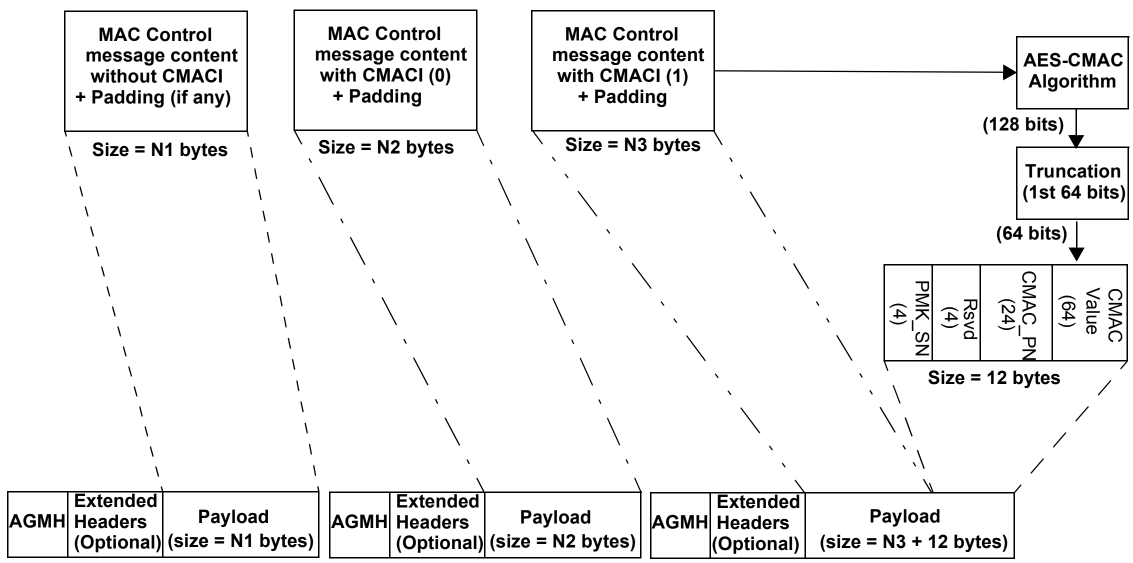


Figure 6-13—MPDU construction with/without CMAC protection

CMAC protected MAC control message together with CMAC tuple can be fragmented at any byte boundary. Figure 6-14 illustrates the construction of a MAC PDU with a fragmented MAC control message that includes CMAC tuple.

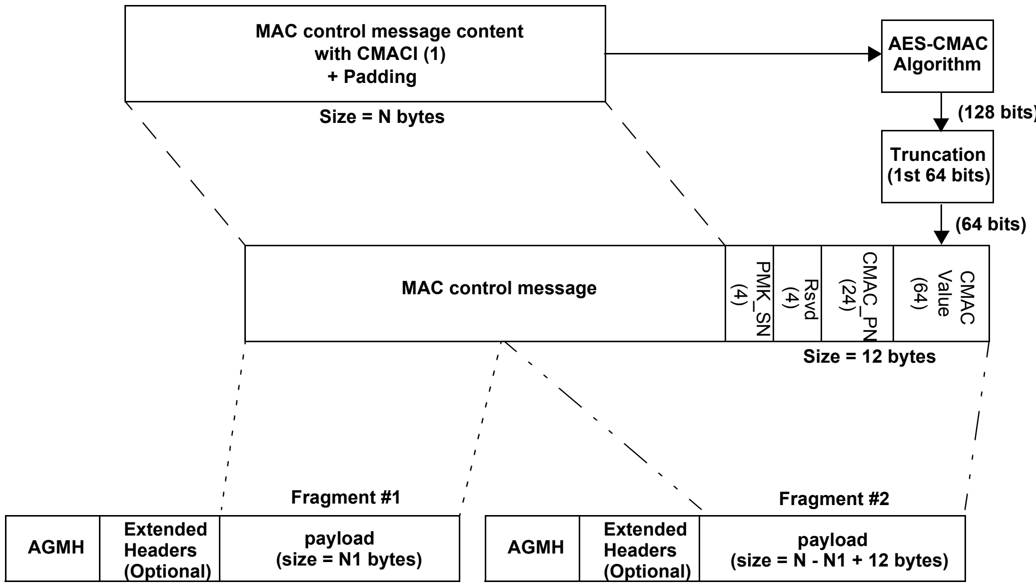


Figure 6-14—MPDU construction of a fragmented MAC control message with CMAC protection

6.2.5 AAI Security

6.2.5.1 Security architecture

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

The security architecture of the WirelessMAN-Advanced Air Interface System consists of the following functional entities: the AMS, the ABS, and the Authenticator. The security functions of the WirelessMAN-Advanced Air Interface System are described in Figure 6-15.

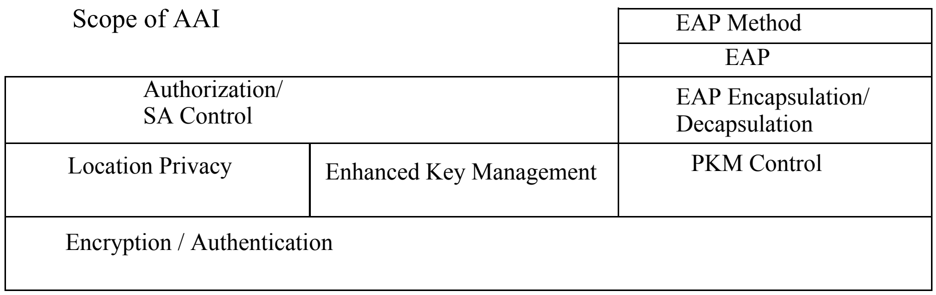


Figure 6-15—Security functions

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

- Security management entity
- Encryption and integrity protection entity

Security management entity functions include the following:

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

Encryption and integrity protection entity functions include the following:

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

6.2.5.2 Key Management protocol (PKMv3)

6.2.5.2.1 Key management

The WirelessMAN-Advanced Air Interface System uses the PKM protocol to achieve the following:

- Transparent exchange of authentication and authorization messages

- Key agreement
- Security material exchange

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

6.2.5.2.1.1 Key derivation

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

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

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

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

Key derivation is performed using AES-CMAC based dot16KDF as defined in 7.5.4.6.1 in IEEE Std 802.16.

6.2.5.2.1.1.1 PMK derivation

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

The PMK is derived upon each successful EAP authentication or reauthentication. The PMK derivation is done by truncating MSK to 160-bit LSB as follows:

PMK = truncate (MSK, 160)

The PMK is derived after each successful authentication (network entry and reauthentication) and has the same lifetime as MSK.

The MSK may be used as a source for more keying material required by upper layers.

6.2.5.2.1.1.2 AK derivation

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

The AK derivation is done as follows:

AK = Dot16KDF (PMK, MS Addressing|ABSID|“AK”, 160)

where
MS Addressing depends on the operation mode.

If either S-SFH Network Configuration bit = 0b0 when AMSID privacy is disabled or S-SFH Network Configuration bit = 0b1, it shall be 48-bit AMSID. Otherwise, MS Addressing input shall be AMSID*—a permutation of AMSID (i.e., AMS MAC address) sent by AMS to ABS in the initial AAI-RNG-REQ message. AMSID* is used to bind the key to the AMSID and it is derived according to 6.2.5.3.1.

CMAC-TEK prekey is derived from AK at each side of AMS and ABS for the period that they have a valid security association and maintain associated context. CMAC-TEK prekey is used to derive CMAC key and TEK.

The CMAC-TEK prekey derivation is done as follows:

CMAC-TEK prekey = Dot16KDF (AK, AK_COUNT|"CMAC-TEK prekey", 160)

where

> AK_COUNT is a counter that is used to ensure different CMAC keys and TEKs are used for the same ABS-AMS pairs across handovers, reentry from idle mode, secured location update, reentry from DCR mode, reentry from coverage loss, and zone switching between LZone and MZone in either direction, even though across these operations AK will remain the same for the same ABS-AMS pairs and the same PMK. AK_COUNT management is defined in 6.2.5.2.1.1.2.1 to 6.2.5.2.1.1.2.4.

6.2.5.2.1.1.2.1 AK_COUNT management

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

The value of this counter maintained by the AMS is denoted as AK_COUNT_M, and the value maintained by the network assumed to be Authenticator is denoted as AK_COUNT_N. Each AK context that an ABS maintains has an AK_COUNT value, which is denoted AK_COUNT_B.

6.2.5.2.1.1.2.2 Maintenance of AK_COUNT_M by the AMS

Upon successful completion of the (re)authentication and establishment of a new PMK, the AMS shall initiate a new AK_COUNT counter and set its value to zero. The AMS shall request reauthentication before the AK_COUNT_M reaches its maximum value of 65 535. The AMS shall manage a separate AK_COUNT_M counter for every active PMK context.

Specifically, during reauthentication, the old AK_COUNT_M (corresponding to the old PMK) shall be used for CMAC generation of applicable MAC control messages as defined in Table 6-28 before the new PMK and AK are activated, while the new AK_COUNT_M shall be used for CMAC generation for all key agreement 3-way handshake messages.

During zone switching or direct handover of AMS between the WirelessMAN-OFDMA R1 Reference System and the WirelessMAN-AdvancedWirelessMAN-Advanced Air Interface, $CMAC\_KEY\_COUNT_M$ used at R1 BS or LZone of ABS and AK_COUNT_M in MZone are interchangeable; i.e., the key count in the serving zone is used as the key count in the target zone as defined following key count management (see 6.2.5.2.1.5.6 and 6.2.5.2.1.5.7).

6.2.5.2.1.1.2.3 AK_COUNT LOCK state

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

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

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

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

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

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

6.2.5.2.1.1.2.4 Processing of AK_COUNT_B by the ABS

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

Upon successful completion of the (re)authentication, the ABS shall obtain a new AK context from the network (assumed to be authenticator) and set AK_COUNT_B by the new AK context. In particular, this shall occur immediately prior to the transmission of the key_agreement-MSG#1 message. The ABS shall manage a separate AK_COUNT_B for every AK context it is maintaining.

Specifically, during reauthentication, the old AK_COUNT_B (corresponding to the old PMK) shall be used for CMAC generation of MAC control messages before the new AK is activated, while the new AK_COUNT_B shall be used for CMAC generation for all key agreement 3-way handshake messages.

Upon receiving the AAI-RNG-REQ message from the AMS containing the AK_COUNT, the ABS shall compare the received AK_COUNT value, which is AK_COUNT_M, with AK_COUNT_B, if ABS has AK context. But, if the ABS has no AK context, it shall request and receive an AK context, which corresponds to PMK SN in the CMAC tuple, from the network (assumed to be authenticator). AK_COUNT_B is set by AK_COUNT_N, and the ABS shall compare it with the received AK_COUNT value, which is AK_COUNT_M.

The ABS validates the AMS as follows:

- If AK_COUNT_M < AK_COUNT_B, the ABS shall process the message as having an invalid CMAC tuple and send an AAI-RNG-RSP message requesting reauthentication; see 6.2.6.3.5.2 and 6.2.18.4.2 .
- If AK_COUNT_B < AK_COUNT_M, the ABS shall generate the CMAC_KEY_* using AK_COUNT_M, set CMAC_PN_* to zero, and validate the received AAI-RNG-REQ message. If it is valid, the ABS shall set $AK\_COUNT_B = AK\_COUNT_M$, and send the AMS an AAI-RNG-RSP message encrypted by the newly generated TEK.

  If the CMAC value is not valid, the ABS shall send an AAI-RNG-RSP message requesting reauthentication; refer to 6.2.6.3.5.2 and 6.2.18.4.2.
- If $AK\_COUNT_B = AK\_COUNT_M$, the ABS shall validate the received AAI-RNG-REQ using the cached AK context. If the CMAC value is valid, the ABS shall send the encrypted AAI-RNG-RSP message to the AMS allowing legitimate entry. If the CMAC value is invalid, the ABS shall send an AAI-RNG-RSP message requesting reauthentication; refer to 6.2.6.3.5.2 and 6.2.18.4.2.

During HO preparation, T-ABS should obtain AK context based on AK_COUNT_N from the authenticator and the ABS shall set $AK\_COUNT_B = AK\_COUNT_N$.

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

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

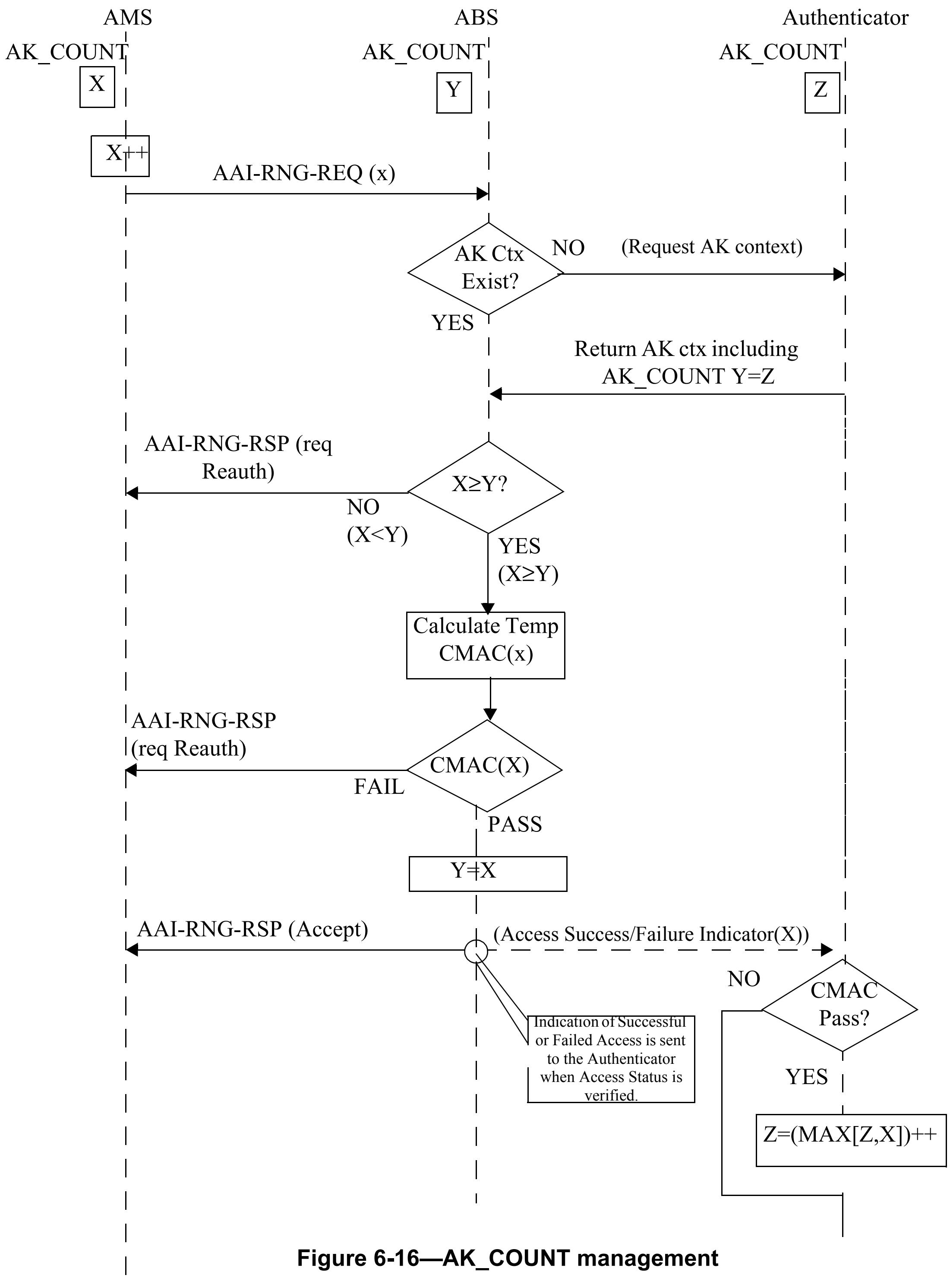


Figure 6-16—AK_COUNT management

AK_COUNT_B is interchangeable with $CMAC\_KEY\_COUNT_B$ at ABS, when ABS is operating in mixed mode or when the Network Configuration bit in the S-SFH is set to 0b1. In particular, when the Network Configuration bit in the S-SFH is set to 0b1, $CMAC\_KEY\_COUNT_B$ (AK_COUNT_B) and

$CMAC\_KEY\_COUNT_N$ are maintained in the network as defined in the WirelessMAN-OFDMA R1 Reference System.

6.2.5.2.1.1.3 CMAC key derivation

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

There are two CMAC keys—one used for UL and one for DL.

The keys derivation is done as follows:

CMAC_KEY_U| CMAC_KEY_D = Dot16KDF (CMAC-TEK prekey, “CMAC_KEYS”, 256)

Each key is 128 bits in size.

All those keys are derived every time a new AK is derived or a new AK_COUNT is used or both.

6.2.5.2.1.1.4 TEK derivation

TEK is the transport encryption key used to encrypt data.

TEK is managed within an SA where each SA contains two TEKs.The TEK is derived at AMS and ABS by applying identity parameters to a key derivation function. All PKMv3 key derivations are based on the Dot16KDF algorithm, which is the same as the AES-CMAC based Dot16KDF algorithm (see 7.5.4.6.1 in IEEE Std 802.16).

The TEK derivation is done as follows:

TEK_i = Dot16KDF (CMAC-TEK prekey, SAID |COUNTER_TEK=i|”TEK”, 128)

where

SAID is the security association to which the TEK belongs.

COUNTER_TEK is a counter used to derive different TEKs for the same SAID; the value of the counter is changed every time a new TEK needs to be derived within the time the same AK and AK_COUNT pair is valid. Each SA shall hold two TEKs in every given time; these two TEKs will be derived from two consecutive counter values. Every time a new CMAC-TEK prekey is derived, this counter is reset.

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

— During initial network entry, handover reentry, reentry from coverage loss, reentry from DCR mode, secured location update, or network reentry from idle mode, where new CMAC-TEK prekey was derived, both TEKs are derived, the counter is reset, and the values 0 and 1 are used for TEK derivation and the value of EKS for each TEK is the same as the value of the COUNTER_TEK that was used to generate the TEK.
— TEK PN space exhausted and there is a need to refresh TEK only (not AK or update AK_COUNT)— in this case, COUNTER_TEK will be increased by 1 and a new TEK will be derived.
— Right after reauthorization where new AK was derived and new TEKs are derived and updated according to 6.2.5.2.1.5.3.

TEK lifetime is identical to AK lifetime.

6.2.5.2.1.2 Key hierarchy

Figure 6-17 outlines the process to calculate the AK when only EAP-based authentication exchange has taken place, yielding an MSK. Figure 6-18 outlines the unicast key hierarchy starting from AK.

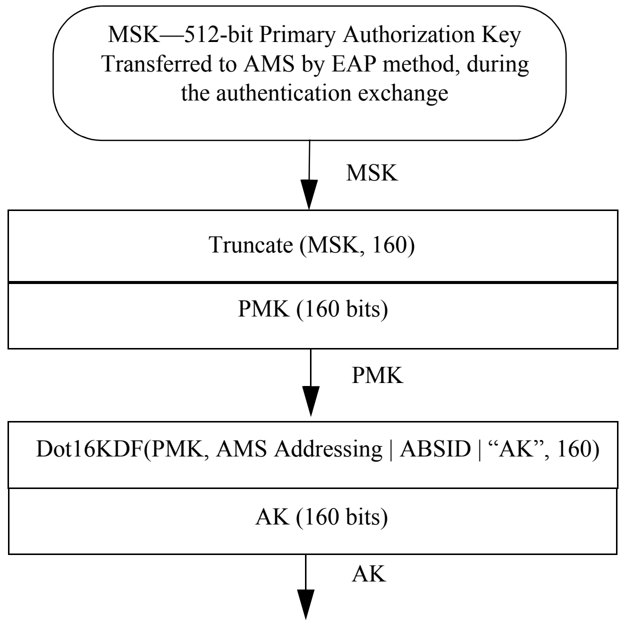


Figure 6-17—AK from PMK

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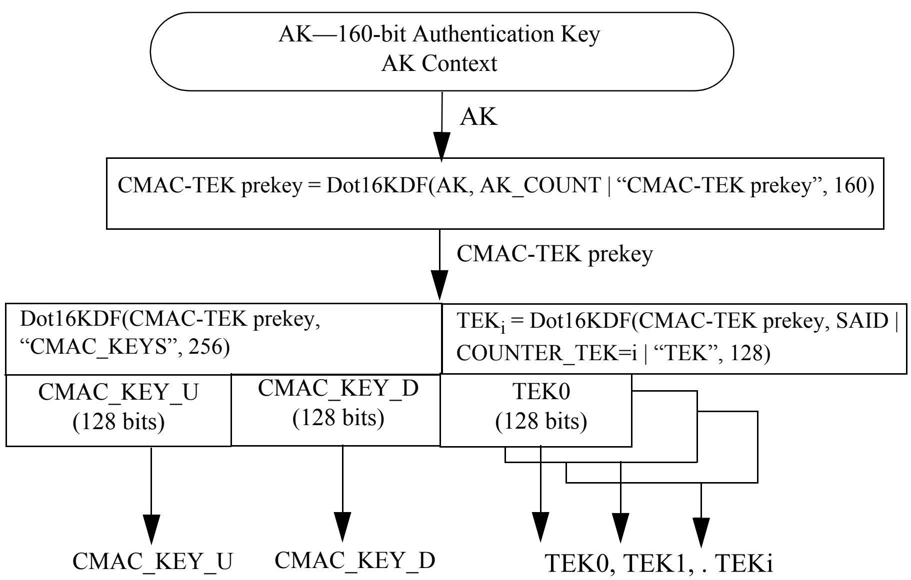

Figure 6-18—CMAC key and TEK derivation from AK

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

The active PMK and AK are maintained as follows:

a) PMK context management: An AMS and an Authenticator cache a new PMK context upon successful completion of the key agreement 3-way handshake procedure. Upon caching a new PMK for a particular AMS and completing the TEK update procedure (updating both TEKs in each SA to be derived from the new PMK), any older PMK for that AMS (as well as all associated derived keys) shall be discarded. For the case of full reauthentication, deletion of old PMKs is done after full TEK update following the switchover mechanism described in this subclause.

b) AK activation and deactivation: Successful completion of the key agreement 3-way handshake causes the activation of the AK associated with the new PMK on any BS under the current Authenticator (i.e., when the AMS hands over or re-enters a T-ABS, and the key agreement 3-way handshake associated with the newest PMK has completed successfully at former ABS under the T-ABS's Authenticator, the AK associated with the newest PMK, and the T-ABS is used without a new key agreement 3-way handshake at the T-ABS). If CMAC_PN or AK_COUNT reach maximum value, the associated AK as well as PMK becomes permanently deactivated. The ABS and AMS shall maintain the AK context as long as they retain the AK. Once the key agreement 3-way handshake begins, the ABS and AMS shall use the new AK matching the new PMK context for the key agreement MSG#2 and key agreement MSG#3 messages. The other MAC control messages shall continue to use the old AK until key agreement 3-way handshake completes successfully. Upon successful completion of the key agreement 3-way handshake, CMAC key from the new AK shall be used. The old AK matching the old PMK context may be used for receiving packets before completion of the TEK update procedure following the key agreement 3-way handshake.

6.2.5.2.1.4 Key agreement 3-way handshake after (re)authentication

The key agreement 3-way handshake procedure takes place right after authentication/reauthentication. It includes exchange of parameters, i.e., ICV size negotiation during network entry authentication, to be used by the SAs.

The key agreement 3-way handshake procedure (as shown in Figure 6-19) includes the following steps:

— EAP authentication completes (Authenticator got "EAP Success" from the AAA and sent it to the AMS). Assuming the AMS received the EAP_Success message, both the AMS and the ABS are supposed to have valid AK and derived CMAC keys.

— The ABS sends a AAI-PKM-RSP message (key agreement MSG#1) protected with CMAC to the AMS. The message shall include a random NONCE_ABS.

— If the AMS receives key agreement MSG#1 before receiving the EAP_Success, it shall verify the CMAC tuple of key agreement MSG#1 based on the MSK shared during the current EAP authentication process as if it had received the key agreement MSG#1 after normally receiving the preceding PKMv3 EAP Transfer with EAP-Success. If CMAC verification fails, the AMS shall silently discard key agreement MSG#1. If CMAC verification is successful, the AMS shall send a AAI-PKM-REQ message (key agreement MSG#2), using the MSK and derived keys, to the ABS. This message shall include the random NONCE_ABS and NONCE_AMS. When the key agreement 3-way handshake procedure is performed during network entry, the security negotiation parameters (ICV size, PN Window size) shall also be included in the key agreement MSG#2.

— Receiving the key agreement MSG#2, the ABS shall confirm that the supplied AKID refers to the AK that it has. If the AKID is unrecognized, the ABS shall ignore the key agreement MSG#2. The ABS shall verify the CMAC. If the CMAC is verified, then the ABS knows it has the same keys that are bound to the AMSID and ABSID. If the CMAC is invalid, the ABS shall ignore the key agreement MSG#2. The ABS shall verify that the NONCE_ABS in the key agreement MSG#2 matches the value provided by the ABS in the key agreement MSG#1. If the NONCE_ABS value does not match, the ABS shall ignore the key agreement MSG#2. If the ABS does not receive the key agreement MSG#2 from the AMS within key Agreement MSG#1 Timeout, it shall resend the previous key agreement MSG#1 up to key agreement MSG#1MaxResends times. If the ABS reaches its maximum number of resends, it shall initiate another full authentication or drop the AMS.

— Upon successful validation of the key agreement MSG#2, the ABS shall send to the AMS AAI-PKM-RSP (key agreement MSG#3) that includes the NONCE_AMS, the NONCE_ABS, and CMAC digest to prove the possession of the keys and their freshness. In case of key agreement procedure during network entry, security negotiation parameters (ICV size, PN Window size) and the supported SAIDs shall be included also in the key agreement MSG#3.

— Receiving the key agreement MSG#3, the AMS verifies the CMAC, derives the TEKs for the supported SAIDs, and applies negotiated security parameters. If the CMAC is invalid, the AMS shall ignore the key agreement MSG#3. The AMS shall verify that the NONCE_AMS in the key agreement MSG#3 matches the value provided by the AMS in the key agreement MSG#2. If the NONCE_AMS value does not match, the AMS shall ignore the key agreement MSG#3. If the AMS does not receive key agreement MSG#3 from the ABS within key agreement 3-way Handshake Timeout, it shall resend the key agreement MSG#2. The AMS may resend the key agreement MSG#2 up to key agreement MSG#2 MaxResends times. If the AMS reaches its maximum number of resends, it shall initiate another full NW entry or attempt to connect to another ABS.

In case of initial network entry, once key agreement 3-way handshake is completed successfully, the AMS sends to the ABS an AAI-REG-REQ message that includes the AMSID as defined in 6.2.15.6.

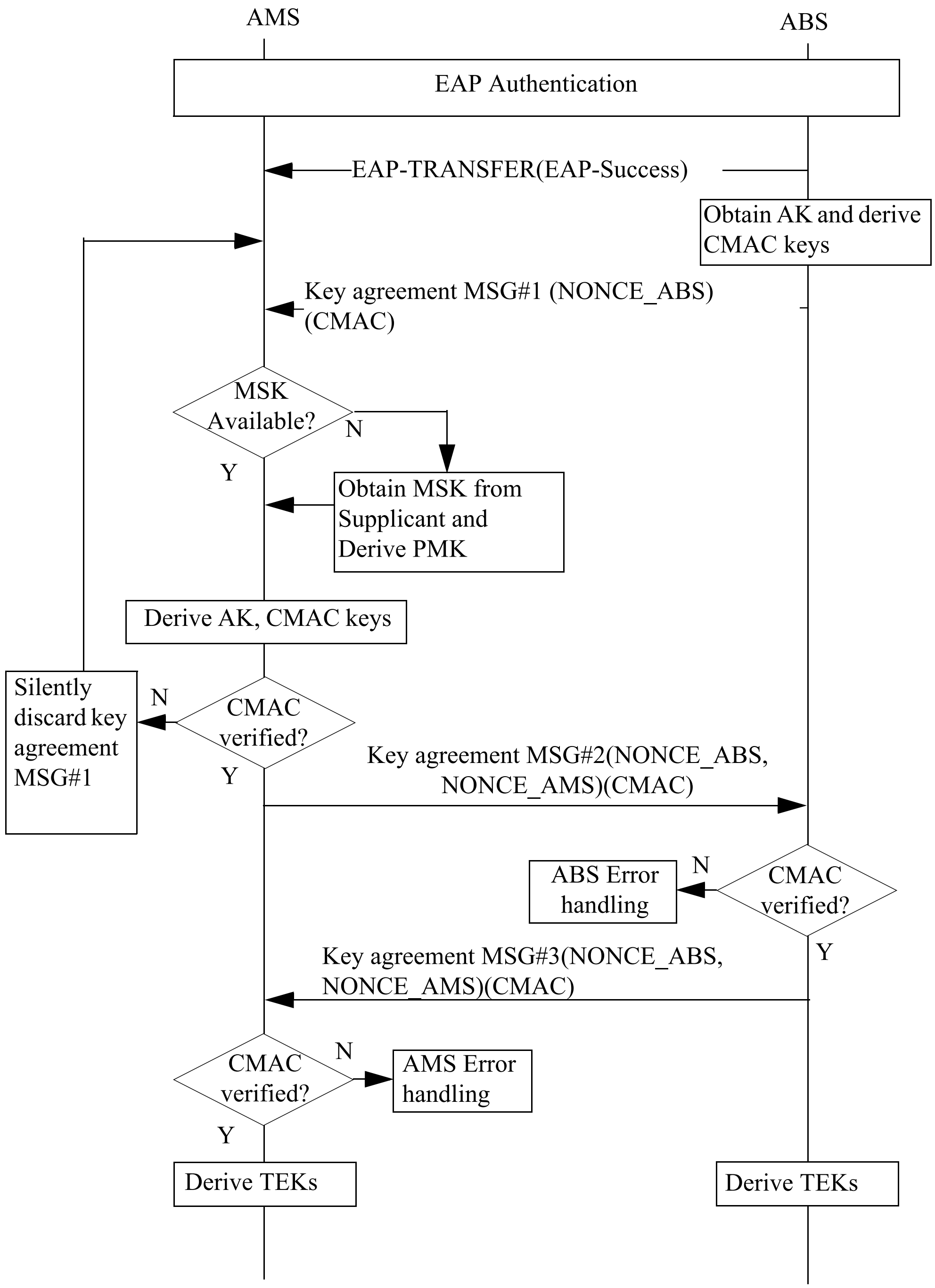

Figure 6-19—Key agreement procedure

6.2.5.2.1.5 Key usage

6.2.5.2.1.5.1 TEK usage

Each SA maintains two TEKs marked as DLE and ULE.

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

Each TEK has its own PN counter size 22 bits.

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

6.2.5.2.1.5.2 TEK update

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

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

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

- Assume the system starts with the ABS using $TEK_{DLE} = TEK_0$ for DL traffic and the AMS using $TEK_{ULE} = TEK_1$ for UL traffic.
- The ABS monitors its $TEK_{DLE} = TEK_0$ DL PN usage and $TEK_{ULE} = TEK_1$ UL PN usage and, when one of them becomes its threshold, updates it and derives TEK_2. The ABS sets $TEK_{DLE} = TEK_1$ and $TEK_{ULE} = TEK_2$ while discarding TEK_0. (Note that after this, both DL and UL traffic is done using TEK_1.)
- The AMS shall monitor $TEK_{ULE} = TEK_1$in its downlink traffic. Once the downlink traffic is received with this key, the AMS knows that the ABS derived new TEK and should update its TEK_{ULE} for uplink traffic with the key update procedure (see Figure 6-20). After the successful update, $TEK_{DLE} = TEK_1$ and $TEK_{ULE} = TEK_2$.
- The AMS shall also monitor TEK_{ULE} both DL and UL PN usages. In the event that one of the PN spaces runs out (in the case of more UL than DL, it may happen that the ABS derived a new TEK but AMS could not identify it due to lack of DL traffic), the AMS shall trigger the key update procedure to update TEK_{ULE}.

The key update procedure is shown in Figure 6-20. The AMS shall send the request message with the associated SAID. The ABS shall indicate the EKS, PMKSN, and COUNTER_TEK in the reply message. If the COUNTER_TEK or EKS is updated, the MS updates its TEK accordingly. If the COUNTER_TEK or

EKS is not updated, it means the ABS did not derive new TEK yet and the AMS shall maintain the current TEKs.

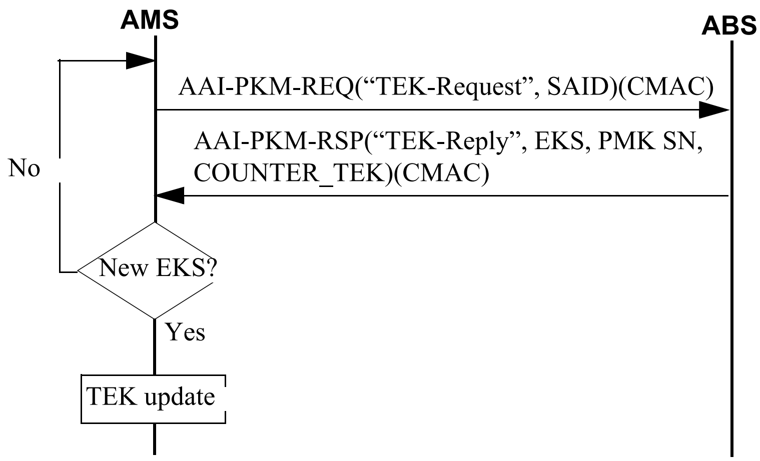

Figure 6-20—MS TEK_{ULE} update procedure

6.2.5.2.1.5.3 TEK update after full reauthentication

Full reauthentication is completed after a successful 3-way handshake using the keys derived from the MSK created during the EAP reauthentication similar to that defined in Figure 6-19. Note that for reauthentication: 1) after the key agreement, the AK_{OLD} is still valid, and 2) only one new TEK is derived right after the 3-way handshake. The detailed procedure is as follows:

— 3-way handshake finishes with generation of AK_{NEW}, but AK_{OLD} is still valid.

— Right after successful completion of a 3-way handshake, the ABS updates its TEK_{DLE} with TEK_{ULE} and derives new TEK_{ULE} from AK_{NEW}.

— Right after the AMS realizes the 3-way handshake finished successfully, it starts the TEK_Reauth_Timer that once expired—the ABS is already expected to derive a fresh TEK_{ULE} from the new AK (at this point, TEK_{DLE} is still derived from the old AK). Once the timer expires or the AMS realizes the ABS uses its TEK_{ULE} in the DL (if AMS monitors this event), the AMS initiates the TEK update procedure in order to obtain new TEK_{ULE}. This procedure is done using the new PMK SN in TEK-Request in which the TEK refresh flag is set to "1" in order to signal the ABS that this is the first TEK update after reauthentication.

— The ABS is expected to respond with the PMK sequence number of AK_{NEW} (which is used in both CMAC and TEK) and the AMS then knows it needs to derive its TEK_{ULE} from AK_{NEW}.

— After the TEK update procedure with the AMS is completed and the ABS knows the AMS possesses TEK_{ULE} derived from the new AK (either by using it in UL or by receiving another TEK_request with the TEK refresh flag set to "0"), it should derive another new TEK and change TEK_{ULE} to be marked as TEK_{DLE} and then mark the new TEK as a TEK_{ULE} and discard all keys dependent on AK_{OLD}. Then it can discard AK_{OLD} as well.

— After obtaining the first TEK from the new AK, i.e., upon receiving TEK-RSP with the new EKS, the AMS initiates another key update procedure using the new PMK seq-number with the TEK refresh flag set to "0" to obtain the second TEK derived from new AK.

6.2.5.2.1.5.4 Key update during handover

During Intra-WirelessMAN-Advanced Air Interface Handover (with handover process optimization bitmap bit 1 = 1 “omit PKM authentication phase”), AK, CMAC keys, and TEKs shall be derived by the T-ABS and the AMS, respectively,as described in 6.2.5.2. In particular,

— AK derivation follows the same procedure as defined in 6.2.5.2.1.1.2, where usage of AMSID or AMSID* is defined in 6.2.5.3.1.
— In TEK derivation, COUNTER_TEK is set to be 0 and 1, in order to generate two new TEKs to be used at the T-ABS. Corresponding EKS is also reset to be 0 and 1, respectively.

When Seamless_Handover Flag = 1 in AAI-HO-CMD, the AMS and the T-ABS may use to derive TEKs for the T-ABS to resume data communications before initiation of AAI-RNG-REQ for network reentry procedure.

When the Network_Reentry_Mode = 1, for which the AMS is to maintain communications with the S-ABS during network reentry at the T-ABS, the AMS shall manage two sets of key context for AK, CMAC keys, and TEKs, where the context associated with the S-ABS is used to maintain communications with S-ABS until Disconnection Time, and the “new” context associated with the T-ABS is used to perform required network reentry procedures with T-ABS. The AMS discards key context associated with the S-ABS when the network reentry procedure finishes. The S-ABS discards this MS’s key context (along with other MAC context associated with the AMS) upon either the expiration of the ABS_Resource_Retain_Timer or a HO-Complete signaling from T-ABS via backbone.

During direct HO procedure from R1 BS to WirelessMAN-Advanced Air Interface ABS with either S-SFH Network Configuration bit = 0b0 when AMSID privacy is disabled or S-SFH Network Configuration bit = 0b1, the PMK context is shared between PKMv2 in the serving BS and PKMv3 in the T-ABS so that its PMK in the serving BS is re-used in the T-ABS, and the AMS obtains a proper value for AK_COUNT from the current CMAC_KEY_COUNT (refer to 6.2.5.2.1.1.2.2). Similarly to Intra-WirelessMAN-Advanced Air Interface Handover, the AMS stays in the Authenticated state of PKM v3 Auth FSM if AAI-RNG-REQ/RSP messages of NW reentry are validated correctly by CMAC/ICV calculated based on the same key update procedure as defined for Intra-WirelessMAN-Advanced Air Interface Handover.

During direct HO from R1 BS to WirelessMAN-Advanced Air Interface ABS with S-SFH Network Configuration bit = 0b0 and AMSID privacy enabled, the PMK context is shared between PKMv2 in the serving BS and PKMv3 in the T-ABS so that its PMK is re-used in the T-ABS, and the AMS obtains a proper value for AK_COUNT from the current CMAC_KEY_COUNT (refer to 6.2.5.2.1.1.2.2). Similarly to Intra-WirelessMAN-Advanced Air Interface Handover, the AMS stays in the Authenticated state of PKM v3 Auth FSM if AAI-RNG-REQ/RSP messages of NW reentry are validated correctly by CMAC/ICV calculated based on the new AK, CMAC keys, and TEKs that are derived as follows:

— AMS obtains the proper value for AK_COUNT according to 6.2.5.2.1.1.2.2.
— AMS sets the value of AMSID* by its AMSID. AMS derives new AK, its CMAC key, and TEK based on the AMSID*.
— AMS sends AAI-RNG-REQ message containing the attributes required for Authenticator to derive AK, i.e., AMSID*, and CMAC tuple, which is based on the new CMAC key.
— On receiving the AAI-RNG-REQ message, network entities, assumed to be Authenticator, derive new AK and transfer AK context to ABS, and ABS subsequently derives TEK and CMAC keys. ABS validates the AAI-RNG-REQ by CMAC tuple. If the CMAC is valid, ABS responds with the AAI-RNG-RSP message, where the AAI-RNG-RSP is transferred in an encrypted manner by the new TEK.
— If the AMS decrypts and decodes successfully the AAI-RNG-RSP message, then the AMS regards it as completion of a successful security key update procedure.

During the direct HO procedure from WirelessMAN-Advanced Air Interface ABS to R1 BS, the PMK context is shared between PKMv3 in the S-ABS and PKMv2 in the target BS so that its PMK is re-used and the AMS obtains a proper value for CMAC_KEY_COUNT from the current AK_COUNT (refer to 6.2.5.2.1.1.2.2). Similarly to Intra-WirelessMAN-OFDMA R1 Reference Interface Handover, the AMS stays in the Authenticated state of PKM v2 Auth FSM if RNG-REQ/RSP messages of NW reentry are validated correctly by CMAC calculated based on the key update procedure of the Intra-WirelessMAN-OFDMA R1 Reference Interface Handover (refer to 7.2.2.2 in IEEE Std 802.16).

6.2.5.2.1.5.5 Key usage during location update and network reentry from idle mode

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

In particular:

- AK derivation follows the same procedure as defined in 6.2.5.2.1.1.2, where usage of AMSID and AMSID* is described in 6.2.5.3.1.
- In TEK derivation, COUNTER_TEK is set to be 0 and 1, in order to generate two new TEKs to be used at the preferred T-ABS. Corresponding EKS is also reset to be 0 and 1, respectively.

6.2.5.2.1.5.6 Key update during zone switching from LZone to MZone

ABS shall include the STID to be used in the target MZone in the zone switch information.

During zone switch from LZone to MZone (with handover process optimization bitmap bit 1 = 1 “omit PKM authentication phase” and S-SFH Network Configuration bit = 0b0 and AMSID privacy enabled), the PMK context is shared between PKMv2 in the serving LZone and PKMv3 in the target MZone so that its PMK is re-used in the MZone, and the AMS obtains a proper value for AK_COUNT from the current CMAC_KEY_COUNT (refer to 6.2.5.2.1.1.2.2). Similarly to Intra-WirelessMAN-Advanced Air Interface Handover, the AMS stays in the Authenticated state of PKM v3 Auth FSM if AAI-RNG-REQ/RSP messages are validated correctly by CMAC/ICV calculated based on new AK, CMAC keys, and TEKs derived as follows:

- AMS obtains proper value for AK_COUNT according to 6.2.5.2.1.1.2.2.
- AMS generates random NONCE_AMS on calculating AMSID*. AMS derives new AK, its CMAC key, and TEK based on the AMSID*.
- AMS sends the AAI-RNG-REQ message containing the attributes required for the Authenticator to derive AK, i.e., AMSID*, and CMAC digest, which is based on the new CMAC key.
- On receiving the AAI-RNG-REQ message, network entities, assumed to be the Authenticator, derive new AK and transfer AK context to ABS, and ABS subsequently derives TEK and CMAC keys. ABS validates the AAI-RNG-REQ by CMAC tuple. If the CMAC is valid, ABS responds with the AAI-RNG-RSP message, where the AAI-RNG-RSP is transferred in an encrypted manner by the new TEK.
- If the AMS decrypts and decodes successfully the AAI-RNG-RSP message, then the AMS regards it as completion of a successful security key update.
- Seamless_Handover Flag shall be 0 for this zone switching scenario.

During zone switch from LZone to MZone (with handover process optimization bitmap bit 1 = 1 “omit PKM authentication phase” and either S-SFH Network Configuration bit = 0b0 when AMSID privacy is disabled or S-SFH Network Configuration bit = 0b1), the PMK context is shared between PKMv2 in the serving LZone and PKMv3 in the target MZone so that its PMK is re-used in the MZone and the AMS obtains a proper value for AK_COUNT from the current CMAC_KEY_COUNT (refer to 6.2.5.2.1.1.2.2). Similarly to Intra-WirelessMAN-Advanced Air Interface Handover, the AMS stays in the Authenticated state of PKM v3 Auth FSM if AAI-RNG-REQ/RSP messages are validated correctly by CMAC/ICV calculated based on new AK, CMAC keys, and TEKs derived as follows:

— AMS obtains a proper value for AK_COUNT according to 6.2.5.2.1.1.2.2.
— AMS derives new AK, its CMAC key, and TEK based on AMSID.
— AMS sends the AAI-RNG-REQ message containing the attributes required for the Authenticator to derive AK, i.e., AMSID, and CMAC digest, which is based on the new CMAC key.
— On receiving the AAI-RNG-REQ message, network entities, assumed to be the Authenticator, derive new AK and transfer AK context to the ABS, and the ABS subsequently derives TEK and CMAC keys. Alternatively, network entities, assumed to be the Authenticator, may derive new AK and transfer AK context to the ABS and the ABS subsequently derives TEK and CMAC keys earlier when zone switching is initiated by the ABS. The ABS validates the AAI-RNG-REQ by CMAC tuple. If the CMAC is valid, the ABS responds with the AAI-RNG-RSP message, where the AAI-RNG-RSP is transferred in a encrypted manner by the new TEK.
— If the AMS decrypts and decodes successfully the AAI-RNG-RSP message, then the AMS regards it as completion of a successful security key update.

6.2.5.2.1.5.7 Key update during zone switch from MZone to LZone

During zone switch from MZone to LZone (with handover process optimization bitmap bit 1 = 1 “omit PKM authentication phase”), the PMK context is shared between PKMv3 in the serving MZone and PKMv2 in the target LZone so that its PMK is re-used in the LZone and the AMS obtains a proper value for CMAC_KEY_COUNT from the current AK_COUNT according to 6.2.5.2.1.1.2.2. Similarly to Intra-WirelessMAN-OFDMA R1 Reference Interface Handover, the AMS stays in the Authenticated state of PKM v2 Auth FSM if RNG-REQ/RSP messages of NW reentry are validated correctly by CMAC calculated based on the key update procedure of the intra-WirelessMAN-OFDMA R1 Reference Interface Handover (refer to 7.2.2.2).

New AK, KEK, and CMAC keys are derived according to 7.2.2.2 in IEEE Std 802.16. New TEKs are derived according to 7.2.2.2 if in the AAI-HO-CMD message Seamless HO is set to 1. Otherwise, TEKs to be used in LZone are obtained via TEK transfer encrypted by KEK.

6.2.5.2.2 SA management

A security association (SA) is the set of information required for secure communication between the ABS and the AMS. SA is shared between the ABS and its client AMS across the AAI network. SA is identified using an SA identifier (SAID). The SA is applied to the respective unicast flows. AAI supports unicast static SA only, and SAs are mapped one-by-one to cryptographic methods. (See Table 6-109.)

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

The Flow ID in the AGMH is used to indicate whether the PDU contains a control message encrypted based on security level. Whether each control message is encrypted or not is decided based on the security level with which the message is associated (see Table 6-28).

If authorization is performed successfully, SAID 0x01 is applied to flows for confidentiality and integrity, and SAID 0x02 for confidentiality only. SAID 0x01 shall be applied to control flows as defined in Table 6-25.

However, SAID 0x02 can be applied to transport flows only if the AMS and ABS decide to create an unprotected transport flow; the Null SAID (i.e., SAID 0x00) is used as the target SAID (see Table 6-109.)

Table 6-109—SA mapping with protection level

SAID	Name of SA	Characteristics	Usage
0x00	Null SA	Neither confidentiality nor integrity protection	For nonprotected transport flow.
0x01	Primary SA	Confidentiality and integrity protection (i.e., AES-CCM mode is applied)	Encryption for unicast control/ transport flow.
0x02		Confidentiality protection only (i.e., AES-CTR mode is applied)	Encryption for unicast transport flow.
0x03–0xFF		*Reserved*	

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

6.2.5.2.2.1 Mapping of flows to SAs

The following rules for mapping flows to SAs apply:

a) The unicast transport flows shall be mapped to an SA.
b) The multicast or broadcast transport flows shall be mapped to Null SA.
c) The encrypted unicast control flows shall be mapped to the Primary SA.
d) The nonencrypted unicast control flows shall not be mapped to any SA.
e) The broadcast control flows shall not be mapped to any SA.

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

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

6.2.5.2.2.2 Mapping of flows to SAs during zone switching

During LZone to MZone zone switch, LZone CIDs are mapped to MZone FIDs as defined in 6.2.6.4.1.3 and their mapping to MZone SA is shown in Table 6-110.

Table 6-110—LZone CID to MZone SA mapping during LZone to MZone zone switch

CIDs in LZone	SA in MZone
Management connections	Null SA (SAID = 0x00), if only security suites with “No data encryption, no data authentication” is supported Primary SA (SAID = 0x01), otherwise
Unicast transport CID with SA using AES-CCM	Primary SA (SAID = 0x01)
Unicast transport CID with Null SA	Null SA (SAID = 0x00)
Broadcast or multicast transport CID	Null SA (SAID = 0x00)

During MZone to LZone zone switch, MZone FIDs are mapped to LZone CIDs as defined in 6.2.6.4.2.3 and their mapping to LZone SA is shown in Table 6-111.

Table 6-111—MZone FID to LZone SA mapping during MZone to LZone zone switch

FIDs in MZone	SA in LZone
Transport FID associated with Primary SA (SAID = 0x01)	Primary SA using AES-CCM and 128-bit AES-key wrap (cryptographic suite value is 0x020104)
FID associated with SAID = 0x02	Primary SA using AES-CCM and 128-bit AES-key wrap (cryptographic suite value is 0x020104)
FID associated with Null SA (SAID = 0x00)	Null SA using “No data encryption; no data authentication”
Broadcast or multicast transport FID	Null SA using “No data encryption; no data authentication”

6.2.5.2.3 Cryptographic methods

6.2.5.2.3.1 Payload encryption methods

AES-CCM [refer to NIST Special Publication 800-38C and FIPS 197 Advanced Encryption Standard (AES)] shall be used as an encryption method when PDUs on the unicast control connection are encrypted. Unicast transport connections may be encrypted with AES-CTR (refer to NIST Special Publication 800-38A) or AES-CCM.

6.2.5.2.3.1.1 AES-CCM

PDU payload format

The MAC PDU payload shall be prepended with a 2-bit EKS and a 22-bit PN (Packet Number). The EKS and PN shall not be encrypted. The plaintext PDU shall be encrypted and authenticated using the active TEK, according to the CCM specification. This includes appending an integrity check value (ICV) to the end of the payload and encrypting both the plaintext payload and the appended ICV where the size of ICV is decided by either 4 bytes or 8 bytes during the key agreement procedure in network entry. The processing yields a payload that is 7 bytes or 11 bytes longer than the plaintext payload.

Packet number (PN)

The PN associated with an SA shall be set to 0x000001 for DL and 0x200001 for UL when the SA is established and when a new TEK is installed. After each PDU transmission, the PN shall be incremented by 1. Any pair value of {PN, TEK} shall not be used more than once for the purposes of transmitting data. The AMS shall ensure that a new TEK is derived on both sides before the PN paired with either TEK for downlink or TEK for uplink reaches maximum value 0x1FFFFF or 0x3FFFFF, respectively. If the PN reaches maximum value without new TEKs being installed, transport communications on that SA shall be halted until new TEKs are installed.

CCM algorithm

NIST Special Publication 800-38C defines a number of algorithm parameters. Those parameters shall be fixed to specific values as follows:

— The payload, *P*, shall be the connection payload, i.e., the PDU excluding the MAC header and any extended headers as well as the EKS, PN, and the Integrity Check Value (ICV) fields (refer to Figure 6-11).
— The message authentication code, *T*, is referred herein as the ICV. The length of *T* in bytes, *t*, is either 4 or 8.
— The cipher block key, *K*, is the current TEK as defined herein.
— The associated data, *A*, is the empty string. The length of the associated data, *a*, is zero.

The nonce, *N*, shall be as shown in Table 6-112. The MAC header, which fills bytes 1 and 2, may be the AGMH or the SPMH. If the STID or the FID has not been assigned, then the corresponding field shall be set to all zeroes. When payloads with different FIDs are multiplexed into the MAC PDU, the FID field of the nonce shall be set to the FID of the first payload connection.

Table 6-112—Nonce construction

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

The block cipher algorithm, $CIPH_K$, is AES as specified in FIPS 197 Advanced Encryption Standard (AES).

The formatting function and the counter generation function are specified in NIST Special Publication 800-38C, Appendix A. In adopting Appendix A, the Length field *Q* shall be 2 bytes long; i.e., the octet length of the Length field, *q*, is 2. It follows that the Flags byte in the initial block, B_0, has value 0x09 if a 4-byte ICV is used, or 0x19 if an 8-byte ICV is used. The initial block B_0 is shown in Figure 6-21.

Byte Number	0	1 13	14 15
Byte significance			MSB LSB
Number of bytes	1	13	2
Field	Flags	Nonce	Q
Contents	0x09 or 0x19	As specified in Table 6-109	Length of Plaintext payload

Figure 6-21—Construction of initial CCM Block B_0

The *j*-th counter block, Ctr_j, is shown in Figure 6-22. Note that the Flags byte in the counter blocks, which is different from the Flags byte in the initial block B_0, has constant value 0x01.

Byte Number	0	1 13	14 15
Byte significance			MSB LSB
Number of bytes	1	13	2
Field	Flags	Nonce	Counter
Contents	0x1	As specified in Table 6-109	*j*

Figure 6-22—Construction of counter blocks Ctr_j

Receive Processing rules

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

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

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

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

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

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

If ABS recognizes that TEK_{ULE} update is required due to ICV errors, it discards current TEK_{DLE} and uses TEK_{ULE} as TEK_{DLE}, and derives a new TEK for TEK_{ULE}. After recognizing ABS's TEK update, AMS performs the TEK update procedure. To expedite the TEK update procedure, the ABS may transmit the PKMv3 TEK-invalid message.

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

6.2.5.2.3.1.2 AES-CTR

The MAC PDU payload shall be prepended with a 2-bit EKS and a 22-bit PN. The EKS and PN shall not be encrypted. Construction of the counter blocks is the same as that for counter blocks of AES-CCM (i.e., the counter blocks CTR_j and NONCE are formatted as shown in Figure 6-22 and Figure 6-21, respectively).

6.2.5.2.3.2 Calculation of cipher-based message authentication code (CMAC)

An ABS or AMS may support MAC control message integrity protection based on CMAC, together with the AES block cipher. The CMAC construction as specified in NIST Special Publication 800-38B shall be used.

The calculation of the keyed hash value contained in the CMAC Digest attribute and the CMAC Tuple shall use the CMAC algorithm with AES. The DL authentication key CMAC_KEY_D shall be used for authenticating messages in the DL direction. The UL authentication key CMAC_KEY_U shall be used for authenticating messages in the UL direction. UL and DL message authentication keys are derived from the CMAC-TEK prekey (see 6.2.5.2.1.1.3 for details).

The CMAC Packet Number Counter, CMAC_PN_*, is a 3-byte sequential counter that is incremented for each MAC Control Message that contains a CMAC Tuple or CMAC Digest in the context of UL messages by the AMS, and in the context of DL messages by the ABS.

If STID or TSTID is not assigned yet, then the STID field shall be stuffed with zeroes. The CMAC_PN_* is part of the AK context and shall be unique for each MAC control message with the CMAC tuple or digest. Any tuple value of {CMAC_PN_*, CMAC_KEY_*} shall not be used more than once. The reauthorization process should be initiated (by the ABS or the AMS) to establish a new PMK/AK before the CMAC_PN_* reaches the end of its number space.

The CMAC value shall be calculated over a field consisting of the AK ID followed by the CMAC_PN_*, expressed as an unsigned 24-bit number, followed by the 12-bit STID and 4-bit FID on which the message is sent, followed by 24-bit zero padding (for the header to be aligned with AES block size) and followed by the entire ASN.1 encoded MAC control message.

The LSB 64-bit of the outcome of AES-CMAC calculation shall be used for CMAC value.

NOTE—This is different from the recommendation in NIST Special Publication 800-38B where the MSB is used to derive the CMAC value.[10]

In other words, if CMAC_KEY_* is derived from CMAC-TEK prekey:

[10]Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

CMAC value ≤ Truncate(CMAC (CMAC_KEY_*, AK ID | CMAC_PN |STID|FID|24-bit zero padding | ASN.1 encoded MAC_Control_Message), 64), where STID '000000000000' should be used if STID is not assigned yet.

Only the MAC control message of CMAC_PN that arrives in order at the receiver side can be accepted. MAC control messages with out-of-order CMAC_PN shall be discarded.

6.2.5.2.4 AMS authentication state machine

The PKMv3 authentication state machine consists of 6 states and 18 events (including receipt of messages and events from other FSMs) that may trigger state transitions and send events/messages. The authentication state machine is present in both a state flow diagram (Figure 6-24) and a state transition matrix (Table 6-113). The state transition matrix shall be used as the definitive specification of protocol actions associated with each state transition.

The PKMv3 Authentication process has two phases—EAP phase and key agreement phase.

The EAP phase is controlled by the EAP_FSM as defined in IETF RFC 3748 and IETF RFC 4173, and it is out of scope in this standard.

The Authentication FSM is responsible for all PKMv3 phases excluding the actual EAP exchange; it is also responsible for communicating with other FSMs in the system using events.

The relationships between the security related FSMs in the system are as described in Figure 6-23.

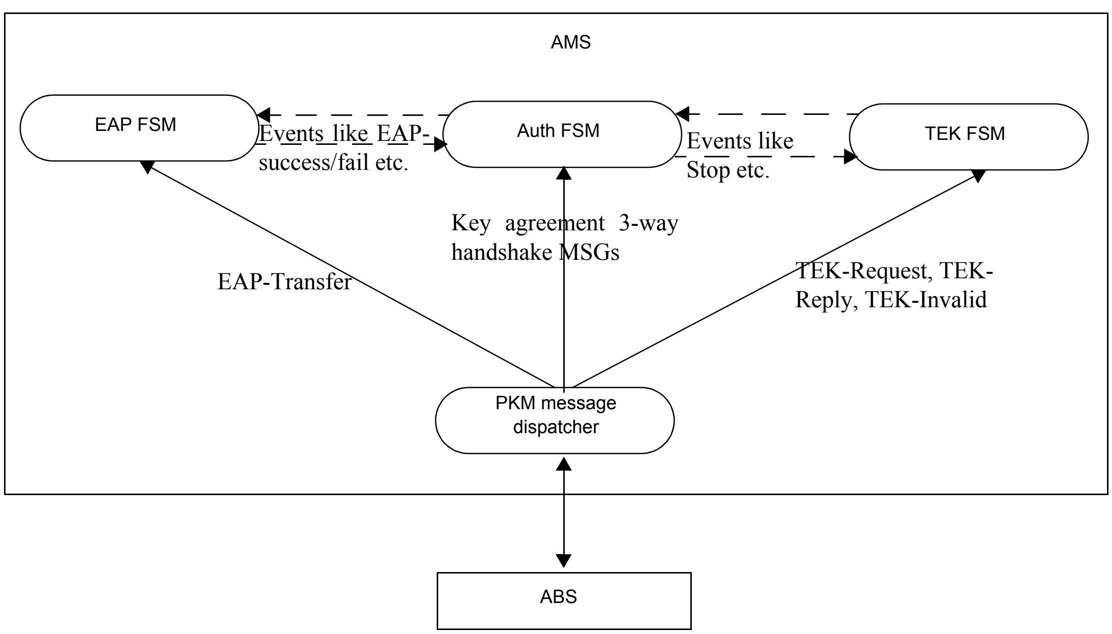

Figure 6-23—System relationships in security-related FSM

Through operation of an Authentication state machine, the AMS attempts to get authenticated with the NW, maintain this authentication, and support Authentication context switching for reauthentication, PMK refresh, HO, zone switching, and Idle situations. The state machine takes care of requesting the BS to renew the key hierarchy before it expires either by initiating reauthentication or PMK refresh only. It also supports key derivations according to definitions for optimized reentry for HO for location update and idle.

The optimized reentry/location update support is done in a special state in which the NW connection is suspended and therefore reauthentication cannot occur. The triggers for re-authentication continue to work in this state, but the initiation is done only after returning to an authenticated state.

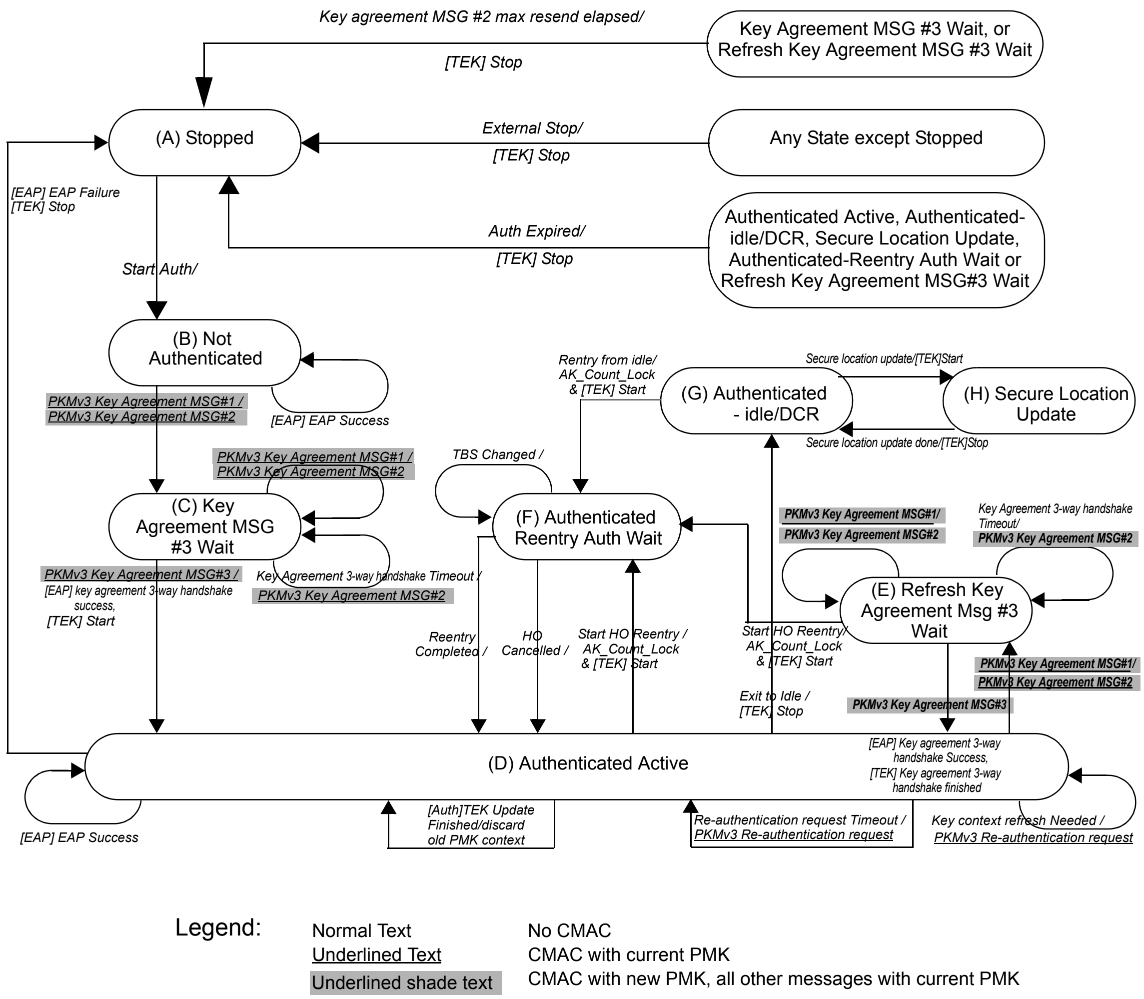

Figure 6-24—Authentication state machine for PKMv3

Table 6-113—Authentication FSM state transition matrix for PKMv3

Event or receive message	State							
	(A) Stopped	(B) Not Authenticated	(C) Key Agreement MSG #3 Wait	(D) Authenticated Active	(E) Refresh Key Agreement MSG #3 Wait	(F) Authenticated reentry Auth Wait	(G) Authenticated idle/ DCR	(H) Secure location update
(1) Start Auth	Not Authenticated							
(2) PKMv3 Key Agreement MSG #1		Key Agreement MSG #3 Wait	Key Agreement MSG #3 Wait	Refresh Key Agreement MSG #3 Wait	Refresh Key Agreement MSG #3 Wait			
(3) PKMv3 Key Agreement MSG #3			Authenticated Active		Authenticated Active			
(4) [EAP] EAP Success		Not Authenticated		Authenticated Active				
(5) Key Agreement 3-way handshake timeout			Key Agreement MSG #3 Wait		Refresh Key Agreement MSG #3 Wait			
(6) Key Agreement MSG #2 max resend elapsed			Stopped		Stopped			
(7) Key Context Refresh needed				Authenticated Active				
(8) Start HO Reentry				Authenticated Reentry Auth Wait	Authenticated Reentry Auth Wait			
(9) Reauthentication request timeout				Authenticated Active				
(10) HO cancelled						Authenticated Active		

Table 6-113—Authentication FSM state transition matrix for PKMv3 *(continued)*

Event or receive message	State							
	(A) Stopped	(B) Not Authenticated	(C) Key Agreement MSG #3 Wait	(D) Authenticated Active	(E) Refresh Key Agreement MSG #3 Wait	(F) Authenticated reentry Auth Wait	(G) Authenticated idle/ DCR	(H) Secure location update
(11) TBS change						Authenticated Reentry Auth Wait		
(12) Reentry Completed						Authenticated Active		
(13) Auth Expired				Stopped	Stopped	Stopped	Stopped	Stopped
(14) [EAP] EAP Failure				Stopped				
(15) External Stop		Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped
(16) Exit to Idle				Authenticated idle/ DCR				
(17) ReEntry from Idle							Authenticated Reentry Auth Wait	
(18) Secure Location Update							Secure location update	
(19) TEK update finished				Authenticated Active				
(20) Secure location update done								Authenticated idle/ DCR

6.2.5.2.4.1 States

Stopped: This is the initial state of the FSM. Nothing is done in this state.

Not Authenticated: The Authentication FSM is not authenticated and waiting for an MSK from the EAP FSM and start of key agreement 3-way handshake.

Key Agreement MSG #3 Wait: The Authentication FSM holds all key hierarchy derived from MSK and is waiting to receive MSG#3 in order to validate the keys with the BS:

- Resend MSG#2 if valid MSG#3 was not received within Key Agreement Timer.
- Resend MSG#2 if MSG#1 with same NONCE received again (reset resend counter).
- Discard MSG#3 received with invalid CMAC.

Authenticated Active: The AMS has successfully completed EAP-based authentication and key agreement 3-way handshake and has valid key context derived from the MSK received from the EAP FSM. All SAs are created and TEK FSM is active for each SA:

- PMK or its derivatives (not including TEK) is about to expire, the AMS sends a reauthentication request, and the reauthentication request timer starts.
- Reauthentication request timer is expired, and the AMS sends a reauthentication request.
- AK_Count/ CMAC_PN_* is about to be exhausted, and the AMS sends a reauthentication request.
- All control messages are protected as defined in Table 6-24.
- Received messages without valid encryption/CMAC are discarded, including MSG#1 with invalid CMAC.
- Manage two key Context during transition period during reauthentication when both old MSK and new MSK coexist.

Refresh Key Agreement 3-way handshake MSG #3 Wait: The Authentication FSM holds all key hierarchy derived from newest MSK (in parallel to active context used for ongoing operation) and is waiting to receive MSG#3 in order to validate the keys with the BS:

- Resend MSG#2 if valid MSG#3 was not received within key agreement 3-way handshake timer.
- Resend MSG#2 if MSG#1 with valid CMAC (using active CMAC key) is received (reset resend counter).
- Discard MSG#3 received with invalid CMAC (using newest CMAC key).

Authenticated Reentry Authentication Wait: In this state, the Authentication FSM has the context of the T-ABS. The AMS should have the AK context of the T-ABS in this state before it sends an AAI-RNG-REQ message with CMAC during HO or reentry from coverage loss:

- Caches AK context of all TBSs until reentry completed or HO canceled.
- Creates new context and key hierarchy for the TBS whenever TBS changes (if context is not cached).
- Maintains AK_COUNT LOCK state.

Authenticated Idle/DCR: In this state, the Authentication FSM caches the PMK context and derives the appropriate key hierarchy for the TBS in case of reentry from idle or DCR mode.

Secure Location Update: In this state, the system is active for a short period of sending location update and for TEKs need to be derived so TEK FSM is started.

6.2.5.2.4.2 Messages

PKMv3 Key Agreement MSG #1: The first message of Key Agreement. It is sent from the ABS to the AMS after EAP-based authentication has finished, and it is protected by CMAC using CMAC_KEY_D derived from the new AK.

PKMv3 Key Agreement MSG #2: The second message of Key Agreement 3-way handshake. It is sent from the AMS to the ABS as a response to a PKMv3 Key Agreement MSG #1 with valid CMAC; it is protected by CMAC using CMAC_KEY_U derived from the new AK.

PKMv3 Key Agreement MSG #3: The last message of Key Agreement 3-way handshake. It is sent from the ABS to the AMS as a response to a valid PKMv3 Key Agreement MSG #2, and it is protected by CMAC-Digest using CMAC_KEY_D derived from the new AK.

PKMv3 reauthentication request: The message used by the AMS to request the ABS to renew all the key hierarchy by initiating full EAP-based reauthentication along with key agreement 3-way handshake. If new key agreement 3-way handshake is not completed within reauthentication request timeout, the AMS may re-send PKMv3 reauthentication request.

PKMv3 EAP transfer: This message is bidirectional and used for transmission of EAP packet. This message is sent unprotected in "Not Authenticated" state. In Authenticated Active state, the message SHALL be encrypted.

6.2.5.2.4.3 Events

Start Authentication: After completion of basic capabilities negotiation, this event is generated to start the Authentication state machine.

[EAP] EAP Success: EAP FSM generates this event to notify the Authentication FSM that it received the EAP Success message from the authenticator.

Key agreement 3-way handshake timeout: This event is generated when the AMS does not receive PKMv3 Key Agreement MSG #3 from the ABS within Key Agreement Timer after transmitting a PKMv3 Key Agreement MSG #2. The AMS resends the PKMv3 Key Agreement MSG #2 up to Key Agreement MSG#2 Max Resends times.

Key agreement MSG #2 max resends elapsed: The Authentication state machine generates this event when the AMS has transmitted the PKMv3 Key Agreement MSG #2 up to Key Agreement MSG #2 Max Resends times and Key Agreement Timer expires.

Key context refresh needed: An internal event to trigger a message to the ABS requesting for a new key agreement 3-way Handshake with reauthentication per ABS decision. This event can be derived from several sources such as Authentication Grace Timeout or other reason that makes authentication close to expiration.

Start HO reentry: An event to inform the Authentication FSM that AMS is in HO or network reentry from coverage loss phase. The FSM should derive the new AK context for the T-ABS.

Reauthentication request timeout: A timer event that causes the AMS to resend a PKMv3 reauthentication request message in order to ask the network to initiate reauthentication. This event is used in the case that key agreement 3-way handshake is not completed successfully during reauthentication request timer from transmitting the PKMv3 reauthentication request message. This timer is active only after the key context refresh needed event occurred.

Reentry completed: An event to notify the Authentication FSM that reentry has finished successfully. This event is issued when the AMS receives an AAI-RNG-RSP message including Reentry Process Optimization Bit #1 set to one (i.e., "omit PKM authentication phase") during HO or network reentry.

HO canceled: An event to notify the Authentication FSM that HO was canceled. The cached AK context for the S-ABS should be retrieved.

TBS (T-ABS) changed: An Event to notify the Authentication FSM that it needs to generate the AK context for the new T-ABS.

Authentication expired: This event indicates the AK context became obsolete due to the expiration of AK lifetime.

[EAP] EAP failure: This event indicates EAP-failure has been received from the NW.

External stop: The event to stop the Authentication FSM and terminate connection with ABS. It is also issued when the Reentry Process Optimization Bit #1 of the AAI-RNG-RSP message is set to one (i.e., "omit PKM authentication phase") during HO or network reentry.

[Auth] TEK update finished: The event received from TEK FSM to notify the Auth FSM that PMK context of old PMK can be discarded.

NOTE 1—The following events are sent by an authentication state machine to the EAP state machine:

[EAP] key agreement 3-way handshake success: Sent to the EAP FSM once key agreement 3-way handshake is completed, which means that new authentication is valid and old keys may be discarded.

NOTE 2—The following events are sent by an Authentication state machine to the TEK state machine:

[TEK] Stop: Sent by the Authentication FSM to an active (non-START state) TEK FSM to terminate the FSM and remove the corresponding SAID's keying material from the AMS's key table.

[TEK] Start: Sent by the Authentication FSM to a nonactive (STOP state), but valid, TEK FSM.

[TEK] Key agreement 3-way handshake finished: Sent from Auth FSM after re-auth key agreement 3-way handshake finished to trigger TEK FSM to renew both TEKs from new AK.

NOTE 3—The following events are sent by an external state machine to the TEK state machine:

Exit to idle: Sent by the idle/DCR FSM when the AMS exits to idle/DCR mode.

Reentry from idle: Sent by idle/DCR FSM when the AMS returns from idle/DCR to active mode.

Secure location update: Sent by the paging FSM when secure location update is required.

Secure location update done: Sent by paging FSM when secure location update is done and the Auth FSM is back to idle.

6.2.5.2.4.4 Parameters

Key agreement 3-way handshake timer: The timer that expires if the AMS does not receive a PKMv3 Key Agreement 3-way handshake MSG #3 after sending a PKMv3 Key Agreement MSG #2.

Re-authentication Request timer: Timeout period between sending PKMv3 reauthentication Request messages from Authenticated active state.

6.2.5.2.4.5 Actions

Actions taken in association with state transitions are listed by the following:

<Start State> (<rcvd message>) --> <End state>:

1-A: Stopped (Start Auth) -> Not Authenticated

a) Enable PKMv3 EAP-Transfer messages to be transferred.

2-B: Not authenticated (Key Agreement MSG#1) -> Key Agreement MSG#3 Wait

a) Obtain MSK from EAP FSM.

b) Derive all Key hierarchy (PMK, AK,CMAC key, TEK).

c) Send Key Agreement MSG#2 with CMAC.

d) Start Key Agreement 3-way handshake timer.

2-C: Key Agreement MSG#3 Wait (Key Agreement MSG#1) -> Key Agreement MSG#3 Wait

a) Send Key Agreement MSG#2.

b) Start Key Agreement 3-way handshake timer.

2-D: Authenticated Active (Key Agreement MSG#1) -> Refresh Key Agreement MSG#3 Wait

a) Obtain MSK from EAP FSM.

b) Derive all Key hierarchy (PMK, AK,CMAC key, TEK).

c) Send Key Agreement MSG#2 with CMAC.

d) Start Key Agreement 3-way handshake timer.

2-E: Refresh Key Agreement MSG#3 Wait (Key Agreement MSG#1) -> Refresh Key Agreement MSG#3 Wait

a) Send Key Agreement MSG#2.

b) Start Key Agreement 3-way handshake timer.

3-C: Key Agreement MSG#3 Wait (Key Agreement MSG#3) -> Authenticated Active

a) Stop Key Agreement 3-way handshake timer.

b) Start TEK FSM per negotiated SA.

c) Start Authentication Grace Timer.

d) Notify EAP FSM that authentication was completed

3-E: Refresh Key Agreement MSG#3 Wait (Key Agreement MSG#3) -> Authenticated Active

a) Stop Key Agreement 3-way handshake timer.

b) Trigger TEK FSMs to update TEK to new AK.

c) Start Authentication Grace Timer.

d) Notify EAP FSM about authentication completion.

e) Notify TEK FSMs about key agreement 3-way handshake finish so they will be able to obtain TEKs from new AK.

4-B: Not authenticated (EAP Success) -> Not authenticated

a) Obtain MSK.

4-D: Authenticated Active (EAP Success) -> Authenticated Active

a) Obtain MSK.

5-C: Key Agreement MSG#3 Wait (Key Agreement Timeout) -> Key Agreement MSG#3 Wait

a) Send Key Agreement MSG#2.

b) Start Key Agreement Timer.

5-E: Refresh Key Agreement MSG#3 Wait (Key Agreement Timeout) -> Refresh Key Agreement MSG#3 Wait

a) Send Key Agreement MSG#2.

b) Start Key Agreement Timer.

6-C: Key Agreement MSG#3 Wait (Key Agreement MSG #2 max resend elapsed) -> Stopped

6-E: Refresh Key Agreement MSG#3 Wait (Key Agreement MSG #2 max resend elapsed) -> Stopped

a) Stop TEK FSMs if active.

b) Delete all authentication context.

c) Stop authentication FSM.

7-D: Authenticated Active (Key context refresh needed) -> Authenticated Active

a) Send PKMv3 re-authentication request message.

b) Start re-authentication request Timer.

8-D: Authenticated Active (Start HO Reentry) -> Authenticated Reentry Authentication Wait

a) Generate AK Context and all derived keys for T-ABS.

b) Enter AK_COUNT LOCK state.

8-E: Refresh Key Agreement MSG#3 Wait (Start HO Reentry) -> Authenticated Reentry Authentication Wait

a) Generate AK Context and all derived keys for T-ABS.

b) Enter AK_COUNT LOCK state.

c) Remove all refresh key agreement created context.

9-D: Authenticated Active (reauthentication request Timeout) -> Authenticated Active

a) Send reauthentication request message.

b) Start reauthentication request timer.

10-F: Authenticated Reentry Authentication Wait (HO canceled) -> Authenticated Active

a) Remove AK context of all T-ABS.

b) Retrieve AK context of S-ABS.

c) Update PMK context with AK key counter value.

d) Exit AK counter lock state.

11-F: Authenticated Reentry Authentication Wait (HO canceled) -> Authenticated Reentry Authentication Wait

a) Cache AK context of former T-ABS.

b) Retrieve or generate if not cached AK context of new T-ABS.

12-F: Authenticated Reentry Authentication Wait (Reentry Completed) -> Authenticated Active

a) mark AK context of last T-ABS as S-ABS.

b) Delete AK context of all cached T-ABSs.

c) Update PMK context with AK_COUNT value.

d) Exit AK_COUNT LOCK state.

13-D,E,F,G,H: Any state with valid authentication (Authentication expired) -> Stopped

a) Stop TEK FSMs.

b) Delete all authentication context.

c) Stop authentication FSM.

14-D: Authenticated Active (EAP Failure) -> Stopped

a) Stop TEK FSMs if active.

b) Delete all authentication context.

c) Stop authentication FSM.

15-B,C,D,E,F,G,H: Any state (External stop) -> Stopped

a) Stop TEK FSMs if active.

b) Delete all authentication context.

c) Stop authentication FSM.

16-D: Authenticated Active (Exit to Idle) -> Authenticated Idle

a) Stop TEK FSM.

17-G: Authenticated idle/DCR (Reentry from idle) -> Authenticated Reentry Auth Wait

a) Generate AK Context and all derived keys for T-ABS.

b) Enter AK_COUNT LOCK state.

c) Start TEK FSM.

18-G: Authenticated idle (Secure location update) -> Secure Location update

a) Update AK context with AK_COUNT.

b) Notify PMK context about AK_COUNT updated value.

c) Derive AK context and all subkeys.

d) Start TEK FSM.

19-D: Authenticated active (TEK update finished) -> Authenticated Active

a) If all TEK FSMs reported TEK update finished, delete old PMK and AKcontext.

20-H: Secure Location Update (Secure location update done) -> Authenticated idle/DCR

a) Stop TEK FSM.

6.2.5.2.5 TEK state machine

The AMS TEK state machine consists of six states and eight events (including messages) that will trigger state transitions. The TEK FSM is present in both a state flow diagram (Figure 6-25) and a state transition matrix (Table 6-114).

TEK FSM under shaded states in Figure 6-25 has a valid SA Context.

The Authentication FSM starts an independent TEK FSM for each of its authorized SAIDs. As mentioned in [1], the AMS maintains two active TEKs for each SAID.

For the TEK update of a given SAID, the ABS includes in its Key Response with parameters such as EKS, PMK Seq_Num, COUNTER_TEK. The BS encrypts DL traffic with TEK_{DLE} and decrypts UL traffic according to the EKS bit, depending on which of the two keys the AMS used at the time. The AMS encrypts UL traffic with TEK_{ULE} and decrypts DL traffic according to the EKS bit. See 6.2.5.2.4 for details on AMS and ABS key usage requirements.

Through operation of a TEK FSM, the AMS attempts to keep the SAID related TEK Context synchronized with the ABS. The TEK state machine issues a TEK-REQ message to update the related TEK Context for the indicated SAID whenever required. When the AMS receives a TEK-RSP message and there is a new COUNTER_TEK (not maintained by the AMS at the moment), AMS shall always update its records with the TEK Context contained in the TEK-RSP message for the associated SAID.

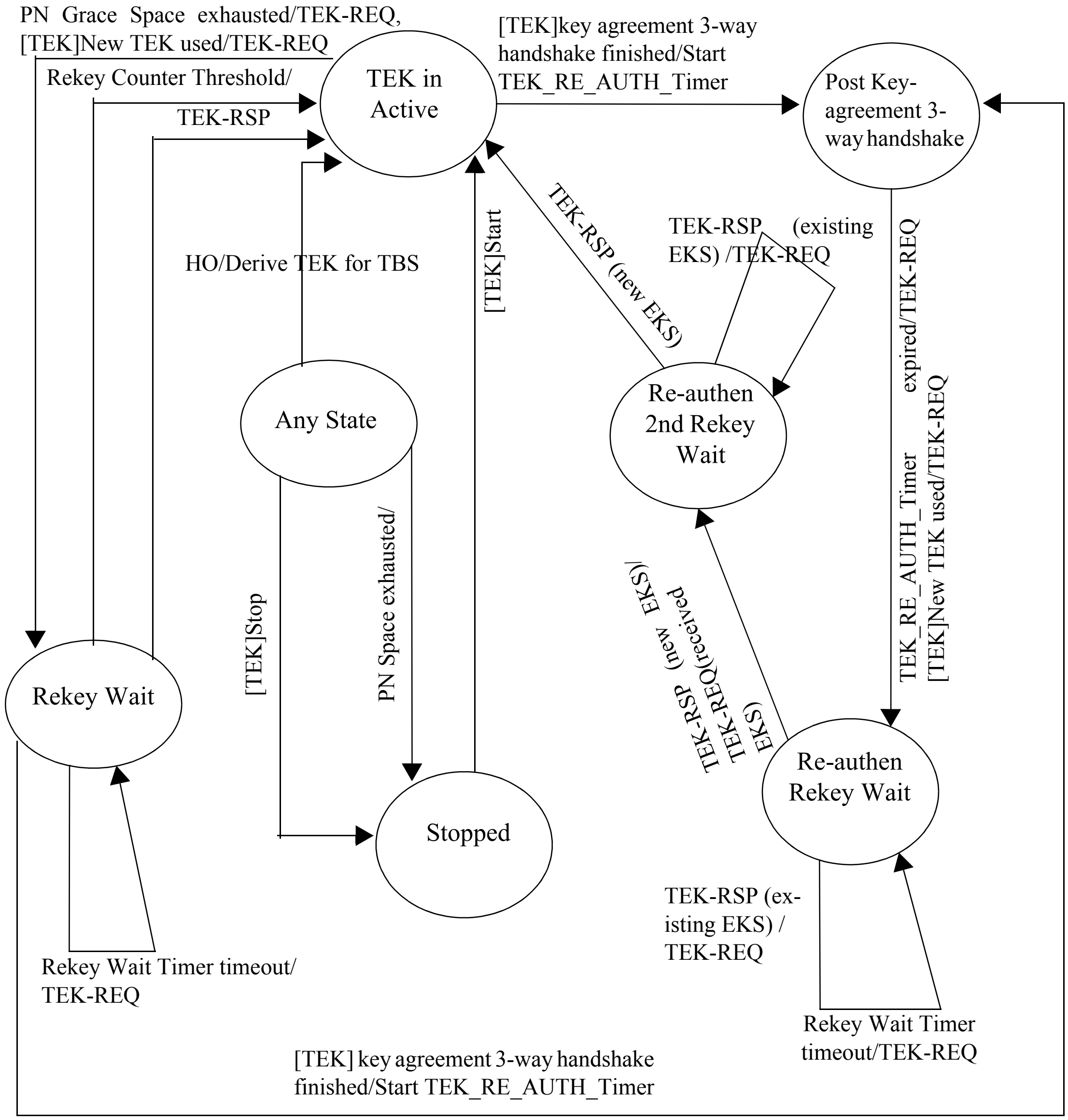

Figure 6-25—TEK state machine for PKMv3

Table 6-114—TEK FSM state transition matrix for PKMv3

Event or Rcvd message	**State**					
	(A) Stopped/ Idle	**(B) TEK in Active**	**(C) Rekey Wait**	**(D) Post key agreement 3-way handshake**	**(E) Re-auth Rekey Wait**	**(F) Re-auth 2nd Rekey Wait**
(1) [TEK]Stop		Stopped/idle	Stopped/idle	Stopped/idle	Stopped/idle	Stopped/idle

Table 6-114—TEK FSM state transition matrix for PKMv3 *(continued)*

Event or Rcvd message	State					
	(A) Stopped/ Idle	(B) TEK in Active	(C) Rekey Wait	(D) Post key agreement 3-way handshake	(E) Re-auth Rekey Wait	(F) Re-auth 2nd Rekey Wait
(2) [TEK]Start	TEK in Active					
(3) [TEK]Key agreement 3-way hand-shake Fin-ished		Post Key agreement 3-way hand-shake	Post Key agreement 3-way hand-shake			
(4)TEK-RSP (existing EKS)			TEK in Active		Re-auth Rekey Wait	Re-auth 2nd Rekey Wait
(5) TEK-RSP (newer EKS)			TEK in Active		Re-auth 2nd Rekey Wait	TEK in Active
(6) New TEK used		Rekey Wait	Rekey Wait	Re-auth Rekey Wait	Re-auth 2nd Rekey wait	
7) PN Space Exhausted		Stopped/idle	Stopped/idle	Stopped/idle	Stopped/idle	Stopped/idle
8) PN Grace space exhausted		Rekey Wait	Rekey Wait			
(9) Rekey Counter threshold			TEK in Active			
(10) Rekey Wait Timer timeout			Rekey Wait		RE-Authen Rekey Wait	Re-auth 2nd Rekey wait
(11) TEK Re-Auth timer expired				RE-Authen Rekey Wait		

6.2.5.2.5.1 States

Stopped: This is the initial state of TEK FSM. No resources are assigned to or used by the FSM in this state; i.e., all timers are off, and no processing is scheduled. This state is used before there are valid TEKs and when TEKs are not active like idle, DCR, and so on.

TEK in Active: The AMS has a valid SA Context for the associated SAID and is not waiting for any TEK-RSP message and AMS is in active/HO mode under this state.

Rekey Wait: The AMS has a valid SA Context for the associated SAID and is waiting for the TEK-RSP message for regular TEK update for this SAID. The AMS is in active mode under this state.

Post key agreement 3-way handshake: This is a transition state after reauthentication to give the BS time to derive first TEK from new AK; in this state, all TEKs are active and the AMS waits for the timer to expire so it can send TEK_REQ to the ABS. While in this state, the AMS SHALL discard all received TEK_RSP messages from the ABS.

Re-auth Rekey Wait: After key agreement 3-way handshake with associated AK refresh, the AMS has sent TEK_RSP and stays in this state to wait for the TEK-RSP message to refresh its TEK_{ULE} derived from new AK. The AMS is in active mode under this state.

Re-auth 2nd Rekey Wait: When receiving the TEK-RSP message and when the AMS successfully refreshes its first TEK_{ULE} associated with new AK, the AMS shall transfer to this state to wait for the second refreshed TEK from the new AK. This state is different than normal Rekey wait in the sense that the MS SHALL not leaves this state without refreshing the second TEK from the new AK.

6.2.5.2.5.2 Messages

TEK-REQ: Refer to 6.2.3.43.6.

TEK-RSP: Refer to 6.2.3.43.7.

6.2.5.2.5.3 Events

[TEK]Stop: Sent by the Authorization FSM to TEK FSM to terminate TEK FSM and remove the corresponding SAID's TEK Context from the AMS's key table.

[TEK]Start: Sent by the Authorization FSM to TEK FSM or a new TEK FSM to activate the TEK FSM for the associated SAID.

[TEK] New TEK used: This event MAY be triggered by the Data Path function (it is implementation specific whether to monitor this event or not) when current PMK is valid and the AMS realizes that the ABS uses its TEK_{ULE} in the DL. Once the active TEK FSM receives this event, it shall start to update the related TEK.

[TEK] Key Agreement 3-way handshake Finished: This event is sent from the Authentication FSM to trigger the TEK update after the re-auth procedure.

[Auth] TEK update finished: This event is sent to the Authentication FSM to notify that both TEKs are updated with new AK and that old AK context can be discarded.

PN space exhausted: This event is triggered when the PN space for the current TEK in use is exhausted.

PN grace space exhausted: This event is triggered when the PN reached its grace space and triggers the TEK update procedure.

Rekey Counter threshold: This event is triggered when the number of times AMS retries TEK-REQ exceeds the maximal Rekey Counter threshold. The AMS shall continue using its current TEK.

Rekey Wait Timer timeout: This event is triggered when the AMS does not receive TEK-RSP by the Rekey Wait Timer expiration.

TEK Re-Authen Timer exhausted: This event triggers the AMS to request for a new KEY after key agreement 3-way handshake.

6.2.5.2.5.4 Parameters

All configuration parameter values take the default values from Table 6-330.

PN Grace Space: PN Grace Space is set to the value smaller than the maximum number of the PN Space to guarantee that the AMS can update related TEK between the interval of PN Grace Space and PN Space gracefully.

It takes the default value from Table 6-330.

Rekey Wait Timer: The timer for TEK FSM to receive the TEK-RSP message after sending out the TEK-REQ message.

It takes the default value from Table 6-330.

Rekey Counter: The counter for re-sending the TEK-REQ if the AMS does not receive the TEK-RSP by the Rekey Wait Timer for the SA.

The initial value is 0. It shall be increased by 1 for each resending. The threshold takes the value from Table 6-330.

TEK Re-Auth Timer:

The timer for the AMS to wait after key agreement 3-way handshake before sending the TEK request to the ABS; this timer is used to allow the ABS enough time to derive a new TEK before asking for it.

The value of this timer is taken from Table 6-330.

6.2.5.2.5.5 Actions

Actions taken in association with state transitions are listed by <state> (<event>) --> <state>:

1-B,C,D,E,F: Any state ([TEK]stop) -> Stopped

a) Remove TEK Context for the related SAID.

b) Clear UL/DL PN number.

2-A: Stopped ([TEK]start) -> TEK in Active

a) Generate TEK context for the related SAID.

b) Set TEK counter to 0.

c) Set PN for each TEK to 1.

3-B: TEK in Active ([TEK] Key agreement 3-way handshake Finished) -> Post key agreement 3-way handshake

a) Start TEK re-Authen Timer.

3-C: Rekey wait ([TEK] Key agreement 3-way handshake Finished) -> Post key agreement 3-way handshake

a) Start TEK re-Authen Timer.

4-C: Rekey wait (TEK-RSP with existing EKS) -> TEK in Active

4-E: Re-auth Rekey wait (TEK-RSP with existing EKS) -> Re-auth Rekey wait

a) Reset Rekey Wait Timer.

b) Sent TEK-REQ.

4-F: Re-auth 2nd Rekey wait (TEK-RSP with existing EKS) -> Re-auth 2nd Rekey wait

a) Reset Rekey Wait Timer.

b) Send TEK-REQ.

5-C: Rekey wait (TEK-RSP with newer EKS) -> TEK in Active

a) Turn off Rekey timer/counter.

b) Install received TEK.

5-E: Re-auth Rekey wait (TEK-RSP with newer EKS) -> Re-auth 2nd Rekey wait

a) Turn off Rekey timer/counter.

b) Install received TEK.

6.2.5.3 Privacy

6.2.5.3.1 AMS identity privacy

AMS identity privacy support is the process of protecting the identity of the AMS so that the AMS MAC Address (i.e., AMSID) is not revealed via air interface. While S-SFH Network Configuration bit = 0b1, AMS identity privacy is not possible due to the need to send the real AMSID as plain text in the AAI-RNG-REQ.

A hash value of the real AMSID, AMSID*, is defined for the privacy of the AMSID. The AMSID* is derived as follows:

AMSID* = Dot16KDF(AMSID|80-bit zero padding, NONCE_AMS, 48),

where

NONCE_AMS is a random 64-bit value generated by the AMS

When AMSID privacy is enabled, the AMSID* is transmitted in the AAI-RNG-REQ message during network entry. If the AMS does not receive a successful AAI-RNG-RSP message from the ABS, and if Ranging Request Retries (see Table 6-330) has not been exhausted, the AMS shall send another AAI-RNG-REQ message with the AMSID* derived from the same NONCE_AMS to the ABS. If Ranging Request Retries has been exhausted, the AMS shall use another AMSID* derived from a newly generated NONCE_AMS.

When operating in S-SFH Network Configuration bit = 0b1:

AMSID is used rather than AMSID* when sending the AAI-RNG-REQ message and deriving AK.

AMSID privacy is applied in the following way:

— If AMSID Privacy Support bit in S-SFH SP2 is set to 0b1, AMSID privacy is enabled in the ABS and AMS. Otherwise, AMSID privacy is disabled in ABS and AMS.

The network with S-SFH Network Configuration bit = 0b0 must allow the AMS to connect using AMSID privacy mode or using the real AMS MAC address (i.e., not using AMSID privacy mode) is based on AMSID Privacy Support in S-SFH SP2.

6.2.5.3.2 AMS location privacy

AMS location privacy support is the process of protecting the mapping between AMS MAC address and STID so that intruders cannot obtain the mapping information between the MAC address and STID. To protect the mapping between STID and AMS MAC address, a TSTID is assigned during the initial ranging process, and is used until STID is allocated.

The STID is assigned during the registration process after successful completion of the initial authentication/ authorization process, and it is encrypted during transmission. The temporary STID is released after STID is securely assigned. The STID is used for all remaining transactions. The detailed procedures are described as follows:

An AMS generates a new NONCE_AMS and derives AMSID* if S-SFH Network Configuration bit = 0b0 and AMSID privacy is enabled; then it sends AAI-RNG-REQ carrying the AMSID* to the ABS. When the ABS receives the AAI-RNG-REQ, it returns AAI-RNG-RSP containing temporary STID (instead of STID) and the AMSID*, which the AMS sent. Alternatively, if either S-SFH Network Configuration bit = 0b0 when AMSID privacy is disabled or S-SFH Network Configuration bit = 0b1, AMSID is used in place of AMSID* when transmitting AAI-RNG-REQ and AAI-RNG-RSP messages.

After being assigned, the temporary STID is used for the subsequent network entry procedures until STID is allocated. The real AMSID is transmitted to an ABS in the AAI-REG-REQ message in an encryption manner. As a response to the AAI-REG-RSP, a STID is assigned and transferred to the AMS through the encrypted AAI-REG-RSP. Once the AMS receives the STID via AAI-REG-RSP, it releases the temporary STID. The STID is then used for remaining transactions. Figure 6-26 shows the overall network entry procedures.

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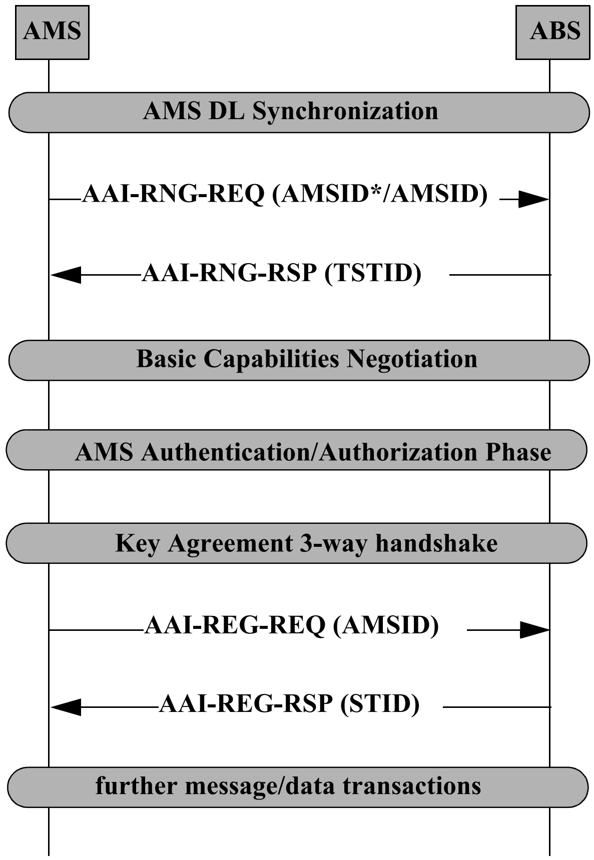


Figure 6-26—Network entry procedure to support AMS location privacy

6.2.5.3.3 Control plane signaling protection

AAI supports the confidentiality protection as well as the integrity protection over MAC control messages. Specifically, encryption is selectively applied to the control messages whenever confidentiality protection is required, as defined in Table 6-28. The encrypted unicast control messages shall be mapped to the primary SA. The selective confidentiality protection over control messages is a mandatory feature, and the negotiated keying materials/ciphersuites are used to encrypt the control messages.

The selective confidentiality protection over control messages is indicated by FID in the AGMH. Contrary to the transport flows where the established SA is applied to all data, the primary SA is selectively applied to the control messages. In particular, whether a control message is encrypted or not is decided on the security level with which the message is associated.

The selective protection over MAC control messages is made possible after the successful completion of local TEK derivation.

Figure 6-27 shows the following three levels of protection over control messages:

— No protection: If the AMS and the ABS have no shared security contexts or protection is not required, then the control messages are neither encrypted nor authenticated. The control messages before the authorization phase also fall into this category.
— CMAC based integrity protection: CMAC Tuple is added in a MAC PDU either carrying an unfragmented CMAC protected MAC control message or the last fragment of a CMAC protected MAC control message. CMAC protects the integrity of entire control messages. An actual control message is plaintext.
— AES-CCM based authenticated encryption: ICV part of the encrypted MAC PDU is used for the integrity protection about the payload of control messages as well as AGMH.

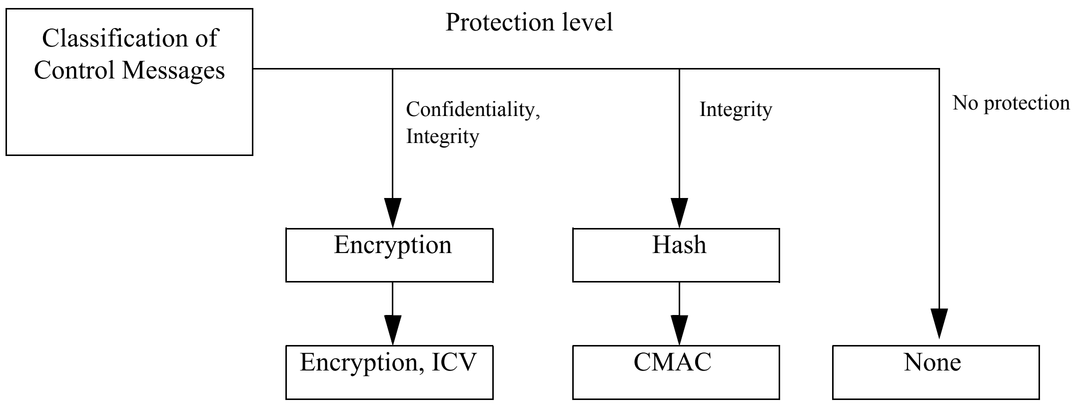


Figure 6-27—Flow of AAI selective control message protection

6.2.5.4 Security context

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

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

6.2.5.4.1 MSK context

The MSK context includes all parameters associated with the MSK. This context is created when EAP Authentication completes.

The MSK context is described in Table 6-115.

Table 6-115—MSK context

Parameter	Size (bits)	Usage
MSK	512	The key yielded from the EAP authentication.
MSK Lifetime	32	The time this MSK is valid. Before this expires, reauthentication is needed.

This context is created upon completion of successful (re)authentication and discarded when no longer valid or if the key agreement 3-way handshake procedure was not completed for 120 s.

The MSK lifetime shall be transferred from the EAP method and could also be configured by the AAA Server.

The lifetime may be enlarged using the key lifetime attribute in the Key_Agreement-MSG#1 message during the key agreement 3-way handshake procedure following EAP-based authorization or EAP-based reauthorization procedures.

If the ABS or the AMS needs to refresh the key, it should initiate reauthentication to create a new one.

6.2.5.4.2 PMK context

The PMK context includes all parameters associated with the PMK. This context is created before a key agreement 3-way handshake procedure and cached after a successful key agreement 3-way handshake procedure.

Two PMK contexts may exist in parallel in the AMS and Authenticator in transition phases where new PMK is created but the current PMK is still in use.

The PMK context is described in Table 6-116.

Table 6-116—PMK context

Parameter	Size (bits)	Usage
PMK	160	The key is created during a key agreement 3-way handshake procedure.
PMK SN	4	PMK sequence number, when the EAP-based authorization is achieved and a key is generated. The 2 LSBs are the sequence counter, and the 2 MSBs are set to 0. The initial value shall be set to zero. For each update, the value shall be increased by 1 mod 4; it is included in CMAC tuple to identify the used PMK.
PMK Lifetime	32	PMK Lifetime = MSK Lifetime.
AK_COUNT	16	Value of the Entry Counter that is used to guarantee freshness of computed CMAC_KEY_* with every entry and to provide replay protection.

6.2.5.4.3 AK context

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

An AMS may manage several AK contexts in parallel in transition phases.

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

The AK context is described in Table 6-117.

Table 6-117—AK context

Parameter	Size (bits)	Usage
AK	160	The key derived from PMK.
AK Lifetime	32	AK Lifetime = PMK Lifetime.
AKID	64	Identifies the authorization key. AKID = Dot16KDF(AK, 0b0000|PMK SN|AMSID* or MS MAC address|ABSID | “AKID”, 64), where either AMSID* or MS MAC address is used depending on the used AK derivation formula.
PMK SN	4	The sequence number of PMK used to derive this AK.
CMAC_KEY_U	128	The key that is used for signing UL MAC control messages.
CMAC_PN_U	24	Used to avoid UL replay attack on the control connection; before this expires, reauthorization is needed. The initial value of CMAC_PN_U is zero, and the value of CMAC_PN_U is reset to zero whenever AK_COUNT is increased.
AK_COUNT	16	A value used to derive the CMAC key and TEK.
CMAC_KEY_D	128	The key that is used for signing DL MAC control messages.
CMAC_PN_D	24	Used to avoid DL replay attack on the control connection; before this expires, reauthorization is needed. The initial value of CMAC_PN_D is zero, and the value of CMAC_PN_D is reset to zero whenever AK_COUNT is increased.
Next available counter_TEK	16	The counter value to be used in the next TEK derivation; after derivation, this is increased by 1.

6.2.5.4.4 SA context

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

The SA context holds two TEK contexts and additional information that belongs to the SA itself.

6.2.5.4.4.1 TEK context

The TEK context includes all relevant parameters of a single TEK and is described in Table 6-118.

Table 6-118—TEK context

Parameter	Size (bits)	Usage
TEK	128	Key used for encryption or decryption of MAC PDUs from FIDs associated with the corresponding SA
EKS	2	Encryption key sequence number
PMK SN	4	The sequence number of PMK from which AK used to derive this TEK is derived
COUNTER_TEK	16	The counter value used to derive this TEK
TEK lifetime	32	TEK lifetime = MSK lifetime
TEK_PN_U	22	The PN used for encrypting UL packets. After each MAC PDU transmission, the value shall be increased by 1. (0x200000–0x3FFFFF)
TEK_PN_D	22	The PN used for encrypting DL packets. After each MAC PDU transmission, the value shall be increased by 1. (0x000000–0x1FFFFF)
PN Window Size	As negotiated in key agreement	The receiver shall track the PNs received inside the PN window

6.2.5.4.4.2 SA Context

The SA context is described in Table 6-119.

Table 6-119—SA context

Parameter	Size (bits)	Usage
SAID	8	The identifier of this SA, which describes the applied en/decryption method and TEK contexts.
TEK_{DLE} context	Sizeof (TEK Context)	TEK context used for downlink encryption and decryption.
TEK_{ULE} context	Sizeof (TEK Context)	TEK context used for uplink encryption and decryption.

6.2.6 MAC HO procedures

MAC HO support is negotiated during AAI-REG-REQ/RSP transaction (see Mobility features support in Table 6-36 and Table 6-37).

This subclause specifies the HO procedures for the AAI. An AMS/ABS shall perform HO using the procedures defined in 6.2.6. A Femto ABS shall follow the handover procedure described in 6.4.8.

6.2.6.1 Network topology acquisition

6.2.6.1.1 Network topology advertisement

An ABS shall periodically broadcast the system information of the neighboring ABSs using an AAI-NBR-ADV message. A broadcast AAI-NBR-ADV message may include the information of Open Subscriber Group Femto and/or macro hot-zone ABSs, but shall not include information of neighbor Closed Subscriber Group (CSG) Femto ABSs. A broadcast AAI-NBR-ADV message may omit information of neighbor cells with Cell Bar information = 1 in its S-SFH.

A S-ABS may unicast the AAI-NBR-ADV message to an AMS upon reception of the AAI-SCN-REP message or in an unsolicited manner. When the AMS needs to obtain the neighbor information of CSG or OSG Femto ABS, it may indicate it through the request BS type in the AAI-SCN-REP message. Upon receiving this AAI-SCN-REP message, the S-ABS may send the neighboring CSG or OSG Femto ABS information through the AAI-NBR-ADV message to the AMS in a unicast manner. The AAI-NBR-ADV message may include parameters required for cell selection, e.g., cell type. The ABS may broadcast different segments of the AAI-NBR-ADV message over multiple MAC PDUs.

6.2.6.1.2 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 a time interval during which the AMS scans neighbor ABS while not available to S-ABS is referred to as a scanning interval. The ABS may specify the different trigger parameter values based on the ABS types in the AAI-SCD message.

The AMS may use any interval to perform autonomous scanning.

Autonomous scanning means an operation where the AMS performs intra-frequency preamble measurement without dedicated allocations for scanning. An AMS shall be capable of autonomous scanning, performing an intra-frequency preamble measurement without dedicated allocations for scanning.

An AMS selects the scanning candidate ABSs using the information obtained from the ABS through messages such as AAI-NBR-ADV and AAI-SCN-RSP. The ABS should prioritize the scanning candidates by presenting the candidate ABSs in descending order of priority in the AAI-SCN-RSP message. The AMS should follow the order of scanning as suggested in the AAI-SCN-RSP message.

An AMS measures the signal from selected scanning candidate ABSs and reports the measurement result back to the S-ABS according to report mode and report parameters defined by the S-ABS.

An AMS may request an allocation of a scanning interval to a candidate ABS by sending the AAI-SCN-REQ message to the S-ABS. Upon reception of the AAI-SCN-REQ message, the S-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 S-ABS may also send an unsolicited AAI-SCN-RSP message to initiate AMS scanning.

6.2.6.2 Trigger condition definitions

The S-ABS may define trigger conditions for the following actions:

a) Conditions that define when the AMS shall initiate the scanning procedure.
b) Conditions that define when the AMS shall report scanning measurement results to the S-ABS.

   When RSSI or CINR triggers are specified, an AMS with multiple receive antennas shall use the linear sum of the RSSI or CINR values calculated over all the receive antennas.
c) Conditions that define when the AMS shall initiate HO by sending AAI-HO-REQ.
d) Conditions for defining when a T-ABS is unreachable.
e) Conditions for defining when the AMS is unable to maintain communication with the S-ABS.
f) Conditions for HO cancellation.

Trigger definitions are encoded using the description in Table 6-120.

Table 6-120—Trigger description

Name	Length (bits)	Value
Number of Triggers	6	Total number of triggers that are defined.
for (i = 0; $i \leq$ Number of Triggers; i++) {		
Number of conditions	2	The number of conditions that are included in this trigger (see For-loop description below this table). When more than one condition is included, this trigger is referred to as a complex trigger and is the logical AND combination of all the included conditions.
ABS type	4	ABS type of T-ABS for this Trigger definition: (Any, Macro ABS, Macro Hot-zone ABS, Femto ABS, etc.). A value representing “any” means this trigger applies to all T-ABSs. This value of ABS type field shall be ignored for triggers with Type = 0x3 or the Function = 0x5 or 0x6 in Table 6-121. 0x0: Any 0x1: Macro ABS 0x2: Macro Hot-zone ABS 0x3: Femto ABS 0x4: R1 BS 0x5–0xF: *Reserved*

Table 6-120—Trigger description *(continued)*

Name	Length (bits)	Value
Trigger averaging parameter for intra-FA measurement	8	The averaging parameter used for averaging this trigger metric according to Equation (2) for T-ABS (which is defined in ABS type). If not present, the default trigger averaging parameter in AAI-SCD is used 0x0: 1 0x1: 1/2 0x2: 1/4 0x3: 1/8 0x4: 1/16 0x5: 1/32 0x6: 1/64 0x7: 1/128 0x8: 1/256 0x9: 1/512 0xA to 0xFF: *Reserved*
Trigger averaging parameter for inter-FA measurement	8	The averaging parameter used for averaging this trigger metric according to Equation (2) for T-ABS (which is defined in ABS type). If not present, the default trigger averaging parameter in AAI-SCD is used 0x0: 1 0x1: 1/2 0x2: 1/4 0x3: 1/8 0x4: 1/16 0x5: 1/32 0x6: 1/64 0x7: 1/128 0x8: 1/256 0x9: 1/512 0xA to 0xFF: *Reserved*
for (j = 0; $j \leq$ Number of conditions; j++) {		
Type/Function/Action	9	See Table 6-121 for description.
Trigger Value	8	Trigger value is the value used in comparing a measured metric for determining a trigger condition.
}		
}		

The Type/Function/Action byte field of the trigger description in Table 6-120 is described in Table 6-121.

Metric averaging is performed according to Equation (2).

Let $x\left[k\right]$ be the metric the AMS is required to average (e.g., RSSI) for the k-th measurement, expressed in linear units. Then $\hat{x}[k]$, the averaged metric expressed in linear units, equals:

$$\hat{x}[k] = \begin{cases} x[0] & k = 0 \\ (1 - \alpha\text{avg})^{n+1}\hat{x}[k-1] + (1 - (1 - \alpha\text{avg})^{n+1})x[k] & k > 0 \end{cases} \quad (2)$$

where

αavg is the trigger averaging parameter in the relevant trigger. If this field is not present, the default trigger averaging parameter in AAI-SCD is used.

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

In those frames in which no measurement is made, the AMS shall report the latest averaged results. When RSSI or CINR triggers are specified, an AMS with multiple receive antennas shall use the linear sum of the RSSI or CINR values calculated over all the receive antennas.

Table 6-121—Description of the trigger type/function/action

Name	Size (bits)	Value	Description
Type	3(MSB)	Trigger metric type: 0x0: CINR 0x1: RSSI 0x2: RTD 0x3: Number of consecutive P-SFHs missed 0x4: RD 0x5–0x7: *Reserved*	

Table 6-121—Description of the trigger type/function/action *(continued)*

Name	Size (bits)	Value	Description
Function	3	Computation defining trigger condition: 0x0: *Reserved* 0x1: Metric of neighbor ABS is greater than absolute value 0x2: Metric of neighbor ABS is less than absolute value 0x3: Metric of neighbor ABS is greater than S-ABS metric by relative value 0x4: Metric of neighbor ABS is less than S-ABS metric by relative value 0x5: Metric of S-ABS greater than absolute value 0x6: Metric of S-ABS less than absolute value 0x7: (For AMS in CA mode): Number of neighbor ABS's carriers (whose CINR/RSSI is greater than absolute value) is higher than the threshold value. The threshold value for the "Number of neighbor ABS's carriers" can be AMS specific or ABS specific. (For AMS specific, the threshold value is defined as the number of AMS's active carriers. For ABS specific, the threshold value is configured by the S-ABS and signaled through AAI-MC-ADV.)	Function 0x1-0x4 not applicable for RTD/RD trigger metric When type 0x1 is used together with function 0x3 or 0x4, the threshold value shall range from –32 dB (0x80) to +31.75 dB (0x7F). When type 0x1 is used together with function 0x1, 0x2, 0x5, 0x6, or 0x07, the threshold value shall be interpreted as an unsigned byte with units of 0.25 dB, such that 0x00 is interpreted as –103.75 dBm and 0xFF is interpreted as –40 dBm Type 0x3 can only be used together with function 0x5 or function 0x6. Function 0x7 can only be used with Action 0x1 and applicable for AMS in CA mode. Non-CA mode AMS shall ignore this trigger.
Action	3(LSB)	Action performed upon trigger condition is satisfied: 0x0: *Reserved* 0x1: Respond on trigger with AAI-SCN-REP 0x2: Respond on trigger with AAI-HO-REQ 0x3: Respond on trigger with AAI-SCN-REQ 0x4: Declare ABS unreachable: 0x5: Cancel HO 0x6 and 0x7: *Reserved*	Action 0x3 applies only to Function 0x5 and 0x6. Action 0x4: If this ABS is the S-ABS (meaning the AMS is unable to maintain communication with the ABS), AMS sends AAI-HO-IND with HO Event Code 0b10 to the S-ABS and proceeds as specified in 6.2.6.3.4. If this ABS is a T-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 T-ABSs included in AAI-HO-CMD during HO execution. The specific actions are described in 6.2.6.3.4.

The ABS may define complex trigger conditions by including multiple conditions within the same trigger definition. In this case, all included conditions shall have the same Action code (as defined in Table 6-121).

The AMS shall perform a logical AND of all the conditions in a complex trigger condition and invoke the action of the trigger only when all trigger conditions are met.

Whenever the condition of a simple trigger or all the conditions of a complex trigger are met, the AMS shall invoke the action of the trigger. If multiple trigger conditions are met simultaneously, the AMS shall invoke the action of at least one of the triggers for which the trigger condition was met. Action 0x2: Respond on trigger with AAI-HO-REQ takes precedence over Action 0x1 and Action 0x3

The ABS may define neighbor-specific triggers by including neighbor-specific triggers in the AAI-NBR-ADV message. The AMS evaluates neighbor-specific triggers only for the specific neighbor ABS metric. Neighbor-specific triggers use the format in Table 6-120, where only function types 0x1, 0x2, 0x3, and 0x4 and actions types 0x1 and 0x2 are allowed. When present, neighbor-specific handover triggers override any general triggers (defined in the AAI-SCD message) of the same type, function, and action.

6.2.6.3 HO procedure

This 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.

6.2.6.3.1 HO Framework

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

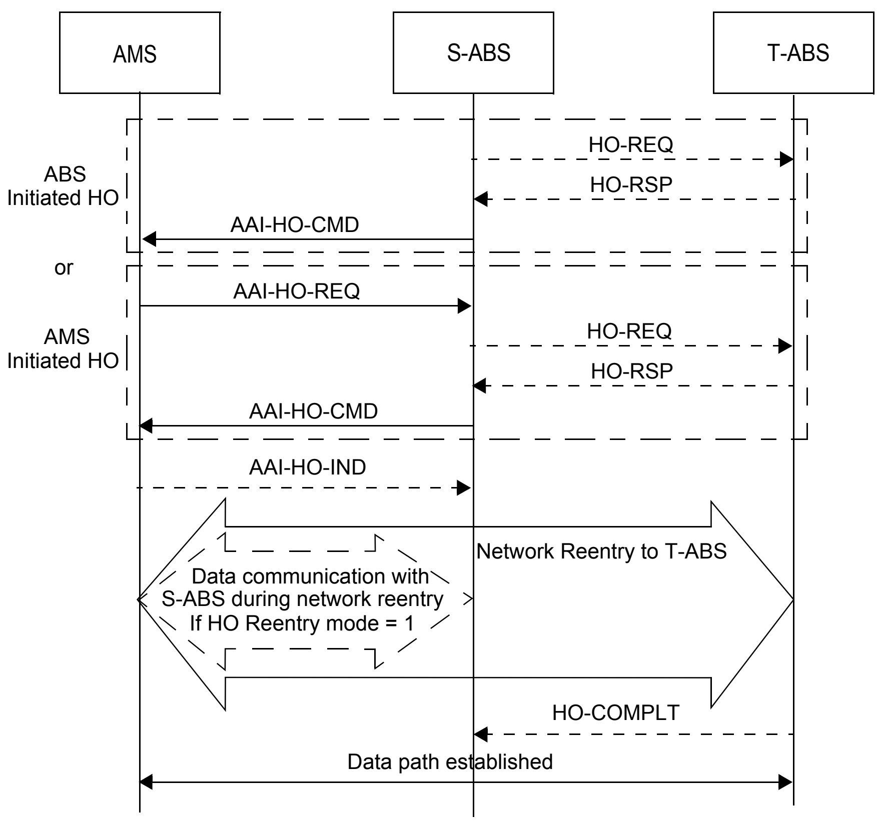


Figure 6-28—Generic HO procedure

6.2.6.3.2 HO decision and initiation

Either the AMS or the S-ABS may initiate handover. If the S-ABS defines trigger conditions for initiating handover, the AMS shall initiate a handover when one or more of the trigger conditions are met.

When HO is initiated by the AMS, an AAI-HO-REQ message is sent by the AMS to start the HO procedure. In case of ABS-initiated HO, HO preparation is performed before HO initiation, and an AAI-HO-CMD message is sent by the ABS to initiate the HO procedure. For ABS-initiated HO, an ABS shall set Polling bit to 1 in MCEH of the AAI-HO-CMD message. Upon receiving the AAI-HO-CMD message, the AMS shall acknowledge it according to the procedure defined in 6.2.22, so that the ABS confirms whether the AMS receives the AAI-HO-CMD message correctly or not.

During handover initiation, the S-ABS may indicate whether the AMS can maintain communication with the S-ABS while performing network reentry with the T-ABS by setting the HO_Reentry_Mode in AAI-HO-CMD to 1. If the AMS is not expected to maintain communication with the S-ABS while performing network reentry in the T-ABS, the HO_Reentry_Mode is set to 0.

The AMS shall not perform HO to a cell with Cell Bar bit = 1 in its S-SFH. The “Cell Bar” bit, when set, indicates that an AMS shall not perform network entry or reentry to this cell. The AAI-HO-CMD message shall not include an ABS with cell bar bit = 1.

6.2.6.3.3 HO preparation

During the HO preparation phase, the S-ABS communicates with the T-ABS(s) selected for HO. The T-ABS may obtain AMS information from the S-ABS via backbone network for HO optimization.

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

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

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

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

The ABS shall not set HO_Reentry_Mode to 1 unless EBB Support was declared (set to 1) by the AMS in AAI-REG-REQ.

When only one T-ABS is included in the AAI-HO-CMD message, the HO preparation phase completes when S-ABS informs the AMS of its handover decision via an AAI-HO-CMD message. When multiple T-ABSs are included in the AAI-HO-CMD message, the HO preparation phase completes when the AMS informs the ABS of its T-ABS selection via an AAI-HO-IND message with HO Event code 0b00. The AAI-HO-CMD message shall include Action Time of each T-ABS for the AMS to start network reentry. The AAI-HO-CMD message shall also include a Disconnect Time Offset for each AMS to calculate Disconnect time for each candidate T-ABS. Disconnect time is the time when the S-ABS expects the AMS to switch to a T-ABS. At Disconnect time, the S-ABS will stop sending DL data and stop providing any regular UL allocations to the AMS. When HO_Reentry_Mode is set to 0, the Disconnect time will be (Action time - Disconnect Time Offset). For HO_Reentry_Mode = 1, Disconnect time will be (Action time + Disconnect Time Offset).

The S-ABS may reject an AMS-initiated handover by transmitting the AAI-HO-CMD message with mode set to 0b10. In this case, the S-ABS shall not include any candidate T-ABS as described in 6.2.6.3.4. If the ABS chooses to accept the handover, it shall set Mode in the AAI-HO-CMD to 0b00. If the ABS sets Mode to 0b00, it may include zero, one, or more T-ABS in the AAI-HO-CMD message. The ABS may include candidate T-ABSs requested by the AMS in the AAI-HO-REQ message and/or alternate candidate ABSs not requested by the AMS.

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

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

6.2.6.3.4 HO execution

HO execution starts with an AAI-HO-CMD message and ends at the AMS's beginning to perform network reentry at Action time. If HO_Reentry_Mode is set to 0, the S-ABS stops sending DL data and providing UL allocations to the AMS after the Disconnect time derived from Action time and Disconnect Time Offset included in the AAI-HO-CMD message or upon receiving AAI-HO-IND with HO Event Code 0b10, whichever occurs first. If HO_Reentry_Mode is set to 1, the S-ABS stops sending DL data and providing UL allocations to the AMS after the Disconnect time, upon receiving AAI-HO-IND with HO Event Code 0b10 or after receiving HO completion confirmation from T-ABS, whichever occurs first.

If the AAI-HO-CMD message includes only one T-ABS, the AMS shall execute the HO as directed by the ABS, unless, during HO execution or network reentry, the AMS finds that the T-ABS is unreachable. The S-ABS defines conditions based on which the AMS decides if it is unable to maintain communication with the

S-ABS. If the AMS decides, based on these conditions, that it cannot maintain communication with the S-ABS until the expiration of Disconnect time, the AMS may send an AAI-HO-IND message with HO Event Code 0b10 to the S-ABS. If the AAI-HO-CMD message includes more than one T-ABS, and at least one of the T-ABSs in the AAI-HO-CMD message is reachable, the AMS shall select one of these targets and inform the S-ABS of its selection by sending an AAI-HO-IND message with HO Event Code 0b00 to the S-ABS before the expiration of Disconnect time. The S-ABS should prioritize the HO candidates by presenting the candidate ABSs in descending order of priority in the AAI-HO-CMD message.

The S-ABS defines conditions based on which the AMS decides when a T-ABS among those that are included in the AAI-HO-CMD message is unreachable. These conditions are defined as triggers with action code 0x4, as specified in 6.2.6.2.

If all T-ABSs included in the AAI-HO-CMD message are unreachable (as defined in this subclause) or if the AAI-HO-CMD message includes no T-ABS, and if the AMS has a preferred T-ABS, it may inform the S-ABS of its preferred T-ABS by sending the AAI-HO-IND message with HO Event Code 0b01. If the AMS has no preferred T-ABS to include in the AAI-HO-IND message, it may perform HO cancellation as described in 6.2.6.3.6.

If a S-ABS receives the AAI-HO-IND message with HO Event Code 0b01, it shall respond to the AMS by sending the AAI-HO-CMD message with T-ABSs that may include the T-ABS proposed by the AMS in the AAI-HO-IND message. The AMS shall wait to receive the AAI-HO-CMD message until expiration of Disconnect time unless the AMS cannot maintain communication with the S-ABS (as defined in this subclause). If the AMS cannot maintain communication with the S-ABS, it may proceed to its preferred T-ABS after sending the AAI-HO-IND message with its preferred T-ABS to the S-ABS. If after receiving a second AAI-HO-CMD message none of the T-ABSs proposed by the serving BS are reachable by the AMS, the AMS may proceed to its preferred T-ABS. If the AMS has no preferred T-ABS to include in the AAI-HO-IND message, it may perform HO cancellation as described in 6.2.6.3.6.

An AMS may request bandwidth for the residual data in the buffer before the Disconnect time. The S-ABS may send information about any unallocated requested bandwidth to the T-ABS over the backhaul so that the T-ABS may allocate the uplink resource immediately after receiving the dedicated ranging code from the AMS or after Action time if CDMA ranging is omitted when the seamless HO is enabled.

If HO_Reentry_Mode is set to 0, the S-ABS shall start the ABS_Resource_Retain_Timer at Disconnect_Time.

The S-ABS shall use the default Resource_Retain_Time value sent to the AMS in the AAI-REG-RSP or AAI-RNG-RSP message to set the ABS_Resource_Retain_Timer unless the AAI-HO-CMD message includes the Resource_Retain_Time field; in which case, it shall use the value sent in the AAI-HO-CMD message. The S-ABS shall retain the context of the AMS including connections, states of MAC state machine, and untransmitted/unacknowledged data associated with the AMS for service continuation until the expiration of the ABS_Resource_Retain_Timer or the AMS has completed network reentry or entry at another BS or ABS.

6.2.6.3.5 Network reentry

6.2.6.3.5.1 CDMA-based HO ranging procedure

The S-ABS indicates in the AAI-HO-CMD how CDMA HO ranging shall be performed by the AMS during network reentry, as shown in Figure 6-29.

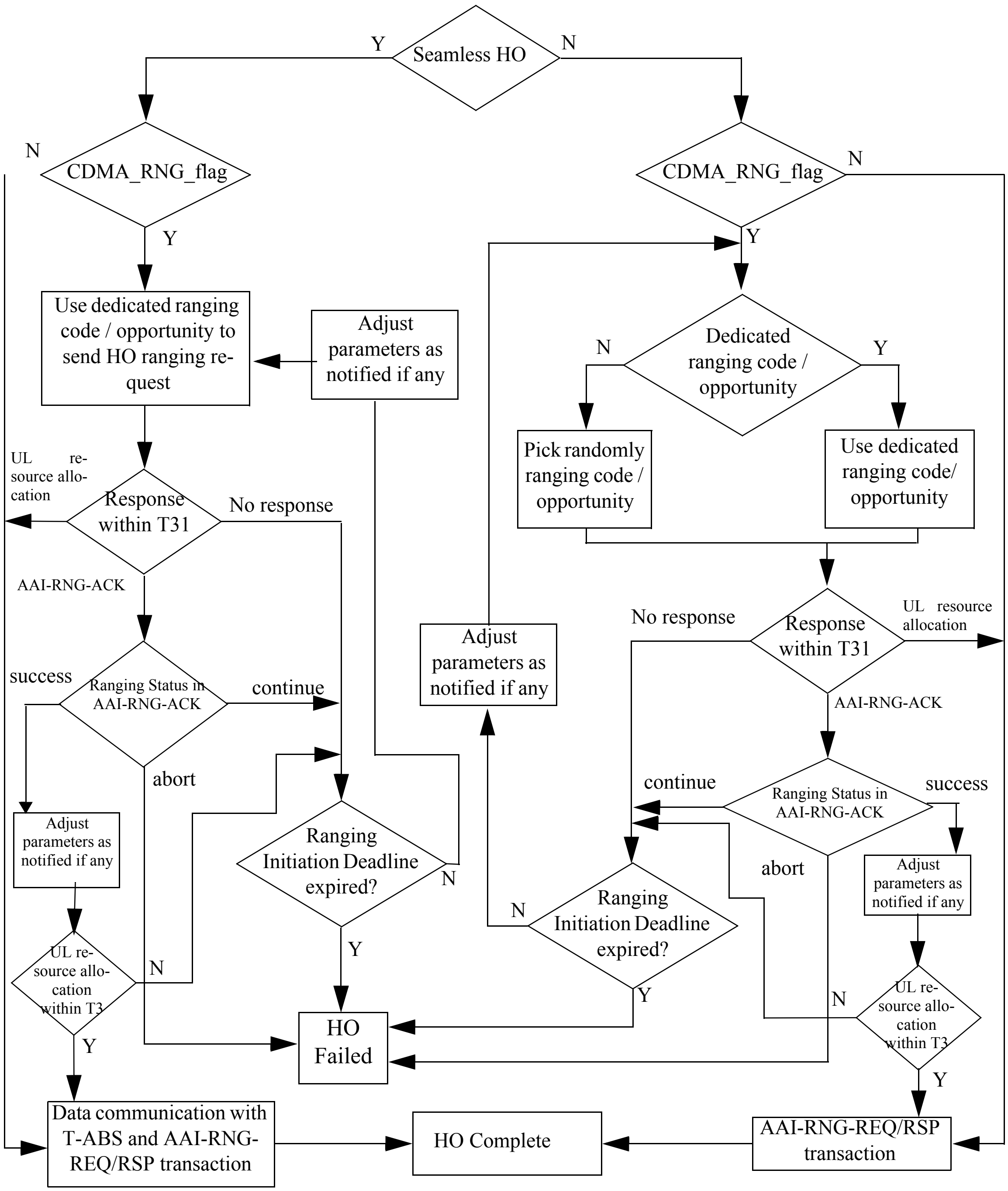


Figure 6-29—AMS network reentry procedure flow diagram

If the S-ABS indicates in AAI-HO-CMD that CDMA-based HO ranging is not omitted by setting CDMA_RNG_FLAG = 1 and a dedicated ranging preamble code is assigned to the AMS by the T-ABS, the AMS shall transmit the dedicated ranging preamble code to the T-ABS during network reentry. A T-ABS may schedule a ranging channel (opportunity) for handover purpose only if Ranging channel allocation periodicity in S-SFH SP1 is not set to 0 (i.e., every frame). If a ranging channel is scheduled by the T-ABS for handover purpose only, the S-ABS shall also inform the AMS about the resource allocation of the ranging channel, and the ranging opportunity index where the ranging opportunity is located via the AAI-HO-CMD message. In such case, the AMS should use that ranging channel. Upon reception of the dedicated ranging preamble code and if ranging is successful, the T-ABS shall allocate uplink resources for AMS to send the AAI-RNG-REQ message and/or UL data through the UL basic assignment A-MAP IE with unicast STID. If the T-ABS does not receive the dedicated ranging preamble code within the Ranging_Initiation_Deadline Timer, the T-ABS shall discard the preassigned STID of the AMS.

If CDMA-based HO ranging is not omitted and if an AMS does not have a dedicated ranging preamble code and a dedicated ranging opportunity at the T-ABS, the AMS shall transmit a random handover ranging preamble code at the earliest available ranging opportunity.

An AAI-RNG-ACK message shall be sent within the T31 Timer from the frame where at least one HO ranging preamble code is detected. If all the detected ranging preamble codes prove “success” status without UL transmission parameter adjustments needed and the ABS provides UL resource allocations to the successfully received ranging preamble codes before the T31 Timer is expired, the ABS may omit the response in the AAI-RNG-ACK.

The AMS may restart the CDMA-based HO ranging procedure when any of the following conditions is met:

— After sending the HO ranging preamble code, AMS receives neither the AAI-RNG-ACK message corresponding to the HO ranging preamble code and opportunity selected by the AMS nor UL resource allocation (i.e., Basic assignment A-MAP IE, CDMA Allocation A-MAP IE) until the T31 Timer expires.
— AMS does not receive either UL resource allocation in the T3 after receiving a success status notification or AAI-RNG-RSP in the T3 after sending AAI-RNG-REQ.
— AAI-RNG-REQ/RSP transaction is not completed in 128 frames.

If the S-ABS determines that the AMS will be sufficiently synchronized with the T-ABS and indicates in AAI-HO-CMD that CDMA-based ranging can be skipped while performing network entry at the T-ABS by setting CDMA_RNG_FLAG = 0, the AMS shall apply the independently calculated adjustments when starting network entry at the T-ABS by comparing A-Preamble signal timing measurements of the T-ABS to S-ABS measurements. If the ‘CDMA_RNG_FLAG’ is set to 0, the T-ABS shall allocate the UL resource for AAI-RNG-REQ after the Action time. The Ranging_Initiation_Deadline – Action Time provides a bounded interval during which the MS may expect UL resource allocation for AAI-RNG-REQ.

Regardless of whether CDMA ranging is omitted or not, the T-ABS may send the AAI-RNG-ACK message with timing/power adjustment parameters for which the AMS shall apply for subsequent uplink transmissions.

The ABS may dynamically allocate additional ranging opportunities for the purpose of CDMA HO ranging.

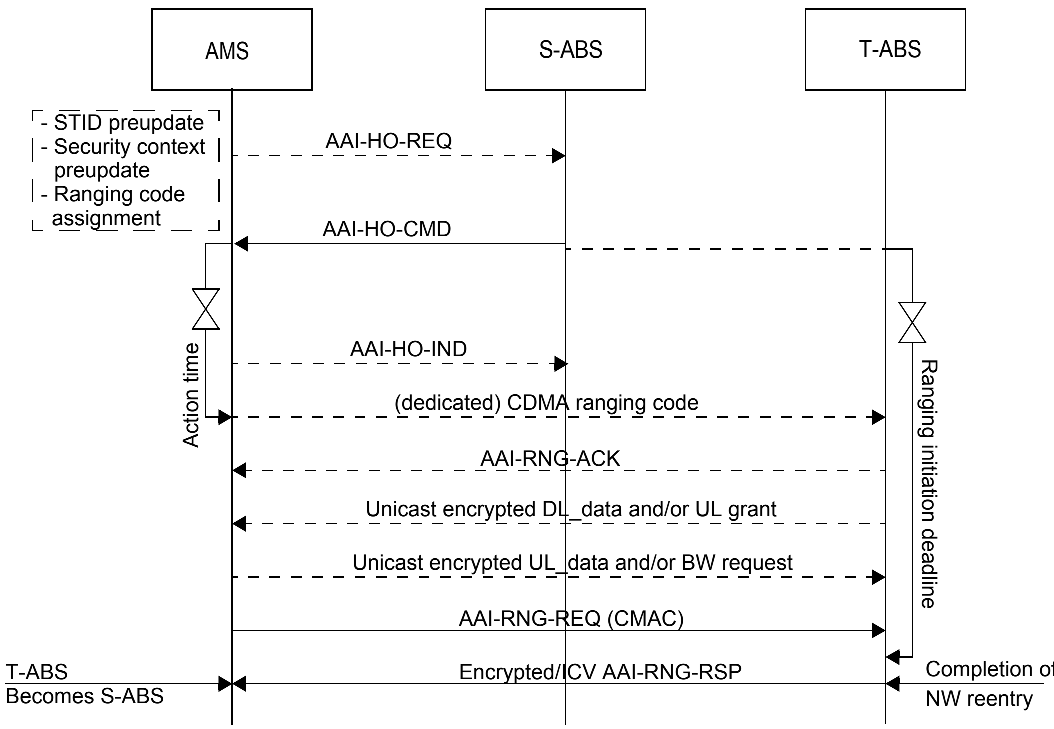
6.2.6.3.5.2 Network reentry procedure

The network reentry procedure with the T-ABS may be optimized by T-ABS possession of AMS information obtained from S-ABS over the backbone network. The T-ABS indicates to the AMS that an optimized network reentry procedure should be carried out by setting the “Reentry Process Optimization” bitmap in Table 6-30.

At the Action time specified in the AAI-HO-CMD message, the AMS performs network reentry at the T-ABS.

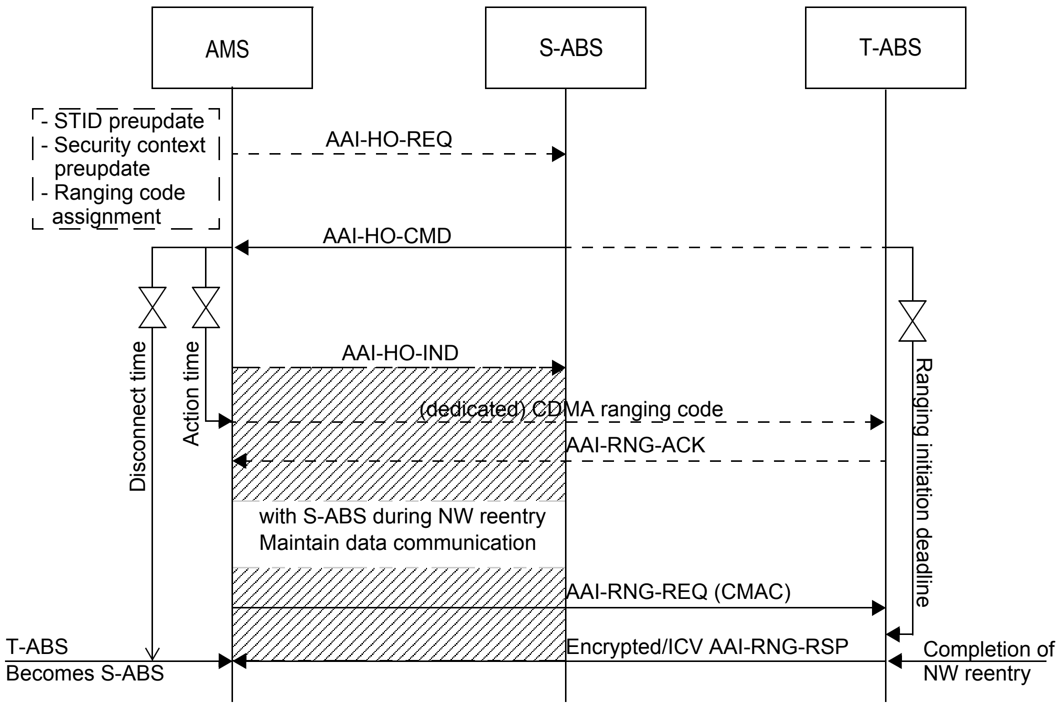
If HO_Reentry_Mode is set to 1, the AMS performs network reentry with the T-ABS at Action Time while continuously communicating with the S-ABS. However, the AMS stops communication with S-ABS after network reentry at T-ABS is completed. In addition, the AMS does not exchange data with T-ABS prior to completion of network reentry. If HO_Reentry_Interleaving_Interval > 0, the AMS communicates with the T-ABS during HO_Reenry_Interval, and with the S-ABS during HO_Reentry_Interleaving_Interval. If HO_Reentry_Interleaving_Interval = 0, the AMS performs the Multicarrier EBB HO reentry procedure per 6.2.8.2.9.2. ABS setting HO_Reentry_Interleaving_Interval = 0 is allowed only for AMS with multicarrier aggregation capabilities. Upon completion of network reentry, the T-ABS informs the S-ABS to stop allocating resources to the AMS and release AMS context.

The network reentry procedure is depicted in Figure 6-30 (HO_Reentry_Mode = 0) and Figure 6-31 (HO_Reentry_Mode = 1), respectively. This procedure corresponds to the block arrow titled "Network reentry" in Figure 6-28 and is described in detail in the following.



Network reentry procedure with HO_Reentry_Mode set to 0. Messages depicted with dotted lines are transmitted only in certain HO scenarios. The dashed line (optional) AAI-RNG-ACK carries time adjustment parameters, etc.

Figure 6-30—Network reentry procedure with HO_Reentry_Mode set to 0



Messages depicted with dotted lines are transmitted only in certain HO scenarios.
The dashed line (optional) AAI-RNG-ACK carries time adjustment parameters, etc.

Figure 6-31—Network reentry procedure with HO_Reentry_Mode set to 1

Seamless handover is the network reentry procedure in which the AMS is allowed to exchange (send or receive) data PDUs with the T-ABS before initiating the AAI-RNG-REQ/RSP transaction. As shown in Figure 6-29, if the Seamless HO flag is set for a particular T-ABS, then the AMS can send/receive data packets to/from the T-ABS before sending AAI-RNG-REQ. If the Seamless HO flag is not set for a particular T-ABS, then the AMS shall first complete network reentry at the T-ABS before sending any data packets to the T-ABS.

During network reentry, the AMS is required to initiate the AAI-RNG-REQ/RSP message transaction by sending an AAI-RNG-REQ message before the deadline specified by the “Ranging Initiation Deadline” attribute included in the AAI-HO-CMD message during handover preparation. The time is measured from the time the AAI-HO-CMD message is transmitted. If the T-ABS does not receive an AAI-RNG-REQ message from the AMS within the deadline defined by the “HO Ranging Initiation Deadline” attribute, the T-ABS considers the HO as failed and stops allocating bandwidth to the AMS. The STID shall not be assigned to another AMS until the ABS assures that the STID is no longer in use. The AMS considers the HO as failed if it does not transmit the 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 preallocated 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 T-ABS before the AAI-RNG-REQ/RSP transaction is completed, the recipient (AMS or T-ABS) should store the received data packets and not release them to the upper layers until the sender is authenticated. If the data packets belong to a service flow associated with an SA that supports data authentication (as indicated by the data authentication algorithm identifier in the cryptographic suite of the SA), the receiver can authenticate the sender by verifying that the ciphertext authentication code included in each data packet was produced with the TEK associated with this SA. If the data packets belong to a service flow associated with an SA that does not support data authentication, the receiver can authenticate the sender when the AAI-RNG-REQ/RSP transaction completes successfully. In all cases, if the sender is authenticated, the decrypted data packets are released to the upper layer in the recipient, and if the sender is not authenticated, the data packets are discarded.

If data packets are exchanged between the AMS and the T-ABS before the AAI-RNG-REQ/RSP transaction is completed, the *sender* (AMS or T-ABS) should store the sent data packets and not discard them before the *receiver* is authenticated. If a service flow from the receiver exists and that service flow is associated with the primary SA that supports data authentication, the sender can authenticate the receiver by verifying that the ICV of the data packet received was generated using the TEK associated with the primary SA. Alternatively, the sender can authenticate the other side (the receiver) when the AAI-RNG-REQ/RSP transaction completes successfully. In all cases, if the sender fails to authenticate the other side, then it shall consider all sent packets as never transmitted and retransmit them to a new ABS or AMS when a new connection is established. If the sender successfully authenticates the other side, the sender shall discard the packets that were sent and stored.

At the same ABS, an AMS shall not send HO ranging code when there is a BR pending for acknowledgment. At the same ABS, an AMS shall not send BR preamble when there is an ongoing initial/ HO ranging procedure.

The AAI-RNG-REQ/RSP transaction for HO is shown in Figure 6-31. The AMS shall initiate the AAI-RNG_REQ/RSP transaction by transmitting an AAI-RNG-REQ message to the T-ABS before the deadline specified by the “Ranging Initiation Deadline” attribute included in the AAI-HO-CMD message during handover preparation. The AAI-RNG-REQ message is protected by CMAC and shall include STID and AK_COUNT, but not include AMS MAC address or previous S-ABSID. When ABS receives the AAI-RNG-REQ message and verifies the CMAC, the ABS shall respond to the AAI-RNG-REQ message by transmitting an encrypted AAI-RNG-RSP message. The AAI-RNG-RSP message shall be addressed to the AMS’s STID. If the T-ABS evaluates a CMAC Tuple included in the AAI-RNG-REQ as valid, the T-ABS shall reply with an AAI-RNG-RSP encrypted and integrity-protected by AES-CCM. The T-ABS shall indicate that the PKM Authentication phase is omitted in the current reentry attempt through the Reentry Process Optimization in the encrypted AAI-RNG-RSP message. If the T-ABS evaluates a CMAC tuple in the AAI-RNG-REQ as invalid, the T-ABS shall reply with an unencrypted and not integrity-protected AAI-RNG-RSP containing Reentry Process Optimization bit #1 = 0 (i.e., the PKM authentication phase is not omitted).

After the AMS finishes network reentry with the T-ABS, the T-ABS becomes the S-ABS of the AMS.

In the case of an uncoordinated handover, where the AMS performs the contention-based CDMA HO ranging at the T-ABS, the AAI-RNG-REQ message shall include the previous serving BSID and previously used STID unless the AMS can determine that the ABS_Resource_Retain_Timer has expired. When the ABS receives the AAI-RNG-REQ message and verifies the CMAC, the ABS shall respond to the AAI-RNG-REQ message by transmitting an encrypted AAI-RNG-RSP message. The AAI-RNG-RSP message shall include a STID for the AMS if the STID has not been preassigned by the AAI-HO-CMD message.

Service flows for which mismatched FID information has been identified in the AAI-RNG-REQ/RSP process shall be considered as deleted by an ABS and an AMS.

6.2.6.3.6 HO cancellation

After HO is initiated, the AMS may cancel the handover at any phase during the HO procedure. The AMS may initiate HO cancellation only when it can determine that the ABS_Resource_Retain_Timer has not expired. An AMS requests HO cancellation to the S-ABS by sending the AAI-HO-IND with HO Event Code 0b11 (HO cancel) with its current AK_COUNT after Disconnect time. The S-ABS shall explicitly acknowledge to the HO cancellation message upon receiving it through the AAI-MSG-ACK message. The AAI-MSG-ACK message is triggered by setting the Polling bit to 1 in MCEH of the AAI-HO-IND message. After the HO cancellation is processed, the ABS resumes communication with the AMS.

The network can advertise HO cancellation trigger conditions. When one or more of these trigger conditions are met, the AMS cancels the HO.

6.2.6.3.7 Drops during HO

A drop during handover is defined as the situation where an AMS experiences coverage loss with its S-ABS (either in the DL or in the UL) before the normal HO procedures with the S-ABS have been completed or where an AMS experiences coverage loss with T-ABS before the network reentry procedure with the T-ABS has been completed.

When the AMS has detected a drop during network reentry with a T-ABS, it may attempt network reentry with its preferred T-ABS as through Cell Reselection, which may include resuming communication with the S-ABS by sending the AAI-HO-IND message with HO Event Code = 0b11 (HO cancel) or performing network reentry at the S-ABS.

The network reentry process at the S-ABS is identical to the network reentry process at any other T-ABS, both for the S-ABS and for the AMS. The ranging purpose indication in AAI-RNG-REQ shall be set to 0b1000. If the S-ABS has discarded the AMS context, the network reentry procedure shall be the same as full network reentry.

6.2.6.4 Handover between WirelessMAN-Advanced Air Interface and reference systems

6.2.6.4.1 Handover from WirelessMAN-OFDMA R1 Reference System to advanced system

6.2.6.4.1.1 Network Topology acquisition

6.2.6.4.1.1.1 Network Topology advertisement

An R1 BS shall broadcast the system information of the LZone of its neighboring ABS using the MOB_NBR-ADV message. This system information is used to facilitate AMS and R1 MS synchronization with the LZone of neighboring ABS without the need to monitor transmission from the neighboring ABS for DCD/UCD broadcasts.

The support of the WirelessMAN-Advanced Air Interface System in the neighbor ABS is indicated in the MAC version TLV in the MOB_NBR-ADV message transmitted in either the R1 BS or the LZone of the ABS.

An ABS uses one reserved bit in FCH to indicate the presence of its MZone, as defined in 6.10.1.1.

The ABS shall be present and the AMS shall rely on the presence of the R1 BS preamble, R1 BS FCH, and MAC version indicator with value > 9 to distinguish the AAI LZone from a WirelessMAN-OFDMA R1 Reference system.

Both LZone and MZone set MAC version to a value > 9.

The AMS may acquire full system information by scanning of the target WirelessMAN-Advanced Air Interface only System.

6.2.6.4.1.1.2 AMS scanning

The AMS shall follow the same scanning procedure as defined in 6.3.20.1.2 in IEEE Std 802.16.

In addition, an AMS may use the scanning interval to perform a scanning for the MZone of a neighboring WirelessMAN-Advanced Air Interface/WirelessMAN-Advanced Air Interface Co-existence System.

6.2.6.4.1.2 Handover procedure

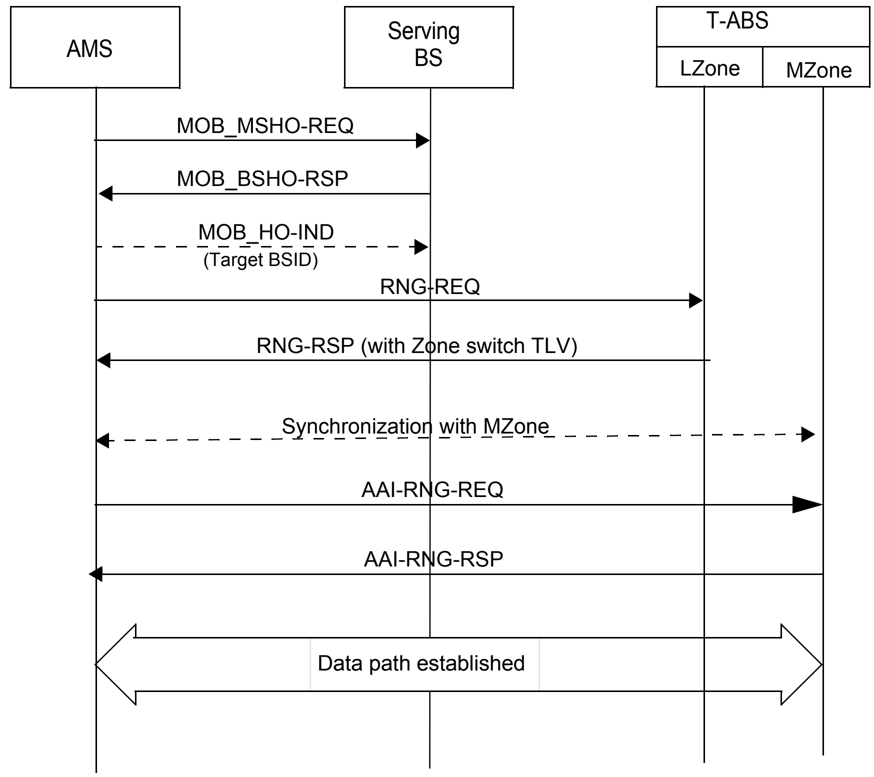
An AMS performs handover from a R1 BS to an ABS either by using the zone switching based handover process or direct handover process. The detailed procedures for zone switch based handover and direct handover are described in 6.2.6.4.1.2.1 and 6.2.6.4.1.2.2, respectively. The zone switching based handover is applicable to the ABS supporting WirelessMAN-OFDMA R1 Reference System/WirelessMAN-Advanced Air Interface Co-existing System. The direct handover is applicable to the ABS that only supports the WirelessMAN-Advanced Air Interface System. An ABS may also decide to keep an AMS in the LZone of a WirelessMAN-OFDMA R1 Reference System/WirelessMAN-Advanced Air Interface Co-existing System.

6.2.6.4.1.2.1 Zone switch based handover procedure

The zone switch based HO begins with a decision for an AMS to HO from the serving R1 BS to the LZone of a T-ABS. The HO decision, initiation, and cancellation follow the same procedures as defined in 6.3.20.2 in IEEE Std 802.16, except that Zone Switch is only initiated by the ABS for which the ABS sends an RNG-RSP message including the zone switch TLV.

The AMS performs network reentry in the LZone of the T-ABS following the same procedures as defined in 6.3.20.2.7 in IEEE Std 802.16. In addition, upon knowing the AMS capability of supporting a WirelessMAN-Advanced Air Interface System based on the MAC version obtained either from the RNG-REQ sent from AMS in the LZone or from the S-ABS over the backbone, the ABS may direct the AMS to switch from LZone to MZone during or after AMS network reentry to the LZone.

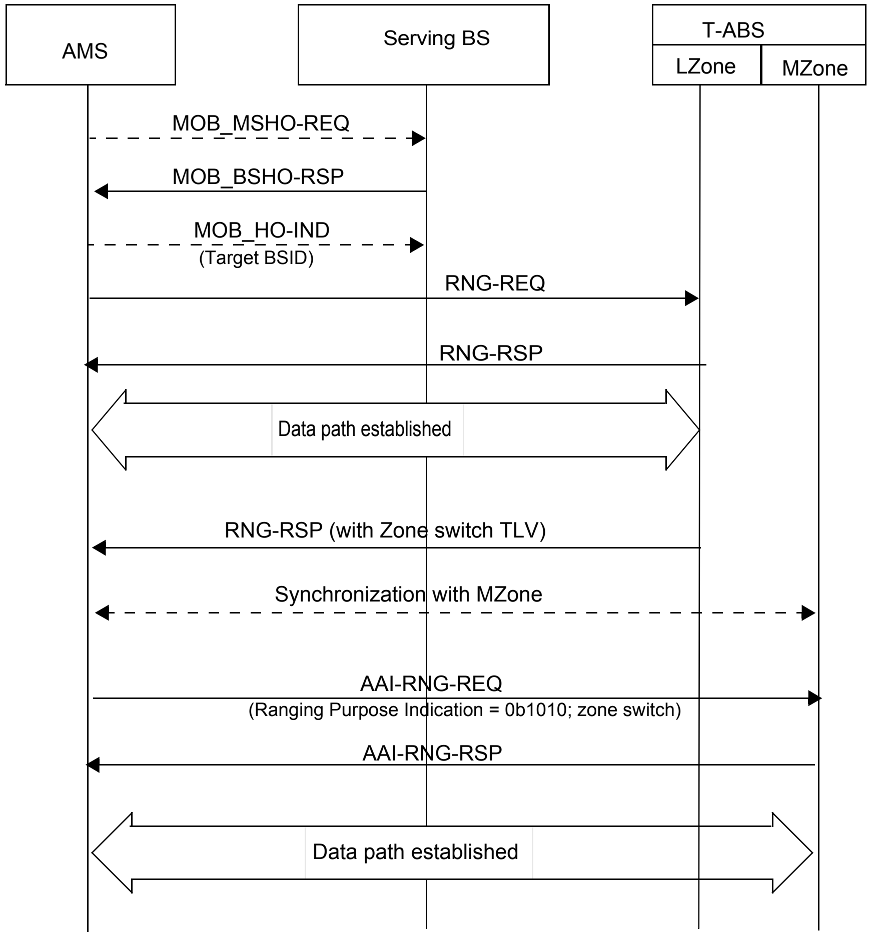
If, during network reentry in the LZone, the AMS receives an RNG-RSP message containing a Zone Switch Mode TLV with value 0x00, the AMS shall discontinue the network reentry procedure in the LZone and start the network reentry procedure in the MZone as specified in 6.2.6.3.5. The AMS shall ignore the HO process optimization bits during network reentry in the MZone. The ABS shall not schedule any data transmission for the AMS in the LZone after sending the RNG-RSP message and shall schedule control transmissions for the AMS in the LZone only to the extent necessary to ensure that the AMS receives the RNG-RSP message. This procedure, referred to as zone switch mode 0, is illustrated in Figure 6-32.



Zone Switch based handover from an R1 BS to an ABS—zone switch before network entry completion at the T-ABS

Figure 6-32—Handover procedure from R1 BS to ABS

If the ABS decides to switch the AMS to the MZone after the AMS finishes the network reentry in the LZone, it sends an unsolicited RNG-RSP with Zone Switch TLV in the LZone, as shown in Figure 6-33.



Zone switch based handover from an R1 BS to an ABS—zone switch after network entry completion at the T-ABS

Figure 6-33—Handover procedure from R1 BS to ABS

The Zone Switch parameters shall include the following and are coded as TLV tuples as defined in 6.10.2.1:

— MZone A-Preamble index.

— Time offset between LZone and MZone.

— Action Time: Action time of zone switch from LZone to MZone. AMS performs zone switch at Action Time. If Zone Switch Mode = 0, the ABS stops all resource allocation for the AMS at the LZone.

— Zone Switch Mode:. If set to 0, the AMS breaks data communication in the LZone before performing network reentry in the MZone. If set to 1, the AMS maintains its data communication with the ABS in the LZone while performing network reentry in thw MZone. The ABS may set Zone Switch Mode = 1, only if the ABS knows the AMS's capability to support this zone switch mode.

— NONCE_ABS: It is used to derive a new PMK to be used in the MZone.

The Zone Switch TLV may also include the following:

— Temporary STID for being used in the MZone

    — Ranging initiation deadline: Valid time for Temporary STID. Shall be included if Temporary STID is included.
- System information of the MZone
    — MZone's SFH TLV: SFH parameters from SP1/SP2 and SP3 required for network reentry in the MZone.

The AMS shall include its Zone Switch capability TLV information, defined in 6.10.2.2, in the RNG-REQ message if the AMS supports Zone Switch. If the AMS does not support Zone Switch, it shall not send Zone Switch capability TLV information in the RNG-REQ message. If an ABS does not receive Zone Switch capability TLV information in the RNG-REQ message from the AMS, the ABS shall not initiate Zone Switch to the AMS.

In case of Zone Switch Mode 0, the AMS performs network reentry in the MZone by performing DL synchronization with the MZone and listening to the ABS's SFH to acquire the system information of the MZone at Action Time.

The ABS may include system information parameters of the MZone (i.e., SP1/SP2 and SP3) in the Zone Switch TLV within the RNG-RSP message inthe LZone.

Upon Action Time, the data communication in the LZone is stopped. In case of Zone Switch Mode 1, the AMS receives the ABS's SFH to acquire the system information and maintains its normal operation in the LZone (e.g., exchanging user data with the ABS in the LZone) while performing network reentry in the MZone if the data path in the LZone has been established before the start of zone switch operation. The data communication in the LZone stops upon completion of network entry in the MZone.

The AMS shall protect the AAI-RNG-REQ message using CMAC if the security context is available for the MZone. The ABS then responds with the AAI-RNG-RSP message. If the ABS receives the AAI-RNG-REQ message and a valid CMAC tuple, the ABS shall respond to the AMS with the encrypted AAI-RNG-RSP message. If the CMAC in the AAI-RNG-REQ message is invalid or not included, the ABS shall trigger the AMS to initiate a network entry procedure.

The AMS shall request UL bandwidth to send the AAI-RNG-REQ by using the preassigned temporary STID if it is provided while in the LZone. Upon reception of such BR, the ABS provides a UL grant for AMS to send an AAI-RNG-REQ message. After receiving the AAI-RNG-REQ, the T-ABS responds with the AAI-RNG-RSP message.

The AMS shall also perform capability negotiation during network reentry in the MZone through the exchange of the AAI-SBC-REQ/RSP message and the AAI-REG-REQ/RSP message. AMS context mapping from LZone to MZone is performed by the ABS per 6.2.6.4.2.3.

6.2.6.4.1.2.2 Direct handover procedure

An AMS served by a R1 BS having neighboring AAI-only ABSs may discover an AAI-only ABS and decide to directly HO to this ABS. The AMS, while served by an R1 BS, may obtain target AAI-only ABS information by receiving an MOB_NBR-INFO message. In this case, the AMS performs a WirelessMAN-OFDMA R1 Reference System HO procedure from the serving R1 BS per 6.3.20.2 in IEEE Std 802.16, and then performs the WirelessMAN-Advanced Air Interface System network reentry procedure to the T-ABS per 6.2.6.3.5.2. The AMS may obtain target AAI-only ABS information by blind scanning.

If T-ABS is capable of identifying the AMS and retrieving its context, it may inform the AMS to skip certain network reentry steps using the "Reentry Process Optimization" bitmap in AAI-RNG-RSP. In this case, it is recommended that the "Reentry Process Optimization" bitmap is set to 01010 to indicate that AAI-SBC-

REQ/RSP and AAI-REG-REQ/RSP transactions are not omitted, PKM Authentication phase and IP address refresh are omitted..Otherwise, the AMS shall perform a full network entry at the T-ABS.

6.2.6.4.1.3 Context mapping

With zone switch based handover, the context management process from serving R1 BS to the LZone of the T-ABS is specified in 6.3.20.2.8.1 in IEEE Std 802.16. This subclause describes the context mapping from the LZone to the MZone of the T-ABS during the network reentry procedure in the MZone in the case of zone switch based handover, or context mapping from serving R1 BS to the T-ABS during the network reentry procedure in the T-ABS in the case of direct handover.

The ARQ context and state machine associated with serving R1 BS or the LZone shall not be used in the MZone and may be discarded upon expiration of the ABS_Resource_Retain_Timer or completion of network reentry into the MZone in both direct handover and zone switch cases. After the AMS completes network reentry into the T-ABS, the T-ABS initiates an AAI-DSC transaction to update ARQ parameters if ARQ is applied to the AMS. In this case, ARQ parameters for multiple service flows may be updated in a single AAI-DSC procedure using “Group Parameter Create/Change” parameter.

6.2.6.4.1.3.1 MAC identifiers

The FIDs for the control connections are set to 0b0000 automatically. The FIDs for the transport connections are sequentially derived starting from 0b0011 for all of the transport CIDs used in the LZone. The AMS autonomously updates its FIDs in the ascending order from the first transport Connection ID.

6.2.6.4.2 Handover from WirelessMAN-Advanced Air Interface System to WirelessMAN-OFDMA R1 Reference System

Handover of an AMS/R1 MS from the LZone of an ABS to the LZone of neighboring ABS or a R1 BS follows the same HO procedure defined in 6.3.20 in IEEE Std 802.16. The following subclause only defines the handover procedure for an AMS from the MZone of the S-ABS to a target R1 BS.

6.2.6.4.2.1 Network topology acquisition

6.2.6.4.2.1.1 Network topology advertisement

In a WirelessMAN-Advanced Air Interface Co-existing System, the ABS shall broadcast the following:

- In its LZone using the MOB_NBR-ADV message, the system information of neighboring R1 BS, and LZone of neighboring ABS
- In its MZone using the AAI-NBR-ADV message, the system information of neighboring R1 BS and LZone of neighboring ABS for cell selection

An AMS obtains the neighbor R1 BS information from the MOB_NBR-ADV message transmitted in its S-ABS LZone by using the NBR-ADV offset/interval in the AAI-NBR-ADV message, or from list of neighbor R1 BSs in the AAI-NBR-ADV message. If AAI-NBR-ADV includes NBR-ADV offset/interval information, the AMS may decode the MOB_NBR-ADV message from the LZone.

6.2.6.4.2.1.2 AMS scanning

The scanning procedure for an R1 MS/AMS served in the LZone of an ABS follows the procedure as defined in 6.3.20.1.2 in IEEE Std 802.16. The scanning procedure for an AMS served in the MZone of an ABS follows the procedure defined in 6.2.6.1.2.

6.2.6.4.2.2 Handover procedure

The handover procedure for R1 MS/AMS served in the LZone of an ABS shall follow the procedure defined in 6.3.20.2 in IEEE Std 802.16. This subclause specifies the handover process for an AMS served in the MZone of the S-ABS to a target R1 BS.

An AMS uses information acquired from the AAI-NBR-ADV message in the MZone and/or if R1 neighbor BSs are indicated in AAI-NBR-ADV, MOB_NBR-ADV messages in the LZone for cell reselection. The S-ABS may schedule scanning intervals for the AMS to conduct cell reselection activity. The cell reselection procedure follows the same procedure defined in 6.3.20.2.1 in IEEE Std 802.16.

The AMS or the ABS initiates and executes the handover using AAI-HO-REQ or AAI-HO-CMD per 6.2.6 (intra-AAI HO), if the selected T-ABS is a R1 BS. The ABS may allocate Basic CID to the AMS to be used in target R1 BS through the AAI-HO-CMD message. Based on the Basis CID, the AMS can derive its primary management CID and transport CIDs autonomously in the target R1 BS as defined in 6.3.20.2 in IEEE Std 802.16. If the AMS information is required to be transferred to the target R1 BS for handover optimization, the S-ABS shall map the AMS context to the format in the WirelessMAN-OFDMA R1 Reference System per 6.2.6.4.2.3, and provide it to the target R1 BS over the backbone. In addition, the S-ABS may indicate the time of the fast ranging opportunity negotiated with the potential target R1 BSs in the AAI-HO-CMD message. The AMS and target R1 BS use fast ranging opportunity as defined in 6.3.20.2.4 in IEEE Std 802.16. The handover cancellation procedure is performed per 6.2.6.3.6.

The AMS follows the same network reentry procedure to the target R1 BS as defined in 6.3.20.2.7 in IEEE Std 802.16. The network reentry procedure shall be the same as network reentry with HO optimization rules and scenarios defined in 6.3.20.2.10 in IEEE Std 802.16.

6.2.6.4.2.3 Context mapping

The ARQ context and state machine associated with serving the WirelessMAN-Advanced Air Interface Co-existence System MZone shall not be used in R1 BS or the LZone and shall be discarded upon completion of network reentry into the WirelessMAN-OFDMA R1 Reference System or the LZone in both direct handover and zone switch cases.

6.2.6.4.2.3.1 MAC identifiers

The AAI control connection with FID (0b0000) is mapped to Basic CID. If the Basic CID is allocated to the AMS by the target R1 BS and provided to the AMS via the S-ABS using the AAI-HO-CMD message, the AMS shall derive the Primary Management CID based on the procedure defined in 6.3.20.2.11 in IEEE Std 802.16. The connection with FID 0b0011 is mapped to the first transport connection. The AMS derives the first transport CID based on the procedure defined in 6.3.20.2.11 in IEEE Std 802.16, and it autonomously updates its remaining transport CIDs in the ascending order from FID 0b0011.

If the Basic CID is not provided to the AMS via the S-ABS using the AAI-HO-CMD message, the AMS obtains its basic, primary management and transport CIDs from the target R1 BS at the network reentry phase as specified in 6.3.20.2 in IEEE Std 802.16. The Station Identifier is released after the AMS handover to the target R1 BS.

6.2.6.4.2.4 Handover from WirelessMAN-Advanced Air Interface-Only System to WirelessMAN-OFDMA R1 Reference System

An AMS served by an AAI-only ABS may discover and handover to an R1 BS. The existence of neighbor R1 BS is indicated by the AAI-NBR-ADV message from the serving AAI-only ABS. The parameters R1 BS preamble and R1 BS ID contained in the AAI-NBR-ADV indicate the existence of a neighbor R1 BS. The AMS scans neighbor R1 BS(s) based on the indication information. After the target R1 BS is determined, the AMS leaves the WirelessMAN-Advanced Air Interface System per 6.2.6.3, and starts the WirelessMAN-OFDMA R1 Reference System network reentry procedure to the target BS. Specifically, in the AAI-HO-CMD sent from an AAI-only ABS for the HO procedure, HO reentry mode shall be 0 (unless it is an MC HO) and no dedicated ranging code is assigned for the network reentry in R1 BS.

The context mapping follows the procedure in 6.2.6.4.2.3.

6.2.6.4.2.5 Zone switch from MZone to LZone

The ABS indicates zone switch of AMSs that currently operate in the MZone for several reasons, such as load balancing purposes. The AAI-HO-CMD message is used to trigger the zone switch from MZone to LZone when HO Mode = 0b01. When the AMS is instructed by the ABS to perform zone switch from MZone to LZone, the AMS is provided with LZone information in prior, such as CID, security parameters, or capability information via the AAI-HO-CMD message in the MZone. In this case, when HO_Reentry_Mode is set to one, the AMS maintains communication with the MZone until the network reentry is finished in the LZone.

In the LZone, if an AMS received Basic CID through the AAI-HO-CMD message during Zone Switching from MZone to LZone, the CID field in the MAC header in the RNG-REQ message includes assigned Basic CID, and Serving BSID and MAC Address is not included in the RNG-REQ message. If an AMS did not receive Basic CID through the AAI-HO-CMD message during Zone Switching from MZone to LZone, Serving BSID and MAC Address shall be included in the RNG-REQ message.

If FID to CID mapping is done through the RNG-RSP message during Zone Switching from MZone to LZone, the CID Update Encodings TLV defined in 11.7.9 in IEEE Std 802.16 is included in the RNG-RSP message. If the AMS has an aGP service flow, an ABS should map the aGP service flow to a service flow of R1 scheduling type as defined in 6.2.12.7.1.1. If FID to CID mapping is not established through the RNG-RSP message, all data connections should be reestablished through the DSA exchanges after completion of network reentry in the LZone.

6.2.6.5 Handover between WirelessMAN-Advanced Air Interface System and other RAT systems

6.2.6.5.1 Inter-RAT capability negotiation

AMS's capabilities for inter-RAT operation can be negotiated with the ABS during network entry through AAI-SBC-REQ/RSP transaction.

Negotiated Inter-RAT capability is used to decide which other RAT information can be provided, and to make sure the handover procedure will be initiated only with supported other RATs.

6.2.6.5.2 Inter-RAT handover procedure

6.2.6.5.2.1 Network topology acquisition

WirelessMAN-Advanced Air Interface Systems advertise information about other RATs (RAT Type, preregistration supported, RAN information, etc.) to assist the AMS with network discovery and selection. WirelessMAN-Advanced Air Interface Systems provide a mechanism for the 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-Advanced Air Interface Systems may obtain the other access network information (RAT Type, preregistration supported, RAN information, etc.) from an information server.

The ABSs may also indicate the boundary area of the WirelessMAN-Advanced Air Interface network by providing a network boundary indication encapsulated as payload in an AAI-L2-XFER message. Upon receiving the network boundary indication and/or measured signal quality from S-ABS that it is below an inter-RAT scanning threshold, the AMS may query for Radio Access Point (RAP) 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.

6.2.6.5.2.1.1 Passive other RAT discovery

The 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 the scanning process.

The L2-Xfer payload field in the AAI-L2-XFER message may include the following:

- Preregistration supported: This field indicates whether preregistration is supported or not for Inter-RAT handover.
- Network boundary indication: This field indicates whether the ABS that is sending this message is located in the boundary area of the AAI network or not.
- RAN information: The RAN information specifies information for different radio access networks with various RATs defined by different standard bodies, including RAT type, which specifies the air interface technology type.
- RAP information: The RAP information specifies information, including carrier frequency, point of attachment (PoA) identifier, preamble, or PHY Profile ID, for different radio access points.

6.2.6.5.2.1.2 Active other RAT discovery

6.2.6.5.2.1.2.1 Active other RAT discovery with MIHF support

The AAI entity may send or receive a generic MAC container to or from the peer AAI entity in order to convey MIHF frames carrying the IEEE 802.21 MIH protocol messages. When the 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 an AAI-PKM-REQ message with the 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 the MIH Acknowledge code. This message does not contain the response to the MIH query, but contains a Cycle TLV that indicates when the response is expected to be ready for delivery to the AMS. This message also contains a Query ID, which the AMS may use to correlate the query with the response, and the delivery method (unicast or broadcast) that the ABS should use. When a unicast delivery method has been negotiated, then if the ABS is ready to transmit the MIH response, the ABS shall allocate bandwidth for the AMS in the A-MAP in the MAC frame indicated by the Cycle TLV. Upon receiving this UL allocation, the AMS shall transmit at least a bandwidth request PDU. If the AMS has no data to transmit, the BR field of the bandwidth request PDU shall be set to 0. The ABS may use the receipt of the bandwidth request PDU to assert the continued presence of the AMS. If the AMS does not send at least a bandwidth request PDU, the ABS shall abort the network entry procedure for the AMS; otherwise, it shall send an AAI-PKM-RSP message with the MIH Comeback Response code containing the encapsulated MIH response. The MIH Comeback Response message shall also contain the Query ID previously sent in the MIH Acknowledge message, which the AMS may use to correlate the MIH response with the MIH query. When a broadcast delivery method has been negotiated, then if the ABS is ready to transmit the MIH response, the ABS shall transmit an AAI-SII-ADV message containing the MIH response in the MAC frame indicated by the Cycle TLV. If the ABS is not ready to transmit the MIH response at the time indicated by the Cycle TLV, the AMS and ABS shall wait for another cycle and repeat the procedures specified in the preceding paragraph. The maximum number of times the AMS and ABS shall perform those procedures is determined by the MIH max cycles system parameter.

6.2.6.5.2.1.2.2 Active other RAT discovery using AAI scanning

The AMS may initiate other RAT discovery using the scanning procedure. The AMS may negotiate the scanning procedure before scanning commencement. If location information of the AMS and other RATs is available, the AMS may transmit its location information with the scanning request message and the network may respond with recommended RAT information based on the AMS's location information.

6.2.6.5.2.1.2.3 Generic active network discovery and selection procedure

During the target RAT selection process, the AMS may communicate with an information repository (e.g., MIH Information Server, server with pertinent inter-RAT information) using its connection to obtain operator-defined rules and preferences that affect the inter-RAT handoff decisions. The handoff policy may be preprovisioned in the AMS and may be updated when the AMS requests the information repository for network discovery and selection information. The target RAT discovery and selection procedure is shown in Figure 6-34. In Figure 6-34, the AAI-L2-XFER message may be used in steps 2, 3, 4, 6, 7, and 10 between the AMS and the ABS.

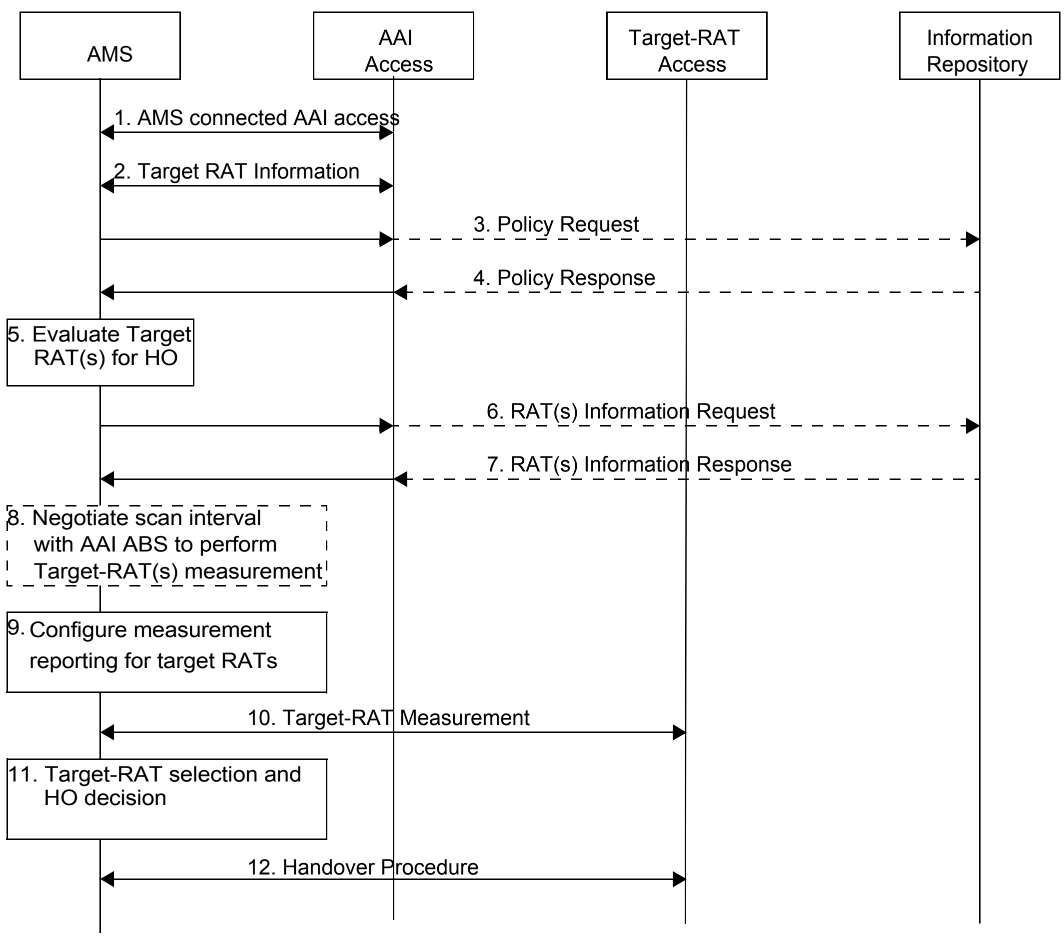


Figure 6-34—Generic target RAT discovery and selection procedure

1) The AMS is connected to the AAI 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 AAI-L2-XFER MAC control message.
3) The AMS requests the inter-RAT handover policy from the information repository.
4) The information repository provides the updated inter-RAT handover policy to the AMS.
5) The AMS evaluates target RATs for handover.
6) The AMS requests more information from the information repository. This can be a unicast information retrieval using MIH messages.
7) The information repository provides information about target RATs as requested by the AMS.
8) In the single-radio case, the AMS negotiates with the AAI ABS about scan intervals by exchanging AAI-SCN-REQ and AAI-SCN-RSP so that it can evaluate the link connections at target RATs.
9) The device configures measurement reporting for target RATs.
10) The AMS conducts measurements and reports the results to the AAI Access.
11) The AMS in conjunction with the ABS and target access conducts the handover procedure.
12) The AMS performs handover to the target RAT

6.2.6.5.2.2 Generic inter-RAT HO procedure

The WirelessMAN-Advanced Air Interface System may forward handover related messages to systems based on external specifications such as 3GPP, 3GPP2, and IEEE Std 802.11. The specifics of these handover messages may be defined elsewhere, e.g., IEEE Std 802.21.

6.2.6.5.2.2.1 Generic other RAT MAC container

Generic other RAT MAC containers are used to convey other RAT control messages as specified in external standards.

6.2.6.5.2.2.2 Measurements

While the AMS is attached to the AAI network and is in active mode, the AMS may need to perform radio measurements on other RATs when directed by the AAI network. The AAI network will provide the AMS required neighbor cell list information and measurement controls. When needed, the AAI ABS will be responsible for configuring and activating the measurements on the AMS via dedicated signaling message with appropriately defined IEs.

For single-radio AMSs, measurement gaps may be needed to allow the AMS to switch to the other RAT and do radio measurements. These measurement gaps may be AMS-controlled or network-controlled. In case of network-controlled scenarios, the AAI ABS is responsible for configuring the gap pattern and providing it to the AMS through dedicated signaling. AMSs can send the bandwidth request to the S-ABS to request to terminate the measurement and resume original DL and UL transmission. Upon receiving the bandwidth request, the ABS could also grant additional UL resources to the AMS for making a measurement report. AMSs with a dual receiver can perform measurements on other RATs neighbor cells without tuning away from the AAI network.

In order to assist the AAI ABS, the AMS shall inform the system of its gap-related capabilities. This capability needs to be transferred along with other AMS capabilities. The AMS needs to indicate if it has a dual receiver. In cases that the measurement gaps are not required, the AAI ABS can request measurements on cells of other RATs without the need to configure measurement gaps. No DL gap patterns will be required for AMSs that are capable of simultaneous reception on the involved frequency bands. No UL gap patterns will be required for AMSs that are capable of simultaneous transmission in one access and of conducting measurements on another access.

6.2.6.5.2.2.2.1 Scanning

When the AMS's location information is available, the 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 the following:

- AMS: When the serving channel quality on current RAT falls below a certain threshold
- ABS: The S-ABS may direct the AMS to perform scanning via scanning control signaling

6.2.6.5.2.2.2.2 Measurement parameters

The AMS may measure the following parameters when considering handover to IEEE Std 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

6.2.6.5.2.2.2.3 Measurement reporting

After completion of scanning, the AMS may report scanning results to an S-ABS via AAI-SCN-REP.

6.2.6.5.2.3 Enhanced inter-RAT HO procedure

6.2.6.5.2.3.1 Dual-transmitter/dual-receiver support

An AMS with dual-radio support may connect to both an ABS and a PoA operating on other RATs 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 S-ABS is kept alive until handover completes.

In this mode, a dual-radio device may receive and transmit simultaneously on both radios. Since both radios may be active simultaneously, these types of devices may connect to a target network to prepare resources while maintaining the connection with the source network during handover.

6.2.6.5.2.3.2 Single-transmitter support

An AMS with a single transmitter may connect to only one RAT at a time. Once target RAT preparation is completed, the AMS may switch from source RAT to target RAT and complete network entry in target RAT.

In this mode, an AMS can transmit on one RAT at a time. Control signaling messages for the target RAT are exchanged between the single-radio AMS and the target RAT, by encapsulating the target RAT signaling messages in an AAI-L2-XFER message.

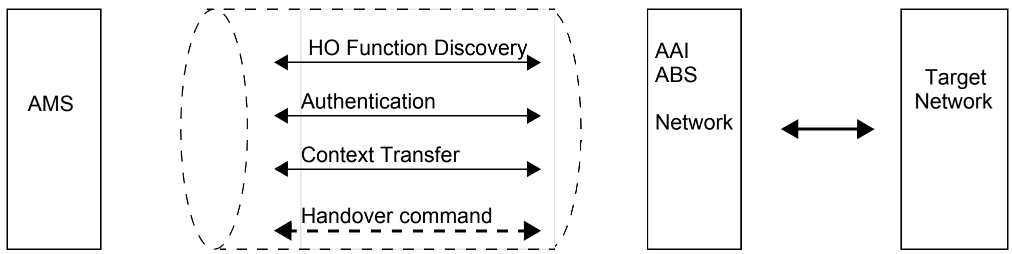


Figure 6-35—Control signaling through MAC container

6.2.6.5.2.3.2.1 Handover execution and completion

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

6.2.7 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 an AMS, the ABS shall transmit the DL Persistent Allocation A-MAP IE for DL allocations and the UL Persistent Allocation A-MAP IE for UL allocations. For a UL-persistent allocation, the AMS should give the intended service flow higher priority to carry data on the allocated resource, if the necessary flow information is available, e.g., through the HARQ channel mapping scheme as specified in 6.2.12.12.7. The configuration parameters of the persistently allocated resource shall be maintained by the ABS and AMS until the persistent assignment is deallocated, 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 each DL retransmission shall be allocated using a DL Basic Assignment A-MAP IE. Resources for a UL retransmission shall be allocated using a using a UL Basic Assignment A-MAP IE only when control information for the retransmission changes.

6.2.7.1 Allocation mechanism

For persistent allocation in the DL/UL, the ABS shall transmit the DL/UL Persistent Allocation A-MAP IE. Allocation of the persistently assigned resource shall begin in the DL/UL AAI subframe that is referenced by the DL/UL Persistent Allocation A-MAP IE and repeats after an allocation period that shall be specified in the DL/UL Persistent Allocation A-MAP IE. The configuration parameters of the persistently allocated resource shall be maintained as per the DL/UL Persistent Allocation A-MAP IE. The values of ACID and N_ACID configured in the DL/UL Persistent Allocation A-MAP IE shall be used together to specify an implicit cycling of HARQ channel identifiers. At the initial transmission with the DL/UL Persistent Allocation A-MAP IE, the ACID of the HARQ burst is set to the value specified in the Initial_ACID field of the DL/UL Persistent Allocation A-MAP IE. From the next new transmission, the ACID of the HARQ burst is incremented by 1, and cycled within the range of [Initial_ACID, Mod (Initial_ACID + N_ACID–1, 16)], where the Initial_ACID is the starting ACID value at the initial transmission. If the retransmission process for the previous HARQ burst is not completed before a new HARQ burst with the same ACID is transmitted, the retransmission process for the previous HARQ burst is terminated and the new HARQ burst overrides it.

In order to facilitate link adaptation and avoid resource holes, the configuration parameters of a persistently allocated resource can be changed. To change a persistent assignment, the ABS shall transmit the DL

Persistent Allocation A-MAP IE for DL reallocation and the UL Persistent Allocation A-MAP IE for UL reallocation, respectively. If an AMS has an existing persistent allocation in a particular AAI subframe and receives a new persistent allocation in the same AAI subframe, the new persistent allocation shall replace the original allocation (i.e., the original persistent allocation is deallocated).

When the ABS sends a DL Persistent Allocation A-MAP IE to reallocate a persistently assigned resource on the DL, a different HARQ feedback channel must be assigned in the Persistent Allocation A-MAP IE used for reallocation. If an ACK for the reallocated DL data burst is detected in the newly assigned HARQ feedback channel, the ABS may assume that the DL Persistent Allocation A-MAP IE that signaled the reallocation was correctly received. The same reallocation DL Persistent Allocation A-MAP IE may be retransmitted after a subsequent allocation period if an ACK is not received.

If the reallocated data burst identified by the UL Persistent Allocation A-MAP IE is successfully decoded, the ABS may assume that the UL Persistent Allocation A-MAP IE that signaled the reallocation was correctly received. The same reallocation UL Persistent Allocation A-MAP IE may be retransmitted after a subsequent period if the reallocated data burst is not decoded successfully.

6.2.7.2 Deallocation mechanism

For deallocation of persistent allocations in the DL/UL, the ABS shall transmit the DL/UL Persistent Allocation A-MAP IE. When the allocation period is set to 0b00 in the DL/UL Persistent Allocation A-MAP IE, the assigned persistent resource in the DL/UL Persistent Allocation A-MAP IE shall be deallocated in the referenced DL/UL AAI subframe and the ABS and AMS shall terminate the persistent allocation.

When the ABS sends a DL PA A-MAP IE to deallocate a persistently assigned resource on the DL, a different HARQ feedback channel must be assigned in the Persistent Allocation A-MAP IE used for deallocation. The AMS shall transmit an ACK in the newly assigned HARQ feedback channel to confirm that the DL Persistent Allocation A-MAP IE that signaled the deallocation was received correctly. The same deallocation DL Persistent Allocation A-MAP IE may be retransmitted after a subsequent allocation period if an ACK is not received.

6.2.7.3 HARQ retransmissions

Asynchronous HARQ retransmission shall be used for downlink persistent allocations. The DL Basic Assignment A-MAP IE shall be transmitted to signal control information for HARQ retransmission. Synchronous HARQ retransmission shall be used for uplink persistent allocations. The UL Basic Assignment A-MAP IE may be transmitted to signal control information for HARQ retransmission.

6.2.7.4 Error handling procedure

For transmissions with HARQ enabled, an ACK is transmitted to acknowledge the successful decoding of a data burst, or a NACK is transmitted to notify failure in decoding a burst transmitted on the DL/UL. If an ACK for the data burst identified by the DL Persistent Allocation A-MAP IE is detected in the HARQ Feedback channel assigned to the associated HARQ process, the ABS may assume that the DL Persistent Allocation A-MAP IE is correctly received by the AMS. If the initial data burst identified by the UL Persistent Allocation A-MAP IE is successfully decoded without any additional transmission of the UL basic assignment A-MAP IE for retransmission, the ABS may assume that the UL Persistent Allocation A-MAP IE is correctly received.

When NULL detection is used, in the absence of an ACK or a NACK in the HARQ feedback channel assigned in the DL Persistent Allocation A-MAP IE for the data burst, the ABS assumes that the AMS has not received the DL Persistent Allocation A-MAP IE and the same DL Persistent Allocation A-MAP IE may be transmitted again after a subsequent allocation period.

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

In the absence of the UL data burst in the resource assigned by the UL Persistent Allocation A-MAP IE, the UL data burst transmitted by the AMS is not successfully decoded at the ABS, but may be detected as a NULL. In such a case, the ABS assumes that the AMS has not received the UL Persistent Allocation A-MAP IE and the ABS may transmit the same UL Persistent Allocation A-MAP IE again after a subsequent allocation period. In order to ensure that resource assignment information for subsequent persistent allocations is received correctly, if the initial data burst identified by the UL Persistent Allocation A-MAP IE cannot be decoded successfully after N_MAX_ReTX HARQ retransmissions, and no subsequent persistent allocation is decoded successfully, the same UL Persistent Allocation A-MAP IE may be transmitted again after a subsequent allocation period.

6.2.8 Multicarrier operation

6.2.8.1 Multicarrier types and operational modes

When supporting multicarrier operations, the following two types of carriers are defined from an AMS point of view:

- Primary carrier: A primary carrier is a standalone carrier where the AMS completes the initial network entry or network reentry procedure. When supporting multicarrier operations, an AMS shall only have one primary carrier and may be assigned with multiple secondary carriers. Except the special handling of PHY control related MAC control messages as defined in 6.2.8.2.8 and 6.2.8.2.8.1, all the unicast MAC control messages relative to multicarrier operations shall be sent to the AMS through its primary carrier.
- Secondary carrier: Secondary carriers are additional carriers that may be assigned to the AMS by the ABS.

When supporting multicarrier operations, a common MAC in the ABS may utilize the radio resources in the primary carrier and one or more of the secondary carriers. The mobility, MAC state, and context of the AMS are managed and controlled by the ABS through the primary carrier.

For the TDD system, each available duplexed frequency channel is individually referred to as a carrier using a physical carrier index. For the FDD system, each available paired downlink and uplink frequency channel or downlink-only frequency channel is individually referred to as a physical carrier index. A physical carrier index is the index assigned for indicating all the available carriers across the entire network and is indexed from lower frequency to higher frequency.

Each physical carrier 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. The fully configured carrier shall be supported by all the AMSs regardless of the support of multicarrier.
- Partially configured carrier: A carrier configured for a downlink-only transmission. The partially-configured carriers may be used only in conjunction with a primary carrier and cannot operate standalone to offer AAI services for an AMS.

A primary carrier is fully configured, while a secondary carrier may be fully or partially configured depending on deployment scenarios. Whether a carrier is fully configured or partially configured is indicated using the PA-Preamble of the carrier. The AMS shall not attempt to perform network entry or handover over the partially configured carriers.

A secondary carrier for an AMS, if fully configured, may serve as the primary carrier for other AMSs. The multiple AMSs with different primary carriers may also share the same physical carrier as their secondary carrier. The following multicarrier operation modes are identified, which may all or independently be supported:

- Multicarrier aggregation: The multicarrier mode in which the AMS maintains its physical layer connection and monitors the control signaling on the primary carrier while proceeding data transmission on the secondary carrier. The resource allocation to an AMS may span across a primary and multiple secondary carriers. Link adaptation feedback mechanisms are independently operated for each carrier. In this mode, the system may assign secondary carriers to an AMS in the downlink and/or uplink asymmetrically based on AMS capability, system load (i.e., for static/dynamic load balancing), peak data rate, or QoS demand.
- Multicarrier switching: The multicarrier mode in which the AMS switches its physical layer connection from the primary to the partially configured or fully configured secondary carrier by the ABS's instruction to receive E-MBS services on the secondary carrier. 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 transmission or reception through the primary carrier.
- Basic MC mode: The basic MC mode in which the AMS operates only with single carrier but shall support the primary carrier change procedure as well as optimized scanning of carriers involved multicarrier operation.

An AMS that supports at least one of the above multicarrier modes is called multicarrier AMS; otherwise, it is called single-carrier AMS.

The following is the general scenario considered for all multicarrier operations:

- The system defines N standalone fully configured carriers; each configured with all synchronization, broadcast, multicast, and unicast control signaling channels needed to support a single-carrier AMS. Each AMS in the cell is connected to, and its state is controlled by, its primary carrier.
- The system may also define M ($M \geq 0$) partially configured carriers, which can only be used as secondary carriers along with a primary carrier, for downlink-only data transmissions.
- The set of all supported carriers in an ABS is called "available carriers."
- The available carriers may be in different parts of the contiguous spectrum block or in noncontiguous spectrum blocks.
- Subset of available carriers is designated as assigned carriers, which are able to be activated for data transmission.
- Subset of assigned carriers is designated as active carriers, which are activated from assigned carrier, and used for data transmission between AMS and ABS.
- In addition to the information about the primary carrier, an ABS can also provide AMSs with some configuration information about its available carriers through such primary carrier by AAI-Global-CFG and AAI-MC-ADV messages.

6.2.8.2 MAC operation

6.2.8.2.1 Addressing

A multicarrier supporting ABS or AMS follows the same MAC addressing mechanism defined in 6.2.1.

6.2.8.2.2 Security

A multicarrier supporting AMS follows the same security procedure defined in 6.2.5. All the security procedures between an AMS and an ABS are performed using the AMS's primary carrier. The security context created and maintained by the procedures is managed per ABS through the primary carrier.

6.2.8.2.3 Network entry

The network entry in multicarrier mode is the same as single-carrier mode as defined in 6.2.15, where the AMS and ABS also indicate their support for multicarrier modes during the registration. An AMS can only perform network entry (or network reentry) procedures with a fully configured carrier. Once the AMS detects the A-PREAMBLE on a fully configured carrier, the AMS may proceed with reading the SFH or the AAI-SCD message.

During the initial network entry, the AMS will inform the ABS of its support of multicarrier transmission by AAI-REG-REQ message and the ABS will indicate if it supports any multicarrier modes for that AMS through the AAI-REG-RSP message. The basic multicarrier capability exchange uses a 3-bit code in the AAI-REG-REQ/RSP message as defined in 6.2.3.8 and 6.2.3.9.

The Basic MC mode involves AMS awareness of multicarrier operation at the ABS that includes support for primary carrier changes as defined in 6.2.8.2.11.2 as well as optimized scanning of carriers involved in multicarrier operation defined in 6.2.8.2.9.

The procedure for initialization of an AMS, following network entry, to prepare for subsequent multicarrier operation shall be as shown in Figure 6-36. This procedure includes the following:

— Obtaining the multicarrier configuration for available carriers at the ABS
— Obtaining information about Assigned Carriers consisting of two steps:
    1) Provide the ABS with information on the AMS's supportable carriers and their combined multicarrier configurations.
    2) Obtain information about the subset of available carriers, hereby referred to as the assigned carriers, which the ABS may utilize in subsequent multicarrier operations for that AMS.

The AMS does not perform any MAC or PHY processing on an assigned carrier until such a carrier is activated per ABS's direction.

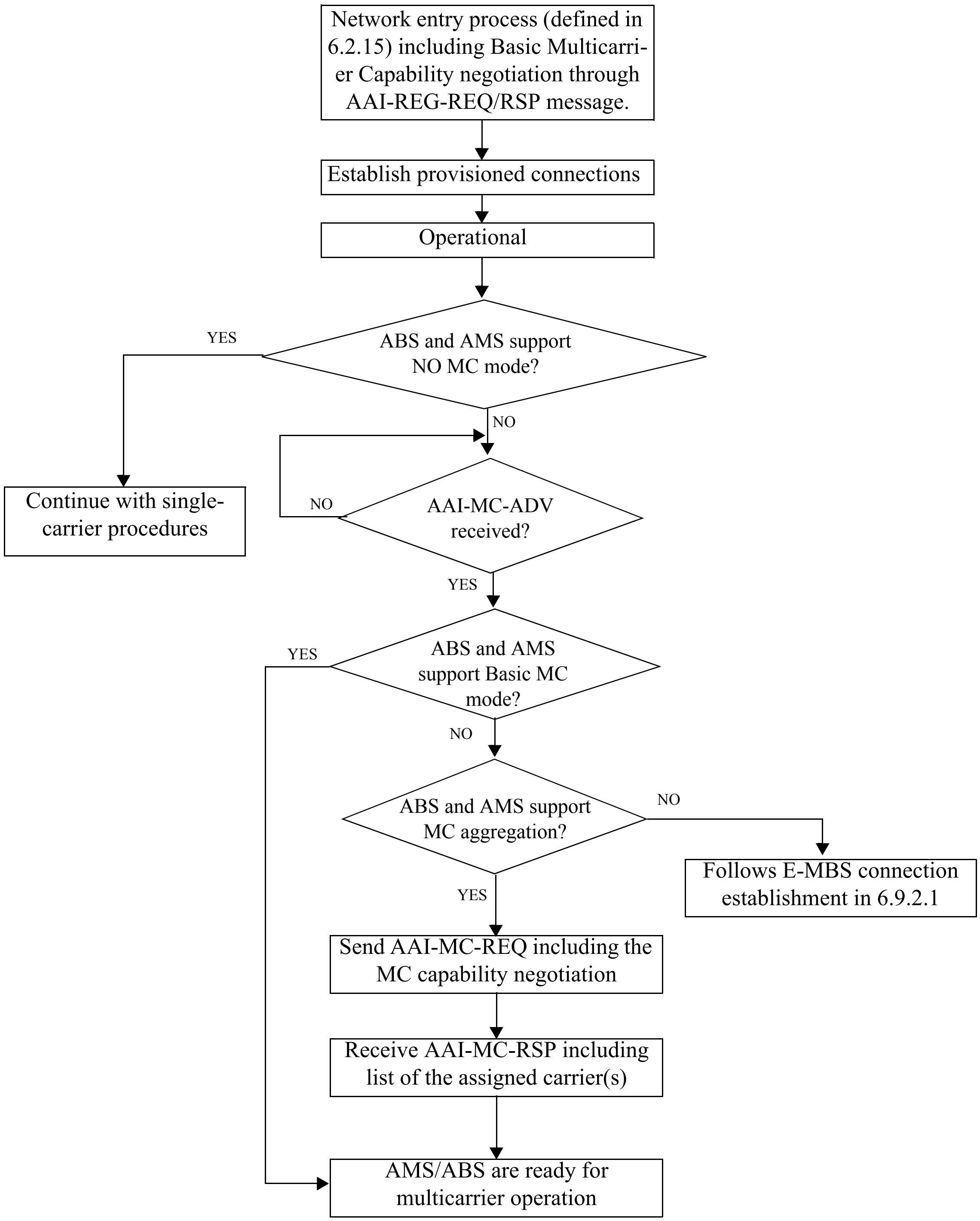


Figure 6-36—AMS initialization overview to support multicarrier transmission

6.2.8.2.3.1 AMSs obtaining MC configuration

The ABS will broadcast the SFH on each carrier with the format defined in 6.3.6.2.1. The ABS shall unicast the AAI-Global-CFG message to an AMS after transmitting the AAI-REG-RSP message. The AAI-Global-

CFG message provides the carrier information for all available carriers in the network. The ABS shall also provide the AMS with a basic radio configuration for all available carriers in the ABS through the AAI-MC-ADV message by using the physical carrier index defined in the AAI-Global-CFG message. This message is periodically broadcast by the ABS, which includes the configurations supported by the ABS. The multicarrier configuration information is relevant to and shall be used by all AMSs in any multicarrier mode or in single-carrier mode.

6.2.8.2.3.2 Secondary carrier assignment

After the initial network entry procedure defined in 6.2.8.2.3 and obtaining the information about the ABS's multicarrier configurations, the AMS shall send the AAI-MC-REQ message to the ABS if the AMS and the ABS both support MC aggregation (i.e., multicarrier capabilities in AAI-REG-REQ/RSP are set to 0b010 or 0b100). The AMS shall inform the ABS of its capability on multicarrier support by the parameters defined in the AAI-MC-REQ message. Based on the AMS's multicarrier capabilities informed in the AAI-MC-REQ message, the ABS shall reply to the AAI-MC-RSP message to assign one or more carriers from its available carriers to the AMS as the assigned secondary carriers. To support E-MBS for an AMS, any carriers (i.e., mixed or dedicated carrier) used for E-MBS service are assigned using AAI-DSA described in 6.2.3.47.

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

6.2.8.2.4 Ranging

In some cases, the AMS may not be able to communicate with the ABS over the secondary carrier(s) without ranging to adjust time/frequency synchronization and power for the carrier(s). If the channel correlations between the primary and the secondary carriers are very high, the transmission parameters of the secondary carrier(s) could be quite similar with those of the primary carrier. If the AMS already completed the network entry with the ABS over the primary carrier, it does not need to perform the initial ranging over the secondary carrier(s). Therefore, only the periodic ranging instead of initial ranging may be performed over the secondary carrier(s). Once the secondary carriers are activated, the AMS may perform the periodic ranging over the active secondary carrier(s) if directed by the ABS in AAI-CM-CMD at secondary carrier activation.

When the AMS omits the ranging for the secondary carrier(s), the AMS may use the same timing, frequency, and power adjustment parameters for the secondary carrier(s) as in the primary carrier for initial transmission. The AMS may perform the fine timing, frequency, and power adjustment on the secondary carrier(s) through measuring the synch channel and/or pilot on the secondary carrier(s).

CDMA initial/periodic ranging with a fully configured carrier shall be the same as defined in 6.3.10.3.1 and 6.3.10.3.2. CDMA handover ranging shall be done only with one of the fully configured carriers of T-ABS.

6.2.8.2.5 MAC PDU processing

The construction and transmission of MAC PDU is the same as that in single-carrier operation. For each service flow, the ARQ operates for a common MAC as defined in 6.2.13.

MAC data shall be processed as defined for a single-carrier physical layer operation and can be mapped to the data region in one of the primary or secondary carriers. The A-MAP IE shall be sent through the carrier where the OFDMA data region is located. The A-MAP IE is the same as the one defined in 6.3.5.5.

6.2.8.2.6 Bandwidth request and resource allocation

6.2.8.2.6.1 Bandwidth request

All bandwidth requests that are transmitted on the AMS's primary carrier follow the same procedures as defined in 6.2.11. When a bandwidth request is sent on AMS's secondary carrier using a contention-based procedure, this indicates that the AMS requests an uplink grant specifically for this secondary carrier. A bandwidth request using piggyback may be transmitted in MAC PDUs over the secondary carrier(s) as well as the primary carrier, but the requested bandwidth is not specifically restricted to a particular carrier.

6.2.8.2.6.2 Resource allocation

The ABS may allocate downlink or uplink resources that belong to a specific active carrier or a combination of multiple active carriers based on available resources, QoS requirements, channel quality, and other factors. The multicarrier resource assignment for carrier aggregation shall use the same A-MAP IEs as the single-carrier mode, where A-MAP IEs for each active carrier are transmitted in the respective carrier.

6.2.8.2.7 QoS and connection management

The STID and all FIDs assigned to an AMS are unique identifiers for a common MAC and used over all the carriers of the AMS. The service setup/change messages (i.e., DSx messages) are transmitted only through the AMS's primary carrier. The service flow is defined for a common MAC entity, and the 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.

6.2.8.2.8 DL/UL PHY level control and UL feedback channel allocation

An ABS may assign UL feedback channels to each active carrier of an AMS as defined in 6.3.5.5.2.4.

In multicarrier aggregation with fully configured carriers, an ABS may assign feedback channels to each active carrier of an AMS. When a feedback channel is assigned, the AMS feedbacks HARQ ACK/NACK and CINR for an active carrier over the assigned feedback channel of the corresponding carrier at the feedback region as defined in 6.3.7.3.3.

When only DL of a fully configured secondary carrier for an AMS has been activated by the AAI-CM-CMD message, the UL feedback channel assigned by the ABS is located at the UL feedback region defined in the SFH on the primary carrier. In this case, the ABS may allocate for an AMS one UL feedback channel per a secondary carrier over a primary carrier. The HFBCH index is calculated by using the HFBCH index parameter transmitted in the non–user-specific A-MAP IE on the primary carrier of the AMS, HFAs that are signaled in the A-MAP IE on the secondary carrier, and L_{HFB} that is signaled in S-SFH SP1 on the primary carrier. If the AMS receives Feedback Allocation A-MAP IE through the DL-only activated carrier, the AMS transmits the UL feedback information for the secondary carrier over the assigned UL Fast Feedback channel of the primary carrier.

In multicarrier aggregation with the DL-only secondary partially configured carrier, the ABS directs the AMS to feedback HARQ ACK/NACK and CINRs of active DL-only secondary carriers through feedback channel(s) on the primary carrier at the feedback region. The feedback region is indicated using the physical carrier index for the primary carrier, the start DLRU index for feedback channel, the number of DLRUs for feedback channel, and the number of HARQ feedback channels per HARQ feedback region in the AAI-SCD message that is transmitted on the active DL-only secondary partially configured carrier. The feedback region of the active DL-only secondary partially configured carrier follows the feedback region of the primary carrier. In multicarrier aggregation with multiple active DL-only secondary partially configured carriers for DL unicast traffic, each active DL-only partially configured carrier is allocated with a distinct non-overlapping UL feedback region in the UL of the primary carrier for the AMSs to transmit HARQ ACK/NACK and fast feedback information.

The MIMO measurement/report-related MAC control messages and headers (AAI-SBS-MIMO-FBK, AAI-MBS-MIMO-FBK, MIMO Feedback header, Correlation Matrix Feedback header) are transmitted in the uplink grant indicated by Feedback Polling A-MAP IE. For fully configured carriers in multicarrier aggregation mode, the uplink grant made with a Feedback Polling A-MAP IE is always allocated from the corresponding downlink active carrier base on the linkage defined in SFH. For a Feedback Polling A-MAP IE on a partially configured carrier in multicarrier aggregation mode, the uplink grant is always assigned on the primary carrier.

The PHY level control not related to MIMO feedback shall be processed per each active carrier. A MAC signaling header or MAC control message not for MIMO feedback may be transmitted over any available uplink grant among any active carrier. A 6-bit carrier index may be included to indicate the corresponding carrier with which this control message or signaling header is associated. The following MAC signaling header and MAC control message are processed in the following way:

— MAC signaling header: Uplink Power Status Report
— MAC control message: AAI-FFR-CMD, AAI-FFR-REP, AAI-UL-PSR-CFG, AAI-UL-POWER-ADJ

6.2.8.2.8.1 Carrier-specific PHY control mode

In order to save overhead, the ABS may choose to broadcast certain restrictions for the transmission of a PHY control related MAC message/header, by indication bit of “carrier-specific PHY control mode” in the AAI-MC-ADV message.

With “carrier-specific PHY control mode” bit set to 0b1, an AMS shall transmit a non-MIMO feedback related MAC control message and MAC signaling header, i.e., Uplink Power Status Report header, and AAI-FFR-REP message through the uplink active carrier corresponding to the DL carrier with which the measurement report of the message/header is associated. In addition, the ABS shall transmit DL PHY control MAC messages, i.e., AAI-FFR-CMD, AAI-UL-PSR-CFG, and AAI-UL-POWER-ADJ, in the downlink active carrier corresponding to the uplink carrier that is relevant to the MAC control message.

In the carrier-specific PHY control mode, the 6-bit carrier index shall not be included in the MAC control message. In addition, the carrier index in the MAC signaling header shall be set to the carrier index of the carrier on which the header is transmitted.

6.2.8.2.9 Handover

The multicarrier handover (MCHO) is defined as the handover procedure that involves multiple radio carriers. An AMS with multicarrier capability may follow the single-carrier handover procedure per 6.2.6. It may also decide to perform the MCHO procedure as defined in this subclause.

For an AMS supported multicarrier aggregation, it shall use its Primary Carrier as reference for S-ABS scanning and follow the trigger/action defined for its Primary Carrier obtained by AAI-SCD broadcast on its Primary Carrier for handover or scanning related operations.

The trigger function 0x7 can only be used with Action 0x1 for the purpose of receiving a scan report for the neighbor ABSs’ carriers that may be supported within the AMS’s multicarrier capability. The trigger function 0x7 with trigger action 0x1 (respond on trigger with AAI-SCN-REP) may be applied by considering whether the number of the neighbor ABS’s carriers of which CINR/RSSI measurement is larger than an absolute value is higher than a threshold value, where the threshold value for the “number of neighbor ABS’s carriers” can be either AMS-specific or ABS-specific. When the ABS-specific threshold value for the “number of neighbor ABS’s carriers” is applied, the S-ABS will configure it through “Number of neighbor ABS’s carriers for ABS-specific MC trigger” field in AAI-MC-ADV. For AMS-specific, Number of neighbor ABS’s carriers for AMS-specific MC trigger is equal to each AMS’s active carriers. The ABS-specific value is used for the S-ABS’s purpose of instructing AMSs to trigger a scanning report of the neighbor ABS’s carriers. If the ABS-specific threshold value is configured, either the ABS-specific MC trigger or the AMS-specific MC trigger is met, the AMS shall send its scan report to the S-ABS. Alternatively, if the ABS-specific threshold value is not configured, the AMS shall send its scan report to the S-ABS when the AMS-specific MC trigger is met.

6.2.8.2.9.1 Network topology acquisition

6.2.8.2.9.1.1 Network topology advertisement

The AAI-NBR-ADV message shall carry the neighbor ABS’s multicarrier configuration information to facilitate the AMS’s scanning of the neighbor ABS’s fully configured carriers.

6.2.8.2.9.1.2 AMS scanning of target carriers

The AMS with multicarrier capability may perform the single-carrier scanning procedure per 6.2.6.1.2. It may also perform the multicarrier scanning procedure, i.e., a scanning procedure that involves multiple radio carriers, as defined in this subclause.

The AMS may scan the carriers of Neighboring ABSs indicated in AAI-NBR-ADV as directed by AAI-SCN-RSP. The AMS may also scan other fully configured carriers of the S-ABS that are not in use by the AMS. Figure 6-37 illustrates the example message flows for neighbor ABS advertisements and scanning of fully configured carriers of serving and neighbor ABSs.

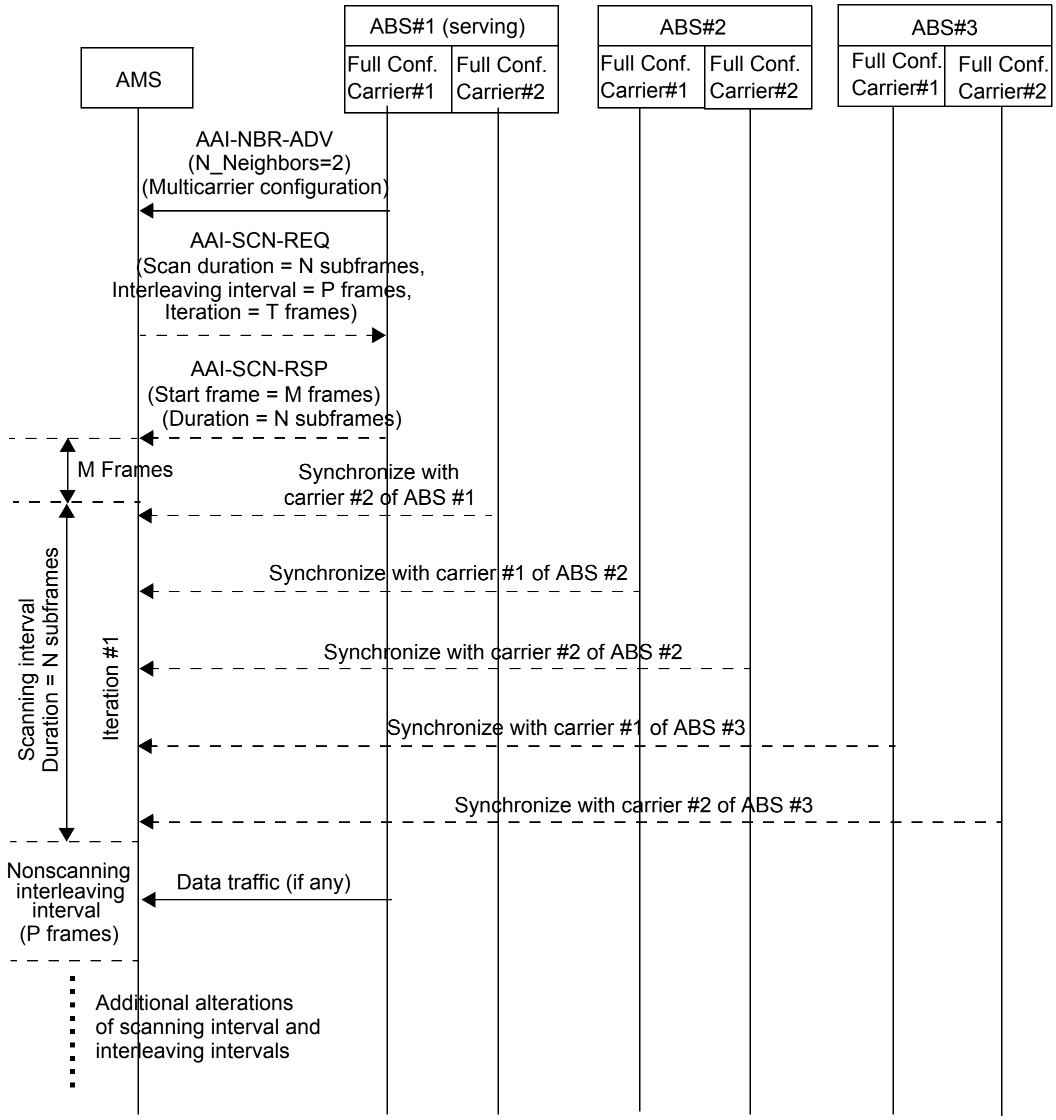


Figure 6-37—Neighbor ABS advertisement and scanning of serving and neighbor ABSs

An AMS capable of concurrently processing multiple radio carriers may perform scanning with neighbor ABSs using one or more of its available radio carriers without interruption to its normal communication with the S-ABS on the primary carrier and/or secondary carriers. In this case, the AMS and the ABS may negotiate through AAI-SCN-REQ/RSP messages the radio carriers to use for scanning operations to avoid resource allocation on those carriers, as illustrated in Figure 6-38. The carrier index will be included in the AAI-SCN-REQ/RSP/REP message.

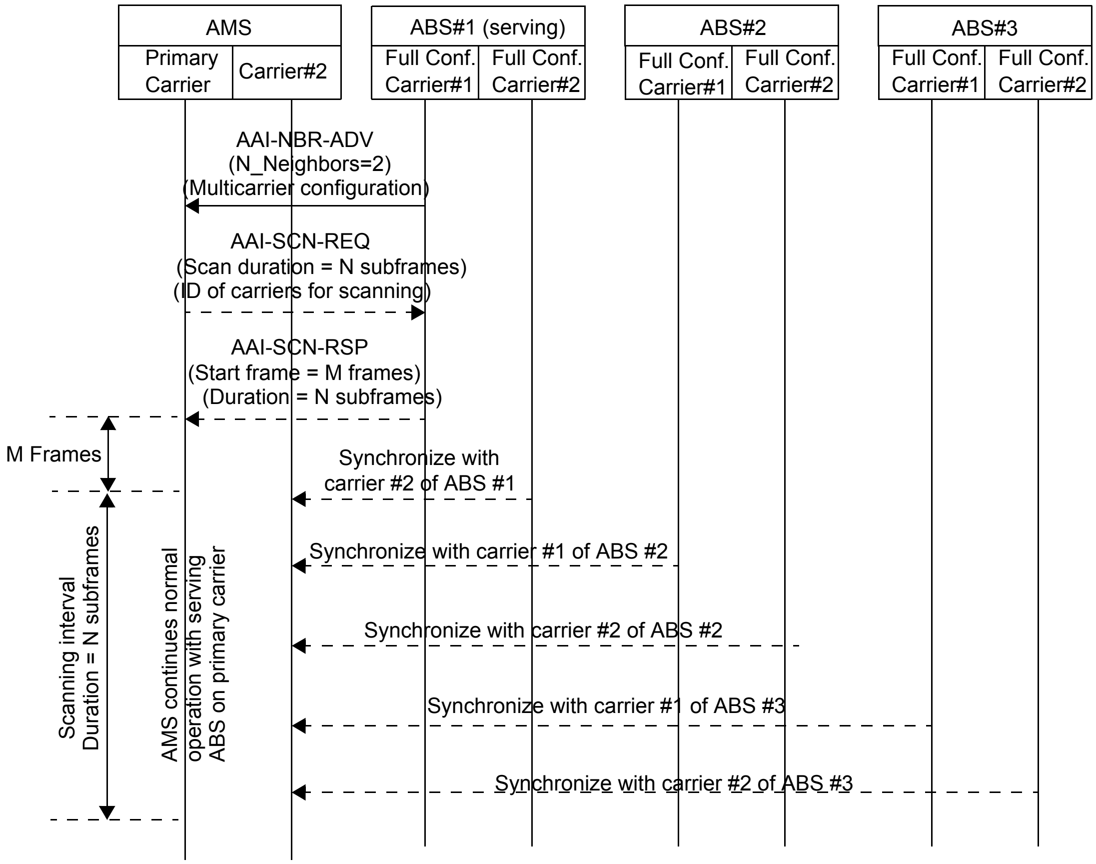


Figure 6-38—Scanning while maintaining communication with S-ABS

6.2.8.2.9.2 Multicarrier handover (MCHO) procedure

The multicarrier handover (MCHO) is defined as the handover procedure that involves multiple radio carriers, which includes multicarrier EBB HO and HO with secondary carrier preassignment as described in 6.2.8.2.9.2.2 and 6.2.8.2.9.2.3, respectively. For an AMS supporting a basic MC mode handover from one carrier to another carrier of the same ABS, the handover procedure follows the primary carrier change procedure per 6.2.8.2.11.2.

6.2.8.2.9.2.1 MCHO preparation

An AMS in multicarrier operation follows the handover operations defined in 6.2.6.3. MAC control messages in relation with handover preparation and initiation between the AMS and the S-ABS are transmitted over the primary carrier of the AMS.

During HO preparation, the AMS may request or be requested by the S-ABS to perform the MCHO procedure through AAI-HO-REQ/AAI-HO-CMD messages. The S-ABS informs the AMS of the carrier information (e.g., target primary carrier index) of the T-ABSs through the AAI-HO-CMD message. The S-ABS may communicate with the T-ABS(s) to help the AMS obtain the preassigned secondary carriers before handover execution. If the S-ABS determines that the secondary carrier(s) need to be preassigned, the S-ABS shall forward the multicarrier capability information of the AMS to the T-ABS(s). The S-ABS shall also respond with the secondary carrier preassignment results to the AMS using the preassigned secondary carrier information in the AAI-HO_CMD message.

6.2.8.2.9.2.2 MCHO execution and network reentry with HO_Reentry_Mode = 1

The AMS with multicarrier capability follows the network reentry procedure per 6.2.6.3.5. When HO_Reentry_Mode is set to 1 and HO_Reentry_Interleaving_Interval is set to 0, the AMS performs network reentry to the T-ABS on one carrier and maintains normal communication with the S-ABS on another carrier not performing the network reentry procedure. The AMS may use the original primary carrier for network reentry to the T-ABS, as illustrated in Figure 6-39. It may also use another carrier different from its original primary carrier for network reentry procedures, as illustrated in Figure 6-40. In this case, Disconnect_time should be long enough that the network reentry procedure to the T-ABS can be completed prior to the expiration of Disconnect_time. In the case of an AAI-HO-CMD message with multiple T-ABS and carriers, the physical carrier index of each candidate carrier provided by each T-ABS should also be indicated in the AAI-HO-CMD message. The AMS should follow the order of the candidate ABSs listed in the AAI-HO-CMD message to make a decision on HO target if the CINR/RSSI values of the ABSs are good enough to support the current services of the AMS. The AMS may inform the S-ABS through AAI-HO-IND and the carrier to be used for network reentry operations to avoid resource allocation by the S-ABS on that carrier.

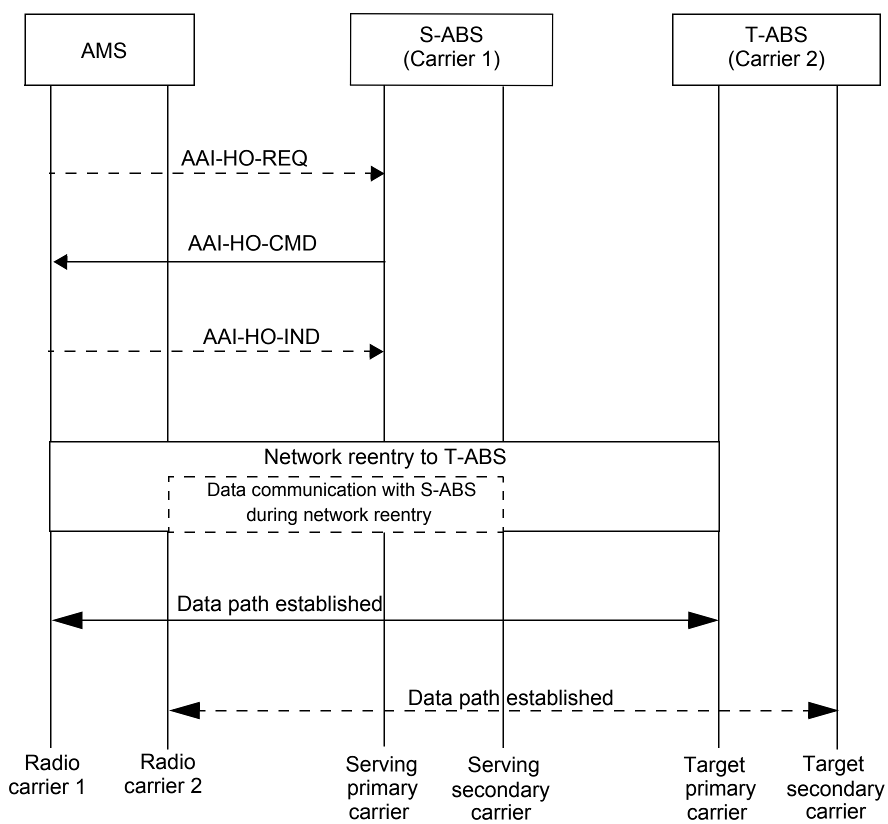


Figure 6-39—Multicarrier HO with network reentry on the T-ABS

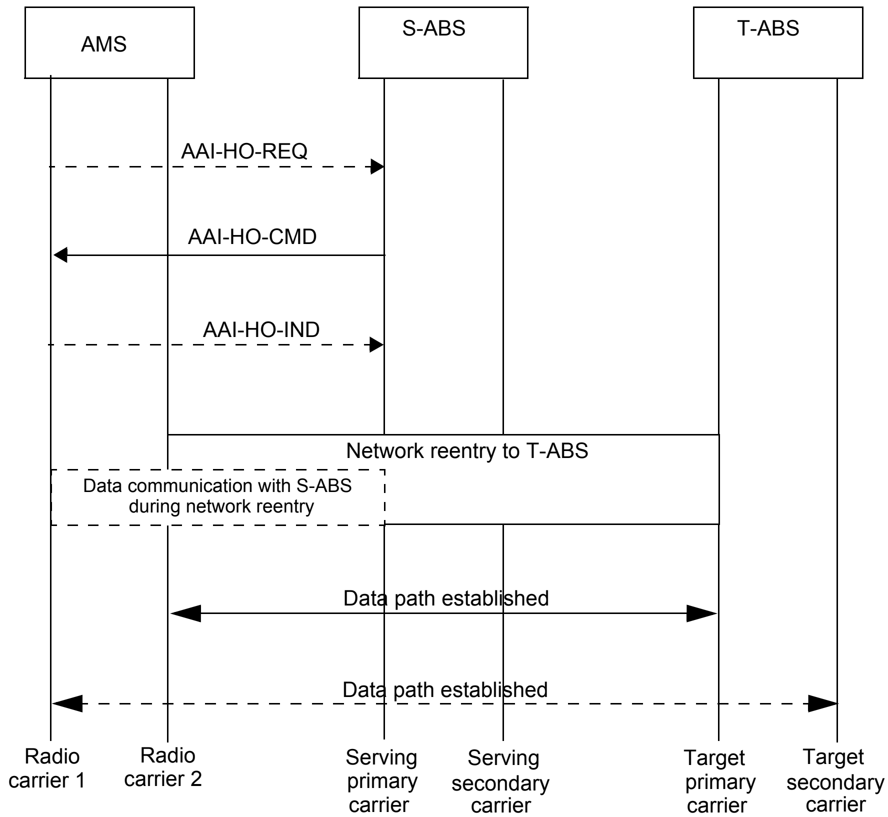


Figure 6-40—Call flow for multicarrier HO in which the AMS performs network reentry on the target primary carrier that is different from the serving primary carrier

From the AMS point of view, if network entry is completed (see 6.2.6), the AMS shall stop communicating with the S-ABS. Then, the AMS may send UL data or a BW-REQ message to the T-ABS.

6.2.8.2.9.2.3 HO with secondary carrier preassignment

The S-ABS may negotiate with the T-ABS for secondary carrier preassignment as illustrated in Figure 6-41. The preassignment information is forwarded from the T-ABS(s) via backbone to the S-ABS, and then sent to the AMS by the S-ABS through AAI-HO-CMD message, and part of the preassigned secondary carriers (indicated by the Carrier Status Indication) may be activated right after network reentry. The AMS starts the activation for the secondary carriers indicated by Carrier Status Indication in the AAI-HO-CMD after receiving the AAI-RNG-RSP message from the T-ABS. The T-ABS may start transmitting data on such activated secondary carrier(s) if the AMS sends the AAI-CM-IND message to the T-ABS after network reentry. If the AAI-CM-IND message is not received by the T-ABS within the Activation Deadline specified in AAI-RNG-RSP, the T-ABS considers the secondary carrier activation as failed. In this case, the T-ABS may send an AAI-CM-CMD message for the AMS to activate another secondary carrier. Before secondary carrier preassignment, the S-ABS shall forward the multicarrier capability of the AMS to the T-ABS(s) via backbone. If the AMS that has received an AAI-HO-CMD with secondary carrier preassignment recognizes that the MC configuration of the T-ABS is different from the S-ABS via the AAI-NBR-ADV message, then the AMS may newly negotiate the MC capability with the T-ABS through AAI-MC-REQ/RSP messages.

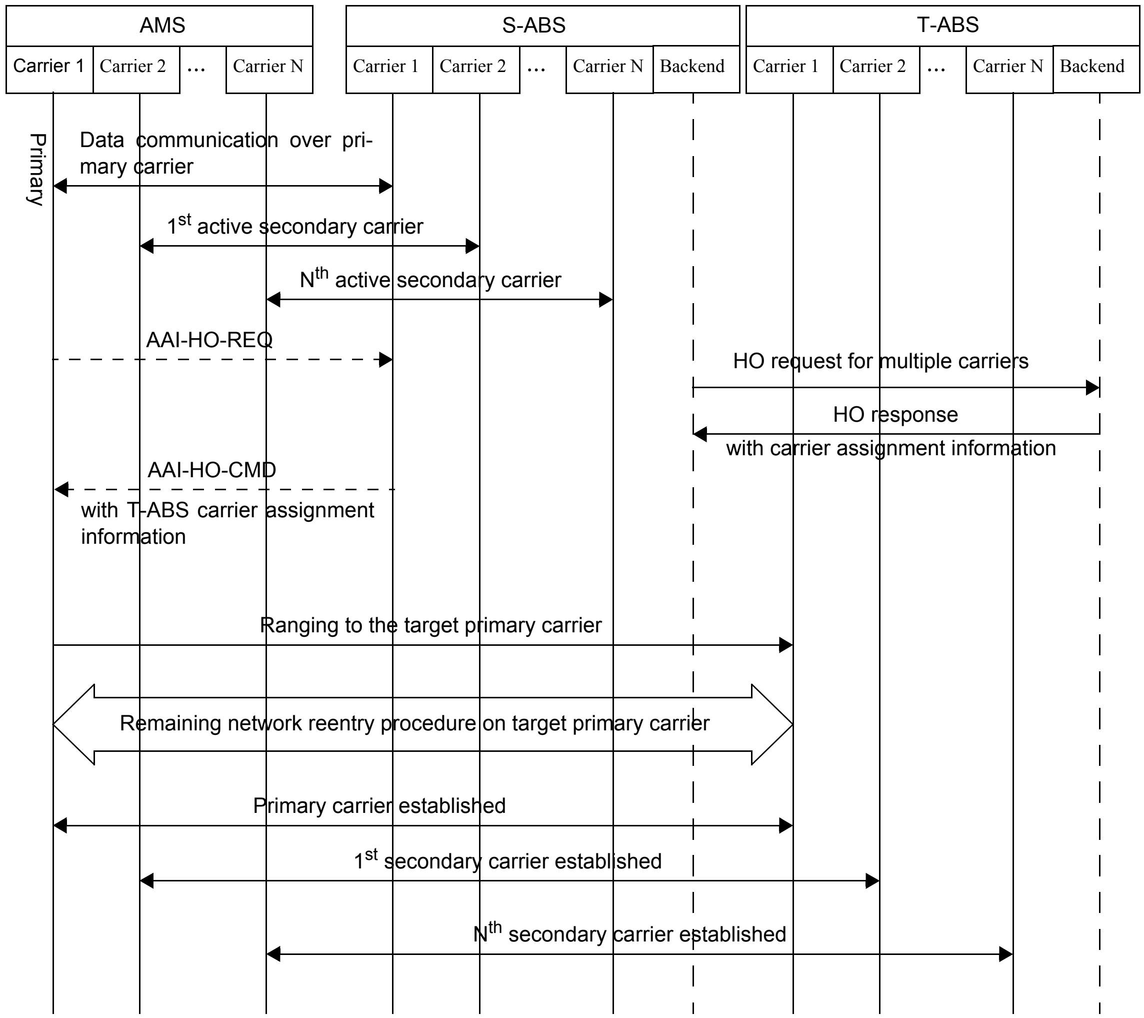


Figure 6-41—Call flow for multicarrier HO with secondary carrier preassignment

If any information about the preassigned secondary carrier is not included in the AAI-HO-CMD message, the AMS follows the operation of secondary carrier assignment (see 6.2.8.2.3.2) and carrier activation (see 6.2.8.2.11.1) after the AMS completes its network reentry with the T-ABS.

6.2.8.2.10 Power management

The power-saving procedures in OFDMA multicarrier mode of operation are the same as single-carrier mode and all messaging including idle mode procedures and state transitions are handled by the primary carrier.

6.2.8.2.10.1 Sleep mode

When an AMS enters sleep mode, the AMS negotiates its sleep mode parameters (i.e., sleep window and listening window configuration) with an ABS. The negotiated parameters of sleep mode are applied to an AMS over all the active carriers. The messages and procedures before entering sleep mode and during sleep mode are processed over the primary carrier. Note that the S-ABS may request the AMS to change its primary carrier upon entering the sleep mode or during the listening window using the AAI-CM-CMD message for load balancing, power saving, or alleviating signaling overhead.

At the beginning of the listening window, data transmission over all the active carriers of the AMS is allowed. The AMS, if the traffic indication is enabled, monitors the traffic indication message with its primary carrier. Upon receiving negative traffic indication in the traffic indication message, the AMS goes back to sleep. If positive traffic indication is received, the AMS continues to receive any DL data on all the active carrier(s). Following the traffic indication, the ABS may send an SCH via the primary carrier to terminate data transmission over some active secondary carrier(s).

If the traffic indication is disabled, data transmission and allocation follows the normal sleep-mode operation during the listening window. In this case, the AMS monitors the active carriers during the listening window, and the ABS may allocate the DL data on the primary carrier and the active secondary carrier(s), and the AMS receives the data on the primary carrier and the active secondary carrier(s) during the listening window. If the traffic indication is disabled, when the DL data transmission on the active secondary carrier(s) is completed, the ABS may instruct the AMS to end data transmission over the active secondary carrier(s) through the SCH that is transmitted in the primary carrier during the listening window. If the ABS receives the bandwidth request from the AMS in its primary carrier during the listening window, it shall regard that DL/UL data transmission over all active carriers is allowed during the listening window.

When an AMS is in the sleep window, and if the AMS has pending UL traffic, it may transmit a bandwidth request on the primary carrier. If the ABS receives the bandwidth request from the AMS, it shall regard that DL/UL data transmission over all active carriers is allowed. After completing UL traffic transmission, the normal sleep cycle operation of the AMS is resumed and all the active carriers shall use the sleep cycle setting.

6.2.8.2.10.2 Idle mode

A multicarrier supporting AMS in idle state follows the same procedures defined in 6.2.18.

In a multicarrier system, the PGID-Info message is transmitted in all fully configured carriers. The AAI-PAG-ADV message for an AMS shall be transmitted in only one of the carriers. An idle mode AMS determines the carrier index for monitoring the paging message within its paging-listening interval using Equation (3):

$$\text{Paging carrier index} = \text{DID modulo } N \tag{3}$$

The value of N is the number of carriers in an ABS that are used for transmitting the AAI-PAG-ADV message for idle mode AMS(s) and belong to the same paging group on a frequency band. The carrier index in the paging carrier indication of the PGID-Info message corresponds to the ascending order of the physical carrier index of the carriers in the AAI-Global-CFG message that are used for transmitting the paging message in the ABS. A paging carrier indication bit is used to specify if a carrier is used for carrying the AAI-PAG-ADV message or not. When the Paging carrier indication = 1, then the corresponding carrier is used for carrying the AAI-PAG-ADV message. When the paging carrier indication = 0, then the corresponding carrier is not used for carrying the AAI-PAG-ADV message. The paging carrier indication of different carriers is included in the PGID-Info message and may be included in the AAI-NBR-ADV message or the AAI-MC-ADV message.

The carrier(s) that is used for carrying the AAI-PAG-ADV message and included in a PGID-Info message is located on the same frequency band that the PGID-Info message is sent over. The ABS composes a PGID-Info message including the carrier(s) that belongs to a frequency band and is indicated by paging carrier indication bitmap; the ABS transmits the PGID-Info message over the fully configured carriers in the same frequency band. The AMS monitors the PGID-Info message at the same frequency band where it has most recently woken. When the AMS uses the paging carrier indication included in the AAI-NBR-ADV message or the AAI-MC-ADV message, the AMS shall decide the value of N as the number of carriers that are used for carrying the AAI-PAG-ADV message and belong to the same paging group in the frequency band where the AMS has most recently woken.

When an idle mode AMS moves to a new ABS and determines that the SFH change count of the new ABS is the same as the information it received through the AAI-NBR-ADV message, then the AMS may use the paging carrier indication received through the AAI-NBR-ADV message if this paging carrier indication is included in the AAI-NBR-ADV message.

The AAI-PAG-ADV message is transmitted starting from the second subframe in the frame where the PGID-Info message is monitored. The frame for an AMS to monitor the AAI-PAG-ADV message is determined as in 6.2.18.2.3.

For an AMS that subscribes to the E-MBS service, the AAI-PAG-ADV message shall be transmitted in the same carrier as the carrier on which E-MBS is provided. In this case, the AMS does not use Equation (3).

An AMS may perform the Location Update process to acquire its preferred carrier for the idle mode support when the AMS cannot find the paging carrier. In this case, Ranging Purpose Indication = 0b0011 in the AAI-RNG-REQ message is used for indicating the paging carrier update in the location update process, and the AMS may include the Paging Carrier Update parameter in the AAI-RNG-REQ message to inform its preferred paging carrier. Upon the AMS receiving an AAI-RNG-RSP message for the corresponding location update procedure, the paging carrier is updated and used in the subsequent paging listening interval.

6.2.8.2.11 Carrier management

6.2.8.2.11.1 Secondary carrier activation/deactivation

The activation or deactivation of secondary carrier(s) is decided by the ABS based on QoS requirement, load condition of carriers, channel quality from CQI for active carrier or scan report for inactive carrier, and other factors. The trigger/action definition associated with the relevant carrier is obtained from AAI-MC-ADV broadcast on the primary carrier of the AMS. The ABS activates and/or deactivates the secondary carrier with the AAI-CM-CMD MAC control message. The ABS sends the AAI-CM-CMD MAC control message on the primary carrier and includes the following information:

- Indication Type per DL/UL: Activation, Deactivation
- List of Secondary Carriers: (referred by physical carrier index)
- Ranging indicator for the activated carrier
- Activation Deadline: The time for the AMS to confirm activation of the secondary carrier by sending the AAI-CMD-IND message before its expiration

The ABS sends the AAI-CM-CMD message with Polling set to 1 in MCEH, and the AMS, upon receiving the AAI-CM-CMD message, transmits an AAI-MSG-ACK message or MAC control ACK extended header (MAEH) to inform that the AAI-CM-CMD message has been successfully received. The AMS transmits the AAI-CM-IND MAC control message through the primary carrier, where this message confirms with the ABS that the AMS has successfully activated/deactivated the carriers listed in the AAI-CM-CMD message. In case of activation, the AAI-CM-IND message is sent by the AMS when DL/UL of the newly activated carrier is ready to be used to transport data traffic. In case of deactivation, the AMS shall disconnect the connection with the target carrier upon receiving the AAI-CM-CMD message and the AMS may omit the transmission of AAI-CM-IND message if the ABS directs only deactivation through the AAI-CM-CMD. If the AAI-CM-IND message is not received by the ABS within the Activation Deadline, the ABS considers the secondary carrier activation as failed. In this case, the ABS may send an AAI-CM-CMD message for the AMS to activate another secondary carrier.

When AMS performs secondary carrier activation while AMS supports data transmission over both the primary carrier and the secondary carrier with a single-radio transceiver, the AMS reconfigures its hardware setting (e.g., RF center frequency). After completing the hardware reconfiguration and synchronization on the new carrier, the AMS notifies the ABS its readiness of the new carrier by sending an AAI-CM-IND message and then resuming communication with ABS.

After the ABS receives the AAI-CM-IND MAC control message, the ABS may start transmitting data on such active secondary carrier(s).

The ABS activates one or more assigned secondary carriers of an AMS through an AAI-CM-CMD message. The ABS may make concurrent resource allocation using A-MAP on multiple active carriers, including primary carrier. The multicarrier allocation and aggregation may be used independently in the downlink or uplink and the ABS performs the operations based on QoS, loading, and AMS's capabilities.

The DL-only activation of fully-configured secondary carrier shall be performed only if the BW, CP, and Frame configuration index in Table 6-151 of secondary carrier are same as those of primary carrier.

The AMS in multicarrier aggregation mode is assigned the same STID to be used across primary and secondary carriers. The AMS supporting multicarrier aggregation mode shall monitor all active carriers and follow the resource allocations while in active mode.

When supported by the AMS, S-ABS, and T-ABS, the carrier aggregation mode may be maintained during the handover procedure through the secondary carrier preassignment procedure per 6.2.8.2.9.

The ABS may trigger the scanning of inactive secondary carrier(s) by transmitting AAI-SCN-RSP when deciding to activate assigned secondary carrier(s) for an AMS. The AMS receiving AAI-SCN-RSP shall perform the scanning for the inactive secondary carrier(s). The ABS may specify trigger parameters for scan reporting of each inactive assigned secondary carrier in the AAI-MC-ADV message. An AMS shall perform the scan reporting when the conditions on the triggers are met. If all of the assigned secondary carriers linked to Reference Carrier are inactive, the AMS may perform the reporting procedure by the trigger conditions only for the carrier corresponding to the lowest physical carrier index among them until at least one of the assigned carriers gets activated. If any of the inactive assigned carriers linked to the Reference Carrier of AAI-MC-ADV is activated, the AMS may not perform the scanning/reporting procedure for the remaining inactive assigned carrier(s) and the ABS may refer to the channel quality of the activated carrier(s).

The ABS may define the following trigger conditions for the each action:

— Conditions that define when the AMS shall report scanning measurement results to the ABS.

Carrier activation (CA)-specific trigger definitions are encoded using the description in Table 6-122.

Table 6-122—CA-specific trigger description

Name	Length (bits)	Value
Number of conditions	2	The number of conditions that are included in this trigger (see For-loop description below this table). When more than one condition is included, this trigger is referred to as a complex trigger and is the logical AND combination of all the included conditions.
for(i = 0; $i \le$ Number of conditions; i++){		

Table 6-122—CA-specific trigger description *(continued)*

Name	Length (bits)	Value
Type/Function/Action	3	See Table 6-123 for description.
Trigger Value	8	Trigger value is the value used in comparing the measured metric for determining a trigger condition.
Trigger averaging parameter	4	The averaging parameter used for averaging this trigger metric according to Equation (2). If not present, the default trigger averaging parameter in AAI-SCD is used. 0x0: 1 0x1: 1/2 0x2: 1/4 0x3: 1/8 0x4: 1/16 0x5: 1/32 0x6: 1/64 0x7: 1/128 0x8: 1/256 0x9: 1/512 0xA to 0xF: *Reserved*
}		

Table 6-123—CA-specific Trigger; Type/Function/Action description

Name	Size (bits)	Value	Description
Type	1(MSB)	Trigger metric type: 0x0: CINR metric 0x1: RSSI metric	
Function	1	Computation defining scan reporting trigger condition: 0x0: Metric of inactive assigned secondary carrier is greater than absolute value 0x1: Metric of active secondary carrier is less than absolute value	
Action	1(LSB)	Action performed upon reaching trigger condition: 0b0: Respond on trigger with AAI-SCN-REP for inactive secondary carrier 0b1: *Reserved*	Action 0b0 applies to Function 0x0 and 0x1

A carrier assigned for the E-MBS is activated without the AAI-CM-CMD/IND transaction after a successful AAI-DSA procedure. If a carrier assigned for the E-MBS is requested to be activated for non–E-MBS traffic, then the carrier is activated through the AAI-CM-CMD/IND transaction.

6.2.8.2.11.2 Primary Carrier Change

The Primary Carrier Change involves changing the primary carrier for an AMS to another assigned fully-configured carrier in a multicarrier ABS without changing the MAC layer security and mobility contexts and, unlike normal inter-FA handover, where the current primary carrier is called the serving carrier, and the fully configured carrier as the candidate for the primary carrier change is called the target carrier. An AMS that has an MC mode not equal to 0b00 shall support primary carrier change. The ABS may instruct the AMS, through the AAI-CM-CMD MAC control message on the current primary carrier, to change its primary carrier to one of the assigned fully configured carriers within the same ABS for load balancing purpose, carriers' varying channel quality, or other reasons. For an AMS supporting basic MC mode, the target primary carrier may be one of the available fully configured carriers within the same ABS. When an AMS receives the AAI-CM-CMD MAC control message with polling set to 1 in MCEH, the AMS transmits the AAI-MSG-ACK message or MAEH in response to the AAI-CM-CMD message and the AMS disconnects the control signal on the serving carrier and switches to the target fully configured carrier at the action time specified by the ABS. The action time in the AAI-CM-CMD message shall be set to a value more than the retransmission timer for the AAI-CM-CMD message.

If the AMS supports the carrier aggregation mode and the target carrier is one of the active secondary carriers of the AMS, the AMS may receive data and a control signal on the target carrier immediately after switching. Otherwise, the AMS first reconfigures its hardware setting (e.g., RF center frequency) and switches to the target carrier. If the Ranging indicator in the AAI-CM-CMD message is set to '1', the AMS shall perform the periodic ranging procedure with the target carrier. After successfully completing this action, the AMS shall transmit an AAI-CM-IND message on the target carrier to notify its readiness of the target carrier to the ABS. The ABS shall transmit data and a control signal using the target primary carrier after the AAI-CM-IND message is received from the AMS through the target primary carrier.

If the AAI-CM-IND message is not received on the target primary carrier until the Activation Deadline is expired, the ABS considers the corresponding primary carrier change procedure failed and it shall keep using the serving carrier as the primary carrier for the AMS. Given that a common MAC manages both serving and target primary carriers, network reentry procedures at the target primary carrier are not required. The ABS may direct an AMS to change the primary carrier without scanning.

The AMS may perform scanning on other assigned carriers that are not serving the AMS in an unsolicited manner or by the instruction of the ABS. The AMS reports the scanning results back to the S-ABS, which may be used by the ABS to determine the carrier to which the AMS should switch. The scanning operation shall follow the trigger/action defined in AAI-SCD. The reference for triggering scanning or a reporting operation defined in AAI-SCD or AAI-MC-ADV shall be the primary carrier and assigned secondary carriers instead of the S-ABS and neighbor ABSs. In this case, if the target carrier is not currently serving the AMS, the AMS may perform synchronization with the target carrier if required.

The ABS may define PCC-specific triggers by including PCC-specific trigger definitions in the AAI-MC-ADV message. PCC-specific triggers use the format in Table 6-120, where only function types 0x1, 0x2, 0x3, and 0x4 and actions types 0x1 and 0x3 are allowed. When present, PCC-specific triggers override any general triggers (defined in the AAI-SCD message) of the same type, function, and action.

The AAI-CM-CMD MAC control message for the primary carrier change is transmitted on the primary carrier and shall include the following information:

- Target primary carrier index (referred by physical carrier index)
- Indication of the next state of serving the primary carrier: If the AMS does not support carrier aggregation, this field shall be always set to '0'
- Action time
- Ranging indicator

The serving primary carrier will be kept active or deactivated depending on the indication of the next state of serving the primary carrier.

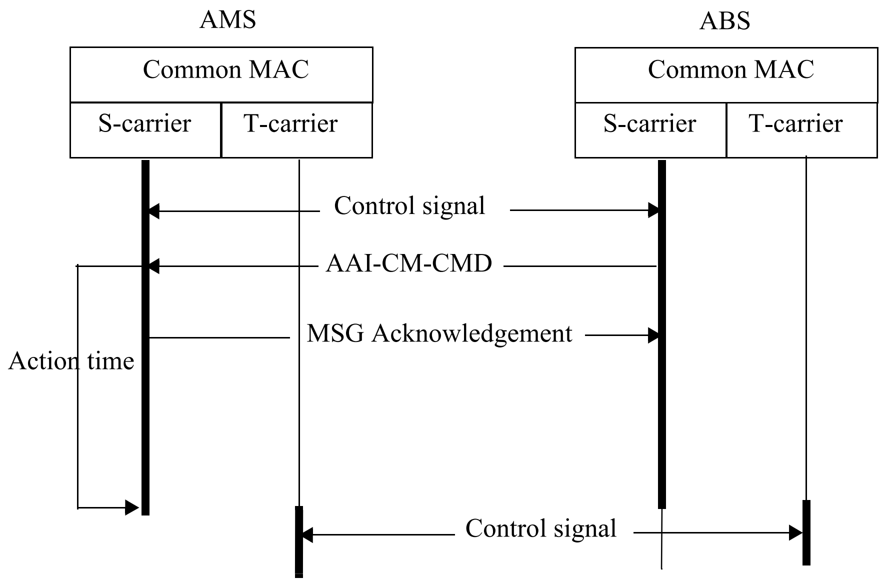


Figure 6-42—Primary carrier change procedure when the target carrier is one of the active carriers

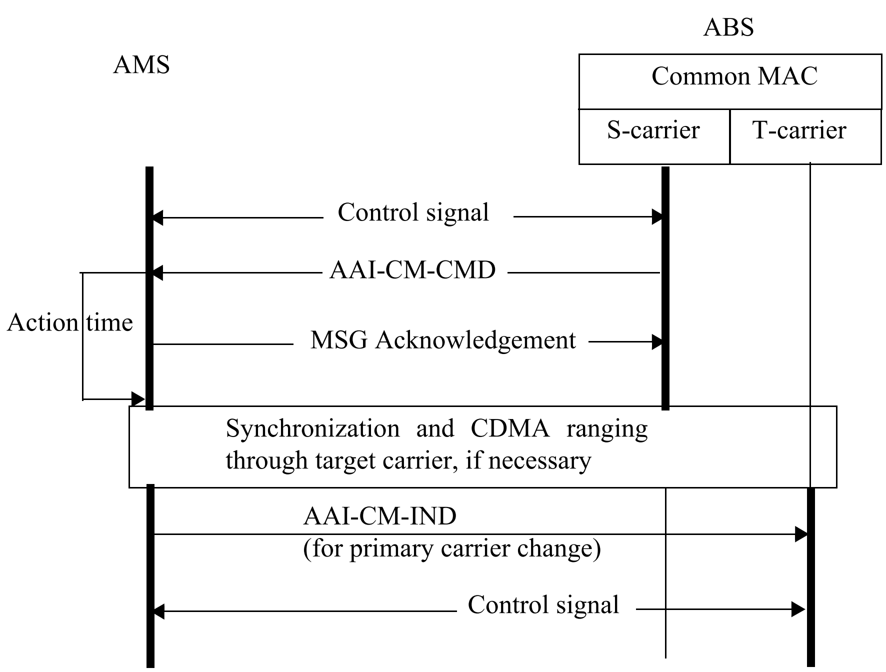


Figure 6-43—Primary carrier change procedure when the target carrier is one of the inactive carriers

6.2.8.2.11.3 Primary to secondary carrier switching

Primary to secondary carrier switching in multicarrier mode is used for E-MBS only. The E-MBS operation on the multicarrier deployment is defined in 6.9.2.4.

6.2.9 Group Resource Allocation

The Group Resource Allocation mechanism allocates resources to multiple users as a group in order to save control overhead. Group Resource Allocation may be used for connections with a periodic traffic pattern and with a relatively fixed payload size.

6.2.9.1 Grouping mechanism

Grouping criteria include MIMO modes and HARQ burst sizes. As a result, every group may correspond to a given set of MIMO modes and HARQ burst sizes.

A flow of an AMS may be assigned to a DL and/or a UL group. Each DL or UL group is identified by a unique 12-bit group ID allocated from the group ID's range as specified in Table 6-195.

6.2.9.2 Group configuration

Dynamic changes within the limited set of MIMO modes and HARQ data burst sizes are facilitated within a group.

The ABS configures a Group MIMO Mode Set for each group among the predefined candidate sets listed in Table 6-124 for the downlink and Table 6-125 for the uplink. When a flow is added into the group, the configured Group MIMO Mode Set ID is indicated through the Group Configuration MAC control message. The assigned MIMO mode to a flow in the group shall be chosen from the configured set.

Table 6-124—DL MIMO mode set candidates

MIMO Mode Set ID	DL Group MIMO mode set	SM restriction
0b00	Mode 0	N/A
0b01	Mode 0, Mode 1	$M_t = 2$
0b10	Mode 2	$M_t = 1$
0b11	*Reserved*	N/A

Table 6-125—UL MIMO mode set candidates

MIMO Mode Set ID	UL Group MIMO mode set	SM restriction
0b00	Mode 0	N/A
0b01	Mode 0, Mode 1	$M_t = 2$
0b10	Mode 2	$M_t = 1$
0b11	Mode 3	$M_t = 1$

The ABS configures a HARQ Burst Size Set for each flow within a group. The HARQ burst size set supports four HARQ burst sizes. The Group Configuration MAC control message signaled to add a flow of an AMS to a group contains the HARQ burst sizes assigned to the flow. The assigned HARQ burst sizes to a flow in the group shall be chosen from the configured set.

The four burst sizes in the set are chosen from the burst sizes defined in Table 6-126. The table also lists the corresponding 5-bit codes that will be used to signal these burst sizes in the Group Configuration MAC control message. Note that these burst sizes are the first 32 sizes supported in the PHY layer as defined in Table 6-305 of 6.3.10.1.2.

Table 6-126—Burst sizes supported in GRA and corresponding codes

Burst size (bytes)	Code	Burst size (bytes)	Code
6	00000	44	10000
8	00001	50	10001
9	00010	57	10010
10	00011	64	10011
11	00100	71	10100
12	00101	80	10101
13	00110	90	10110
15	00111	100	10111
17	01000	114	11000
19	01001	128	11001
22	01010	144	11010
25	01011	164	11011
27	01100	180	11100
31	01101	204	11101

Table 6-126—Burst sizes supported in GRA and corresponding codes *(continued)*

Burst size (bytes)	Code	Burst size (bytes)	Code
36	01110	232	11110
40	01111	264	11111

6.2.9.3 Group management

6.2.9.3.1 Addition of an AMS to a group

The addition of a flow of an AMS to a group occurs when group resource allocation is initialized for a flow of the AMS or when a flow of an AMS in a group moves to another group. For inclusion, all the group information that is required to interpret resource assignment information from group resource allocation A-MAP IE shall be signaled to an AMS. The information is transmitted through a unicast Group Configuration MAC control message. Note that the addition of a flow to a group for group resource allocation does not preclude the use of individual or dynamic allocations for packets of that flow.

6.2.9.3.1.1 ABS operation

When an ABS decides to use group resource allocation for a flow of an AMS, the ABS adds the flow of the AMS into an appropriate group among existing groups. If the existing groups are not appropriate to the flow of the AMS, the ABS may form a new group. The ABS shall indicate group configuration information via the Group Configuration MAC control message, which includes the FID of the added flow, the Group ID of the group to which the flow is added, and the assigned User Bitmap Index to the flow.

The addition of the AMS's flow to a group shall apply starting at least one frame following the frame in which the ABS receives a successful acknowledgment from the AMS for the Group Configuration MAC control message. Once the flow is added to the group, resources used for initial transmission of an HARQ data burst may be allocated as part of the group until the flow is deleted from the group.

6.2.9.3.1.2 AMS operation

Upon receiving the Group Configuration MAC control message, the AMS knows the group ID of the group to which its flow is added, the periodicity of group resource allocation, and the AMS's flow index in the group's user bitmap. In addition, the AMS receives the required information to interpret the assigned MIMO mode, HARQ burst size, and resource size from the bitmaps in the corresponding group resource allocation A-MAP IE. Once the AMS successfully acknowledges a Group Configuration MAC control message, starting the next frame, the AMS shall monitor its allocation in the corresponding Group resource allocation A-MAP IE until its flow is deleted from the group.

When an AMS's flow is added to a group, the flow shall be assigned a set of consecutive ACIDs to be used for group allocations. This set of ACIDs is determined by the parameters *Initial_ACID* and *N_ACIDs* signaled in the Group Configuration MAC control message. The set of allowable ACIDs belong to the range [*Initial_ACID, Mod(Initial_ACID+N_ACIDs-1,16)*], where the operation Mod(x,y) is the remainder of division of x by y. For integers x and y, Mod(x,y) lies between 0 and y – 1.

6.2.9.3.2 Deletion of a flow from a group

The ABS may delete a flow from a group when one or more of the following conditions applies:

a) The corresponding connection is terminated.
b) The MIMO mode/HARQ burst size suitable for the flow no longer belongs to the MIMO Mode Set/ HARQ burst size set corresponding to the group.

6.2.9.3.2.1 ABS operation

The ABS may delete multiple flows from a group in an AAI subframe. The deletion information shall be signaled individually for each flow of an AMS via the Group Configuration MAC control message. The deletion can be signaled explicitly by setting the Deletion Flag field in the control message to 1. The deletion from the current group can be implicit if the flow is reassigned to a group by setting the Deletion Flag to 0.

Once the Group Configuration MAC control message for deletion of a flow is sent to an AMS, no allocations for that flow shall be provided to the AMS in the group in the subsequent frames. After sending the deletion information, the ABS shall wait for an ACK from the AMS. The ABS shall not allocate the corresponding bitmap position to another AMS until an ACK for deletion has been received.

6.2.9.3.2.2 AMS operation

After decoding a Group Configuration MAC control message, if an AMS finds that its flow has been deleted from the group, then it shall stop expecting allocations for that flow in that group after the AAI subframe in which deletion information was sent. The AMS shall send an ACK to the ABS signaling that the AMS has successfully received the Group Configuration MAC Control message.

6.2.9.4 Normal GRA operation

An ABS shall provide contiguous allocations to the flows belonging to a group, which have the corresponding bit in the user bitmap set to ‘1’. The order of resource allocation shall be the same as the order in which they appear in the group’s user bitmap. If there is no transmission for a given AMS flow in a certain AAI subframe, then the ABS shall set the corresponding bit in the user bitmap to ‘0’.

When an AMS receives a group resource allocation IE in which the bits corresponding to one or more flows in the user bitmap is set to ‘1’, then the AMS shall decode the remaining bitmaps to determine other attributes of the allocated resource. If an AMS does not receive the group resource allocation IE in any of the AAI subframes of a frame in which the IE was expected, then the AMS shall assume no allocations for the group in that frame.

When an AMS receives UL group resource allocation, the AMS shall use the given UL group resource allocation to transmit the data of the flow or flows of the group, except that the AMS is allowed to use the UL group resource allocation to transmit urgent MAC control messages and/or urgent data of other flows, e.g., for emergency services; and the AMS is also allowed to use any leftover resources of a UL group resource allocation after serving the flow or flows of the group to transmit the data of other flows.

The ACID corresponding to a resource allocated to a flow in a given frame is not explicitly signaled in the group resource allocation A-MAP IE. The ACIDs for a flow implicitly cycle in the ACID range defined in 6.2.9.3.1.2. The ACID for an allocation shall be determined using Equation (4):

$$\mathrm{ACID} = \mathrm{Mod}(\mathit{Initial\_ACID} + \mathrm{Mod}(\,\mathrm{floor}(\,\mathit{Frame\_Number} / \mathit{Periodicity}),\ \mathit{N\_ACID}), 16) \tag{4}$$

where

ACID — is the ACID used for current allocation
Initial_ACID — is the Initial ACID parameter signaled in the Group Configuration MAC Control Message
Periodicity — is the Periodicity of group resource allocation in terms of number of frames signaled in the Group Configuration MAC Control message

N_ACIDs is the number of ACIDs assigned to the flow for group resource allocation, signaled in the Group Configuration MAC Control message

Frame_Number is the current frame number, which is given by Equation (5):

$$Frame\_Number = Superframe\_Number \times 4 + \mathrm{FRAME\_OFFSET} \quad (5)$$

where

Superframe_Number is the current superframe number

FRAME_OFFSET is the offset of the current frame with respect to the start of the corresponding superframe and $0 \leq \mathrm{FRAME\_OFFSET} \leq 3$

The Frame_Number parameter corresponds to the frame in which the group resource allocation A-MAP IE is transmitted.

If the calculated ACID is still performing retransmissions of a previous packet, then the previous packet shall be dropped and the ACID shall be freed for the new allocation. The packet drop shall happen in the frame in which group resource allocation A-MAP IE is received.

6.2.9.4.1 Bitmaps in group resource allocation

The ABS uses bitmaps to signal resource allocation information for flows within a group. These bitmaps are sent in the group resource allocation A-MAP IE. The first bitmap is the user bitmap, which uses 1 bit per flow to signal which users are scheduled in the frame. The user bitmap size can be 4, 8, 16, or 32 bits. Each flow belonging to the group shall be assigned a unique index in the user bitmap of that group. The bitmap size for a given group shall remain fixed. As flows are deleted from the group, some bit indices in the user bitmap may become empty or unassigned. These empty bits may be assigned to new flows of existing or new users as they are added to the group.

In addition to the user bitmap, a second bitmap called the MIMO bitmap is used to indicate the assigned MIMO mode, when multiple MIMO modes and SM parameters are supported in the group. The MIMO bitmap is only required for certain MIMO mode sets and may not always be transmitted. The existence of the MIMO bitmap and the number of bits per scheduled flow in the MIMO bitmap are listed in Table 6-127 and Table 6-128.

Table 6-127— MIMO bitmap Information for DL

MIMO mode set	Existence of MIMO bitmap	Number of bits per scheduled AMS	MIMO mode indication
0b00	No	N/A	OL SU-MIMO (SFBC with nonadaptive precoder)
0b01	Yes	1	0b0: OL SU-MIMO (SFBC with nonadaptive precoder) 0b1: OL SU-MIMO (SM with nonadaptive precoder) with $M_t = 2$
0b10	No	N/A	CL SU-MIMO with $M_t = 1$

Table 6-128—MIMO Bitmap Information for UL

MIMO mode set	Existence of MIMO bitmap	Number of Bits per scheduled AMS	MIMO mode indication
0b00	No	N/A	OL SU-MIMO (SFBC with nonadaptive precoder)
0b01	Yes	1	0b0: OL SU-MIMO (SFBC with nonadaptive precoder) with $M_t = 2$ 0b1: OL SU-MIMO (SM with nonadaptive precoder) with $M_t = 2$
0b10	No	N/A	CL SU-MIMO with $M_t = 1$, TNS = 1
0b11	Yes	1	OL MU-MIMO (CSM with non-adaptive precoder) with $M_t = 1$, TNS = 2 0b0: SI = 1 0b1: SI = 2

In the case where UL MIMO mode set ID is 0b11 (Mode3), the resource of *N*-th scheduled flow is allocated by the following rules. Among flows set to 1 in the user bitmap, the ABS assigns stream index 1 and 2 to the different flows. The assigned stream index is signaled in the SI bitmap. All SI = 1 flows are assigned contiguous resources in increasing order of their indices starting from resource offset for the group signaled in the group resource allocation A-MAP IE. All SI = 2 flows are also assigned contiguous resources in increasing order of their indices starting from resource offset.

The third bitmap is the resource allocation bitmap, which uses 2 bits per flow to signal the HARQ burst size and 3 bits per flow to signal the resource size for the scheduled flow in the AAI subframe or extended AAI subframe that are scheduled in the frame. The resource size refers to the number of LRUs allocated to the flow. The resource size supported in GRA is limited to 16 LRUs. Each group supports eight resource sizes for each burst size supported in the group. The set of resource sizes for each burst size belongs to the range [1,16] LRUs. The set of HARQ burst sizes and resource sizes supported in the group is signaled in the Group Configuration MAC control message. For groups corresponding to all MIMO mode sets except UL(0b11), the intended AMS calculates the starting location of resources of its flow with User Bitmap Index *i* in the AAI subframe as follows:

$$R_i = R_0 + \sum_{j=1}^{j<i} L_j$$

where

R_0 is the resource offset of the group as signaled in the DL/UL Group Resource Allocation A-MAP IE.

L_j is the resource size in LRUs of the flow in the group whose user bitmap index is *j*.

If the flow with user bitmap index *j* is not indicated as present in the IE of the user bitmap in Group_Resource_Allocation_A-MAP_IE, $L_j = 0$.

Examples of utilizing the bitmaps are shown in Figure 6-44,Figure 6-45, and Figure 6-46.

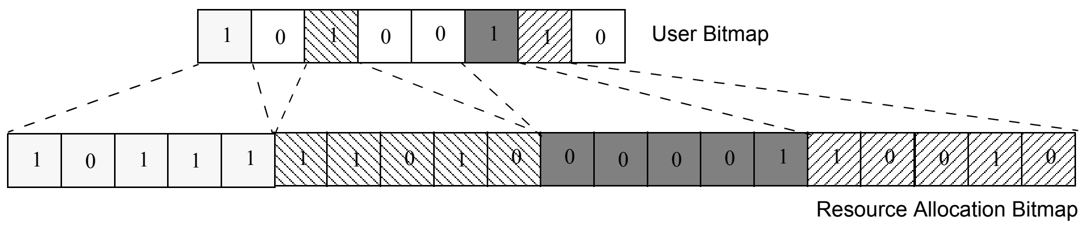


Figure 6-44—Example of bitmaps with Group MIMO Mode Set: DL (0b00, 0b10), UL(0b00, 0b10)

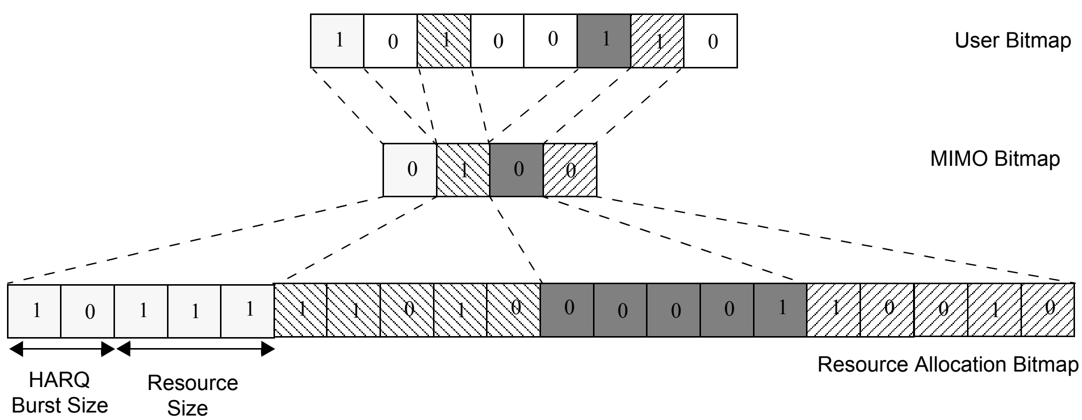


Figure 6-45—Example of bitmaps for Group MIMO Mode Set: DL (0b01), UL(0b01)

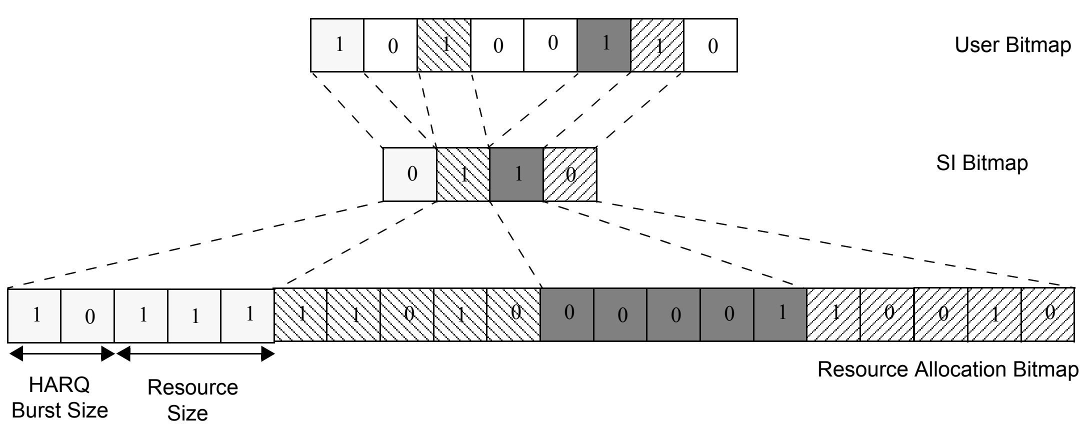


Figure 6-46—Example of bitmaps for Group MIMO Mode Set: UL(0b11)

6.2.10 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. As specified in 6.3.5.5.2.4, messages sent over unicast connections are distinguished by either one of the following:

a) The 16-bit CRC masking in the unicast assignment A-MAP IEs using the STID, TSTID, or RA-ID.

b) The 16-bit CRC masking and user bitmap in the GRA A-MAP IE. RA-ID shall be used for CRC masking of the CDMA Allocation A-MAP only.

Broadcast connections are intended for reception by all AMSs that may be listening, not to any specific AMS. Messages sent over broadcast connections are distinguished by the 16-bit CRC masking in the broadcast assignment A-MAP IEs as specified in 6.3.5.5.2.4.

Two types of connections are used: control connections and transport connections. Control connections are used to carry MAC control messages. Transport connections are used to carry user data including upper layer signaling messages such as DHCP and data plane signaling such as ARQ feedback. A MAC control message shall never be transferred over the transport connections, and user data (except SMS over AAI-RNG-REQ/RSP and AAI-L2-XFER) shall never be transferred over the control connections.

6.2.10.1 Control connections

One pair of bidirectional (DL/UL) unicast control connections are automatically established when an AMS performs initial network entry. When FID is required to be present in a control connection, the FID value shall be set to the unicast or broadcast control FID value (see Table 6-1).

Once the TSTID is allocated to the AMS, the control connections are established automatically. FIDs for the control connections shall never be changed during WirelessMAN-Advanced Air Interface System handover or network reentry.

6.2.10.2 Transport connections

All user data communications are in the context of transport connections. A transport connection is unidirectional, and identified by a unique FID that is assigned during the DSA procedure per 6.2.12.6, excluding the transport connections associated with the default service flows. The transport connections for the default service flows in uplink and downlink direction are each identified by the preassigned FID (FID = 0011) and established by the registration procedure during network entry.

If a coupled group create/change parameter is included in a DSA message (see 6.2.3.47.1), it indicates whether the DL and UL transport connections are coupled to be considered together in admission. Each transport connection is associated with an active or admitted service flow to provide various levels of QoS required by the service flow. The transport connection is established when the associated active service flow is admitted or activated, and released when the associated service flow becomes inactive. Once established, the FID of the transport connection is not changed during WirelessMAN-Advanced Air Interface System handovers.

To reduce bandwidth usage, the ABS and AMS may establish/change/release multiple connections using a single DSx message transaction on a control connection. The multiple connections are indicated with the group create/change parameter in the AAI-DSx message.

Service flows can be preprovisioned or dynamically created. Transport connections associated with preprovisioned service flows are established by the DSA procedure triggered by completion of the AMS network entry. Especially, the transport connections associated with the default service flows in uplink and downlink direction each are established with the preassigned FIDs (see Table 6-1) by successful registration procedure.

On the other hand, the ABS or the AMS can create new service flows and their associated transport connections dynamically using the DSA procedure if needed. A transport connection is created, changed, or deleted when the associated service flow is created, changed, or deleted, respectively.

6.2.11 Bandwidth request and allocation mechanism

6.2.11.1 Bandwidth request

Bandwidth requests (BRs) 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 BR using a BR preamble sequence and an optional quick access message on the BR channel, a standalone BR carried in a BR signaling header, a piggybacked BR carried in a PBREH, or a BR using P-FBCH. The BR from the AMS except for the signaling header shall indicate the amount of the requested data in units of bytes exclusive of any header, security, or other MAC PDU overhead and PHY overhead that may be applied during transmission over the air interface. The BR from the AMS for the signaling header indicated by BR FID 0b0010 shall indicate the amount of the requested signaling header in units of bytes exclusive PHY overhead that may be applied during transmission over the air interface.

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

6.2.11.1.1 Contention-based random access bandwidth request

The ABS may advertise a sequence of minimum access classes in the BR Channel Configuration MIN Access Class elements within the AAI-SCD for each frame in a superframe. This sequence of minimum access classes is maintained until another advertisement with the AAI-SCD. Based on the sequence of minimum access classes, the AMS can select the frame used for the contention-based random access in order to minimize collision. If no minimum access classes are advertised in the AAI-SCD, then all access classes are allowed. An access class for Transport FIDs is assigned to a service flow via DSx MAC control messages during the service flow establishment/modification. An access class 0 shall be used for the connections that are not established by DSx exchange. When an AMS has information to send and decides to use the contention-based random access bandwidth request, the AMS shall check if the information the AMS has to send is for an access class with priority higher than or equal to the minimum access class advertised by BR channel configuration in the AAI-SCD. If it is not (the minimum access classes are not sufficiently low such that the AMS access class is allowed), then the AMS shall wait until the BR channel configuration in the AAI-SCD advertises a sequence of minimum access classes, one of 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 randomly select a backoff value within the backoff window specified by either the connection priority or S-SFH SP3, if no connection priority is indicated in the DSx. This random backoff value indicates the number of BR opportunities that the AMS shall defer before transmitting a bandwidth request.

As specified in 6.3.8.2.5, bandwidth request channel and bandwidth request preamble sequences shall be used for contention-based random access BRs. Each BR channel indicates a BR opportunity.

The order of mapping opportunity indices, which starts from opportunity index ‘0’, is the same as the order of the bandwidth request channel(s), which is allocated in a frame in the time domain. For the WirelessMAN-OFDMA R1 Reference System with an FDM-based UL PUSC Zone, bandwidth request channels are mapped to opportunity indices in a frequency-first order.

The AMS decides whether to send the BR preamble sequence only or to send the BR preamble sequence together with a quick access message for the random access-based BR procedure.

The three-step random access-based BR procedure is illustrated in Figure 6-47. At step 1, the AMS shall transmit a BR preamble sequence and a quick access message on a randomly selected opportunity. If the ABS detects at least one BR preamble sequence in the BR opportunities of frame *n*, and the ABS does not grant UL resources by the CDMA Allocation A-MAP IE, the UL subband assignment A-MAP IE, or the UL Basic assignment IE to all the successfully received BR requests before or in the frame n + BR_ACK_Offset, at least one BR-ACK A-MAP IE shall be sent at the DL frame of the frame n + BR_ACK_Offset, where the BR-ACK-Offset is defined in 6.11. The ABS may send multiple BR-ACK A-MAP IEs in the subframes in the DL frame of frame n + BR_ACK_Offset, with each BR-ACK A-MAP IE containing its own bitmap relating to the preamble sequences being acknowledged/granted in this A-MAP IE alone. Each AMS should try to decode all BR-ACK MAP-IEs at the DL frame of frame n + BR_ACK_Offset after it transmitted a BR preamble sequence. In this case, if no BR-ACK A-MAP IEs are sent at the DL frame of frame n + BR_ACK_Offset and the AMS does not receive any UL grant before or in frame n + BR_ACK_Offset, the AMS considers it as an implicit-NACK and may restart the BR procedure.

The BR-ACK A-MAP IE indicates the following:

— The decoding status of each BR opportunity in the *n*-th frame (no or at least one BR preamble sequence is detected). Each BR-ACK A-MAP IE contains its own BR-ACK Bitmap of size equal to the number of BR opportunities in the *n*-th frame. The BR preamble sequence indices in BR opportunities acknowledged in each BR-ACK A-MAP IE shall be mutual exclusive.

— The correctly received BR preamble sequences in the BR opportunities of the *n*-th frame being acknowledged/granted in this A-MAP IE.

— The decoding status of the quick access message for each correctly received BR preamble sequence being acknowledged/granted in this A-MAP IE.

If the BR-ACK Bitmap(s) indicates no BR preamble sequence is detected at the BR opportunity selected by the AMS, or the AMS's BR preamble sequence is not included at the selected BR opportunity in the BR-ACK A-MAP IE(s), the AMS shall consider that it has received a Negative-ACK. The AMS shall wait until the last DL subframe of the frame where the BR-ACK A-MAP IE(s) is transmitted before deciding it has received an implicit Negative-ACK.

The AMS shall start a BR timer if the AMS receives a BR-ACK A-MAP IE indicating a successful reception of the BR preamble sequence but the AMS does not receive any UL grant before or in the frame that the BR-ACK A-MAP IE is received. If the BR-ACK A-MAP IE indicates successful reception of a BR preamble sequence and quick access message, the BR Timer value shall be set to the differentiated BR timer acquired during the DSx transaction. For all other cases, the BR timer value shall be fixed.

The AMS shall stop the BR timer upon reception of the UL grant.

The AMS considers the BR as failed and may restart the BR procedure (according to the rules defined later in this subclause) when any of the following conditions is met:

a) AMS receives a Negative-ACK.

b) BR timer expires.

When an AMS restarts the BR procedure, the AMS shall randomly select a backoff value within its backoff window specified by the connection priority. This random backoff value indicates the number of BR opportunities that the AMS shall defer before retransmitting the BR. The connection priority is defined by the tuple of initial and maximum window sizes and a backoff window scaling factor. The backoff scaling factor is the base of the exponent in an exponential backoff. For instance, with a backoff scaling factor of B, an initial window size of S will increase to $B \times S$ at backoff stage 1, $B \times B \times S$ at backoff stage 2, $B \times B \times B \times S$ at backoff stage 3, and so on. Note that for the specific value of $B = 2$, this is precisely the binary exponential backoff. The ABS transmits initial connection priority parameters—initial and maximum window sizes and backoff window scaling factor—in DSx-REQ and/or DSx-RSP messages. If the DSx messages do not include backoff window parameters (BR backoff start, BR backoff end, and backoff window scaling factor), the values specified in the S-SFH SP3 shall be used for the service flow, with a default backoff scaling factor of 2 (indicating a binary exponential backoff). Otherwise, the values in the DSx messages shall override the values in the S-SFH SP3 for the service flow.

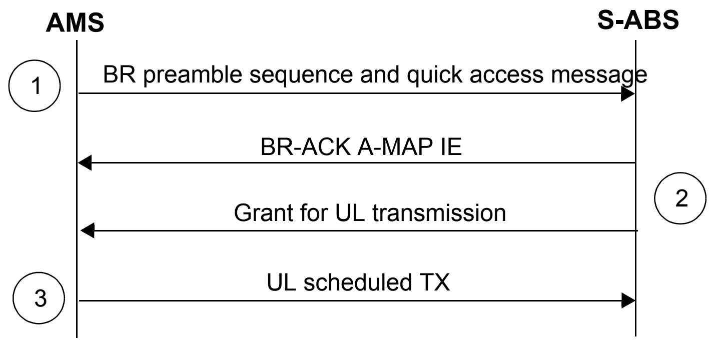


Figure 6-47—Three-step random access BR procedure

During the three-step BR procedure of Figure 6-47, if the ABS is unable to decode the quick access message, the ABS falls back to the five-step BR procedure illustrated in Figure 6-48. In that case, in step 2, the ABS shall provide a UL grant to the AMS using a BR-ACK A-MAP IE or CDMA Allocation A-MAP IE. The maximum HARQ retransmission of the allocation mode through the BR-ACK A-MAP IE or CDMA Allocation A-MAP IE is set to the default value defined in 6.2.14.2. In step 3, the AMS transmits a standalone BR header only.

In case of the five-step procedure, the AMS shall start the BR timer after sending the BR header in step 3. The BR timer value shall be set to the differentiated BR timer acquired during the DSx transaction.

The AMS shall stop the BR timer upon reception of the UL grant.

The AMS may restart (according to the rules defined later in this subclause) the BR procedure if the BR timer is expired.

When the AMS restarts the BR procedure, the AMS shall select a random backoff value that decides the number of BR opportunities it will defer before retransmitting the BR. This random value is defined by the connection priority, or S-SFH SP3, as described in the three-step procedure.

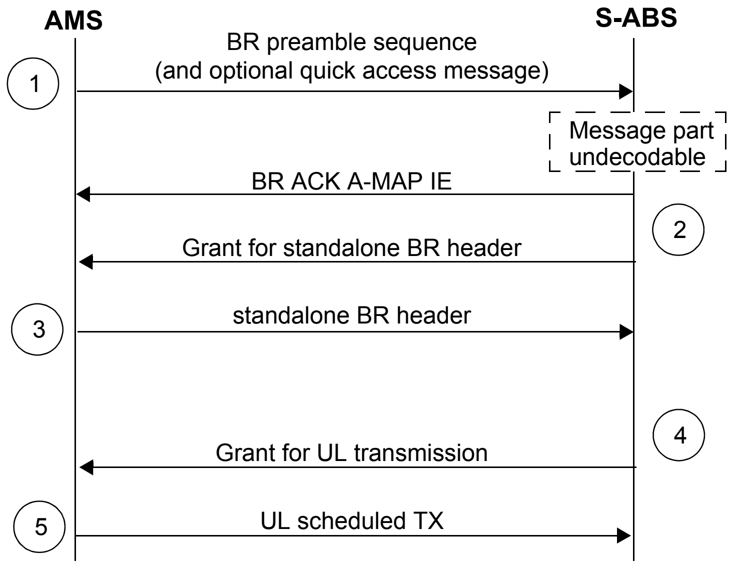


Figure 6-48—Example of five-step random access BR procedure

In the regular five-step random access BR procedure, an AMS shall send a BR preamble sequence only. The AMS should select the BR preamble randomly among 24 BR preamble indices. If the ABS detects at least one BR preamble sequence in frame *n*, and does not grant UL resources by the CDMA Allocation A-MAP IE to all the successfully received BR requests before or in the frame *n* + BR_ACK_Offset, the ABS shall send at least one BR-ACK A-MAP IE at the frame *n* + BR_ACK_Offset.

If the AMS receives a UL grant before or in frame *n* + BR_ACK_Offset, then the BR procedure proceeds as the five-step procedure in Figure 6-48, starting with step 3.

Otherwise, if the AMS receives a BR-ACK A-MAP IE in frame *n* + BR_ACK_Offset that indicates a successful reception of the BR preamble sequence, the AMS shall start a BR timer and set its expiration value to the fixed value defined in 6.11 and Table 6-330. Upon receiving a UL grant for the standalone BR header, the AMS shall stop the BR timer and the BR procedure proceeds as the five-step procedure in Figure 6-48, starting with step 3.

If the AMS does not receive a UL grant before or in frame *n* + BR_ACK_Offset, nor a BR-ACK A-MAP IE in frame *n* + BR_ACK_Offset that indicates a successful reception of the BR preamble, then the AMS considers the BR as failed and may restart the BR procedure (according to the rules defined in this subclause).

The rest of the BR procedure shall be the same as the five-step procedure of Figure 6-48.

6.2.11.1.2 Standalone bandwidth request header

The standalone bandwidth request header is used by AMS to send a bandwidth request in step 3 in the five-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.

6.2.11.1.3 Piggybacked bandwidth request

A piggybacked bandwidth request is used by the AMS to request bandwidth for the same or different connections of the data payload in the MAC PDU. It is carried in the extended header defined in 6.2.2.2.6.

6.2.11.1.4 Bandwidth request using P-FBCH

A bandwidth request can also be sent from an AMS to the ABS through P-FBCH. Two P-FBCH codewords are reserved for the AMS to send a BR indication flag and an ertPS/aGPS BR flag. In order to maintain operation of link adaptation mechanisms at the ABS and adequate CINR reporting, the AMS shall not transmit either one of the BR codewords on two consecutive P-FBCH allocations that are allocated to it.

6.2.11.1.4.1 BR indication flag feedback

An AMS can send a BR indication flag on the P-FBCH. The BR indication flag is used by the AMS to indicate to the ABS its intention to request UL allocation without the need to perform the random access bandwidth request. The codeword 0b111110 is used for that purpose. After receiving the BR indication flag from the AMS, the ABS may allocate the required UL resource for the signaling header to the AMS.

6.2.11.1.4.2 ertPS/aGP service BR

If an AMS has ertPS connections, the AMS may inform the S-ABS of the existence of pending ertPS data. If an AMS has aGP Service connections, the AMS may inform the S-ABS of the existence of pending aGP service data related to primary QoS parameters. The codeword 0b111111 is used for those purposes.

If the ABS receives the codeword (i.e., 0b111111) on P-FBCH from the AMS, the ABS should make a UL allocation as follows:

1) If an AMS has ertPS connections only, the ertPS/aGP BR indicator indicates that the AMS is requesting a UL burst corresponding to the largest Maximum Sustained Traffic Rate of the AMS's stopped ertPS UL service flows. The codeword also implicitly indicates the stopped ertPS UL service flow to resume.

2) If an AMS has aGP Service connections only, the ertPS/aGP BR indicator indicates that the AMS is requesting UL bursts corresponding to the Primary service flow QoS parameter set of the AMS's aGP Service UL service flow, which has the largest Grant_Size_primary among all aGP Service flows that currently do not use primary QoS parameters. The ABS may send adaptation response carried by the Service-Specific Scheduling Control header to either acknowledge AMS-suggested QoS parameters or assign alternative GPI and/or grant size of the chosen aGP service flow. Upon receiving the adaptation response, if the AMS intends to make adaptation on an aGP service flow different from the FID indicated in the Service-Specific Scheduling Control header, the AMS may send the adaptation request again.

3) If an AMS has both ertPS and aGP Service connections, the ertPS/aGP BR indicator indicates that the AMS is requesting UL bursts corresponding to the largest Maximum Sustained Traffic Rate of the AMS's stopped ertPS UL service flows and aGP Service UL service flows that currently do not use primary QoS parameters. If the largest Maximum Sustained Traffic Rate chosen belongs to an aGP service flow, the ABS may send an adaptation response carried by the Service-Specific Scheduling Control header to either acknowledge AMS-suggested QoS parameters or assign alternative GPI and/or grant size of the chosen aGP service flow. Upon receiving the adaptation response, if the AMS intends to make adaptation on an aGP service flow different from the FID indicated in the Service-Specific Scheduling Control header, the AMS may send the adaptation request again.

6.2.11.1.5 Bandwidth request message format

6.2.11.1.5.1 Quick access message format

When a three-step BR procedure is used, in step 1 the quick access message carries 12-bit information including AMS addressing information with a BR preamble sequence carrying additional 4-bit BR information.

The following parameters are carried in the quick access message as shown in Table 6-129:

— STID (12 bits).

— Predefined BR index (4 bits): The mapping between "predefined BR index" and "BR size and QoS level" is negotiated during the AAI-DSx procedure,and its encoding is defined in 6.2.3.47.

Table 6-129—Quick access message format

Syntax	Size (bits)	Notes
Quick Access Message() {		
STID	12	Station ID.
Predefined BR index	4	Range: 0–15. Definition is MS specific based on AAI-DSx negotiation.
}		

6.2.11.1.5.2 Bandwidth Request header format

When the standalone Bandwidth Request header is transmitted in step 3 in the five-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, it may request a grant polling interval (GPI) change for aGP service or minimum delay of the requested grant for BE, and it may contain the following parameters. An ABS should use the size of a single-flow standalone Bandwidth Request header as the minimum allocation size for polling allocation:

— FID of the requesting connection

— Aggregate or incremental bandwidth

— New GPI value for aGP service or minimum delay of the requested grant for BE

— GPI change indicator for aGP service

The minimum delay interval from the bandwidth request to the grant allocation for a BE service flow is indicated by the "Minimum Grant Delay" field of the Service-Specific Scheduling Control header. It specifies the minimum number of frames that the ABS should wait to allocate for the requested grant after receiving the corresponding Service-Specific Scheduling Control header.

6.2.11.1.5.3 Piggyback Bandwidth Request Extended header format

The 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.

6.2.12 Quality of service (QoS)

6.2.12.1 Theory of operation

The various protocol mechanisms described in this standard may be used to support QoS for both UL and DL traffic through the AMS and the ABS. This subclause provides an overview of the QoS protocol mechanisms and their part in providing end-to-end QoS.

The requirements for QoS include the following:

a) A configuration and registration function for default service flows.
b) A signaling function for provisioned or dynamically establishing QoS-enabled service flows and traffic parameters.
c) Utilization of MAC scheduling and QoS traffic parameters for UL service flows.
d) Utilization of QoS traffic parameters for DL service flows.
e) Grouping of service flow properties into named service classes, so upper layer entities and external applications (at both the AMS and the ABS) may request service flows with desired QoS parameters in a globally consistent way.

The principal mechanism for providing QoS is to associate packets traversing the MAC interface into a service flow as identified by the SFID. A service flow is a unidirectional flow of packets that is provided with a particular QoS. The AMS and the ABS provide this QoS according to the QoS parameter set defined for the service flow.

The primary purpose of the QoS features defined here is to define transmission ordering and scheduling on the air interface. However, these features often need to work in conjunction with mechanisms beyond the air interface in order to provide end-to-end QoS or to police the behavior of AMSs.

Service flows exist in both the UL and the DL direction and may exist without actually being activated to carry traffic. All service flows have a 32-bit SFID; admitted and active service flows also have a 4-bit FID.

6.2.12.2 Service flows

A service flow is a MAC transport service that provides unidirectional transport of packets either to UL packets transmitted by the AMS or to DL packets transmitted by the ABS. A service flow is characterized by a set of QoS parameters such as latency, jitter, and throughput assurances. In order to standardize operation between the AMS and the ABS, these attributes include details of how the AMS requests UL bandwidth allocations and the expected behavior of the ABS UL scheduler.

A service flow is partially characterized by the following attributes:

a) Service Flow ID: An SFID is assigned to each existing service flow. The SFID serves as the principal identifier for the service flow in the AMS. A service flow has at least an SFID and an associated direction.
b) FID: The identifier of the transport connection that exists only when the service flow is admitted or active. The relationship between SFID and FID, when present, is unique. An SFID shall never be associated with more than one FID, and a FID shall never be associated with more than one SFID. The FID uniquely identifies the transport connection within an AMS.

c) ProvisionedQoSParamSet: A QoS parameter set provisioned via means outside of the scope of this standard, such as the network management system.

d) AdmittedQoSParamSet: Defines a set of QoS parameters for which the ABS (and possibly the AMS) is reserving resources. The principal resource to be reserved is bandwidth, but this also includes any other memory or time-based resource required to subsequently activate the flow.

e) ActiveQoSParamSet: Defines a set of QoS parameters for the service actually being provided to the service flow. Only an active service flow may forward packets.

f) Authorization Module: A logical function within the ABS that approves or denies every change to QoS parameters and classifiers associated with a service flow. As such, it defines an “envelope” that limits the possible values of the AdmittedQoSParamSet and ActiveQoSParamSet.

The relationship between the QoS parameter sets is as shown in Figure 6-49 and Figure 6-50. The ActiveQoSParamSet is always a subset of the AdmittedQoSParamSet, which is always a subset of the authorized “envelope.” In the dynamic authorization model, this envelope is determined by the Authorization Module (labeled as the AuthorizedQoSParamSet). In the provisioned authorization model, this envelope is determined by the ProvisionedQoSParamSet. It is useful to think of three types of service flows states:

1) Provisioned: A service flow in this state is associated with the ProvisionedQoSParamSet. The ProvisionedQoSParamSet is known via provisioning by, for example, the network management system or AAI-DSA exchanges initiated by the ABS. The AdmittedQoSParamSet and ActiveQoSParamSet of the service flow are both null. A provisioned service flow is the one that is provisioned but not immediately activated (sometimes called “deferred”) by the setup of the flow. The network assigns an SFID for such a service flow during provisioning. For activation or admission of a provisioned service flow, the ABS may also require an authorization from a policy module prior to activation or admission. As a result of external action beyond the scope of this specification, the AMS may choose to activate a provisioned service flow by passing the SFID and the associated active QoS parameter sets to the ABS in the AAI-DSC-REQ message. If authorized and resources are available, the ABS shall respond by mapping the service flow to a FID. As a result of external action beyond the scope of this specification, the ABS may choose to activate a provisioned service flow by passing the SFID as well as the FID and the associated active QoS parameter sets to the AMS in the AAI-DSC-REQ message. Such a provisioned service flow may be activated and deactivated many times (through AAI-DSC exchanges). In all cases, the original SFID shall be used when reactivating the service flow.

2) Admitted: A service flow in this state has resources reserved by the ABS for its AdmittedQoSParamSet, but its resources are not assigned until its state changes to active (i.e., its ActiveQoSParamSet is null). Admitted service flows may have been provisioned or may be created dynamically and immediately admitted. The Admitted state supports a two-phase activation model that is often utilized in telephony applications. In the two-phase activation model, the resources for a “call” are first “admitted,” and then once the end-to-end negotiation is completed (e.g., called party’s gateway generates an “off-hook” event), the resources are “activated.” The two-phase model serves the following purposes:

— Conserving network resources until a complete end-to-end connection has been established

— Performing policy checks and admission control on resources as quickly as possible and, in particular, before informing the far end of a connection request

— Preventing several potential theft-of-service scenarios

For example, if an upper layer service were using UGS, and the addition of upper layer flows could be adequately provided by increasing the Maximum Sustained Traffic Rate QoS parameter, then the following procedure might be used. When the first higher layer flow is pending, the AMS issues an AAI-DSA-REQ with the admitted Maximum Sustained Traffic

Rate parameter equal to that required for the first higher layer flow, and the active Maximum Sustained Traffic Rate parameter equal to zero. Later when the higher layer flow becomes active, it issues an AAI-DSC-REQ with the instance of the active Maximum Sustained Traffic Rate parameter equal to that required for the higher layer flow. Admission control was performed at the time of the reservation, so the later AAI-DSC-REQ, having the active parameters within the range of the previous reservation, is guaranteed to succeed. Subsequent higher layer flows would be handled in the same way. If there were three higher layer flows establishing connections, with one flow already active, the service flow would have admitted Maximum Sustained Traffic Rate equal to that required for four higher layer flows, and active Maximum Sustained Traffic Rate equal to that required for one higher layer flow. An activation request of a service flow where the new ActiveQoSParamSet is a subset of the AdmittedQoSParamSet shall be allowed, except in the case of catastrophic failure. An admission request where the AdmittedQoSParamSet is a subset of the previous AdmittedQoSParamSet, so long as the ActiveQoSParamSet remains a subset of the AdmittedQoSParamSet, shall succeed. A service flow that has resources assigned to its AdmittedQoSParamSet, but whose resources are not yet completely activated, is in a transient state. It is possible in some applications that a long-term reservation of resources is necessary or desirable. For example, placing a telephone call on hold should allow any resources in use for the call to be temporarily allocated to other purposes, but these resources shall be available for resumption of the call later. The AdmittedQoSParamSet is maintained as "soft state" in the ABS; this state shall be maintained without releasing the nonactivated resources. Changes may be signaled with an AAI-DSC-REQ message.

3) Active: A service flow in this state has resources committed by the ABS for its ActiveQoSParamSet (e.g., is actively sending maps containing unsolicited grants for a UGS-based service flow). A service flow that has a non-NULL ActiveQoSParamSet is said to be an active service flow. It is requesting (according to its Request/Transmission Policy) and being granted bandwidth for transport of data packets. An admitted service flow may be activated by providing an ActiveQoSParamSet, signaling the resources actually desired at the current time. This completes the second stage of the two-phase activation model (see Admitted service flow). A service flow may be provisioned and immediately activated. Alternatively, a service flow may be created dynamically and immediately activated. In these cases, two-phase activation is skipped and the service flow is available for immediate use upon authorization.

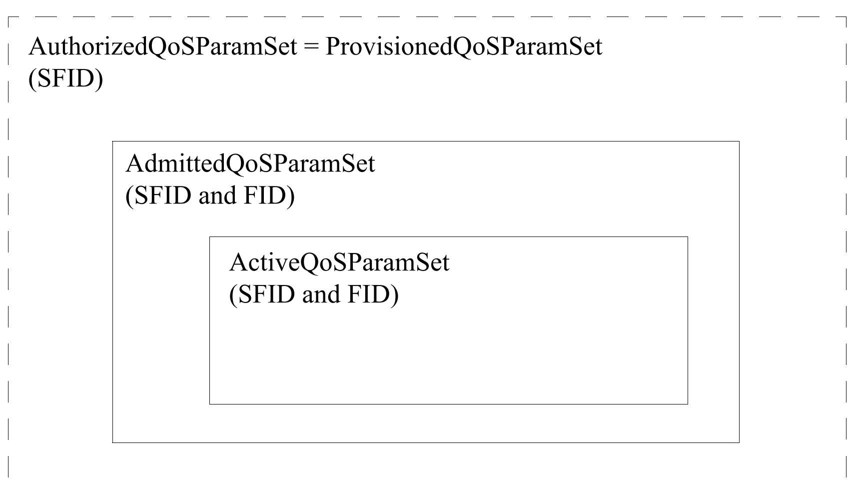


Figure 6-49—Provisioned authorization model "envelopes"

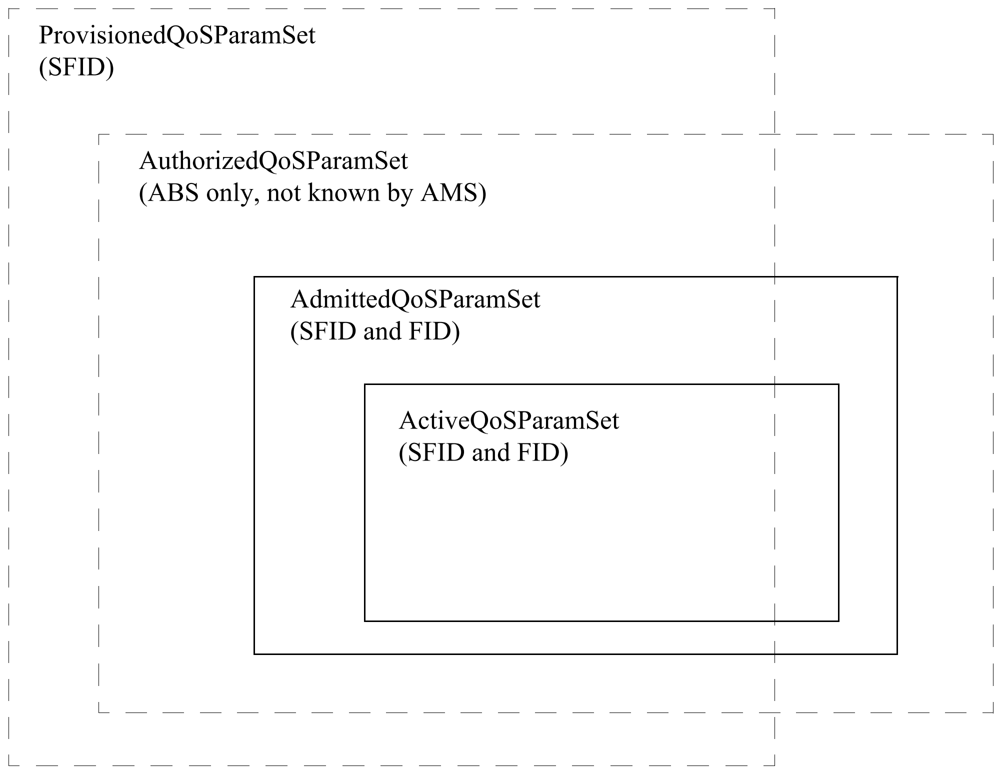


Figure 6-50—Dynamic authorization model "envelopes"

6.2.12.3 Object model

The major objects of the architecture are represented by named rectangles in Figure 6-51. Each object has a number of attributes; the attribute names that uniquely identify it are underlined. Optional attributes are denoted with brackets. The relationship between the number of objects is marked at each end of the association line between the objects. For example, a service flow may be associated with 0 to *N* (many) PDUs, but a PDU is associated with exactly one service flow. The service flow is the central concept of the MAC protocol. In an AMS, it is uniquely identified by a 32-bit SFID. Service flows may be in either the UL or the DL direction. There is a one-to-one mapping between admitted and active service flows (32-bit SFID) and transport connections (4-bit FID).

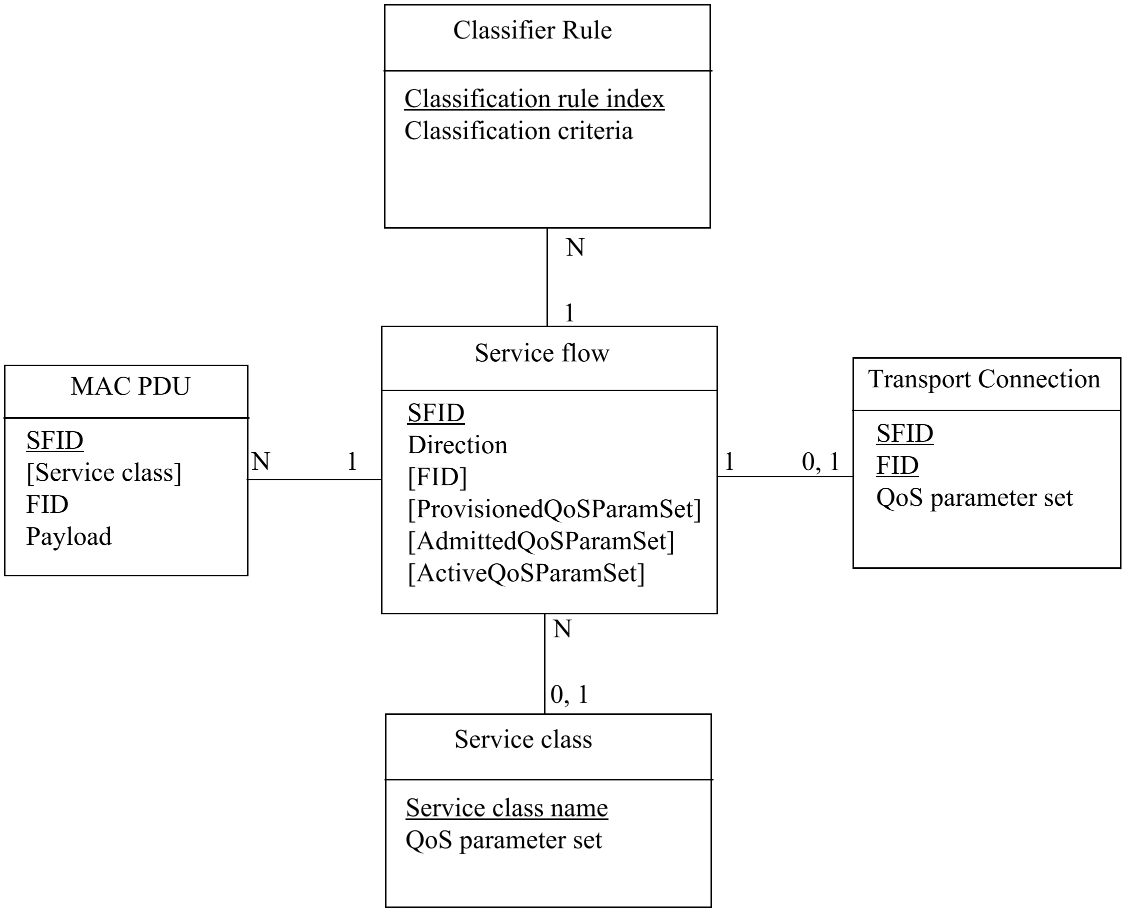


Figure 6-51—Theory of operation object model

Outgoing user data is submitted to the MAC SAP by a CS process for transmission on the MAC interface. The information delivered to the MAC SAP includes the FID identifying the transport connection across which the information is delivered. The service flow for the connection is mapped to a MAC transport connection identified by the FID.

A Classifier Rule uniquely maps a packet to its transport connection.

The service class is an optional object that may be implemented at the ABS. It is referenced by an ASCII name, which is intended for provisioning purposes. A service class is defined in the ABS to have a particular QoS parameter set. The QoS parameter sets of a service flow may contain a reference to the service class name as a “macro” that selects all of the QoS parameters of the service class. The service flow QoS parameter sets may augment and even override the QoS parameter settings of the service class, subject to authorization by the ABS.

6.2.12.4 Service classes

The service class serves the following purposes:

a) It allows operators, who so wish, to move the burden of configuring service flows from the provisioning server to the ABS. Operators provision the AMSs with the service class name; the implementation of the name is configured at the ABS. This allows operators to modify the implementation of a given service to local circumstances without changing AMS provisioning. For example, some scheduling parameters may need to be tweaked differently for two different ABSs to provide the same service. As another example, service profiles could be changed by time of day.
b) It allows higher layer protocols to create a service flow by its service class name. For example, telephony signaling may direct the AMS to instantiate any available provisioned service flow of class “G711.”

NOTE—Service classes are merely IDs for a specific set of QoS parameter set values. Hence, the use of service classes is optional. A service identified by a service class is treated no differently, once established, than a service that has the same QoS parameter set explicitly specified.

Any service flow may have its QoS parameter set specified in any of the following three ways:

— By explicitly including all traffic parameters.
— By indirectly referring to a set of traffic parameters by specifying a service class name.
— By specifying a service class name along with modifying parameters.

The service class name is “expanded” to its defined set of parameters at the time the ABS successfully admits the service flow. The service class expansion can be contained in the following ABS-originated messages: AAI-DSA-REQ, AAI-DSC-REQ, AAI-DSA-RSP, and AAI-DSC-RSP. In all of these cases, the ABS shall include a service flow encoding that includes the service class name and the QoS parameter set of the service class. If an AMS-initiated request contained any supplemental or overriding service flow parameters, a successful response shall also include these parameters.

When a service class name is given in an admission or activation request, it is possible that the returned QoS parameter set may change from activation to activation. This can happen because of administrative changes to the service class’s QoS parameter set at the ABS. If the definition of a service class name is changed at the ABS (e.g., its associated QoS parameter set is modified), it has no effect on the QoS parameters of existing service flows associated with that service class. An ABS may initiate DSC transactions to existing service flows that reference the service class name to affect the changed service class definition.

When an AMS uses the service class name to specify the admitted QoS parameter set, the expanded parameter set of the service flow shall be returned to the AMS in the response message (AAI-DSA-RSP or AAI-DSC-RSP). Use of the service class name later in the activation request may fail if the definition of the service class name has changed and the new required resources are not available. Thus, the AMS should explicitly request the expanded parameter set from the response message in its later activation request.

6.2.12.4.1 Global Service classes

A Global Service class name is a rules-based, composite name parsed in a variable number of information fields of the following formats:

— For I = 1, format is ISBRLSPS1R and length is 5 bytes
— For I = 0 and S2 = 0 or 1, format is ISBRLSPS1S2R and length is 5 bytes
— For I = 0 and S2 = 2 or 3, format is ISBRLSPS1S2S3R and length is 6 bytes
— For I = 0 and S2 = 4, format is ISBRLSPS1S2S3S5R and length is 6 bytes
— For I = 0 and S2 = 5, format is ISBRLSPS1S2L1S3S4R and length is 7 bytes
— For I = 0 and S2 = 6, format is ISBRLSPS1S2L1S4R and length is 7 bytes
— For I = 0 and S2 = 7, format is ISBRLSPS1S2L1S3S6S7S8S9S10R and length is 11 bytes

Table 6-130—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 6-189 (value 0b111111 indicates TLV to follow)
B	Maximum traffic burst	6	Extensible look-up Table 6-189 (value 0b111111 indicates TLV to follow)
R	Minimum reserved traffic rate	6	Extensible look-up Table 6-189 (value 0b111111 indicates TLV to follow)
L	Maximum latency	6	Extensible look-up Table 6-189 (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	7	Bit 0: If this bit is set to 1, the service flow shall not use broadcast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 1: If this bit is set to 1, the service flow shall not use multicast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 2: If this bit is set to 1, the service flow shall not piggyback requests with data (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 3: If this bit is set to 1, the service flow shall not fragment data Bit 4: If this bit is set to 1, the service flow shall not suppress payload headers (CS parameter). If bit 4 is set to 0 and both the SS and the BS support PHS (according to 11.7.7.3 in IEEE Std 802.16), each SDU for this service flow shall be prefixed by a PHSI field, which may be set to 0 (see 5.2). If bit 4 is set to 1, none of the SDUs for this service flow shall have a PHSI field Bit 5: If this bit is set to 1, the service flow shall not pack multiple SDUs (or fragments) into single MAC PDUs Bit 6: If this bit is set to 1, the service flow shall not compress payload headers using ROHC. If bit 6 is set to 0 and both the SS and the BS support ROHC (according to 11.7.7.4 in IEEE Std 802.16), each SDU for this service flow shall be compressed using ROHC. If bit 6 is set to 1, none of the SDUs shall be compressed

Table 6-130—Global Service Class Name Information Field parameters *(continued)*

Position	Name	Size (bits)	Value
S2	Uplink Grant Scheduling Type	3	(Refer to 11.13.10 in IEEE Std 802.16) 1 = Undefined 2 = BE 3 = nrtPS 4 = rtPS 5 = ertPS 6 = UGS 7 = aGP Service This field is included when I = 0
L1	Tolerated Jitter	6	Extensible look-up Table 6-190 (value 0b111111 indicates TLV to follow). This is available only for Uplink Grant Scheduling Type = ertPS, aGP service or UGS. This field is included when I = 0 and S2 = 5 or 6.
S3	Traffic Priority	3	(Refer to 11.13.5 in IEEE Std 802.16.). This is used only for Uplink Grant Scheduling Type = rtPS, ertPS, nrtPS, aGP service, or BE.This field in included when I = 0 and S2 = 2 or 3 or 4 or 5.
S4	Unsolicited Grant Interval	6	Extensible look-up Table 6-191 (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 6-191 (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.
S6	Primary GPI	6	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I = 0 and S2 = 7.
S7	Primary Grant Size	6	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I = 0 and S2 = 7.
S8	Secondary GPI	6	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I = 0 and S2 = 7.
S9	Secondary Grant Size	6	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I = 0 and S2 = 7.
S10	Adaptation Method	1	This is available only for Uplink Grant Scheduling Type = aGP Service. This field is included when I = 0 and S2 = 7.
R	Padding	*variable*	Padding bits to ensure byte aligned. Shall be set to zero.

Maximum sustained traffic rate per flow

A parameter that defines the peak information rate of the service. The rate is expressed in bits per second and pertains to the service data units (SDUs) at the input to the system. Explicitly, this parameter does not include transport, protocol, or network overhead such as MAC headers or CRCs, or nonpayload session maintenance overhead like SIP, MGCP, H.323 administration, and so on. 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 this standard.

6.2.12.5 Authorization

Every change to the service flow QoS parameters shall be approved by an authorization module. This includes every AAI-DSA-REQ message to create a new service flow and every AAI-DSC-REQ message to change a QoS parameter set of an existing service flow. Such changes include requesting an admission control decision (e.g., setting the AdmittedQoSParamSet) and requesting activation of a service flow (e.g., setting the ActiveQoSParamSet). Reduction requests regarding the resources to be admitted or activated are also checked by the authorization module.

In the static authorization model, the authorization module stores the provisioned status of all “deferred” service flows. Admission and activation requests for these provisioned service flows shall be permitted, as long as the admitted QoS parameter set is a subset of the provisioned QoS parameter set, and the active QoS parameter set is a subset of the admitted QoS parameter set. Requests to change the provisioned QoS parameter set shall be refused, as shall requests to create new dynamic service flows. This defines a static system where all possible services are defined in the initial configuration of each AMS.

In the dynamic authorization model, the authorization module also communicates through a separate interface to an independent policy server. This policy server may provide the authorization module with advance notice of upcoming admission and activation requests, and it specifies the proper authorization action to be taken on those requests. Admission and activation requests from an AMS are then checked by the authorization module to ensure that the ActiveQoSParamSet being requested is a subset of the set provided by the policy server. Admission and activation requests from an AMS that are signaled in advance by the external policy server are permitted. Admission and activation requests from an AMS that are not presignaled by the external policy server may result in a real-time query to the policy server or may be refused.

Prior to initial connection setup, the ABS shall retrieve the provisioned QoS parameter set for an AMS. This is handed to the authorization module within the ABS. The ABS shall be capable of caching the provisioned QoS parameter set and shall be able to use this information to authorize dynamic flows that are a subset of the provisioned QoS parameter set. The ABS should implement mechanisms for overriding this automated approval process (such as described in the dynamic authorization model). For example it could:

a) Deny all requests regardless of whether they have been preprovisioned.
b) Define an internal table with a richer policy mechanism but seeded by the Provisioned QoS Set.
c) Refer all requests to an external policy server.

6.2.12.6 Service flow management

Service flows may be created, changed, or deleted. This is accomplished through a series of MAC management messages referred to as AAI-DSA, AAI-DSC, and AAI-DSD. The AAI-DSA messages create a new service flow. The AAI-DSC messages change an existing service flow. The AAI-DSD messages delete an existing service flow. This is illustrated in Figure 6-52.

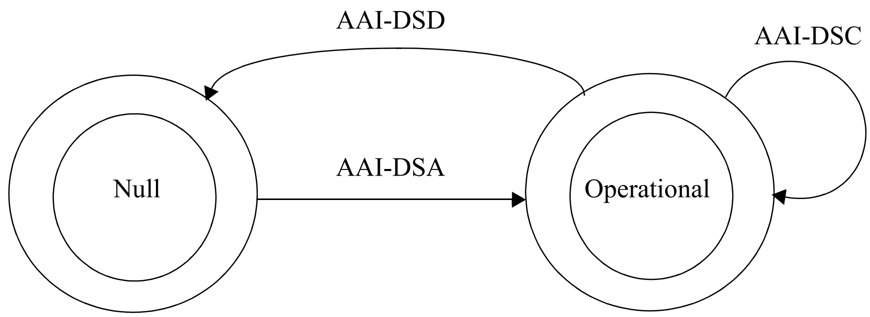


Figure 6-52—Service flow state transition overview

The Null state implies that no service flow exists that matches the SFID and/or FID Change Count.

Once the service flow exists, it is operational and has an assigned SFID. In steady-state operation, a service flow resides in a Nominal state. When AAI-DSx messaging is occurring, the service flow may transition through other states, but remains operational. Since multiple service flows may exist, there may be multiple state machines active, one for every service flow. AAI-DSx messages only affect those state machines that match the SFID and/or FID Change Count. Both the AMS and the ABS shall decrypt and validate the encrypted AAI-DSx messages before processing them, and discard any messages that fail the decryption.

FID Change Count is unique per transaction and is increased by one (modulo 16) by the initiating device (ABS or AMS). Each AAI-DSx message sequence is a unique transaction with an associated unique FID Change Count. The AAI-DSA/DSC transactions consist of a request/response/acknowledge sequence. The AAI-DSD transactions consist of a request/response sequence. The response messages shall return a CC of "request was successful" unless some exception condition was detected. The acknowledge messages shall return the CC in the response unless a new exception condition arises.

The AMS and the ABS shall support the scheduling services described in 6.3.5. The AMS and the ABS shall support adaptation of service flow (SF) QoS parameters. One or more QoS parameter set(s) may be defined during the initial service negotiation, depending on the types of the scheduling services for the service flow, e.g., a mandatory primary SF QoS parameter set, an optional secondary SF QoS parameter set, and so on. 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.

For aGPS scheduling services, 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 resources according to the adapted SF QoS parameters.

The value of the FID field specifies the FID assigned by the ABS to a service flow of an AMS with a non-null AdmittedQosParamSet and/or ActiveQosParamSet. The 4-bit value of this field is used in BRs and in MAC PDU headers. This field shall be present in an ABS-initiated AAI-DSA-REQ or AAI-DSC-REQ message related to establishing an admitted or active service flow. This field shall also be present in AAI-DSA-RSP and AAI-DSC-RSP messages in response to AMS-initiated AAI-DSA-REQ and AAI-DSC-REQ messages related to the successful establishment of an admitted or active service flow.

AAI-DSA-REQ/RSP shall include the MAC Header type field to indicate which MAC header format is to be used for such service flow. When MAC Header type = 0, the given service flow shall use AGMH. When MAC Header type = 1, the given service flow shall use SPMH.

6.2.12.6.1 Dynamic service flow creation

Creation of service flows may be initiated by either the ABS or the AMS.

An AAI-DSA-REQ message from an ABS contains an SFID for either one UL or one DL service flow, possibly its associated FID, and a set of active or admitted QoS parameters. The protocol is illustrated in Figure 6-53. An AMS responds with the AAI-DSA-RSP message indicating acceptance or rejection. In the case when rejection was caused by presence of a nonsupported parameter of a nonsupported value, a specific parameter may be included into the AAI-DSA-RSP message.

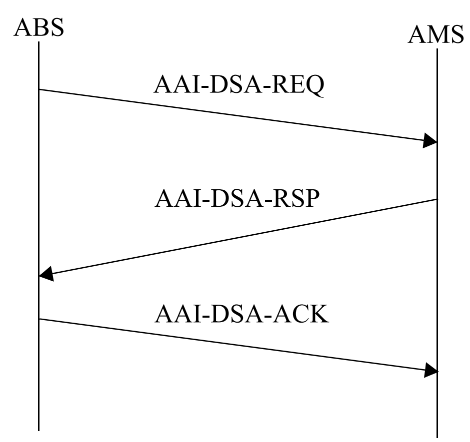


Figure 6-53—ABS-initiated AAI-DSA message flow

The AMS-initiated protocol is illustrated in Table 6-54. An AAI-DSA-REQ message from an AMS contains a QoS parameter set (marked either for admission-only or for admission and activation). An ABS responds with an AAI-DSA-RSP message indicating acceptance or rejection. In the case when rejection was caused by presence of a nonsupported parameter of nonsupported value, a specific parameter may be included into the AAI-DSA-RSP message.

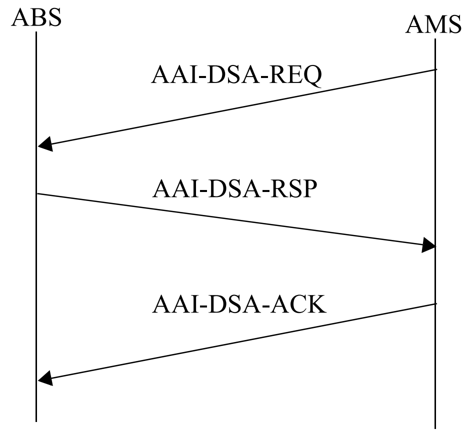


Figure 6-54—AMS-initiated AAI-DSA message flow

6.2.12.6.2 Dynamic service flow modification and deletion

In addition to the methods presented in 6.2.12.6.1 for creating a service flow, protocols are defined for modifying and deleting a service flow.

Both provisioned and dynamically created service flows are modified with the AAI-DSC message, which can change the admitted and active QoS parameter sets of the flow. A successful AAI-DSC transaction changes a service flow's QoS parameters by replacing both the admitted and active QoS parameter sets. If the message contains only the admitted set, the active set is set to null and the flow is deactivated. If the message contains neither set ("000" value used for QoS parameter set type; see 6.2.3.47.4), then both sets are set to null and the flow is de-admitted. When the message contains both QoS parameter sets, the admitted set is checked first, and if admission control succeeds, the active set in the message is checked against the admitted set in the message to ensure that it is a subset. If all checks are successful, the QoS parameter sets in the message become the newly admitted and active QoS parameter sets for the service flow. If either of the checks fails, the AAI-DSC transaction fails and the service flow QoS parameter sets are unchanged.

When a service flow is deleted using the AAI-DSD message, all resources associated with it are released. If a service flow for a provisioned service is deleted, the ability to reestablish the service flow for that service is network management dependent.

6.2.12.7 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 the WirelessMAN-OFDMA R1 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.

6.2.12.7.1 Adaptive granting and polling service

The set of QoS parameters associated with adaptive granting and polling services are categorized into primary QoS parameters and secondary QoS parameters. The ABS may grant or poll the AMS periodically and may negotiate only primary SF QoS parameters, or both primary and secondary QoS parameters with the AMS. Initially, ABS uses primary SF QoS parameters including Primary Grant and Polling Interval (GPI) and Primary Grant Size.

During the service, the traffic characteristics and QoS requirement may change, for example, silence-suppression enabled VoIP alternates between talk spurt and silence period, which triggers adaptation of the scheduling service state machine as described in the paragraphs that follow. Adaptation of the scheduling state includes switching between using primary and using secondary SF QoS parameters or changing of GPI/Grant size.

Depending on the adaptation method specified during the service flow addition through AAI-DSA messages, either the AMS or the ABS may initiate the adaptation of the grant size or GPI. The adaptation trigger condition is implementation dependent and may include the change of observed traffic activity, bandwidth need from AMS, or offered load at ABS.

There are two adaptation methods. Only one method is used for a service flow, and cannot be changed via AAI-DSC messages:

— **ABS-initiated adaptation**: ABS may initiate the GPI and grant size change by sending the unsolicited adaptation response carried in the Service Specific Scheduling Control Header. The adaptation may be either changes of GPI and/or Grant size; or switches between GPI_primary/Grant_Size_primary and GPI_secondary/Grant_Size_secondary if the secondary SF QoS parameter set is defined. The AMS shall respond by sending the adaptation ACK or adaptation NACK carried by the Service Specific Scheduling Control header to acknowledge or reject ABS-suggested QoS parameters. The new QoS parameters start to be effective after Adaptation ACK is received.

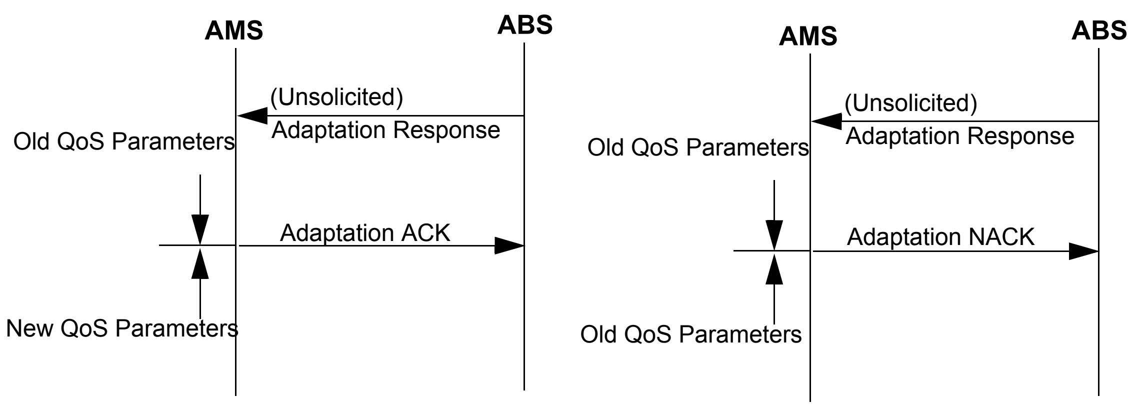


Figure 6-55—ABS-initiated adaptation

— **AMS-initiated adaptation**: The AMS may initiate the GPI and grant size change by sending the adaptation request carried by SSSCH, quick access message in BR channel, or ertPS/aGP Service BR on P-FBCH. The ABS may respond by sending the adaptation response carried by the Service Specific Scheduling Control header to either acknowledge AMS-suggested QoS parameters or assign alternative QoS parameters. The adaptation start time of new QoS parameters is determined by the Adaptation Start Frame field included in adaptation response. Such a change is sustained until the next change request. After the request, if the granted bandwidth does not meet the request grant size, the AMS may send the adaptation request again until it receives an adaptation response or the bandwidth grant as requested. When the adaptation request includes the longer GPI than before, if the bandwidth grant is made based on the previous GPI or the adaptation response is not received until the next expected scheduling interval, the AMS may send the adaptation request again. When the adaptation request includes the shorter GPI than before, if the adaptation response or bandwidth grant is not received until the next expected scheduling interval based on a new GPI value after the AMS initiates the adaptation request, the AMS may send the adaptation request again. 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 indicated by the adaptation request carried by the Service Specific Scheduling Control header, quick access message in BR channel, or ertPS/aGP Service BR on P-FBCH; otherwise, GPI and grant size changes as indicated by the QoS requirement carried by the Service Specific Scheduling Control header. If an AMS has requested a change in GPI or grant size (different than GPI_Primary and Grant_size_primary, respectively), when this AMS performs handover to another ABS, it should retransmit the adaptation request to the T-ABS after network reentry is completed.

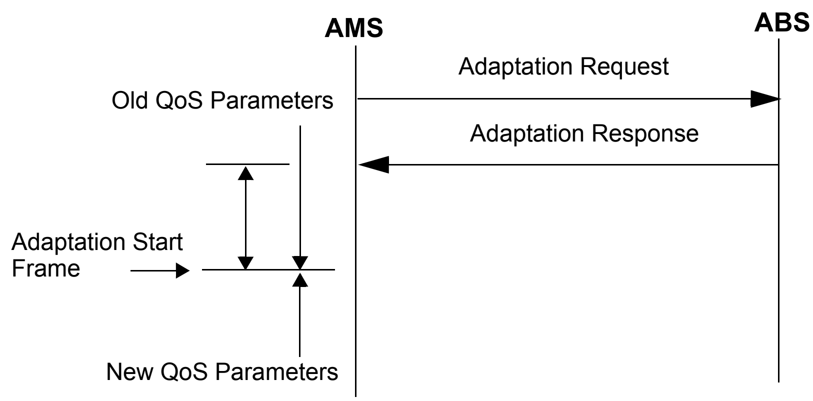


Figure 6-56—AMS-initiated adaptation

Table 6-131 describes the SF QoS parameters for the adaptive grant and polling scheduling service (aGP service).

Table 6-131—SF QoS parameters for aGP service scheduling service

Parameter	Notes
Maximum latency (unsigned int)	Refer to 11.13.13 in IEEE Std 802.16
Tolerated Jitter (unsigned int)	Refer to 11.13.12 in IEEE Std 802.16
Minimum reserved traffic rate (unsigned int)	Refer to 11.13.8 in IEEE Std 802.16
Maximum sustained traffic rate (unsigned int)	Refer to 11.13.6 in IEEE Std 802.16
Traffic Priority (unsigned int)	Refer to 11.13.5 in IEEE Std 802.16
Request/Transmission Policy (unsigned int)	Bit 0: If this bit is set to 1, the service flow shall not use broadcast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 1: If this bit is set to 1, the service flow shall not use multicast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 2: If this bit is set to 1, the service flow shall not piggyback requests with data.(UL only) (see 6.3.5 in IEEE Std 802.16) Bit 3: If this bit is set to 1, the service flow shall not fragment data Bit 4: If this bit is set to 1, the service flow shall not suppress payload headers (CS parameter). If bit 4 is set to 0 and both the SS and the BS support PHS (according to 11.7.7.3 in IEEE Std 802.16), each SDU for this service flow shall be prefixed by a PHSI field, which may be set to 0 (see 5.2). If bit 4 is set to 1, none of the SDUs for this service flow shall have a PHSI field Bit 5: If this bit is set to 1, the service flow shall not pack multiple SDUs (or fragments) into single MAC PDUs Bit 6: If this bit is set to 1, the service flow shall not compress payload headers using ROHC. If bit 6 is set to 0 and both the SS and the BS support ROHC (according to 11.7.7.4 in IEEE Std 802.16), each SDU for this service flow shall be compressed using ROHC. If bit 6 is set to 1, none of the SDUs shall be compressed
if (uplink service flow) { (Boolean)	
Scheduling Type (unsigned int)	aGP service
GPI_primary (unsigned int)	Primary GPI used initially
Grant_size_primary (unsigned int)	Primary grant size. If the primary grant size equals *x* bytes (the newly defined bandwidth request header size), this indicates a primarily polling based service; otherwise, it is a 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 *x* bytes (the newly defined bandwidth request header size), this indicates a secondarily polling based service; otherwise, it is a secondarily granting based service
Adaptation Method (unsigned int)	— ABS-initiated adaptation — AMS-initiated adaptation
}	

The mandatory QoS parameters of the aGP Service are the Maximum Sustained Traffic Rate, the Request/Transmission Policy, Primary GPI, and Primary Grant Size.

6.2.12.7.1.1 Handover support

During AMS handover from MZone/ABS to LZone/R1 BS, an ABS should map an aGP service flow to a service flow of R1 scheduling type. An aGP service flow should be mapped to an ertPS service flow or a rtPS service flow based on the value of “GrantSize_primary.” If the “GrantSize_primary” value is equal to the bandwidth request header size, an aGP service flow should be mapped to an rtPS service flow. Otherwise, an aGP service should be mapped to an ertPS service flow.

Table 6-132—Mapping from aGP service to ertPS/rtPS

AAI aGP service flow	Mapped R1 service flow	
QoS parameters	Scheduling type	QoS parameters
GrantSize_primary != 6 bytes	ertPS	— UPI = Primary GPI — and map equally all the other common QoS parameters between ertPS and aGP service
GrantSize_primary = 6 bytes	rtPS	— UGI = Primary GPI — and map equally all the other common QoS parameters between rtPS and aGP service

6.2.12.8 Emergency and NS/EP service flows

The AAI system shall support two types of emergency services, E-911 type emergency services for all users and National Security/Emergency Preparedness (NS/EP) services for designated emergency service personnel.

Service flow parameters for emergency service (e.g., E-911) may be predefined in the system. When such emergency service flow is predefined, a FID for the emergency service flow is either predefined or allocated by the ABS.

During the network entry, if the FID is not predefined, the ABS shall allocate the emergency service FID for the emergency service flow through AAI-RNG-RSP upon receiving AAI-RNG-REQ with Ranging Purpose Indication set to code 0b0101. For the NS/EP service flow, an NS/EP FID shall be assigned through AAI-RNG-RSP upon receiving AAI-RNG-REQ with Ranging Purpose Indication set to code 0b1101.

During the Connected State, if the FID for the emergency service flow is not predefined, the ABS shall allocate the FID for the service flow through AAI-DSA-RSP upon receiving the appropriate indication in the AAI-DSA-REQ. For the NS/EP service flow, the ABS shall allocate the FID through AAI-DSA-RSP upon receiving the NS/EP service indication in the AAI-DSA-REQ.

6.2.12.9 Emergency and NS/EP service notification during initial ranging

The AMS may request emergency or NS/EP Service flow setup during initial ranging process by setting the Ranging Purpose Indication to code 0b0101 for Emergency type services or code 0b1101 for NS/EP services in the AAI-RNG-REQ message.

Upon receiving the request for emergency service from the AMS, the ABS shall allocate a FID for the Emergency service flow through the AAI-RNG-RSP, if the FID is not predefined. Upon receiving the request for NS/EP Service from the AMS, the ABS shall allocate a FID for the NS/EP service flow though the AAI-RNG-RSP.

If the service flow parameters are predefined, the AMS transmits the Emergency or NS/EP message using the FID for the appropriate emergency or NS/EP service flow without going through the complete service flow setup through DSA transaction. The ABS grants resources according to the service flow parameters predefined for emergency or NS/EP service. If no service flow parameters are predefined for the emergency or NS/EP service, the AMS and the ABS shall establish the emergency or NS/EP service flow via DSA transaction.

If a service provider wants to support National Security/Emergency Preparedness (NS/EP) services, the ABS uses its own algorithm as defined by its local country regulation body. For example, in the U.S., the algorithm to support NS/EP is defined by the FCC in the so-called Hard Public Use Reservation by Departure Allocation (PURDA).

6.2.12.10 Emergency and NS/EP service notification during connected state

When an AMS requests emergency service in the connected state and service flow parameters are predefined for the emergency services, the AMS shall send a bandwidth request using the appropriate FID for the emergency service flow without going through the complete service flow setup through DSA transaction.

When no service flow parameters are predefined for either the emergency or the NS/EP services, the AMS shall establish the appropriate emergency or NS/EP service flow using the service flow setup procedure through DSA transaction and raise (set to 1) either the emergency indication parameter or the NS/EP service indication parameter (see Table 6-85), whichever is appropriate, in the AAI-DSA-REQ.

6.2.12.11 Emergency Alert Service

The Emergency Alert Service is defined as a service that would provide the public with alerts on imminent emergency events, such as earthquake, storm, and so on. The alerts would target subscribers in a specific geographical location. The Emergency Alert Service includes the transmissions of emergency information. The emergency information is broadcasted through AAI-L2-XFER.

6.2.12.12 Service flow/convergence sublayer parameters

Table 6-133 defines the parameters associated with UL/DL scheduling for a service flow.

Table 6-133—Service flow/convergence sublayer parameters

Fields	Size (bits)	Description
FID	4	An identifier of a service flow
SFID	32	
Uplink/Downlink Indicator	1	Whether parameters are for uplink or for downlink
Differentiated BR timer	6	Grant reception timeout before contention-based BR is attempted again for the service flow. Value of range 1~64 frame(s)

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
MAC in-order delivery indicator	1	Indicate whether or not the order of delivery in the connection is preserved by the MAC. 0: Not preserved 1: Preserved For ARQ connections, it shall be always set to 1
GPI primary	16	Primary Grant and Polling Interval in unit of milliseconds
Grant size primary	16	Primary grant size. If the primary grant size equals *x* bytes (the newly defined bandwidth request header size), this indicates a primarily polling based service; otherwise, it is a primarily granting based service
GPI secondary	16	Secondary Grant and Polling Interval in unit of milliseconds
Grant size secondary	8	Secondary grant size (optional). If the secondary grant size is defined and equals *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	1	— ABS-initiated adaptation — AMS-initiated adaptation
Service Class Name	16 ~ 1024	Null-terminated string of ASCII characters. The length of the string, including the null-terminator, may not exceed 128 bytes. Present when a prdefined BS service configuration is used for this service flow
QoS Parameter Set Type	3	Bit 0: Provisioned Set Bit 1: Admitted Set Bit 2: Active Set
Traffic Priority	3	0 to 7: Higher numbers indicate higher priority Default 0
Access Class	2	This parameter specifies the priority assigned to a service flow. This priority is used in prioritizing access requests as described in 6.2.11.1.1
Maximum Sustained Traffic Rate	32	Rate (in bits per second). Refer to 11.13.6 in IEEE Std 802.16 for the usage of this parameter
Maximum Traffic Burst	32	Burst size (bytes). Refer to 11.13.7 in IEEE Std 802.16 for the usage of this parameter
Minimum Reserved Traffic Rate	32	Rate (in bits per second). Refer to 11.13.8 in IEEE Std 802.16 for the usage of this parameter
Vendor ID	24	Vendor identification specified by the 3-byte, vendor-specific organizationally unique identifier of the AMS or ABS MAC address
Vendor-Specific QoS Parameter	*variable*	Refer to 6.2.12.12.8.3 for the usage of this parameter. 3-byte-Vendor ID shall be the first information of this parameter

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
Uplink Grant Scheduling Type	3	Refer to 11.13.11 in IEEE Std 802.16. In addition to the R1 scheduling services described in 11.13.10 in IEEE Std 802.16, aGP Service is supported. 0: *Reserved* 1: Undefined (BS implementation-dependent) 2: BE (default) 3: nrtPS 4: rtPS 5: Extended rtPS 6: UGS 7: aGP Service
Request/Transmission Policy	7	Bit 0: If this bit is set to 1, the service flow shall not use broadcast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 1: If this bit is set to 1, the service flow shall not use multicast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 2: If this bit is set to 1, the service flow shall not piggyback requests with data (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 3: If this bit is set to 1, the service flow shall not fragment data Bit 4: If this bit is set to 1, the service flow shall not suppress payload headers (CS parameter). If bit 4 is set to "0" and both the SS and the BS support PHS (according to 11.7.7.3 in IEEE Std 802.16), each SDU for this service flow shall be prefixed by a PHSI field, which may be set to 0 (see 5.2). If bit 4 is set to 1, none of the SDUs for this service flow shall have a PHSI field Bit 5: If this bit is set to 1, the service flow shall not pack multiple SDUs (or fragments) into single MAC PDUs Bit 6: If this bit is set to 1, the service flow shall not compress payload headers using ROHC. If bit 6 is set to"0" and both the SS and the BS support ROHC (according to 11.7.7.4 in IEEE Std 802.16), each SDU for this service flow shall be compressed using ROHC. If bit 6 is set to 1, none of the SDUs shall be compressed
Tolerated Jitter	32	Milliseconds. Refer to 11.13.12 in IEEE Std 802.16 for the usage of this parameter
Maximum Latency	32	Milliseconds. Refer to 11.13.13 in IEEE Std 802.16 for the usage of this parameter
Target SAID	8	SAID onto which service flow is mapped
ARQ Enable	1	0 = ARQ Not Requested/Accepted 1 = ARQ Requested/Accepted
ARQ_WINDOW_SIZE	16	>0 and ≤(ARQ_BSN_MODULUS/2)
ARQ_BLOCK_LIFETIME	16	0 = Infinite 1–6 553 500 s (100 s granularity)
ARQ_SYNC_LOSS_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
ARQ_RX_PURGE_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)
ARQ_SUB_BLOCK_SIZE	3	Bit 0–2: encoding for selected block size (P), where the selected block size is equal to $2^{(P+3)}$, $0 \le P \le 7$. ARQ subblock size is byte unit
ARQ_ERROR_DETECTION_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)
ARQ_FEEDBACK_POLL_RETRY_TIMEOUT	16	0 = Infinite 1–6 553 500 s (100 s granularity)
CS Specification	8	0: *Reserved* 1: Packet, IPv4 2: Packet, IPv6 3: Packet, IEEE 802.3/Ethernet[a] 4: *Reserved* 5: *Reserved* 6: *Reserved* 7: *Reserved* 8: *Reserved* 9: *Reserved* 10: *Reserved* 11: *Reserved* 12: *Reserved* 13: *Reserved* 14: Packet, IP[b] 15: Multiprotocol flow 16–255 *Reserved* (a: Classifiers for IEEE 802.1Q VLAN tags may be applied to service flows of this CS type) (b: SDUs for service flows of this CS type may carry either IPv4 or IPv6 in the payload)
Unsolicited Grant Interval	16	Milliseconds. Refer to 11.13.19 in IEEE Std 802.16 for the usage of this parameter
Unsolicited Polling Interval	16	Milliseconds. Refer to 11.13.20 in IEEE Std 802.16 for the usage of this parameter
Global Service Class Name	*variable*	ISBRLPS1S2L1S3S4S5
I: Uplink/Downlink indicator	1	0 = UL 1 = DL
S: Maximum Sustained Traffic Rate	6	Extensible look-up Table 6-189
B: Maximum Traffic Burst	6	Extensible look-up Table 6-189
R: Minimum Reserved Traffic Rate	6	Extensible look-up Table 6-189
L: Maximum Latency	6	Extensible look-up Table 6-190
P: Paging preference	1	0 = No paging generation 1 = Paging generation

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
S1: Request/Transmission Policy	7	Bit 0: If this bit is set to 1, the service flow shall not use broadcast BR opportunities (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 1: If this bit is set to 1, the service flow shall not use multicast BR opportunities. (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 2: If this bit is set to 1, the service flow shall not piggyback requests with data (UL only) (see 6.3.5 in IEEE Std 802.16) Bit 3: If this bit is set to 1, the service flow shall not fragment data. Bit 4: If this bit is set to 1, the service flow shall not suppress payload headers (CS parameter). If bit 4 is set to 0 and both the SS and the BS support PHS (according to 11.7.7.3 in IEEE Std 802.16), each SDU for this service flow shall be prefixed by a PHSI field, which may be set to 0 (see 5.2). If bit 4 is set to 1, none of the SDUs for this service flow shall have a PHSI field Bit 5: If this bit is set to 1, the service flow shall not pack multiple SDUs (or fragments) into single MAC PDUs Bit 6: If this bit is set to 1, the service flow shall not compress payload headers using ROHC. If bit 6 is set to 0 and both the SS and the BS support ROHC (according to 11.7.7.4 in IEEE Std 802.16), each SDU for this service flow shall be compressed using ROHC. If bit 6 is set to 1, none of the SDUs shall be compressed
S2: Uplink Grant Scheduling Type	3	0: *Reserved* 1: Undefined (BS implementation-dependent) 2: BE (default) 3: nrtPS 4: rtPS 5: Extended rtPS 6: UGS 7: aGP Service
L1: Tolerated Jitter	6	Extensible look-up Table 6-190. This is available only for Uplink grant scheduling type = ertPS, aGP service, or UGS
S3: Traffic priority	3	This is used only for Uplink Grant Scheduling Type = rtPS, ertPS, nrtPS, aGP service, or BE
S4: Unsolicited Grant Interval	6	Extensible look-up Table 6-191. This is available only for Uplink grant scheduling type = ertPS or UGS
S5: Unsolicited Polling Interval	6	Extensible look-up Table 6-191. This is available only for Uplink grant scheduling type = rtPS
Type of Data Delivery Services	3	0: Unsolicited Grant Service 1: Real-Time Variable Rate Service 2: Non-Real-Time Variable Rate Service 3: Best Effort Service 4: Extended Real-Time Variable Rate Service 5: aGP Service

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
SDU Inter-arrival Interval	16	SDU inter-arrival interval in the resolution of 0.5 ms
Time Base	16	Time base in milliseconds
Paging Preference	1	0 = No paging generation 1 = Paging generation
Authorization Token	*variable*	Authorization token that is used for authorizing the QoS for one or service flows generated by AMS-initiated higher level service flow creation or modification procedures. Refer to 11.13.32 in IEEE Std 802.16
ROHC Parameter payload	*variable*	Refer to Table 6-134
Packet Error Rate	8	MSB (bit 7): 0: PER measured by the application, post-ARQ, and post-HARQ process 1: PER measured on the airlink, before the application of ARQ and HARQ Bit 6: 0: Interpret bits 0–5 as an integer %; i.e., if bits 0–5 are the binary representation of the integer N, then the PER = $N/100$ (= N%) 1: Interpret bits 0–5 as 10 times a negative exponent of 10; i.e., if bits 0–5 are the binary representation of the integer N, then the PER = $10 - N/10$ LSB 6 bits (bits 0–5): PER value If bit 6 = 0, [0% to 63%] PER If bit 6 = 1, [~$5 \times 10 - 7$ to $1 \times 10 - 0$] PER
Emergency Indication	1	Indicates the associated flow is used for emergency purposes
NS/EP Service Indication	1	Indicates the associated flow is used for NS/EP services 0 = Not an NS/EP flow 1 = NS/EP flow
MAC Header Type	1	Indicates whether AGMH or SPMH is presented at the start of MAC PDUs of the service flow 0 = AGMH (Advanced Generic MAC Header) 1 = SPMH (Short-Packet MAC header)
Initial Backoff Window Size	4	Window size expressed as a power of 2
Maximum Backoff Window Size	4	Window size expressed as a power of 2
Backoff Scaling Factor	4	“0010” for Binary Exponential Backoff
E-MBS service	3	Indicates whether the MBS service is being requested or provided for the connection that is being setup. 1 indicates support, 0 indicates not support. Bit 0: E-MBS in S-ABS only Bit 1: E-MBS in a multi-ABS Zone supporting macro-diversity Bit 2: E-MBS in a multi-ABS Zone not supporting macro-diversity If all Bit 0~Bit 2 are set to 0, it indicates no E-MBS is supported

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
Num of E-MBS zone ID	3	Number of E-MBS zone ID to add
fullNumE-MBSIdArr[1..8]	*variable*	
A) E-MBS_Zone_ID	7	Indicates an E-MBS zone ID where the connection for associated service flow is valid
B) Physical Carrier Index	6	Target carrier to which the AMS switches or is redirected by ABS
C) Number of E-MBS ID_FID Mappings (M)	4	Number of E-MBS ID_FID Mappings in the E-MBS_Zone_ID to add
D) fullEMBSIdFidMappingArr[0...16]		
D.1) E-MBS ID and FID	*variable* (16 × N)	Mapping of E-MBS ID and FID. Based on the value of Number of E-MBS ID_FID Mappings
Quick Access Predefined BR Index Parameter	*variable*	Refer to 6.2.12.12.4
SCID	4	Sleep cycle ID
SDU Size	8	Number of bytes Default = 49
Non_ARQ_reordering_timeout	6	0 > and ≤ 32. Unit is PHY frame (5 ms)
Classification Rule Priority	8	//packet classification rule parameter 0–255
Protocol field	8	//packet classification rule parameter Protocol
IP Masked Source Address	32 × 2 (IPv4) or 128 × 2 (IPv6)	//packet classification rule parameter src, smask
IP Masked Destination Address	32 × 2 (IPv4) or 128 × 2 (IPv6)	//packet classification rule parameter dst, dmask
Protocol Source Port Range	16 × 2	//packet classification rule parameter sportlow, sporthigh
Protocol Destination Port Range field	16 × 2	//packet classification rule parameter dportlow, dporthigh
Associated PHSI	8	//packet classification rule parameter Index value
Packet Classification Rule Index	16	//packet classification rule parameter Packet Classification Rule Index
IPv6 Flow Label field	24	//packet classification rule parameter Flow Label
Classification Action Rule	8	//packet classification rule parameter Bit 0: 0 = none. 1 = Discard packet Bit 1–7: *Reserved*

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
IP Type of Service	8	//packet classification rule parameter Bit 0–Bit 1: *Reserved*. Shall be set to 0b00 Bit 2–Bit 7: DSCP value
PHS DSC Action field	2	//packet classification rule parameter 0: Add PHS Rule 1: Set PHS Rule 2: Delete PHS Rule 3: Delete all PHS Rules
PHSI field	8	//packet classification rule parameter Index value
PHSS field	8	//packet classification rule parameter Number of bytes in the suppression string
PHSF field	$\lceil PHSS/8 \rceil$	//packet classification rule parameter String of bytes suppressed
PHSM field	$\lceil PHSS/8 \rceil$	//packet classification rule parameter Bit 0: 0 = Do not suppress first byte of the suppression field 1 = Suppress first byte of the suppression field Bit 1: 0 = Do not suppress second byte of the suppression field 1 = Suppress second byte of the suppression field Bit x: 0 = Do not suppress (x + 1) byte of the suppression field 1 = Suppress (x + 1) byte of the suppression field
PHSV field	1	//packet classification rule parameter 0: Verify 1: Don't verify
Classifier DSC Action	8	0: DSC Add classifier 1: DSC Release classifier 2: DSC Delete classifier
IEEE 802.3/Ethernet Destination MAC Address parameter	48×2	dst.msk
IEEE 802.3/Ethernet Source MAC Address parameter	48×2	src, msk
Ethertype/IEEE 802.2 SAP	2/34/18	type, eprot1, eprot2 (See Table 6-85)
IEEE 802.1D User Priority field	3×2	pri-low, pri-high Valid range: 0–7 for pri-low and pri-high
IEEE 802.1Q VLAN ID field	12	vlan_id1, vlan_id2
Number of HARQ Channels	4	Indicates the number of HARQ channels that are intended to the flow
fullNumHarqChArr[0..15]		
A) HARQ Channel Mapping	4	Indicates the index (ACID) of each HARQ channel

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
Group Parameter Create/Change {	*variable*	Only one instance of the Group Parameter Create/Change may be included in AAI-DSA or AAI-DSC message
Common for Group Create/Change	*variable*	Common service flow encodings that are common to all flows specified in Group Parameter Create/Change. All the rules and settings that apply to the service flow encodings when used in an AAI-DSA or AAI-DSC message apply to the contents encapsulated in this parameter. Except FID, SFID, E-MBS service related information, Group Parameter Create/Change related information, and Coupled Group Create/Change related information, Service flow/convergence sublayer parameters in Table 6-133 may be encapsulated in this field. Shall be included only once in a Group Parameter Create/Change as the first attribute
Qty SFID Request	5	Qty SFID Request is the quantity of service flows of the same common parameter set configuration. Shall only be sent by the AMS as the last attribute of Group Parameter Create/Change in AAI-DSA-REQ or AAI-DSC-REQ
Group FID List	$N \times 4$	List of N FIDs The maximum value of N is 32
Group FID Parameter List {		Encapsulates an FID of a service flow and associated non-common service flow encodings for that service flow, specified in this Group Parameter Create/Change. If included, shall be the last attribute of Group Parameter Create/Change. The maximum number of Group FID Parameter Lists is 32
FID	4	FID of a service flow in the Group FID Parameter List
Non-Common for Group Create/Change	*variable*	Encapsulates the noncommon service flow encodings that are specific to individual service flows specified in the Group FID Parameter List. All the rules and settings that apply to the service flow encodings when used in an AAI-DSA or AAI-DSC message apply to the contents encapsulated in this parameter. Except FID, SFID, E-MBS service-related information, Group Parameter Create/Change related information, and Coupled Group Create/Change related information, Service flow/convergence sublayer parameters in Table 6-133 may be encapsulated in this field
}		
}		

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
Coupled Group Create/Change {	*variable*	This parameter encapsulates service flow encodings for Coupled UL and DL unicast service flows in an AAI-DSA or AAI-DSC message
Common for Coupled Group	*variable*	The common service flow encodings that are common to the Coupled UL and DL unicast service flows of an AMS in this Coupled Group Create/Change parameter. Except FID, SFID, E-MBS service-related information, Group Parameter Create/Change related information,and Coupled Group Create/Change related information, Service flow/convergence sublayer parameters in Table 6-133 may be encapsulated in this field. If included, this parameter shall be the first attribute of the Coupled Group Create/Change parameter
Qty Coupled SFID request	5	Qty Coupled SFID request is the quantity of Coupled UL and DL unicast service flows of an AMS, of the same common parameter set configuration. Used only as the last attribute of a Coupled Group Create/Change in an AAI-DSA-REQ or an AAI-DSC-REQ
Coupled FID List	N × 8	N × (4 MSB for DL FID and 4 LSB for UL FID) The maximum number of N is 16
Coupled FID Parameter List {		Encapsulates an FID of a service flow and associated non-common service flow encodings for that service flow, specified in this Coupled Group Create/Change. If included, shall be the last attribute of Coupled| Parameter Create/Change. The maximum number of Coupled FID Parameter Lists is 32
FID	4	FID of a service flow in the Coupled FID Parameter List
Non-Common for Coupled Group	*variable*	Encapsulates the noncommon service flow encodings that are specific to individual service flows specified in the Coupled FID Parameter List. All the rules and settings that apply to the service flow encodings when used in an AAI-DSA or AAI-DSC message apply to the contents encapsulated in this parameter. Except FID, SFID, E-MBS service-related information, Group Parameter Create/Change related information, and Coupled Group Create/Change related information, Service flow/convergence sublayer parameters in Table 6-133 may be encapsulated in this field
Number of HARQ Channels	4	Indicates the number of HARQ channels that are intended to the flow
fullNumHarqChArr[0…15]		
A) HARQ Channel Mapping	4	Indicates the index (ACID) of each HARQ channel
}		

Table 6-133—Service flow/convergence sublayer parameters *(continued)*

Fields	Size (bits)	Description
}		

Table 6-134 defines the ROHC parameter payload.

Table 6-134—ROHC parameter payload

Name	Size (bits)	Value
ROHC Max Context ID	16	Non-negative integer
Large Context IDs	8	0: FALSE (Small Context ID) 1: TRUE (Large Context ID) 2–255: *Reserved*
ROHC MRRU	16	0: No segmentation 1..65535: MRRU Maximum reconstructed reception unit

Table 6-135 defines the default service flow parameters.

Table 6-135—Parameters for default service flow setting

Name	Value/Note
UL grant scheduling type	Best Effort
DL data delivery service type	Best Effort
Maximum sustained traffic rate	UL: 0 DL: 0
Request/transmission policy parameter	0000101 (see request/transmission policy parameter in Table 6-133)
Default traffic priority	0 (default)
Target SAID parameter	If authorization policy supports in basic capability negotiation, Target SAID = 1. Otherwise, Target SAID = 0.
ARQ enable	0 (ARQ disabled)
Packet classification rule parameter	Packet Classification Rule Index field = 2 Classification Action Rule = 0 protocol field: omit IP Masked Source Address parameter: omit (in DL) IP Masked Destination Address parameter: omit (in UL) Protocol Source Port Range field: omit Protocol Destination Port Range field: omit Associated PHSI field: omit IP Type of Service: omit

6.2.12.12.1 FID

The value of this parameter specifies the FID assigned by the ABS to a service flow. The ABS shall use this parameterization to assign FIDs in ABS-initiated AAI-DSA-REQ messages and in its AAI-DSA-RSP to AMS-initiated AAI-DSA-REQ messages. The FID shall be used for DSx message signaling as the identifier for a service flow.

6.2.12.12.2 Uplink/Downlink indicator

The value of this parameter specifies whether a service flow is for uplink or for downlink. If the service flow is for uplink, the value of this parameter is set to 0. Otherwise, it is set to 1. The Uplink/Downlink Indicator shall be used for DSx message signaling as the indicator of uplink/downlink for a service flow.

6.2.12.12.3 Differentiated BR timer

This parameter is negotiated upon connection setup or during operation, based on other service flow parameters such as Uplink Grant Scheduling Type, Maximum Latency, and so on. The AMS-initiated AAI-DSA-REQ message may contain the suggested value for this parameter. The ABS-initiated AAI-DSA-REQ and AAI-DSA-RSP message shall contain the confirmation value or an alternate value for this parameter. An AMS and ABS may send the AAI-DSC-REQ message to dynamically change the parameters of an existing service flow. The ABS shall send the AAI-DSC-RSP message containing the confirmation value or an alternate value for this parameter in response to a received AAI-DSC-REQ. The value of this parameter is the number of frames before the contention-based BR procedure is attempted again for the service flow. The ABS should try to allocate a UL grant within the confirmed value of this parameter when it receives BR for the service flow during the contention-based BR procedure.

6.2.12.12.4 Predefined BR index parameter

Table 6-136—Predefined BR index parameters

Syntax	Size (bits)	Notes
Predefined BR Index Parameter () {		
Number of predefined BR Indexes (K)	4	Range: 0–15
For (*i*=1 to K+1) {		
Predefined BR index	4	Refer to 6.2.3.47
BR Action	2	0b00: ertPS service flow requests to resume to maximum sustained rate 0b01: aGP service flow requests to switch to Primary QoS parameters 0b10: BR 0b11:*Reserved*
If (BR Action == 0b10){		
BR size	11	Number of bytes requested by the predefined BR index
}		
}		

Table 6-136—Predefined BR index parameters *(continued)*

Syntax	Size (bits)	Notes
}		

6.2.12.12.5 Coupled Group Create/Change

This parameter provides a method to allow an AMS or an ABS to create or change a DL service flow and a UL service flow together in a single DSA or DSC procedure. If any requested service flow fails to create or change, then an AAI-DSA-RSP or AAI-DSC-RSP shall be sent with Confirmation code set to nonzero.

The Coupled Group Create/Change parameter shall not be included together with Group Parameter Create/Change in an AAI-DSA or AAI-DSC message.

6.2.12.12.5.1 Qty Coupled SFID request

This parameter is used to inform the number of service flows to create or change with the Coupled Group Create/Change parameter in the AAI-DSA or AAI-DSC procedure.

6.2.12.12.6 Group Parameter Create/Change

This parameter provides a method to allow an AMS or an ABS to create or change a number of service flows in a single DSA or DSC procedure. If at least one service flow is successfully created or changed, then an AAI-DSA-RSP or AAI-DSC-RSP shall be sent with Confirmation code set to 0. The FID of a service flow that fails to create or change shall not be transmitted in the AAI-DSA-RSP or AAI-DSC-RSP message.

6.2.12.12.6.1 Qty SFID request

This parameter is used to inform the number of service flows to create or change with the Group Parameter Create/Change parameter in the AAI-DSA or AAI-DSC procedure.

6.2.12.12.7 HARQ channel mapping

This parameter specifies the set of HARQ channels that is intended to be used for carrying UL data on this service flow. When this parameter is present in AAI-DSA-REQ or AAI-DSC-REQ, the service flow should be given higher priority for carrying data via the specified set of HARQ channels. A unique set of HARQ channels shall be mapped to each flow for which the HARQ channel mapping is specified.

6.2.12.12.8 Vendor-specific information

Vendor-specific information for AMSs, if present, shall be encoded in the vendor-specific information field (VSIF) using the Vendor ID field to specify which tuples apply to which vendor's products. The Vendor ID shall be the first parameter embedded inside VSIF. If the first parameter inside VSIF is not a Vendor ID, then the VSIF parameters shall be discarded. When used as a subfield of vendor-specific information, i.e., vendor-specific classification parameters, vendor-specific PHS parameters, and vendor-specific QoS parameters, the Vendor ID identifies the Vendor ID of the AMSs that are intended to use this information.

This configuration setting may appear multiple times. The same Vendor ID may appear multiple times. This configuration setting may be nested inside a Packet classification configuration setting or a Service flow configuration setting. However, there shall not be more than one Vendor ID inside a single VSIF.

Example: Configuration with vendor-A-specific fields and vendor-B-specific fields:

(VSIF #1)

Vendor ID of Vendor A

Vendor A Specific parameter #1

Vendor A Specific parameter #2

(VSIF #2)

Vendor ID of Vendor B

Vendor B Specific parameter #1

Vendor B Specific parameter #2

NOTE—The vendor-specific information may present in any MAC control messages based on vendor-specific function.

6.2.12.12.8.1 Vendor-specific classification parameters

This allows vendors to encode vendor-specific classification rule parameters. The Vendor ID shall be the first parameter embedded inside vendor-specific classification rule parameters. If the first parameter inside vendor-specific classification rule parameters is not a Vendor ID, then the vendor-specific classification rule parameters shall be discarded.

6.2.12.12.8.2 Vendor-specific PHS parameters

This allows vendors to encode vendor-specific PHS parameters. The Vendor ID shall be the first parameter embedded inside vendor-specific PHS parameters. If the first parameter inside vendor-specific PHS parameters is not a Vendor ID, then the vendor-specific PHS parameters shall be discarded.

6.2.12.12.8.3 Vendor-specific QoS parameters

This allows vendors to encode vendor-specific QoS parameters. The Vendor ID shall be the first parameter embedded inside vendor-specific QoS parameters. If the first parameter inside vendor-specific QoS parameters is not a Vendor ID, then the vendor-specific QoS parameters shall be discarded.

6.2.13 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.

6.2.13.1 ARQ block usage

6.2.13.1.1 Initial transmission

An ARQ block is generated from one or multiple MAC SDU(s) or MAC SDU fragment(s) of the same flow. An ARQ block is variable in size.

An ARQ block is constructed by fragmenting MAC SDU or packing MAC SDUs and/or MAC SDU fragments. The fragmentation information for the ARQ block is included in MAC PDU using a FEH or a PEH. The packing information of MAC SDUs and/or MAC SDU fragments is included in the MAC PDU using a PEH.

When a transmitter generates a MAC PDU for transmission, the MAC PDU payload may contain one or more ARQ blocks. If the MAC PDU payload contains traffic from a single connection, the PDU payload itself shall be a single ARQ block. If traffic from multiple ARQ connections is multiplexed into one MAC PDU, the MAC PDU payload contains multiple ARQ blocks, with every ARQ block being a Connection Payload as in Figure 6-7.

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

6.2.13.1.2 Retransmission

When an ARQ block transmission fails in the initial transmission, a retransmission is scheduled with or without rearrangement.

In case of ARQ block retransmission without rearrangement, the MAC PDU shall contain the same ARQ block and corresponding fragmentation and packing information, which was used in the initial transmission.

In case of ARQ block retransmission with rearrangement, a single ARQ block shall be fragmented into a sequence of multiple ARQ subblocks. The size of ARQ subblock is defined by ARQ_SUB_BLOCK_SIZE (see 6.2.13.3.3), which is fixed in size. The last ARQ subblock of the ARQ block may be smaller in size than ARQ_SUB_BLOCK_SIZE. ARQ subblocks are sequentially numbered using ARQ subblock SN (SSN). ARQ subblock and SSN are maintained during retransmission. When a MAC PDU payload is constructed from one or more ARQ subblocks, it shall include RFPEH (see 6.2.2.2.7), which includes SDU and ARQ information about the MAC PDU payload.

Figure 6-57 illustrates an ARQ block initial transmission and retransmissions; two options for retransmission are presented—with and without rearrangements of the failed ARQ block.

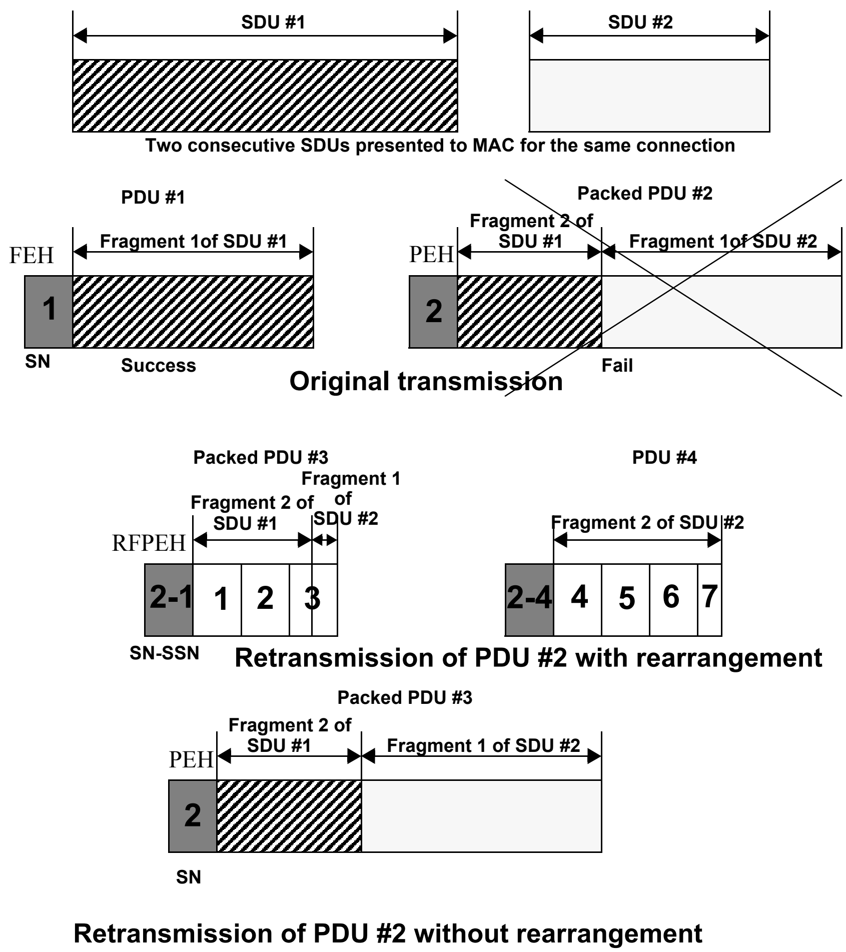


Figure 6-57—ARQ block initial transmission and retransmission

6.2.13.2 ARQ feedback

6.2.13.2.1 ARQ feedback transmission

An AAI-ARQ-Feedback message is used by the receiver to signal positive or negative acknowledgments for the ARQ block and subblocks. The ARQ receiver may use the MAC layer acknowledgment as defined in 6.2.22 to reliably transmit the unsolicited ARQ feedback.

6.2.13.2.2 ARQ feedback poll

The transmitter uses an ARQ feedback poll to update the reception status of the transmitted ARQ blocks. The ARQ feedback poll is sent using an APEH (see 6.2.2.2.8). When the transmitter sends an ARQ feedback poll, ARQ_Polling_Timeout is started. If there is no ARQ feedback from the receiver during ARQ_Polling_Timeout, the transmitter may retry the ARQ feedback poll. The transmitter shall perform an ARQ feedback poll when the ARQ buffer is full or the last ARQ block in the “not sent” state is sent.

In downlink, after transmitting APEH, an ABS may assign unsolicited bandwidth using A-MAP for the AMS to send the cumulative ACK information as an ARQ feedback. When the unsolicited bandwidth is granted to the AMS, the AMS should send ARQ feedback. If the granted bandwidth is not enough for sending ARQ feedback for cumulative ACK information, the AMS should send a BW request header instead of sending ARQ feedback.

6.2.13.2.3 ARQ feedback triggering conditions

The receiver shall send an ARQ feedback when at least one of the following conditions is met:

- An ARQ feedback poll is received from the transmitter.
- An ARQ block is declared as an error by the receiver.
- An ARQ Discard message is received from the transmitter.
- An ARQ block is purged by the receiver.

6.2.13.3 ARQ parameters and timers

6.2.13.3.1 ARQ_SN_MODULUS

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

6.2.13.3.2 ARQ_WINDOW_SIZE

ARQ_WINDOW_SIZE is defined in 6.3.4.3.2.

6.2.13.3.3 ARQ_SUB_BLOCK_SIZE

ARQ_SUB_BLOCK_SIZE is the ARQ subblock length when an ARQ block is fragmented into a sequence of multiple ARQ subblocks prior to retransmission with rearrangement. The last ARQ subblock of an ARQ block may be smaller in size than ARQ_SUB_BLOCK_SIZE.

6.2.13.3.4 ARQ_BLOCK_LIFETIME

ARQ_BLOCK_LIFETIME is defined in 6.3.4.3.3.

6.2.13.3.5 ARQ_RX_PURGE_TIMEOUT

ARQ_RX_PURGE_TIMEOUT is defined in 6.3.4.3.6 in IEEE Std 802.16.

6.2.13.3.6 ARQ_MAX_ BUFFER_SIZE

The ARQ_MAX_BUFFER_SIZE is the maximum size of the buffer (in bytes) that the AMS is able to allocate for all ARQ connections. The AMS shall inform this parameter to the ABS during capability negotiation.

6.2.13.3.7 ARQ_SYNC_LOSS_TIMEOUT

ARQ_SYNC_LOSS_TIMEOUT is defined in 6.3.4.3.5 in IEEE Std 802.16.

6.2.13.3.8 ARQ_ERROR_DETECTION_TIMEOUT

An ARQ block may arrive out-of-order due to HARQ retransmission. ARQ_ERROR_DETECTION_TIMEOUT is the time duration for which the receiver shall wait before declaring an ARQ block as being in error. For example, if ARQ block SN #n arrives before #n – 1, this timer starts for ARQ block SN # n – 1 in the receiver. When the timer expires, the ARQ block SN #n – 1 is declared as being in error in the receiver.

6.2.13.3.9 ARQ_FEEDBACK_POLL_RETRY_TIMEOUT

ARQ_FEEDBACK POLL_RETRY_TIMEOUT is the time duration for which the transmitter shall wait on ARQ feedback from the receiver after an ARQ feedback poll. When the timer expires, the transmitter may retry the ARQ feedback poll.

6.2.13.4 ARQ state machine variables

All ARQ state machine variables in the transmitter and receiver are set to zero when a connection setup or an ARQ reset occurs.

6.2.13.4.1 ARQ_TX_WINDOW_START

ARQ_TX_WINDOW_START is used in the transmitter ARQ state machine and represents the lower edge of the ARQ window in the transmitter in that all the ARQ blocks up to (ARQ_TX_WINDOW_START – 1) are regarded as positively acknowledged.

6.2.13.4.2 ARQ_TX_NEXT_SN

ARQ_TX_NEXT_SN is used in a transmitter ARQ state machine and corresponds to the lowest ARQ SN of the next ARQ block to be sent by the transmitter. ARQ_TX_NEXT_SN is a value in the interval ARQ_TX_WINDOW_START to (ARQ_TX_WINDOW_START + ARQ_WINDOW_SIZE).

6.2.13.4.3 ARQ_RX_WINDOW_START

It is used in a receiver ARQ state machine and represents the lower edge of ARQ window in the receiver in that all the ARQ blocks up to (ARQ_RX_WINDOW_START – 1) are regarded as correctly received.

6.2.13.4.4 ARQ_RX_HIGHEST_SN

It is used in a receiver ARQ state machine and corresponds to the highest ARQ SN of the ARQ block received, plus one. ARQ_RX_HIGHEST_SN is a value in the interval ARQ_RX_WINDOW_START to (ARQ_RX_WINDOW_START + ARQ_WINDOW_SIZE).

6.2.13.5 ARQ operation

6.2.13.5.1 Sequence number comparison

The ARQ SN comparison procedure is the same as defined in 6.3.4.6.1 in IEEE Std 802.16.

6.2.13.5.2 Transmitter operation

6.2.13.5.2.1 ARQ block state machine

Each ARQ-enabled connection shall have an independent ARQ state machine. The ARQ state transitions shall be ARQ block based (i.e., not based on the ARQ subblock).

An ARQ block may be in one of the following six states—not-sent, outstanding, waiting-for-retransmission, rearrangement, discard, and done state.

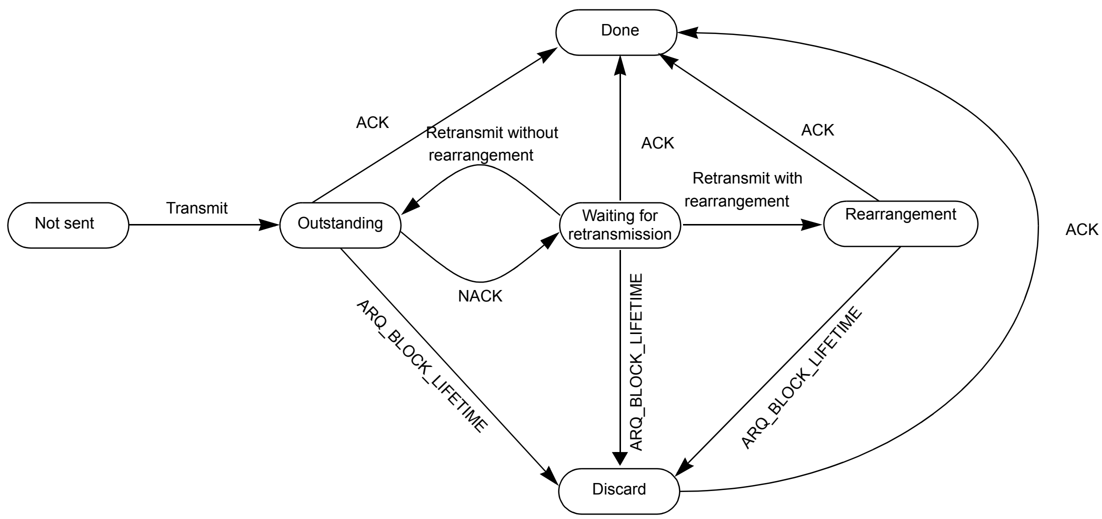


Figure 6-58—ARQ Tx block states

Any ARQ block in the buffer begins from the “not-sent” state before being transmitted. ARQ block formation continues with a connection’s “not-sent” MAC SDUs. The transmitter builds each ARQ block using the rules for fragmentation and packing. As each “not-sent” ARQ block is formed and constructs a MAC PDU, an ARQ block is assigned the current value of ARQ_TX_NEXT_SN, which is then incremented by one.

When an ARQ block is initially transmitted, the ARQ_BLOCK_LIFETIME timer is started for this ARQ block and the ARQ block state transits from “not-sent” state to “outstanding” state.

While an ARQ block is in the “outstanding” state, the transmitter waits for an acknowledgment. If a positive acknowledgment (ACK) arrives, the ARQ block state transits to the “done” state. If the ARQ block is negatively acknowledged (NACK or Local NACK), the ARQ block state transits to the “waiting-for-retransmission” state. If the ARQ_BLOCK_LIFETIME period expires, the ARQ block state transits to the “discard” state.

While an ARQ block is in the “waiting-for-retransmission” state, the transmitter prepares for ARQ block retransmission. If an ARQ block is retransmitted without rearrangement, the ARQ block state transits to the “outstanding” state. If an ARQ block is retransmitted with rearrangement, the ARQ block state transits to the “rearrangement” state. If a positive acknowledgment (ACK) arrives, the ARQ block state transits to the “done” state. If the ARQ_BLOCK_LIFETIME period expires, the ARQ block state transits to the “discard” state.

While an ARQ block is in the “rearrangement” state, the transmitter prepares for ARQ block retransmission with rearrangement. The “rearrangement” state includes the ARQ subblock state, which is described in

6.2.13.5.2.3. When an ARQ block is staying in the “rearrangement” state and if positive acknowledgments arrive regarding an ARQ block or all ARQ subblocks of a single ARQ block, the corresponding ARQ block state transits to the “done” state. If the ARQ_BLOCK_LIFETIME of an ARQ block expires, the corresponding ARQ block state transits to the “discard” state.

While an ARQ block is in the “discard” state, the transmitter sends the Discard message (see 6.2.3.45) and waits for the acknowledgment from the receiver. If a positive acknowledgment (ACK) of the ARQ block corresponding to the Discard message arrives, the ARQ block state transits to the “done” state.

When an ARQ block is in the “done” state, the transmitter shall flush the ARQ block and remove the timers and state variables associated with the flushed ARQ block.

For a given connection, the transmitter shall first handle (transmit or discard) blocks in the “waiting-for-retransmission” state and the “rearrangement” state and only then blocks in the “non-sent” state. Blocks in the “outstanding” or the “discarded” state shall not be transmitted. When ARQ blocks or subblocks are retransmitted, the ARQ block or subblock with the lowest SN or SSN shall be retransmitted first.

6.2.13.5.2.2 ARQ subblock state machine

An ARQ subblock may be in one of the following four states—not-sent, outstanding, waiting-for-retransmission, and done state as described in Figure 6-59.

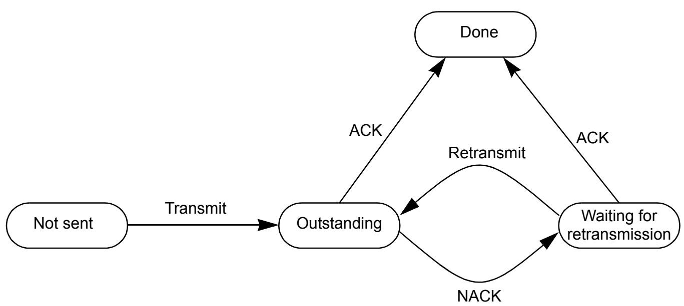


Figure 6-59—ARQ Tx subblock states

Once an ARQ block is in the “rearrangement” state, an ARQ block begins from the “not-sent” state. In the “not-sent” state, an ARQ block is fragmented into ARQ subblocks and subblock SN (SSN) is sequentially assigned. These ARQ subblocks and SSN are maintained during ARQ retransmission. When an ARQ subblock is transmitted, the ARQ subblock state transits from the “not-sent” to the “outstanding” state.

While the ARQ subblock is in the “outstanding” state, the transmitter waits for an acknowledgment. If a positive acknowledgment (ACK) arrives regarding the ARQ subblock, the ARQ subblock state transits to the “done” state. If the ARQ subblock is negatively acknowledged (NACK or Local NACK), the ARQ subblock transits to the “waiting-for-retransmission” state.

While the ARQ subblock is in the “waiting-for-retransmission” state, the transmitter prepares for ARQ subblock retransmission. If the ARQ subblock is retransmitted, the ARQ subblock state transits to the “outstanding” state. If a positive acknowledgment (ACK) arrives, the ARQ block state transits to the “done” state.

When the ARQ subblock is in “done” state, the transmitter may flush the ARQ subblock and wait for positive acknowledgment regarding the remaining ARQ subblocks of the ARQ block having a same SN.

Regardless of any state of ARQ subblock, if the ARQ block or all ARQ subblocks of a single ARQ block are positively acknowledged or the ARQ_BLOCK_LIFETIME of the ARQ block expires, all ARQ subblocks from the corresponding ARQ block shall be flushed.

6.2.13.5.2.3 ARQ feedback processing

In response to the transmitted ARQ block, the transmitter receives ARQ feedback sent by the receiver. The ARQ feedback may include either a positive (ACK) or a negative acknowledgment (NACK). Optionally, when ARQ and HARQ interaction (see 6.2.14.5) is enabled, the ARQ feedback may also be received in the form of a local NACK, which is a negative acknowledgment that is generated locally at the transmitter. When local NACK occurs in a certain ARQ block, the ARQ NACK of the corresponding ARQ block should be ignored until HARQ transmission is finished.

When the transmitter receives an ARQ feedback, the transmitter shall check the validity of the SN of the ARQ blocks being acknowledged. If the ARQ SN is in the interval ARQ_TX_WINDOW_START to ARQ_TX_NEXT_SN – 1 (inclusive), then the ARQ SN is valid; otherwise it is invalid and shall be ignored by the transmitter.

If the SN is valid and the ARQ feedback includes Cumulative ACK, the transmitter shall consider all the ARQ blocks in the interval ARQ_TX_WINDOW_START to SN (inclusive) as positively acknowledged, and set the ARQ_TX_WINDOW_START to SN + 1.

If the SN is valid and the ARQ feedback includes a selective ACK MAP, it shall consider all ARQ blocks in the interval ARQ_TX_WINDOW_START to SN (not inclusive) as positively acknowledged, and set the ARQ_TX_WINDOW_START to SN. The selective ACK MAP is processed from left to right (MSB to LSB), and the left-most bit indicates SN. Each bit in the selective ACK MAP that is set to "1" indicates that the corresponding ARQ block has been received correctly. Each bit that is set to "0" in the selective ACK MAP indicates that the corresponding ARQ block has been received incorrectly. If "NSI" is set to "1", the transmitter ignores all the bits set to "0" in the selective ACK MAP and the transmitter only considers those bits set to "1" in the selective ACK MAP. If ARQ feedback includes selective ACK MAP and "EXT" field set to "1", the transmitter shall process ARQ feedback information of ARQ subblocks. "Num_SSN" represents the number of ARQ subblocks that has been received correctly from "START_SSN" onward. If "NSI" is set to "1", the transmitter only considers correctly received ARQ subblocks.

6.2.13.5.3 Receiver operation

6.2.13.5.3.1 Receiver state machine

The ARQ state machine procedure in a receiver is defined in Figure 6-44 (6.3.4.6.3 in IEEE Std 802.16). In the figure, BSN is equal to SN.

When a MAC PDU is received, the receiver checks the extended header (FEH/PEH/RFPEH) and obtains all ARQ block information for the ARQ operation. After the receiver knows the ARQ SN and corresponding ARQ block in the MAC PDU, the state machine adds SN to the list of SN to be acknowledged. The state machine checks the SN that falls in the ARQ window range (ARQ_RX_WINDOW_START + ARQ_WINDOW_SIZE). If ARQ SN is not valid, the receiver discards the corresponding ARQ block.

If ARQ SN is valid, but the corresponding ARQ block is already received, the state machine resets ARQ_RX_PURGE_TIMEMOUT and discards the ARQ block. If an ARQ block is received and it is valid and not duplicated, the receiver state machine begins to update the ARQ state.

The procedure for an ARQ state update is as follows:

— If SN is equal to or larger than ARQ_RX_HIGHEST_SN, the receiver updates ARQ_RX_HIGHEST_SN as SN + 1.
— If SN is less than ARQ_RX_HIGHEST_SN and more than ARQ_RX_WINDOW_START, the receiver state variables are not changed.
— If SN is not equal to ARQ_RX_WINDOW_START, ARQ_RX_PURGE_TIMEOUT for this SN shall be (re)set. If SN is less than ARQ_RX_HIGHEST_SN and equal to ARQ_RX_WINDOW_START, ARQ_RX_WINDOW_START is advanced to the next lowest numbered ARQ block that has not been received. The ARQ_SYNC_LOSS_TIMEOUT shall be (re)set. After finishing the ARQ state update, the ARQ block is stored in the receiver buffer.

6.2.13.5.3.2 Error detection and ARQ feedback generation

When an ARQ block arrives out of sequence, then each ARQ block with an intermediate SN is declared as missing and the ARQ_ERROR_DETECTION_ TIMEOUT for every missing ARQ block is started. If the missed block does not arrive within ARQ_ERROR_DETECTION_TIMEOUT, the receiver declares the corresponding ARQ block as an error.

The receiver shall send ARQ feedback corresponding to each ARQ block using the ARQ feedback (see 6.2.13.2.1). ARQ feedback is sent when one of the ARQ feedback triggering conditions as defined in 6.2.13.2.3 are met.

If all the ARQ blocks in the ARQ window have been received correctly, the ARQ feedback should contain a cumulative ACK. If one or more ARQ blocks in the ARQ window have an error, the ARQ feedback should contain a selective ACK MAP for indicating the error.

6.2.13.5.3.3 ARQ discard message reception

When a discard message is received from the transmitter with a valid ARQ SN, the receiver shall discard the ARQ blocks specified by valid ARQ SN and advance ARQ_RX_WINDOW_START to the SN of the first block not yet received after the SN provided in the discard message, and mark all not received blocks in the interval from the previous to new ARQ_RX_WINDOW_START values as received for ARQ Feedback reporting.

6.2.13.5.3.4 ARQ block purge procedure

When a block does not result in an advance of the ARQ_RX_WINDOW_START, the ARQ_RX_PURGE_TIMEOUT for that block shall be started. When the value of the timer for a block exceeds ARQ_RX_PURGE_TIMEOUT, the timeout condition is marked. When the timeout condition is marked, ARQ_RX_WINDOW_START is advanced to the SN of the next block not yet received after the marked block. Timers for delivered blocks remain active and are monitored for timeout until the SN values are outside the receiver ARQ window.

When ARQ_RX_WINDOW_START is advanced, any SN values corresponding to blocks that have not yet been received residing in the interval between the previous and current ARQ_RX_WINDOW_START value shall be marked as received and the receiver shall send an ARQ Feedback to the transmitter with the updated information. Any blocks belonging to complete SDUs shall be delivered. Blocks from partial SDUs shall be discarded.

6.2.13.5.3.5 SDU reconstruction and in-order delivery

MAC SDU at the receiver is reconstructed from the received ARQ blocks. MAC SDUs shall be delivered to the upper layers in order. Only completely reconstructed MAC SDU shall be delivered to the upper layers.

Whenever a complete SDU is reconstructed from the ARQ blocks, the receiver shall check if there are any incomplete SDUs in front of the newly reconstructed SDU in the order of the components' ARQ block SNs. If so, the receiver does not deliver the complete SDU until the incomplete SDUs are recovered or explicitly skipped.

6.2.13.5.4 ARQ reset procedure

The ARQ reset procedures defined in Figure 6-60 and Figure 6-61 shall be supported by both the ARQ receiver and the ARQ transmitter. Each side (receiver or transmitter) may initiate an ARQ reset procedure when ARQ synchronization loss (see 6.2.13.5.5) happens or for any other implementation-specific reason. When the ARQ reset error happens during the ARQ reset procedure, the ABS or the AMS may reinitialize its MAC.

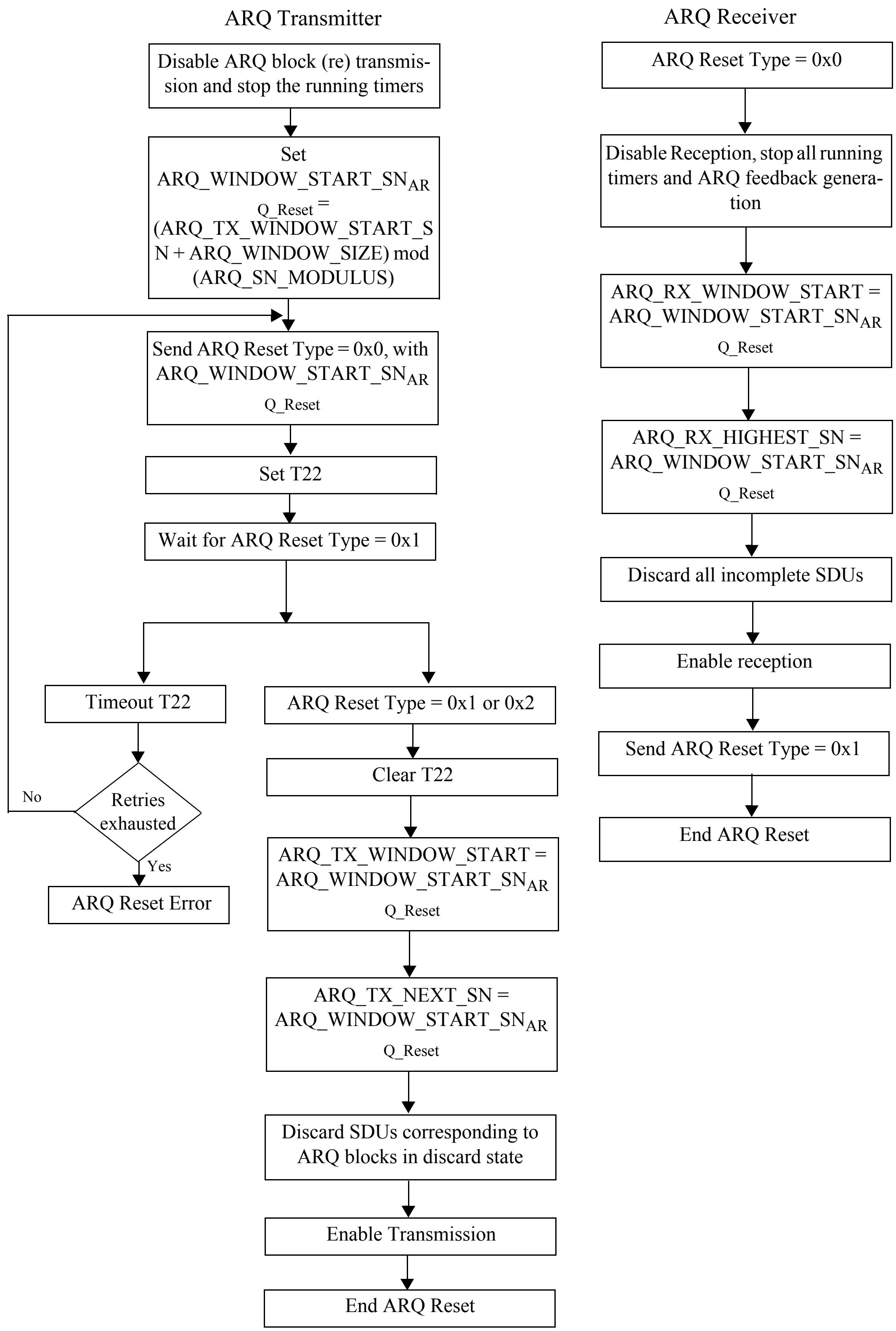


Figure 6-60—Transmitter-initiated ARQ reset

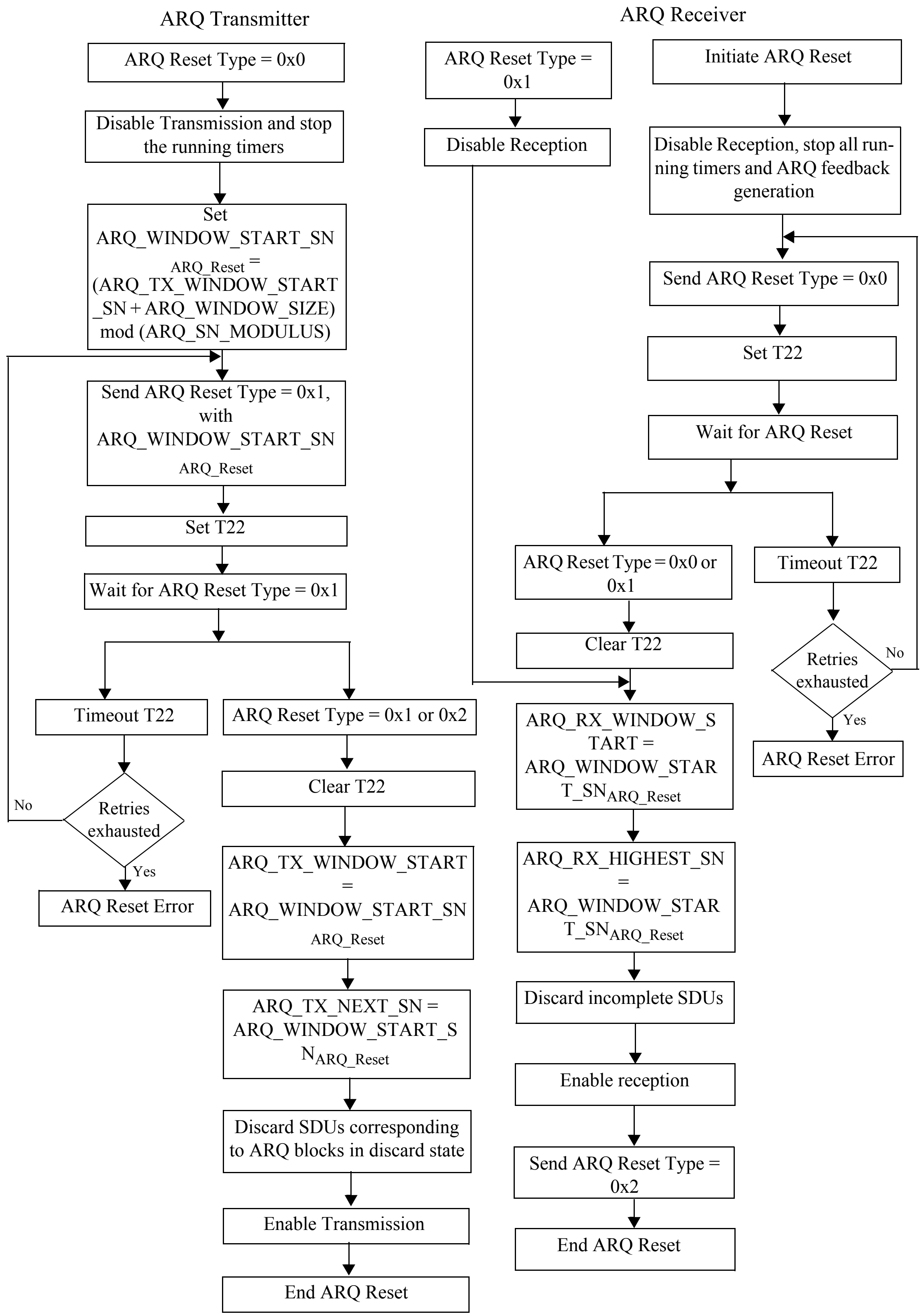


Figure 6-61—Receiver-initiated ARQ reset

6.2.13.5.5 ARQ synchronization loss

Synchronization of the ARQ state machines is governed by the ARQ_SYNC_LOSS_TIMEOUT timer managed by the transmitter and receiver state machines. Each time ARQ_TX_WINDOW_START is updated in the transmitter or ARQ_RX_WINDOW_START is updated in the receiver, the ARQ_SYNC_LOSS_TIMEOUT timer is set to zero. When the ARQ_SYNC_LOSS_TIMEOUT timer expires at the transmitter or receiver, the transmitter or receiver declares ARQ synchronization loss.

6.2.13.5.6 ARQ buffer management

When transmitting a new ARQ block, the ABS should ensure that the size of the new ARQ block does not exceed ARQ_MAX_BUFFER_SIZE – ARQ_BUFFER_USED. ARQ_BUFFER_USED is defined as the sum of ARQ_BUFFER_USED_PER_FLOW for all the ARQ-enabled flows for the AMS. ARQ_BUFFER_USED_PER_FLOW is calculated as the occupied buffer size of the ARQ transmitter window [ARQ_TX_WINDOW_START to ARQ_TX_NEXT_SN–1(inclusive)].

If the ARQ blocks, with SN smaller than ARQ_TX_WINDOW_START, are part of the same SDU as the first ARQ block in the ARQ transmitter window, then those ARQ blocks shall be included in the calculation of ARQ_BUFFER_USED_PER_FLOW.

6.2.14 HARQ functions

HARQ shall be used for unicast data traffic and unicast MAC control messages in both downlink and uplink. The HARQ shall be based on a stop-and-wait protocol. ABS and AMS shall be capable of maintaining multiple HARQ channels. DL HARQ channels are identified by downlink HARQ channel identifier (ACID). UL HARQ channels are identified by uplink HARQ channel identifier (ACID).

6.2.14.1 HARQ subpacket generation and transmission

Generating the HARQ subpackets shall follow 6.3.10. 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 the codeword determined by a subpacket identifier (SPID).

The rule of subpacket transmission is as follows:

For downlink,

a) At the first transmission, the ABS shall send the subpacket labeled 0b00.
b) The ABS may send one among subpackets labeled 0b00, 0b01, 0b10, and 0b11 in any order.

For uplink,

c) At the first transmission, the AMS shall send the subpacket labeled 0b00.
d) The AMS shall send one among subpackets labeled 0b00, 0b01, 0b10, and 0b11 in sequential order.
e) The AMS shall send the subpacket labeled 0b00 when the AMS receives the UL Basic Assignment A-MAP IE or the UL Subband Assignment A-MAP IE regardless of the transmission number.

In order to specify the start of a new transmission, a 1-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 the previous HARQ attempt with the same ACID.

6.2.14.2 Generic HARQ signaling and timing

In this subclause, “assignment A-MAP IE” is confined to assignment A-MAP IEs that convey allocation information of an HARQ burst. DL and UL basic assignment A-MAP IEs, and DL and UL subband assignment A-MAP IEs, follow the HARQ signaling and timing described in this subclause. For CDMA allocation A-MAP IE, feedback polling A-MAP IE, and BR-ACK A-MAP IE, HARQ timing is applied as specified in 6.2.14.2.2. The basic rule of HARQ signaling for those assignment A-MAP IEs follows the description in 6.2.14.2.1, but the details can be different according to its specific operation defined in 6.3.5.5.2.4. The HARQ signaling and timing for GRA A-MAP IE and DL and UL PA A-MAP IEs are described in 6.2.14.3 and 6.2.14.4, respectively.

6.2.14.2.1 HARQ signaling

6.2.14.2.1.1 Downlink

Upon receiving a DL assignment A-MAP IE, the AMS attempts to receive and decode the data burst as allocated to it by the DL assignment A-MAP IE. If the decoding is successful, the AMS shall send a positive acknowledgment to the ABS; otherwise, the AMS shall send a negative acknowledgment to the ABS.

The process of retransmissions shall be controlled by the ABS using the ACID and AI_SN fields in the DL assignment A-MAP IE. If the AI_SN field for the ACID remains the same between two HARQ burst allocations, it indicates retransmission. Through the DL assignment A-MAP IE for retransmission, the ABS may allocate different resource allocations and transmission formats. If the AI_SN field for the ACID is toggled, i.e., from 0 to 1 or vice versa, it indicates the transmission of a new HARQ burst, and the retransmission process for the previous HARQ burst with the same ACID is terminated if the retransmission process is still in progress. When DL Basic Assignment A-MAP IE is used for retransmission of the first transmission allocated using Group Resource Allocation A-MAP IE, the AI_SN value is irrelevant and should be ignored by the AMS.

The maximum number of HARQ channels per AMS in a carrier, in DL, is 16. For an AMS operating over carriers in DL, the maximum number of total HARQ channels per AMS, $N_{DL\_HARQ\_CH}$, is (16 × number of used carriers). If the *i*-th physical carrier is assigned to an AMS, the ACID in the physical carrier index *i* is calculated as $(16 \times i + n) \bmod N_{DL\_HARQ\_CH}$, where *n* is the 4-bit ACID value signaled in DL assignment A-MAP IE, and *i* is indexed from 0 to *i*.

The delay between two consecutive HARQ transmissions of the same data burst shall not exceed the T_ReTx_Interval that is signaled via the AAI-SCD message. The number of retransmissions of the same data burst shall not exceed DL_N_MAX_ReTx. The values for DL_N_MAX_ReTx are 4 or 8. The default value is 4. The ABS may configure a maximum number of DL HARQ retransmissions via S-SFH SP1 IE.

6.2.14.2.1.2 Uplink

Upon receiving a UL assignment A-MAP IE, the AMS shall transmit the subpacket of HARQ data burst through the resource assigned by the UL assignment A-MAP IE.

The ABS shall attempt to decode the data burst. If the decoding is successful, the ABS shall send a positive acknowledgment to the AMS; otherwise, the ABS shall send a negative acknowledgment to the AMS.

Upon receiving the negative acknowledgment, the AMS shall trigger the retransmission procedure.

In the retransmission procedure, if the AMS does not receive a UL assignment A-MAP IE for the HARQ data burst in failure, the AMS shall transmit the next subpacket through the resources assigned to the latest subpacket transmission with the same ACID as specified in Table 6-138 for FDD and Table 6-140 for TDD, respectively. A UL 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 assignment A-MAP IE, the AMS shall perform the HARQ retransmission as instructed in this UL assignment A-MAP IE. As an example, the ABS may change the resource index of the HARQ data burst or may command to skip retransmission in the corresponding AAI subframe. If the AI_SN field for the ACID is toggled, i.e., from 0 to 1 or vice versa, it indicates the transmission of a new HARQ burst, and the retransmission process for the previous HARQ burst with the same ACID is terminated if the retransmission process is still in progress. When UL Basic Assignment A-MAP IE is used for retransmission of the first transmission allocated using Group Resource Allocation A-MAP IE, the AI_SN value is irrelevant and should be ignored by the AMS.

The maximum number of HARQ channels per AMS in a carrier, in UL, is 16. For an AMS operating over carriers in UL, the maximum number of total HARQ channels per AMS, $N_{UL\_HARQ\_CH}$, is (16 × number of used carriers). If the *i*-th physical carrier is assigned to an AMS, the ACID in the physical carrier index *i* is calculated as $(16 \times i + n) \bmod N_{UL\_HARQ\_CH}$, where *n* is the 4-bit ACID value signaled in UL assignment A-MAP IE, and *i* is indexed from 0 to *i*.

The number of retransmissions of the same data burst shall not exceed UL_N_MAX_ReTx. The values for UL_N_MAX_ReTx are 4 or 8. The default value is 4. The ABS may configure a maximum number of UL HARQ retransmissions via S-SFH SP1 IE.

6.2.14.2.1.3 DL HARQ buffering capability

The AMS shall report its buffering capability by stating the steady amount of information bits in 4800 byte units it can receive while providing the aimed combining gain in the following benchmark scenario:

— The reception errors of each FEC block transmitted are identical and independent (e.g., each of the AMS antennas is connected through an attenuator to one ABS antenna).
— Frame is entirely DL with eight subframes.
— A number of HARQ channels (or eight ACIDs) are evenly distributed over a frame (that is, one ACID per each subframe), each with the same amount of information bits carried over and the same HARQ channels (ACIDs) are allocated over frames.
— Each burst is always transmitted with the same constellation (or modulation order) and over the same amount of LRUs.
— Burst error rate of the first HARQ transmission can be up to 50%.
— The SPID increases by 1 circularly every retransmission.
— DL HARQ retransmission time delay of 5 ms.

Where the aimed combining gain is:

— The error rate of second transmission is not higher than 5%.

“Buffer overflow” is defined as a condition of no available buffer for storing soft bits of a failed burst. Upon buffer overflow, the AMS should indicate to the ABS the overflow condition with Event Driven Indication (EDI) as defined in 6.3.8.3.1. The EDI shall be transmitted at the first fast feedback opportunity the AMS is allocated following the AMS DL processing time from the overflow condition. Even upon buffer overflow event, the AMS shall attempt to receive DL HARQ bursts allocated to itself and to transmit the appropriate HARQ feedback to the ABS.

Upon reception of overflow EDI from the AMS, the ABS may consider as a worst-case assumption that all soft bits of bursts that the AMS failed to receive in their last transmission are not buffered at the AMS.

Consequently, to make sure that the systematic bits are used for decoding by the AMS, the ABS may retransmit with SPID = 0 for the failed bursts that were transmitted only one time.

The ABS may consider the overflow indications from the AMS when selecting the amount of information bits, the SPID, or the MCS of the bursts transmitted to that AMS. Clearly, the ABS may also consider the HARQ feedbacks from the AMS for different retransmissions when selecting the amount of information bits, the SPID, or the MCS of the bursts transmitted to it.

6.2.14.2.1.4 UL HARQ buffering capability

The AMS shall report the amount of information bits in 4800 bytes units it can buffer in the UL. The ABS shall not exceed this buffer.

6.2.14.2.2 A-MAP relevance and HARQ timing

Transmissions of assignment A-MAP IE, the HARQ subpacket, and the corresponding feedback shall be in accordance with a predefined timing. In UL, retransmission of the HARQ subpacket shall also follow a predefined timing.

Each transmission time is represented by frame index and AAI subframe index.

To determine A-MAP relevance and HARQ timing, DL HARQ feedback offset z, UL HARQ Subpacket Tx offset v, and UL HARQ feedback offset w shall be set. In DL HARQ transmission, the DL Rx processing time $T_{\text{DL\_Rx\_Processing}}$ at the AMS shall be considered for the DL HARQ feedback offset(z). In UL HARQ transmission, UL Tx processing time $T_{\text{UL\_Tx\_Processing}}$ at the AMS and the UL Rx processing time $T_{\text{UL\_Rx\_Processing}}$ at the ABS are considered for the UL HARQ Subpacket Tx offset(v) and the UL HARQ feedback offset(w), respectively.

Both $T_{\text{DL\_Rx\_Processing}}$ and $T_{\text{UL\_Tx\_Processing}}$ at the AMS are three AAI subframes. The $T_{\text{UL\_Rx\_Processing}}$ at the ABS is three or four AAI subframes broadcast via S-SFH SP1 IE.

6.2.14.2.2.1 FDD

6.2.14.2.2.1.1 Downlink

DL HARQ subpacket transmission corresponding to a DL Assignment A-MAP IE inthe 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 the frame index j shall be determined by using l and i, as shown in Table 6-137.

Table 6-137—FDD DL HARQ timing

Content	AAI subframe index	Frame index
DL Assignment A-MAP IE Tx	l	i
DL HARQ Subpacket Tx	$m = l$	i

Table 6-137—FDD DL HARQ timing *(continued)*

Content	AAI subframe index	Frame index
UL HARQ feedback Tx	$n = \mathrm{ceil}(m + F/2) \bmod F$	$j = \left(i + (\mathrm{floor})\left(\frac{\mathrm{ceil}(m + F/2)}{F}\right) + z\right) \mathrm{mod} 4$ where $z = \begin{cases} 0, & \text{if } ((\mathrm{ceil}(F/2) - N_{TTI}) \ge T_{\mathrm{DL\_Rx\_Processing}}) \\ 1, & \text{else} \end{cases}$

where

F is the number of subframes as defined by the frame configuration table.

l is the reference to the DL subframe, starting from 0 for the first downlink subframe and numbering up to $F - 1$, where the A-MAP is transmitted. In case of long TTI transmission, l is only allowed from 0 to $F - 4$;
i.e., $l \in \{0, 1, \ldots, F - 4\}$.

m is the reference to the DL subframe, starting from 0 for the first downlink subframe and numbering up to $F - 1$, where the HARQ subpacket begins its transmission.

n is the reference for the UL subframe, starting from 0 for the first uplink subframe and numbering up to $F - 1$, where the HARQ acknowledgment is sent.

i is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the A-MAP is transmitted and the HARQ subpacket begins.

j is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the HARQ acknowledgment is sent.

N_{TTI} is the number of AAI subframes that a HARQ subpacket spans, i.e., 1 for the default TTI and 4 for long TTI in FDD DL.

$T_{\mathrm{DL\_Rx\_Processing}}$ is the data burst Rx processing time required by the AMS and measured in subframes.

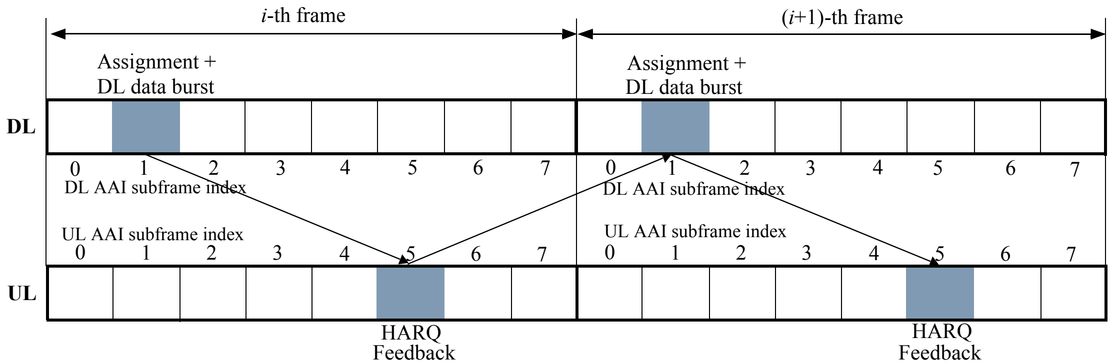


Figure 6-62—Example of FDD DL HARQ timing for 5 MHz, 10 MHz, and 20 MHz channel bandwidths

Figure 6-62 shows an example of the timing relationship among a DL Assignment A-MAP IE, a DL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in the FDD frame structure, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, $T_{\text{DL\_Rx\_Processing}}$ is three AAI subframes.

6.2.14.2.2.1.2 Uplink

UL HARQ subpacket transmission corresponding to a UL 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 DL HARQ feedback indicates a negative acknowledgment, retransmission of the UL HARQ subpacket shall begin in the m-th UL AAI subframe of the p-th frame. The AAI subframe index m and frame index j, k, p shall be calculated as shown in Table 6-138.

Table 6-138—FDD UL HARQ timing

Content	AAI subframe index	Frame index
UL Assignment A-MAP IE Tx	l	i
UL HARQ Subpacket Tx	$m = \text{ceil}(l + F/2) \bmod F$	$j = \left(i + \text{floor}\left(\frac{\text{ceil}(l+F/2)}{F}\right) + v\right)\text{mod}4$ where $v = \begin{cases} 0, & \text{if } ((\text{ceil}(F/2) - 1) \geq T_{\text{UL\_Tx\_Processing}}) \\ 1, & \text{else} \end{cases}$
DL HARQ feedback Tx	l	$k = \left(j + \text{floor}\left(\frac{(m+F/2)}{F}\right) + w\right)\text{mod}4$ where $w = \begin{cases} 0, & \text{if } ((\text{floor}(F/2) - N_{TTI}) \geq T_{\text{UL\_Rx\_Processing}}) \\ 1, & \text{else} \end{cases}$

Table 6-138—FDD UL HARQ timing *(continued)*

Content	AAI subframe index	Frame index
UL HARQ Subpacket ReTx	m	$p = \left(p + \text{floor}\left(\frac{\text{ceil}(l + F/2)}{F}\right) + v\right) \text{mod} 4$ where $v = \begin{cases} 0, & \text{if } ((\text{ceil}(F/2) - 1) \geq T_{\text{UL\_Tx\_Processing}}) \\ 1, & \text{else} \end{cases}$

where

F is the number of subframes as defined by the frame configuration table.

l is the reference to the DL subframe, starting from 0 for the first downlink subframe and numbering up to $F - 1$, where the A-MAP is transmitted or the HARQ acknowledgment is sent. In case of long TTI transmission, l is only allowed from $F - 4$ to 0; i.e., $l \in \{F - 4, F - 3, \ldots, F - 1, 0\}$.

m is the reference to the UL subframe, starting from 0 for the first uplink subframe and numbering up to $F - 1$, where the HARQ subpacket begins its transmission.

i is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the A-MAP is transmitted.

j is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the HARQ subpacket begins.

k is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the HARQ acknowledgment is sent.

p is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where a retransmission of the HARQ subpacket begins.

N_{TTI} is the number of AAI subframes that a HARQ subpacket spans, i.e., 1 for the default TTI and 4 for long TTI in FDD UL.

$T_{\text{UL\_Tx\_Processing}}$ is the data burst Tx processing time required by the AMS and measured in subframes.

$T_{\text{UL\_Rx\_Processing}}$ is the data burst Rx processing time required by the ABS and measured in subframes.

Figure 6-63 shows an example of the timing relationship between a UL Assignment A-MAP IE, a UL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in the FDD frame structure, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, $T_{\text{UL\_Tx\_Processing}}$ and $T_{\text{UL\_Rx\_Processing}}$ are three AAI subframes.

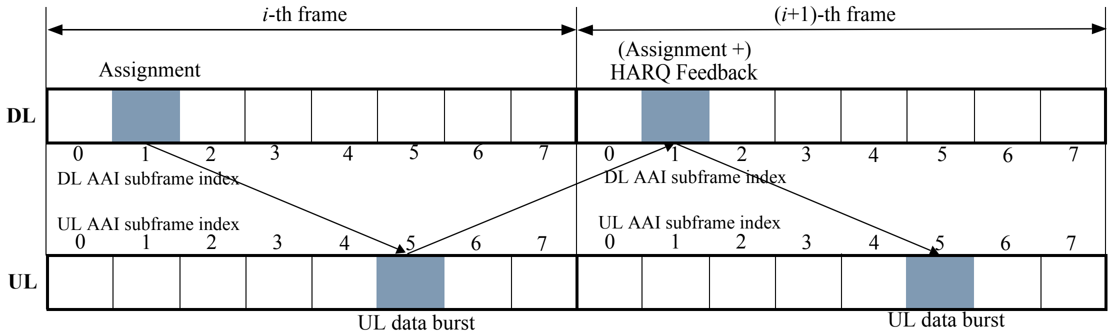


Figure 6-63—Example of FDD UL HARQ timing for 5 MHz, 10 MHz, and 20 MHz channel bandwidths

6.2.14.2.2.2 TDD

6.2.14.2.2.2.1 Downlink

DL HARQ subpacket transmission corresponding to a DL 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 the frame index *j* shall be determined by using *l* and *i*, as shown in Table 6-139.

Table 6-139—TDD DL HARQ timing

Content	AAI subframe index	Frame index
DL Assignment A-MAP IE Tx	l	i
DL HARQ Sub-packet Tx	$m = l$	i
UL HARQ feed-back Tx	For $D > U$ $n = \begin{cases} 0, \text{ for } 0 \le m < K \\ m - K, \text{ for } K \le m < U + K \\ U - 1, \text{ for } U + K \le m < D \end{cases}$ where $K = \text{floor}((D - U)/2)$ For $D \le U$ $n = m - K$ where $K = -\text{ceil}((U - D)/2)$	$j = (i + z)(\text{mod})\ 4$ where $z = \begin{cases} 0, \text{ if } ((D - m - N_{TTI} + n) \ge T_{\text{DL\_Rx\_Processing}}) \\ 1, \text{ else} \end{cases}$

where

D	is the number of downlink subframes as defined by the frame configuration table.
U	is the number of uplink subframes as defined by the frame configuration table.
l	is the reference to the DL subframe, starting from 0 for the first downlink subframe and numbering up to $D - 1$, where the A-MAP is transmitted.
m	is the reference to the DL subframe, starting from 0 for the first downlink subframe and numbering up to $D - 1$, where the HARQ subpacket begins its transmission.
n	is the reference for the UL subframe, starting from 0 for the first uplink subframe and numbering up to $U - 1$, where the HARQ acknowledgment is sent.
i	is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the A-MAP is transmitted and the HARQ subpacket begins.
j	is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the HARQ acknowledgment is sent.
N_{TTI}	is the number of AAI subframes that a HARQ subpacket spans, i.e., 1 for the default TTI and D for long TTI in TDD DL.
$T_{\mathrm{DL\_Rx\_Processing}}$	is the data burst Rx processing time required by the AMS and measured in subframes.
ceil(x)	is a step function of x that is the least integer greater than or equal to x.
floor(x)	is a step function of x that is the greatest integer less than or equal to x.

A DL Assignment A-MAP IE in the l-th DL subframe (when l is not 0) of the i-th frame may also indicate the long TTI transmission. In this case, the long TTI transmission of the DL HARQ subpacket shall begin in the 0-th DL subframe of the (i + 1) frame. A HARQ feedback for this long TTI transmission shall be transmitted in the n-th UL subframe of the j-th frame. The subframe index n and the frame index j shall be calculated according to equations in Table 6-139, replacing the subframe index m and the frame index i by l and $i + 1$, respectively.

When the long TTI DL HARQ subpacket is signaled to be transmitted in the frame where the SFH exists, the DL HARQ subpacket shall begin in the second DL subframe, while the same HARQ timing shall be applied as for the case when the SFH does not exist in a frame. Figure 6-64 shows an example of the timing relationship among a DL Assignment A-MAP IE, a DL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in the TDD frame structure, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, $T_{\mathrm{DL\_Rx\_Processing}}$ is three AAI subframes.

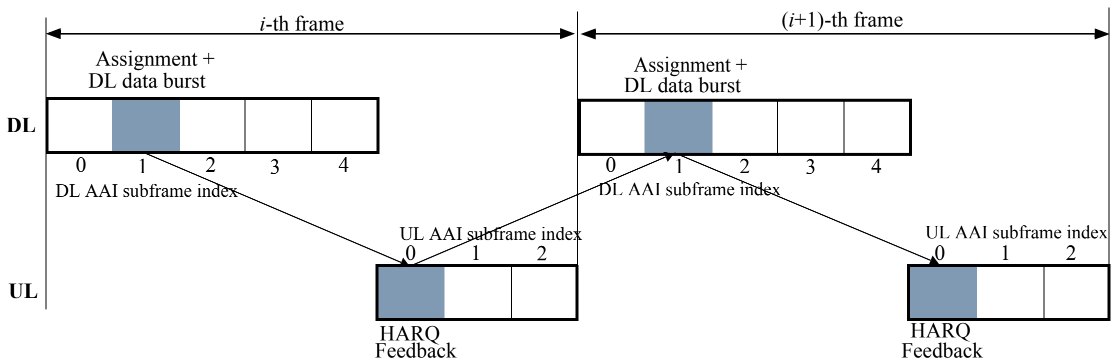


Figure 6-64—Example of TDD DL HARQ timing for 5 MHz, 10 MHz, and 20 MHz channel bandwidths

6.2.14.2.2.2.2 Uplink

UL HARQ subpacket transmission corresponding to a UL 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 DL HARQ feedback indicates a negative acknowledgment, retransmission of the UL HARQ subpacket shall begin in the *m*-th UL AAI subframe of the *p*-th frame. The AAI subframe index *m*, *n* and the frame index *j*, *k*, *p* shall be calculated as shown in Table 6-140.

Table 6-140—TDD UL HARQ timing

Content	AAI subframe index	Frame index
UL Assignment A-MAP IE Tx in DL	*l*	*l*

Table 6-140—TDD UL HARQ timing *(continued)*

Content	AAI subframe index	Frame index
UL HARQ Subpacket Tx	For default TTI and $D \geq U$ $m = \begin{cases} 0, & \text{for } 0 \leq l < K \\ l - K, & \text{for } K \leq l < U + K \\ U - 1, & \text{for U} + K \leq l < D \end{cases}$ where $K = \text{floor}((D - U)/2)$	$j = (i + v) \bmod 4$ where $v = \begin{cases} 0, & \text{if } ((D - l - 1 + m) \geq T_{\text{UL\_Tx\_Processing}}) \\ 1, & \text{else} \end{cases}$
	For default TTI and $D < U$ $m = \begin{cases} \{0, \ldots, l - K\}, & \text{for } l = 0 \\ l - K, & \text{for } 0 < l < D - 1 \\ \{l - K, \ldots, U - 1\}, & \text{for } l = D - 1 \end{cases}$ where $K = -\text{ceil}((U - D)/2)$	
	For long TTI $m = 0$	
DL HARQ feed-back Tx	l	$k = (j + 1 + w) \bmod 4$ where $w = \begin{cases} 0, & \text{if } ((U - m - N_{TTI} + l) \geq T_{\text{UL\_Rx\_Processing}}) \\ 1, & \text{else} \end{cases}$
UL HARQ Sub-packet ReTx	m	$p = (k + v) \bmod 4$ where $v = \begin{cases} 0, & \text{if } ((D - l - 1 + m) \geq T_{\text{UL\_Tx\_Processing}}) \\ 1, & \text{else} \end{cases}$

where

D is the number of downlink subframes as defined by the frame configuration table.

U is the number of uplink subframes as defined by the frame configuration table.

l is the reference to the DL subframe, starting from 0 for the first downlink subframe and numbering up to $D - 1$, where the A-MAP is transmitted or the HARQ acknowledgment is sent.

m is the reference to the UL subframe, starting from 0 for the first downlink subframe and numbering up to U-1, where the HARQ subpacket begins its transmission.

i is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the A-MAP is transmitted.

j is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the HARQ subpacket begins.

k is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where the HARQ acknowledgment is sent.

p is the reference for the frame, starting from 0 for the first frame of a superframe and numbering up to 3, where a retransmission of the HARQ subpacket begins.

N_{TTI} is the number of AAI subframes that a HARQ subpacket spans, i.e., 1 for the default TTI and *U* for long TTI in TDD UL.

$T_{UL\_Tx\_Processing}$ is the data burst Tx processing time required by the AMS and measured in subframes.

$T_{UL\_Rx\_Processing}$ is the data burst Rx processing time required by the ABS and measured in subframes.

Figure 6-65 shows an example of the timing relationship among a UL Assignment A-MAP IE, a UL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in the TDD frame structure, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, $T_{UL\_Tx\_Processing}$ and $T_{UL\_Rx\_Processing}$ are three AAI subframes.

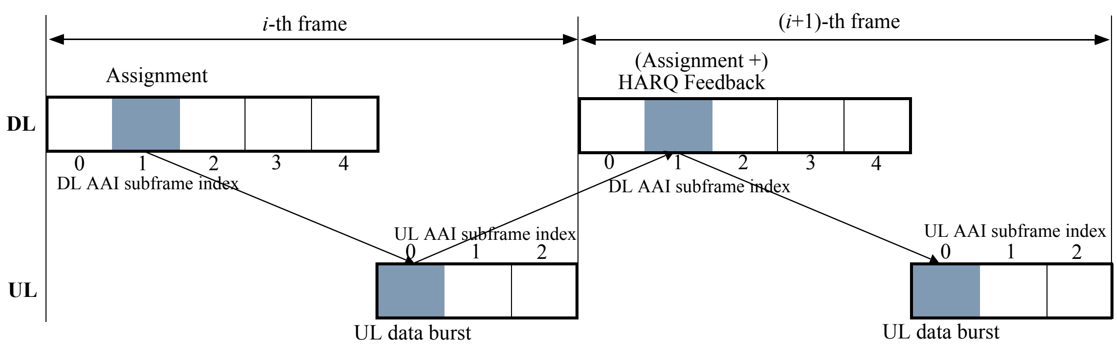


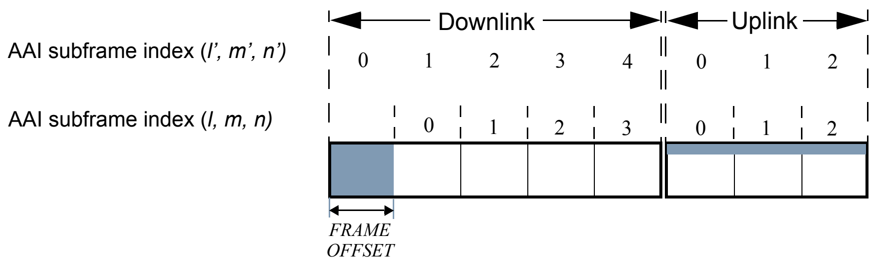
Figure 6-65—Example of TDD UL HARQ timing for 5 MHz, 10 MHz, and 20 MHz channel bandwidths

6.2.14.2.2.2.3 HARQ timing in frame structure supporting the WirelessMAN-OFDMA R1 Reference System frames

The A-MAP relevance and HARQ timing defined in 6.2.14.2.2.2 shall be applied to the frame structure supporting the WirelessMAN-OFDMA R1 Reference System TDD frames in 6.3.3.5.

AAI subframes in the frame supporting the WirelessMAN-OFDMA R1 Reference System TDD frames shall be indexed as follows: The DL AAI subframe index shall range from 0 to *D* – 1, where *D* is the number of DL AAI subframes dedicated to the Advanced Air Interface operation in frame. The UL AAI subframe index shall range from 0 to *U* – 1, where *U* is the number of UL AAI subframes dedicated to the Advanced Air Interface operation in frame.

Figure 6-66 shows an example of AAI subframe indexing for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, the ratio of whole DL AAI subframes to whole UL AAI subframes, *D*' : *U*' is 5:3. *FRAME_OFFSET* is 1, and UL AAI subframes of the WirelessMAN-OFDMA R1 Reference System and the WirelessMAN-Advanced Air Interface are frequency-division multiplexed. Then, the ratio of DL to UL AAI subframes for the Advanced Air Interface, D:U, is 4:3. The AAI subframe index, l, m, and n are the renumbered index of l', m', and n', respectively.



Example showing a frame structure supporting the WirelessMAN-OFDMA R1 Reference System frame

Figure 6-66— Example of AAI subframe indexing

The same equations and rules in Table 6-139 for the TDD DL and Table 6-140 for the TDD UL 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:

D' is the number of downlink subframes as defined by the frame configuration table.

U' is the number of uplink subframes as defined by the frame configuration table.

D is the DL length of the subframe provision as defined by the frame configuration table.

U is the UL length of the subframe provision as defined by the frame configuration table.

For TDD DL HARQ timing,

$$z = \begin{cases} 0, \text{ if } ((D' - m' - N_{TTI} + n') \geq T_{\text{DL\_Rx\_Processing}}) \\ 1, \text{ else} \end{cases} \tag{6}$$

where

m is the reference to the DL subframe dedicated to the Advanced Air Interface operation in frame, starting from 0 for the first downlink subframe and numbering up to $D - 1$, where the HARQ subpacket begins its transmission.

n is the reference for the UL subframe, starting from 0 for the first uplink subframe and numbering up to $U - 1$, where the HARQ acknowledgment is sent.

m' is the reference to the DL subframe of the TDD frame, starting from 0 for the first downlink subframe and numbering up to $D' - 1$, where the HARQ subpacket begins its transmission.

n' is the reference for the UL subframe of the TDD frame, starting from 0 for the first uplink subframe and numbering up to $U' - 1$, where the HARQ acknowledgment is sent.

N_{TTI} is the number of AAI subframes that a HARQ subpacket spans. Note that long TTI is not allowed for DL HARQ subpacket transmission, and N_{TTI} is 1 for the default TTI in TDD DL.

For TDD UL HARQ timing,

$$v = \begin{cases} 0, & \text{if } ((D' - l' - 1 + m') \geq T_{\text{UL\_Tx\_Processing}}) \\ 1, & \text{else} \end{cases} \tag{7}$$

$$w = \begin{cases} 0, & \text{if } ((U' - m' - N_{TTI} + l') \geq T_{\text{UL\_Rx\_Processing}}) \\ 1, & \text{else} \end{cases} \tag{8}$$

where

l is the reference to the DL subframe dedicated to the Advanced Air Interface operation in frame, starting from 0 for the first downlink subframe and numbering up to $D – 1$, where the A-MAP is transmitted.

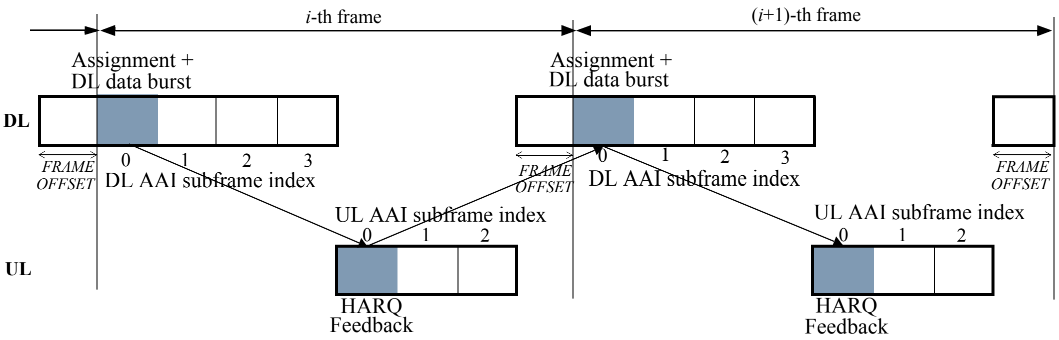
m is the reference to the UL subframe dedicated to the Advanced Air Interface operation in frame, starting from 0 for the first uplink subframe and numbering up to $U – 1$, where the HARQ subpacket begins its transmission. Note that if $D = 1$ and $D < U$, the UL AAI subframe index m for UL HARQ subpacket transmission shall be $m = \{0,...,U–1\}$ for default TTI.

l' is the reference to the DL subframe of TDD frame, starting from 0 for the first downlink subframe and numbering up to $D' – 1$, where the A-MAP is transmitted.

m' is the reference to the UL subframe of the TDD frame, starting from 0 for the first uplink subframe and numbering up to $U' – 1$, where the HARQ subpacket begins its transmission.

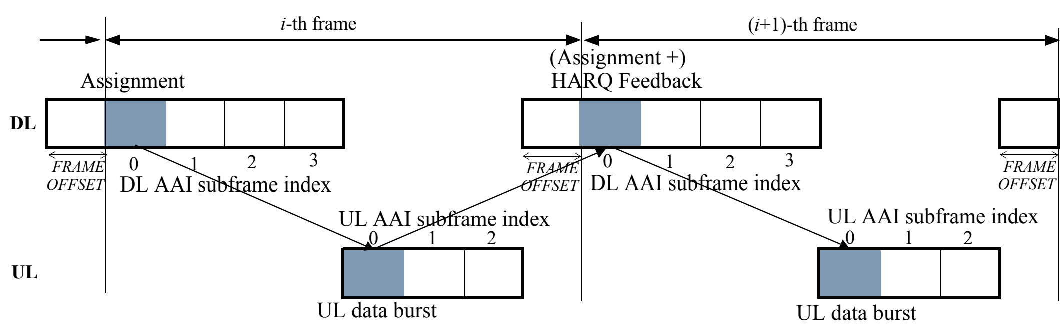
N_{TTI} is the number of AAI subframes that a HARQ subpacket spans, i.e., 1 for the default TTI and U for long TTI in TDD UL.

Figure 6-67 and Figure 6-68 show examples of the DL and UL timing relationships among a Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. The ratio of whole DL AAI subframes to whole UL AAI subframes, $D':U'$, is 5:3. In this example, *FRAME_OFFSET* is 1, UL AAI subframes of the WirelessMAN-OFDMA R1 Reference System and the Advanced Air Interface are frequency-division multiplexed, the ratio of DL to UL AAI subframes for the Advanced Air Interface, $D:U$, is 4:3, and $T_{\text{DL\_Rx\_Processing}}$,$T_{\text{UL\_Tx\_Processing}}$,and $T_{\text{UL\_Rx\_Processing}}$ are three AAI subframes.



Example showing a frame structure supporting the WirelessMAN-OFDMA R1 Reference System frame

Figure 6-67— Example of TDD DL HARQ timing



Example showing a frame structure supporting the WirelessMAN-OFDMA R1 Reference System frame

Figure 6-68— Example of TDD UL HARQ timing

6.2.14.3 Group resource allocation HARQ signaling and timing

6.2.14.3.1 Downlink

Upon receiving a group resource allocation A-MAP IE for DL allocations, the scheduled AMS attempts to decode the data burst intended for it. If the decoding is successful, the AMS shall send a positive acknowledgment to the ABS; otherwise, the AMS shall send a negative acknowledgment to the 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 6.2.14.2.1.1. 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.

6.2.14.3.2 Uplink

Upon receiving a group resource allocation A-MAP IE for UL allocations, the AMS shall transmit the subpacket of HARQ data burst through the resource assigned by the group resource allocation A-MAP IE.

The ABS shall attempt to decode the data burst. If the decoding is successful, the ABS shall send a positive acknowledgment to the AMS; otherwise, the ABS shall send a negative acknowledgment to the AMS.

With UL group resource allocation, the HARQ retransmissions shall be allocated individually. HARQ retransmissions shall be done as described in 6.2.14.2.1.2. 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.

6.2.14.4 Persistent allocation HARQ signaling and timing

6.2.14.4.1 Downlink

Upon receiving a DL persistent allocation A-MAP IE, the AMS attempts to decode the data burst at every periodic AAI subframe specified in the DL persistent allocation A-MAP IE. If the decoding is successful, the AMS shall send a positive acknowledgment to the ABS; otherwise, the AMS shall send a negative acknowledgment to the ABS.

With DL persistent allocation, HARQ retransmissions shall be done by using a DL Basic Assignment A-MAP IE, as described in 6.2.14.2.1.1.

When allocation is signaled through a DL persistent allocation A-MAP IE, the AI_SN for the corresponding ACID is set to 0. The AI_SN keeps toggling every ACID cycling period (= allocation period × N_ACID) until allocation or deallocation is signaled through a DL persistent allocation A-MAP IE. Note that during the period where persistent allocation is in progress, the ACIDs, which are reserved for persistent allocation, shall not be used for other allocations.

6.2.14.4.2 Uplink

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

The ABS shall attempt to decode the data burst. If the decoding is successful, the ABS shall send a positive acknowledgment to the AMS; otherwise, the ABS shall send a negative acknowledgment to the AMS.

With UL persistent allocation, HARQ retransmissions shall be done as described in 6.2.14.2.1.2. A UL basic assignment A-MAP IE may be sent to signal control information for the retransmission of the data burst in the UL persistent allocation corresponding to the ACID without AI_SN being toggled.

When allocation is signaled through a UL persistent allocation A-MAP IE, the AI_SN for the corresponding ACID is set to 0. The AI_SN keeps toggling every ACID cycling period (= allocation period × N_ACID) until allocation or deallocation is signaled through a UL persistent allocation A-MAP IE. Note that during the period where persistent allocation is in progress, the ACIDs, which are reserved for persistent allocation, shall not be used for other allocations.

6.2.14.5 HARQ and ARQ interactions

When both ARQ and HARQ are applied for a flow, the HARQ and ARQ interactions described here may be applied to the corresponding flow.

The HARQ entity in the transmitter declares a HARQ data burst failure when a HARQ data burst will no longer be retransmitted and has not been positively acknowledged by the receiver. In this case, the HARQ entity in the transmitter shall inform to the ARQ entity in the transmitter about the failure of the HARQ data burst. This notification is referred to as Local NACK. In response to the information provided by the HARQ entity, the ARQ entity in the transmitter can then initiate retransmission of the ARQ blocks that correlate to the failed HARQ data burst.

6.2.14.6 Combined feedback scheme for ROHC and HARQ

When both HARQ and ROHC are applied for a flow, the cross-layer design between HARQ and ROHC (combined feedback scheme for ROHC and HARQ) may be applied to the corresponding flow.

If the HARQ entity in the transmitter receives the feedback from the HARQ entity in the receiver, it shall report the HARQ feedback to the ROHC compressor that replaces ROHC feedback explicit feedback mechanisms.

Once the ROHC compressor receives the HARQ feedback, it will estimate the decompression state; it determines its own adjusted compression rate state based on the HARQ feedback information and the context of the ROHC packet transmissions. The compressor transmits ROHC packets according to the adjusted compression rate state and, at the same time, informs the lower layers to do operations such as adding header information to the MAC packets in the cache, discarding the MAC packets, or HARQ data burst in the cache.

The capability to support the combined feedback scheme for ROHC and HARQ shall be negotiated between the ABS and the AMS during the network entry procedure.

6.2.15 Network entry and initialization

The procedure for initialization of an AMS is shown in Figure 6-69. This figure shows the overall flow between the stages of initialization in an AMS. This figure does not include error paths and is shown simply to provide an overview of the process.

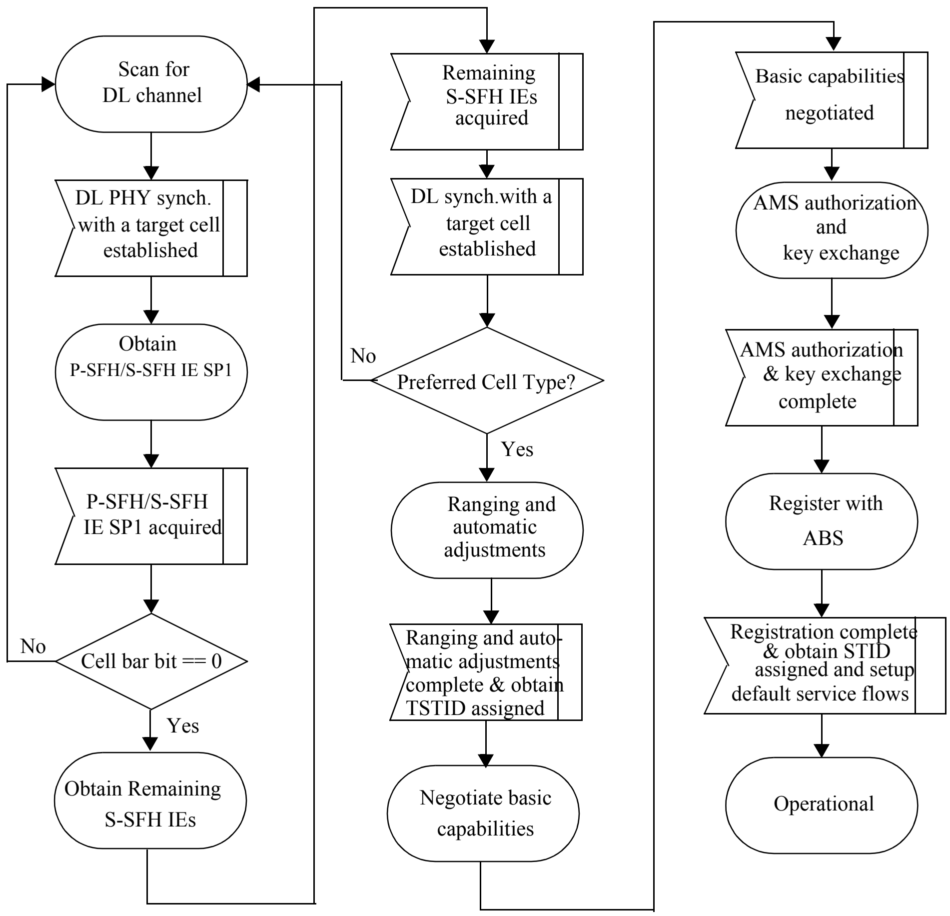


Figure 6-69—AMS initialization overview

Systems shall support the applicable procedures for entering and registering a new AMS to the network. When the AMS powers on and it has no context information of any ABS, the AMS shall perform the initial network entry procedure with the following steps:

a) Scan for DL channel and establish DL PHY synchronization with the ABS.
b) Obtain DL/UL parameters (from P-SFH/S-SFH IEs, etc.) and establish DL MAC synchronization.
c) Perform ranging and automatic adjustment.
d) Negotiate basic capability.
e) Perform AMS authorization and key exchange.
f) Perform registration, and set up default service flows.

In network entry, if the AMS cannot attach to the preferred cell, the AMS may choose to perform a network entry without any preference of the BS type, even though the AMS has preference of the BS type in general.

Figure 6-70 and Figure 6-71 describe the state machine of the AMS and the ABS for the initial NW entry process, respectively.

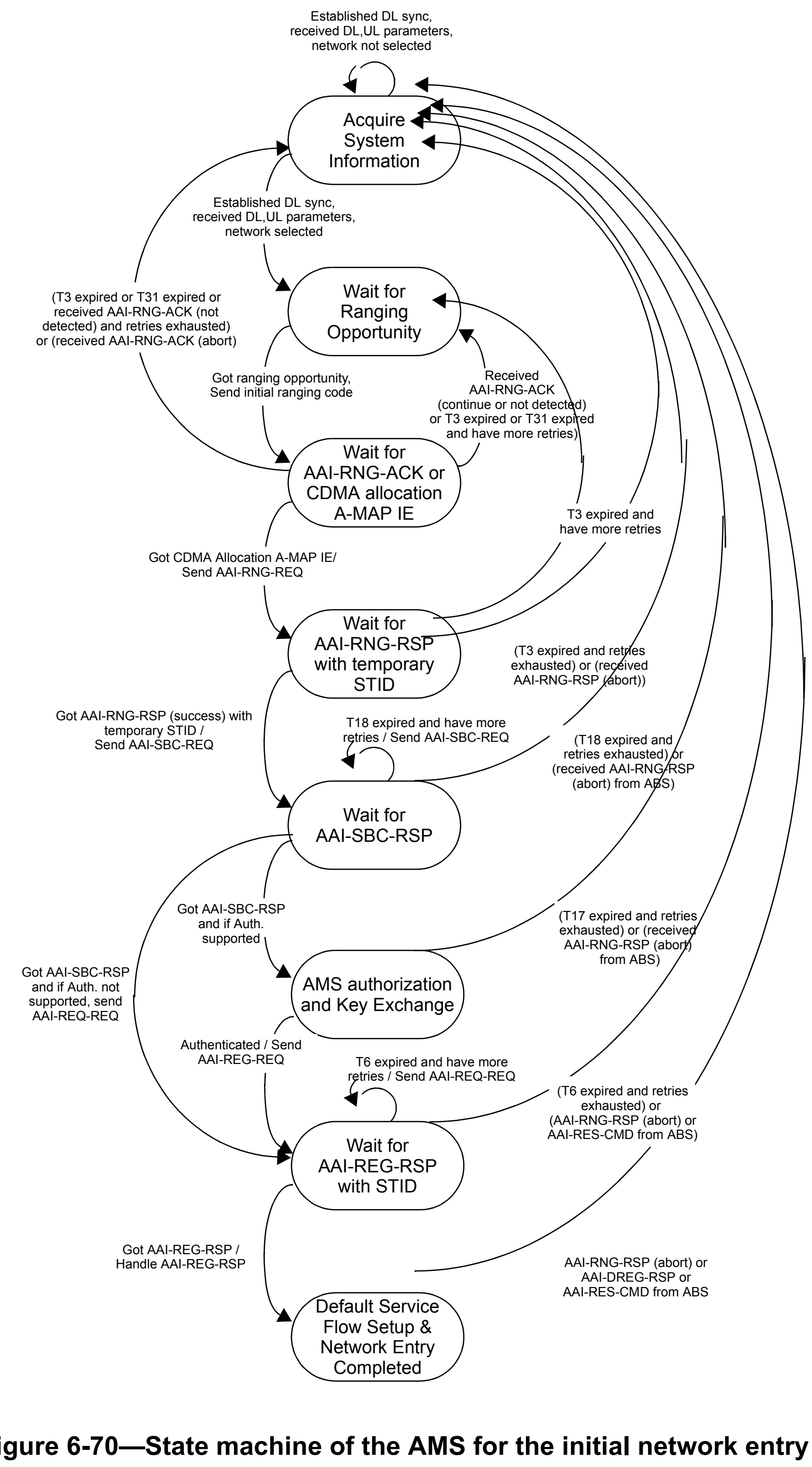


Figure 6-70—State machine of the AMS for the initial network entry process

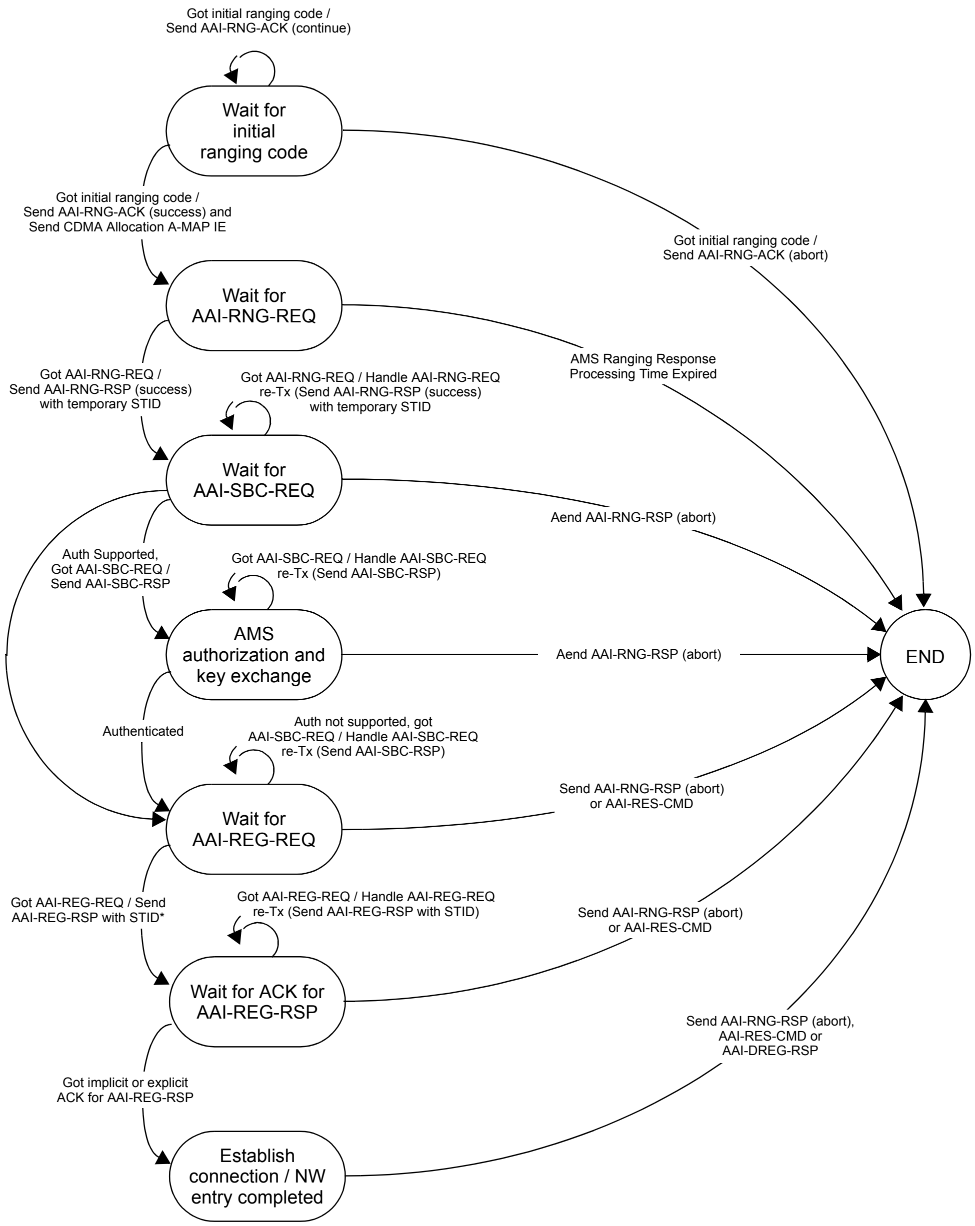


Figure 6-71—State machine of the ABS for the initial NW entry process

During network entry, an ABS may allocate a UL bandwidth for transmission or retransmission of BR without STID header, without a contention-based bandwidth request from the AMS by setting the unsolicited bandwidth grant indicator in an AAI-RNG-RSP message to the AMS. If the unsolicited bandwidth indicator is enabled, the ABS should allocate UL bandwidth within the BR grant time duration for transmission or retransmission of the BR without STID header during network entry.

An AMS should monitor the A-MAP IE during the BR grant time duration for possible bandwidth allocation without performing any bandwidth request. If the AMS fails to identify allocated bandwidth within the BR grant time duration, the AMS may perform a contention based bandwidth request. When the allocated resource is not sufficient for transmission of MAC messages, the AMS shall send a piggyback bandwidth request.

The BR grant timer in the ABS is started when the ABS transmits the AAI-RNG-RSP message with the unsolicited bandwidth grant indicator set to 1 to the AMS and is restarted when the ABS transmits an MAC message in the subsequent network entry procedure.

The BR grant timer in the AMS is started when the AMS receives the AAI-RNG-RSP message with the unsolicited bandwidth grant indicator set to 1 sent to it and is restarted when the AMS receives an MAC message in the subsequent network entry procedure.

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

- A 48-bit universal MAC address (per IEEE Std 802-2001) assigned during the manufacturing process. This is used to identify the AMS to the various provisioning servers during initialization.
- Security information (e.g., X.509 certificate) used to authenticate the AMS to the security server and to authenticate the responses from the security and provisioning servers.

6.2.15.1 AMS DL PHY synchronization

On initialization or after signal loss, the AMS shall acquire the DL PHY synchronization by A-Preamble. The detailed procedure for DL PHY synchronization is described in 6.3.5.1.

The AMS shall have nonvolatile storage in which the last operational parameters are stored, and when the AMS needs to acquire DL PHY synchronization, it may at first try synchronization using the stored DL channel information. But if the trial fails, the AMS shall begin to scan the possible channels of the DL frequency band of operation until it finds a valid DL signal.

6.2.15.2 AMS obtaining DL/UL parameters

For initial network entry, once the AMS has achieved DL PHY synchronization with an ABS, the AMS shall decode the P-SFH and S-SFH in order to obtain the necessary system information containing the DL and UL parameters for the initial network entry. Based on the network information such as NSP list, which may be obtained from the AAI-SII-ADV message, the AMS shall decide whether to continue the network entry process with this ABS or to scan for other ABSs. If the AMS reads Cell_Bar = 1 in SFH, this means this cell shall not allow access of new AMS and the AMS shall select a different cell to restart the network entry procedure.

If the AMS succeeds in decoding the essential system information, the AMS is DL MAC synchronized with the ABS.

6.2.15.3 Initial ranging and automatic adjustments

After DL synchronization, the AMS shall attempt to perform initial ranging with the ABS. If the ranging procedure is successfully completed, the AMS is UL synchronized with the ABS and obtains TSTID from the ABS. The TSTID is used until the ABS assigns the AMS an STID through the registration procedure.

Ranging is the process of acquiring the correct timing offset, frequency offset, and power adjustments so that the AMS’s transmissions are aligned with the ABS, and they are received within the appropriate reception thresholds.

Ranging channel and ranging preamble codes for initial ranging are specified in 6.3.8.2.4. Each ranging channel indicates a ranging opportunity.

When a regular NS-RCH is allocated in a frame by S-SFH SP1, it shall be mapped into the opportunity index ‘0b00’. When an S-RCH is allocated in a frame by S-SFH SP1 (i.e., for the Femto ABS or WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone) or AAI-SCD message, it shall be mapped into opportunity index ‘0b11’. When a dynamic NS-RCH(s) is allocated in a frame by AAI-HO-CMD and/or Broadcast Assignment A-MAP IE, it shall be mapped into the remaining opportunity indices. The order of mapping the remaining opportunity indices is the same as the order of the NS-RCH(s) that is allocated by the A-MAP IE in the time domain.

An AMS that wishes to perform initial ranging shall take the following steps:

a) The AMS, after acquiring downlink synchronization and uplink transmission parameters, shall select one ranging channel using random backoff. When random backoff is used, the AMS shall select one ranging channel from all available ranging channels in the corresponding backoff window using a uniform random process. The random backoff shall use a binary truncated exponent algorithm to calculate the backoff window. After selecting the ranging channel, the AMS shall choose a ranging preamble code (from the Initial Ranging domain) using a uniform random process. The AMS shall send the selected ranging preamble code to the ABS in the selected ranging channel.
b) The ABS should respond with an AAI-RNG-ACK message within the T31 Timer from the frame where at least one initial ranging preamble code is detected as defined in 6.2.3.3. The AAI-RNG-ACK message provides responses to all the successfully received and detected ranging preamble codes in all the ranging opportunities in a frame indicated by the frame identifier. If all the detected ranging preamble codes prove “success” status without needing UL transmission parameter adjustments and the ABS provides all UL BW allocations for each detected ranging preamble code before the T31 Timer is expired, the AAI-RNG-ACK may be omitted. If the AMS receives neither the AAI-RNG-ACK message corresponding to the initial ranging preamble code and channel selected by the AMS nor UL resource allocation (i.e., CDMA Allocation A-MAP IE) until the T31 Timer expires, the AMS considers its initial ranging request failed and restarts the initial ranging procedure.
c) There are three possible ranging status responses from the ABS to the AMS provided in the AAI-RNG-ACK message. They are as follows:
    1) Continue: The ABS provides the needed adjustments (e.g., time, power, and possibly frequency corrections) and a status notification of “continue”.
    2) Success: The ABS provides a status notification of “success”, but may have adjustment suggestions to the AMS if necessary. With status success, the ABS shall provide the AMS a UL BW allocation for the AMS to send the AAI RNG-REQ message.
    3) Abort: The ABS requests the AMS to abort the ranging process.
d) Based on the received response of ranging status, the AMS performs the following:
    1) Upon receiving a Continue status notification and parameter adjustments in the AAI-RNG-ACK message, the AMS shall adjust its parameters accordingly and continue the ranging process as done on the first entry using the next available ranging channel with ranging preamble code randomly chosen from the initial ranging domain sent on the initial ranging channel.
    2) Upon receiving a Success status notification, the AMS shall wait for the ABS to provide UL BW allocation. If the AMS has not received the CDMA Allocation A-MAP IE for UL BW allocation by T3 after sending a ranging preamble code, it restarts the initial ranging procedure or, if “ranging retries” is exhausted, it retries DL PHY synchronization. When receiving a UL BW allocation, the AMS shall send the AAI-RNG-REQ message. If the granted BW allocation cannot accommodate the entire AAI-RNG-REQ message, the AMS may fragment the AAI-RNG-REQ message to fit the provided BW allocation, and request additional UL bandwidth through either BR without STID header (refer to 6.2.2.1.3.2) or PBREH as defined in 6.2.2.2.6 for the remaining fragments. In response to the BR without STID header or PBREH, the ABS shall provide UL BW allocation through CDMA Allocation A-MAP IE, which is identified by

the same RA-ID used for the previous BW allocation. The RA-ID is used until AAI-RNG-RSP transmission is completed, but if AMS does not receive any UL bandwidth allocation in T3 or the AAI-RNG-REQ/RSP transaction is not completed in 128 frames, it sends ranging code to perform the ranging procedure again.

3) Upon receiving an Abort status notification, the AMS shall start the ranging abort timer and abort the ranging process until the ranging abort timer expires.

e) ABS assigns and transfers a TSTID by AAI-RNG-RSP message when ranging status is success. The initial ranging process is over after receiving the AAI-RNG-RSP message. The TSTID is used until STID is newly assigned and received at successful registration. If the AMS has not received AAI-RNG-RSP by T3 after sending an AAI-RNG-REQ, it restarts the initial ranging procedure, or if "ranging retries" is exhausted, it retries DL PHY synchronization.

If either S-SFH Network Configuration bit = 0b0 when AMSID privacy is disabled or the Network Configuration bit in the S-SFH is set to 0b1, the AMS provides its actual MAC address in the AAI-RNG-REQ message.

6.2.15.4 Basic capability negotiation

Immediately after completion of ranging, the AMS informs the ABS of its basic capabilities by transmitting an AAI-SBC-REQ message. A "Capability Class" is defined as a set of features and configuration parameters that can uniquely describe a mobile station implementation or configuration while operating in the network. Each Capability Class is indicated by its corresponding CAPABILITY_INDEX. The AMS, by default, shall support the basic capabilities associated with "Capability Class 0" (i.e., CAPABILITY_INDEX = 0). If the AMS has higher capability than the capability suggested by CAPABILITY_INDEX = 0, then the AMS may transmit a higher version of the capability index or the AMS may additionally include parameters in the AAI-SBC-REQ message that represent the difference with respect to the transmitted capability index.

Upon receipt of the AAI-SBC-REQ message, the ABS determines whether it could allow or support the requested feature set and configuration parameters. If the ABS does support or allow the use of enhanced features and configuration parameters, it shall respond with an AAI-SBC-RSP message to inform the AMS of its decision. The ABS shall transmit the AAI-SBC-RSP message containing "CAPABILITY_INDEX" which may be numerically different than that requested by the AMS.

The "CAPABILITY_INDEX" values range from 0 to N, where N denotes the maximum CAPABILITY_INDEX value. The CAPABILITY_INDEX = 0 indicates the default capability index and basic feature set or configuration parameters.

The features and configuration parameters included in the Capability Class 0 shall be sufficient to meet the minimum performance requirements.

Figure 6-72 shows the relationship between the Capability Classes.

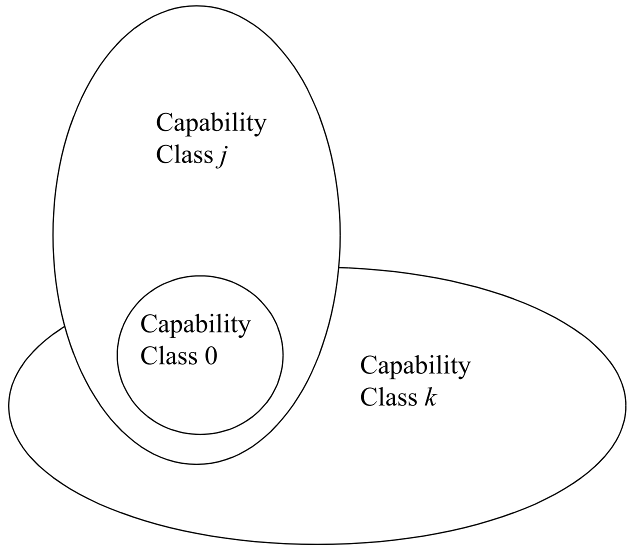


Figure 6-72—Relationship between capability classes

The content of “Capability Class 0” is defined in Annex F.

6.2.15.5 AMS authorization and key exchange

If authorization support is enabled in basic capability negotiation, the ABS and the AMS shall perform authorization and key exchange through EAP-based authentication (IETF RFC 3748) and key agreement procedure (see 6.2.5.2.1.4). If this procedure completes successfully, all parameters for TEK generation are shared, and TEKs are derived at each side of the AMS and the ABS. If authorization support is disabled, the step of AMS authorization and key exchange shall be skipped.

6.2.15.6 Registration

Registration is the process by which the AMS is allowed to enter into the network.

After authorization and key exchange are finished, the AMS informs the ABS of its capabilities and requests the registration for entry into the network by AAI-REG-REQ. If an ABS receives an AAI-REG-REQ, the ABS shall respond with an AAI-REG-RSP.

In the AAI-REG-REQ, the AMS informs the ABS of its capability parameters to be negotiated except those capabilities already negotiated with the ABS through AAI-SBC-REQ/RSP messages. In AAI-REG-RSP, the ABS responds with the accepted capability parameters. If the AMS omits some capability parameters in the AAI-REG-REQ, the ABS considers that the AMS follows the default values for those parameters, and if acceptable, the ABS may omit those parameters applying default value in its AAI-REG-RSP.

Within the AAI-REG-REQ message, the AMS shall indicate its latest received global carrier configuration change count. Upon receiving this message, the ABS shall check if AMS’s global carrier configuration information is valid. As a response, the ABS shall include the current global carrier configuration change count in the AAI-REG-RSP message. If the AMS’s global carrier configuration change count is out of date, the ABS shall unicast the AAI-Global-CFG message to the AMS after AAI-REG-REQ/RSP and AAI-MSG-ACK transactions are completed. The ABS shall set the Polling bit to 1 in MCEH of the MAC PDU containing the AAI-Global-CFG message to receive an acknowledgment for the AAI-Global-CFG message. If the ABS does not receive the AAI-MSG-ACK message until ACK timer expires, the ABS shall retransmit the AAI-Global-CFG message.

Also, if the AMS's global carrier configuration information is out of date, the AMS shall not perform any procedure that refers to the AAI-Global-CFG message until the valid AAI-Global-CFG message is received from the ABS.

The ABS shall allocate and transfer an STID to the AMS through an encrypted AAI-REG-RSP message.

The ABS shall trigger the AMS to transmit an AAI-MSG-ACK message by setting Polling bit to 1 in MCEH of the AAI-REG-RSP message. Upon receiving the AAI-REG-RSP, the AMS shall send a BR with STID header containing the STID to transmit AAI-MSG-ACK or PDU including MAEH. Upon ABS successful reception of a BR with STID header containing the STID, or PDU from AMS including MAEH with the STID, the ABS shall:

a) Allocate uplink bandwidth using the STID for the AMS
b) Discard the temporary STID that was allocated during the initial ranging procedure
c) Begin use of STID in communications with the AMS

The ABS shall retain TSTID and continue use of TSTID until successful installation of STID on the AMS has been verified using the method identified above. The AMS shall discard the temporary STID when it receives an Assignment A-MAP IE CRC-masked using the STID that was assigned through the encrypted AAI-REG-RSP message. The AMS shall retain TSTID and continue use of TSTID until successful installation of STID on the ABS has been verified using the method identified above.

The AAI-REG-RSP message contains the CRID, where the network retains the AMS contexts including the CRID and the AMS MAC address.

Upon successful registration, a DL FID and a UL FID, reserved for the default service flow, are activated at the AMS and the ABS without using the DSA procedure for each UL and DL direction that can be used for upper layer signaling (e.g., DHCP). The AMS shall set up the default service flow using predefined values for its service flow parameters (see Table 6-135) and CS type indicated in the AAI-REG-RSP message.

When multiple CS types are enabled, the one CS type associated with the default service flow shall be defined using the CS type for default service flow parameter. Nondefault service flows shall be set up, as needed, after the registration procedure.

During the registration procedure, the AMS and the ABS shall negotiate IP versions. The AMS shall inform the supported IP version(s) (for example, IPv4, IPv6 or both) to the network through the ABS by including the CS type in the AAI-REG-REQ message. After the network selects one of the supported IP version(s), the ABS shall inform the AMS of the selected IP service type (for example, IPv4 only, IPv6 only, or IPv4/IPv6 dual mode) by including the CS type in the AAI-REG-RSP message.

The AMS may indicate its capability of configuring host parameters (for example, host address or home network prefix) and request the additional parameters (for example, DNS Server Address) to the network through the ABS by including the Host-Configuration-Capability-Indicator IE in the AAI-REG-REQ message.

If the AMS indicates its capability of configuring host parameters and the ABS is configured to support the requested host configuration parameters, the ABS shall include either the IPv4-Host-Address IE or the IPv6-Home-Network-Prefix IE or both and the requested host configuration parameter(s) in the AAI-REG-RSP message. If the AMS does not indicate its capability of configuring host parameters, the ABS shall not include any of those host configuration parameters in the AAI-REG-RSP message assuming that the AMS will be configured by using the upper layer protocol.

If the AMS wants to configure additional host configuration parameters, the AMS may indicate those parameters by including Requested-Host-Configurations IE in the AAI-REG-REQ message. If the AMS indicates additional host configuration parameters or the network decides to configure additional host configuration parameters, the ABS may include Additional-Host-Configurations IE in the AAI-REG-RSP message.

The format of the value field of Requested-Host-Configurations IE and Additional-Host-Configurations IE is defined in IETF RFC 2132 for IPv4 and IETF RFC 3315 for IPv6. Note that the list of parameters can be found in IANA documents "Dynamic Host Configuration Protocol (DHCP) and Bootstrap Protocol (BOOTP) Parameters" and "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)".

6.2.16 Periodic ranging

Periodic ranging is the process of maintaining the correct AMS's UL transmission parameters, including timing offset, frequency offset, and power adjustments, so that the AMS's transmissions are aligned with the ABS, and they are received within the appropriate reception thresholds.

An AMS that wishes to perform periodic ranging shall follow the following procedure:

a) The AMS maintains and controls a Periodic Ranging timer (T4 timer), and the period of periodic ranging timer (periodOfPeriodicRngTimer) is broadcasted by S-ABS via the AAI-SCD message. Using the period of periodic ranging timer given by ABS, the AMS shall start the periodic ranging timer upon the completion of the initial network entry or the network reentry. The AMS shall restart or reset the periodic ranging timer upon triggered by the events specified in the periodic ranging procedure below. The AMS shall stop the periodic ranging timer when it is disconnected from the ABS, e.g., entering idle mode, de-registered, or HO.

b) Upon timeout of the periodic ranging timer, the AMS shall randomly choose a periodic ranging opportunity and a periodic ranging preamble code. The AMS shall send the selected ranging preamble code to the ABS in the selected ranging opportunity.

c) The ABS shall respond with a broadcast AAI-RNG-ACK message (i.e., transmitted in a broadcast DL allocation) in a DL frame that is in a predefine period, if the ABS detects at least one periodic preamble code in the previous periodic ranging region. The predefined period for the AAI-RNG-ACK transmission is after the UL frame containing the previous periodic ranging region and is before the UL frame containing the next periodic ranging region. The AAI-RNG-ACK message provides responses to all the successfully received and decoded periodic ranging preamble codes in all the ranging opportunities in the previous periodic ranging region. There are four different cases at the AMS that sent a random access based periodic ranging request as follows:

    1) If the AMS does not receive an AAI-RNG-ACK message in the predefine period after it sent its periodic ranging request or the AMS receives the AAI-RNG-ACK message and does not find any response to its periodic ranging request identified by the periodic ranging opportunity and the periodic ranging preamble, the AMS considers that its periodic ranging request was failed, and it may send another randomly selected periodic ranging preamble code at the next appropriate periodic ranging transmission opportunity and adjust its transmission power level up to PTX_IR_MAX (6.3.9.5.1 in IEEE Std 802.16).

    2) If the AMS receives a periodic ranging response in the AAI-RNG-ACK message and the ranging status is "success", the AMS shall adjust its UL transmission parameters as notified in the received periodic ranging response if any; then the AMS shall restart the periodic ranging timer.

3) If the AMS receives a periodic ranging response in the AAI-RNG-ACK message and the ranging status is "continue", the AMS shall adjust its UL transmission parameters as notified in the received periodic ranging response; then the AMS shall continue the periodic ranging process with further randomly chosen periodic ranging opportunity and periodic ranging preamble code.
4) If the AMS receives a periodic ranging response in the AAI-RNG-ACK message and the ranging status is "abort", the AMS shall abort the periodic ranging process.

d) The ABS may send a unicast unsolicited AAI-RNG-ACK (i.e., transmitted in the DL allocation for a specific AMS) to adjust the UL transmission parameters of a specific AMS, based on the measurement made on other received data from the AMS. When an AMS receives an unsolicited AAI-RNG-ACK message, it shall perform one of the above cases (2, 3, 4) depending on ranging status in the AAI-RNG-ACK message.

6.2.17 Sleep mode

Sleep mode in connected state is a mode in which an AMS conducts prenegotiated periods of absence from the S-ABS air interface. Sleep Mode support is negotiated during AAI-REG-REQ/RSP transaction (see Mobility features support in Table 6-36 and Table 6-37). Sleep mode can be activated through explicit signaling when an AMS is in active mode. During the activation of sleep mode, the AMS is provided with a set of sleep cycles that consist of a listening window (except for initial SC) followed by a sleep window.

When sleep mode is active for the AMS, the AMS shall be in either available state or unavailable state:

— Available state in sleep mode means the state in which the AMS is ready to receive and transmit to the ABS; transmissions include MAC PDUs and signals like HARQ feedback.
— Unavailable state in sleep mode means the state in which the AMS is not available to the ABS for DL transmissions.

During a sleep window, the ABS shall not transmit DL unicast MAC PDU to the AMS; therefore, the AMS may power down one or more physical operation components or perform other activities that do not require transmission of DL unicast MAC PDUs.

During a listening window, the AMS is expected to receive all DL transmissions in the same way as in active mode. An AMS in sleep mode shall ensure that it has up-to-date system information for proper operation. To ensure that the AMS has up-to-date system information, the following scenarios may occur during a sleep window of the sleep mode AMS:

— Case 1: If there is no possible change on any S-SFH SP IE (i.e., S-SFH SP1 IE, SP2 IE, and SP3 IE) during AMS's sleep window (i.e., the sleep window terminates before the SFH where the S-SFH SP IE may change), then the AMS determines it does not have to decode this S-SFH SP IE during its sleep window.
— Case 2: If there is only one S-SFH SP IE change possibility during the sleep window, then the AMS performs operations defined in 6.2.24 to receive this S-SFH SP IE during the sleep window at SFH just before the sleep window termination where this SP IE is transmitted.
— Case 3: If there are multiple S-SFH SP IEs change possibilities during the sleep window, then the AMS performs operations defined in 6.2.24 for each of these S-SFH SP IEs during the sleep window at SFHs just before the sleep window termination where these SP IEs are transmitted.

The synchronization and system configuration information acquisition and verification may be done by AMS transiting to the available state at some Super Frame header just prior to the frame in which its listening window is located to ensure that the Super Frame number and the S-SFH Change Count are as expected. If the AMS detects that it is not synchronized, then it shall stay in the available state until the AMS is successfully synchronized with the S-ABS. If the AMS detects another ABS than the S-ABS, then it shall exit sleep mode and perform network reentry as described in 6.2.15 or 6.2.6.3.5. If the AMS detects that the system information it has is not up-to-date, then it shall not transmit until it receives the up-to-date system configuration information.

The length of successive sleep cycles may remain constant or may be adaptive based on traffic conditions. Sleep windows and listening windows may also be dynamically adjusted for the purpose of data transportation as well as MAC control signaling transmission. The AMS may send and receive data and MAC control signaling without deactivating the sleep mode.

For each AMS, the AMS and the ABS shall keep at least 16 previously negotiated sleep cycle settings and associated SCIDs.

If an AMS requests to switch its sleep cycle setting to a prenegotiated sleep cycle setting by the AAI-SLP-REQ including associated SCID, the ABS shall respond with the AAI-SLP-RSP including approval or other SCID. Per AMS, a single sleep cycle setting is indicated by a SCID and it shall be applied across all the active connections of the AMS.

6.2.17.1 Sleep mode initiation

Sleep mode activation may be initiated either by an AMS or an ABS. When an AMS in the active mode decides to enter sleep mode, it shall negotiate sleep cycle settings with the ABS. The ABS makes the final decision regarding the AMS request and instructs the AMS to enter sleep mode. The negotiation of the sleep cycle setting is performed by the exchange of corresponding MAC control messages AAI-SLP-REQ and AAI-SLP-RSP.

The AMS may initiate the negotiation by sending an AAI-SLP-REQ message and shall expect an AAI-SLP-RSP message from the S-ABS as response. Alternatively, the ABS may initiate the negotiation by sending an unsolicited AAI-SLP-RSP message to the AMS. In this case, the ABS should request the AMS to send an acknowledgment (i.e., AAI-MSG-ACK) to the AAI-SLP-RSP.

In the event that the ABS-initiated request (i.e., unsolicited AAI-SLP-RSP) 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 the AAI-SLP-RSP message in response to AAI-SLP-REQ, the AMS shall abandon 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 sleep mode initiation request.

6.2.17.2 Sleep mode operation

6.2.17.2.1 Sleep cycle operations

The period of the sleep cycle is measured in units of frames. The first sleep cycle when entering sleep mode from active mode contains only a sleep window that equals the initial sleep cycle.

A sleep cycle, except for the first initial cycle, shall begin with a listening window. A sleep window shall follow the listening window and 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 be in the available state in certain AAI subframes during each frame in the listening window. The AMS shall be synchronized using procedures defined in 6.3.5.1 and 6.3.5.2 prior to the scheduled listening window.

The AMS’s exact mechanism for maintaining synchronization with the ABS, based on the preamble, is implementation-specific.

The listening window within a sleep cycle may be dynamically extended, as specified in 6.2.17.2.3.2.

The length of a sleep cycle may be changed implicitly. If there is negative indication in the AAI-TRF-IND message or if there is no unicast data traffic during the listening window, the AMS and the ABS shall update the length of the sleep cycle as follows in Equation (9):

$$\text{Current Sleep Cycle} = \min(2 \times \text{Previous Sleep Cycle}, \text{Final Sleep Cycle}) \tag{9}$$

The value of the default listening window shall remain unchanged when the sleep cycle is changed implicitly according to Equation (9).

If there is positive indication in the AAI-TRF-IND or there is unicast data traffic during the listening window, the AMS and the ABS shall update the length of the sleep cycle based on NSCF, which was negotiated through the AAI-SLP-REQ/RSP transaction, as follows:

Current Sleep Cycle = Initial Sleep Cycle, when NSCF = 0b00

Current Sleep Cycle = min (2 × previous sleep cycle, Final Sleep Cycle), when NSCF = 0b01

Current Sleep Cycle = New Initial Sleep Cycle, when NSCF = 0b10

The parameters associated with the 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
- Start Frame Number: Six least significant bits of frame number. This indicates the frame number 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 a 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 to every listening window
- Next Sleep Cycle Flag (NSCF)

When TIMF = 0, the AMS shall stay in the available state during the whole listening window.

When the final sleep cycle is equal to or larger than 2 times the initial sleep cycle, the length of the sleep cycle exponentially doubles until the final sleep cycle is reached. This sleep cycle operation is suitable for the BE-traffic scenario. If the traffic indication message is positive for the AMS, then the length of the current sleep cycle shall be determined based on the value of the NSCF that was included in the AAI-SLP-RSP. The sleep cycle could be the different length according to the Next Sleep Cycle Flag (NSCF) within the AAI-SLP-REQ/RSP message. If the NSCF is set to 0b00, then the initial sleep cycle is always the same as the first initial one. When the NSCF is set to 0b01, then the current sleep cycle is doubled in the previous sleep cycle.

When the NSCF is set to 0b10, the current sleep cycle is reset to the new initial sleep cycle included in the AAI-SLP-RSP message after positive traffic indication.

When the final sleep cycle is equal to the initial sleep cycle, the length of the sleep cycle is fixed. This sleep cycle operation is suitable for “real-time traffic-only” or “real-time and BE-traffic mixed” scenario.

6.2.17.2.2 Sleep window operations

During the sleep window, the AMS is unavailable to receive any DL data and MAC control signaling from the S-ABS. The AMS may perform power-down or autonomous scan or any other autonomous operations that does not involve the reception of DL transmissions. Handling of MAC control signaling during the sleep mode is specified in 6.2.17.2.6. The AMS may interrupt the sleep cycle operation to request UL bandwidth in the sleep window.

The protocols and procedures relating to interruptions of normal sleep cycle operation are provided in 6.2.17.2.6.

6.2.17.2.3 Listening window operations

During the listening window, the AMS is in the available state except for the case the AMS may be in the unavailable state during the first half of the listening window after receiving the traffic location indicator bitmap set to 1 in the AAI-TRF-IND message. If the traffic indication is enabled, the AMS shall receive and decode a traffic indication message sent by an ABS during the listening window. Otherwise, the AMS shall ignore the traffic indication message.

The listening window is measured in units of frames.

At an AMS, a listening window shall end on encountering one of the following conditions:
- On reception of an SCH from the ABS to terminate the listening window
- On reaching the end of the current listening window including any extension
- On reaching the end of the sleep cycle

At the S-ABS, a listening window shall end on encountering one of the following conditions:
- On transmission of an SCH to the AMS to terminate the listening window
- On reaching the end of the current listening window including any extension
- On reaching the end of the sleep cycle

The ABS may send an SCH to terminate the current listening window. The AMS may send an SCH to terminate the current listening window. In this case, the ABS shall send SCH with “Response Indication” bit = 1 and regard the AMS as returning to the unavailable state. When an ABS has a last PDU in the DL buffer during the listening window, the ABS may transmit an explicit indication using SCH with “Response Indication” bit = 0. Upon receiving the SCH with “Response Indication” bit = 1 from the AMS, the ABS shall regard the AMS as returning to sleep (i.e., the sleep window starts).

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.

6.2.17.2.3.1 Traffic indication

Traffic indication is enabled when TIMF = 1 in AAI-SLP-REQ/RSP and is sent for one or a group of AMS using the AAI-TRF-IND message.

If the traffic indication is enabled for an AMS by TIMF = 1 in AAI-SLP-REQ/RSP and SLPID is assigned, the ABS shall transmit a traffic indication message during the listening window. Upon receiving the traffic indication message, the AMS shall check whether there is positive traffic indication (e.g., by the SLPID-Group Indication bitmap and Traffic Indication bitmap or the SLPID assigned to it). The ABS shall include Traffic Location Indicator Bitmap field in the AAI-TRF-IND message if there is at least one SLPID that has a positive traffic indication and its Traffic Location Indicator is set to 1. In this case, the Traffic Location

Indicator field indicates whether the positive traffic indicated the AMS may be in the unavailable state in the first half of the listening window. The first half of the listening window is defined as the floor (N/2) first frames of the listening window where N is the length of the listening window. If the AMS receives the positive traffic indication during the listening window, the current sleep cycle (i.e, which contains the listening window) shall be reset to the value corresponding to the NSCF (i.e., initial sleep cycle, new initial sleep cycle, or doubles of previous sleep cycle) to synchronize the listening window of AMSs in sleep mode.

If the AMS receives a negative traffic indication, then it shall end the listening window and proceed with the sleep window operation for the remainder of the sleep cycle, unless the AMS has UL signaling or traffic pending for transmission. If the ABS transmits a negative indication to the AMS, the ABS shall not transmit any DL data traffic to the AMS during the remaining part of the listening window.

If the AMS receives a positive traffic indication, it shall remain in the available state until the end of the listening window for unicast data unless the listening window is terminated explicitly by SCH. 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.

Traffic indication is considered positive when the AAI-TRF-IND message is lost or not detected by the AMS, but unicast data is received by the AMS. If the AMS receives any unicast data during the listening window, then it considers 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 then send an AAI-TRF-IND-REQ message after its current default listening window to ask the ABS the location of the next scheduled listening window. The ABS shall respond to the AMS by unicasting an AAI-TRF-IND-RSP message containing the starting frame number and the length of the next sleep cycle. On receiving the AAI-TRF-IND-RSP message, the AMS shall be synchronized with the next sleep cycle.

The SLPID may be updated via the AAI-TRF-IND-RSP message. When the ABS has sent the AAI-TRF-IND message including the SLPID update of the AMS and it receives the AAI-TRF-IND-REQ message from the AMS, the ABS shall include this parameter in the AAI-TRF-IND-RSP message.

6.2.17.2.3.2 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 in units of frames. For each extension, the AMS or the ABS has the option to specify a bitmap that indicates the subframes the AMS needs to be in the available state in for receiving/sending traffic. This subframe level bitmap may be the same as the one used for the default listening window.

The listening window can be extended implicitly if one of the following conditions is true:

— Exchange of MAC PDUs including the BR Header between an AMS and an ABS within the listening window
— Pending HARQ retransmission in UL or DL

The AMS shall maintain an inactivity timer during the listening window called the T_AMS timer, and a similar timer is maintained by the ABS called the T_ABS timer. The value of the T_ABS timer shall be less than or the same as the T_AMS timer.

An AMS shall remain in the available state if any of the following condition is true:

— The listening window has not been explicitly terminated
— The T_AMS timer has not expired

— The T_HARQ_Retx timer has not expired
— The number of retransmissions of the UL HARQ burst has not reached the maximum number of HARQ retransmission attempts
— The default listening window has not ended and TIMF = 0
— If TIMF = 1 and the AMS received a positive traffic indication

The rules regarding the starting/restarting of the 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 the AMS receives a HARQ ACK or DL MAC PDU or Assignment-A-MAP IE from an ABS, the AMS shall restart the T_AMS timer.
— If there is NAK for HARQ retransmission in UL or DL, the T_HARQ_Retx timer for the associated HARQ process shall be started/restarted. If there is an ACK for HARQ retransmission in UL or DL, the T_HARQ_Retx timer for the associated HARQ process shall be set to zero.
— If there is an NAK for UL HARQ transmission, the AMS shall not sleep until an ACK is received or the maximum retransmissions of the HARQ burst are exhausted.
— If T_HARQ_ReTx expires and the 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.

An ABS shall consider the associated AMS is in the available state if any of the following conditions is true:

— The listening window has not been explicitly terminated
— The T_ABS timer has not expired
— The T_HARQ_Retx timer has not expired
— The number of retransmissions of the DL HARQ burst has not reached the maximum number of HARQ retransmission attempts
— The default listening window has not ended

The rules regarding the starting/restarting of the 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 the 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 the AMS has transited to the unavailable state until it transmits the maximum number of HARQ retransmissions. If the maximum retransmissions of the HARQ burst are exhausted, the ABS considers that the AMS has transited to the unavailable state.

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 or there is no pending HARQ retransmission for DL of the AMS, the ABS shall regard the AMS as returning to the unavailable state.

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 SCH including the number of frames for the extended listening window to the control extension of the listening window during the Default listening window. Upon receiving the explicit signaling, the AMS shall send SCH with “Response Indication” bit = 1 and extend its listening window until the frame specified in signaling. The AMS may also send an explicit signaling in SCH including the number of frames for the extended listening window to the control extension of the listening window during the default listening window. Upon receiving the explicit signaling to the extend listening window, the ABS shall send SCH with “Response Indication” bit = 1 and regard the AMS as extending the listening window until the frame specified in SCH.

6.2.17.2.4 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 a request to reactivate 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, to propose alternate settings, or to deny the requested change. At the frame specified by Start_Frame_Number, the newly updated sleep cycle settings shall be applied. Alternatively, the ABS may initiate a sleep cycle parameter change by sending an unsolicited AAI-SLP-RSP message to the AMS. In this case, the ABS shall request the AMS to send an acknowledgment using AAI-MSG-ACK or MAEH to the AAI-SLP-RSP.

The sleep cycle change/switching may be performed with the exchange of DSx MAC control messages when the AMS is in sleep mode. In case the AMS in sleep mode sends an AAI-DSx-REQ with sleep cycle setting (refer to Table 6-85, Table 6-88, and Table 6-91), the ABS shall regard the sleep cycle setting included in the AAI-DSx-REQ as negotiation of sleep cycle parameters in AAI-SLP-REQ. If the ABS decides to accept the sleep cycle setting, the ABS shall include the Response Code = 0b01 (i.e., Approval) with the parameters (refer to Table 6-86, Table 6-89, and Table 6-92) that are different from the AMS’s request. Otherwise, the ABS shall either omit the entire sleep cycle setting or include both the Response Code = 0b10 (i.e., Reject) and/or the REQ_duration in the AAI-DSx-RSP message, as rejection of the AMS’s request. If the ABS rejects the sleep cycle setting negotiation while accepting creation/change/deletion of service flow, the ABS or the AMS may initiate another sleep mode transaction to change/switch the sleep cycle setting by AAI-SLP-REQ/RSP. On the other hand, if the ABS sends the AMS an AAI-DSx-REQ with the sleep cycle setting (refer to Table 6-85, Table 6-88, and Table 6-91), the AMS shall regard the sleep cycle setting in AAI-DSx-REQ as negotiation of sleep cycle parameters in unsolicited AAI-SLP-RSP. Therefore, the AMS shall apply the sleep cycle setting sent in the frame specified by Start_Frame_Number in the sleep cycle setting included in AAI-DSx-REQ sent by the ABS (refer to Table 6-85, Table 6-88, and Table 6-91).

If the DSx transaction is failed with Confirmation Code = Non-zero, the AMS and the ABS shall ignore the sleep cycle setting in the AAI-DSx-REQ/RSP message, as well.

In the event that an ABS-initiated request (i.e., Unsolicited AAI-SLP-RSP) and an AMS-initiated request for sleep cycle setting change or switch (i.e., AAI-SLP-REQ, Service Specific Scheduling Control Header) 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 the 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.

6.2.17.2.5 FFBCH operation during sleep mode

In case of an FFBCH_Operation in AAI-SLP-RSP = 0b00, the fast feedback channel assigned to the AMS is kept. In this case, the MS shall transmit feedback information on the fast feedback channel to the BS during the listening window. The AMS may transmit a feedback information on the fast feedback channel to the BS during the sleep window. If the ABS detects the feedback information on the fast feedback channel, the ABS shall process it. The sleep mode shall not impact on the scheduling order of fast feedback channels (e.g., the sequence/period of short-term and long-term feedback).

In case of the FFBCH_Operation = 0b01, the fast feedback channel is deallocated at the frame specified by Start_Frame_Number in AAI-SLP-RSP.

In case of the FFBCH_Operation = 0b10, whenever the fast feedback channel is newly assigned to the AMS during the listening window, the allocated fast feedback channel is automatically deallocated at the beginning of sleep window.

6.2.17.2.6 Interruptions to normal sleep cycle operation

Events specified in 6.2.17.2.6.1 and 6.2.17.2.6.2 can interrupt the normal sleep cycle operation without deactivating sleep mode.

6.2.17.2.6.1 Sleep cycle operation during control signaling transactions

During a control signaling transaction between an ABS and an AMS, the AMS shall remain in the Available state after it has transmitted any UL signaling to which the ABS is expected to respond unless it is instructed by the ABS to resume normal sleep cycle operation. The UL signaling for which this shall be applicable includes any type of ranging, any request type signaling header, and any MAC control message requiring an ABS response. The AMS shall remain in the Available state 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 SCH 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 frame location 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 SCH along with Resume Sleep Cycle Indication. The AMS shall be in the Available state 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 frame location of the sleep cycle(s) to which it coincides.

6.2.17.2.6.2 Sleep operation with reception of broadcast/multicast transmissions

With the exception of AAI-TRF-IND, reception of broadcast/multicast transmission does not affect the normal sleep cycle operation of the AMS in sleep mode. An AMS may receive the broadcast/multicast traffic regardless of its sleep cycle if the AMS is aware of when the broadcast/multicast traffic is transmitted.

6.2.17.3 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 a deactivation 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. In this case, the ABS shall request the AMS to send an acknowledgment using AAI-MSG-ACK or MAEH to the AAI-SLP-RSP. When the AMS successfully exits from sleep mode, the ABS shall keep the sleep mode context until the ABS_Resource_Retain_Timer expires and the AMS shall keep the sleep mode context until it can determine that the ABS_Resource_Retain_Timer has expired. Sleep mode shall be implicitly terminated when an AMS successfully achieves idle mode, handover, or scanning mode transaction by explicit signaling.

In the event that the ABS-initiated request (i.e., unsolicited sleep response) and an AMS-initiated request for sleep mode exit is being handled concurrently, the ABS-initiated request shall take precedence over the AMS-initiated request. In this case, even though the AMS receives the ABS-initiated request while it is waiting for the 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.

6.2.18 Idle mode

An ABS may be assigned to one or more paging groups. Being assigned to a paging group, the ABS shall advertise the paging group ID (PGID) in the PGID-Info message.

An AMS is assigned during deregistration or location update to one or more paging groups and, per paging group, a specific paging cycle and paging offset. The values of the paging cycle and paging offset can be different among AMSs assigned to the same paging group. The assignment of paging offset shall be performed in such a way that the paging offset of different idle mode AMSs is pseudo-randomized.

When an AMS operating in R1 idle mode operation selects a mixed-mode ABS as a preferred ABS, the AMS may stay in the LZone of the mixed-mode ABS and perform the R1 Idle Mode operation as specified in 6.3.22 in IEEE Std 802.16.

If an AMS in Idle Mode decides to change its Idle Mode operation mode between R1 Idle Mode operation and advanced Idle Mode operation, the AMS shall perform full network reentry in the corresponding operation zone (MZone or LZone) of the new Idle Mode operation mode.

The Idle Mode operation mode change is caused also by zone switching between the LZone and the MZone of a mixed-mode ABS and handover between an ABS and a R1 Reference BS.

When an Idle Mode AMS is paged in the LZone of a mixed-mode ABS, the AMS shall perform the network reentry in the LZone of the ABS and may switch to the MZone of the ABS using LZone-to-MZone handover procedures as defined in 6.2.6.4.1.2.1.

An AMS may be assigned to one or more paging groups. If an AMS is assigned to multiple paging groups, it may be assigned multiple paging offsets within a paging cycle where each paging offset corresponds to a separate paging group. If the Paging Group Location Update Timer (PG_LU_TIMER) has not expired, the AMS is not required to perform a location update when it moves within its assigned paging groups. The assignment of multiple paging offsets to an AMS allows the AMS to monitor the paging message from different paging groups.

When an AMS is assigned to more than one paging group, one of the paging groups is the primary paging group of the AMS and the rest of the paging groups are secondary paging groups of the AMS.

When the AMS is assigned to multiple paging groups with the same paging cycle and different paging offsets, the primary paging group is the one with the smallest offset. The paging offset associated with the primary paging group is called the primary paging offset, while the paging offsets associated with secondary paging groups are called secondary paging offsets. The time difference between two adjacent paging offsets should be long enough so that the ABS can:

a) Send a paging message to the AMS in the primary paging offset within the paging cycle.
b) When the AMS is in the primary paging group, receive a response to the paging message from the AMS before the secondary paging offset.
c) Retransmit the paging message to the AMS at the secondary offset within the same paging cycle only if the response to the paging message in the primary paging offset is not received.

By monitoring the PGIDs advertised by its preferred ABS during a paging listening interval, an AMS determines if it is within its primary paging group or within a secondary paging group or not within its paging groups. The AMS determines that it is within a paging group if the PGID of that paging group is advertised by AMS's preferred ABS. Otherwise, the AMS determines that it is not within said paging group. If the AMS determines that it is in its primary paging group, the AMS wakes up at its primary paging offset and responds to paging messages that are sent in the primary paging offset and are addressed to it. If the AMS determines that it is not in its primary paging group, and that one or multiple secondary paging groups are present, the AMS wakes up at the shortest secondary paging offset and responds to paging messages that are sent in this paging offset and are addressed to it. If the AMS determines that none of the paging groups it has been assigned to are present, the AMS shall perform a location update.

6.2.18.1 Idle mode initiation

Idle mode for an AMS is initiated either by the AMS or by its S-ABS.

In the event that an ABS-initiated request (i.e., unsolicited AAI-DREG-RSP) and an AMS-initiated request for Idle Mode entry is being handled concurrently, the ABS-initiated request shall take precedence over the AMS-initiated request. In this case, even though the AMS receives the ABS-initiated request while it is waiting for the AAI-DREG-RSP message in response to AAI-DREG-REQ, the AMS shall stop the remaining procedure of the AMS-initiated request and continue with the ABS-initiated request. The ABS shall ignore the AMS-initiated request from an AMS if the ABS has already conducted the ABS-initiated request to that AMS.

6.2.18.1.1 AMS initiated

In case of an AMS-initiated idle mode entry, an AMS may signal intent to begin idle mode by sending a AAI-DREG-REQ message with the Deregistration_Request_Code parameter = 0x01 that indicates a request for AMS deregistration from S-ABS and initiation of AMS idle mode. The AMS may request the paging controller to retain a specific AMS service and operational information for idle mode management purposes through inclusion of the Idle Mode Retain Information element in the AAI-DREG-REQ control message. When the ABS decides to allow an AMS-initiated idle mode request, the ABS shall send a AAI-DREG-RSP with action code 0x07 in response to the AAI-DREG-REQ message. When the ABS decides to reject an AMS-initiated idle mode request, the ABS shall send a AAI-DREG-RSP message with action code 0x06 in response to this AAI-DREG-REQ message. The ABS may include REQ-Duration in this AAI-DREG-RSP message. In this case, the AMS may retransmit the AAI-DREG-REQ message after the expiration of REQ_Duration. If the AMS does not receive the AAI-DREG-RSP message within T45 timer expiry after it sends the AAI-DREG-REQ message to the ABS, the AMS may retransmit the AAI-DREG-REQ message as long as the DREG Request Retry Count has not been exhausted. Otherwise, the AMS shall determine that service with the ABS has been lost, and the AMS shall behave according to 6.2.26.3. The ABS shall start the Management_Resource_Holding_Timer to maintain connection information with the AMS as soon as it sends the AAI-DREG-RSP message with action code 0x07 to the AMS. If the 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 6-73 and Figure 6-74.

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

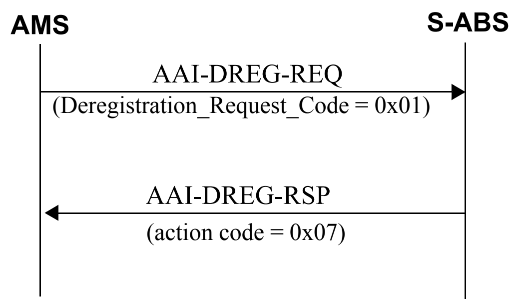


Figure 6-73—Call flow for AMS-initiated idle mode entry

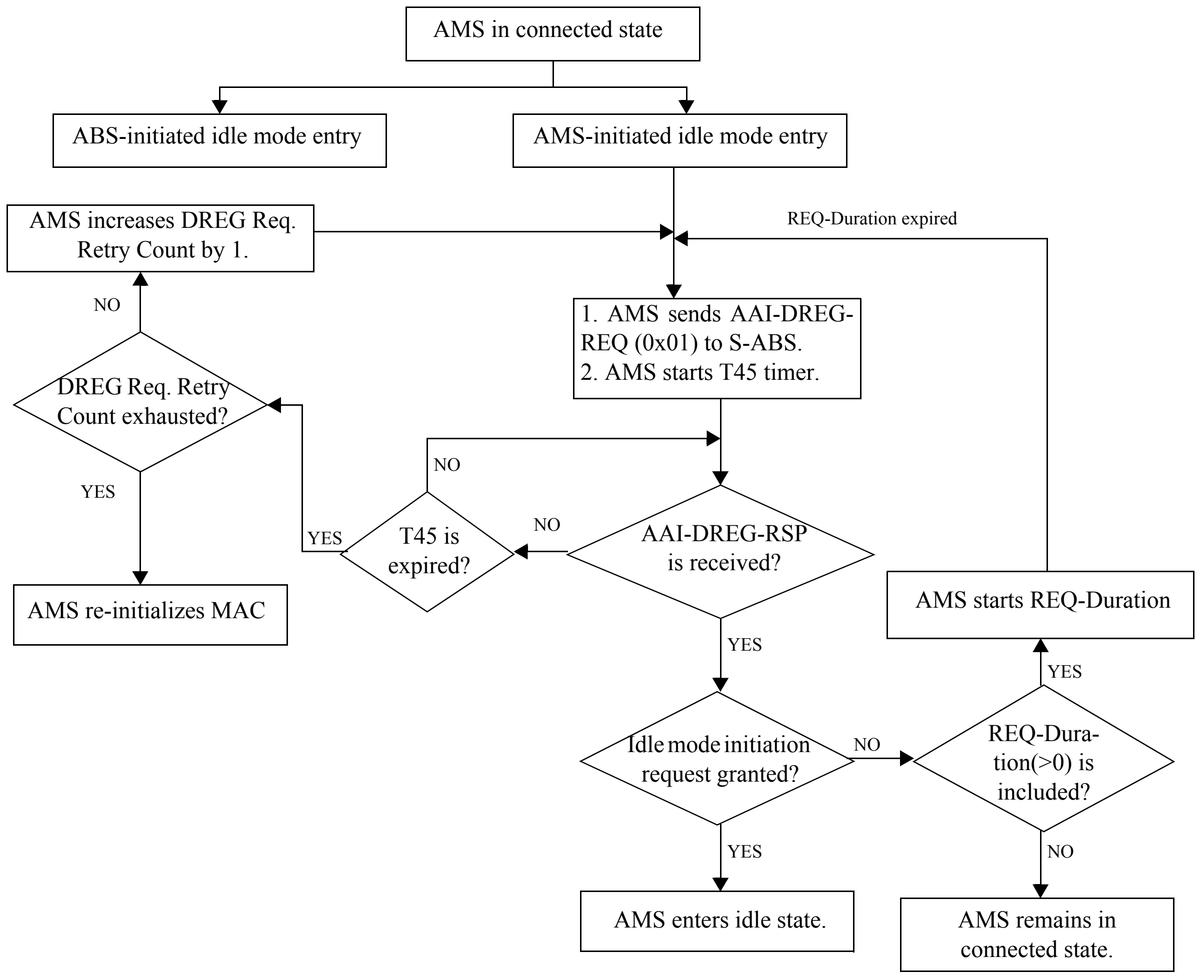


Figure 6-74—Procedures during AMS-initiated idle mode entry

6.2.18.1.2 ABS initiated

Using ABS-initiated idle mode entry, a S-ABS may signal for an AMS to begin idle mode by sending an AAI-DREG-RSP message with action code 0x05 in an unsolicited manner. This unsolicited AAI-DREG-RSP may include REQ-Duration. When an AMS receives an unsolicited AAI-DREG-RSP without REQ_Duration, the AMS shall immediately start the idle mode initiation procedures. This method of ABS-initiated idle mode entry is defined as Type 1 ABS-initiated idle mode entry. In case of Type 1 ABS-initiated idle mode entry, after sending the AAI-DREG-RSP message with action code 0x05, the S-ABS shall start the T46 timer as well as the Management_Resource_Holding_Timer at the same time. If the ABS does not receive the AAI-DREG-REQ message with the Deregistration_Request_Code parameter = 0x02 or the AAI-DREG-REQ message with the Deregistration_Request_Code parameter = 0x03 from the AMS in response to the unsolicited AAI-DREG-RSP message with action code 0x05 within T46 timer expiry, the ABS may retransmit the AAI-DREG-RSP message with action code 0x05 in an unsolicited manner as long as DREG command retry count has not been exhausted. When the AMS sends the AAI-DREG-REQ message with the Deregistration_Request_Code parameter = 0x02 in response to the unsolicited AAI-DREG-RSP message with action code 0x05, the AMS shall set the polling bit to 1 in MCEH. The AMS shall not enter idle mode immediately after sending a message indicating that it will enter idle mode because that message could get lost in the air link. Rather, the AMS shall wait for the AAI-MSG-ACK message from the ABS. If the AMS detects the AAI-MSG-ACK message before an ACK timer is expired, the AMS shall enter idle mode. If the ACK timer expires before the AAI-MSG-ACK message is received, the AMS may resend the same AAI-DREG-REQ message as long as DREG Request Retry Count has not been exhausted. If the AMS has a pending UL data to transmit, it shall send the AAI-DREG-REQ message with Deregistration_Request_Code parameter = 0x03 in response to the unsolicited AAI-DREG-RSP message with action code 0x05 by the ABS. These procedures are illustrated in Type 1 in Figure 6-75, Figure 6-76, and Figure 6-77.

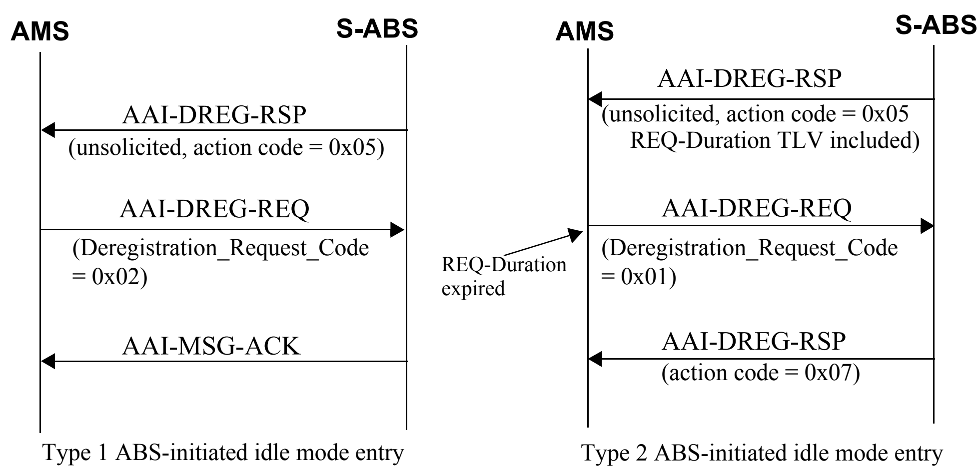


Figure 6-75—Call flow for ABS-initiated idle mode entry

As another case of ABS-initiated idle mode entry defined as Type 2 ABS-initiated idle mode entry, the S-ABS may also include a REQ-duration with an Action Code = 0x05 in the unsolicited AAI-DREG-RSP, signaling for an AMS to initiate an Idle Mode request through a AAI-DREG-REQ message with Deregistration_Request_Code = 0x01 at REQ-duration expiration. In this case, the ABS shall not start the T46 timer. The AMS may include Idle Mode Retain Information within the AAI-DREG-REQ message with Deregistration_Request_Code = 0x01 transmitted at the REQ-duration expiration. If the ABS receives the AAI-DREG-REQ message with Deregistration_Request_Code = 0x01, the ABS shall transmit another AAI-DREG-RSP message with Action Code = 0x07 including Idle Mode Retain Information. These procedures are illustrated in Type 2 in Figure 6-75, Figure 6-78, and Figure 6-79.

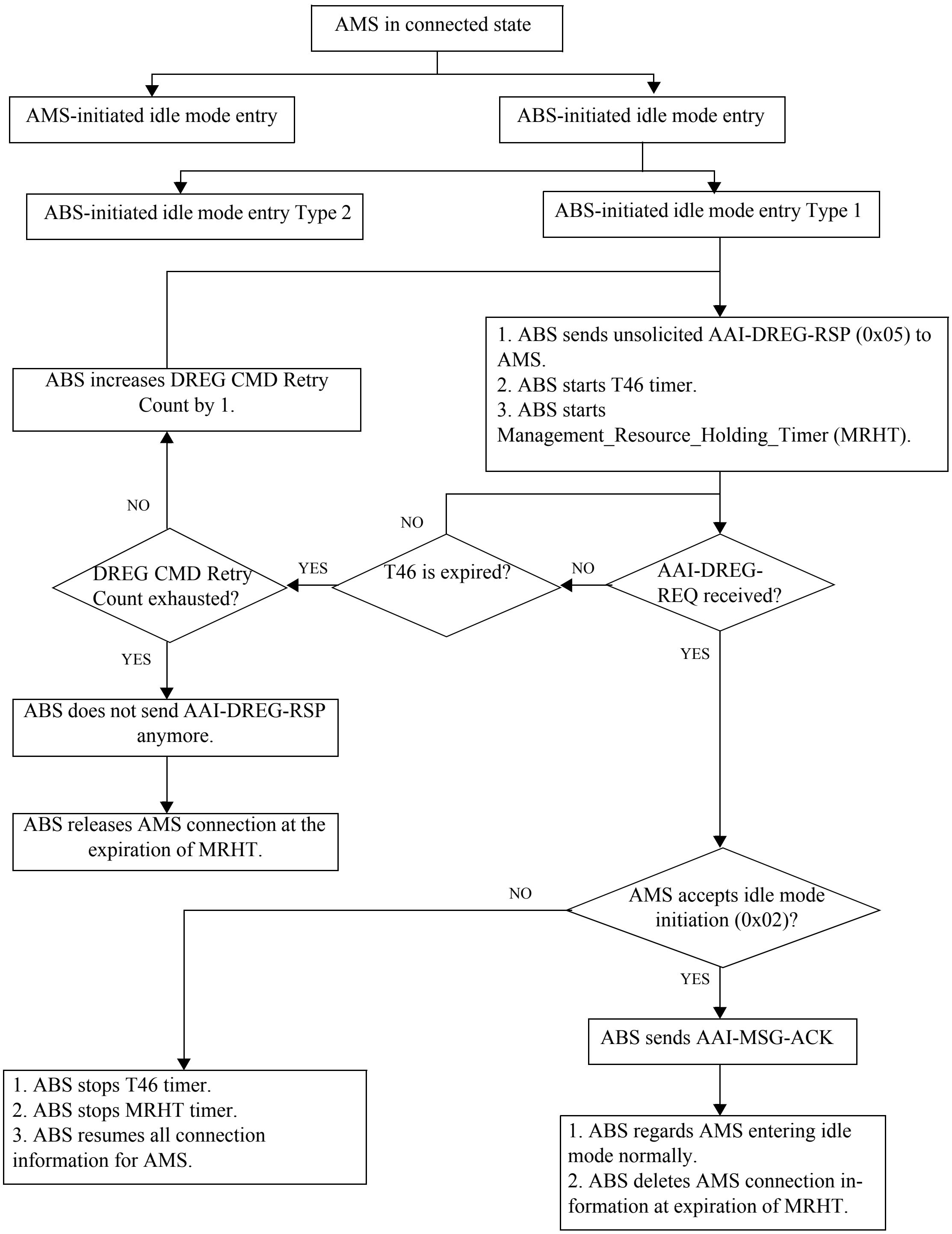


Figure 6-76—ABS procedures during Type 1 ABS-initiated idle mode entry

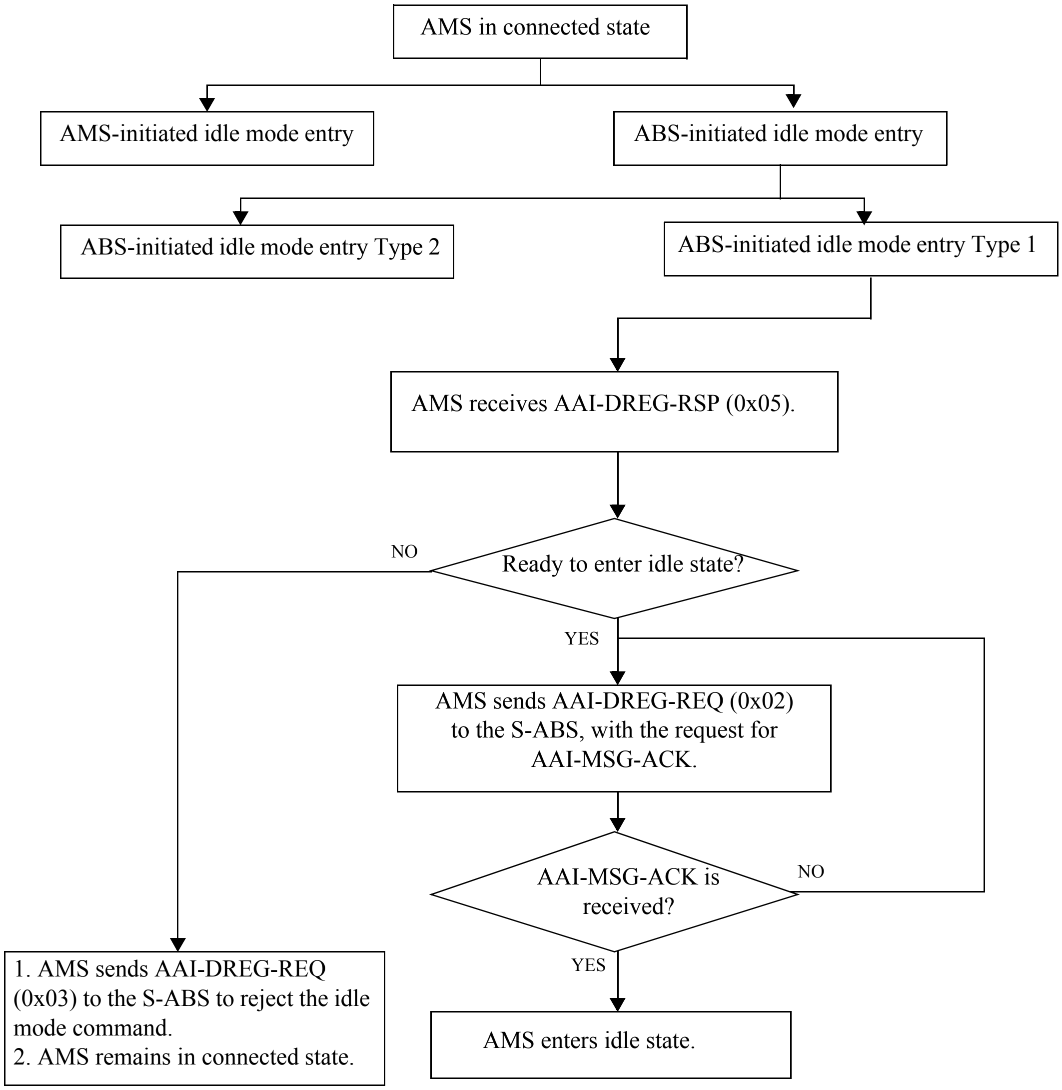


Figure 6-77—AMS procedures during Type 1 ABS-initiated idle mode entry

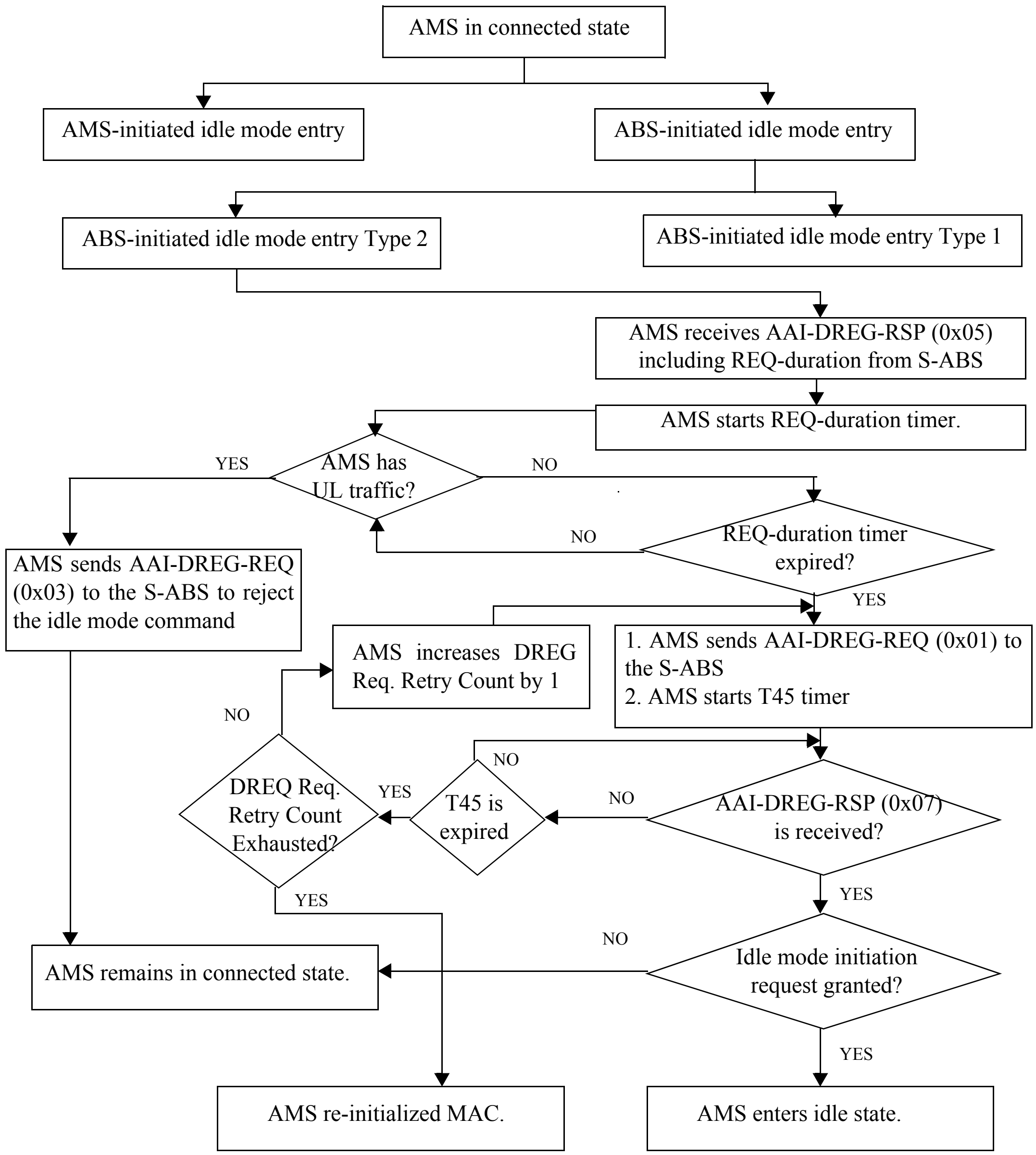


Figure 6-78—AMS procedures during Type 2 ABS-initiated idle mode entry

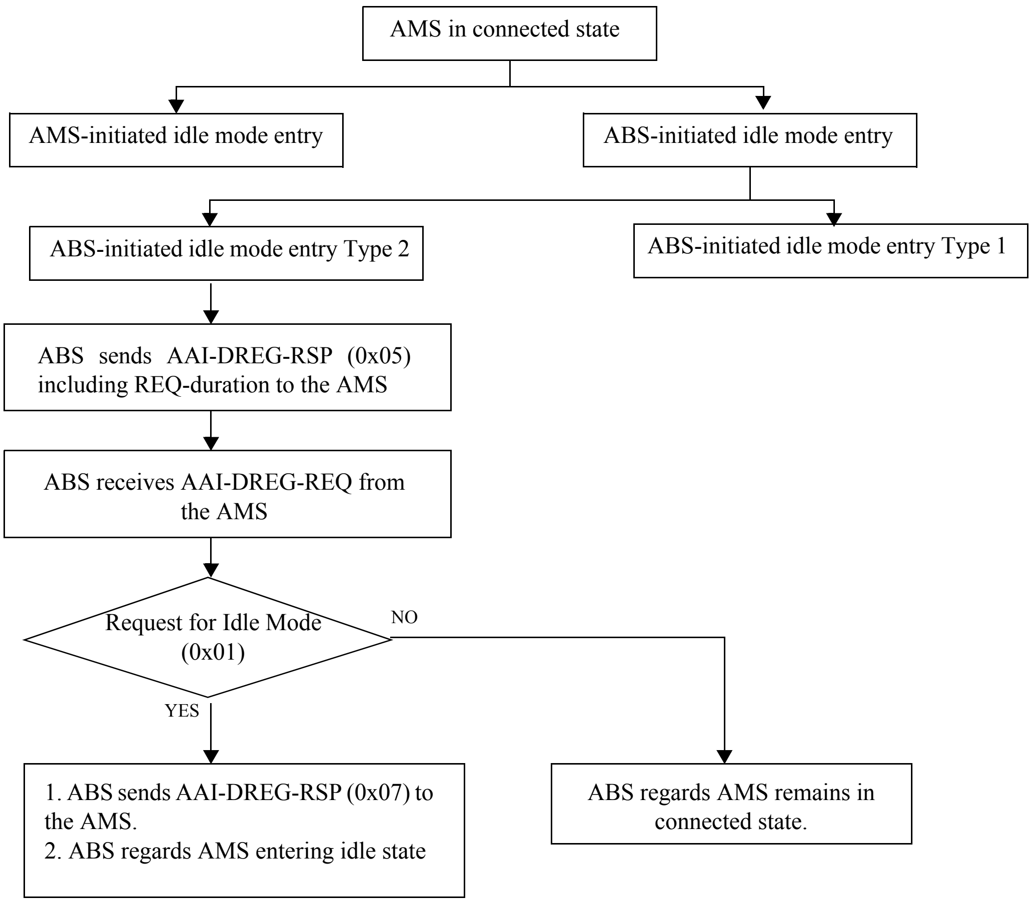


Figure 6-79—ABS Procedures during Type 2 ABS-initiated idle mode entry

6.2.18.2 Operation during idle mode

6.2.18.2.1 Operation during paging unavailable interval

An ABS shall not transmit any DL traffic or paging message to the AMS during a paging unavailable interval.

During a 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 a paging unavailable interval by evaluating and selecting an ABS with the best air interface DL properties, which may include the RSSI, CINR, cell type, available radio resources, and so on.

At evaluation and selection of the preferred ABS, the AMS shall synchronize and decode the SFH (superframe header) for the preferred ABS and extract the superframe number to determine the time that is remaining until the next regular paging listening interval for the preferred ABS.

If the Network Configuration bit in the S-SFH is set to 0b1, the ABS receives the R1 paging parameters (paging cycle and paging offset) for an idle mode AMS from the paging controller. The ABS translates these

R1 paging parameters into corresponding WirelessMAN-Advanced Air Interface paging parameters (paging cycle and paging offset). The ABS communicates these WirelessMAN-Advanced Air Interface paging parameters to the AMS using the AAI-DREG-RSP message during idle mode initiation and AAI-RNG-RSP during location update.

6.2.18.2.2 Broadcast paging message

A paging message is an AMS notification message that either indicates the presence of DL traffic pending for the specified AMS or polls an AMS for requesting a location update without requiring a full network entry. In addition, the paging message may include an emergency alert indicator used to notify the idle AMSs about emergency situation(s). Upon reception of the emergency alert indicator that is set to ‘1’, the AMS shall decode the Assignment A-MAP to obtain the emergency information.

A paging message may include the information for multiple AMSs.

A paging message includes identification of the AMSs to be notified of pending DL traffic and location update.

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

— 0b0: Perform network reentry
— 0b1: Perform ranging for location update

An AMS shall terminate idle mode and reenter the network if it decodes a paging message that contains its identification and action code 0b0 (Re-enter Network). In the event that an AMS decodes a paging message that contains its identification and action code 0b1, it performs ranging for location update. When the AMS decodes a paging message that does not include its identification, it means that the AMS is not being paged and the AMS may enter its next paging unavailable interval.

The ABS shall transmit the paging message within a frame specified in 6.2.18.2.3. Using the A-MAP IE, an idle mode AMS determines the location of paging messages in the subframe(s) of this predetermined frame. The paging message may be segmented, and these segments are transmitted in different subframes of the predetermined frame. If the segments of the paging message cannot be transmitted in the last DL AAI subframe of a frame, then the segments of the paging message may be transmitted in the next frame after the predetermined paging frame. The frame-level extension of the paging listening interval (due to existence of pending untransmitted segments of the paging message) shall be indicated by the extension flag in the paging message. Thus, if the paging message is segmented, an idle mode AMS shall remain awake and monitor the subsequent AAI subframe (i.e., next subframe of the subframe where the segment of the AAI-PAG-ADV message is sent) or frames (i.e., next frame of the frame where the segment of the AAI-PAG-ADV message is sent) for the remaining segments unless its identifier is already found in the received segments. After receiving the complete paging message, the idle mode AMSs return to the paging unavailable interval if the AMS is not paged.

If an idle mode AMS is paged by an ABS whose Cell Bar bit = 1, with Action Code = 0b0, then the AMS shall not attempt network reentry to this ABS. Instead, the AMS shall perform reselection of the preferred ABS. If the preferred ABS with Cell Bar bit = 0 is found, the AMS shall try network reentry to the ABS.

If the Network Configuration bit in the S-SFH is set to 0b1, the AMS MAC Address Hash as used in the R1 network shall be used for paging the AMS.

6.2.18.2.3 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 start at the superframe whose superframe number $N_{\text{superframe}}$ meets the following condition:

$$N_{\text{superframe}} \text{ modulo PAGING\_CYCLE} == \text{PAGING\_OFFSET}$$

The length of the paging listening interval is one superframe per paging cycle.

At the beginning of the paging listening interval, the AMS shall scan and synchronize on the A-PREAMBLE of its preferred ABS and decode the P-SFH of the ABS.

The ABS shall transmit the PGID-Info at a predetermined location in the paging listening interval in order to advertise the paging group(s) that is supported by the ABS. The PGID-Info shall be transmitted by the ABS regardless of whether or not there is any notification for AMSs.

The ABS transmits the PGID-Info right after SFH and A-MAP of the first AAI subframe during the AMS's paging listening interval as shown in Figure 6-80. The PGID-Info shall be transmitted as described in 6.3.5.5.2.1.

The PGID-Info includes the PGID(s) to which the ABS belongs.

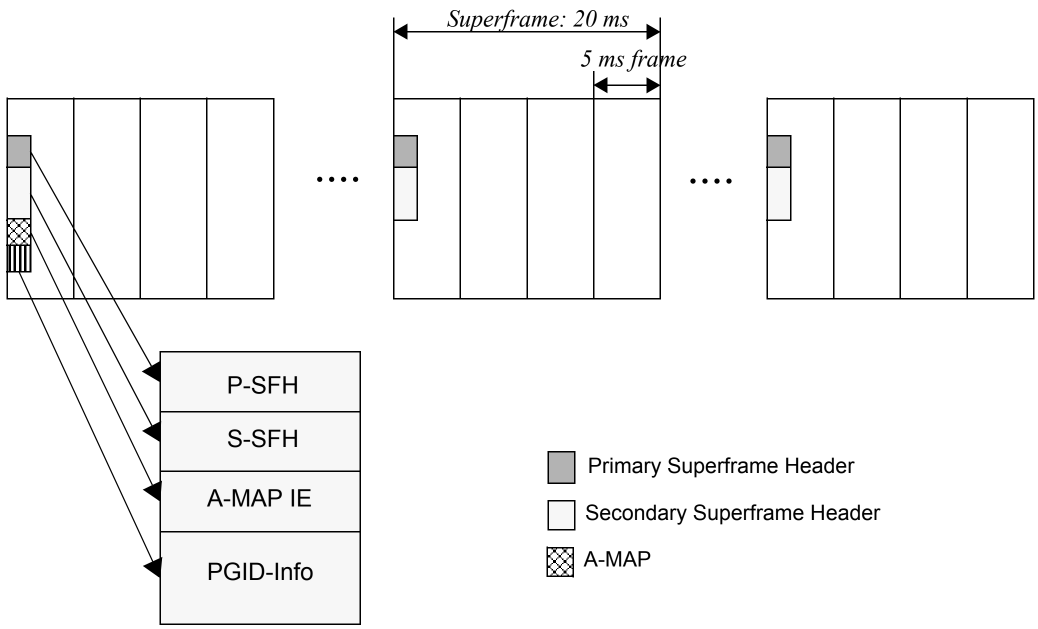


Figure 6-80—Transmission of PGID-Info

The AMS shall determine whether the preferred ABS supports any of its currently assigned paging groups through the PGID-Info message.

If none of the PGs to which the AMS currently belongs is detected at the ABS, the AMS shall perform location update as described in 6.2.18.4.

If the P-SFH indicates a change in SFH, then the AMS shall acquire the latest S-SFH information when the system information is broadcast by the ABS using the procedures defined in 6.2.24.

The AMS shall monitor a predetermined frame for the paging message. The predetermined frame $N_{paging\ frame}$ for an AMS is implicitly determined as follows:

$$N_{paging\ frame} = \text{AMS's deregistration identifier mod m}$$

where
m = 1 or 2 or 3 or 4

m is indicated by an ABS using the PGID-Info message.

When the Network Configuration bit in the S-SFH is set to 0b1, AMS MAC address replaces the AMS deregistration identifier in the previous formula.

If AMS's identification is included in the paging message, the AMS shall perform network reentry or location update depending on the notification in the paging message. Otherwise, the AMS may return to the paging unavailable interval.

6.2.18.3 Idle mode termination

Idle mode may only be terminated through the following:

— AMS reentry to the network
— Paging controller detection of AMS unavailability through repeated, unanswered paging messages
— Expiration of the idle mode timer
— AMS enters DCR mode from idle mode

An AMS may terminate idle mode at any time. For the termination of the idle mode, the AMS performs network reentry with its preferred ABS as described in 6.2.18.5. If the preferred ABS has Cell Bar bit = 1 in its S-SFH, the AMS shall not select that ABS for network reentry.

6.2.18.4 Location update

Location update comprises condition evaluation and update processing.

6.2.18.4.1 Location update trigger conditions

An AMS in idle mode shall perform a location update if any of the location update trigger conditions is met. There are four location update trigger conditions: paging group-based update, timer-based update, power-down update, and MBS update. The AMS may also perform a location update at will.

When an AMS performs a location update, the AMS may include Paging Cycle Change in the AAI-RNG-REQ message to change the paging cycle. An ABS may also change the AMS's paging cycle by requesting the AMS to perform a location update using the paging message with action code = 0b1 (i.e., Perform ranging to establish location and acknowledge message). The ABS shall include an appropriate paging cycle configuration in the AAI-RNG-RSP message, in response to the AAI-RNG-REQ message including Paging Cycle Change sent by the AMS during Location Update.

An AMS may inform its mobility (slow, medium, fast) during the location update procedure. The AMS mobility information may be used to assign new paging group(s) to the AMS.

During location update, the AMS's deregistration identifier, paging cycle, and paging offset may be updated.

6.2.18.4.1.1 Paging group-based update

An AMS shall perform a Location Update process when an AMS detects that the selected preferred ABS does not support any of its currently assigned paging group(s). The AMS shall detect that by monitoring the PGIDs, which are transmitted by the preferred ABS in PGID-Info message.

In case an AMS is currently assigned to multiple paging groups, it starts the Paging Group Location Update Timer (PG_LU_TIMER) when it leaves the primary paging group but stays within a secondary paging group. An AMS shall perform the paging group location update after the PG_LU_TIMER expires and may inform its mobility (slow, medium, fast) to the ABS. Based on the AMS mobility information, the ABS may assign new paging group(s) to the AMS.

If the AMS returns to the primary paging group before the expiration of the PG_LU_TIMER, it resets the timer. In this case, the AMS is not mandated to perform location update.

6.2.18.4.1.2 Timer-based update

An AMS shall periodically perform the 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.

6.2.18.4.1.3 Power-down update

An AMS shall attempt to complete a location update once as 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 a successful power-down location update, the paging controller shall release all idle mode retaining information related to the AMS.

6.2.18.4.2 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 the AAI-SCD message from the preferred ABS.

If the AMS shares a valid security context with the preferred ABS so that the AMS protects the AAI-RNG-REQ message with CMAC, then the AMS shall conduct initial ranging with the ABS by sending a AAI-RNG-REQ message protected with CMAC including Ranging Purpose Indication set to Location Update Request and Paging Controller ID.

If the ABS evaluates the CMAC Tuple as valid, then the ABS shall reply with an encrypted AAI-RNG-RSP message including the Location Update Response completing the location update process. If the ABS receives the AAI-RNG-REQ message from the AMS including Ranging Purpose Indication set to 0b0011 and if none of the PGID(s) to which the AMS is assigned to is supported by the ABS, then the ABS shall include New Paging Group ID(s) in the AAI-RNG-RSP message. The ABS may elect to redirect the AMS to conduct secure location update at another ABS by including a Location Update Response with a value of 0x01 in the AAI-RNG-RSP message, including Redirection Info that may assist the AMS identifying the redirected location update to the referenced ABS. The AMS may elect to reattempt a secure location update at the referenced ABS.

If the AMS and the ABS do not share a current, valid security context, they shall proceed using the Network Reentry procedure from Idle Mode in 6.2.18.5. This decision can be also made by the ABS at will.

If the Network Configuration bit in the S-SFH is set to 0b1, the AMS provides its actual MAC address in the AAI-RNG-REQ message, instead of providing the DID.

6.2.18.5 Network reentry from idle mode

If a Cell Bar bit is set to 1 in a S-SFH from a preferred ABS, then the AMS shall reselect another ABS to perform network reentry. For the network reentry from idle mode, the AMS shall initiate network reentry with the ABS by sending a ranging sequence from the Handover Ranging domain. When the ranging processes is successful, the AMS sends an AAI-RNG-REQ message including the Ranging Purpose Indication set to network reentry from idle mode and Paging Controller ID. If the AMS shares a valid security context with the ABS, the AAI-RNG-REQ message with CMAC. If the ABS receives the AAI-RNG-REQ message and a valid CMAC tuple, then the ABS shall reply with an encrypted AAI-RNG-RSP message. The network reentry procedure may be shortened if the ABS possesses the AMS's information that may be obtained from the paging controller or other network entity over the backbone network. To notify an AMS performing network reentry from idle mode of the reentry process with MAC control messages that may be omitted during the current reentry due to the availability of the AMS service and operational context information obtained over the backbone network, the ABS shall include a Reentry Process Optimization (see Table 6-31) in the AAI-RNG-RSP message indicating which reentry MAC control messages may be omitted.

If the T-ABS evaluates a CMAC tuple included in the AAI-RNG-REQ message as valid, then the T-ABS shall reply with an AAI-RNG-RSP message encrypted using AES-CCM and the T-ABS shall indicate that the PKM Authentication phase shall be omitted in the current reentry attempt using the Reentry Process Optimization bitmap. If the T-ABS evaluates a CMAC tuple as invalid, then the T-ABS shall reply with an unencrypted AAI-RNG-RSP message with bit 1 in the Reentry Process Optimization bit set to 0 (i.e., the PKM authentication phase shall not be omitted). If an AMS decrypts and validates the encrypted AAI-RNG-RSP message, the AMS considers that the security contexts are successfully shared.

If the Network Configuration bit in the S-SFH is set to 0b1, the AMS provides its actual MAC address in the AAI-RNG-REQ message, instead of providing the DID.

6.2.18.6 Idle mode support for MBS

6.2.18.6.1 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 that 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.

6.2.19 Deregistration with context retention (DCR) mode

Deregistration with context retention (DCR) mode is a mode in which an AMS is deregistered from the network while its context is kept in a network entity until the Context Retention Timer expires.

While the Context Retention Timer is valid, the network retains AMS's information that is used to expedite AMS's network reentry.

CRID is used to uniquely identify the DCR mode AMSs.

DCR Mode support is negotiated during an AAI-REG-REQ/RSP transaction (see Mobility features support in Table 6-36 and Table 6-37).

6.2.19.1 DCR initiation in connected state

The AMS may initiate DCR mode by transmitting an AAI-DREG-REQ message with the Deregistration_Request_Code parameter = 0x04, request for AMS deregistration from S-ABS, and retention of AMS's connection information. The AMS may request the network to retain a specific AMS service and operational information for DCR mode management purposes through inclusion of the Idle Mode Retain Information element in the AAI-DREG-REQ message. When the ABS decides to allow the AMS's DCR mode request, the ABS shall send an AAI-DREG-RSP message with action code 0x08 in response to the AAI-DREG-REQ message. Upon receiving the action code 0x08, the AMS shall start its Context Retention Timer. When the ABS decides to reject the AMS's DCR mode request, the ABS shall send an AAI-DREG-RSP message with action code 0x09 in response to the AAI-DREG-REQ message.

6.2.19.2 DCR mode initiation from idle mode

The AMS may initiate the DCR mode in the idle mode state by performing the location update with the ranging purpose indication set at value 0b0111 in the AAI-RNG-REQ message for transition to the DCR mode.

When the ABS decides to allow the AMS's DCR mode request, the ABS shall send an AAI-RNG-RSP message with location update response = 0x4. Upon receiving the location update response 0x4, the AMS shall start its Context Retention Timer. When the ABS decides to reject the AMS's DCR mode request, the ABS shall send an AAI-RNG-RSP message with location update response = 0x5.

Upon a successful DCR mode change request, the network shall initiate the DCR mode operation by retaining the AMS's information until the Context Retention Timer is valid. At the time of a DCR mode change, the CRID shall be used to uniquely identify DCR mode AMS.

6.2.19.3 DCR mode extension

An AMS in DCR mode can extend its Context Retention Timer by sending an AAI-RNG-REQ message with the ranging purpose indication set at value 0b0100 in combination with CRID to extend the timer before it expires. When the ABS decides to allow the AMS's extension request, the ABS shall send an AAI-RNG-RSP message with location update response = 0x4 in response to the AAI-RNG-REQ message. The ABS may also reject the AMS's extension request; in this case, the ABS shall send an AAI-RNG-RSP message with location update response = 0x5 in response to the AAI-RNG-REQ message. Upon receiving the rejected indication in AAI-RNG-RSP, the AMS shall perform reentry to the network as defined in 6.2.19.4.

6.2.19.4 Network reentry from DCR mode

For the network reentry from DCR mode, the AMS shall initiate network reentry with the ABS by sending an AAI-RNG-REQ message with the ranging purpose indication set at value 0b1000 and the CRID. The rest of the reentry procedure shall be performed in the same manner as network reentry from idle mode described in 6.2.18.5.

6.2.19.5 DCR mode termination

The DCR mode may only be terminated through the following:

— AMS reentry to the network
— Expiration of the Context Retention timer

6.2.20 Co-located coexistence (CLC)

The AMS conducts prenegotiated periodic absences from the S-ABS to support concurrent operation of co-located non-IEEE 802.16 radios, (IEEE 802.11, IEEE 802.15.1, etc.). The time pattern of such periodic absence is referred by the ABS and the AMS as CLC class.

Terminologies used in this subclause include the following:

— CLC active interval: The time duration of a CLC class designated for co-located non-IEEE 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 6-141. Support of all three types of CLC classes is mandatory for ABS and optional for AMS.

Table 6-141—Time unit of CLC class parameters

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

The AMS shall determine the CLC active interval and CLC active cycle based on the activities of its co-located non-IEEE 802.16 radios and its IEEE 802.16 performance requirements. The AMS shall determine the CLC start time of the Type I CLC class. The ABS shall determine the CLC start time of the Type II or III CLC class.

The Type I CLC class is recommended for non-IEEE 802.16 radio activity that has low-duty cycle, and may not align with IEEE 802.16 frame boundary. Otherwise, the Type II CLC class is recommended for better scheduling flexibility. The Type III CLC class is recommended for continuous non-IEEE 802.16 radio activity that lasts for a long time, e.g., seconds.

The S-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 the Type I, II, and III CLC class, respectively.

The ABS may include the CLC Limits in AAI-REG-RSP. Details of CLC Limit parameters are defined in Table 6-37 in 6.2.3.9.The higher value of a limit indicates better support for non-AAI radio activities. The CLC limits, if set, shall be no less than the default values in Table 6-142. If not specified in AAI-REG-RSP, the CLC limits shall assume the values in Table 6-142.

Table 6-142—Default value of CLC limits

	N_i	R_i	T_i
Type I	1	5%	8 AAI subframes (5 ms)
Type II	1	30%	64 AAI subframes (40 ms)
Type III	N/A	N/A	150 superframes (3 s)

The S-ABS shall not schedule A-MAP, data, and HARQ feedback of the AMS's allocations in the CLC active interval of an active CLC class. Whether only DL or only UL or both are prohibited depends on the configuration of the CLC class. The default is both DL and UL allocations are prohibited.

The ABS and the AMS should set the starting time of a CLC class appropriately to prevent its CLC active interval from overlapping with SFH (superframe header) as much as possible.

The ABS shall not schedule a Long TTI allocation when a CLC active interval overlaps with any part of the Long TTI allocation.

Any part of a previously scheduled persistent allocation that overlaps with a prenegotiated CLC active interval shall not be transmitted in the designated resource. Since both the ABS and the AMS have full knowledge of CLC activity, the ABS and the AMS shall skip such a transmission that was scheduled during the CLC active interval. Nonpersistent scheduling with all the attributes of the skipped allocation may be used to transmit such data at the next available opportunity. Subsequent persistent allocations that do not overlap with the CLC interval shall retain the attributes that were assigned in the Persistent Allocation A-MAP IE until an explicit deallocation or reallocation occurs. Implicit ACID cycling shall continue with the original pattern, and the ACID corresponding to the skipped allocation is skipped in order to maintain the cycle.

When a prenegotiated CLC active interval overlaps with any part of the initial transmission of a group resource allocation, the ABS shall not schedule the allocation in the designated resource and the GRA transmission shall be scheduled at the next available opportunity.

Any part of a synchronous HARQ retransmission that overlaps with a prenegotiated CLC active interval shall not be transmitted in the designated resource. Since both the ABS and the AMS have full knowledge of CLC activity, the ABS and the AMS shall skip the retransmission that occurs in the CLC active interval, and continue to maintain the original timing relationship for all subsequent retransmissions. The retransmission number is incremented for the skipped retransmission.

Figure 6-81 illustrates the protocol for a skipped HARQ retransmission. In the example shown, the first retransmission is scheduled to occur in a CLC active interval. The first retransmission is skipped, and the allocation originally scheduled for the second retransmission is then used for the first retransmission. The allocation originally scheduled for the third retransmission will be used for the second retransmission and so on.

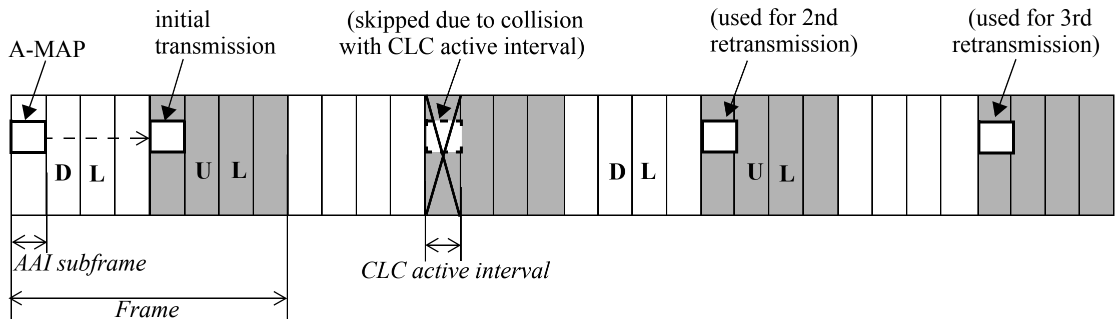


Figure 6-81—Skipping for synchronous HARQ due to collision with the CLC Active Interval

The S-ABS shall accept the request from the AMS to activate a CLC class, and should 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 S-ABS may reject or accept the request, and even if the requested CLC class is accepted initially, the S-ABS may deactivate it at any time by sending an 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 6.2.20.1, 6.2.20.2, and 6.2.20.3, 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 6-142. The AMS may request to activate 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 min to request another Type III CLC class.

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

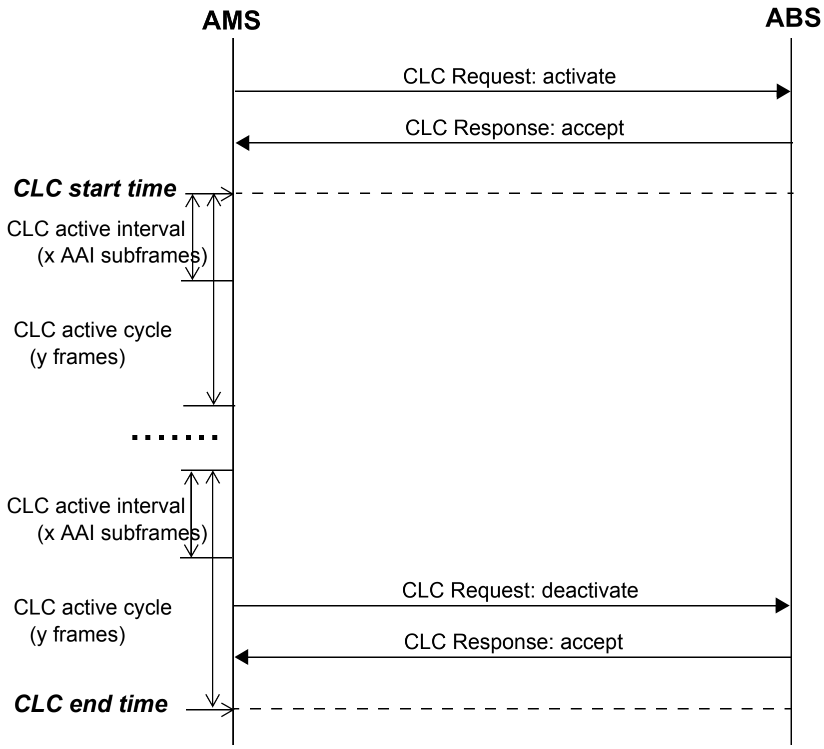


Figure 6-82—CLC Request/Response exchange

The S-ABS should send a CLC Response before the CLC start time defined in the CLC Request. If the AMS receives a CLC Response, or the ABS sends a CLC Response, after the starting time of the CLC class that it activates, the ABS and the AMS shall consider the CLC class as active and starting at the beginning of the next CLC active cycle. If the class is Type III, the ABS and the AMS shall consider the CLC class starting immediately and ending at the ending superframe calculated with CLC start time and CLC active interval as defined in the 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 S-ABS shall locally deactivate all CLC classes after the AMS enters idle state.

The AMS shall locally terminate the active Type III CLC class at the Disconnect Time or upon transmission of AAI-HO-IND with code 0b10. The AMS shall also locally suspend all active Type I and II CLC classes at the Disconnect Time or upon transmission of AAI-HO-IND with code 0b10, and reactivate them with the new S-ABS. During HO preparation, the T-ABS may obtain information on active CLC classes from the S-ABS via backbone network.

During network reentry, the T-ABS may include the CLC Response parameter in the AAI-RNG-RSP message (see Table 6-30) to indicate activation/termination of each Type I or II CLC class that was active at the S-ABS. The T-ABS shall indicate activation of only those CLC classes that meet the CLC limits of the T-ABS. The CLC active cycle and interval parameters of activated Type I and Type II CLC classes at the T-ABS shall remain the same, and CLC classes terminated by the T-ABS shall be discarded by the AMS. If the CLC Response parameter is not included in the AAI-RNG-RSP message, the AMS shall terminate and discard all CLC classes that were active at the S-ABS. The T-ABS may set the Super Frame Number of the start time to the suggested value in CLC Request from the AMS in case of an uncoordinated handover, or to the beginning of the next CLC active cycle based on the information obtained from the previous S-ABS via the backbone network. For the Type II class, the new S-ABS may set the Start Frame Index of the start time to a different value than that of the value in the AMS's CLC Request or of the previous S-ABS. For the Type I class, the new S-ABS shall keep the Start Frame Index the same as suggested by the AMS or obtained from the previous S-ABS. The ABS shall send the start time information to the AMS in AAI-RNG-RSP during network reentry for fast reactivation if the AMS supports CLC mode. The AMS and the S-ABS shall automatically reactivate the suspended CLC classes if the handover is canceled.

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

Figure 6-82 shows an example of the CLC Request/Response exchange for activating and deactivating a Type II CLC class.

6.2.20.1 Type I CLC class

The parameters for the Type I CLC class (settings) are specified as follows:

- S_1 : start superframe number
- F_1 : start frame index
- f_1 : start AAI subframe index
- a_1 : time duration of CLC active intervals in each cycle (AAI subframe)
- b_1 : time duration of CLC active cycle (microsecond)

The combination of the start superframe number and the start frame index indicates in which frame the first CLC active cycle starts. The start AAI subframe index further indicates in which AAI subframe the first CLC active cycle of a Type I CLC class starts in a frame.

The following parameters are needed in addition to N_1, R_1, and T_1 in determining whether a Type I CLC class meets the CLC limits:

- n_1 : number of currently active Type I CLC classes for the requesting AMS
- s: latency limit (millisecond)
- d: latency margin (millisecond)
- m: total number of AAI subframes in a frame

The latency limit indicates the minimum value of the Maximum Latency parameter and the Tolerated Jitter parameter of all active service flows of the requesting AMS. It shall assume infinite if none of the active service flows of the requesting AMS has explicitly configured the Maximum Latency parameter or the Tolerated Jitter parameter. The latency margin provides additional time for meeting the Maximum Latency and Tolerated Jitter requirement of all active service flows of the requesting AMS, and it shall be set to 10 ms.

The default value of m is 8. For an 8.75 MHz and a 7 MHz frame structure, m is 7 and 6, respectively.

A Type I CLC class meets the CLC limits, if all of the following conditions are met:

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

Figure 6-83 shows an example of the Type I CLC class.

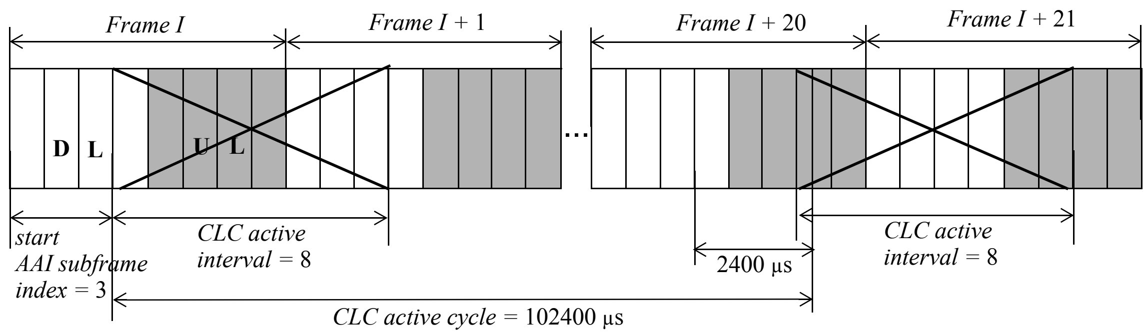


Figure 6-83—Type I CLC class example (a_1 = 8, b_1 = 102400)

6.2.20.2 Type II CLC class

The parameters for the Type II CLC class (settings) are specified as follows:

— S_2 : start superframe number
— F_2 : start frame index
— a_2 : time duration of CLC active intervals in each cycle (AAI subframe)
— b_2 : time duration of CLC active cycle (frame)

The combination of the start superframe number and the start frame index indicates in which frame the first CLC active cycle starts.

The following parameters are needed in addition to N_2, R_2, T_2 in determining whether a Type II CLC class meets the CLC limits:

— n_2 : number of currently active Type II CLC classes for the requesting AMS
— s: latency limit (millisecond)
— d: latency margin (millisecond)
— m: total number of AAI subframes in a frame

The AMS may use one of the following three subtypes to configure a Type II CLC class, depending on the length of the CLC Active Cycle; see Table 6-143. Support of Extended CLC Active Bitmap is optional for the ABS.

Table 6-143—Type II CLC class subtype

Subtype	CLC active cycle (frame)	Information elements
1	1	— CLC Active bitmap
2	>1	— CLC Active interval — CLC Active Cycle
3	2, 3, or 4	— Extended CLC Active bitmap

6.2.20.2.1 Type II CLC class—Subtype 1

If the CLC active cycle is one frame, the AMS shall use the CLC Active Bitmap to configure a Type II CLC class. The bitmap setting is in unit of bit for indicating the CLC active interval within the designated frame, where the field set to "1" indicates the corresponding AAI subframe is the CLC active interval. The first LSB of the CLC Active Bitmap corresponds to the last AAI subframe of each frame. If a frame consists of m AAI subframes, the AMS and the S-ABS shall consider the first $m-1$ LSBs of the field, and never configure the first AAI subframe of a frame to be the 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 of the following conditions are met:

— $n_2 < N_2$

— $a_2 / m \le R_2$

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

Figure 6-84 shows an example of a Type II CLC class with Subtype 1.

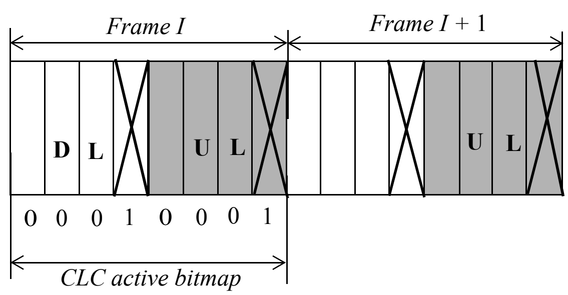


Figure 6-84—Example of Type II CLC class Subtype 1 (a_2 = 2)

6.2.20.2.2 Type II CLC class—Subtype 2

If the 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 of the following conditions are met:

— $a_2 \le (\min)(T_2, (s-d)/5 \times m)$

— $n_2 < N_2$

— $a_2 / (m \times b_2) \le R_2$

Table 6-85 shows an example of a Type II CLC class with Subtype 2.

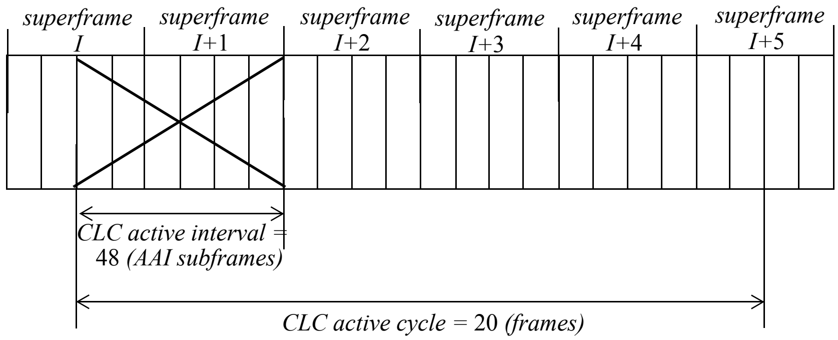


Figure 6-85—Example of Type II CLC class Subtype 2 (a_2 = 48, b_2 = 20)

6.2.20.2.3 Type II CLC class—Subtype 3

If the Extended CLC Active Bitmap is enabled at the ABS and the CLC active cycle is 2, 3, or 4 frames, the AMS may use Subtype 3 to configure a Type II CLC class. The AMS shall never configure the first AAI subframe of a frame to be the CLC active interval if Subtype 3 is used.

A Type II CLC class with Subtype 3 meets the CLC limits, if all of the following conditions are met:

— $n_2 < N_2$

— $a_2 / (m \times b_2) \le R_2$

wherein a_2 is set to the total number of “1” bits in the Extended CLC Active Bitmap, and b_2 is set to the bitmap length in bytes.

Figure 6-86 shows an example of aType II CLC class with Subtype 3.

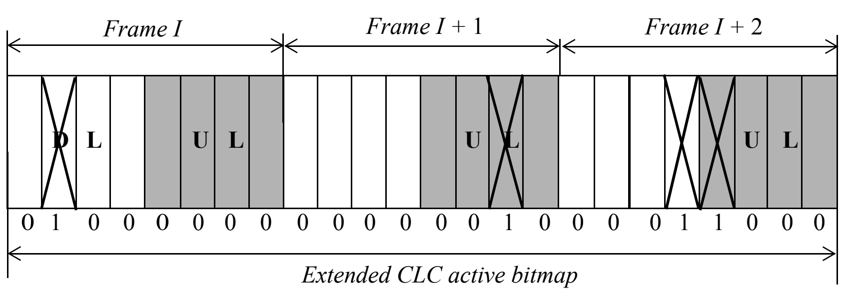


Figure 6-86—Example of Type II CLC class Subtype 3 (a_2 = 4, b_2 = 3)

6.2.20.3 Type III CLC class

The parameters for the 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 of the following conditions are met:

— $a_3 \le T_3$

— The AMS only has Best-Effort service flows active

6.2.21 Interference mitigation mechanism

6.2.21.1 DL FFR

Fractional frequency reuse (FFR) techniques allow different frequency reuse factors to be applied over different frequency partitions. The maximum number of frequency partition is four. Note that the frequency partition is defined in 6.3.4.2.3.

The frequency partition boundary is aligned with PRU units. The frequency partitions are indexed from lowest Logical Resource Unit (LRU) index to highest LRU index. It always starts from reuse-1 partition if it exists and is then followed by the three reuse-3 partitions or two reuse-2 partitions depending on the value of DFPC and system bandwidth. They are numbered as frequency partition 0 (FP_0), frequency partition 1 (FP_1), frequency partition 2 (FP_2), and frequency partition 3 (FP_3) and FP3 does not exist for reuse-2. The frequency partition configuration is signaled using the DFPC field in S-SFH SP2.

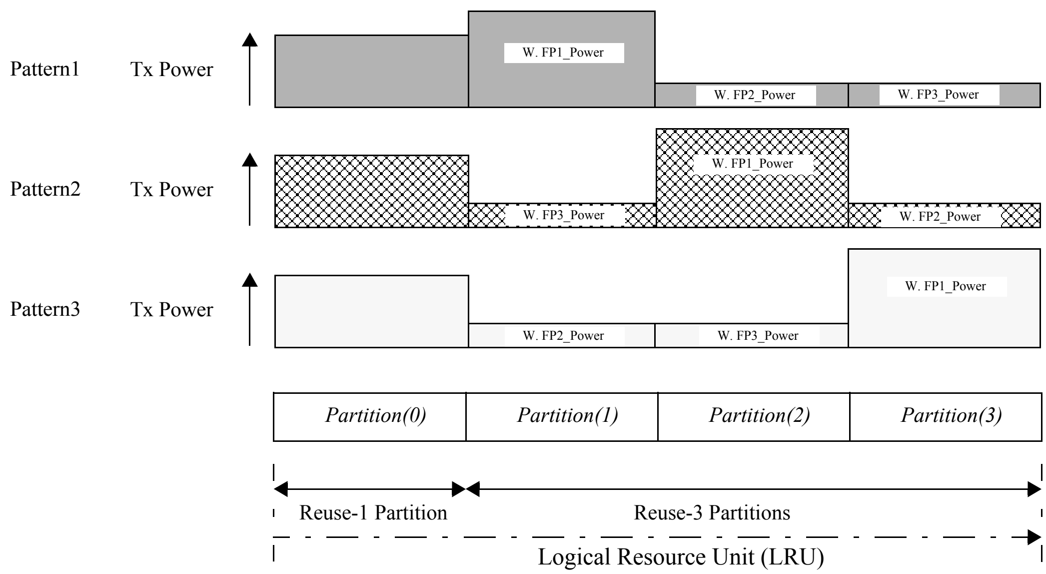


Figure 6-87—Basic concept of fractional frequency reuse for reuse-3 scenario

The boosted frequency partition is the partition with a power level of FP1_power. Each partition may have a different power level per cell. The transmission power level relative to the reference power level on different frequency partitions is decided by the ABS and signaled using the AAI-DL-IM MAC control message or S-SFH SP3. When an AMS measures CQI, interference, and/or SINR for each partition, it shall assume the transmit power level (FP1_power, FP2_power and FP3_power) of other ABSs are the same as its serving ABS.

When FFR is applied in the cell (i.e., FPCT > 1), the different FFR power pattern is used by different ABSs. When FPCT = 4, for example, each ABS chooses one of the three FFR patterns (pattern 1, pattern 2, and pattern 3) as shown in Figure 6-87 (when FPCT = 3 and $FPS_3 > 0$, the same FFR patterns exist only excluding FP_0). The index of the FFR power pattern is set by a particular ABS with its Segment ID. That is, each ABS adopts the FFR power pattern corresponding to the pattern *k* in Figure 6-87 and *k* is decided by the following equation:

$$k = \text{Segment ID} + 1$$

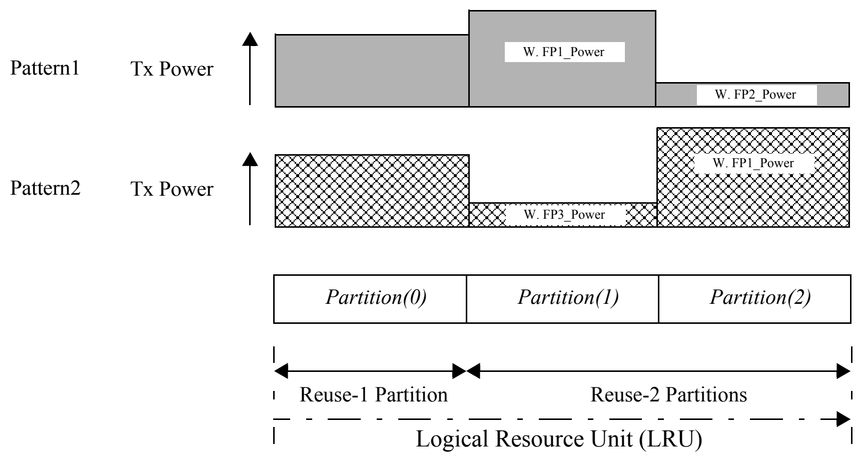


Figure 6-88—Basic concept of fractional frequency reuse for reuse-2 scenario

When FPCT = 3 and $FPS_3 = 0$, for example, each ABS chooses one of the two FFR patterns (pattern 1 and pattern 2) as shown in Figure 6-88 (when FPCT = 2, the same FFR patterns exist only excluding FP_0). The index of FFR power pattern is set by a particular ABS with its Segment ID, which is restricted in these cases to be either 0 or 1. That is, each ABS adopts the FFR power pattern corresponding to the pattern k in Figure 6-88 and k is decided by the following equation:

k = Segment ID + 1

6.2.21.1.1 DL/UL signaling

When supporting the FFR operation, the AMS shall be capable of measuring the interference statistics over specific frequency partitions. The AMS shall be capable of reporting the preferred frequency partition through the fast feedback channel.

An ABS may instruct an AMS to feedback interference and/or SINR measurement for one or more frequency partitions through the AAI-FFR-CMD message. The AMS shall report interference and/or SINR measurement for one or more frequency partitions through the AAI-FFR-REP message as a response to the AAI-FFR-CMD message. For MFM 0, 4, and 7, the ABS instructs the AMS to feedback the relevant information for the frequency partition by the ABS. For MFM 0, the ABS may instruct the AMS to feedback wideband CQI and STC rate for one more alternative frequency partition in addition to the active frequency partition by puncturing every 2^q-th short period report for the active frequency partition. The ABS may use the interference statistics reported by the AMS using AAI-FFR-REP to schedule DL data transmission.

The AAI-SCD message includes resource metric information, as shown in Table 6-144, which is needed for the AMS to select the DL frequency partition in case of distributed permutation, or to select the subband in case of localized permutation.

Table 6-144—Resource metric information

Syntax	Size (bits)	Notes
Content format () {		
If (FPCT ≥ 3 and FPS_3 > 0) {		Reuse-3
for (*i* = 2; *i* ≤ 3 ; *i*++) {		

Resource_Metric FP_i	4	Resource metric for the two power deboosted frequency partitions in reuse-3 frequency region.
		
		The resource metric of two power deboosted frequency partitions is defined as a fractional number x between 0 and 1. It is encoded as an unsigned integer y from 0 to 15, and:
		
		if $0 \le x < 0.5$:
		$y = \mathrm{floor}(x / 0.125)$
		if $(0.5 \le x < 0.8)$:
		$y = \mathrm{floor}((x - 0.5) \times 8 / 0.3) + 4$
		otherwise:
		$y = \mathrm{floor}((x - 0.8) / 0.05) + 12$
		
		When AMS receives the quantized resource metric of two power deboosted frequency partitions, it will decode the resource metric as below:
		if $0 \le y < 4$:
		$x = (y + 1) \times 0.125$
		if $4 \le y < 12$:
		$x = (y - 3) \times 0.3 / 8 + 0.5$
		if $12 \le y \le 15$:
		$x = (y - 11) \times 0.05 + 0.8$
		
		Resource metric of frequency partition FP_0 (reuse-1 partition) has a fixed value equal to 1. Resource metric of frequency partition FP_1 with power boosting is calculated as follows:
		Resource_Metric_FP_1 = 3–Resource_Metric_FP_2–Resource_Metric_FP_3

}		
} else if (FPCT > 1 and FPS_3 = 0) {		Reuse-2
Resource_Metric_FP_2	4	Resource metric for the power deboosted frequency partition in reuse-2 frequency region. The encoding method is the same as Resource_Metric_FP_2 and Resource_Metric_FP_3 for reuse-3. The resource metric for the power boosted frequency partition is as follows: Resource_Metric_FP_1 = 2– Resource_Metric_FP_2
}		
}		

Resource_Metric_FPi corresponds to the resource metric of the frequency partition with FPi_Power.

A Preferred Frequency Partition Indicator (PFPI) is defined in PFBCH for PFBCH encoding type 0, 1, and 3, using 4 codewords with index 58 to 61. An AMS may send PFPI to an ABS in an unsolicited manner. The PFPI indicates the change in preferred active frequency partition. When there are two frequency partitions on which to report (long and short feedback periods), the PFPI indicates the new preferred active frequency partition for allocations in the partition reported on using the short feedback period.

6.2.21.1.2 Operation procedure

6.2.21.1.2.1 Broadcast and update of DL FFR information by ABS

The FFR partition information is broadcasted in S-SFH SP2, the resource metric is broadcasted in the AAI-SCD message, and the transmission power level is broadcasted in the AAI-DL-IM message and/or S-SFH SP3.

6.2.21.1.2.2 Feedback of preferred frequency partition by AMS

In case of Distributed permutation, an AMS may send a Preferred Frequency Partition Indicator (PFPI) through PFBCH to an ABS to indicate its preferred FFR partition, if it is different from the current FFR partition.

The ABS may send a new Feedback allocation IE to respond to PFPI by the AMS. After the AMS receives a Feedback allocation IE, the AMS shall send the CQI report to the ABS according to the new configuration.

Two examples of the above operation procedure are illustrated in Figure 6-89 and Figure 6-90.

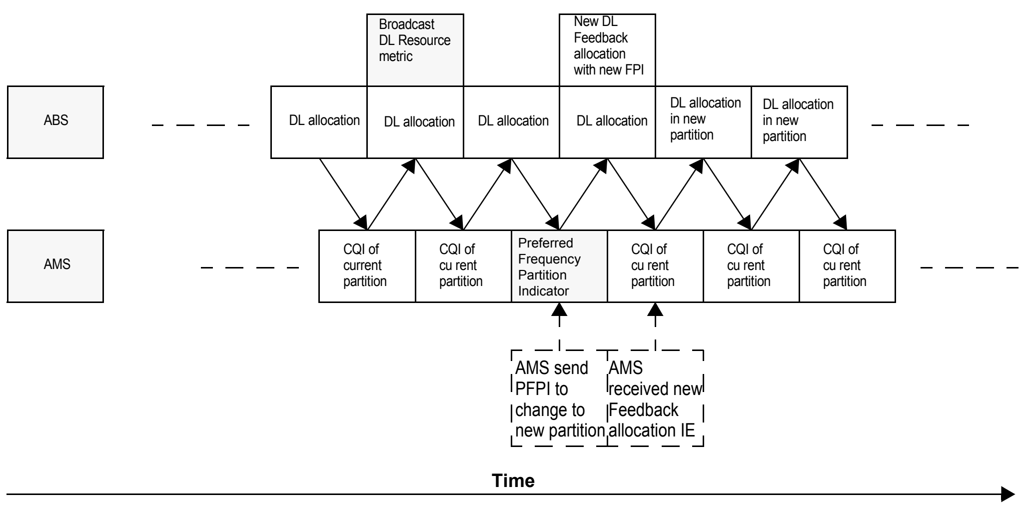


Figure 6-89—Example where the AMS sends the PFPI and the ABS agrees to change the FFR partition

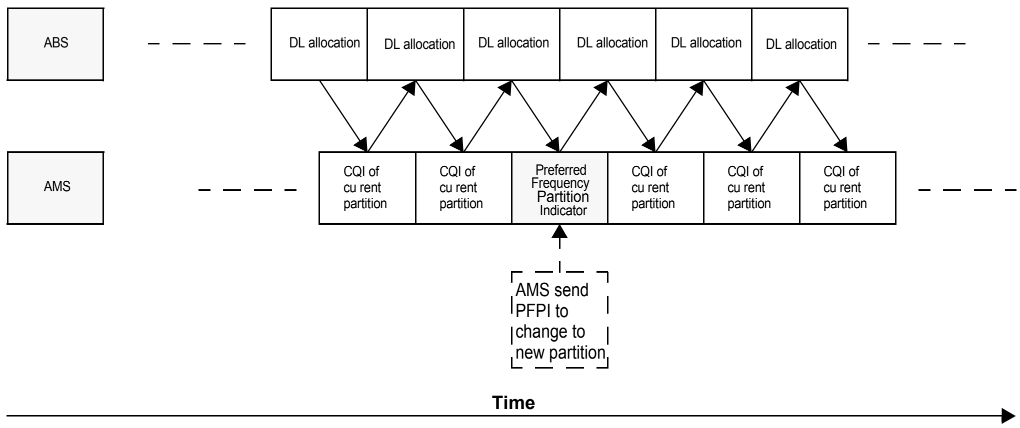


Figure 6-90—Example where the AMS sends the PFPI and the ABS refuses to change the FFR partition

6.2.21.1.2.3 Initial frequency partition at system entry

When the AMS enters a system with FPCT > 1, it initially uses the frequency partition indicated by the ABS. Once the AMS has received the first superframe with resource metric information, it may start to use the resource metric to recommend its preferred partition to the ABS in case of DLRU or NLRU, or select the preferred subbands in case of SLRU.

6.2.21.1.2.4 Frequency partition selection by the AMS in case of DLRU or NLRU

In the case where the Resource_Metrics of all frequency partitions is equal to 0b1111, then the AMS shall skip the following procedures. Otherwise, the AMS selects the preferred frequency partition as follows:

The AMS estimates the average SINR on each frequency partition, and then it computes the expected spectral efficiency (SE) for each partition. For example, the expected SE can be computed based on data rate, PER, and partition BW of one frequency partition as follows:

— Expected_SE = Data_Rate × (1–PER) / BW

The data rate is a function of average SINR per partition and is determined according to the modulation and coding rate selected by the Link Adaptation procedure.

— Data_Rate is the uncoded data in length of bit transmitted on 4LRUs in the Type 1 AAI subframe as a resource allocation.
— PER is the AMS estimated Packet Error Rate on the same 4LRUs.
— BW is the time and frequency resource occupied by the same 4LRUs.

The AMS then calculates the normalized SE(i) of frequency partition (i) as follows:

— Normalized_SE(i) = Expected_SE(i) / Resource_Metric(i)

The AMS compares the Normalized_SE(i) of all partitions, and it selects the partition with maximum Normalized_SE(i) as the preferred frequency partition (PFP). The Normalized SE(i) may be smoothed (filtered) to avoid rapid changes in partition selection. If the PFP is different from the previous partition choice and has relatively stable higher normalized SE, the AMS shall send a PFPI through PFBCH to recommend the FP as its PFP.

6.2.21.1.2.5 Subband partition selection by the AMS in case of SLRU

When the AMS is requested to report SLRU feedback, it indicates to the ABS its preferred subbands for downlink transmission.

In the case where the Resource_Metrics of all frequency partitions is equal to 0b1111, then the AMS shall skip the following procedures. Otherwise, the AMS selects the preferred subband as follows.

The AMS estimates average SINR on each subband of all frequency partition, and then it computes the expected spectral efficiency (SE) for each subband. For example, the expected SE can be computed based on data rate, PER, and partition BW of each subband as follows:

— Expected_SE = Data_Rate × (1–PER) / BW

The Data Rate is a function of average SINR per subband and is determined according to the modulation and coding rate selected by the Link Adaptation procedure.

— Data_Rate is the uncoded data in length of bit transmitted on 4LRUs in the Type 1 AAI subframe as a resource allocation.
— PER is the AMS estimated Packet Error Rate on the same 4LRUs.
— BW is the time and frequency resource occupied by the same 4LRUs.

The AMS then calculates the normalized SE of each subband as follows:

— Normalized_SE(m) = Expected_SE(m) / Resource_Metric(i).

Here, "i'" is the frequency partition index of the corresponding subband "m". The AMS then selects the subband with maximum Normalized_SE(m).

6.2.21.2 UL FFR

UL FFR allows the system to designate a different UL IoT control parameter, i.e., γ_{IoT} per frequency partition. Note that the UL frequency partition is defined in 6.3.7.2.3.

For UL FFR, the ABSs shall be capable of measuring the interference statistics over each frequency partition. In order to support UL FFR, the ABS transmits the necessary information. The UL FFR configuration including the number of frequency partitions and size of each frequency partition is broadcasted through S-SFH. The S-SFH SP2 IE related to UL FFR is given in 6.3.5.5.1.2. The UL frequency partition configuration (UFPC) information is given in 6.3.7.2.3. Also, the UL IoT control parameter for each frequency partition is broadcasted as shown in 6.2.3.31 through the AAI-SCD message.

The UL IoT control parameter, γ_{IoT}, signaled through the AAI-SCD message, is used in UFPC based on a cell-specific FFR pattern. When UL FFR is applied in the cell (i.e., FPCT > 1), the different FFR pattern is used by different cells. When FPCT = 4, for example, each cell chooses one of the three FFR patterns (pattern 1, pattern 2, and pattern 3) as shown in Figure 6-91 (when FPCT = 3 and $FPS_3 > 0$, the same FFR patterns shown in Figure 6-91 are used only excluding FP_0). The index of the FFR pattern is set by a particular cell with its Segment ID. That is, each cell adopts the FFR pattern corresponding to the pattern k decided by the following equation:

k = Segment_ID + 1

Figure 6-91 shows an illustration of UL FFR when FPCT is four. Power-boosted reuse-3 partition (or power-boosted reuse-2 partition) in UL is defined as the partition with the UL FFR pattern index; i.e., if the

UL FFR pattern index is *i*, power-boosted reuse-3 partition (or power-boosted reuse-2 partition) in UL is FP_i.

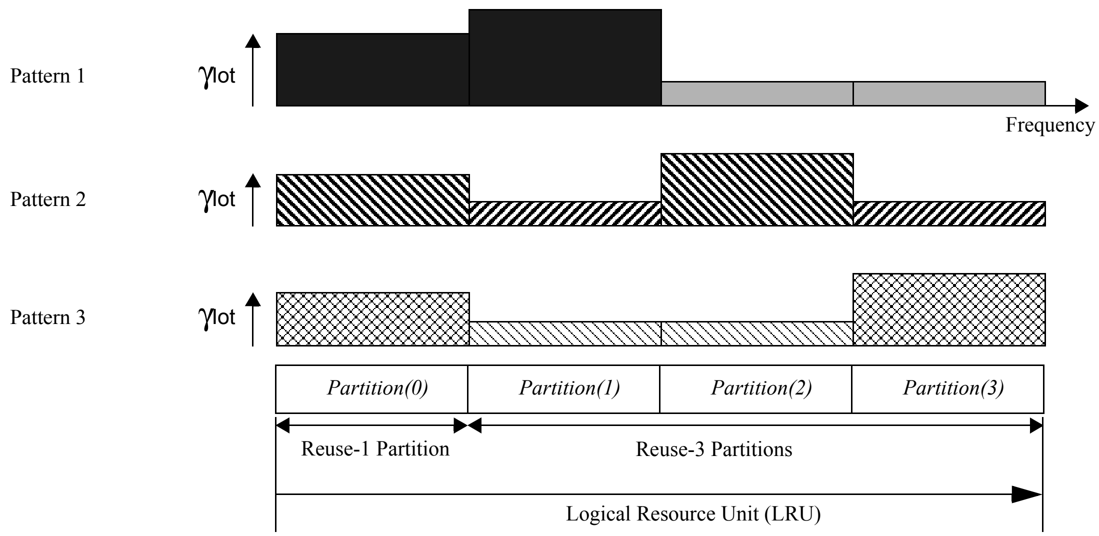


Figure 6-91—Basic concept of UL FFR for the reuse-3 scenario

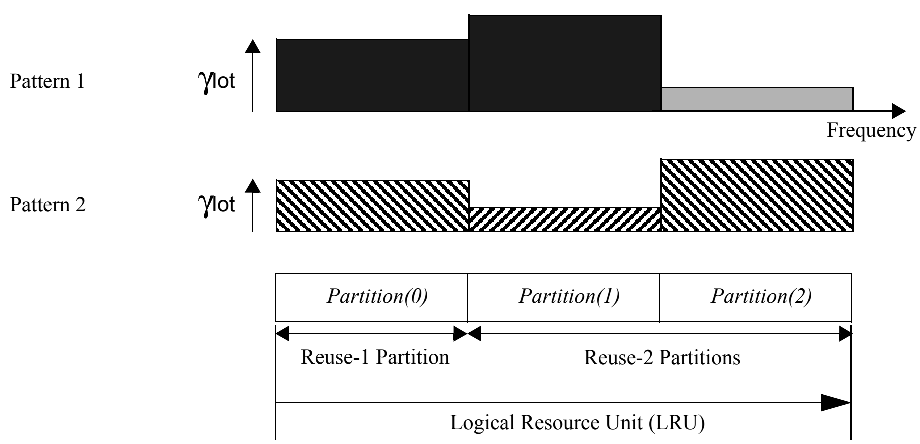


Figure 6-92—Basic concept of fractional frequency reuse for the reuse-2 scenario

When FPCT = 3 and FPS3 = 0, for example, each ABS chooses one of the two FFR patterns (pattern 1 and pattern 2) as shown in Figure 6-92 (when FPCT = 2, the same FFR patterns exists only excluding FP0). The index of the FFR pattern is set by a particular ABS with its Segment ID, which is restricted in these cases to be either 0 or 1. That is, each ABS adopts the FFR pattern corresponding to the pattern k in Figure 6-92 and k is decided by the following equation:

k = Segment_ID + 1

6.2.21.3 FFR partition configuration

The interval between two FFR partition changes is determined by the FFR Partition Update Interval parameters, as defined in Table 6-330. At each FFR Partition Update Interval, the ABS should report to the upper entity the following information—BSID, the number of MS in the BS, MS location distribution, and MS UL/DL SINR distributions, UL / DL traffic distribution, ABS's transmission power of each frequency partition, UL IoT control parameter γ_{IoT} per FFR partition (as defined in 6.2.21) that are to be used to calculate the FFR partition size, Power Levels, Relative Load indicator, and Reference UL IoT control parameter γ_{IoT} for each partition that will be used for FFR partition configuration.

6.2.22 MAC control reliability

All MAC control messages shall be fragmentable. HARQ shall be applied to all unicast MAC control messages. Retransmission timers shall be defined for MAC control messages that require reliable transmission. The retransmission timer is started when MAC control message transmission is initiated by the transmitter to wait for the response message (for example, AAI-RNG-RSP is a response message for AAI-RNG-REQ). The retransmission timer is stopped if the response message is received from the receiver. If Local NACK for MAC control message is enabled and if the HARQ process is terminated with an unsuccessful outcome before the expiration of the retransmission timer, the transmitter may initiate retransmission of the complete control message or the control message fragment, transmitted in the failed HARQ burst. During retransmission of the control message fragment initiated by Local NACK, the transmitter shall retransmit the control message fragment with same information (MCEH and payload) as was transmitted during the initial transmission.

The transmitter may request the receiver to send a MAC layer acknowledgment to determine the status of the transmitted control message if the transmitted control message does not have a corresponding response message or transmitted control message does not require an immediate response but it requires reliable transmission. When a MAC layer acknowledgement is used, the transmitter shall set the Polling bit to 1 in MCEH of the MAC PDU containing the complete control message or the last pending fragment of the control message. The transmitter shall start an ACK timer immediately after the transmission of the MAC PDU with Polling bit set to 1 in MCEH to wait for the AAI-MSG-ACK message or Message ACK extended header. If the local NACK is received for a MAC PDU carrying the MCEH with Polling bit set to 1, the transmitter shall set the Polling bit to 1 in MCEH while retransmitting the MAC PDU containing the last pending fragment. The ACK timer is stopped if the local NACK is received. The ACK timer stopped by the local NACK shall be started again while retransmitting the last pending fragment. The ACK timer is stopped if the AAI-MSG-ACK message or Message ACK extended header is received from the receiver. If the ACK timer expires before an acknowledgment is received or the retransmission timer expires, the transmitter may initiate the retransmission of the entire message. The transmitter shall stop the ACK timer if the retransmission timer expires. The transmitter shall reset the retransmission timer, if it initiates the retransmission, after the ACK timer or retransmission timer expiry.

If a receiver receives a control message or control message fragment in a MAC PDU with Polling bit set to 1 in MCEH, the receiver shall respond with an AAI-MSG-ACK message or a Message ACK extended header to indicate the reception of the complete control message. For the fragmented control messages, the receiver shall send the AAI-MSG-ACK message or a Message ACK extended header after receiving all fragments of the control message.

6.2.23 Power management for the active mode

Enhanced power savings for an AMS in active mode may be supported. In this mode, the ABS may allocate resources, adjust operation modes, and set transmission parameters to optimize energy savings at the AMS.

An AMS may report its battery level using the AMS Battery Report header (in Table 6-10) when the battery level changes. The AMS shall update its battery report (with AMS Battery Status = 0b0 in AMS Battery Report header) as soon as the AMS is plugged in a charger.

The ABS may update the AMS power upon receiving a battery level report by using the AAI-UL-POWER-ADJ message.

6.2.24 Update of S-SFH IEs

The S-SFH subpacket (SP) IEs (i.e., S-SFH SP1 IE, SP 2 IE, and SP3 IE) are transmitted by the ABS at the scheduled superframe of each SP, respectively, with different periodicity (i.e., $T_{SP1} < T_{SP2} < T_{SP3}$). This SP scheduling periodicity information is specified in Table 6-179 and is transmitted in the S-SFH SP3 IE.

In every superframe, the ABS transmits P-SFH IE containing the S-SFH scheduling information, S-SFH change count, S-SFH SP change bitmap, and S-SFH application hold indicator.

The S-SFH change count shall remain constant as long as all of the values (except the MSB of superframe number in S-SFH SP1 IE) in the S-SFH SP IEs remain constant. The S-SFH change count shall be incremented only in the specific superframe number (SFN) that satisfies SFN modulo S-SFH change cycle = 0, where the S-SFH change cycle is indicated in S-SFH SP3 IE. The modified S-SFH change count shall be maintained until the next superframe (satisfying SFN modulo S-SFH change cycle = 0) in which the S-SFH change count is incremented, as shown in Figure 6-93.

The S-SFH change count shall be incremented by 1 modulo 16 whenever any of the values (except the MSB of the superframe number in S-SFH SP1 IE) in any of the S-SFH IEs change.

If the AMS determines that the “S-SFH change count” field in P-SFH has not changed, then the AMS determines that it has up-to-date information.

Each bit of the S-SFH SP change bitmap in P-SFH IE indicates the change status of the corresponding S-SFH SP IE in association with the S-SFH change count. Bit 0 (LSB), bit 1, and bit 2 (MSB) are mapped to S-SFH SP1 IE, S-SFH SP 2 IE, and S-SFH SP3 IE, respectively. If any of the values (except the MSB of the superframe number in S-SFH SP1 IE) in an S-SFH SP IE are changed, the bit corresponding to the changed S-SFH SP IE is set to 1. The value of the S-SFH SP change bitmap shall be changed only when the S-SFH change count is changed. That is, the modified S-SFH SP change bitmap shall be maintained until the next superframe (satisfying SFN modulo S-SFH change cycle = 0) in which the S-SFH change count is incremented, as shown in Figure 6-93.

The S-SFH SP IE(s) associated with the incremented S-SFH change count shall be transmitted in their scheduled superframes, starting from the superframe where the S-SFH change count is changed.

Once the contents in S-SFH SP IEs are changed, all of the values (except the MSB of the superframe number in S-SFH SP1 IE) in S-SFH SP IEs shall remain unchanged during one or more S-SFH change cycle periods, until the S-SFH change count in P-SFH IE is changed again.

To guarantee enough time for AMSs to receive the changed S-SFH SPx IE(s), the changed contents are applied beginning in a specific SFN determined by the SFN in which the S-SFH SPx IE is changed, as described as follows:

a) If the S-SFH SP1 IE is changed, the changed contents are applied in the superframe immediately following the second regularly scheduled transmission of the modified S-SFH SP1 IE.
b) If the S-SFH SP2 IE is changed, the changed contents are applied in the superframe immediately following the second regularly scheduled transmission of the modified S-SFH SP2 IE.
c) If the S-SFH SP3 IE is changed, the changed contents are applied in the superframe immediately following the first regularly scheduled transmission of the modified S-SFH SP3 IE.

If more than one S-SFH SPx IE is changed within the S-SFH change cycle, their changed contents shall be applied simultaneously beginning with the latest superframe among the superframes indicated in the corresponding cases above.

The S-SFH application hold indicator in the P-SFH IE is used to explicitly indicate which S-SFH SPx IE content shall be applied in the current superframe—either the content corresponding to the value of S-SFH change count transmitted in the current superframe or the previously transmitted value. If the S-SFH application hold indicator is set to 0, the AMS shall use the S-SFH contents associated with the currently transmitted S-SFH change count. Otherwise, if the S-SFH application hold indicator is 1, the AMS shall use the S-SFH contents associated with the previously transmitted S-SFH change count [that is, (the current S-SFH change count –1) modulo 16].

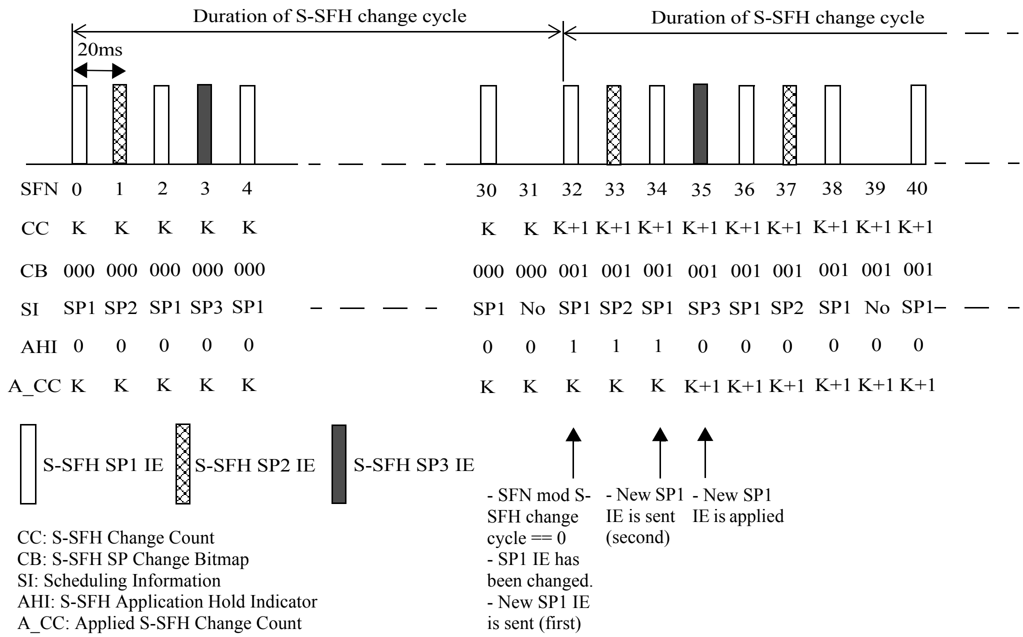
Based on the S-SFH change count, S-SFH SP change bitmap, S-SFH change cycle, and S-SFH application hold indicator, the AMS knows if it needs to decode S-SFH SP IEs in the current superframe to update the system parameters broadcast within the S-SFH SP IEs, and the AMS may decide to disregard the S-SFH SP IEs with the presumption that there is no change in S-SFH SP IEs compared to that already stored in the AMS.

The AMS shall compare the value of the S-SFH change count in the current P-SFH IE with that stored last, whenever the validity check of the last stored S-SFH SP IEs is required.

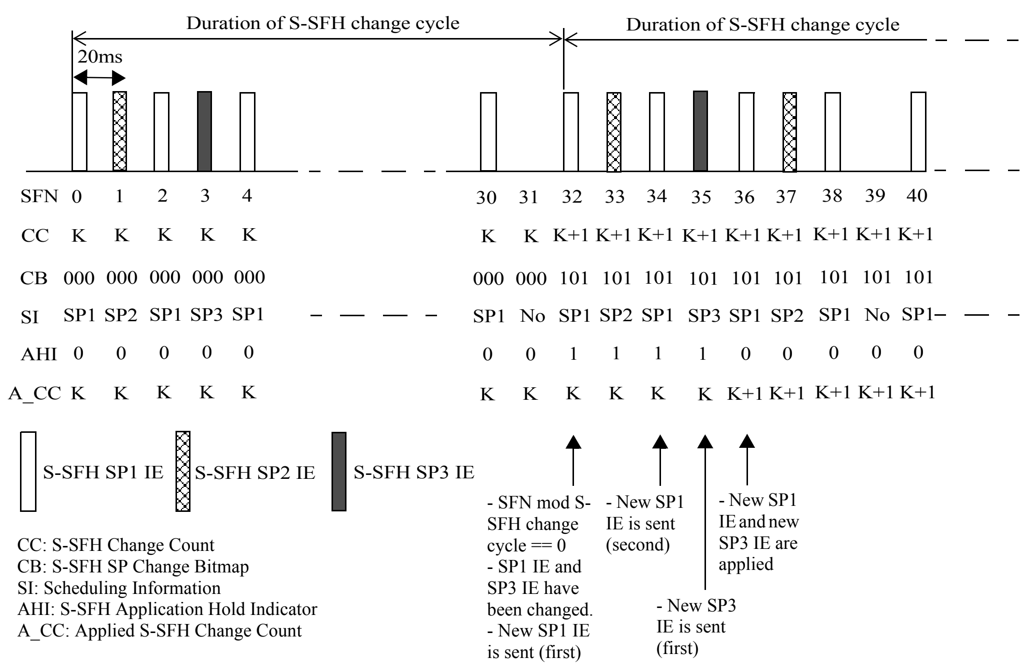
— If there is no difference between two S-SFH change counts, the AMS may not decode S-SFH IE during a certain period where the S-SFH change count remains unchanged.
— Else if the difference between two S-SFH change counts is one, the AMS shall update the S-SFH SP IE(s) whose bit in the S-SFH SP change bitmap is set to 1.
— Else if the difference between two S-SFH change counts is greater than one, the AMS shall update all S-SFH SP IEs.

Figure 6-93 shows examples of the S-SFH update procedure. This figure considers the following assumptions:

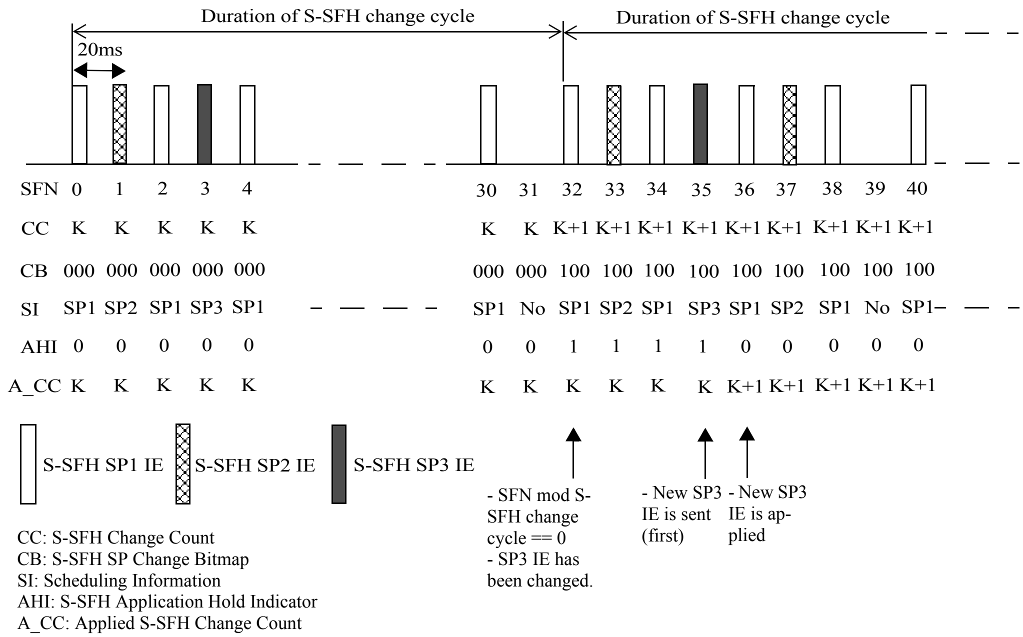
— The periodicity of SP1 IE, SP2 IE, and SP3 IE are 40 ms, 80 ms, and 160 ms, respectively
— The S-SFH change cycle is 32.
— “No” means that no SPx IE is scheduled.



(a) SP1 IE is changed



(b) SP1 IE and SP3 IE are changed



(c) SP3 IE is changed

Figure 6-93—Illustrations of S-SFH update procedure

6.2.25 Short message service

In connected mode, AAI-L2-XFER is used to send/receive SMS and SMS confirmation. In idle mode, Short Message Service information may be included in an AAI-RNG-REQ/RSP message. The maximum size of the short message body is 140 bytes. This parameter may be included only when the action code of AAI-PAG-ADV indicates location update or when the AAI-RNG-REQ with Ranging Purpose Indication value has 0b0011.

When UL SMS is included in an AAI-RNG-REQ message with a Ranging Purpose Indication that has a value of 0b0011, an AAI-RNG-RSP is transmitted as a confirmation of the SMS.

When an AAI-RNG-RSP message includes DL SMS, an AAI-MSG-ACK message is sent as a confirmation of the DL SMS. The ABS grants a CDMA Allocation A-MAP IE for the AAI-MSG-ACK in an unsolicited manner by an ACK timer, where MCRC is masked with the same RA-ID as in the CDMA Allocation A-MAP IE for the AAI-RNG-REQ message. When the AMS receives the AAI-RNG-RSP with the DL SMS, the AMS starts the ACK timer and waits for the CDMA Allocation A-MAP IE to send the AAI-MSG-ACK message.

Table 6-145—Short message service

Name	Value	Usage
SMS	Short Message content up to the size of 140 bytes	Used to carry short text messages

6.2.26 Coverage loss detection and recovery from coverage loss

An AMS may lose signal temporarily due to various reasons, such as entering into an area without coverage and fading. A coverage loss refers to such a situation.

6.2.26.1 Coverage loss detection at ABS and ABS's behavior

For each AMS, the ABS shall maintain a timer called the active_ABS_timer. The timer starts upon the completion of the initial network entry, identified by the completion of the AAI-REG-REQ/AAI-REG-RSP handshake, or the completion of network reentry, according to the Reentry Process Optimization in the AAI-RNG-RSP message. The timer is reset whenever the ABS receives any data (e.g., MAC PDU or feedback information) from the AMS.

Upon each expiration of the active_ABS_timer, to check whether an AMS is still alive in active mode, the ABS shall grant UL burst to the AMS and the AMS shall transmit a UL MAC PDU or if the AMS has no pending UL MAC PDU to transmit, then just padding bytes (see 6.2.4.7) on the UL grant. If the ABS successfully receives a UL data burst from the AMS in the UL allocation granted to it, the ABS shall reset the active_ABS_timer for the AMS. The ABS may send a unicast AAI-RNG-ACK message with status "success" to the AMS with or without adjustment parameters based on the measurement on the received UL burst from the AMS.

In sleep mode, the ABS may grant the UL burst at the listening window that is the nearest to the point of the active_ABS_timer's expiration. Similarly, at the point of active_ABS_timer's expiration, if the AMS is in the scanning interval, the ABS may grant the UL burst for the coverage loss detection at the next interleaving interval of the AMS.

If the ABS does not receive a UL burst on a predetermined number of successive UL grants, called the number of Coverage Loss Detection UL grants $N_{\text{CLD\_UL\_Grant}}$, the ABS shall send an unsolicited AAI-RNG-RSP message to request the AMS to perform ranging, as described in the paragraphs that follow.

The ABS shall send an unsolicited AAI-RNG-RSP message with the Ranging Request bit set to '1' to request the AMS to perform ranging using periodic ranging codes. The ABS shall then start the T58 timer. Upon receiving an AAI-RNG-CFM message with the AMS's STID, which indicates a successful periodic ranging initiated by this unsolicited AAI-RNG-RSP, the ABS shall restart the active_ABS_timer. If the ABS does not receive the AAI-RNG-CFM message upon the expiration of T58, the ABS shall start the ABS_Resource_Retain_Timer.

Once the ABS_Resource_Retain_Timer is started, the ABS shall not restart the active_ABS_timer.

Upon expiration of the ABS_Resource_Retain_Timer, the ABS may release the AMS's dynamic context and move AMS's static context to the network entity that stores AMS's context.

In case of an HO, the ABS shall stop the coverage loss detection procedure for the AMS at the frame specified by Disconnect Time in the AAI-HO-CMD message. Once the S-ABS receives a MAC control message (i.e., bandwidth request) from the AMS that is assumed to handover to a neighbor ABS (i.e., T-ABS), the S-ABS shall initiate the coverage loss detection procedure by starting the active_ABS_timer for the AMS.

When an AMS is successfully deregistered from the ABS by explicit control message transaction, e.g., entering the idle mode as specified in 6.2.18 or completing a deregistration procedure as specified in 6.2.27, the ABS shall stop the active_ABS_timer for the AMS.

6.2.26.2 Coverage loss detection at AMS and AMS's behavior

The AMS can detect a coverage loss when it loses PHY synchronization or DL synchronization or UL synchronization; i.e., if the AMS cannot decode a predetermined number of contiguous SFHs, called the number of lost SFHs denoted as $N_{\text{Lost-SFH}}$, the AMS shall regard it as Link Loss from the ABS.

Upon receiving an unsolicited AAI-RNG-RSP message with the Ranging Request bit to be one, which indicates that the ABS requests the ranging procedure to detect coverage loss, the AMS shall perform periodic ranging. Upon successful ranging initiated by an unsolicited AAI-RNG-RSP message with Ranging Request bit to be one, indicated by receiving an AAI-RNG-ACK message with a success status and corresponding periodic ranging code, the AMS shall request bandwidth and send back an AAI-RNG-CFM message that includes its STID. Upon exhausted HARQ retransmissions of the AAI-RNG-CFM message, the AMS shall regard it as Link Loss from the ABS, and the AMS shall perform the coverage loss recovery procedure as indicated in 6.2.26.3.

6.2.26.3 Coverage loss recovery procedure

Upon detection of a coverage loss, the AMS scans for a new channel. After achieving PHY synchronization and DL synchronization with the discovered ABS, the AMS shall perform network reentry with CRID as indicated in the following paragraphs.

During the network reentry, the AMS shall perform CDMA ranging using HO ranging codes. Upon the discovered ABS's sending AAI-RNG-ACK with success status, the ABS shall provide a UL BW allocation. When receiving the UL BW allocation, the AMS shall send the AAI-RNG-REQ message, with the Ranging Purpose Indication = 0b1000 (i.e., indicating a network reentry after a coverage loss). If the AMS shares valid security context, the AMS shall send AAI-RNG-REQ protected with a CMAC derived from new AK. In AAI-RNG-REQ, the AMS shall provide identity based on network configuration. In case of Network Configuration = 0b0 in S-SFH SP2, the AMS shall include its CRID, and in case of Network Configuration = 0b1 in S-SFH SP2, the AMS shall include its AMSID. In addition, unless the AMS can determine that the ABS_Resource_Retain_Timer has expired, the AMS shall include its previous serving ABS ID and its previous STID in the AAI-RNG-REQ message.

After receiving the AAI-RNG-REQ message, the discovered ABS identifies AMS's reentry attempt after a coverage loss and checks its context availability. The discovered ABS may request the AMS's context over a backbone network, which is beyond the scope of this standard. Based on the AMS's relevant context retained at the network, the T-ABS shall place in AAI-RNG-RSP an Reentry Process Optimization parameter indicating which reentry MAC control messages may be omitted. The AMS shall complete the processing of all indicated messages before entering Connected State with T-ABS.

6.2.26.4 Recovery from coverage loss due to the ABS restart

The ABS maintains a restart count that is incremented by one whenever the ABS restarts. The restart count is included in the AAI-SCD message (refer to 6.2.3.31). The AMS stores the restart count advertised in the latest instance of the AAI-SCD message. Whenever the AMS detects a restart count that is different than the latest stored value, it shall determine that the ABS has been restarted. Then the AMS performs network reentry as defined in 6.2.26.3.

6.2.27 AMS deregistration

AMS deregistration is a common scenario caused by graceful shutdown or some failure situation where an the AMS is deregistered from network service and its context is deleted.

An AMS may trigger AMS deregistration from the network by transmitting an AAI-DREG-REQ message with Deregistration_Request_Code = 0x00, request for deregistration from ABS and network. Upon receipt of the AAI-DREG-REQ message including the Deregistration_Request_Code = 0x00, the ABS sends an AAI-DREG-RSP message with Action code = 0x04.

When an ABS triggers the AMS deregistration process, the ABS sends an AAI-DREG-RSP message including one of Action code 0x00, 0x01, 0x02, or 0x03 that indicates the requested deregistration action. The AMS replies with the AAI-DREG-REQ message including Deregistration_Request_Code = 0x05 to the ABS.

The handling of AMS deregistration among the related network entities is beyond the scope of this specification.

6.2.28 Support for multicast service

Multicast service provides an efficient method for concurrent transport of DL data common to a group of users, using a common Multicast Group ID and an FID in an ABS. Multicast service is associated with an ABS and is offered in the downlink only. Each multicast connection is associated with a service flow provisioned with the QoS and traffic parameters for that service flow. Service flows to carry multicast data are instantiated on individual AMSs participating in the service while in Connected State. During such instantiation, the AMS learns the parameters that identify the service and associated service flows.

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

6.2.28.1 Multicast operation

An ABS may establish a DL multicast service by creating a multicast connection with each AMS to be associated with the service. Any available FID may be used for the multicast service (i.e., there are no dedicated FIDs for multicast transport connections). To ensure proper multicast operation, the FID used for the service shall be the same for all AMSs on the same channel that participates in the connection. The multicast connection shall be established using a combination of Multicast Group ID and FID assigned through the AAI-DSA MAC control message. Since a multicast connection is associated with a service flow, it is associated with the QoS and traffic parameters of that service flow. For multicast connections, ARQ is not applicable, and the Null SAID is used as the target SAID field in the DSA-REQ/RSP message.

6.2.28.2 Multicast connection establishment

When an AMS registers to receive multicast services, the S-ABS or the AMS may initiate the DSA procedure for multicast connections. The AMS’s discovery and registration of multicast services with the ABS through upper layer signaling are outside the scope of this standard.

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

6.2.28.3 Multicast operation in connected state

When an AMS performs handover to a new ABS while in active mode or sleep mode, the AMS shall send the AAI-RNG-REQ message with Ranging Purpose Indication = 0b0001 at the T-ABS. Upon receipt of the AAI-RNG-REQ message from the AMS, the ABS shall include Multicast Group ID in the AAI-RNG-RSP parameters to provide an updated Multicast Group ID, if any.

6.3 Physical layer

6.3.1 Introduction

The Advanced Air Interface is designed for NLOS operation in the licensed frequencies below 6 GHz.

The Advanced Air Interface supports TDD and FDD duplex modes, including H-FDD AMS operation. Unless otherwise specified, the frame structure attributes and baseband processing are common for all duplex modes.

The Advanced Air Interface uses OFDMA as the multiple access scheme in the downlink and uplink.

6.3.2 OFDMA symbol description, symbol parameters, and transmitted signal

6.3.2.1 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 the multipath, while maintaining the orthogonality of the tones. Figure 6-94 illustrates this structure.

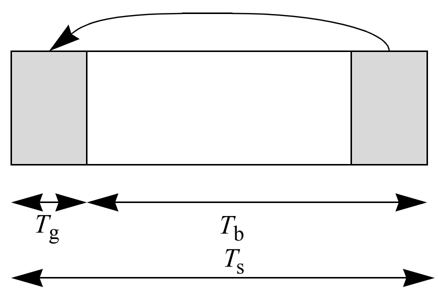


Figure 6-94—OFDMA symbol time structure

6.3.2.2 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 as follows:

- Data subcarriers: for data transmission
- Pilot subcarriers: for various estimation purposes
- Null subcarriers: no transmission at all, for guard bands and DC subcarriers

The purpose of the guard bands is to enable the signal to naturally decay and create the FFT “brick wall” shaping.

6.3.2.3 Primitive parameters

The following four primitive parameters characterize the OFDMA symbol:

- BW: 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 6-146 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.

6.3.2.4 Derived parameters

The following parameters are defined in terms of the primitive parameters of 6.3.2.3:

— N_{FFT}: Smallest power of two greater than N_{used}

— Sampling frequency: $F_s = \text{floor}(n \times BW/8000) \times 8000$

— Subcarrier spacing: $\Delta f = F_s / N_{FFT}$

— Useful symbol time: $T_b = 1/\Delta f$

— CP time: $T_g = G \times T_b$

— 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 6-146 and Table 6-147. The parameter values given in Table 6-147 shall be used only for the bandwidths given in the table when tone dropping is not applied. Tone dropping based on 10 MHz and 20 MHz systems can be used to support other various bandwidths.

Table 6-146—OFDMA parameters

The nominal channel bandwidth, BW (MHz)			5	7	8.75	10	20
Sampling factor, n			28/25	8/7	8/7	28/25	28/25
Sampling frequency, F_s (MHz)			5.6	8	10	11.2	22.4
FFT size, N_{FFT}			512	1024	1024	1024	2048
Subcarrier spacing, Δf (kHz)			10.94	7.81	9.77	10.94	10.94
Useful symbol time, T_b (μs)			91.4	128	102.4	91.4	91.4
CP ratio, G = 1/8	OFDMA symbol time, T_s (μs)		102.857	144	115.2	102.857	102.857
CP ratio, G = 1/8	FDD	Number of OFDMA symbols per 5 ms frame	48	34	43	48	48
CP ratio, G = 1/8	FDD	Idle time (μs)	62.857	104	46.40	62.857	62.857
CP ratio, G = 1/8	TDD	Number of OFDMA symbols per 5ms frame	47	33	42	47	47
CP ratio, G = 1/8	TDD	TTG + RTG (μs)	165.714	248	161.6	165.714	165.714

Table 6-146—OFDMA parameters *(continued)*

CP ratio, G = 1/16	OFDMA symbol time, T_s (μs)		97.143	136	108.8	97.143	97.143
	FDD	Number of OFDMA symbols per 5 ms frame	51	36	45	51	51
		Idle time (μs)	45.71	104	104	45.71	45.71
	TDD	Number of OFDMA symbols per 5 ms frame	50	35	44	50	50
		TTG + RTG (μs)	142.853	240	212.8	142.853	142.853
CP ratio, G = 1/4	OFDMA symbol time, T_s (μs)		114.286	160	128	114.286	114.286
	FDD	Number of OFDMA symbols per 5 ms frame	43	31	39	43	43
		Idle time (μs)	85.694	40	8	85.694	85.694
	TDD	Number of OFDMA symbols per 5 ms frame	42	30	37	42	42
		TTG + RTG (μs)	199.98	200	264	199.98	199.98

Table 6-147—Additional OFDMA parameters

The nominal channel bandwidth, BW (MHz)		5	7	8.75	10	20
Number of guard subcarriers	Left	40	80	80	80	160
	Right	39	79	79	79	159
Number of used subcarriers		433	865	865	865	1729
Number of physical resource unit (18 × 6) in a Type 1 AAI subframe.		24	48	48	48	96

Values of the derived parameters and the primitive parameters based on tone dropping from 10 MHz and 20 MHz shall follow the parameters for 10 MHz and 20 MHz, respectively, as defined in Table 6-146. When the bandwidth BW (MHz) satisfies $5 < BW < 10$, the 10 MHz parameters are used; when $10 < BW < 20$, the 20 MHz parameters are used. Additional OFDMA parameters applicable when tone dropping is used are specified in Table 6-148 and Table 6-149.

6.3.2.5 Transmitted signal

Equation (185) specifies the transmitted signal voltage to the antenna, as a function of time, during any OFDMA symbol.

Table 6-148—OFDMA parameters for 2048 FFT when tone dropping is applied

BW range, x (MHz)	Number of guard subcarriers		Number of used subcarriers	Number of PRUs (N_{PRU})
	Left	Right		
$20.0 > x \geq 19.2$	196	195	1657	92
$19.2 > x \geq 18.4$	232	231	1585	88
$18.4 > x \geq 17.5$	268	267	1513	84
$17.5 > x \geq 16.7$	304	303	1441	80
$16.7 > x \geq 15.9$	340	339	1369	76
$15.9 > x \geq 15.0$	376	375	1297	72
$15.0 > x \geq 14.2$	412	411	1225	68
$14.2 > x \geq 13.4$	448	447	1153	64
$13.4 > x \geq 12.5$	484	483	1081	60
$12.5 > x \geq 11.7$	520	519	1009	56
$11.7 > x \geq 10.9$	556	555	937	52
$10.9 > x > 10.0$	592	591	865	48

Table 6-149—OFDMA parameters for 1024 FFT when tone dropping is applied

BW range, x (MHz)	Number of guard subcarriers		Number of used subcarriers	Number of PRUs (N_{PRU})
	Left	Right		
$10.0 > x \geq 9.2$	116	115	793	44
$9.2 > x \geq 8.4$	152	151	721	40
$8.4 > x \geq 7.5$	188	187	649	36
$7.5 > x \geq 6.7$	224	223	577	32
$6.7 > x \geq 5.9$	260	259	505	28
$5.9 > x > 5.0$	296	295	433	24

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{\substack{k=-(N_{used}-1)/2 \\ k \neq 0}}^{(N_{used}-1)/2} c_k \cdot e^{j2\pi k\Delta f(t-T_g)} \right\} \tag{185}$$

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 quadrature amplitude modulation (QAM) constellation.

T_g is the guard time.

Δf is the subcarrier frequency spacing.

f_c is the radio carrier frequency.

6.3.2.6 Definition of basic terms on the transmission chain

The basic terms related with the transmission chain are defined as illustrated in Figure 6-95.

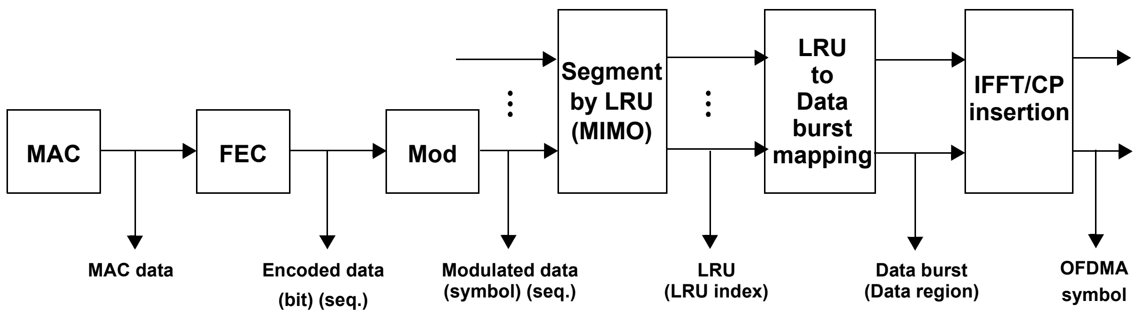


Figure 6-95—Definition of basic terms on the transmission chain

6.3.3 Frame structure

6.3.3.1 Basic frame structure

The Advanced Air Interface basic frame structure is illustrated in Figure 6-96. Each 20 ms superframe is divided into four equally sized 5 ms radio frames. When using the same OFDMA parameters as in Table 6-146 and Table 6-147 with the channel bandwidth of 5 MHz, 10 MHz, or 20 MHz, each 5 ms radio frame further consists of eight AAI subframes for G = 1/8 and 1/16. For G = 1/4, the 5 ms radio frame consists of seven AAI subframes. With the channel bandwidth of 8.75 MHz, the 5 ms radio frame consists of seven AAI subframes for G = 1/8 and 1/16, and six AAI subframes for G = 1/4. With the channel bandwidth of 7 MHz, the 5 ms radio frame consists of six AAI subframes for G = 1/16, and five AAI subframes for G = 1/8 and G = 1/4. An AAI subframe shall be assigned for either DL or UL transmission. There are four types of AAI subframes:

1) Type 1 AAI subframe that consists of six OFDMA symbols.
2) Type 2 AAI subframe that consists of seven OFDMA symbols.
3) Type 3 AAI subframe that consists of five OFDMA symbols.
4) Type 4 AAI subframe that consists of nine OFDMA symbols. This type shall be applied only to a UL AAI subframe for the 8.75 MHz channel bandwidth when supporting the WirelessMAN-OFDMA R1 Reference System frames.

The basic frame structure is applied to FDD and TDD duplexing schemes, including the H-FDD AMS operation. The number of switching points in each radio frame in TDD systems shall be two, where a switching point is defined as a change of directionality, i.e., from DL to UL or from UL to DL.

When H-FDD AMSs are included in an FDD system, the frame structure from the point of view of the H-FDD AMS is similar to the TDD frame structure; however, the DL and UL transmissions occur in two separate frequency bands. The transmission gaps between DL and UL (and vice versa) are required to allow switching the Tx and Rx circuitry.

A data burst shall occupy either one AAI subframe (i.e., the default TTI transmission) or contiguous multiple AAI subframes (i.e., the long TTI transmission). Any two long TTI bursts allocated to an AMS shall not be partially overlapped; i.e., any two long TTI bursts in FDD shall either be over the same four subframes or without any overlap.The long TTI in FDD shall be four AAI subframes for both DL and UL. For DL (UL), the long TTI in TDD shall be all DL (UL) AAI subframes in a frame. A subframe can have default TTI allocations and long TTI allocations. Default TTI for DL and UL transmission shall be supported. The support of long TTI for DL transmission is dependent on AMS implementation, and it is negotiated through the AAI-SBC-REQ/RSP messages during network entry. Long TTI for UL transmission shall be supported.

In the downlink, the total number of Allocation Sizes (the number of LRUs multiplied by the STC rate per AMS as defined in 6.3.10.1.2) of the DL bursts allocated to a specific AMS, where the DL bursts end at the same subframe boundary irrespective of the burst type (default TTI burst and long TTI burst), shall not be larger than the number of LRUs in a single subframe duration multiplied by the maximum allowable DL STC Rate of the AMS as capability negotiated during network entry. That is, the ABS shall not allocate to a specific AMS the total number of Allocation Sizes of the DL bursts, where the sum of the number of Allocation Sizes that default TTI bursts occupy within a specific subframe and the number of Allocation Sizes that long TTI bursts ending in the specific subframe occupy over the long TTI durations is considered, larger than the maximum allowable Allocation Size within a subframe considering the maximum DL STC Rate supported by the AMS. In case of multicarrier aggregation support, the number of LRUs in a subframe duration considers the total number of LRUs within a subframe duration over the used carriers by the AMS.

In the uplink, the total number of Allocation Sizes (the number of LRUs multiplied by the STC rate per AMS as defined in 6.3.10.1.2) of the UL bursts allocated to a specific AMS, where the UL bursts start from the same subframe boundary irrespective of the burst type (default TTI burst and long TTI burst), shall not be larger than the number of LRUs in a single subframe duration multiplied by the maximum allowable UL STC Rate of the AMS as capability negotiated during network entry. That is, the ABS shall not allocate to a specific AMS the total number of Allocation Sizes of the UL bursts, where the sum of the number of Allocation Sizes that default TTI bursts occupy within a specific subframe and the number of Allocation Sizes that long TTI bursts starting from the specific subframe occupy over the long TTI durations is considered, larger than the maximum allowable Allocation Size within a subframe considering the maximum UL STC Rate supported by the AMS. In case of multicarrier aggregation support, the number of LRUs in a subframe duration considers the total number of LRUs within a subframe duration over the used carriers by the AMS.

For an AMS operating over carriers with a sum of FFT sizes that is 2048 subcarriers or less, the ABS may allocate it up to 4 DL HARQ bursts (using DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent Allocation A-MAP IE, or Group Resource Allocation A-MAP IE) per AAI subframe per AMS. The ABS shall not allocate more than 4 DL HARQ bursts per AAI subframe per AMS. Here, a long TTI burst shall be counted as one burst for each and every AAI subframe that the long TTI burst spans.

For an AMS operating over carriers with a sum of FFT sizes that is larger than 2048 subcarriers, the ABS may allocate it with a number of bursts that is equal to floor (4 × sum of FFT sizes of all used carriers/2048).

The ABS shall not allocate more than one broadcast data burst with time domain repetition per frame, more than one broadcast data burst without time domain repetition per AAI subframe (using Broadcast Assignment A-MAP IE with the field “Transmission Format” indicating with or without time domain repetition), more than one E-MBS burst (using E-MBS A-MAP IE) per AAI subframe, and more than one multicast burst (using Broadcast Assignment A-MAP IE with Function Index = 0b10) per AAI subframe.

Here, a long TTI burst shall be counted as one burst for each and every AAI subframe that the long TTI burst spans.

For an AMS operating over carriers with a sum of FFT sizes that is 2048 subcarriers or less, the ABS shall not allocate more than four UL HARQ bursts per UL AAI subframe (including all allocations made with any UL Assignment A-MAP IE, e.g., UL Basic Assignment A-MAP IE, UL Subband Assignment A-MAP IE, CDMA Allocation A-MAP IE, UL Persistent Allocation A-MAP IE, Group Resource Allocation A-MAP IE, Feedback Polling A-MAP IE, or BR-ACK A-MAP IE) to the AMS. This constraint shall be applied regardless of the DL AAI subframes in which the UL assignment A-MAP IEs are transmitted. Here, a long TTI burst shall be counted as one burst for each and every AAI subframe in which it is transmitted.

Due to the anonymous nature of the UL BW allocation made through a CDMA Allocation A-MAP IE or BR-ACK A-MAP IE, the ABS may happen to allocate more than four UL HARQ bursts (e.g., four bursts through any UL assignment A-MAP IE type and one additional burst with the CDMA Allocation A-MAP IE or BR-ACK A-MAP IE) to the AMS. In this case, the AMS may choose to transmit only four of the UL HARQ bursts and ignore the remaining allocation(s).

If the AMS operates over carriers with a sum of FFT sizes that is larger than 2048 subcarriers, the ABS may allocate it with a number of bursts that is equal to floor ($4 \times$ sum of FFT sizes of all used carriers/2048).

The AMS shall support one separate HARQ channel other than the maximum number of total UL HARQ channels per AMS (refer to 6.2.14.2.1.2) for an UL allocation made through the CDMA Allocation A-MAP IE or BR-ACK A-MAP IE, in which the HARQ channel is not explicitly indicated with an ACID. If an allocation is made to an AMS with the CDMA Allocation A-MAP IE or BR-ACK A-MAP IE, while such a previous allocation is still under HARQ retransmission, the new allocation shall override the previous one.

The ABS shall not allocate to an AMS more than two concurrent DL allocations that are either group resource allocations or persistent allocations. In other words, the ABS may allocate either two DL group resource allocations, two DL persistent allocations, one DL group resource allocation, one DL persistent allocation, or one DL allocation of these types to any specific AMS.

The ABS shall not allocate to an AMS more than two concurrent UL allocations that are either group resource allocations or persistent allocations. In other words, the ABS may allocate either two UL group resource allocations, two UL persistent allocations, one UL group resource allocation, one UL persistent allocation, or one UL allocation of these types to any specific AMS.

Every superframe shall contain a superframe header (SFH). The SFH shall be located in the first DL AAI subframe of the superframe, and shall include broadcast channels. The SFH carries the superframe number. For TDD, the ABS shall synchronize the superfarme number across the entire system deployed in a given geographic area.

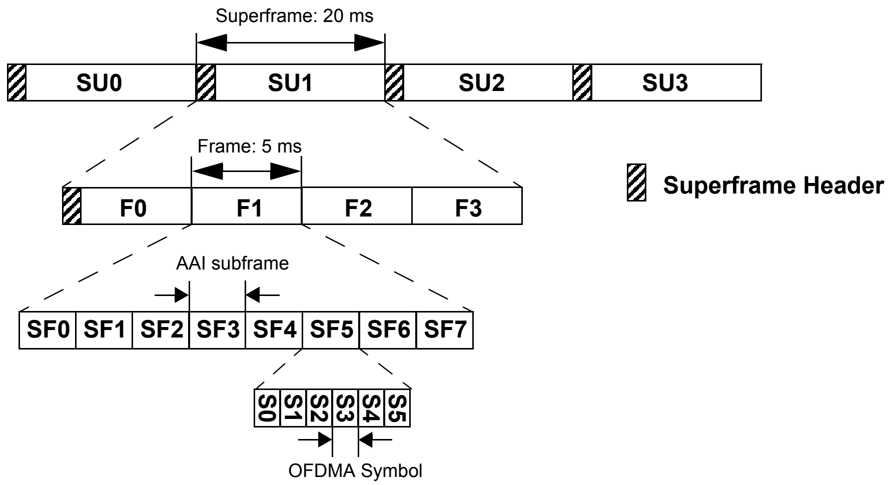


Figure 6-96—Basic frame structure for 5 MHz, 10 MHz, and 20 MHz channel bandwidths

6.3.3.2 Frame structure for CP = 1/8 T_b

6.3.3.2.1 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 6.3.3.1. In each frame, all AAI subframes are available for both DL and UL transmissions. The DL and UL transmissions are separated in the frequency domain.

An FDD AMS is able to receive a data burst in any DL AAI subframe while accessing an UL AAI subframe at the same time. For an H-FDD AMS, either transmission or reception, but not both, is allowed in each AAI subframe. In addition, the allocation of AAI subframes for transmission and reception shall provide idle subframes in order for an H-FDD AMS to receive the SFH or A-Preamble and to secure the transition gaps between transmission and reception. Then, the ABS shall schedule the AAI subframes for an H-FDD AMS, excluding the first, second, and last AAI UL subframes with the associated DL subframes connected in HARQ-timing as specified in 6.2.14.2.2.1.

The idle time specified in Table 6-146 shall be placed at the end of each FDD frame as shown in Figure 6-97.

Figure 6-97 illustrates an example FDD frame structure, which is applicable to the nominal channel bandwidth of 5 MHz, 10 MHz, and 20 MHz with G = 1/8.

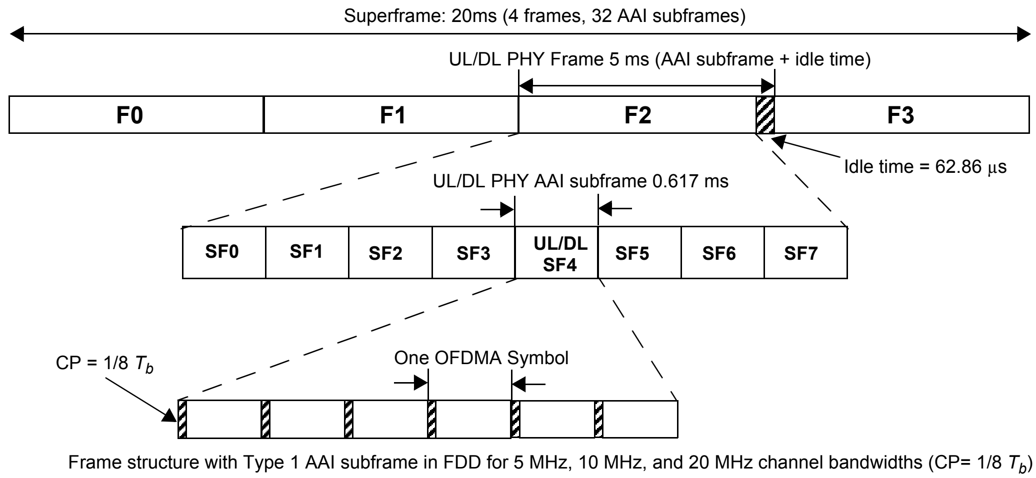


Figure 6-97—Frame structure with Type 1 FDD AAI subframe

Figure 6-98 illustrates an example FDD frame structure, which is applicable to the nominal channel bandwidth of 7 MHz with G = 1/8. Four AAI subframes among five AAI subframes are Type 2 AAI subframes, and the other AAI subframe is a Type 1 AAI subframe.

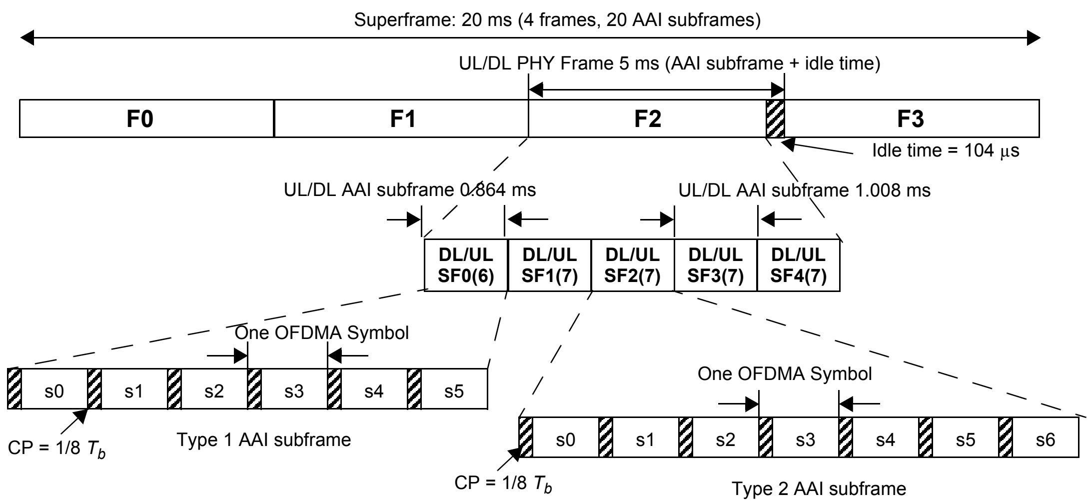
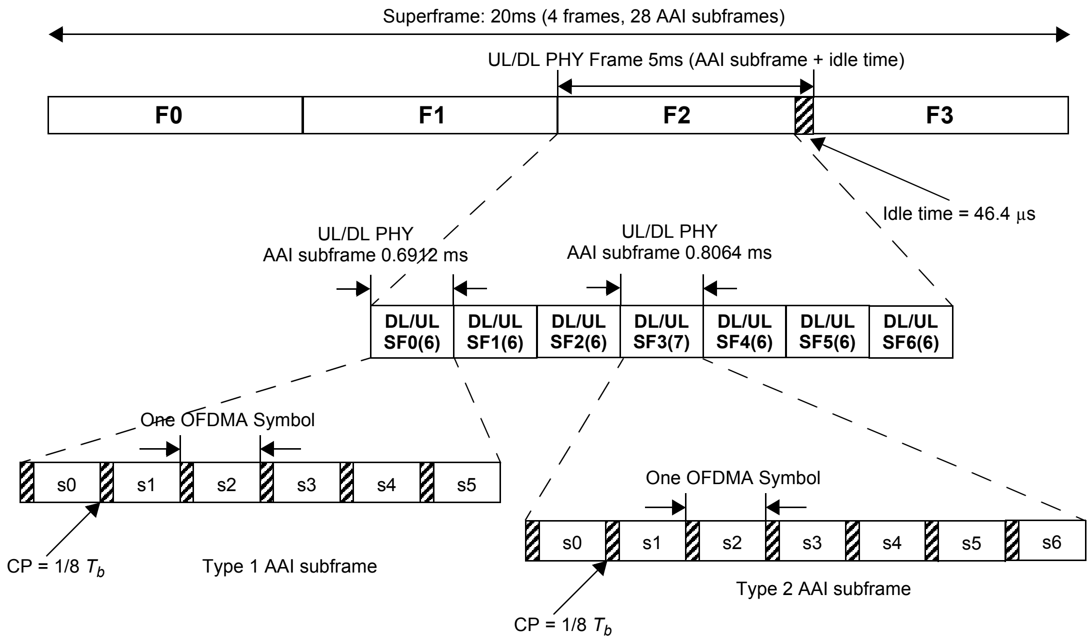


Figure 6-98—Frame structure for 7 MHz FDD mode (G = 1/8)

Figure 6-99 illustrates an example FDD frame structure, which is applicable to the nominal channel bandwidth of 8.75 MHz with G = 1/8. In Figure 6-99, the fourth AAI subframe is a Type 2 AAI subframe and the other AAI subframes are Type 1 AAI subframes.



Frame structure with Type 1 and Type 2 AAI subframes in FDD for 8.75 MHz channel bandwidths (CP= 1/8 T_b)

Figure 6-99—Frame structure for 8.75 MHz FDD mode (*G* = 1/8)

6.3.3.2.2 TDD frame structure

The TDD frame shall be constructed on the basis of the basic frame structure defined in 6.3.3.1.

In a TDD frame with a DL/UL ratio of D:U, the first contiguous D AAI subframes and the remaining U AAI subframes are assigned for DL and UL, respectively, where $D + U = 8$ for 5 MHz, 10 MHz, and 20 MHz channel bandwidths, $D + U = 7$ for 8.75 MHz channel bandwidth, and $D + U = 5$ for 7 MHz channel bandwidth. The ratio of D:U shall be selected from one of the following values: 6:2, 5:3, 4:4, or 3:5 for 5 MHz, 10 MHz, and 20 MHz channel bandwidths, and 3:2 or 2:3 for 7 MHz channel bandwidth and 5:2, 4:3, or 3:4 for 8.75 MHz channel bandwidth.

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

Figure 6-100 illustrates an example of a TDD frame structure with D:U = 5:3, which is applicable to the nominal channel bandwidths of 5 MHz, 10 MHz, and 20 MHz with G = 1/8. In Figure 6-100, the last DL AAI subframe, i.e., DL SF4, is a Type 3 AAI subframe and the other AAI subframes are Type 1 AAI subframes. TTG and RTG are 105.714 µs and 60 µs, respectively.

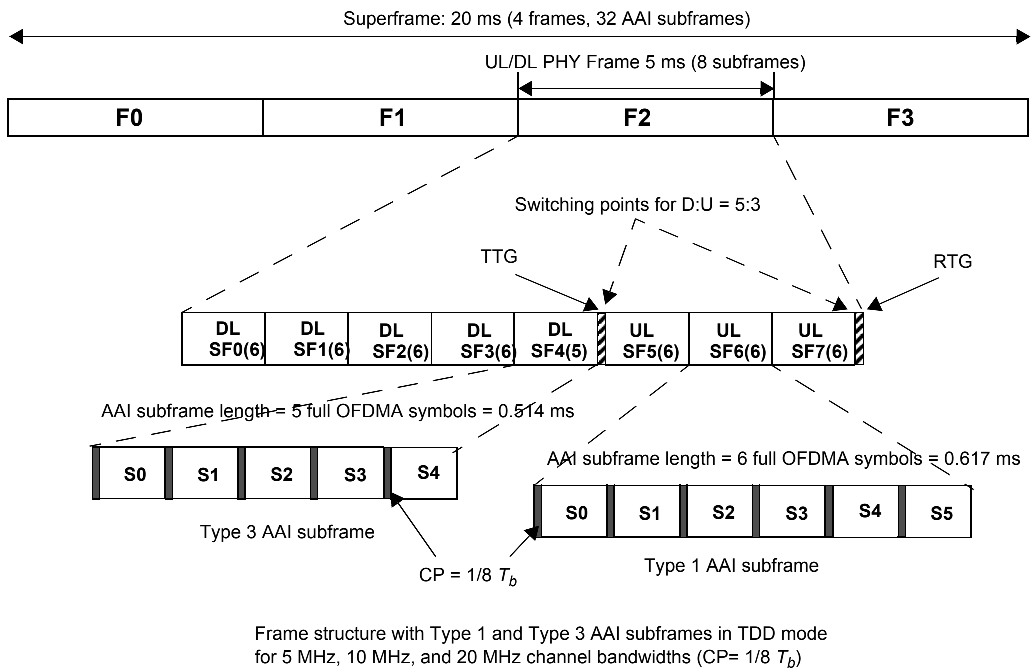


Figure 6-100—Frame structure for 5/10/20 MHz mode

Figure 6-101 illustrates an example TDD frame structure with D:U = 3:2, which is applicable to the nominal channel bandwidths of 7 MHz with G = 1/8. Three AAI subframes among five AAI subframes are Type 2 AAI subframes, and the other two AAI subframes are the Type 1. The TTG and RTG are 188 μs and 60 μs, respectively.

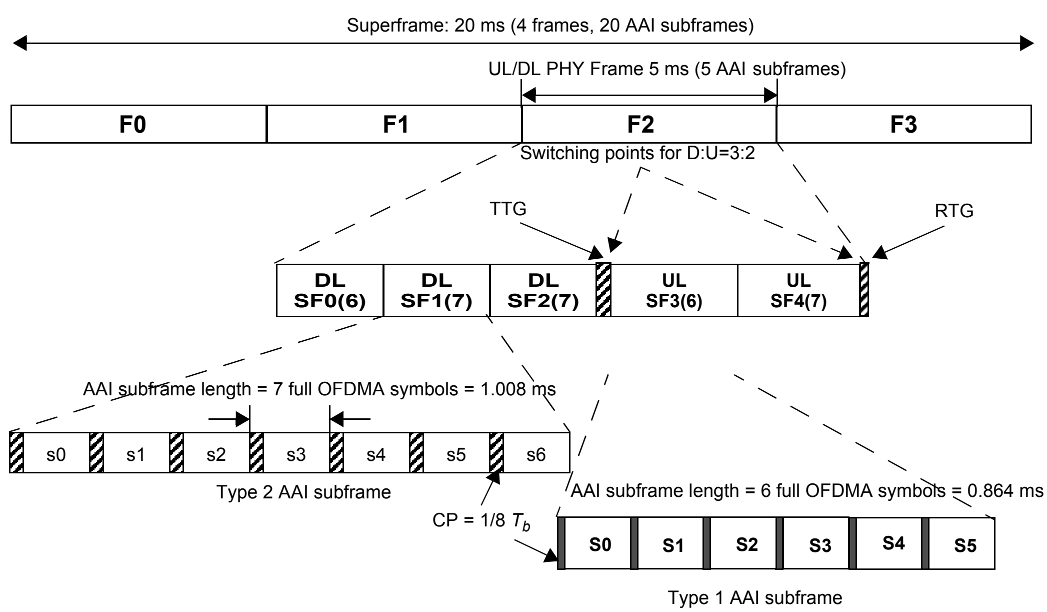


Figure 6-101—Frame structure for 7 MHz TDD mode

Figure 6-102 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 6-102, all seven AAI subframes in a frame are Type 1 AAI subframes. TTG and RTG are 87.2 µs and 74.4 µs, respectively.

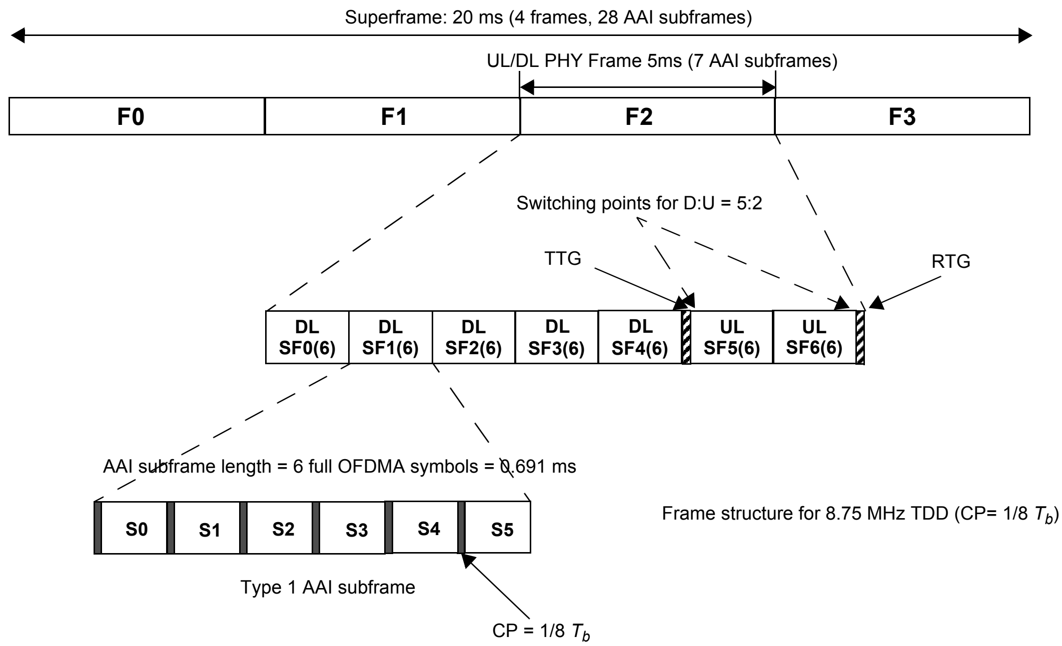
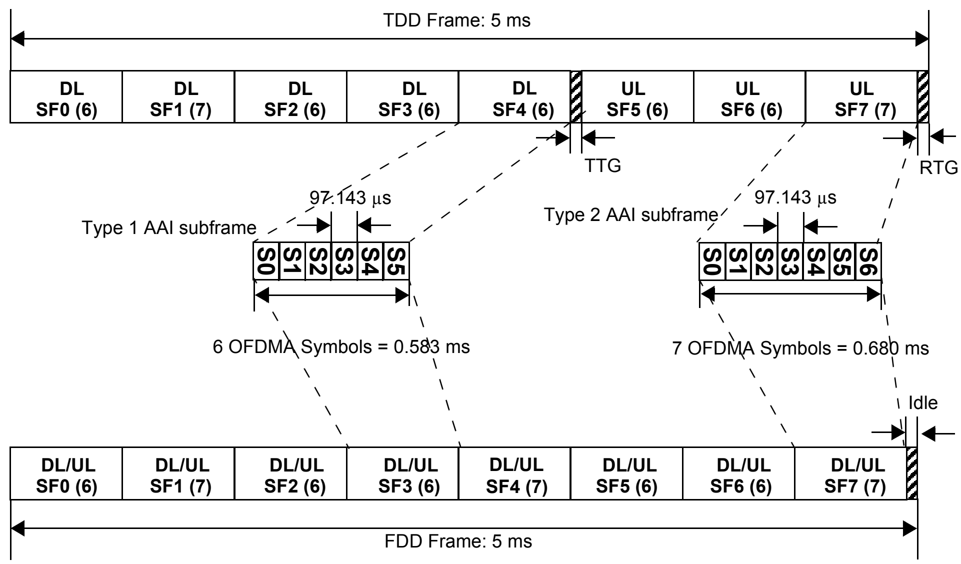


Figure 6-102—Frame structure for 8.75 MHz TDD mode

6.3.3.3 Frame structure for CP = 1/16 T_b

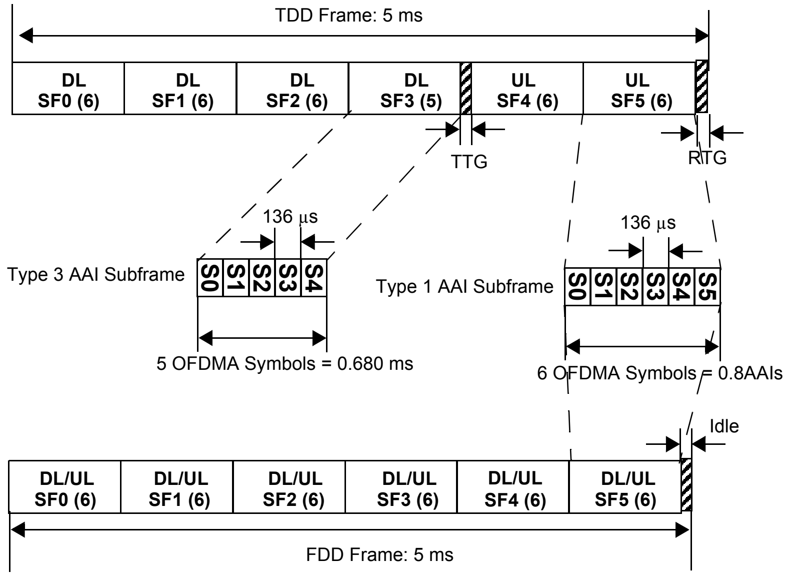
For channel bandwidths of 5 MHz, 10 MHz, and 20 MHz, an FDD frame shall have five Type 1 AAI subframes and three Type 2 AAI subframes, and a TDD frame shall have six Type 1 AAI subframes and two Type 2 AAI subframes. The AAI subframe preceding a DL to UL switching point shall be a Type 1 AAI subframe. In the TDD frame, the second and last AAI subframes within each frame shall be Type 2 AAI subframes. In the FDD frame, the second, fifth, and last AAI subframes within each frame shall be Type 2 AAI subframes. Figure 6-103 illustrates an example of a TDD and an FDD frame structure for 5 MHz, 10 MHz, and 20 MHz channel bandwidths with a CP of 1/16 T_b. Assuming OFDMA symbol duration of 97.143 µs and a CP length of 1/16 T_b, the length of Type 1 and Type 2 AAI subframes are 0.583 ms and 0.680 ms, respectively. TTG and RTG are 82.853 µs and 60 µs, respectively.



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

Figure 6-103—Frame structures for 5 MHz, 10 MHz, and 20 MHz of TDD and FDD mode (*G* = 1/16)

For a channel bandwidth of 7 MHz, a frame shall have six Type 1 AAI subframes for FDD, and five Type 1 AAI subframes and one Type 3 AAI subframes for TDD. In the TDD frame, the AAI subframe preceding a DL to UL switching point is a Type 3 AAI subframe. Figure 6-104 illustrates an example of a TDD and an FDD frame structure for the 7 MHz channel bandwidth with a CP of 1/16 T_b. Assuming OFDMA symbol duration of 136 µs and a CP length of 1/16 T_b, the length of Type 1 and Type 3 AAI subframes are 0.816 ms and 0.680 ms, respectively. TTG and RTG are 180 µs and 60 µs, respectively.



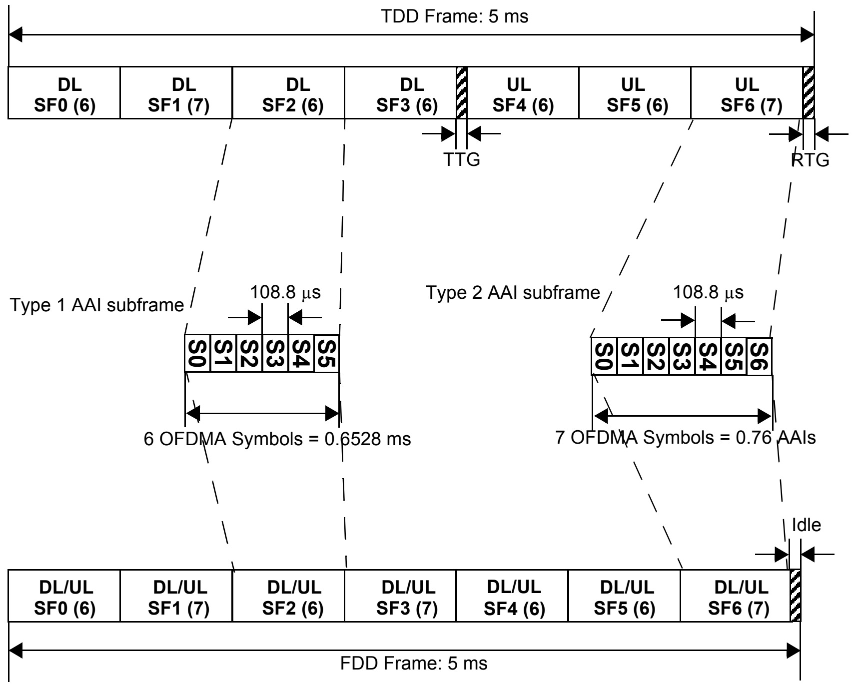
TDD and FDD frame structures for 7 MHz channel with a CP of 1/16 T_b (DL/UL ratio of 4:2).

Figure 6-104—Frame structures for 7 MHz TDD and FDD modes (*G* = 1/16)

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

In the TDD frame, the second and last AAI subframes within each frame shall be Type 2 AAI subframes. In the FDD frame, the second, fourth, and last AAI subframe within each frame shall be Type 2 AAI subframes.

Figure 6-105 illustrates an example of a TDD and an FDD frame structure for the 8.75 MHz channel bandwidth with a CP of 1/16 T_b. Assuming OFDMA symbol duration of 108.8 µs and a CP length of 1/16 T_b, the length of Type 1 and Type 2 AAI subframes are 0.6528 ms and 0.7616 ms, respectively. TTG and RTG are 138.4 µs and 74.4 µs, respectively.



TDD and FDD frame structures for 8.75 MHz channel with a CP of 1/16 T_b (DL/UL ratio of 4:3).

Figure 6-105—Frame structures for 8.75 MHz TDD and FDD modes (*G* = 1/16)

6.3.3.4 Frame structure for CP = 1/4 T_b

The frame structure for a CP length of 1/4 T_b shall consist of Type 1 and Type 2 AAI subframes. For a channel bandwidth of 5 MHz, 10 MHz, or 20 MHz, an FDD frame shall have six Type 1 AAI subframes and one Type 2 AAI subframe. A TDD frame shall have seven Type 1 AAI subframes.

Figure 6-106 illustrates an example of a TDD and an FDD frame structure with DL/UL ratio = 4:3 for the 5 MHz, 10 MHz, or 20 MHz channel bandwidth with a CP of 1/4 T_b. Assuming an OFDMA symbol duration of 114.286 µs and a CP length of 1/4 T_b, the length of Type 1 and Type 2 AAI subframes are 0.6857 ms and 0.80 ms, respectively. TTG and RTG are 139.988 µs and 60 µs, respectively.

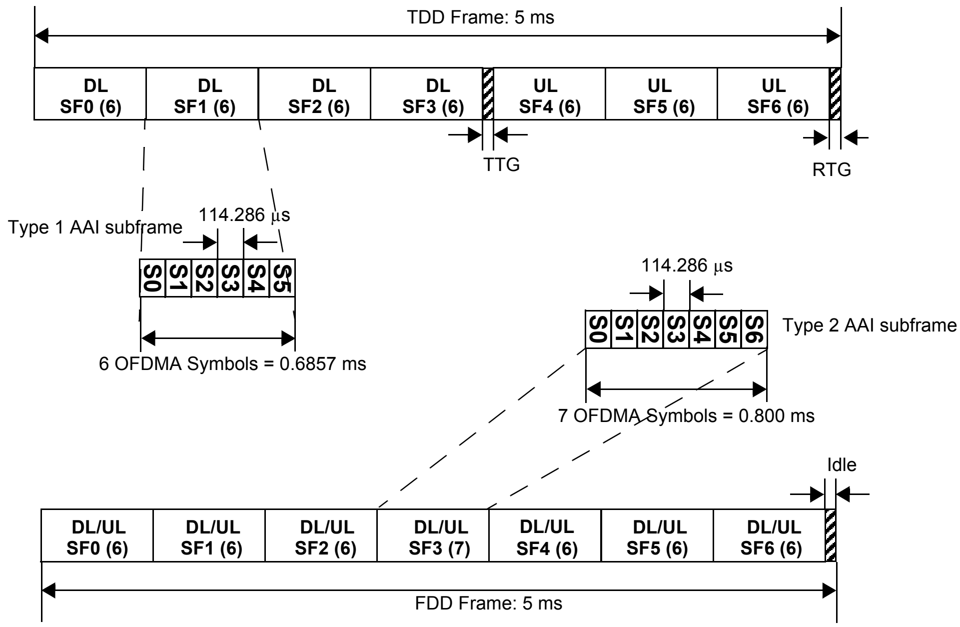


Figure 6-106—Frame structures for 5 MHz, 10 MHz, and 20 MHz of TDD and FDD modes (*G* = 1/4)

For a channel bandwidth of 7 MHz, an FDD frame shall have four Type 1 AAI subframes and one Type 2 AAI subframe. A TDD frame shall have five Type 1 AAI subframes.

Figure 6-107 illustrates an example of a TDD and an FDD frame structure with DL/UL ratio = 3:2 for the 7 MHz channel bandwidth with a CP of 1/4 T_b. Assuming OFDMA symbol duration of 160 µs and a CP length of 1/4 T_b, the length of Type 1 and Type 2 AAI subframes are 0.960 ms and 1.120 ms, respectively. TTG and RTG are 140 µs and 60 µs, respectively.

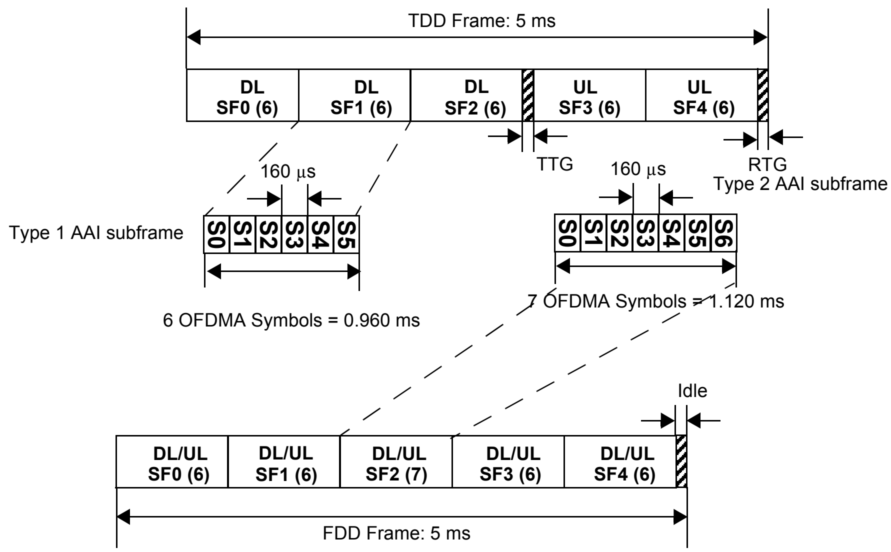


Figure 6-107—Frame structures for 7 MHz TDD and FDD modes (*G* = 1/4)

For a channel bandwidth of 8.75 MHz, an FDD frame shall have three Type 1 AAI subframes and three Type 2 AAI subframes. A TDD frame shall have five Type 1 AAI subframes and one Type 2 AAI subframe.

Figure 6-108 illustrates an example of a TDD and an FDD frame structure with DL/UL ratio = 4:2 for the 8.75 MHz channel bandwidth with a CP of 1/4 T_b. Assuming an OFDMA symbol duration of 128 µs and a CP length of 1/4 T_b, the length of Type 1 and Type 2 AAI subframes are 0.768 ms and 0.896 ms, respectively.

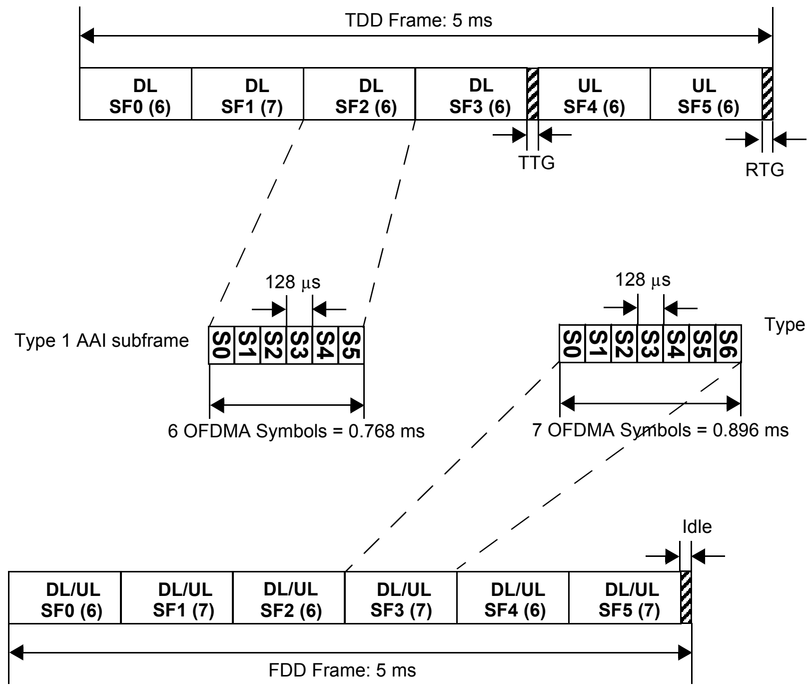


Figure 6-108—Frame structures for 8.75 MHz TDD and FDD modes (*G* = 1/4)

6.3.3.5 Frame structure supporting the WirelessMAN-OFDMA R1 Reference System

6.3.3.5.1 TDD frame structure

The WirelessMAN-OFDMA R1 Reference System and the Advanced Air Interface frames shall be offset by a fixed number of AAI subframes, FRAME_OFFSET = 1, 2, ..., *K*, as shown in Figure 6-109 and Figure 6-110. Regarding the TDD frame structure supporting the WirelessMAN-OFDMA R1 Reference System, all ABSs with the same center frequency within the same deployment region shall have the same FRAME_OFFSET value regardless of ABS type. When the Advanced Air Interface frames support the WirelessMAN-OFDMA R1 Reference System for 5 MHz, 10 MHz, 20 MHz channel bandwidths, all AAI subframes in the Advanced Air Interface DL Zone are Type 1 AAI subframes. The number of symbols in the first WirelessMAN-OFDMA R1 Reference System DL Zone is 5 + 6 × (FRAME_OFFSET – 1). When the Advanced Air Interface frames support the WirelessMAN-OFDMA R1 Reference System for the 8.75 MHz channel bandwidth with 15 UL OFDM symbols and for the 7 MHz channel bandwidth with 12 UL OFDM symbols, all AAI subframes in the Advanced Air Interface DL Zone are Type 1 AAI subframes. The number of symbols in the first WirelessMAN-OFDMA R1 Reference System DL Zone is 3 + 6 × (FRAME_OFFSET – 1) for 8.75 MHz and 9 + 6 × (FRAME_OFFSET – 1) for 7 MHz. The maximum value of parameter *K* is equal to the number of DL AAI subframes minus two. The minimum value of FRAME_OFFSET shall be two for 8.75 MHz channel bandwidth, and the minimum value of FRAME_OFFSET shall be one for other bandwidths.

In the DL, a subset of DL AAI subframes is dedicated to the WirelessMAN-OFDMA R1 Reference System operation to enable one or more WirelessMAN-OFDMA R1 Reference System DL time zones. The subset includes the first WirelessMAN-OFDMA R1 Reference System DL time zone to support the transmission of the preamble, FCH, and MAP, which are defined in 8.4.4 in IEEE Std 802.16.

The subset of DL AAI subframes dedicated to the WirelessMAN-OFDMA R1 Reference System operation should comprise either one group of contiguous DL AAI subframes or two separate groups of contiguous DL AAI subframes. When comprising the two separate groups, the second group shall include the last DL AAI subframe.

Data bursts for the R1 MSs shall not be transmitted in the DL AAI subframes for operation of the Advanced Air Interface. Those DL AAI subframes shall be indicated as a DL time zone by transmitting an STC_DL_ZONE_IE() with the Dedicated Pilots field set to 1, as defined in Table 8-123 in IEEE Std 802.16, in the DL-MAP messages.

DL/UL MAPs and bursts for AMS may be scheduled in either zone (Advanced Air Interface DL Zone or WirelessMAN-OFDMA R1 Reference System DL Zone) according to the mode (Advanced Air Interface or WirelessMAN-OFDMA R1 Reference System) with which the AMS is connected to the ABS, but shall not be scheduled in both zones in the same frame.

In the UL, the following two configurations are applicable:

1) FDM mode: A group of subcarriers (subchannels), spanning the entire UL transmission, is dedicated to the WirelessMAN-OFDMA R1 Reference System operation. The remaining subcarriers, denoted the Advanced Air Interface UL subchannels group and forming the Advanced Air Interface UL AAI subframes, are dedicated to the Advanced Air Interface operation. Figure 6-109 illustrates an example frame configuration for supporting the WirelessMAN-OFDMA R1 Reference System operation when FDM mode is used. In the case of 5 MHz, 7 MHz, 10 MHz, and 20 MHz, all UL AAI subframes are Type 1 AAI subframes. In the case of 8.75 MHz with 15 UL OFDM symbols, the first UL AAI subframe is a Type 1 AAI subframe and the second UL AAI subframe is a Type 4 AAI subframe.

   In case the PUSC subchannel rotation is activated for R1 MSs, the ABS shall transmit TLV 157 of the UCD, i.e., “UL allocated subchannels bitmap” for MSs to recognize the available subchannels. Available subchannels for R1 MSs shall be logically contiguous in terms of subchannel index and shall not be allocated for AMSs.

   Data bursts from the R1 MSs shall not be transmitted in the UL subchannels group for operation of the Advanced Air Interface.

   Control channels and bursts for the AMS may be scheduled in either group of UL subchannels (group of UL subchannels for Advanced Air Interface or WirelessMAN-OFDMA R1 Reference System) according to the mode (Advanced Air Interface or WirelessMAN-OFDMA R1 Reference System) with which the AMS is connected to the ABS, but shall not be scheduled in both groups in the same frame.

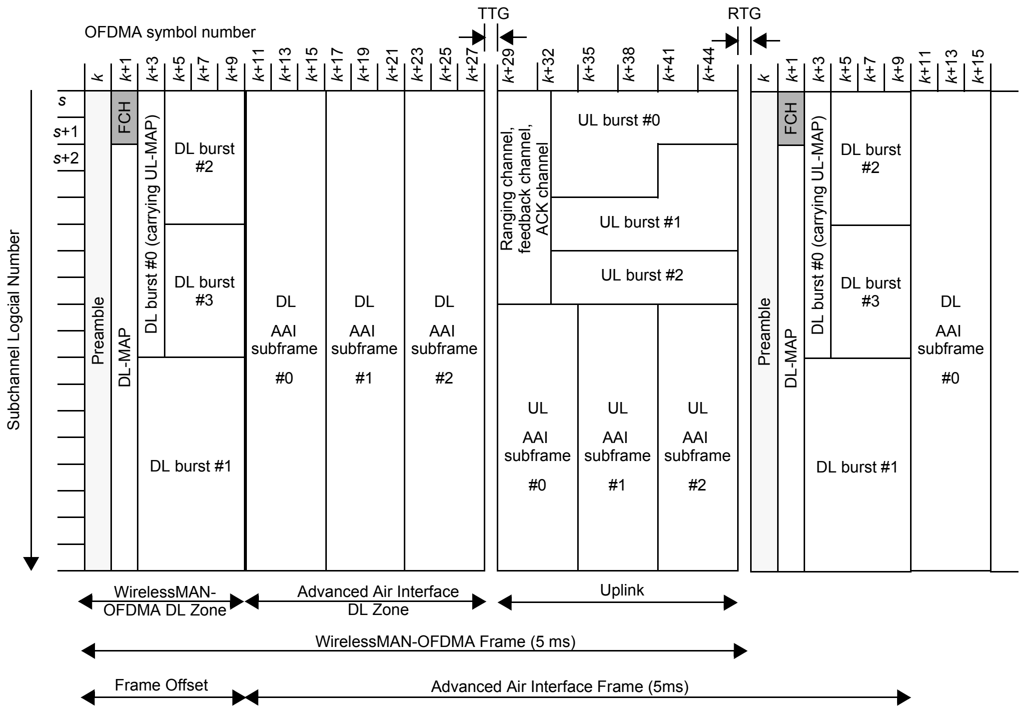


Figure 6-109—TDD frame configuration to support WirelessMAN-OFDMA R1 Reference System UL FDM operation

2) TDM mode: A subset of UL AAI subframes is dedicated to the WirelessMAN-OFDMA R1 Reference System operation to enable one or more WirelessMAN-OFDMA R1 Reference System UL time zones. The subset includes the first WirelessMAN-OFDMA R1 Reference System UL time zone to support the transmission of the ranging channel, feedback channel and ACK channel, which are defined in 8.4.4.6. Figure 6-110 illustrates an example frame configuration for supporting the WirelessMAN-OFDMA R1 Reference System operation when TDM mode is used. In the case of 5 MHz, 7 MHz, 10 MHz, 20 MHz, and 8.75 MHz, all AAI subframes in the Advanced Air Interface UL Zone are Type 1AAI subframes.

   Data bursts from the R1 MSs shall not be transmitted in the UL AAI subframes for operation of the Advanced Air Interface. Those UL AAI subframes shall be indicated as a UL time zone by transmitting an UL_ZONE_IE(), defined in IEEE Std 802.16, in the UL-MAP message.

   Control channels and bursts for the AMS may be scheduled in either zone (Advanced Air Interface UL Zone or WirelessMAN-OFDMA R1 Reference System UL Zone) according to the mode (Advanced Air Interface or WirelessMAN-OFDMA R1 Reference System) with which the AMS is connected to the ABS, but shall not be scheduled in both zones in the same frame.

Femto ABS shall not use the frame configuration supporting the WirelessMAN-OFDMA R1 Reference System when overlay Macro ABS(s) with the same center frequency is (are) operating in the frame configuration supporting AAI only.

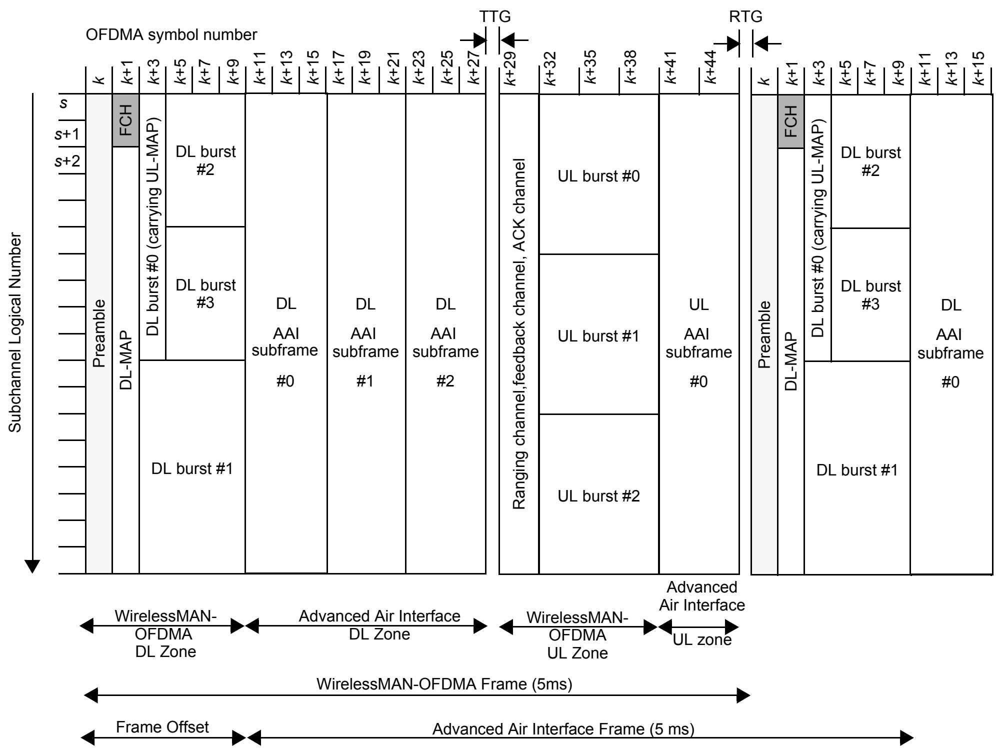


Figure 6-110—TDD frame configuration to support WirelessMAN-OFDMA R1 Reference System UL TDM operation

6.3.3.5.2 FDD frame structure

The WirelessMAN-OFDMA R1 Reference System and the WirelessMAN-Advanced Air Interface frames shall be offset by a fixed number of AAI subframes, FRAME_OFFSET = 1, 2, … , K, as shown in Figure 6-111. When the Advanced Air Interface frames support the WirelessMAN-OFDMA R1 Reference System for 5 MHz, 10 MHz, 20 MHz channel bandwidths, all AAI subframes in the Advanced Air Interface DL and UL Zones are Type 1 AAI subframes. The FDD frame structure is separated into two regions in the DL and UL for supporting the coexistence of R1 FDD/H-FDD MSs and AAI FDD MSs in the same frame. An ABS shall be able to simultaneously support FDD and H-FDD AMSs in the AAI DL/UL zone. The ABS also supports R1 FDD/H-FDD MSs in the WirelessMAN-OFDMA R1 Reference System DL/UL zone. For R1 H-FDD MSs, by using the "No. of OFDMA Symbols" field in DL-MAP1 and UL-MAP1 of the WirelessMAN-OFDMA R1 Reference System frame, the ABS shall indicate the number of symbols in DL and UL of the WirelessMAN-OFDMA R1 Reference System frame for non-overlapped allocation between the WirelessMAN-OFDMA R1 Reference System UL zone and the AAI UL zone. In addition, the data bursts for the R1 FDD/H-FDD MSs shall not be transmitted in the AAI DL zone.

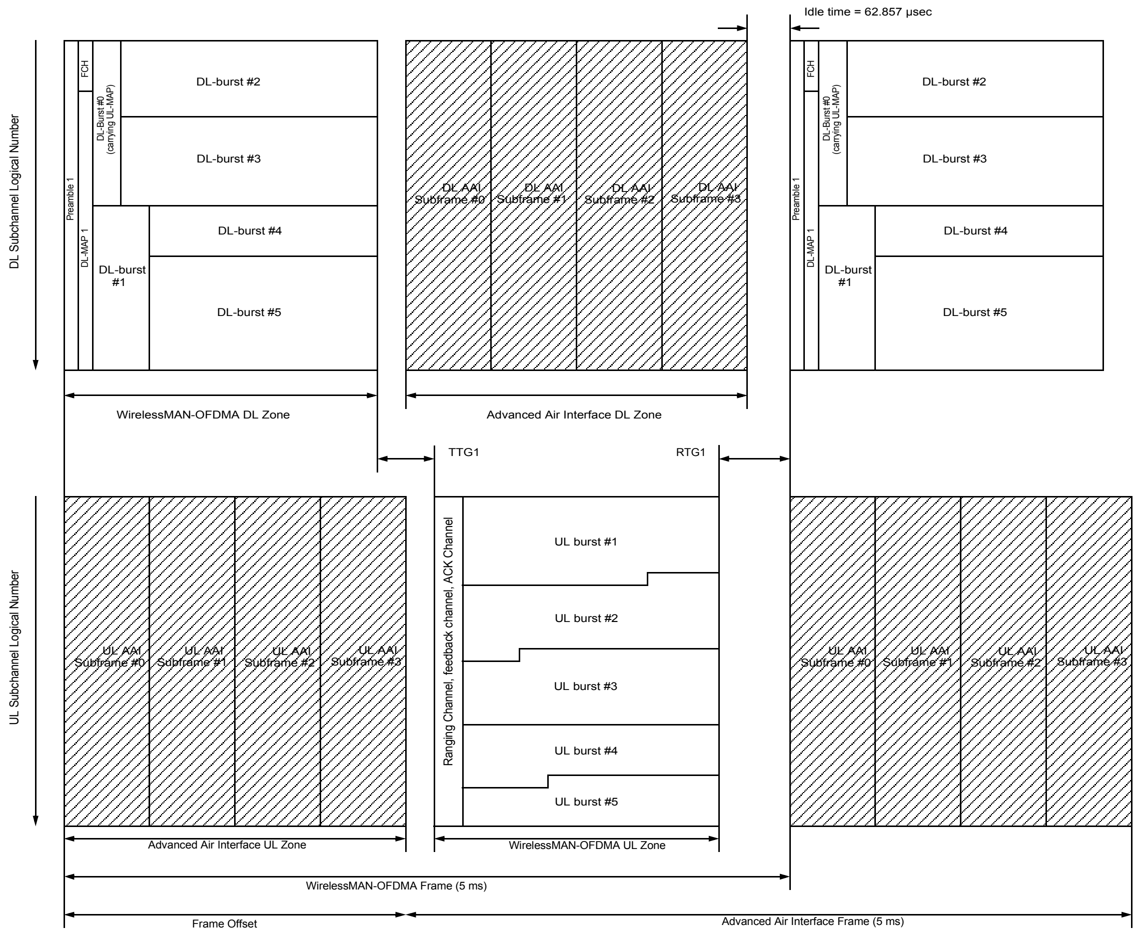


Figure 6-111—FDD frame configuration to support WirelessMAN-OFDMA FDD/H-FDD operation (e.g., 5 MHz, 10 MHz, and 20 MHz with 1/8 Tb CP)

6.3.3.6 Frame structure supporting wider bandwidth

The same frame structure (6.3.3.1, 6.3.3.2, 6.3.3.3) is used for each carrier in multicarrier mode operation. Each carrier shall have its own superframe header. Figure 6-112 illustrates the example of the frame structure to support multicarrier operation. For FDD UL, the preamble and superframe headers are replaced with traffic OFDMA symbols.

The multiple carriers involved in multicarrier operation may be in a contiguous or non-contiguous spectrum. When carriers are in the same spectrum and adjacent and when the separation of center frequency between two adjacent carriers is multiples of subcarrier spacing, no guard subcarriers are necessary between adjacent carriers.

Each AMS is controlled through an RF carrier that is the primary carrier. When a multicarrier feature is supported, the system may define and utilize additional RF carriers to improve the user experience and QoS or provide services through additional RF carriers configured or optimized for specific services. These additional RF carriers are the secondary carriers. The detailed description of the multicarrier operation can be found in 6.2.8.

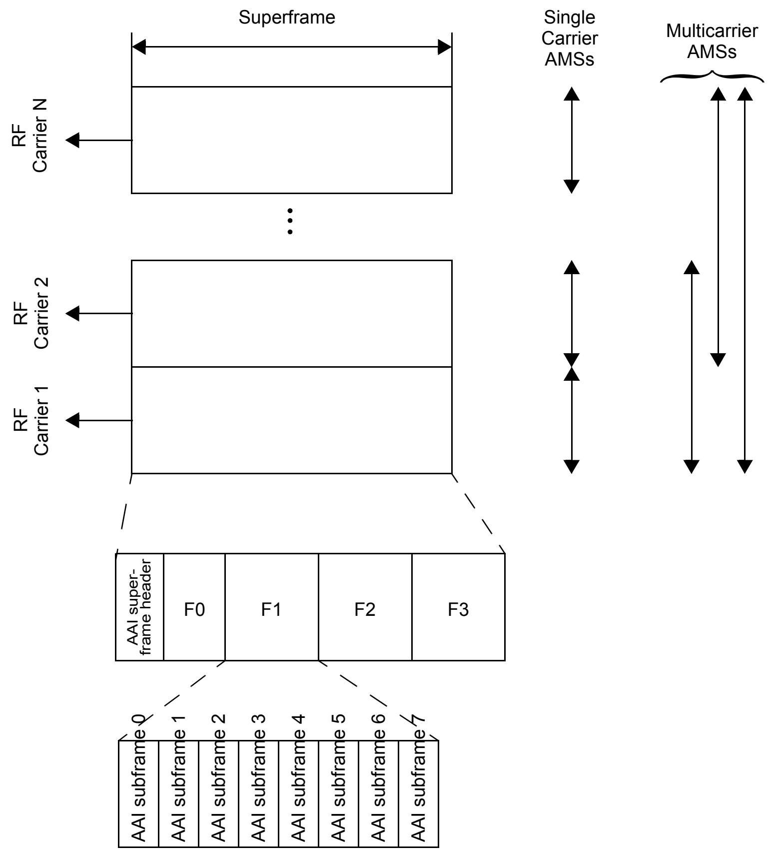


Figure 6-112—Example of the frame structure to support multicarrier operation

6.3.3.6.1 Support for WirelessMAN-OFDMA R1 Reference System with multicarrier operation

In the multicarrier mode supporting the WirelessMAN-OFDMA R1 Reference System, each carrier can have either a basic frame structure (6.3.3.2.2) or a basic frame structure configured to support the WirelessMAN-OFDMA R1 Reference System (6.3.3.5.1). Figure 6-113 illustrates an example of the frame structure in the multicarrier mode supporting the WirelessMAN-OFDMA R1 Reference System. In the multicarrier mode, to support the WirelessMAN-OFDMA R1 Reference System, the uplink can be also configured as TDM as defined in 6.3.3.5.

Multicarrier operation is only performed between Advanced Air Interface (AAI) subframes over different carriers that belong to the same ABS. No multicarrier operation is defined between the Advanced Air Interface subframes and WirelessMAN-OFDMA R1 Reference System frames.

When two adjacent carriers both contain AAI zone and WirelessMAN-OFDMA R1 Reference System zone (e.g., RF Carrier 2 in Figure 6-113), the FRAME_OFFSET, UL support configuration (i.e., TDM or FDM), DL/UL ratio, and CP length applied in each of these two carriers shall be the same. The frame configuration of another carrier is informed by the S-SFH SP1 in the AAI-MC-ADV and AAI-NBR-ADV messages.

Furthermore, the guard subcarriers in the UL frame structure to support the WirelessMAN-OFDMA R1 Reference System PUSC FDM mode shall not be used in this case.

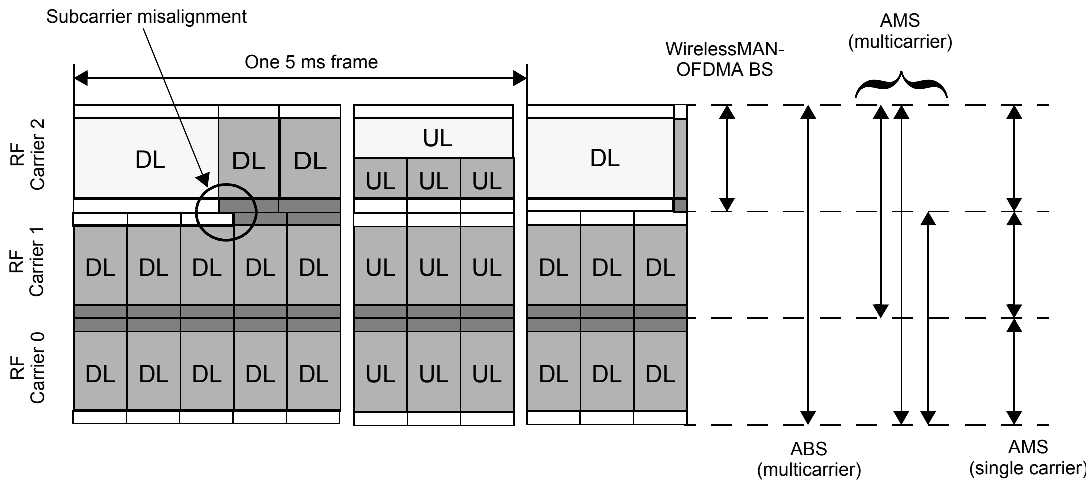


Figure 6-113—Example of the frame structure to support WirelessMAN-OFDMA with multicarrier operation

6.3.3.6.2 Subcarrier alignment for multicarrier operation

In order to align the overlapped subcarriers of the OFDMA signals transmitted over adjacent carriers, a permanent frequency offset (Δf_c) will be applied over the original center frequency. The basic principle is shown by the example in Figure 6-114. A carrier group is defined as the set of contiguous carriers whose subcarriers are aligned with a subcarrier spacing, Δf.

When contiguous carriers only contain AAI zone and are involved in multicarrier operation, the overlapped subcarriers should be aligned in the frequency domain.

When one carrier contains both AAI zone and WirelessMAN-OFDMA R1 Reference System zone while its adjacent carrier only contains AAI zone, the overlapped subcarriers should be aligned. The center frequency of the carrier that contains both AAI zone and WirelessMAN-OFDMA R1 Reference System zone shall exactly locate on the channel raster grid.

ABSs may have different configurations according to the available spectrum resources and the restriction due to support of WirelessMAN-OFDMA R1 Reference System zone. When two adjacent carriers both contain AAI zone and WirelessMAN-OFDMA R1 Reference System zone, the overlapped subcarriers may not be aligned. If the AMS cannot support carrier aggregation due to hardware restriction under subcarrier misalignment configuration, the AMS shall inform the ABS which carriers it can simultaneously process through the AAI-MC-REQ message.

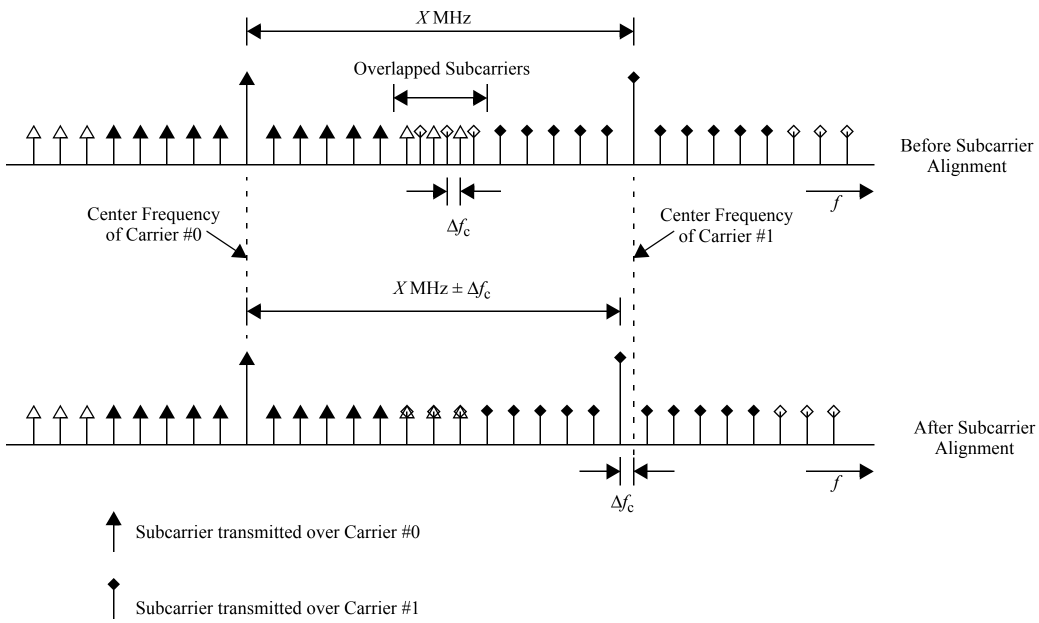


Figure 6-114—Example of subcarrier alignment of adjacent carriers

During the network entry procedure (defined in 6.2.8.2.3), the AMS is notified of the frequency offset to be applied over each carrier for subcarrier alignment through an AAI-Global-CFG message. According to the center frequency of the first carrier in each carrier group, frequency offset Δf_c, bandwidth, and the Physical Carrier Index in the AAI-Global-CFG message and the AAI-MC-ADV message, the AMS derives the center frequency of the available carriers by the associated frequency offset Δf_c. The frequency offsets specified in the AAI-Global-CFG message are calculated based on Equation (186):

$$\Delta f_c = \begin{cases} |f_c' - f_{c,r}| \bmod \Delta f, & \text{if } 0.5\Delta f \geq |f_c' - f_{c,r}| \bmod \Delta f \\ -\Delta f + (|f_c' - f_{c,r}| \bmod \Delta f), & \text{if } 0.5\Delta f < |f_c' - f_{c,r}| \bmod \Delta f \end{cases} \tag{186}$$

where f_c' is the center frequency of the carrier before applying frequency offset Δf_c and $f_{c,r}$ is the center frequency of the reference carrier in each carrier group. The center frequency of the reference carrier in each carrier group is always located on the channel raster grid.

The center frequency shifted is derived as follows in Equation (187):

$$f_c = \begin{cases} f_c' - \Delta f_c, & \text{if } f_c' \geq f_{c,r} \\ f_c' + \Delta f_c, & \text{if } f_c' < f_{c,r} \end{cases} \tag{187}$$

Note that the absolute value of the frequency offset Δf_c is smaller than the subcarrier spacing value depicted in Figure 6-114.

In Table 6-151, a look-up table is defined to indicate the configurations for a carrier group. If the network supports multiple carrier groups, the AAI-Global-CFG message separately indicates each carrier group by referring to the index of this table. For example, the multicarrier configuration {5, 10} indicates two contiguous carriers are supported. The first one is a 5 MHz carrier, and the other one is a 10 MHz carrier, where the order in this configuration is sorted from lower frequency to higher frequency.

Based on the center frequency of the first carrier in each carrier group and the bandwidth of each carrier that an AMS received from the AAI-Global-CFG message, the center frequency of each carrier before subcarrier alignment can be derived. Then the AMS can obtain the frequency offset Δf_c to be applied over each carrier from the AAI-Global-CFG message so that the AMS can obtain the correct center frequency of each carrier including the subcarrier alignment effect.

When two adjacent, but subcarrier non-aligned carriers, both contain AAI zone and WirelessMAN-OFDMA R1 Reference System zone, they are included in different carrier groups in the AAI-Global-CFG message. The ABS and the AMS shall be capable of encoding and decoding each multicarrier configuration depicted in Table 6-150 and apply the corresponding frequency offset before activating multicarrier operations.

6.3.3.6.3 Data transmission over guard subcarriers in multicarrier operation

When contiguous carriers are involved in multicarrier operation, the guard subcarriers between contiguous frequency channels may be utilized for data transmission. During the secondary carrier assignment procedure defined in 6.2.8.2.3.2, the ABS will notify the information on available guard subcarriers eligible for data transmission to the AMS.

Table 6-150—Multicarrier configuration index

Index	Multicarrier configuration (MHz)	Frequency offset Δf (kHz)
1	{5}	{0}
2	{7}	{0}
3	{8.75}	{0}
4	{10}	{0}
5	{20}	{0}
6	{10, 10}	{0, –3.125}
7	{20, 20}	{0, –6.25}
8~64	*Reserved*	*Reserved*

6.3.3.7 Set of frame configurations

Table 6-151, Table 6-152, and Table 6-153 show sets of the frame configurations and indexing for 5/10/20 MHz, 8.75 MHz, and 7 MHz, respectively. Note that per each combination of bandwidth and CP length, frame configuration information is carried by frame configuration index in S-SFH SP1 IE in Table 6-182.

The frame structure supporting the WirelessMAN-OFDMA R1 Reference System frame defined in 6.3.3.5.1shall be configured with one of the following configuration numbers (i.e., "No." in the tables): 11 to 22 and 26 to 36 in Table 6-151 for 5/10/20 MHz channel bandwidths; 9 to 15 in Table 6-152 for 8.75 MHz channel bandwidth; 7 to 9 in Table 6-153 for 7 MHz channel bandwidth. In this case, DL offset and DL length denote Frame_Offset and the number of DL AAI subframes dedicated to Advanced Air Interface operations, respectively. UL length denotes the number of UL AAI subframes dedicated to Advanced Air Interface operations.

When supporting the WirelessMAN-OFDMA R1 Reference System, for the case when UL length is less than the total number of UL AAI subframes in a frame, the UL TDM mode defined in 6.3.3.5.1 is applied. For the case when UL length is the same as the total number of UL AAI subframes in a frame, the UL FDM mode defined in 6.3.3.5.1 is applied.

PA-Preamble index 10 and the frame configuration index corresponding to an FDD mode shall be applied to a partially configured carrier.

Table 6-151—Frame configuration and indexing (5/10/20 MHz channel bandwidth)

No	BW	CP	Frame configuration index	Duplex	D:U	Subframe provision			AAI subframe type								TTG/ RTG (µs)
						DL Offset	DL Length	UL Length	#0	#1	#2	#3	#4	#5	#6	#7	
1	5/10/20	1/16	0	TDD	6:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type2	82.853 / 60
2	5/10/20	1/16	1	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type2	82.853 / 60
3	5/10/20	1/16	2	TDD	4:4	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	UL Type2	82.853 / 60
4	5/10/20	1/16	3	TDD	3:5	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	UL Type1	UL Type1	UL Type1	UL Type1	UL Type2	82.853 / 60
5	5/10/20	1/16	4	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type2	N/A
6	5/10/20	1/16	5	TDD	6:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type2	179.996 / 60
7	5/10/20	1/16	6	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type3	DL Type3	UL Type1	UL Type1	UL Type2	275.139 / 60
8	5/10/20	1/8	0	TDD	6:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	105.714 / 60
9	5/10/20	1/8	1	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	UL Type1	105.714 / 60
10	5/10/20	1/8	2	TDD	4:4	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	UL Type1	UL Type1	105.714 / 60
11	5/10/20	1/8	3	TDD	3:5	N/A	N/A	N/A	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	UL Type1	UL Type1	UL Type1	105.714 / 60
12	5/10/20	1/8	4	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	N/A
13	5/10/20	1/8	5	TDD	5:3	3	2	3	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	Not used	Not Used	Not Used	105.714 / 60
14	5/10/20	1/8	6	TDD	5:3	3	2	1	DL Type1	DL Type1	Not Used	Not Used	UL Type1	Not used	Not Used	Not Used	105.714 / 60
15	5/10/20	1/8	7	TDD	5:3	2	3	3	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
16	5/10/20	1/8	8	TDD	5:3	2	3	2	DL Type1	DL Type1	DL Type1	Not Used	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
17	5/10/20	1/8	9	TDD	5:3	2	2	3	DL Type1	DL Type1	Not used	UL Type1	UL Type1	UL Type1	Not used	Not Used	105.714 / 60
18	5/10/20	1/8	10	TDD	5:3	2	2	1	DL Type1	DL Type1	Not used	Not used	Not Used	UL Type1	Not Used	Not Used	105.714 / 60
19	5/10/20	1/8	11	TDD	5:3	1	4	3	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	Not Used	105.714 / 60
20	5/10/20	1/8	12	TDD	5:3	1	4	2	DL Type1	DL Type1	DL Type1	DL Type1	Not Used	UL Type1	UL Type1	Not Used	105.714 / 60
21	5/10/20	1/8	13	TDD	5:3	1	3	3	DL Type1	DL Type1	DL Type1	Not used	UL Type1	UL Type1	UL Type1	Not Used	105.714 / 60
22	5/10/20	1/8	14	TDD	5:3	1	3	2	DL Type1	DL Type1	DL Type1	Not used	Not used	UL Type1	UL Type1	Not Used	105.714 / 60
23	5/10/20	1/8	15	TDD	5:3	1	2	3	DL Type1	DL Type1	Not used	Not used	UL Type1	UL Type1	UL Type1	Not Used	105.714 / 60
24	5/10/20	1/8	16	TDD	5:3	1	2	1	DL Type1	DL Type1	Not used	Not used	Not used	Not used	UL Type1	Not Used	105.714 / 60
25	5/10/20	1/8	17	TDD	6:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type3	DL Type3	UL Type1	UL Type1	208.571 / 60
26	5/10/20	1/8	18	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type3	DL Type3	UL Type1	UL Type1	UL Type1	208.571 / 60
27	5/10/20	1/8	19	TDD	5:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type3	DL Type3	DL Type3	UL Type1	UL Type1	UL Type1	311.428 / 60

Table 6-151—Frame configuration and indexing (5/10/20 MHz channel bandwidth) *(continued)*

No	BW	CP	Frame configuration index	Duplex	D:U	Subframe provision			AAI subframe type								TTG/ RTG (μs)
						DL Offset	DL Length	UL Length	#0	#1	#2	#3	#4	#5	#6	#7	
28	5/10/20	1/8	20	TDD	5:3	2	1	3	DL Type2	Not Used	Not Used	UL Type1	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
29	5/10/20	1/8	21	TDD	5:3	1	1	3	DL Type2	Not Used	Not Used	Not Used	UL Type1	UL Type1	UL Type1	Not Used	105.714 / 60
30	5/10/20	1/8	22	TDD	6:2	1	1	2	DL Type2	Not Used	Not Used	Not Used	Not Used	UL Type1	UL Type1	Not Used	105.714 / 60
31	5/10/20	1/8	23	TDD	6:2	1	2	2	DL Type1	DL Type1	Not Used	Not Used	Not Used	UL Type1	UL Type1	Not Used	105.714 / 60
32	5/10/20	1/8	24	TDD	6:2	1	3	2	DL Type1	DL Type1	DL Type1	Not Used	Not Used	UL Type1	UL Type1	Not Used	105.714 / 60
33	5/10/20	1/8	25	TDD	6:2	1	4	2	DL Type1	DL Type1	DL Type1‘	DL Type1	Not Used	UL Type1	UL Type1	Not Used	105.714 / 60
34	5/10/20	1/8	26	TDD	6:2	1	5	2	DL Type1	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	Not Used	105.714 / 60
35	5/10/20	1/8	27	TDD	6:2	2	1	2	DL Type2	Not Used	Not Used	Not Used	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
36	5/10/20	1/8	28	TDD	6:2	2	2	2	DL Type1	DL Type1	Not Used	Not Used	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
37	5/10/20	1/8	29	TDD	6:2	2	3	2	DL Type1	DL Type1	DL Type1	Not Used	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
38	5/10/20	1/8	30	TDD	6:2	2	4	2	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	Not Used	Not Used	105.714 / 60
39	5/10/20	1/4	0	TDD	5:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1		139.988 / 60
40	5/10/20	1/4	1	TDD	4:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1		139.988 / 60
41	5/10/20	1/4	2	TDD	3:4	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	UL Type1		139.988 / 60
42	5/10/20	1/4	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type1		N/A

Table 6-152—Frame configuration and indexing (8.75 MHz channel bandwidth)

No	BW	CP	Frame configuration index	Duplex	D:U	Subframe provision			AAI subframe type								TTG/ RTG (μs)
						DL Offset	DL Length	UL Length	#0	#1	#2	#3	#4	#5	#6	#7	
1	8.75	1/16	0	TDD	5:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	DL Type1	UL Type1	UL Type2		138.4/ 74.4
2	8.75	1/16	1	TDD	4:3	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	UL Type1	UL Type1	UL Type2		138.4/ 74.4
3	8.75	1/16	2	TDD	3:4	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	UL Type1	UL Type1	UL Type1	UL Type2		138.4/ 74.4
4	8.75	1/16	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type2	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type2		N/A
5	8.75	1/8	0	TDD	5:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1		87.2/ 74.4
6	8.75	1/8	1	TDD	4:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1		87.2/ 74.4
7	8.75	1/8	2	TDD	3:4	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1	UL Type1		87.2/ 74.4
8	8.75	1/8	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type1	D/U Type2	D/U Type1	D/U Type1	D/U Type1		N/A
9	8.75	1/8	4	TDD	5:2	3	2	2	DL Type1	DL Type1	UL Type1	UL Type4	Not Used	Not Used	Not Used		87.2/ 74.4
10	8.75	1/8	5	TDD	5:2	3	2	1	DL Type1	DL Type1	Not Used	UL Type1	Not Used	Not Used	Not Used		87.2/ 74.4
11	8.75	1/8	6	TDD	5:2	2	3	2	DL Type1	DL Type1	DL Type1	UL Type1	UL Type4	Not Used	Not Used		87.2/ 74.4

Table 6-152—Frame configuration and indexing (8.75 MHz channel bandwidth) ***(continued)***

No	BW	CP	Frame configuration index	Duplex	D:U	Subframe provision			AAI subframe type								TTG/ RTG (µs)
						DL Offset	DL Length	UL Length	#0	#1	#2	#3	#4	#5	#6	#7	
12	8.75	1/8	7	TDD	5:2	2	3	1	DL Type1	DL Type1	DL Type1	Not Used	UL Type1	Not Used	Not Used		87.2/ 74.4
13	8.75	1/8	8	TDD	5:2	2	2	2	DL Type1	DL Type1	Not Used	UL Type1	UL Type4	Not Used	Not Used		87.2/ 74.4
14	8.75	1/8	9	TDD	5:2	2	2	1	DL Type1	DL Type1	Not Used	Not Used	UL Type1	Not Used	Not Used		87.2/ 74.4
15	8.75	1/8	10	TDD	5:2	2	1	2	DL Type2	Not Used	Not Used	UL Type1	UL Type4	Not Used	Not Used		87.2/ 74.4
16	8.75	1/4	0	TDD	4:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	DL Type1	UL Type1	UL Type1			189.6/ 74.4
17	8.75	1/4	1	TDD	3:3	N/A	N/A	N/A	DL Type1	DL Type2	DL Type1	UL Type1	UL Type1	UL Type1			189.6/ 74.4
18	8.75	1/4	2	TDD	2:4	N/A	N/A	N/A	DL Type1	DL Type2	UL Type1	UL Type1	UL Type1	UL Type1			189.6/ 74.4
19	8.75	1/4	3	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type2	D/U Type1	D/U Type2	D/U Type1	D/U Type2			N/A

Table 6-153—Frame configuration and indexing (7 MHz channel bandwidth)

No	BW	CP	Frame configuration index	Duplex	D:U	Subframe provision			AAI subframe Type								TTG/ RTG (µs)
						DL Offset	DL Length	UL Length	#0	#1	#2	#3	#4	#5	#6	#7	
1	7	1/16	0	TDD	4:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1			180/ 60
2	7	1/16	1	TDD	3:3	N/A	N/A	N/A	DL Type1	DL Type1	DL Type3	UL Type1	UL Type1	UL Type1			180/ 60
3	7	1/16	2	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1	D/U Type1			N/A
4	7	1/8	0	TDD	3:2	N/A	N/A	N/A	DL Type1	DL Type2	DL Type2	UL Type1	UL Type2				188/ 60
5	7	1/8	1	TDD	2:3	N/A	N/A	N/A	DL Type1	DL Type2	UL Type1	UL Type2	UL Type2				188/ 60
6	7	1/8	2	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type2	D/U Type2	D/U Type2	D/U Type2				N/A
7	7	1/8	3	TDD	3:2	1	2	2	DL Type1	DL Type1	UL Type1	UL Type1	Not Used				188/ 60
8	7	1/8	4	TDD	3:2	1	2	1	DL Type1	DL Type1	Not Used	UL Type1	Not Used				188/ 60
9	7	1/8	5	TDD	3:2	1	1	2	DL Type2	Not Used	UL Type1	UL Type1	Not Used				188/ 60
10	7	1/4	0	TDD	3:2	N/A	N/A	N/A	DL Type1	DL Type1	DL Type1	UL Type1	UL Type1				140/ 60
11	7	1/4	1	TDD	2:3	N/A	N/A	N/A	DL Type1	DL Type1	UL Type1	UL Type1	UL Type1				140/ 60
12	7	1/4	2	FDD	N/A	N/A	N/A	N/A	D/U Type1	D/U Type1	D/U Type2	D/U Type1	D/U Type1				N/A

6.3.4 Downlink physical structure

Each downlink AAI subframe is divided into four or fewer frequency partitions; each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the AAI subframe. Each frequency partition can include contiguous (localized) and/or non-contiguous (distributed) physical resource units. Each frequency partition can be used for different purposes such as fractional frequency reuse (FFR). Figure 6-115 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.

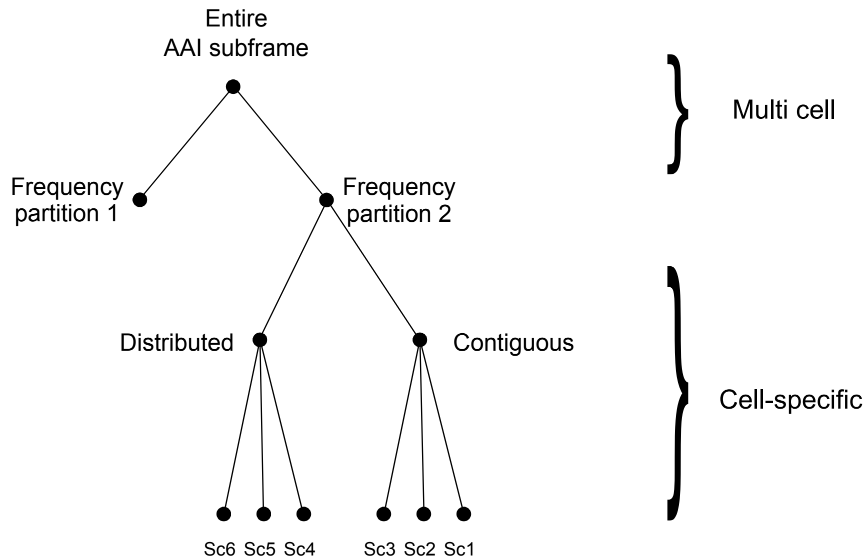


Figure 6-115—Example of downlink physical structure

6.3.4.1 Physical and logical resource unit

A physical resource unit (PRU) is the basic physical unit for resource allocation that comprises P_{sc} consecutive subcarriers by N_{sym} consecutive OFDMA symbols. P_{sc} is 18 subcarriers and N_{sym} is 6, 7, and 5 OFDMA symbols for Type 1, Type 2, and Type 3 AAI subframes, respectively. A logical resource unit (LRU) is the basic logical unit for distributed and contiguous resource allocations.

6.3.4.1.1 Distributed logical resource unit

The downlink distributed logical resource unit (DLRU) contains a group of subcarriers that are spread across the distributed resource allocations within a frequency partition. The minimum unit for forming the DLRU is equal to a pair of subcarriers, called a tone-pair, as defined in 6.3.4.3.2. The downlink DLRUs are obtained by subcarrier permuting on the data subcarriers of the distributed resource units (DRUs). The size of the DRU equals the size of PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols.

6.3.4.1.2 Contiguous logical resource unit

The contiguous logical resource unit (CLRU) contains a group of subcarriers that are contiguous across the localized resource allocations. CLRU consists of the data subcarriers only in the contiguous resource unit (CRU) of which size equals the size of the PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The CLRUs are obtained from direct mapping of CRUs. Two types of CLRUs, subband LRU (SLRU) and miniband LRU (NLRU), are supported according to the two types of CRUs, subband and miniband based CRUs, respectively.

6.3.4.2 Multi-cell resource mapping

6.3.4.2.1 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 number of subbands is denoted by K_{SB}. The number of PRUs allocated to subbands is denoted by L_{SB}, where $L_{SB} = N_1 \times K_{SB}$. A 5-, 4-, or 3-bit field called the Downlink Subband Allocation Count (*DSAC*) determines the value of K_{SB} depending on FFT size. The *DSAC* is transmitted in the SFH. The remaining PRUs are allocated to minibands. The number of minibands in an allocation is denoted by K_{MB}. The number of PRUs allocated to minibands is denoted by L_{MB}, where $L_{MB} = N_2 \times K_{MB}$. The total number of PRUs is denoted as N_{PRU}, where $N_{PRU} = L_{SB} + L_{MB}$. The maximum number of subbands that can be formed is denoted as N_{sub}, where $N_{sub} = \lfloor N_{PRU}/N_1 \rfloor$.

Table 6-154 through Table 6-156 show the mapping between *DSAC* and K_{SB} for FFT sizes of 2048, 1024, and 512, respectively.

For those system bandwidths in the range of [10, 20], the relation between the system bandwidth and supported number of N_{PRU} is listed in Table 6-148. The mapping between *DSAC* and K_{SB} is based on Table 6-154, the maximum valid value of K_{SB} is $N_{PRU}/4–3$.

For those system bandwidths in the range of [5, 10], the relation between the system bandwidth and supported number of N_{PRU} is listed in Table 6-149. The mapping between *DSAC* and K_{SB} is based on Table 6-155, the maximum valid value of K_{SB} is $N_{PRU}/4–2$.

Table 6-154—Mapping between *DSAC* and K_{SB} for 2048 FFT size

DSAC	Number of subbands allocated (K_{SB})	*DSAC*	Number of subbands allocated (K_{SB})
0	0	16	16
1	1	17	17
2	2	18	18
3	3	19	19
4	4	20	20
5	5	21	21
6	6	22	N/A
7	7	23	N/A
8	8	24	N/A
9	9	25	N/A
10	10	26	N/A
11	11	27	N/A
12	12	28	N/A
13	13	29	N/A
14	14	30	N/A
15	15	31	N/A

Table 6-155—Mapping between *DSAC* and K_{SB} for 1024 FFT size

DSAC	Number of subbands allocated (K_{SB})	*DSAC*	Number of subbands allocated (K_{SB})
0	0	8	8
1	1	9	9
2	2	10	10
3	3	11	N/A
4	4	12	N/A
5	5	13	N/A
6	6	14	N/A
7	7	15	N/A

Table 6-156—Mapping between *DSAC* and K_{SB} for 512 FFT size

DSAC	Number of subbands allocated (K_{SB})	*DSAC*	Number of subbands allocated (K_{SB})
0	0	4	4
1	1	5	N/A
2	2	6	N/A
3	3	7	N/A

PRUs are partitioned and reordered into two groups: subband PRUs and miniband PRUs, denoted by PRU_{SB} and PRU_{MB}, respectively. The set of PRU_{SB} is numbered from 0 to (L_{SB} – 1). The set of PRU_{MB} is numbered from 0 to (L_{MB} – 1). Equation (188) defines the mapping of PRUs to PRU_{SB}s. Equation (189) defines the mapping of PRUs to PRU_{MB}s. Figure 6-116 illustrates the mapping from PRU to PRU_{SB} and PRU_{MB} for a 10 MHz bandwidth with K_{SB} equal to 7.

$$PRU_{SB}[j] = PRU[i]; \quad j = 0, 1, \ldots, L_{SB} - 1 \tag{188}$$

where

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

where

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

$$PRU_{MB}[k] = PRU[i];k = 0, 1, \ldots, L_{MB} - 1 \tag{189}$$

where

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

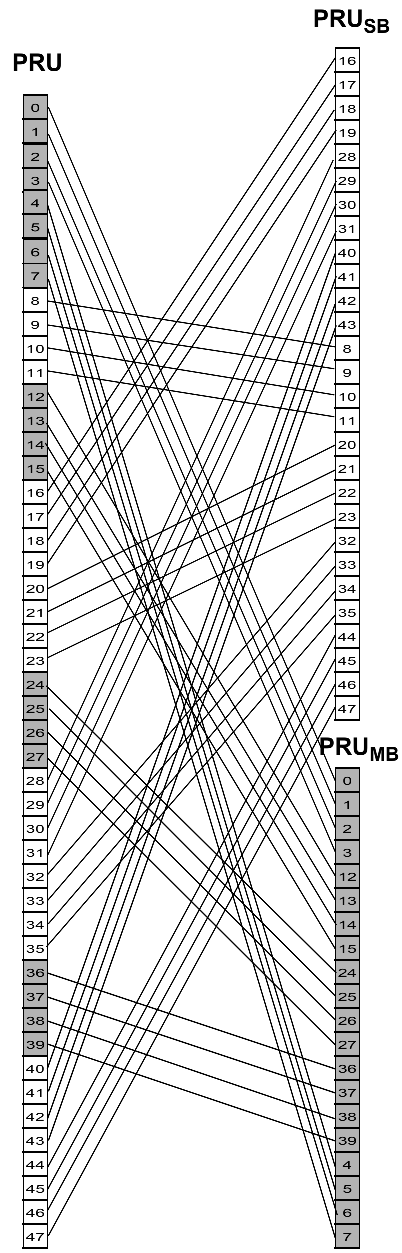


Figure 6-116—PRU to PRU_{SB} and PRU_{MB} mapping for BW = 10 MHz, K_{SB} = 7

6.3.4.2.2 Miniband permutation

The miniband permutation maps the PRU_{MB}s to Permuted PRU_{MB}s ($PPRU_{MB}$s) to ensure frequency diverse PRUs are allocated to each frequency partition. Equation (190) describes the mapping from PRU_{MB} to $PPRU_{MB}$s:

$$PPRU_{MB}[j] = PRU_{MB}[i]; j = 0, 1, \ldots, L_{MB} - 1 \tag{190}$$

where

$$i = (q(j)\mathrm{mod}(D)) \cdot P + \left\lfloor \frac{q(j)}{D} \right\rfloor$$

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

$$r(j) = \max(j - (K_{MB}\mathrm{mod}(P) \cdot D), 0)$$

$$q(j) = j + \left\lfloor \frac{r(j)}{D-1} \right\rfloor$$

$$D = \left\lfloor \frac{K_{MB}}{P} + 1 \right\rfloor$$

Figure 6-117 depicts the mapping from PRUs to PRU_{SB} and $PPRU_{MB}$.

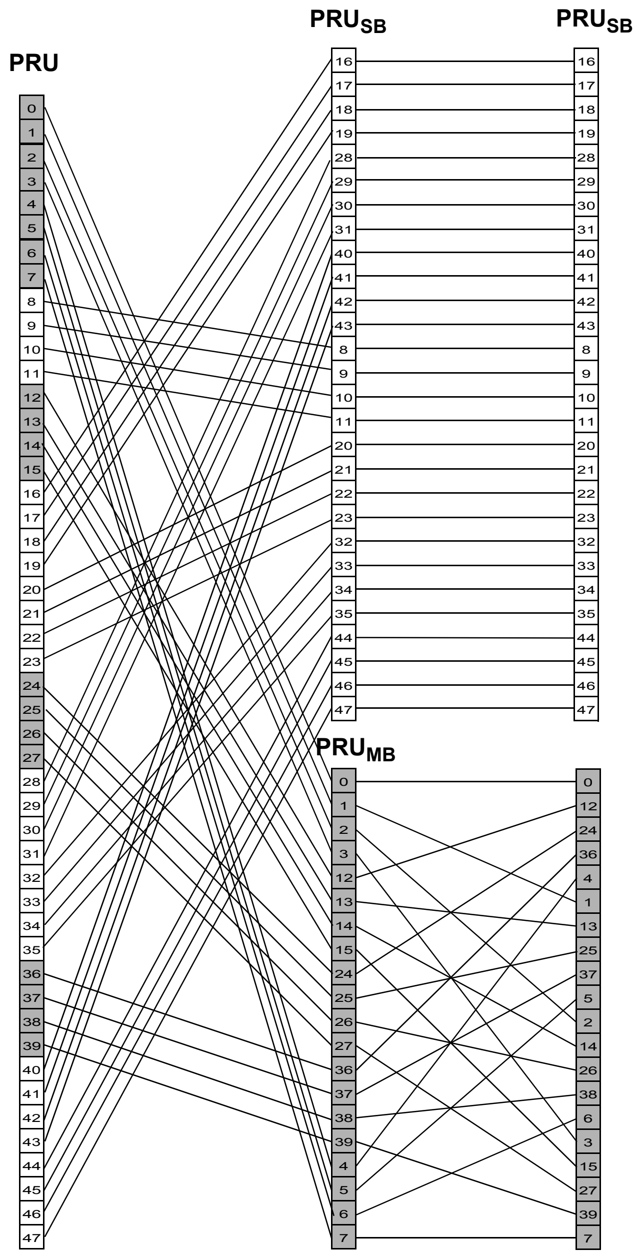


Figure 6-117—Mapping from PRUs to PRU_{SB} and PRU_{MB} mapping for BW = 10 MHz, K_{SB} = 7

6.3.4.2.3 Frequency partitioning

The PRU_{SB}s and $PPRU_{MB}$s are allocated to one or more frequency partitions. By default, only one partition is present. The maximum number of frequency partitions is 4. The frequency partition configuration is transmitted in the SFH in a 4- or 3-bit field called the Downlink Frequency Partition Configuration (*DFPC*) depending on FFT size. The Frequency Partition Count (*FPCT*) defines the number of frequency partitions.

The Frequency Partition Size (FPS_i) defines the number of PRUs allocated to the i-th frequency partition, FP_i. *FPCT,* and FPS_i are determined from the *DFPC* as shown in Table 6-157 through Table 6-159. A 3-, 2-, or 1-bit field called the Downlink Frequency Partition Subband Count (*DFPSC*) defines the number of subbands allocated to FP_i, $i > 0$.

Table 6-157—Mapping between *DFPC* and frequency partitioning for 2048 FFT size

DFPC	**Freq. Partitioning (FP_0:FP_1:FP_2:FP_3)**	***FPCT***	FPS_0	FPS_i **($i > 0$)**
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$FPS_1 = N_{PRU} - 2 \times \text{floor}(N_{PRU}/3)$ $FPS_2 = \text{floor}(N_{PRU}/3)$ $FPS_3 = \text{floor}(N_{PRU}/3)$
2	1 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/4)$	$\text{floor}(N_{PRU}/4)$
3	3 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/6)$	$\text{floor}(N_{PRU}/6)$
4	5 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/8)$	$\text{floor}(N_{PRU}/8)$
5	9 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/12)$	$\text{floor}(N_{PRU}/12)$
6	9 : 5 : 5 : 5	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU} \times 5/24)$	$\text{floor}(N_{PRU} \times 5/24)$
7	0 : 1 : 1 : 0	2	0	$N_{PRU}/2$ for $i = 1, 2$ 0 for $i = 3$
8	1 : 1 : 1 : 0	3	$N_{PRU} - 2 \times \text{floor}(N_{PRU}/3)$	$\text{floor}(N_{PRU}/3)$ for $i = 1, 2$ 0 for $i = 3$
9–15	*Reserved*			

The number of subbands in the i-th frequency partition is denoted by $K_{SB,FPi}$. The number of minibands is denoted by $K_{MB,FPi}$, which is determined by the FPS_i and *DFPSC* fields. When $DFPC = 0$, the *DFPSC* must be equal to 0. The number of subband PRUs in each frequency partition is denoted by $L_{SB,FPi}$, which is given by $L_{SB,FPi} = N_1 \times K_{SB,FPi}$. The number of miniband PRUs in each frequency partition is denoted by $L_{MB,FPi}$, which is given by $L_{MB,FPi} = N_2 \times K_{MB,FPi}$. The number of subbands for each frequency partition is given by Equation (191).

$$K_{SB,FP_i} = \begin{cases} K_{SB} - (FPCT - 1) \cdot DFPSC & i = 0,\ FPCT = 4 \\ DFPSC & i > 0,\ FPCT = 4 \\ DFPSC & i > 0,\ FPCT = 3,\ DFPC = 1 \\ K_{SB} - (FPCT - 1) \cdot DFPSC & i = 0,\ FPCT = 3,\ DFPC \neq 1 \\ DFPSC & i = 1,2,\ FPCT = 3,\ DFPC \neq 1 \\ DFPSC & i = 1,2,\ FPCT = 2 \\ K_{SB} & i = 0,\ FPCT = 1 \\ 0 & \text{Otherwise} \end{cases} \quad (191)$$

When $FPCT = 2$, *DFPSC* shall be $K_{SB}/2$. (192)

Table 6-158—Mapping between *DFPC* and frequency partitioning for 1024 FFT size

DFPC	Freq. Partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i (i>0)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$FPS_1 = N_{PRU} - 2 \times \text{floor}(N_{PRU}/3)$ $FPS_2 = \text{floor}(N_{PRU}/3)$ $FPS_3 = \text{floor}(N_{PRU}/3)$
2	1 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/4)$	$\text{floor}(N_{PRU}/4)$
3	3 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/6)$	$\text{floor}(N_{PRU}/6)$
4	5 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/8)$	$\text{floor}(N_{PRU}/8)$
5	9 : 5 : 5 : 5	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU} \times 5/24)$	$\text{floor}(N_{PRU} \times 5/24)$
6	0 : 1 : 1 : 0	2	0	$N_{PRU}/2$ for $i = 1, 2$ 0 for $i = 3$
7	1 : 1 : 1 : 0	3	$N_{PRU} - 2 \times \text{floor}(N_{PRU}/3)$	$\text{floor}(N_{PRU}/3)$ for $i = 1, 2$ 0 for $i = 3$

Table 6-159—Mapping between *DFPC* and frequency partitioning for 512 FFT size

DFPC	Freq. Partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i (i>0)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$N_{PRU}/3$
2	1 : 1 : 1 : 1	4	$N_{PRU}/4$	$N_{PRU}/4$
3	3 : 1 : 1 : 1	4	$N_{PRU}/2$	$N_{PRU}/6$
4	9 : 5 : 5 : 5	4	$N_{PRU} \times 3/8$	$N_{PRU} \times 5/24$
5	0 : 1 : 1 : 0	2	0	$N_{PRU}/2$ for $i = 1, 2$ 0 for $i = 3$
6	1 : 1 : 1 : 0	3	$N_{PRU}/3$	$N_{PRU}/3$ for $i = 1, 2$ 0 for $i = 3$
7	*Reserved*			

The number of minibands for each frequency partition is given by Equation (193).

$$K_{MB,FP_i} = (FPS_i - K_{SB,FPi} \cdot N_1)/N_2 \qquad 0 \le i < 4 \tag{193}$$

The mapping of subband PRUs and miniband PRUs to the frequency partition i is given by Equation (194).

$$PRU_{FP_i}(j) = \begin{cases} PRU_{SB}(k_1) & \text{for } 0 \le j < L_{SB,FP_i} \\ PPRU_{MB}(k_2) & \text{for } L_{SB,FP_i} \le j < (L_{SB,FP_i} + L_{MB,FP_i}) \end{cases} \tag{194}$$

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 6-118 depicts the frequency partitioning for BW = 10 MHz, K_{SB} = 7, $FPCT$ = 4, $FPS_0 = FPS_i$ = 12, and $DFPSC$ = 2.

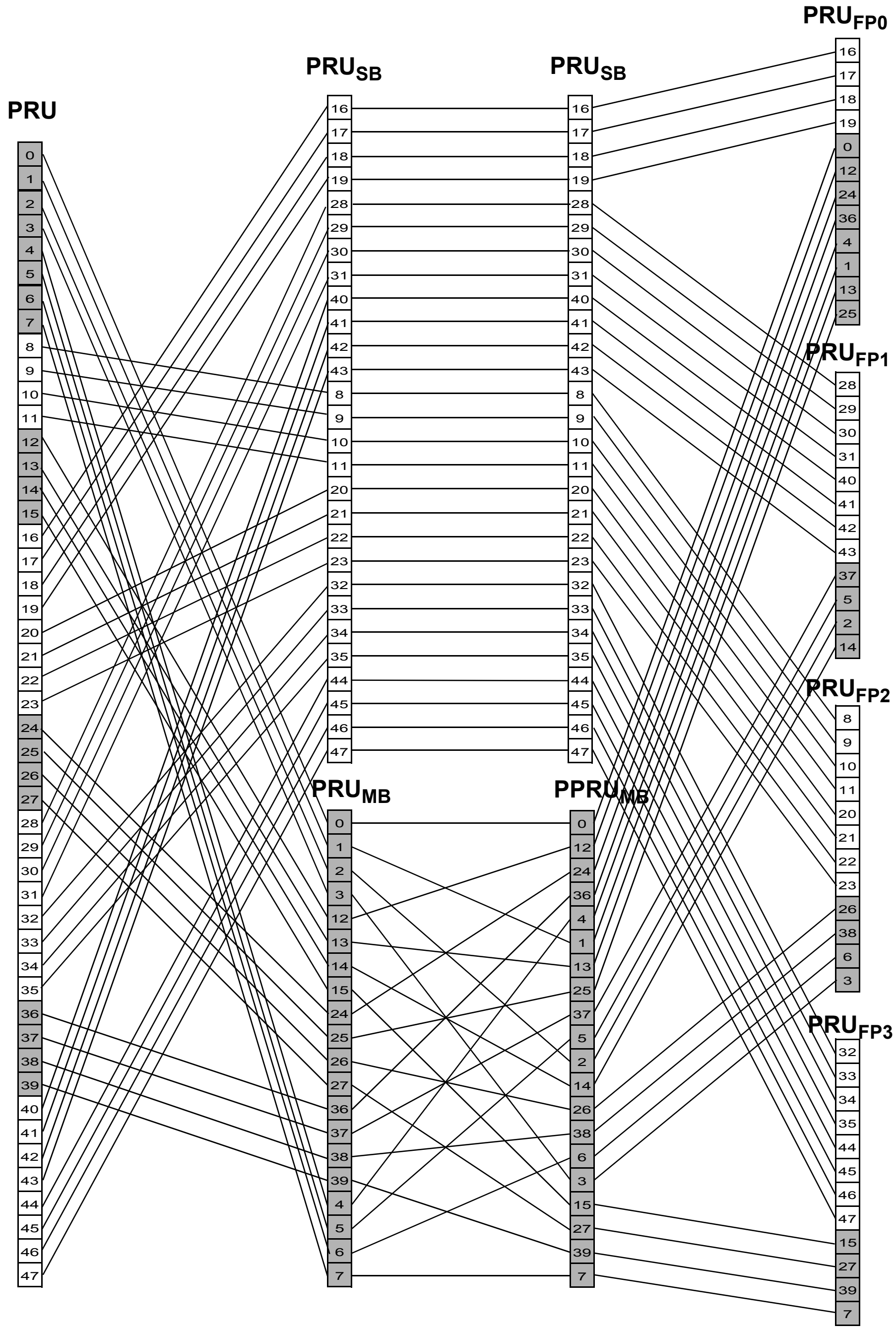


Figure 6-118—Frequency partition for *BW* = 10 MHz, K_{SB} = 7, *FPCT* = 4, $FPS_0 = FPS_i$ = 12, and *DFPSC* = 2

6.3.4.3 Cell-specific resource mapping

PRU_{FPi}s are mapped to LRUs. All further PRU and subcarrier permutations are constrained to the PRUs of a frequency partition.

6.3.4.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector-specific basis. Let $L_{SB\text{-}CRU,\ FPi}$ and $L_{MB\text{-}CRU,\ FPi}$ denote the number of allocated subband CRUs and miniband CRUs for FP_i ($i \geq 0$). The number of total allocated subband and miniband CRUs, in units of a subband (i.e., N_1 PRUs), for FP_i ($i \geq 0$) is given by the downlink CRU allocation size, $DCAS_i$. The numbers of subband-based and miniband-based CRUs in FP_0 are given by $DCAS_{SB,0}$ and $DCAS_{MB,0}$, in units of a subband and miniband, respectively. When $DFPC = 0$, $DCAS_i$ must be equal to 0.

For FP_0, the value of $DCAS_{SB,0}$ is explicitly signaled in the SFH as a 5-, 4-, or 3-bit field to indicate the number of subbands in unsigned-binary format. $DCAS_{SB,0} \leq K_{SB,\ FPi}$. A 5-, 4-, or 3-bit Downlink miniband-based CRU allocation size ($DCAS_{MB,0}$) is sent in the SFH only for partition FP_0, depending on FFT size. The number of subband-based CRUs for FP_0 is given by the Equation (195).

$$L_{SB-CRU,FP_0} = N_1 \times DCAS_{SB,0} \tag{195}$$

The mapping between $DCAS_{MB,0}$ and the number of miniband-based CRUs for FP_0 is shown in Table 6-160 through Table 6-162 for FFT sizes of 2048, 1024, and 512, respectively.

For those system bandwidths in the range of [10, 20], the mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 is based on Table 6-160, the maximum valid value of $L_{MB\text{-}CRU,\ FP0} <$ floor($88 \times N_{PRU}/96$).

For those system bandwidths in the range of [5, 10], the mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 is based on Table 6-161, the maximum valid value of $L_{MB\text{-}CRU,\ FP0} <$ floor($42 \times N_{PRU}/48$).

Table 6-160—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 2048 FFT size

$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e., $L_{MB\text{-}CRU,\ FP0}$)	$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e., $L_{MB\text{-}CRU,\ FP0}$)
0	0	16	28
1	2	17	32
2	4	18	36
3	6	19	40
4	8	20	44
5	10	21	48
6	12	22	52
7	14	23	56
8	16	24	60
9	18	25	64
10	19	26	68
11	20	27	72

Table 6-160—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 2048 FFT size *(continued)*

$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e., $L_{MB\text{-}CRU,\ FP0}$)	$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e., $L_{MB\text{-}CRU,\ FP0}$)
12	21	28	76
13	22	29	80
14	23	30	84
15	24	31	88

Table 6-161—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 1024 FFT size

$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e., $L_{MB\text{-}CRU,\ FP0}$)	$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e., $L_{MB\text{-}CRU,\ FP0}$)
0	0	8	16
1	2	9	18
2	4	10	20
3	6	11	22
4	8	12	24
5	10	13	38
6	12	14	40
7	14	15	42

Table 6-162—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 512 FFT size

$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e., $L_{MB\text{-}CRU,\ FP0}$)	$DCAS_{MB,0}$	Number of miniband-based CRU for FP_0 (i.e., $L_{MB\text{-}CRU,\ FP0}$)
0	0	4	8
1	2	5	10
2	4	6	18
3	6	7	20

For $FP_i(i > 0, FPCT \neq 2)$,only one value DCAS-i is explicitly signaled for all $DCAS_i$ ($i > 0$) in the SFH as a 3-, 2-, or 1-bit field to signal the same numbers of allocated CRUs for $FP_i(i > 0, FPCT \neq 2)$.

For $FP_i(i > 0, FPCT \neq 2)$, the number of subband CRUs ($L_{SB\text{-}CRU,FPi}$) and miniband CRUs ($L_{MB\text{-}CRU,FPi}$) are derived using Equation (196) and Equation (197), respectively.

$$L_{SB-CRU, FPi} = N_1 \cdot (\min)\{DCAS_i, K_{SB, FPi}\} \tag{196}$$

$$L_{MB-CRU, FPi} = \begin{cases} 0, & DCAS_i \le K_{SB, FPi} \\ (DCAS_i - K_{SB, FPi}) \cdot N_1 & DCAS_i > K_{SB, FPi} \end{cases} \tag{197}$$

When $FPCT = 2$, $DCAS_{SB,i}$ and $DCAS_{MB,i}$ for $i = 1$ and 2 are signaled using the $DCAS_{SB,0}$ and $DCAS_{MB,0}$ fields in the SFH. Since FP_0 and FP_3 are empty, $L_{SB\text{-}CRU,FP0} = L_{MB\text{-}CRU,FP0} = L_{DRU,FP0} = 0$ and $L_{SB\text{-}CRU,FP3} = L_{MB\text{-}CRU,FP3} = L_{DRU,FP3} = 0$. For $i = 1$ and 2, $L_{SB\text{-}CRU,FPi} = N_1 * DCAS_{SB,0}$ and $L_{MB\text{-}CRU,FPi}$ is obtained from $DCAS_{MB,0}$ using the mapping in Table 6-160 through Table 6-162 for FFT sizes of 2048, 1024, and 512, respectively.

The total number of CRUs in frequency partition FP_i, for $0 \le i < 4$, is denoted by $L_{CRU,FPi}$, where

$$L_{CRU, FPi} = L_{SB-CRU, FPi} + L_{MB-CRU, FPi} \tag{198}$$

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

$$L_{DRU, FPi} = FPS_i - L_{CRU, FPi} \tag{199}$$

and FPS_i is the number of PRUs allocated to FP_i.

The mapping from PRU_{FPi} to CRU_{FPi} is given by Equation (200).

$$CRU_{FPi}[j] = \begin{cases} PRU_{FPi}[j], & 0 \le j < L_{SB-CRU, FPi} \\ PRU_{FPi}[k + L_{SB-CRU, FPi}], & L_{SB-CRU, FPi} \le j < L_{CRU, FPi} \end{cases} \tag{200}$$

where

$k = s[j - L_{SB\text{-}CRU,FPi}]$

$s[\ ]$ is the CRU/DRU allocation sequence defined in Equation (201) and $0 \le s[j] < FPS_i - L_{SB-CRU, FPi}$

$$s[j] = \{\text{PermSeq}(j) + \text{DL\_PermBase}\} \bmod (FPS_i - L_{SB-CRU, FPi}) \tag{201}$$

In Equation (201), PermSeq() is the permutation sequence of length ($FPS_i - L_{SB\text{-}CRU,FPi}$) and is determined by $SEED = \{IDcell \times 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in 6.3.4.3.3. DL_PermBase is set to *IDcell* derived from SA-Preamble. If the OLRegion parameter in the S-SFH SP2 is set to 0b1, then the SEED and DL_PermBase in FP_0 shall both be set to 0 in Equation (201). For the AAI subframe where SFH is located, SEED and DL_PermBase in Equation (201) shall be set to zero.

The mapping of PRU_{FPi} to DRU_{FPi} is given by Equation (202).

$$DRU_{FPi}[j] = PRU_{FPi}[k + L_{SB-CRU, FPi}], \quad 0 \le j < L_{DRU, FPi} \tag{202}$$

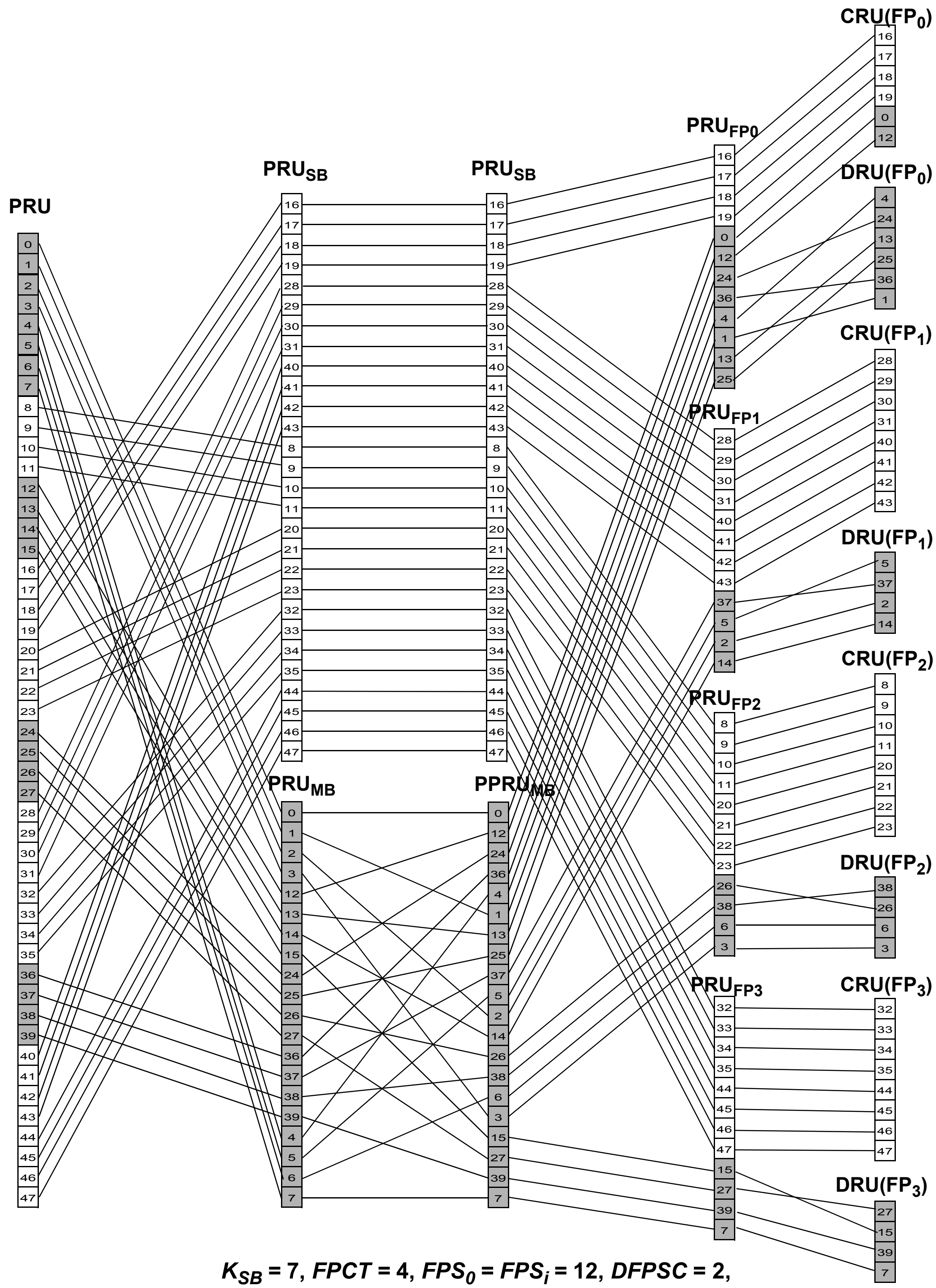
where $k = s[j + L_{CRU,FPi} - L_{SB\text{-}CRU,FPi}]$.

Figure 6-119 presents an example to illustrate the various steps of subband partitioning, miniband permutation, frequency partitioning, and CRU/DRU allocation for the case of a 10 MHz system bandwidth. For this example, K_{SB} = $DSAC$ = 7, $FPCT$ = 4, FPS_i = 12 (for $i \geq 0$), $DFPSC$ = 2, $DCAS_{SB,0}$ = 1, $DCAS_{MB,0}$ = 1, $DCAS_i$ = 2, and $IDcell$ = 0.

Table 6-163 presents a summary of the parameters used to configure the DL PHY structure.

Table 6-163—DL PHY structure—Summary of parameters

	Operation procedure	**Related signaling field (FFT size 2048/1024/ 512)**	**Channel for signaling**	**Parameters calculated from signaled fields**	**Definition**	**Units**
Sector Common	Subband partitioning	$DSAC$ (5/4/3 bits)	S-SFH SP2	K_{SB}	Number of subbands	Subbands
				$L_{SB} = N_1 \times K_{SB}$	Number of PRUs assigned to subbands	PRUs
	Mini-band partitioning			$L_{MB} = N_2 \times K_{MB}$	Number of PRUs assigned to minibands	PRUs
	Frequency partitioning	$DFPC$ (4/3/3 bit)		$FPCT$	Number of frequency partitions	Frequency partitions
				FPS_i	Number of PRUs in FP_i	PRUs
		$DFPSC$ (3/2/1 bit)		$K_{SB,\ FPi}$	Number of subbands assigned to FP_i	Subbands
				$K_{MB,\ FPi}$	Number of minibands assigned to FP_i	Minibands
				$L_{SB,\ FPi} = N_1 \times K_{SB,\ FPi}$	Number of PRUs assigned to be subbands in FP_i	PRUs
				$L_{MB,\ FPi} = N_2 \times K_{MB,\ FP}$	Number of PRUs assigned to be minibands in FP_i	PRUs
Sector Specific	CRU/DRU allocation	$DCAS_{SB,0}$ (5/4/3 bit)	S-SFH SP1	$L_{SB\text{-}CRU,\ FPi}$	Number of subband-based CRUs in FP_i	CRUs
		$DCAS_{MB,0}$ (5/4/3 bit)		$L_{MB\text{-}CRU,\ FPi}$	Number of miniband-based CRUs in FP_i	CRUs
				$L_{CRU,FPi} = L_{SB\text{-}CRU,\ FPi} + L_{MB\text{-}CRU,\ FPi}$	Number of CRUs in FP_i	CRUs
		$DCAS_i$ (3/2/1 bit)		$L_{DRU,FPi} = FPS_i - L_{CRU,FPi}$	Number of DRUs in FP_i	DRUs
	Subcarrier permutation	$IDCell$ (10 bits)	Obtained from SA-Preamble			



K_{SB} = 7, $FPCT$ = 4, FPS_0 = FPS_i = 12, $DFPSC$ = 2,
$DCAS_{SB,0}$ = 1, $DCAS_{MB,0}$ = 1, $DCAS_i$ = 2, and $IDcell$ = 0.

Figure 6-119—Frequency partition for *BW* = 10 MHz

6.3.4.3.2 Subcarrier permutation

The downlink DRUs are used to form two-stream DLRUs by subcarrier permutation. The subcarrier permutation defined for the DL distributed resource allocations within a frequency partition spreads the subcarriers of the DRU across the whole distributed resource allocations. The granularity of the subcarrier permutation is equal to a pair of subcarriers.

After mapping all pilots, the remaining used subcarriers are used to define the distributed LRUs. To allocate the LRUs, the remaining subcarriers are paired into contiguous tone-pairs. Each LRU consists of a group of tone-pairs.

Let $L_{SC,l}$ denote the number of data subcarriers in the l-th OFDMA symbol within a PRU; i.e., $L_{SC,l} = P_{sc} - n_l$, where n_l denotes the number of pilot subcarriers in the l-th OFDMA symbol within a PRU. Let $L_{SP,l}$ denote the number of data subcarrier-pairs in the l-th OFDMA symbol within a PRU and is equal to $L_{SC,l} / 2$. The permutation sequence PermSeq() is defined in 6.3.4.3.3. The DL subcarrier permutation is performed as follows:

For each l-th OFDMA symbol in the AAI subframe:

a) Allocate the n_l pilots within each DRU as described in 6.3.4.4. Denote the data subcarriers of $DRU_{FPi}[j]$ in the l-th OFDMA symbol as $SC^{FPi}_{DRUj,l}[k]$ for $0 \le j < L_{DRU,FPi}$ and $0 \le k < L_{SC,l}$.

b) Renumber the $L_{DRU,FPi} \times L_{SC,l}$ data subcarriers of the DRUs in order, from 0 to $L_{DRU,FPi} \times L_{SC,l} - 1$. Group these contiguous and logically renumbered subcarriers into $L_{DRU,FPi} \times L_{SP,l}$ pairs, and renumber them from 0 to $L_{DRU,FPi} \times L_{SP,l} - 1$. The renumbered subcarrier pairs in the l-th OFDMA symbol are denoted by $RSP_{FPi,l}$ and are calculated as shown in Equation (203).

$$RSP_{FPi,l}[u] = \{ \; SC^{FPi}_{DRUj,l}[2v], \quad SC^{FPi}_{DRUj,l}[2v+1] \; \}, \qquad 0 \le u < L_{DRU,FPi}L_{SP,l} \tag{203}$$

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

c) Apply the subcarrier permutation formula as Equation (204) to map $RSP_{FPi,l}$ into the s-th distributed LRU, $s = 0,1,..., L_{DRU,FPi} - 1$. The subcarrier permutation formula is given by Equation (204).

$$SP^{FP_i}_{LRU_{s,l}}[m] = RSP_{FPi,l}[k] \qquad 0 \le m < L_{SP,l} \tag{204}$$

where

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

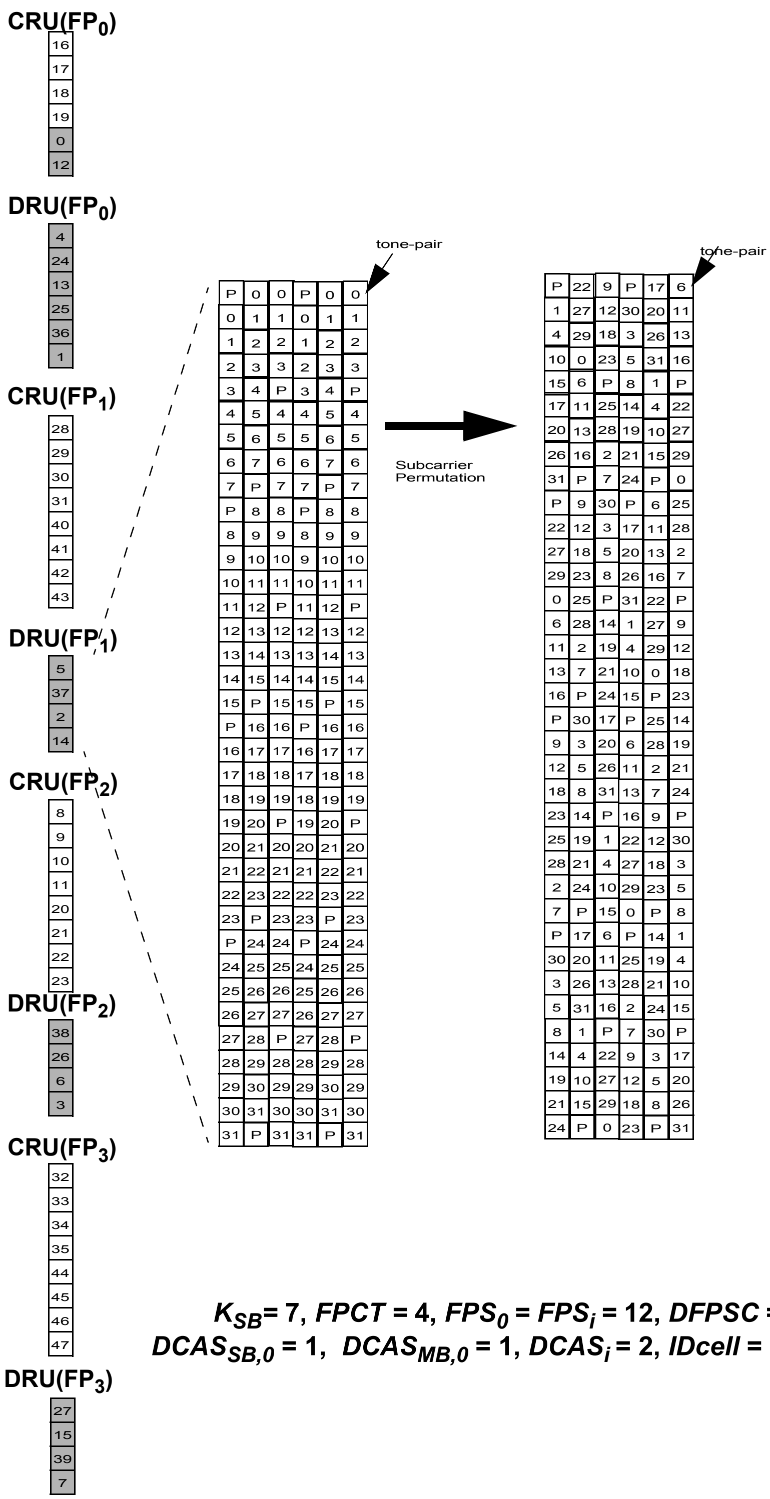
$SP^{FPi}_{LRUs,l}[m]$	is the m-th subcarrier pair in the l-th OFDMA symbol in the s-th distributed LRU of the t-th AAI subframe.
m	is the subcarrier pair index, 0 to $L_{SP,l} - 1$.
l	is the OFDMA symbol index, 0 to $N_{sym} - 1$.
s	is the distributed LRU index, 0 to $L_{DRU,FPi} - 1$.
PermSeq()	is the permutation sequence of length $L_{DRU,FPi}$ and is determined by $SEED = \{IDcell \times 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in 6.3.4.3.3.
$g(PermSeq(),s,m,l)$	is a function with the value from the set $[0, L_{DRU,FPi} - 1]$, which is defined according to Equation (205), where DL_PermBase is set to preamble *IDcell*.

$f(m,s,l) = (m + 13 \times (s+l)) \bmod L_{SP,l}$.

$$g(PermSeq(), s, m, l) = \{PermSeq[\{f(m, s, l) + s + l\} \bmod L_{DRU,FPi}] + DL\_PermBase\} \bmod L_{DRU,FPi} \quad (205)$$

The permutation sequence generation algorithm with 10-bit *SEED* (*Sn*–10, *Sn*–9, …, *Sn*–1) generates a permutation sequence of size *M* as described in the following paragraph:

Figure 6-120 presents the subcarrier permutation for $BW = 10$ MHz, $K_{SB} = 7$, $FPCT = 4$, $FPS_0 = FPS_i = 12$, $DFPSC = 2$, $DCAS_{SB,0} = 1$, $DCAS_{MB,0} = 1$, $DCASi = 2$, $IDcell = 0$, and 2 data streams. The entries denoted by "P" represent the pilot subcarriers.



K_{SB}= 7, $FPCT$ = 4, FPS_0 = FPS_i = 12, $DFPSC$ = 2,
$DCAS_{SB,0}$ = 1, $DCAS_{MB,0}$ = 1, $DCAS_i$ = 2, $IDcell$ = 0, and two data streams.

Figure 6-120—Subcarrier permutation for *BW* = 10 MHz

6.3.4.3.3 Random sequence generation

The permutation sequence generation algorithm with 10-bit *SEED* ($Sn - 10$, $Sn - 9$, …, $Sn - 1$) generates a permutation sequence of size M as described in the following list:

a) Initialization:
   1) Initialize the variables of the first order polynomial equation with the 10-bit seed, *SEED*. Set $d_1 = \text{floor}(SEED/2^5) + 619$ and $d_2 = SEED \bmod 2^5$.
   2) Initialize an array A with size M with the numbers 0, 1, … , $M - 1$ (i.e., $A[0] = 0$, $A[1] = 1$, … , $A[M - 1] = M - 1$).
   3) Initialize the counter i to $M - 1$.
   4) Initialize x to –1.

b) Repeat the following steps if $i > 0$:
   1) Increment x by i.
   2) Calculate the output variable of $y = \{(d_1 \times x + d_2) \bmod 1031\} \bmod M$.
   3) If $y \geq i$, set $y = y \bmod (i + 1)$.
   4) Swap $A[i]$ and $A[y]$.
   5) Decrement i by 1.

c) PermSeq[i] = $A[i]$, where $0 \leq i < M$.

6.3.4.3.4 A-MAP symbols to subcarrier pair mapping

The mapping of A-MAP symbols to tone-pairs in LRU is given as follows:

a) 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 OFDMA symbol, the renumbered tone-pairs in the A-MAP region are denoted by RMP[u], where u ranges from 0 to $L_{AMAP} \times N_{sym} \times L_{SP} - 1$, and L_{AMAP} is the number of LRUs allocated to the A-MAP.

b) A distributed tone-pair, $SP^{FPi}_{LRUs,\,l}[m]$, is mapped to RMP[u], where $u = s \times N_{\text{sym}} \times L_{\text{SP}} + m \times N_{\text{sym}} + l$. $SP^{FPi}_{LRUs,\,l}[m]$ is the tone-pair index of the m-th tone-pair in the l-th OFDMA symbol in the s-th distributed LRU of frequency partition i as defined in 6.3.4.3.2.

c) A-MAP symbols of an A-MAP channel are mapped to logically contiguous RMP[u]s. For example, suppose RMP[v] is the first tone-pair for Assignment A-MAP. The k-th MLRU is formed by tone-pairs from RMP[$v + k \times N_{MLRU} / 2$] to RMP[$v + (k + 1) \times N_{MLRU} / 2 - 1$], where N_{MLRU} is the size of an MLRU.

6.3.4.3.5 Logical resource unit mapping

Both contiguous and distributed LRUs are supported in the downlink. The CRUs are directly mapped into contiguous LRUs, including subband LRUs and miniband LRUs. The mapping between CRU_{FPi} and $SLRU_{FPi}$ or $NLRU_{FPi}$ is defined as shown in Equation (206) and Equation (207).

$$SLRU_{FPi}[j] = CRU_{FPi}[j] \text{ for } 0 \leq j < L_{SB-(CRU,\,FPi)}[j],\ 0 \leq i \leq 3 \tag{206}$$

$$NLRU_{FPi}[j] = CRU_{FPi}[j + L_{SB-CRU,\,FPi}] \text{ for } 0 \leq j < L_{MB-CRU,FPi}[j],\ 0 \leq i \leq 3 \tag{207}$$

The DRUs are permuted as described in 6.3.4.3.2 to form distributed LRUs. For FP_i, $0 \leq i \leq 3$, $DLRU_{FPi}[j]$ is composed of $L_{SP,l} \times N_{sym}$ subcarrier pairs, e.g., $SP^{FPi}_{LRUj,\,l}[m]$ for $0 \leq m < L_{SP,l}[j]$ and $0 \leq l < N_{sym}$.

6.3.4.4 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, and so on. To optimize the system performance in different propagation environments and applications, AAI supports both common and dedicated pilot structures. The categorization in common and dedicated pilots is done with respect to their usage. The common pilots can be used by all MSs, and the pilots are precoded in the same way as the data subcarriers within the same PRU. Dedicated pilots can be used with both localized and distributed allocations. The dedicated pilots are associated with a specific resource allocation, are intended to be used by the MSs allocated to said specific resource allocation, and therefore shall be precoded or beamformed in the same way as the data subcarriers of the resource allocation. The pilot structure is defined for up to eight transmission (Tx) streams, and there is a unified pilot pattern design for common and dedicated pilots. There is equal pilot density per Tx stream, while there is not necessarily equal pilot density per OFDMA symbol of the downlink AAI subframe. Further, within the same AAI subframe there is equal number of pilots for each PRU of a data burst assigned to one MS.

6.3.4.4.1 Pilot patterns

Pilot patterns are specified within a PRU.

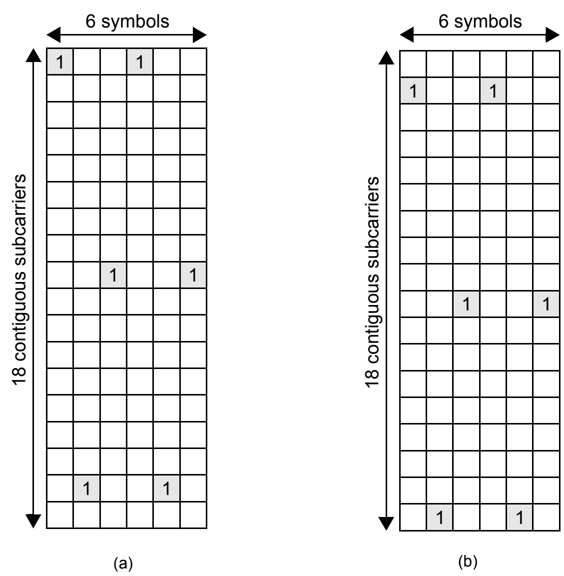


Figure 6-121—Pilot patterns used for one DL data stream outside the open-loop region

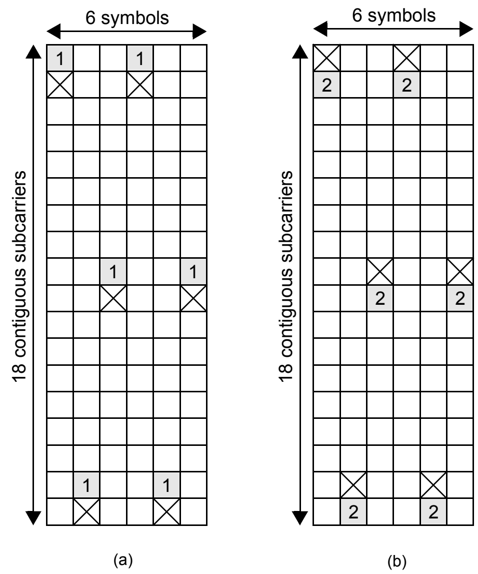


Figure 6-122—Pilot patterns used for two DL data streams

Base pilot patterns used for DL data transmission with one data stream in dedicated and common pilot scenarios are shown in Figure 6-121, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Figure 6-121 shows the pilot locations for stream set 0 and stream set 1, respectively.

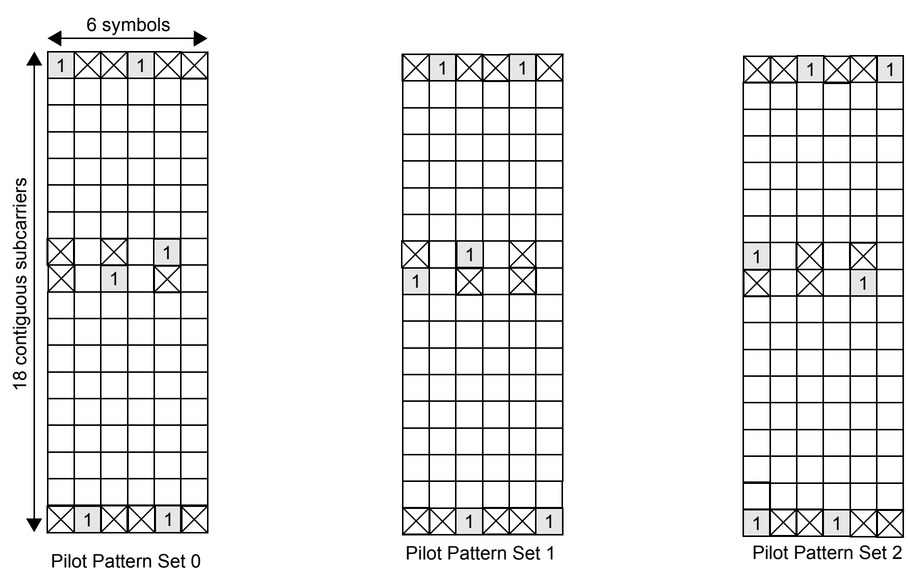


Figure 6-123—CoFIP pattern for AAI subframes with six OFDM symbols

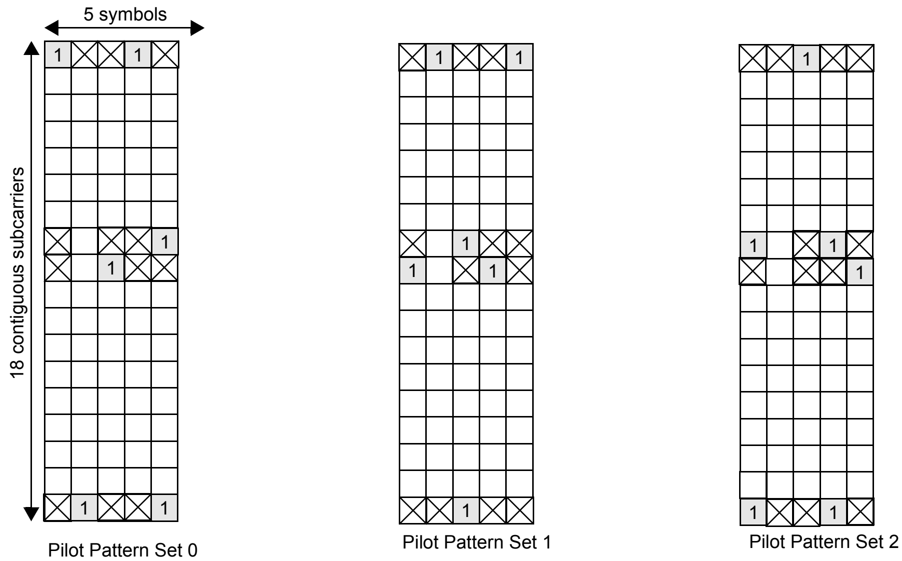


Figure 6-124—CoFIP pattern for AAI subframes with five OFDM symbols

The base pilot patterns used for two DL data streams in dedicated and common pilot scenarios are shown in Figure 6-122, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Figure 6-122 shows the pilot location for pilot stream 1 and pilot stream 2 in a PRU, respectively. The number on a pilot subcarrier indicates the pilot stream to which the pilot subcarrier corresponds. The subcarriers marked as “X” are null subcarriers, on which no pilot or data is transmitted.

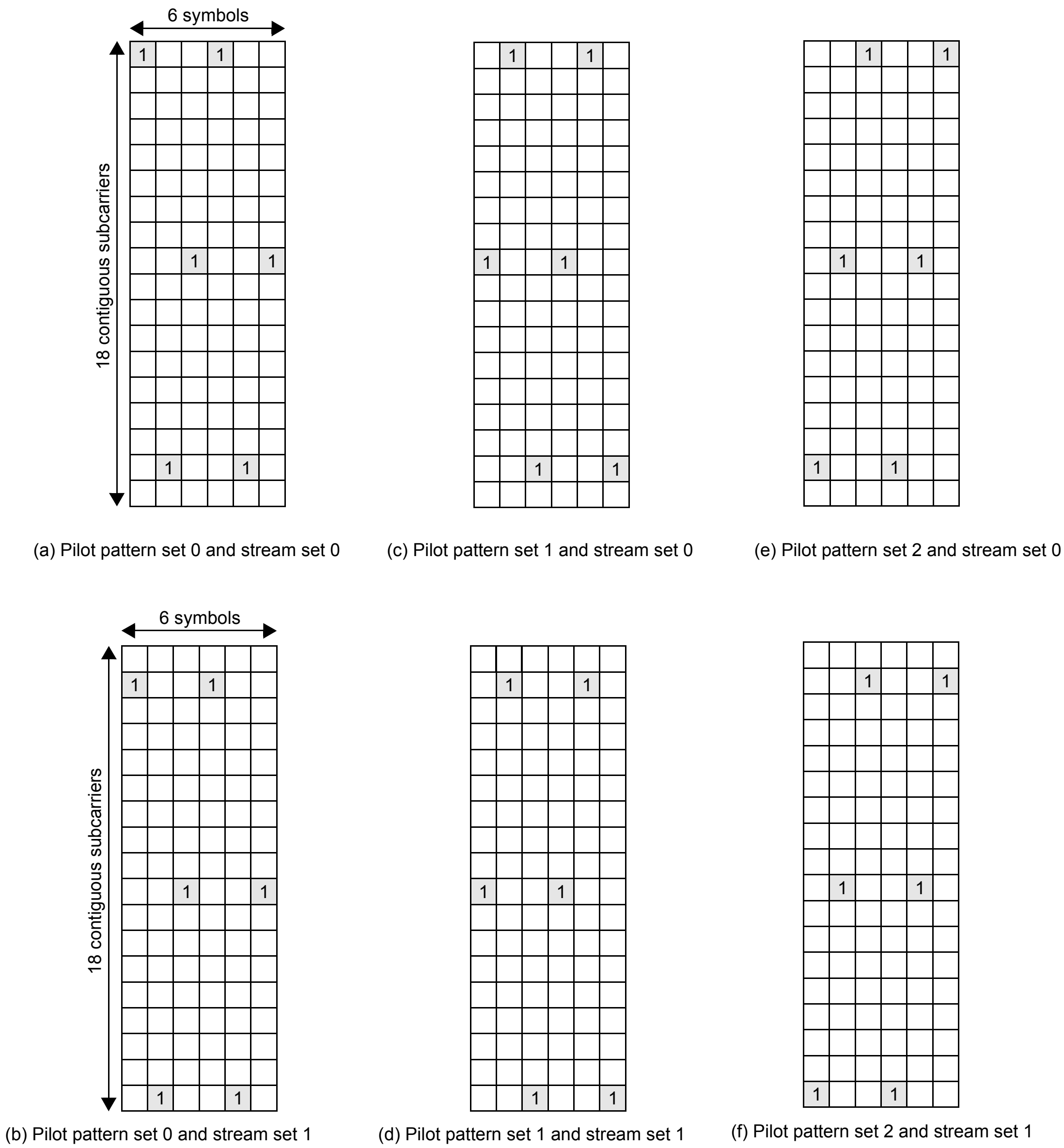
The interlaced pilot patterns are generated by cyclic shifting the base pilot patterns. The interlaced pilot patterns are used by different BSs for one and two streams. Interlaced pilot patterns for one stream is shown in Figure 6-125 and interlaced pilot patterns on stream 1 and stream 2 for two streams are shown in Figure 6-126 and Figure 6-127, respectively. Each BS chooses one of the three pilot pattern sets (pilot pattern set 0, 1, and 2) as shown in Figure 6-125, Figure 6-126, and Figure 6-127. The index of the pilot pattern set used by a particular BS with *IDcell* = *k* is denoted by p_k. The index of the pilot pattern set is determined by the *IDcell* according to Equation (208).

$$p_k = \mathrm{floor}(k/256) \tag{208}$$

For one stream, each ABS additionally chooses one of the two stream sets (stream set 0 and 1) within each pilot pattern set. The index of the stream, denoted by s_k, shall be determined according to Equation (209).

$$s_k = \mathrm{mod}(k, 2) \tag{209}$$

For the AAI subframe consisting of five symbols, the last OFDM symbol in each pilot pattern set shown in Figure 6-122 is deleted. For the AAI subframe consisting of seven symbols, the first OFDM symbol in each pilot pattern set shown in Figure 6-122 is added as the seventh symbol.



(a) Pilot pattern set 0 and stream set 0

(c) Pilot pattern set 1 and stream set 0

(e) Pilot pattern set 2 and stream set 0

(b) Pilot pattern set 0 and stream set 1

(d) Pilot pattern set 1 and stream set 1

(f) Pilot pattern set 2 and stream set 1

Figure 6-125—Interlaced pilot patterns for one data stream outside the open-loop region

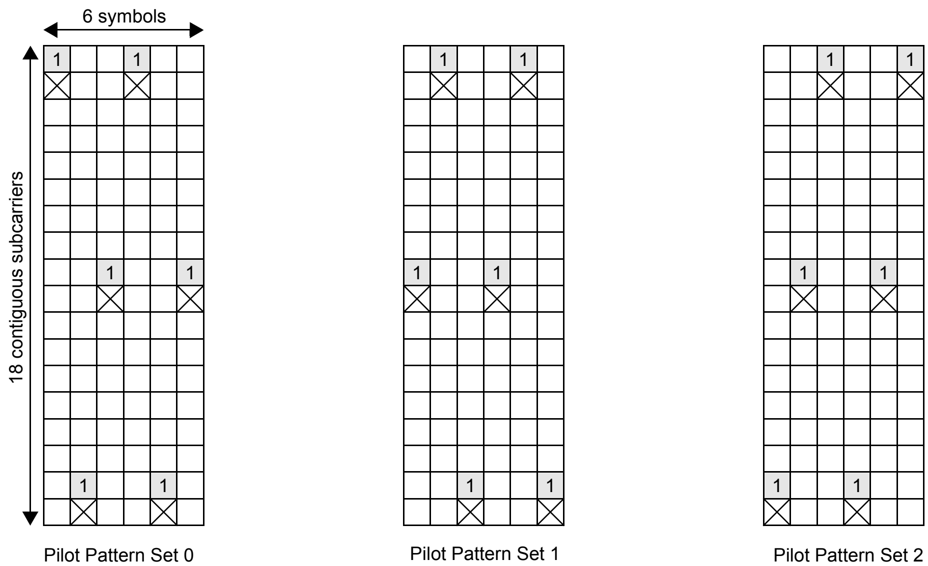


Figure 6-126—Interlaced pilot patterns on stream 0 for two data streams

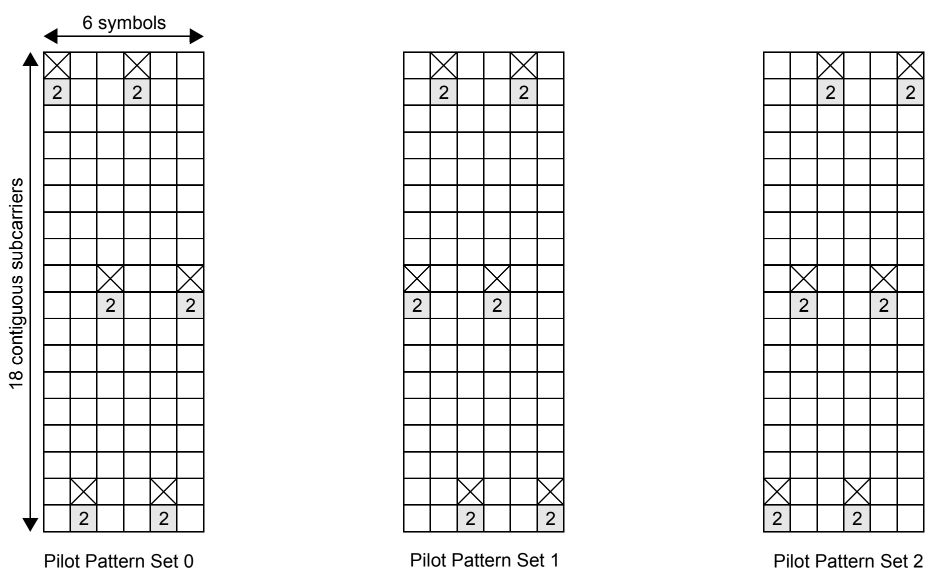


Figure 6-127—Interlaced pilot patterns on stream 1 for two data streams

The Type 1 OL MIMO region shall use a Collision Free Interlaced Pilot (CoFIP) pattern. Figure 6-123 shows the CoFIP pattern for AAI subframes consisting of six OFDM symbols. The index of the pilot pattern set used by a particular BS with *IDcell* = *k* is denoted by p_k. The index of the pilot pattern set is determined by the *IDcell* according to Equation (210).

$$p_k = \text{floor}(k/256) \tag{210}$$

For AAI subframes consisting of seven OFDM symbols, the first OFDM symbol, which contains pilot tones and null tones in each pilot pattern set shown in Figure 6-123, is added as the seventh symbol. Figure 6-124 shows the pilot pattern set for AAI subframes consisting of five OFDM symbols

The pilot patterns on stream 0–stream 3 for four pilot streams are shown in Figure 6-128 through Figure 6-131, respectively, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) in Figure 6-128 through Figure 6-131 show the pilot pattern for four pilot streams in AAI subframe with six OFDM symbols; Subfigure (b) in Figure 6-128 through Figure 6-131 show the pilot pattern for four pilot streams in AAI subframe with five OFDM symbols; Subfigure (c) in Figure 6-128 through Figure 6-131 show the pilot pattern for four pilot streams in AAI subframe with seven OFDM symbols.

For three streams MIMO transmissions, the first three of the four pilot streams will be used and the unused pilot stream is allocated for data transmission.

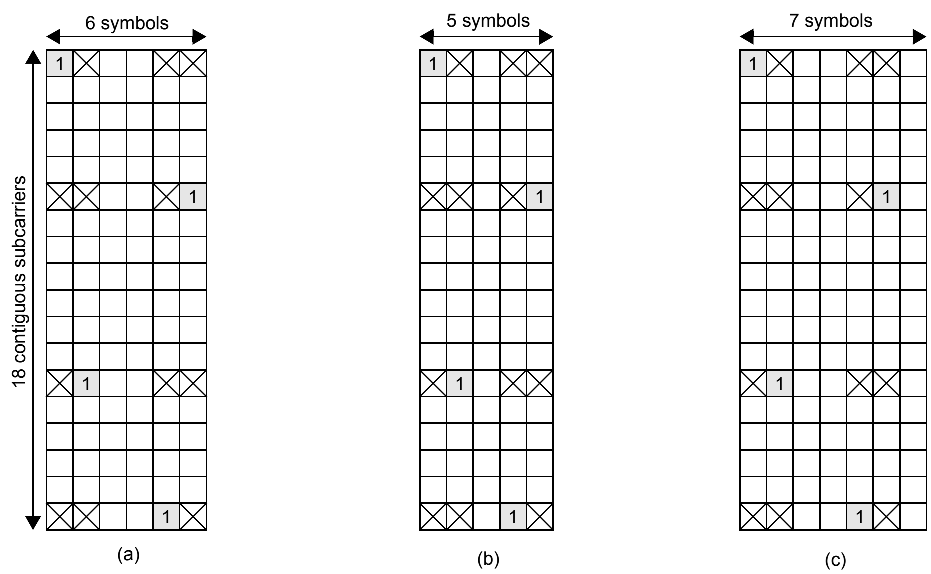


Figure 6-128—Pilot patterns on stream 0 for four data streams

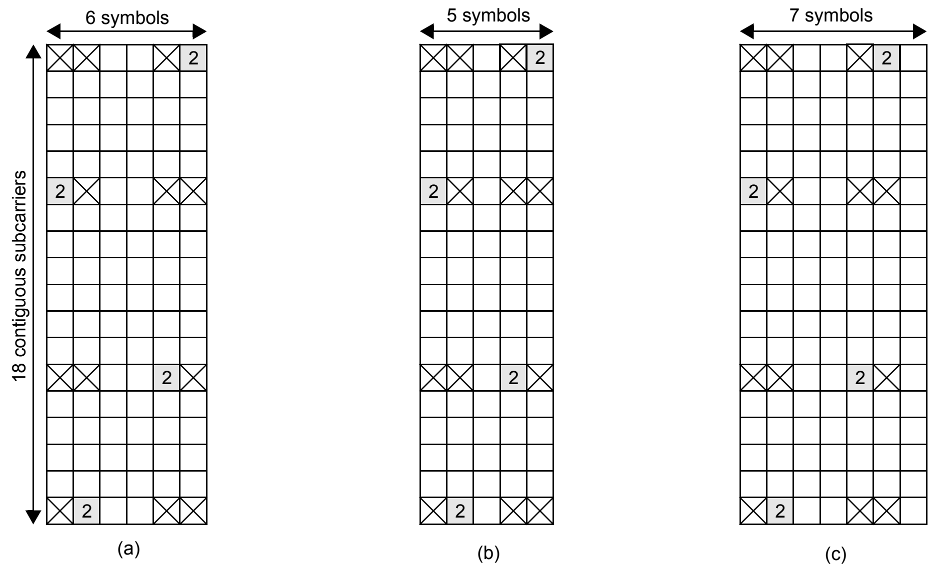


Figure 6-129—Pilot patterns on stream 1 for four data streams

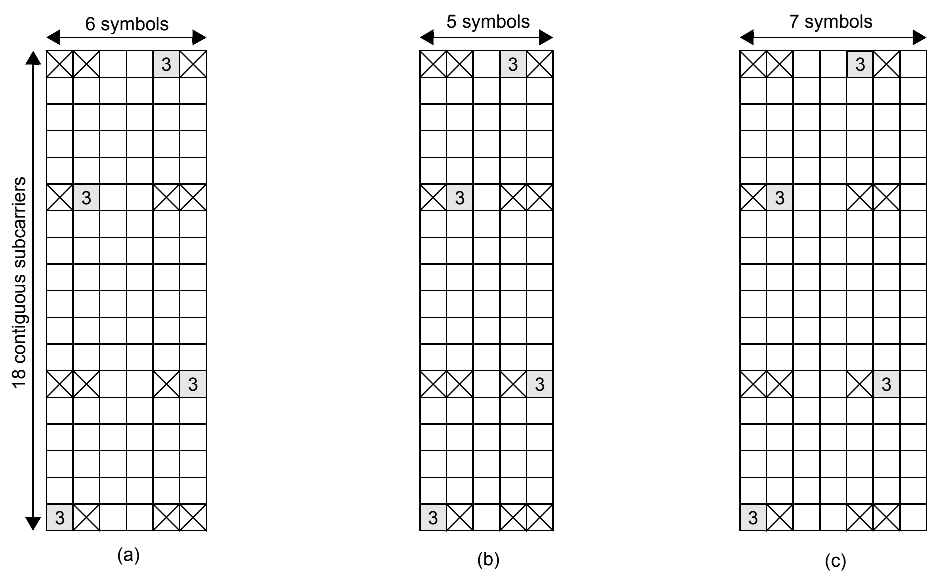


Figure 6-130—Pilot patterns on stream 2 for four data streams

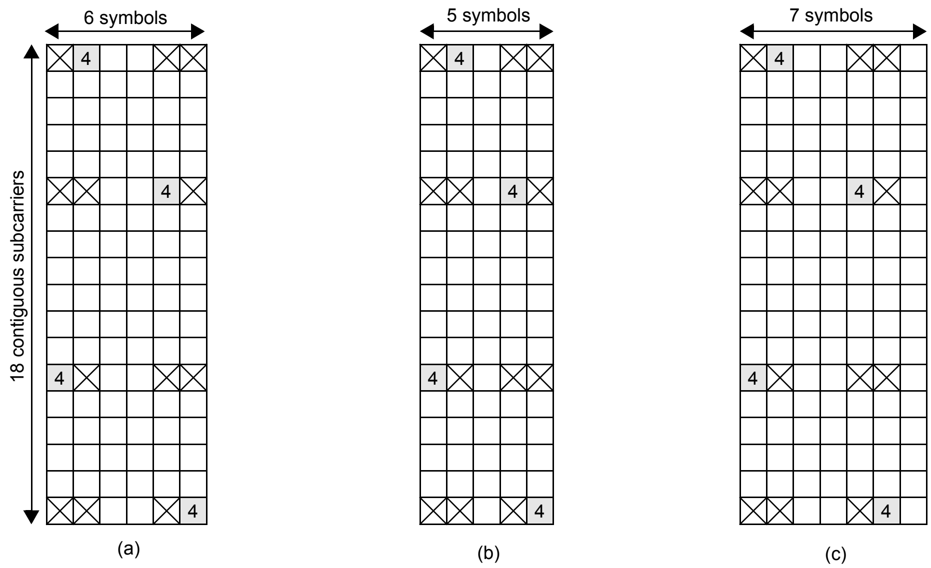


Figure 6-131—Pilot patterns on stream 3 for four data streams

The pilot patterns for eight pilot streams are shown in Figure 6-132 with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Figure 6-132(a) shows the pilot pattern for eight pilot streams in AAI subframe with six OFDM symbols; Figure 6-132(b) shows the pilot pattern for eight pilot streams in AAI subframe with five OFDM symbols; Figure 6-132(c) shows the pilot pattern for eight pilot streams in AAI subframe with seven OFDM symbols.

For 5, 6, and 7 streams MIMO transmissions, the first five, six, and seven of the eight pilot streams will be used, respectively. The unused pilot stream is allocated for data transmission.

For MU-MIMO outside the OL MIMO region, if the number of assigned data streams within allocation is smaller than the maximum number of streams over the entire allocation, the pilots associated with the unassigned data streams are not transmitted.

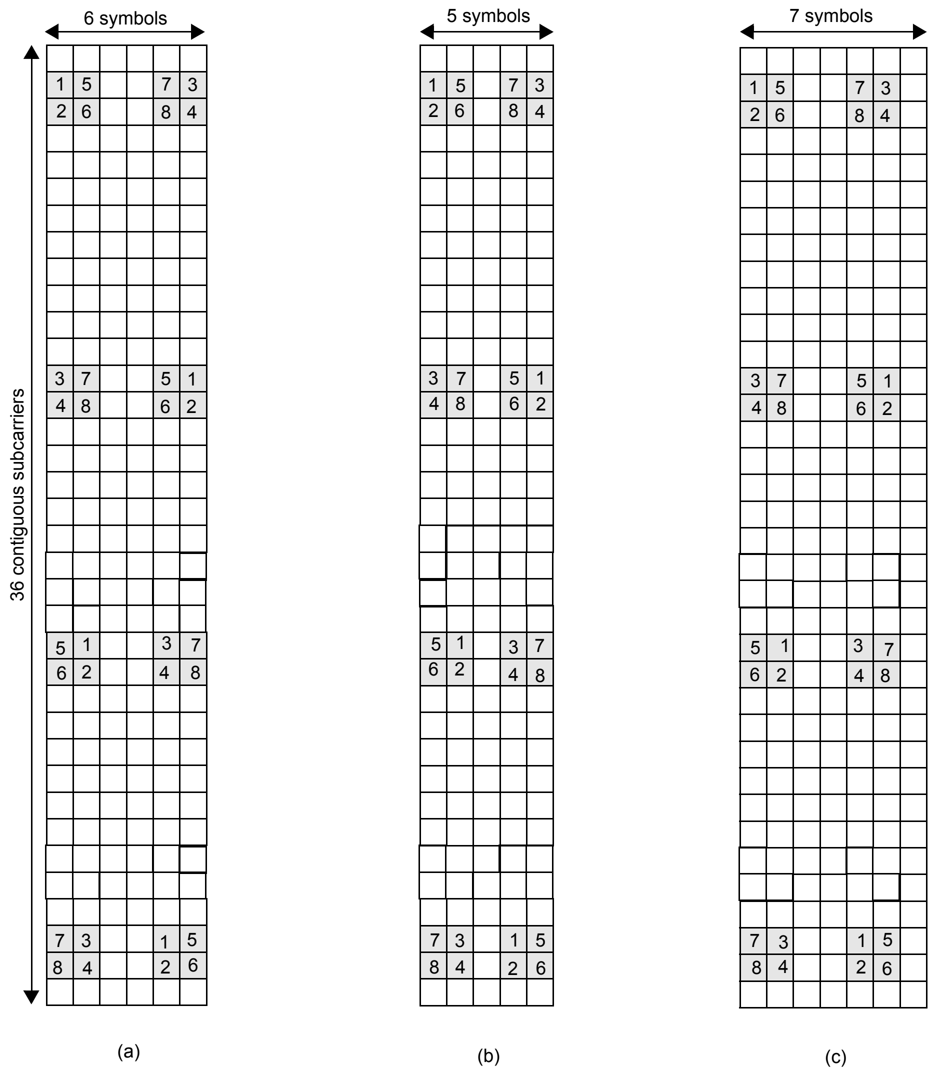


Figure 6-132—Pilot patterns for eight data streams

6.3.4.4.2 MIMO midamble

MIMO midamble is used for PMI selection and CQI calculation in closed-loop MIMO. For OL MIMO, midamble can be used to calculate CQI. MIMO midamble shall be transmitted every frame on the second DL AAI subframe. The midamble signal occupies the first OFDMA symbol in a DL Type 1 or Type 2 AAI subframe. For the Type 1 AAI subframe case, the remaining five consecutive symbols form a Type 3 AAI subframe. For the Type 2 AAI subframe case, the remaining six consecutive symbols form a Type 1 AAI subframe.

For the special case where the frame structure supports R1 MSs and Frame Configuration Index provisions that the DL Length is equal to 1 subframe, the MIMO midamble will be transmitted every frame on the last symbol of the first DL AAI subframe. In these cases, the first DL AAI subframe will always be a Type 2 AAI subframe. The first symbol of this Type 2 AAI subframe will be occupied by a preamble symbol, and the last symbol will be occupied by the MIMO midamble. The remaining five consecutive symbols form a Type 3 AAI subframe.

The MIMO midamble signal transmitted by the ABS antenna is defined by Equation (211):

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{\substack{k=0 \\ k \neq \frac{N_{used}-1}{2}}}^{k=N_{used}-1} b_k \cdot e^{j2\pi\left(k - \frac{N_{used}-1}{2}\right)\Delta f(t - T_g)} \right\} \tag{211}$$

where b_k is a coefficients modulating subcarriers in the midamble symbol defined by Equation (212):

$$b_k = \begin{cases} 2.18 \cdot \{1 - (2G([k + u + offset(fft)] \bmod fft))\}, k \neq \dfrac{N_{used}-1}{2}, (k-s) \bmod (3 \times N_t) = 3g + \left(\left\lfloor \dfrac{IDCell}{256} \right\rfloor + \left\lfloor \dfrac{k-s}{N_1 \times P_{SC}} \right\rfloor\right) \bmod 3 \\ 0, \text{otherwise} \end{cases} \tag{212}$$

where k is the subcarrier index $(0 \le k \le N_{used} - 1)$; N_{used} is the number of used subcarriers; *G(x)* is the Golay sequence defined in Table 6-164 $(0 \le x \le 2047)$; *fft* is the FFT size used; *u* is a shift value, where the actual value of *u* is derived from *u* = mod (*IDcell*, 256); *offset(fft)* is an FFT size specific offset as defined in Table 6-165; *g* is an ABS transmit antenna index (in the range of 0 to $N_t - 1$); N_t is the number of ABS transmit antennas; and parameter *s* = 0, for $k \le (N_{used} - 1)/2$, and *s* = 1, for $k > (N_{used} - 1)/2$. *IDcell* shall correspond to SA-Preamble.

Example of physical structure of MIMO midamble is shown in Figure 6-133 for 4Tx antenna and *IDcell* = 0.

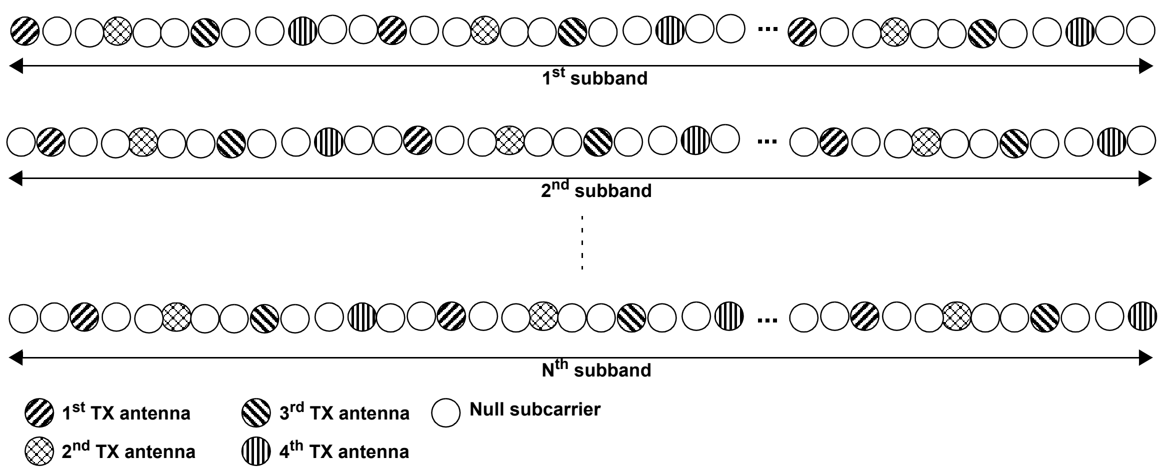


Figure 6-133—MIMO midamble physical structure for 4TX antennas and *IDcell* = 0

Table 6-164—Golay sequence of length 2048 bits

0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2
0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D
0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2
0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2	0x121D	0x12E2	0xEDE2	0x12E2
0x121D	0x12E2	0x121D	0xED1D	0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2
0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D
0xEDE2	0xED1D	0xEDE2	0x12E2	0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2
0xEDE2	0xED1D	0x121D	0xED1D	0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D
0x121D	0x12E2	0x121D	0xED1D	0x121D	0x12E2	0xEDE2	0x12E2	0x121D	0x12E2	0x121D	0xED1D
0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D
0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D				

Table 6-165—Offsets in the Golay sequence

FFT size	Offset
2048	30
1024	60
512	40

In Table 6-164, the hexadecimal series should be read as a sequence of bits where each 16-bit word is started at the MSB and ends at the LSB where the second word MSB follows. The first bit of the sequence is referenced as offset 0.

6.3.4.4.3 Usage of downlink pilots

The demodulation pilots in a given PRU on a given pilot stream shall be precoded the same way as the data transmitted on the same stream in that PRU. In DLRU, the data transmitted in a given PRU on a given stream may be sent to several AMSs but in different tones using the same precoder.

Two pilot streams shall always be transmitted in the DLRUs, whether inside or outside the open-loop region Type 0, and whether or not data is being transmitted by the ABS in all DLRUs.

Inside an open-loop region of Type 1 or Type 2, the $MaxM_t$ pilots shall always be transmitted across all CLRUs in that open-loop region. Outside an open-loop region, the pilots shall not be transmitted on CLRUs where no data is sent.

The precoder may be adaptive (user-specific) or non-adaptive (non-user-specific) depending on the DL MIMO mode. Non-adaptive precoders are determined according to the DL MIMO mode, the number of streams, the type of LRU, the operation inside or outside the open-loop region, and the physical index of the subband or miniband where the precoder is applied.

In MU-MIMO transmissions in CLRU, each pilot stream is dedicated to one AMS. A pilot stream dedicated to an AMS shall be used by the AMS for channel estimation within the allocation. Pilot streams dedicated to other AMSs may be used for inter-stream interference estimation. The total number of streams in the transmission and the index of the dedicated pilot stream are indicated in the DL Basic Assignment A-MAP IE, DL Persistent Allocation A-MAP IE, or DL Subband Assignment A-MAP IE.

Channel estimation for demodulation of data burst at the AMS should be performed as follows:

- In DLRU: The 2-streams non-adaptively precoded common pilots across the DLRU should be used for channel estimation by all AMSs allocated a burst in the DLRU. Within each frequency partition, all pilots are shared by all AMSs for demodulation in DLRU.
- In CLRU: The AMS should use its dedicated pilot streams for channel estimation in the allocation. Pilots are not shared by AMSs for demodulation in CLRU, whether they are non-adaptively or adaptively precoded.

MIMO feedback measurements at the AMS should be performed as follows:

- For MIMO feedback reports requested with a MIMO feedback mode for operation in an open-loop region, measurements should be taken on the $MaxM_t$ streams non-adaptively precoded pilots in that open-loop region. All pilots are shared by all AMSs for MIMO feedback measurements in each open-loop region.
- Wideband CQI reports inside OL region should be averaged over OL region pilots of the PRUs in the frequency partition 0.
- For MIMO feedback reports requested with a MIMO feedback mode for operation outside the open-loop region, measurements should be taken on the downlink MIMO midamble.
- Wideband CQI reports outside OL region (measured on MIMO midamble) should be averaged over the frequency partition as instructed in 6.3.5.5.2.4.5or as defined in 6.3.5.5.2.4.11.
- For reports requested with a MIMO feedback mode for open-loop MIMO operation, the AMS should adjust the non-precoded MIMO channel estimated from the midamble by applying it with the non-adaptive precoder according to the MFM, the subband index, and assumption on STC rate.
- For reports requested with a MIMO feedback mode for closed-loop MIMO operation, the AMS should adjust the non-precoded MIMO channel estimated from the midamble with an estimated adaptive precoder.
- Subband CQI reports (inside and outside OL region) should be reported for subbands in SLRUs indicated by SFH.

6.3.4.4.4 E-MBS zone-specific pilot patterns

E-MBS zone-specific pilots are transmitted for multi-cell multicast broadcast single frequency network (MBSFN) transmissions. An E-MBS zone is a group of ABSs involved in an SFN transmission. The E-MBS zone-specific pilots are common inside one E-MBS zone. Synchronous transmission of the same pilots from multiple ABSs helps an AMS to estimate the composite channel response within an E-MBS zone.

The E-MBS pilot pattern is robust for various cell size MBSFN deployments and supports channel estimation of up to two transmit streams within an E-MBS zone. The structures of the E-MBS zone specific pilot pattern for Type 1 subframes are shown in Figure 6-134.

The E-MBS zone specific pilot pattern for Type 2 subframes is derived from the E-MBS zone specific pilot pattern for Type 1 subframes by duplicating the second symbol and appending to the end of the last symbol.

The E-MBS zone specific pilot pattern for Type 3 subframes is derived from the E-MBS zone specific pilot pattern for Type 1 subframes by removing the fourth symbol.

Figure 6-135 and Figure 6-136 show the E-MBS zone specific pilot patterns for Type 2 and Type 3 subframes, respectively.

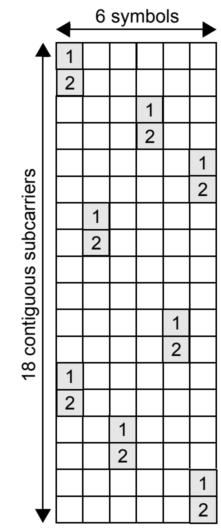


Figure 6-134—E-MBS zone specific pilot patterns for 1 and 2 stream transmission in Type 1 subframe

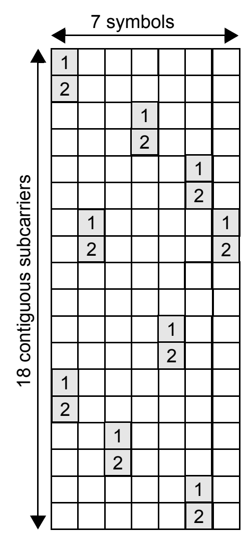


Figure 6-135—E-MBS zone specific pilot patterns for 1 and 2 stream transmission in Type 2 subframe

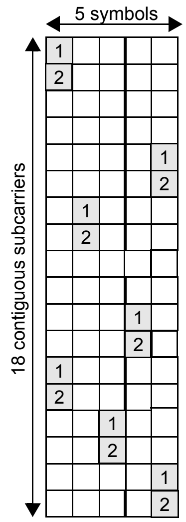


Figure 6-136—E-MBS zone specific pilot patterns for 1 and 2 stream transmission in Type 3 subframe

6.3.4.5 Downlink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRUs are the same as the structure defined in 6.3.4.1 and 6.3.4.4. The guard PRUs are used as miniband CRUs at partition FP0 for data transmission only. The number of usable guard subcarriers is predefined and should be known to both the AMS and the ABS based on carrier bandwidth. The number of guard PRUs on the left and right edge of each carrier are shown in Table 6-166. Denote the number of guard PRUs on the left (right) edge of the carrier by N_{LGPRU} (N_{RGPRU}). The total number of guard PRUs are $N_{GPRU} = N_{LGPRU} + N_{RGPRU}$.

Table 6-166—Number of guard PRUs

BW	**Number of guard PRUs on the left edge of carrier**[a]	**Number of guard PRUs on the right edge of carrier**[b]
5 MHz	0	0
10 MHz	1	1
20 MHz	2	2
7 MHz	0	0
8.75 MHz	0	0

[a]When a carrier occupies the left most spectrum among multiple contiguous carriers, the number of guard PRUs on the left edge of the carrier is zero.
[b]When a carrier occupies the right most spectrum among multiple contiguous carriers, the number of guard PRUs on the right edge of the carrier is zero.

Denote left guard PRUs and right guard PRUs by $GPRU_L[0],\ldots GPRU_L[N_{LGPRU}-1]$ and $GPRU_R[0],\ldots GPRU_R[N_{RGPRU}-1]$ from the lowest frequency. Then, guard PRUs are indexed by interleaving $GPRU_L$ and $GPRU_R$ one by one. That is, $GPRU[i] = GPRU_L[i/2]$, for i is an even number and $GPRU[i] = GPRU_R[(i-1)/2]$, for i is an odd number, If $N_{LGPRU} = 0$, then $GPRU[i] = GPRU_R[i]$. If $N_{RGPRU} = 0$, then $GPRU[i] = GPRU_L[i]$.

The N_{GPRU} guard PRUs are used as miniband LRUs, i.e., NLRUs at frequency partition FP0 without any permutation for data transmission only. In detail, i-th guard NLRU, i.e., GNLRU[i] is always allocated along with the i-th last NLRU at partition FP_0. In other words, when an allocation including the i-th last NLRU at partition FP_0 is made to an AMS for multicarrier support, the i-th guard NLRU, i.e., GNLRU[i], is allocated together. The mapping to the GNLRU[i] is made after mapping to the i-th NLRU at partition FP_0.

When an adjacent carrier is not an active carrier of the AMS, the guard subcarriers in between active and non-active carriers shall not be utilized for data transmission for that AMS.

When the overlapped guard subcarriers are not aligned in the frequency domain, they shall not be used for data transmission.

6.3.4.6 Downlink physical structure for E-MBS support

In a carrier that is not dedicated to E-MBS traffic, it may be required to multiplex E-MBS and unicast traffic. When multiplexed with unicast data, the E-MBS traffic is FDMed with the unicast traffic in the downlink subframes. More specifically, the E-MBS traffic is transmitted using subbands assigned in frequency partition FP_0. The first AAI subframe in every superframe transmits SFH and does not contain any subbands. Therefore, no E-MBS traffic is scheduled in the first AAI subframe of every superframe. The number of subband logical resource units (SLRUs) used for E-MBS data, denoted by $K_{SB,E\text{-}MBS}$, is indicated in the Zone Allocation BitMAP in the AAI-SCD message. This set of subbands form the E-MBS region in the downlink subframes. The Zone Allocation BitMAP is valid for the set of superframes over which the AAI-E-MBS_CFG indicators are valid. If frequency partition FP_0 is available, $K_{SB,E\text{-}MBS}$ subbands are assigned from the lowest $SLRU_{E\text{-}MBS}$ in frequency partition FP_0. If not, however, $K_{SB,E\text{-}MBS}$ subbands are assigned equitably to the remaining partitions FPi ($i > 0$).

The mapping between SLRUE-MBS index and the PRU index shall be done as follows:

If FP_0 is used, only the subbands from FP_0 shall be assigned for E-MBS and the $SLRU_{E\text{-}MBS}$ index is determined by

$$SLRU_{E\text{-}MBS}[k] = SLRU_{FP0}[k], \text{ for } 0 \quad k \le N_1 \times K_{SB,E\text{-}MBS}$$

In case the FP_0 is not available (e.g., reuse-3 only), the number of PRUs for E-MBS in each frequency partition, FPi ($i > 0$), is derived as Equation (213).

$$L_{EMBS,FPm} = \begin{cases} N_1 \cdot \left\lceil \dfrac{K_{SB,EMBS}}{FPCT} \right\rceil & m < q+1 \\ N_1 \cdot \left\lfloor \dfrac{K_{SB,EMBS}}{FPCT} \right\rfloor & \text{Otherwise} \end{cases} \tag{213}$$

where

$$q = K_{SB,E\text{-}MBS} - \text{FPCT} \times \text{floor}(K_{SB,E\text{-}MBS}/\text{FPCT}),\ 1 \le m < \text{FPCT}$$

For each frequency partition i ($i > 0$), the total number of PRUs for E-MBS up to and including that partition may be calculated as Equation (214).

$$X_i = \sum_{m=1}^{i} L_{EMBS,FPm} \qquad 1 \le i < FPCT \qquad \text{and} \qquad X_0 = 0 \tag{214}$$

Then, the $\mathrm{SLRU}_{\text{E-MBS}}$ index is given by

$\mathrm{SLRU}_{\text{E-MBS}}[k + X_{i-1}] = \mathrm{SLRU}_{\mathrm{FPi}}[k]$, for $0 \le k < \mathrm{L}_{\mathrm{EMBS,FPi}}$ with $1 \le i <$FPCT

where the mapping from the $\mathrm{SLRU}_{\mathrm{FPi}}$ to the PRU indices is as specified in 6.3.4.3.5. The subbands index for E-MBS is determined by

$SB_{EMBS}[m] = \{AllSLRU_{EMBS}[k]$, with indices k such that $\left\lfloor \frac{k}{N_1} \right\rfloor = m\}$ with $0 \le m < \mathrm{K}_{SB,\ EMBS.}$

6.3.5 Downlink control structure

6.3.5.1 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 two SA-Preamble symbols exist within the superframe. The location of the A-Preamble symbol is specified as the first symbol of the frame except for the last frame. PA-Preamble is located at the first symbol of the second frame in a superframe, while SA-Preamble is located at the first symbol of the first and the third frames. Figure 6-137 depicts the location of A-Preamble symbols.

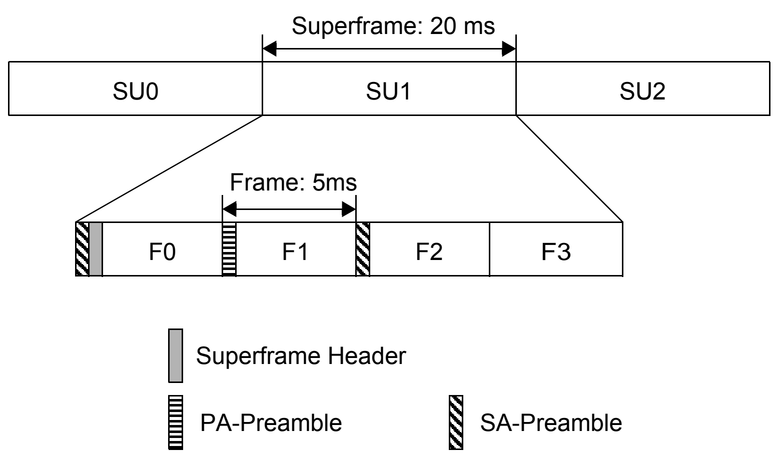


Figure 6-137—Location of the A-Preamble

6.3.5.1.1 Primary Advanced Preamble (PA-Preamble)

The length of sequence for the PA-Preamble is 216 regardless of the FFT size. PA-Preamble carries the information of system bandwidth and carrier configuration. When the subcarrier index 256 is reserved for DC, the allocation of subcarriers is accomplished by Equation (215).

$$PAPreambleCarrierSet = 2k + 41 \tag{215}$$

where

PAPreambleCarrierSet	specifies all subcarriers allocated to the PA-Preamble.
k	is a running index 0 to 215.

Figure 6-138 depicts the symbol structure of the PA-Preamble in the frequency domain.

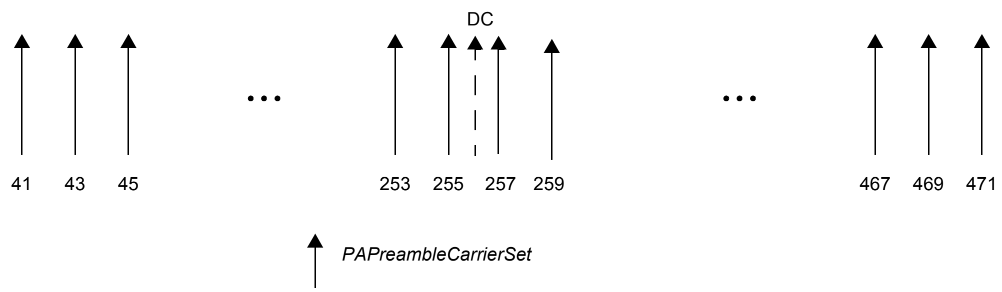


Figure 6-138—PA-Preamble symbol structure

In Table 6-167, 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 6-167—PA-Preamble series

Index	Carrier	BW	Series to modulate
0	Fully configured	5 MHz	6DB4F3B16BCE59166C9CEF7C3C8CA5EDFC16A9D1DC01F2AE6AA08F
1	Fully configured	7, 8.75, and 10 MHz	1799628F3B9F8F3B22C1BA19EAF94FEC4D37DEE97E027750D298AC
2	Fully configured	20 MHz	92161C7C19BB2FC0ADE5CEF3543AC1B6CE6BE1C8DCABDDD319EAF7
3	Fully configured	*Reserved*	6DE116E665C395ADC70A89716908620868A60340BF35ED547F8281
4	Fully configured	*Reserved*	BCFDF60DFAD6B027E4C39DB20D783C9F467155179CBA31115E2D04
5	Fully configured	*Reserved*	7EF1379553F9641EE6ECDBF5F144287E329606C616292A3C77F928

Table 6-167—PA-Preamble series *(continued)*

Index	Carrier	BW	Series to modulate
6	Fully configured	*Reserved*	8A9CA262B8B3D37E3158A3B17BFA4C9FCFF4 D396D2A93DE65A0E7C
7	Fully configured	*Reserved*	DA8CE648727E4282780384AB53CEEBD1CBF79 E0C5DA7BA85DD3749
8	Fully configured	*Reserved*	3A65D1E6042E8B8AADC701E210B5B4B650B6 AB31F7A918893FB04A
9	Fully configured	*Reserved*	D46CF86FE51B56B2CAA84F26F6F204428C1BD 23F3D888737A0851C
10	Partially configured	N/A	640267A0C0DF11E475066F1610954B5AE55E189 EA7E72EFD57240F

The sequences of indexes from 3 to 9 in Table 6-167 are reserved for the irregular nominal channel bandwidth to support tone dropping.

The magnitude boosting levels for different FFT sizes are shown in Table 6-168.

Table 6-168—PA-Preamble boosting levels

512	1k	2k
1.9216	2.6731	4.6511

For 512-FFT, the boosted PA-Preamble at the$k$-th subcarrier can be written as

$$c_k = \frac{1.9216}{\sqrt{N_t}} \times b_k$$

where b_k represents the PA-Preamble before boosting (+1 or –1) and N_t is the number of transmit antennas.

In the case where the Advanced Air Interface supports R1 MSs in mixed mode as shown in Figure 6-139, the A-Preamble symbol with a different time domain waveform from the WirelessMAN-OFDMA R1 Reference System preamble should be transmitted with an offset of an integer number of symbols in the first WirelessMAN-OFDMA R1 Reference System DL zone, as specified in 6.3.3.5.1.

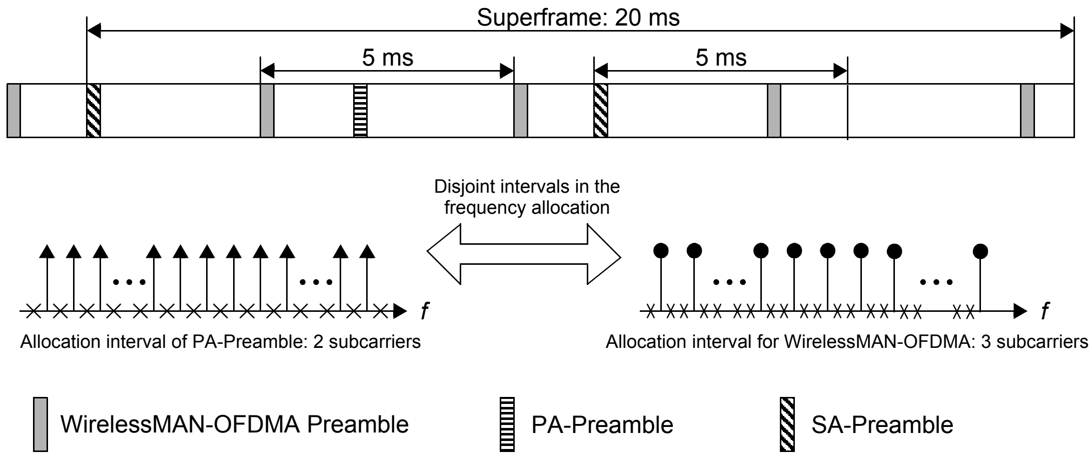


Figure 6-139—A-Preamble transmission structure supporting WirelessMAN-OFDMA

6.3.5.1.2 Secondary advanced preamble (SA-Preamble)

The N_{SAP}, the number of subcarriers allocated for SA-Preamble, are 144, 288, and 576 for 512-FFT, 1024-FFT, and 2048-FFT, respectively. The allocation of subcarriers is accomplished by Equation (216), when the subcarrier indexes 256, 512, and 1024 are reserved for DC for 512-FFT, 1024-FFT, and 2048-FFT, respectively.

$$SAPreambleCarrierSet_n = n + 3 \cdot k + 40 \cdot \frac{N_{SAP}}{144} + \left\lfloor \frac{2k}{N_{SAP}} \right\rfloor \quad (216)$$

where

$SAPreambleCarrierSet_n$	specifies all subcarriers allocated to the specific SA-Preamble.
n	is the index of the SA-Preamble carrier-set 0, 1, and 2 representing segment ID.
k	is a running index 0 to $N_{SAP} - 1$ for each FFT sizes.

No circular shift is assumed in Equation (216).

Each segment uses an SA-Preamble composed of a carrier-set out of the three available carrier-sets in the following manner:

- — Segment 0 uses SA-Preamble carrier-set 0.
- — Segment 1 uses SA-Preamble carrier-set 1.
- — Segment 2 uses SA-Preamble carrier-set 2.

Each cell ID has an integer value *IDcell* from 0 to 767. The *IDcell* is defined by segment index and an index per segment as follows:

$IDcell = 256n + Idx$

where

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

$Idx = 2\mathrm{mod}(q, 128) + \lfloor q/128 \rfloor$, q is a running index 0 to 255.

SA-Preamble sequences are partitioned, and each partition is dedicated to a specific base station type such as Macrocell ABS, Macro Hot-zone ABS, Femto ABS, or TTR Relay ABS. STR Relay ABS can be included in either the macro ABS partition or the Macro Hot-zone partition based on deployment. The base station types are categorized into macro ABS and non-macro ABS cells by hard partition with 258 sequences (86 sequences per segment × 3 segments) dedicated for macro ABS. The non-macro ABS information is broadcasted in a hierarchical structure, which is composed of S-SFH SP3 and the AAI-SCD message. In S-SFH SP3, non-macro ABS cell type is partitioned as public and CSG femto base stations. A total of 16 cases of *IDcell* partition for public and CSG-femto ABS are shown in Table 6-169, which is composed of *IDcell* partitions based on 30 sequence (10 sequences per segmentation) granularity.

Table 6-169—*IDcell* partitioning for public ABS and CSG-femto ABS

Value indicated in 4bit-SFH SP3	*IDcell* partition for public ABS (Number of sequences per each segmentation)	*IDcell* partition for CSG-femto ABS (Number of sequences per each segmentation)
0000	(0)	86+256n ~ 255+256n (170)
0001	86+256n ~ 105+256n (20)	106+256n ~ 255+256n (150)
0010	86+256n ~ 115+256n (30)	116+256n ~ 255+256n (140)
0011	86+256n ~ 125+256n (40)	126+256n ~ 255+256n (130)
0100	86+256n ~ 135+256n (50)	136+256n ~ 255+256n (120)
0101	86+256n ~ 145+256n (60)	146+256n ~ 255+256n (110)
0110	86+256n ~ 155+256n (70)	156+256n ~ 255+256n (100)
0111	86+256n ~ 165+256n (80)	166+256n ~ 255+256n (90)
1000	86+256n ~ 175+256n (90)	176+256n ~ 255+256n (80)
1001	86+256n ~ 185+256n (100)	186+256n ~ 255+256n (70)
1010	86+256n ~ 195+256n (110)	196+256n ~ 255+256n (60)
1011	86+256n ~ 205+256n (120)	206+256n ~ 255+256n (50)
1100	86+256n ~ 215+256n (130)	216+256n ~ 255+256n (40)
1101	86+256n ~ 225+256n (140)	226+256n ~ 255+256n (30)
1110	86+256n ~ 235+256n (150)	236+256n ~ 255+256n (20)
1111	86+256n ~ 255+256n (170)	(0)

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

For the support of macro, public and CSG femto deployment, if $0 \le Idx \le 85$, it is reserved for macro ABS, if $86 \le Idx \le z$, it belongs to public ABS, and if $z + 1 \le Idx \le 255$, it belongs to CSG femto ABS, where z is calculated from SA-Preamble sequence soft partitioning information in S-SFH SP3 IE. The public ABS and CSG femto ABS may use different segments to the co-located macro ABS. CSG femto ABS may be further restricted to one segment to reduce interference to public ABS. Public ABS may choose a different segment to CSG femto ABS. For example, the public ABS may choose the segment as $i = \text{mod}((n + 1), 3)$, and CSG femto may choose the segment as $j = \text{mod}((n - 1), 3)$ if the co-located macro ABS uses segment n. The *IDcell* of public ABS may be $256i + Idx$, $86 \le Idx \le z$, and that of CSG femto ABS may be $256j + Idx$, $z + 1 \le Idx \le 255$. The public ABS also may choose the segment as $j = \text{mod}((n - 1), 3)$ to reduce interference between public ABSs.

The AAI-SCD message provides finer partition information. The non-macro public ABS category can be further divided into Macro hot-multicarrier zone, TTR Relay, and OSG femto. The CSG femto category can be further divided into CSG-closed and CSG-open.

AAI-SCD includes a 4-bit SA_PreamblePartitionforBS type indicator for each partition, which is ordered by the ABS type; macro hot-zone, TTR Relay, OSG femto, CSG-open femto, and CSG-closed femto ABSs. Each SA_PreamblePartitionforBStype indicates the last index of the preamble sequence of the corresponding ABS type as shown in Table 6-170. The range of Macro hot-zone starts from the beginning of the non-macro public ABS category. The range of CSG-open Femto starts from the beginning of the CSG femto ABS category. For all other ABS types within either the non-macro public ABS category or the CSG femto ABS category, the range of the preamble sequence of the corresponding ABS type starts right after the last index of the preamble sequence for the previous ABS type in the same category.

Table 6-170—*IDcell* partitioning

Value indicated by SA_Preamble Partition for BS type in AAI-SCD	The last index of *IDcell*
0000	85+256n
0001	105+256n
0010	115+256n
0011	125+256n
0100	135+256n
0101	145+256n
0110	155+256n
0111	165+256n
1000	175+256n
1001	185+256n
1010	195+256n
1011	205+256n
1100	215+256n
1101	225+256n
1110	235+256n
1111	255+256n

For 512-FFT size, the 288-bit SA-Preamble sequence is divided into 8 main subblocks, namely, A, B, C, D, E, F, G, and H. The length of each subblock is 36 bits. Each segment ID has different sequence subblocks. Table 6-171 to Table 6-173 depict the 8 subblocks of each segment ID where the sequence {+1, +j, –1, –j} for each subblock for each segment is represented in a QPSK manner. Table 6-171, Table 6-172, and Table 6-173 include 128 sequences indexed by q from 0 to 127 in a hexadecimal format for segment 0, segment 1, and segment 2, respectively. The modulation sequence is obtained by converting a hexadecimal $X_i^{(q)}$ of a subblock into two QPSK symbols $v^{(q)}{}_{2i}$ and $v_{2i+1}^{(q)}$, where $i = 0, 1, \ldots, 7, 8$. The converting equations are as follows:

$$v_{2i}^{(q)} = \exp\left(j\frac{\pi}{2}(2 \cdot b_{i,0}^{(q)} + b_{i,1}^{(q)})\right)$$

$$v_{2i+1}^{(q)} = \exp\left(j\frac{\pi}{2}(2 \cdot b_{i,2}^{(q)} + b_{i,3}^{(q)})\right)$$

where

$$X_i^{(q)} = 2^3 \cdot b_{i,0}^{(q)} + 2^2 \cdot b_{i,1}^{(q)} + 2^1 \cdot b_{i,2}^{(q)} + 2^0 \cdot b_{i,3}^{(q)}$$

The other 128 sequences indexed by q from 128 to 255 can be obtained by the following equation:

$$v_k^{(q)} = (v_k^{(q-128)})^*$$

where

$q = 128, 129, \ldots, 254, 255$

For 512-FFT size, A, B, C, D, E, F, G, and H are modulated and mapped sequentially in ascending order onto the circular-shifted SA-Preamble subcarrier-set corresponding to segment ID, as shown in Figure 6-140. For higher FFT sizes, the basic subblocks (A, B, C, D, E, F, G, H) are repeated in the same order. For instance, in 1024-FFT size, E, F, G, H, A, B, C, D, E, F, G, H, A, B, C, D are modulated and mapped sequentially in ascending order onto the circular-shifted SA-Preamble subcarrier-set corresponding to segment ID.

Table 6-171—SA Preamble for *n* = 0 (Segment 0)

q\blk	A	B	C	D	E	F	G	H
0	314C8648F	18BC23543	06361E654	27C552A2D	3A7C69A77	011B29374	277D31A46	14B032757
1	281E84559	1A0CDDF7E	2473A5D5B	2C6439AB8	1CA9304C1	0AC3BECD0	34122C7F5	25362F596
2	00538AC77	38F9CBBC6	04DBCCB40	33CDC6E42	181114BE4	0766079FA	2DD2F5450	13E0508B2
3	3BE4056D1	2C7953467	0E5F0DE66	03C9B2E7D	1857FD2E3	15A276D4F	210F282AF	27CE61310
4	3DBAAE31E	254AE8A85	168B63A64	05FDF74FB	3948B6856	33656C528	1799C9BA1	004E0B673
5	177CE8FBC	21CEE7F09	397CD6551	01D4A1A10	1730F9049	067D89EA9	3AC141077	3D7AD6888
6	3B78215A1	17F921D66	385006FDC	011432C9D	24ED16EA6	0A54922F1	02067E65D	0FEC2128D
7	01FF4E172	2A704C742	3A58705E1	3F3F66CD2	07CA4C462	1854C8AA3	03F576092	06A989824
8	1A5B7278E	1630D0D82	3001EF613	34CCF51A1	2120C250A	06893FA2D	156073692	07178CFA7
9	032E31906	2DD318EAA	1DE55B14D	0EF4B6FB3	27DED0610	1BC8440D3	0ED86BF8D	14FAFDE2C
10	174725FFD	0D2FB1732	124470F56	292D9912B	1571408A7	227197AE9	2430BC576	0B67304E0

Table 6-171—SA Preamble for *n* = 0 (Segment 0) *(continued)*

11	1F1DCD669	293DD1701	0C34F1B84	28496EE51	3DC41327F	071C06523	28E1657B6	02588EFDA
12	22E4AA041	3810362F1	1955F1DE7	0D6D2F8BE	11F31358E	3EB27BB12	1F4E60111	119BDA927
13	14300B522	152E6D482	168DF6E43	0740B7AE0	14FE7DCDD	0FA092626	23697615A	1F1331EB8
14	12C65ED00	317643CD7	2C637A415	15E3E5185	0F5CBB9E0	23290B156	26F37EFE8	1AA174793
15	1DD6453F0	032C4BD39	082659BD5	320C5E691	224E555B2	3A9615A8D	1BED03424	28E6A9CED
16	068AE7EE9	16F724910	3803DD9BD	2A31A2FFB	010BF5237	33CB067E6	0280C28B7	184417B94
17	1D651280A	2C7BCF443	17324EFB0	236E5C411	381215183	2F076E64E	0A6F2EE74	3DA4196B7
18	27341650F	1B520099C	09AC91114	000A5F48B	30AB4B9B6	2D0DB0DE6	1CF57978A	2D424406B
19	3A01E2FB2	0DF5B257B	019D1C63A	0EA7DCDDB	242D96605	2DA675F15	1DEC54193	3B6341C16
20	2DDFAEB05	21D0A1700	0FA09BB78	17DA7F8BB	06E883B3F	02E6B929B	2C1C413B4	030E46DD1
21	1B625E3F9	0F708F756	00CD97B18	3F036B4DF	2CF08C3E5	213A5A681	14A298D91	3D2ED63BC
22	2DA48D5A9	0C085BD17	01903428A	3DF2A30D9	29061309A	16F7DC40E	2AF88A583	27C1DA5E9
23	30DBAC784	20C3B4C56	0F1538CB7	0DDE7E1BE	2C312903B	0FF21E6C2	032C15DE3	26C9A6BA4
24	3188E8100	385FEFE2D	3967B56C7	3F62D246B	1826A755E	2CDA895EA	2FAB77825	1B525FF88
25	339467175	2DE49506B	27B7282A9	0254470A3	3374310AF	2DF20FD64	3848A6806	11C183E49
26	02AFA38DC	0F2AFDDF4	1A05650E2	061439F88	11C275BE0	30C41DEC9	119E070E9	1E76542C1
27	1B364E155	086FF808C	29F1BA9DC	0A830C788	2E70D0B3A	34EA776B1	3D13615C0	15FC708D4
28	38ECFC198	07034E9B3	2340F86B3	07562464C	22823E455	1F68D29E9	257BB66C6	1083992F1
29	375C4F5AB	3C0F5A212	0EA21BC30	13E8A26F2	17C039773	283AD6662	1F63AB833	2DE933CAF
30	2B773E3C5	3849BBE6C	1CAD2E5AB	0405FA1DE	1B27B4269	3B3BF258F	300E77286	39599C4B1
31	1E878F0BE	0AE5267EC	376F42154	1CD517CC2	302781C47	123FEC7E0	16664D3D8	24B871A55
32	20E200C0A	1C94D2FF1	213F8F01B	369A536E0	161588399	29389C7FC	259855CAC	06025DCE2
33	28D2E001C	3C51C3727	106F37D0E	1FB0EFDD1	2CD9D33C3	1EA190527	0BB5A6F9E	074867D50
34	08EFC44B5	1B484EABE	05FEB2DE2	211AF91B5	0CF52B1E1	002B5C978	11D6E5138	0D402BDD2
35	337C618F4	0A4C31DDA	1D93003D6	006D7D088	348043A6D	325E05758	2C53EEEB8	15ED8E614
36	38375C2FF	18C78FD02	30C11EF53	3916581DD	1B75263FF	2D8DFD6A9	00C4E8482	1D201F96A
37	2E10B0D05	2EF203893	2491D95F1	34D995B51	32214BDF5	3E45674B1	3E74AC66E	1B813A999
38	153E7269D	2391C7BFC	1ADD3A595	0EFD3086E	00AD88A8E	0D8B007CA	0F22C5F9D	010E86385
39	3B58C7BFF	0BA76496E	3AD0B7BBF	1D6D10FB3	3A607BEFC	28F122A95	057950727	179449CB7
40	37AC5194A	390BD9C00	3A48C0461	12FBCE4C6	2A8DD4171	10E9F1E34	251F5D167	1124E96B1
41	0FEF20C67	31EC9EA3F	275B31143	22DA4F02B	352C0F648	21FF5B9F3	3E5BC2372	0A1AE08FE
42	080EDC49B	17AD7F7BA	390775B3C	1380B00DA	2477FF17C	2E6D9E5AF	05381F2DD	26143CC17
43	2DB485795	1B3252799	39AD0211C	3AAE31B76	30532A187	1C8EA5F5A	2EA6E4D6B	30570A2E4
44	11BB4F78A	12CCE1428	2C67EEF99	20E3F841A	20CFCD5F2	1618A7B94	111FF6092	2ED034E06
45	1C66335E5	0CA9B9BD2	3213028AE	15542DD28	290F7DAE2	2137F02D5	17DF9445D	24F162FFB
46	360FB966B	17D878955	1C1D67093	065B84F3A	1A1D955E3	24C73C11E	270EA9EB2	114DCA02C
47	002CE84DD	0616DD253	3EB188345	1FF852926	37E160F00	040DF51EC	1857A33BA	230FD8A0D
48	233C0A71F	22E428104	0325F8170	39566B188	32DA16A4A	039FDF1DC	27A3E946C	0D69F26D9
49	0583F9F73	378380CB6	059D8A960	3E3442C7F	026138ADB	25F370F1E	09D3EB2CC	2D37D50C0

Table 6-171—SA Preamble for *n* = 0 (Segment 0) *(continued)*

50	08DF9CC66	2C2E7AA8F	3CB241ED2	03216B4D2	39736B451	25F6F113F	08FD2AC3C	1974574FD
51	3D1FF6041	2CE2AB97F	01A734F3B	1DCF9F3C5	268D595CA	1FBD2A8B8	0F1449F86	370C352FD
52	123218E40	3AA057589	20F73A16F	26E3BCA5F	3A7330DC6	12C659384	39D99FF1B	276DFC540
53	185AEDEA4	0418B3643	382F7700A	3FC35ED60	07BA2F838	1BC840C93	2469A41EC	0CE7B4CB0
54	2E194E2BF	3302A0B28	1836001EE	154A4738A	36A3BBD72	23CCD0EB1	044B3A13B	2B50C8057
55	0B76405D3	231AAA728	0EE05E9B6	0093A21F2	2065A01D0	1F2B810D4	1082F3A73	1DAFEA492
56	07AD23A3A	2091957F1	3B9D8CBF0	21E4160BE	1BFB25224	3D9085D16	03076DD39	1DBCF8D03
57	226D70EBF	3ED15246C	364130C46	22F6D4AA3	3FCC9A71B	3B9283111	0484F0E58	14574BD47
58	3F49B0987	305231FA6	0CF4F6788	3B9296AED	2346190C5	3365711F4	078900D4A	352686E95
59	1D62AC9A4	104EDD1F5	1B0E77300	1CED8E7F0	388E8002C	1FE6199F4	02239CB15	1FE5D49A2
60	21314C269	28600D12A	22E4F1BAA	044E211B1	0DECFE1B4	3E5B208CC	1CFC91293	21E7A906B
61	02C029E33	1BA88BE4D	3742AE82F	21EF0810F	17D23F465	240446FB5	17CCE51D9	2C0B0E252
62	16F9D2976	10185ECE6	2821673FD	02674271C	3A8A75B7C	226D4BF0F	2216004E5	0E8605674
63	06E4CB337	32A31755D	062BE7F99	1417A922D	2271C07E5	24D6111FA	3F2639C75	0CE2BB3A0
64	18D139446	2426B2EA8	352F18410	1133C535E	10CC1A28F	1A8B54749	22A54A6F4	2F1920F40
65	22443017D	2265A18F5	14E1DAE70	11AC6EA79	31A740502	3B14311E7	3AA31686D	26A3A961C
66	2018F4CA9	3A0129A26	39BDA332E	1941B7B49	03BBCE0D8	20E65BD62	2E4A6EE6C	3B095CCB3
67	0CC97E07D	11371E5FF	31DFF2F50	17D46E889	352B75BEA	1F1529893	21E6F4950	1BD034D98
68	275B00B72	125F0FE20	0FB6DE016	0C2E8C780	3026E5719	119910F5F	3B647515B	1D49FED6F
69	250616E04	0882F53BF	11518A028	3E9C4149D	09F72A7FB	0CC6F4F74	2838C3FD1	08E87689B
70	212957CC2	03DD3475B	044836A0B	2463B52C0	0342FB4B0	34AD95E9B	2936E2045	3B0592D99
71	2922BD856	22E06C30C	390070AED	09D6DC54F	3485FA515	064D60376	07E8288B3	3DD3141BF
72	29CB07995	007EE4B8B	16E787603	07C219E93	1031B93DD	23DEFF60B	30F1D7F67	0EFE02882
73	11F3A0A2F	38C598A57	3FE72D35B	1F655E0D1	0B3AC0D92	3430DDB1A	3BAADBF42	02D6124C0
74	05FC8085D	345A5C470	07DAAE1E9	0D7150B88	25D2A5B10	16F8E5021	3240EFC71	0F0F5922D
75	399F32F6E	2EEB17A8E	0D61665D0	2138EE96F	3F8119063	01B5048F7	27075153D	265DF8280
76	3962CC581	2337D2983	286FD7BBA	185126E0E	1F95AD927	0F7EBC374	1E3A4B6FF	20CA9B9BD
77	1C85C13AF	290C37167	1FDD26E8F	0C38736B8	0174DB972	0A921E3CC	097557C9D	09452C1E6
78	2D48D6C00	2D9BC8DFE	10FF1E128	25C96BA85	0FB071B8E	0F09B3C9C	1A3E11441	38EDDA03D
79	396B88B2F	0029F4BDB	30D098CAD	0D54D12CB	1D0823F55	2DC53B9AA	11BCF7438	33F6EC091
80	21E03CD65	1A2FE5B92	2851F8445	0251E386C	1468950D8	1A8B39748	001B42236	26CD82DA5
81	2CEA1E6BB	006C97E74	00C2B887D	23461AF95	0E9CB2BD2	0B0EA3022	1FB56A7A3	25A7FA625
82	208FC2A1F	381C5733A	03F11D7E3	07ED6A7B7	1FEC85E09	3D61E0440	356F4B1C3	3756E5042
83	2061E47F0	22EAA0AD3	24796BB65	03C59B4D8	32A75E105	22155381B	23E5F041C	155D2D7F9
84	381AFFB73	212B5E400	1F1FE108E	04BF2C90D	3C1A949D9	2854A9B45	001B09322	3A9372CC1
85	058B23433	0904C6684	158CADB9E	11BA4B978	1854368F4	1919ECEA7	147F1FD34	2E228AA3C
86	34857F3DB	2CB44F7BF	111A065D3	1BEAB392E	27F081ED8	3E67D1186	0F6265AC5	27716FAF9
87	38EBB8BF1	32ED6E78F	2B0BA4966	2188282AA	00D49B758	1765BA752	2B50AFDCC	068C82450
88	234F0B406	02FB239CD	15AD61139	2250A5A05	1CD8117E0	0D849163F	268C7A5A6	22A802020

Table 6-171—SA Preamble for *n* = 0 (Segment 0) *(continued)*

89	2D0FE8D16	0C14E3771	07DE5320C	0640C2762	1CBD9FF4E	37A91986D	2024DA401	164D4A84C
90	3225B4D60	3013B75F2	2A77AE5C5	2C25377EE	03C8DF835	346E80FCB	116B79FA5	356D2B604
91	0D55231FD	247907F31	0CFA0B049	36D069A95	10D4CDE71	1A32544D7	38336885F	173ECC08D
92	207420EAC	26FCFE182	3FE7B31C6	15B320E13	187AA34A8	1B52253BF	1FA16669D	3725A81A5
93	3C9C7404A	092B77FEB	3B9865B46	349456F61	39B7C6A66	3075EC990	01BE637DF	330897B17
94	1CA4C048D	2B4D50621	2BF917627	3EA2CC5E1	33EC0A1E3	05FE0F747	349553D72	396077301
95	04CEC1C82	1F828DD00	30122C790	1AD8A7895	1CE0912C0	298382F37	2D4D33F06	001364B36
96	37F8BB035	2F0897994	333F5F096	0F28AB363	20036829F	338017E2D	3A5A05D76	0CC02E5E0
97	02FD351E6	03E316288	2FCAEB4F8	1C5A80CE3	3D3AC3FDD	3E456746D	119A5381F	1581C894E
98	1623B3D0F	103224DB0	0FB936BC8	2EED7F082	26C91513A	2F12E4C31	290F3AEF2	392CBFF67
99	02F75DE8F	2E61A834D	02A692866	1F21044A3	2D7881A95	18651EE05	11FE3D308	39EED56DA
100	3A858659E	2F7A87BE0	135FD561D	27B3B651A	05E131CB9	0D5865123	2CD6991E5	3EE6DF705
101	3F3B247E1	32D02B245	16B98A593	1E4CCFF18	0C4A9D285	06D519FE2	023A336CD	1B20E999E
102	3A9E8B49B	239656AD1	3396D1C51	06F4DCF40	15D819D3F	2A3061144	20BD2A33E	2FFB139CD
103	38622F3AF	24BF9BB7F	1D2729010	15877B93A	00376B0E7	0FF064887	3505CFD9B	354C366B6
104	2A0AB7033	1AFA65DE1	1198D0AD6	38E80C86A	27693D541	3BB26F3D4	39154881C	0E7DD6B6B
105	1B0DE4333	27FE0F6D1	0F00B2888	0BDA322FF	2759B5A4F	0543A2D27	0C36DD1E5	04E9A262D
106	1C7E636BF	000E9C271	2B44F4F30	28255BF77	1CC4D69CE	03F4C57B2	3E926D59B	00AA39BDB
107	1FDE98AE0	0CD076B07	171124FB5	33F098288	1E0B3043E	39731D117	3E7ABC2C8	19CC50279
108	28EE855ED	2A704C371	03288F4B0	3C83E26C2	0A905148B	18C66BB94	1BCC32537	10D71AB44
109	26238A065	0FBD7BCDD	02507CF76	059F69484	3FE0D6F77	2466A50DB	3C07A75B2	2DC0F099E
110	3CDCD6CBE	1446783DA	1626C83F9	2FD4C4DF3	13A59A2D1	2C903D2A3	0FD37F076	0B1039EDD
111	043B07DD7	28D9C2155	2CCEF57A8	34254C1B7	09B933B2F	1FA410127	10BD5E9E6	010EC6389
112	345E8FCAC	226BD7EFA	27341A51C	23854F031	04C297212	044DED8E8	319B3BFB8	37DBBBF57
113	16FBEFA72	1B5EF9484	2DEE7A5BF	097695C12	08AEAD5E8	3DA7C1327	2B81F3E2D	31AFBED32
114	3484086B1	2DFA56B9E	226E8AFE5	285F45484	3E69AC8E1	1CB33645F	2DE53BC30	2F6ED567E
115	1117B5E7D	122A4D471	1AC936544	267010D71	10428CA47	24B72A000	2E27FE185	1E62C1403
116	0B3161E37	038C3DC98	100793647	1A95D8D36	399668787	06C0D4922	25F48AA58	2DFFF1789
117	04FEF7231	381910B63	298783078	30CE5EC1C	29F6F299D	3C34CA770	37BAAB139	3D2069B65
118	18F644052	2051880EC	23ADBF949	04237280A	18304E663	287364EFF	314698D78	149A21E51
119	39E14BBCB	1DBDA9EF4	3ECCAD8D3	1BA3EF99D	26D85CEBF	270547292	0FB3C7826	0131E73D6
120	2DD6F3F93	0FC282088	14A143DDD	0AB840813	0B973037C	29535C9AB	0DF8DA2AC	271CBC095
121	1C1D063F9	3F4EF6DCC	00128D932	145E31F97	0B21590D1	38F1602D8	3AC2EBB74	2320957C5
122	3383C846F	12128F29B	19985CE7D	2834CBBF2	1E1513B3D	364DB5800	33EE3F46C	01A865277
123	0129D260B	238A85BA0	2D81AA924	3917048B6	36F857692	1D2F813C3	0505FB48B	3DC438BC5
124	05E0F8BDC	3D978C1F1	266F83FCA	0E89D715A	01821DEA4	12D9AE517	22F8EAC2C	3C098DA58
125	1575D1CE9	26F291851	3A7BB6D2C	12CC21A3A	2975589B0	39CF607FF	388ABF183	3D3BAAB0B
126	101E5EC7A	0B75BCF3B	13ED25A86	35FC032B6	2F6209FF0	13C7B2041	1F2791466	3A759A6C2
127	1EF89091A	11A653D2C	223FC1F42	2F7B97B31	2CA4EE011	00F68767D	10FE34682	018339212

Table 6-172—SA Preamble for *n* = 1 (Segment 1)

q\blk	A	B	C	D	E	F	G	H
0	20A601017	10D0A84DE	0A8C74995	07B9C4C42	23DB99BF9	12114A3F5	25341EDB0	362D37C00
1	1364F32EC	0C4648173	08C12DA0C	19BD8D33A	3F5F0DDA6	24F99C596	026976120	3B40418C7
2	1C6548078	0A0D98F3C	0AC496588	38CBF2572	22D7DA300	1CCEAF135	356CA0CCF	093983370
3	03A8E3621	2D2042AF5	2AB5CC93B	05A0B2E2E	0B603C09E	117AC5C94	2D9DEA5A0	0BDFF0D89
4	07C4F8A63	3E6F78118	32CCD25F2	1792A7B61	0A8659788	1F9708C04	086AF6E64	040B9CD78
5	2D7EE485A	2C3347A25	3B98E86AF	242706DC3	1CEF639AF	2E1B0D6A9	3E9F78BC1	0FB31275F
6	0307936D0	21CE15F03	392655B2D	17BE2DE53	3718F9AB8	01A986D24	077BDA4EB	1D670A3A6
7	05A10F7B7	31900ACE0	28DCA8010	2D927ABE5	370B33E05	31E57BCBE	030DC5FE1	093FDB77B
8	092C4FED1	268BF6E42	24576811F	09F2DAA7F	24EFFC8B1	21C205A90	1E7A58A84	048C453EB
9	29F162A99	1F739A8BF	09F684599	1BEC37264	38ED51986	286325300	344FC460A	3907B1161
10	0E4616304	0FABDCD08	0F6D6BE23	1B0E7FEDD	0047DE6C2	36742C0C6	2D7ABB967	10D5481DF
11	32DD51790	237D6ACFA	2F691197A	16724EA58	149143636	3810C6EE1	3A78B3FC6	1B1259333
12	1BB0FD4D3	235F10A55	1C7302A27	1148B18E5	04F25FBC8	2A0A8830C	3646DBE59	2F25F8C30
13	0FB38C45B	069DF29E9	00F93771B	3AA35746D	2CAF48FD0	0A42CDD55	19A23CE8F	26318A30F
14	365FBEDAC	27710945F	2AA367D61	05A484318	2563F27D9	2D37D5C00	287D18FBB	3ADB44805
15	3038BC77D	2A45D29EC	156173792	03EC7679E	07577E1A4	1B6A94A74	1D26E5A94	0FD878D5A
16	1F22158E4	3F02A1D37	2767EC03F	1C8CD535A	23DA2E5AB	2D5F25A59	0971AA889	3E78C1846
17	16521E709	12C2DB8FE	3A596C221	1562D5C27	1D9E1F39A	345B96872	301C7894E	2797F032D
18	2EC951A24	1ED768F3F	11217930A	39DB44855	36E41B3FC	0F6E48C44	36254C517	14493C673
19	3EA159E72	24ADE96FE	3458C73A6	30674E1FB	242109AF2	24DAF32B6	24B1EDFFE	291CB9D15
20	2AD0E6696	04F4077D9	1BB279A53	38957605B	379B7A6A0	0BAD35616	1285EAE51	37425C7FF
21	083637980	34F2ED66F	282846A88	19D5E40A6	21205942C	27AC551E9	0F3F4C262	0505FB522
22	3E7D64856	1DB0E599E	159120A4B	1FC788139	235C454FB	3CE5B67C8	339EADB32	0F9F7DDC1
23	3956371B8	1D67BE6E5	1EFCF7D53	041A5C363	2E281EB3F	00AF8A1ED	2DE24A56F	1332C0793
24	0818C47A9	1F945634B	1C5ED3403	1043B5BF4	149702D22	024CBB687	34B01FA8B	1E9F5992F
25	3A6618167	3A0007886	3EDB5756B	2F2FA6FCD	21A5252B8	396FFAD9D	05347B60C	2E0ECA200
26	0D45F89A1	3F9C2C26E	1CBCF809E	3CBE5FCD0	3D2DCF245	14F351A1E	224F5B3FF	2AA6ED34B
27	3BA85ADF8	282005732	3AD7C0223	2E73D1800	23DEA3F46	2275280F6	1586270F9	0CEF4287B
28	07DFE662E	314B74F2F	397BDDC4C	223A8071F	1F5BE3BB4	093BB1F33	0FCA2D129	21B3526A9
29	39FEADC12	0ECE1CD67	206228FAA	38FCCA606	0C5EEE08F	1C1BBDD4E	1459E42ED	11FD64ADF
30	2735FFB20	2AE9B244A	1A5AED974	38FCFD5CB	20310DB81	1C5FC3E24	19FB3BA17	3785BE865
31	24FF6B7EC	01C682673	19CB14113	2C8CD3C2A	066725853	02CD0A23B	279B54315	0CD571063
32	015E28584	30B497250	127E9B2E1	2C675E959	05F442DEE	394AEF6E2	079E5C840	12703D619
33	3CE4B1266	35270B10F	03549C4B3	3B3E6C375	1DBEF270E	0042C9737	049522EC6	24961653E
34	34176CD90	2B5E9EAE1	1C95E3C2B	1EF541D4D	26D1450E6	3B9D895AB	1B0C84349	104B6B428
35	07A813421	2B39EAADC	33553571C	0F8046CDF	2CF6A7F23	0AE3BE8C8	308BFF531	2DBC0F9E3
36	168276972	2CF41744F	3CF2512E0	0F8B68ABC	2E609F6AF	04E03AC8C	0F9B66F49	3AFE28736
37	03456021F	1982574F3	0BB2B3F49	15A4A1CDE	15487D58E	2907C9ABB	15C0D2D73	28D8CFEC3

Table 6-172—SA Preamble for *n* = 1 (Segment 1) *(continued)*

38	3D3FD677C	33AF2628F	3D217FDCF	30027E85F	0A463F23B	2F2AE8324	1D1E945E0	2EB355D28
39	3BCAF9076	3A7D2FF70	3C541F38B	249BD8A94	287BC4833	141391EB7	05B6443D0	2FEACC5E7
40	275F118FA	3A96B346D	0C713CDE5	02F394A28	3EBB1D18D	1BE7A9FDD	223C53CA1	2BF040F77
41	1161DE4F5	0544F9DB7	230847E45	322AF4E17	26944A0B4	3299F1420	1C9405B8E	2DBABD4CE
42	33165C531	268FE9B9B	081A914B4	39100772B	27DBF03E9	3E3A18AB0	13F2D2B83	2CEEE5FF4
43	275F97006	0A578F2EF	16CEE7EC8	38A5B0084	00DC9A1F5	1B88CFA3D	0D8B0B8EF	29FC4CCF2
44	04BBE4F2C	1546C3988	237105A43	339042B36	3A5DEBE2B	1BD09449D	38EFF588B	1CDD3A6C0
45	002E32D38	1E85D3125	3F51120D7	00420ED63	3384713AF	1D941BD34	2B39EA9CF	05B6D9E94
46	2B3100F7B	335EDB2E6	1AC8C8EE4	337FF7139	0672D7995	38A54856E	0124753F2	3A3560851
47	046207CE9	0FE1BC312	09BA5B289	39376EF2B	33F826C2C	2F6531496	3933B8616	23125B50F
48	3E5849C45	01EEDB390	141D9A024	2DE07E565	1813D12BB	36DB8D404	0E8A272AB	3A66B71AD
49	1A2A88A4C	3F0C9B4DB	266CFBDF9	163420CA5	281ABBE99	34771C295	3AC051848	3C53CB875
50	16F795184	3466F1FFA	1F433B456	1DDF13810	25F58CF69	1DD6CFE4E	10A236FDF	12AE697ED
51	1C8D17F4F	07C43B7D1	1C8DAD395	28F6C112E	3A336ADB3	0EB6889AB	2783A6A1F	2CDA40458
52	16044624E	252AA04B2	11484E85C	07F5024B7	286E3A67F	2EE6BACE4	277F1F864	22F3CF57D
53	2D1A3F4CF	0EEB6DEC1	30CD76F42	20403D1AC	3A72EF9D6	1DAAF2A39	03AB76CE0	0A2856267
54	0FA2A786B	38273EDF2	228A45016	0309DF52D	093BDAEDC	1B11E9300	1DA9C5324	03365EB1E
55	24DCFDC06	11CF909D6	2FF693F4C	366338F1F	22E641569	0ACA60D55	32D1B009E	035472E09
56	17F5D6662	062FCF913	35B211035	21ACE73FB	3B4148706	2D0CD106F	2CAB457A4	103E1E49B
57	21859E8DA	2F1E3B3D9	1F1014BE2	062A3DEB5	354C0C786	05A8982D4	35A758943	346EBA72A
58	00CB49E5F	211B1034A	3A5D2DAF1	21D3F3EB0	24B2D1150	1097C3685	2AA3671CE	0E5DC1308
59	24C8401BE	217B1F994	1FB9664A8	3D5057708	05A506088	1314842B9	3C8657064	14B1FA77F
60	2AD698E2E	3C129D1F6	2C744FF4E	1C1C052F8	18C38A9FE	252168A10	2EB68D098	3A001CBD2
61	2AF71324C	2BF41D408	0FC498E18	149A1A407	0FDC2C4A3	19D00C4A1	0F6B0DD29	268CF8E86
62	19F4D82A5	342C73FD5	0F5AEEDE7	21A2A8953	15ADB7A94	11DBE038D	0A5B6634A	0FA382B77
63	0A5985778	35AC3032D	35691C85D	2829D55EE	04A3FBD8C	2C85BFA8E	0F459B864	3E878F0BC
64	10C785EB0	054D4CE18	1BF657A8E	101DC64EF	0B4E3032A	24ECFD9C2	00C98BE0A	2A1F82444
65	300E8B09C	31A079FB3	0C41DEC5F	216CCFE4D	226C5A693	3C31A41DD	3A019974C	23B64EAFC
66	249BDC80F	0316ED79E	1E42B5567	0CFF04A4B	310678543	34D986980	1E3195429	280966E65
67	359A72B64	186A3999D	065825DDF	2D28E6000	10964C1E1	1468C970E	34C8B606A	33CC94DB1
68	370B29C05	12841A9E8	2147E7160	1835345EE	06DB43F37	33854A725	065E6614C	151E2D7B1
69	0EAADDB27	004EC6DDD	30AA39B8B	2AEB34AD4	2A13D6649	00EC67B83	1176417CE	0E3683151
70	0832BA87B	3B67515B9	0FD34BC87	1688F83CB	370B52AD5	3A2CD6F3F	3343BF461	37BD48546
71	16EA2751C	1799D9C42	24055CEC9	226A907D4	133C68F80	22CA03BF0	05F723395	2D35008AF
72	122A5C67D	3E46230BC	09F475BA9	15B4B6754	11DE75C50	28C17544F	1D85FAB8D	0D5AD9537
73	1C5497CD9	3D405F487	05535D737	06952087B	1C4744AF4	3E0EF881C	3CED3D1BB	1D91157CE
74	1D276153D	14604EA77	1661FB979	3BAC5E9FB	089F41406	283154122	2AFDCE892	1FD5E0810
75	2A620F4C2	0DE484180	2D05E6458	3E6D15A27	0A92FF0B7	2CBF7BF53	25A2F28FA	19A10CE02
76	3A77B1FBE	2B262F810	2BEEA0F46	39706BBA2	09257163F	1026D5D74	2E2483EBF	1D6527C1E

Table 6-172—SA Preamble for *n* = 1 (Segment 1) *(continued)*

77	0DC1EBA02	383C59C77	28C7ED115	06FED31D4	16F610DC3	000890B82	2FAD16A3A	35C9AD95F
78	3E5C1EBE2	3C65A7691	2394005B6	251B1BB49	1F42BFA23	0E8608C07	24666F55C	11A5214DF
79	323E882C5	2DBFF5E13	3638BC43F	38CC5CBB5	1DBF783FB	0499418C7	2285E5A40	1A61D17E7
80	1E508F19D	0CF345F97	0E5648601	0A0951DF3	1194EE717	0A6C0B374	03C4E19EC	06F725799
81	0B54F4AEF	186A12343	04C4A60C6	27C2CC0E9	3973075A1	392C5EEB7	3933C99B1	005F98CB2
82	021B6635A	3764D0696	20942B266	0155C4EDD	3FDBF7497	37356D442	374F3DB06	2718357FE
83	120DF6F80	0E41F376A	03544C7B2	2D6795EFD	29E8811F1	1B3EFD388	01CA4C48D	2067E8033
84	07703D649	35221AB50	22141A0D7	268061A59	2D9192B05	3834711FF	3A07258C0	36253B5AA
85	1C4A564C1	26804247A	16A4DB29D	0BEF93C88	37A3EAB6C	25547B136	3FC935878	250E3BF1C
86	17049BB43	0D6426761	2BF3A471E	1665820E9	14412A13D	30D5744B0	2ECE5CAE6	01395189C
87	29615B890	0A2C5A664	216DA64F4	3D4AA9D2C	07B98342C	2603F0D76	0574BDFA8	3F9B35D5D
88	3A0414B22	0A8BE885E	155C220E4	2D3B17AA6	3017E1B48	26508C6C8	3FF25EC63	240EFF072
89	2ACD81CE3	0468D7943	2A4108121	1F2E8E67F	3AB446179	33325CA24	3006DD3A5	1A33F3A2C
90	2B038BAF7	070660C4E	30953C7B7	3E7375D04	1D6A39944	001BE5C8D	199A89253	0A82087BB
91	03BF7C836	2CBF9FC48	38EAB1C98	11C303993	3D748807F	1EBD41D17	351085EF2	1C55B94D3
92	116E0BE61	17BC8C403	31BD1EAA2	1CF87C049	2A41CC04D	3883EFEC1	3971BBBE2	190CAE3B7
93	172799BB5	3301DB193	2480B569B	34DBEFE9C	003287827	38DAEA1CB	0B0E25BB4	1972B37E3
94	3EF1F9EF4	189D8C3E0	1941998D3	259838BC9	28E545988	33BFC60D8	3572B10F3	197913B6B
95	24CF96D66	285347801	22BC70E5E	394231BCC	077583F4E	0364420AF	278FBF5CB	3850AFC8B
96	1B38C4A50	04439E0B5	3A7BEB18B	3003A36CD	329D5A2B6	1BB123AFA	049C2CC94	0F604D1DC
97	28D47EF33	24CF66B6B	24B716FA9	34ED7F6BB	186AE44B4	1380D0726	1CC51324E	16BA74F62
98	04422E60A	3424BA16C	3FF1B39DD	1A1E658F7	33457317D	14E822151	3EC02F279	28593D11D
99	0F2DF0912	21BBFA838	32D634EBF	2061148FD	09A565B74	2BCE430B7	34DAAD9FA	228ADAFE5
100	2D7EE0544	25D57B7CA	0FADAF20D	19B4F6444	3A75DF1C1	0AD3EDD56	0A4D61EEA	28C1262A5
101	1B6AEE253	0BFE02772	24AB19547	186A377A5	03089B4E8	128955F60	3A8DA9AC8	2931648B3
102	21BE0200F	00F34B4F5	34FF3261B	1A0E27AED	0A821AEFB	21B0BA404	1C6A644A4	1734EBB33
103	201FBFD73	0592E9D86	053D87C9D	3CAFC7479	22F1BA3FA	3DB25DD15	31D468990	22FF2B539
104	06C77404E	18AE64252	3963D899A	37179C03C	0FD2E3D04	191E64DBB	380B841FB	368E1DEAA
105	3A561759B	156243DE8	04325D217	33993D0B0	0CEAC2109	002242D1B	33C1D9F5E	1EC4195D3
106	17D7A9B74	1F44ABA75	17B572FE3	096008B9B	1F1E00AAE	05489F7A1	17A4C131D	1C018E923
107	0A4ACCEC8	1F294A30D	19CAEE64E	002787A1B	03EB3238D	27C10F626	1C9E656A0	3F73609F0
108	1E0E3C802	1B52D12AA	2F4E003B7	23BA7A6F1	3CAA0998A	32E96C916	168EFA1EE	28147EE33
109	1CEC9799E	215D9302B	176BB6639	003D5E371	12FE4ADB3	3106B64E2	001D9C28E	0F39059DC
110	31570792D	2260D7FEF	1AC830374	118FE7C78	08F982159	23BB2B13A	2C7944305	376396F3C
111	2D340540B	272E94D06	097C70995	0E70DDADA	1DBD644E5	341A72A58	01CBF5334	2C7999AF9
112	3FF17764D	0701DFAD3	146BDBB97	229D2D7F0	03C5DA21D	3A5916EC7	2390AC01D	197D64233
113	3E9759D5A	00B237425	0B7E646B9	190CB4D16	2646AA1D4	1A373103D	337E5EFB1	0199DE4A1
114	3FD5ADE8A	26B843860	0A2D0AA7B	3C351E07F	1B25376AE	05C553CDD	1DBC3F38D	019823A2A
115	30FF187B4	112F9D7A1	1AE977517	3760AF555	004F86368	3700975C2	0518029DE	032427D9B

Table 6-172—SA Preamble for *n* = 1 (Segment 1) *(continued)*

116	3A86D49BB	057E649D8	2FDE33D7E	31254217C	30E05CE12	10BCC1CD7	1889C5139	38A163ECF
117	2610F5174	02A7ACB27	208B84FF0	14609CA80	0F3526318	38EBC7384	287C57BAA	279661A9C
118	014F6D77B	1036B3D2C	294F1999A	33A059187	26CCE0507	180DF3129	00A6CAE22	2AC0F23A2
119	347C62997	1912A710D	2260C531F	2F54BBEBB	0A2D90305	1BBEE20E4	0AF79997E	2376F3D0F
120	04484EB82	181977944	1C1CC2693	227ECAB0F	23F32982B	19E2F290C	1BA2300F8	0EFB06247
121	0EC048AD8	3B2168495	34FC02DA1	2C0CDEF52	0553CA222	25DFA4581	29CF66B6B	0AB9C21CD
122	2AF502148	3B00632F9	387CDC4BF	3F8B9F716	19084CD65	0354918C7	39D1FD9AA	0F5ABDB77
123	2C6E2557A	3E8A19D6B	3E6756A28	237E6E5BF	24CA57004	1D52401AD	0237F1D80	0FB2B335D
124	228F4B540	07532BF5D	101F67F52	29D8598EE	0421A0E23	2D89C2AFF	0963D2F3B	24C472A63
125	0CF3598E8	196A40BD2	00E63B26D	088A0BFCA	1C78E9016	03835236C	33071A836	3949DC586
126	3E815D747	1588D4E96	073C8D44A	303281AE4	095D31EC8	1F10F69DC	200F057D8	1F270128F
127	34F9ACB6B	384870FF1	257A863DE	34B36BA0F	3FA3D216B	27425041B	0E0DD0BAD	2E95AD35D

Table 6-173—SA Preamble for *n* = 2 (Segment 2)

q\blk	A	B	C	D	E	F	G	H
0	13F99E8EC	3CF776C2A	3300A482C	0B2BF4791	17BECDFE8	35998C6D4	05F8CB75C	259B90F0B
1	116913829	05188F2A4	2DB0A8D00	2F770FE4A	185BE5E33	0F039A076	212F3F82C	116635F29
2	004EE1EC6	18EF4FDD9	26C80900E	1A63FB8A7	1DAA917D4	0E6716114	02690646D	0CC94AD36
3	06D4FF377	2716E8A54	16A1720C8	08750246F	393045CCB	1DBCCDE43	114A0CAD6	181690377
4	3DC4EF347	1F53452FC	01584B5D3	11D96034F	1FA62568E	11974FACA	191BE154D	397C9D440
5	05A1B6650	29835ADAD	2F6DDABE4	0976A607B	11BA92926	2456B1943	3E3FD608B	095E7584B
6	00CC66282	0560BE767	21EBAA7C6	2D8E9ACE3	198A9E285	05F3E73DD	13DA751A2	176B75E43
7	03D08ADC1	2254606FC	3C695D892	1DA9E0280	2CD4FF589	19B78A5A4	0CE67A7C6	12535A61C
8	0984647CF	0822BA46B	3EB2BC076	212596F54	11CC2E64E	120BADF9F	0DA72CEDE	30D0E106F
9	083CE5726	1F05DA925	169D93EF6	1FCADF3D3	08A5CF0BC	317C8508F	19BDCCFE7	0FACE3631
10	27583A466	1CB1634D5	03C7849F7	38C6CED00	1161C173A	15A645D3E	281A7ED92	076ADA797
11	33BA1AE8F	187F578EE	32473D69A	2458B703B	267E59071	0F317883B	3E7DEDBF1	3B9859BA7
12	0322609A3	20C4C957C	3FD638746	3FB716D79	36BD0CF1C	333B11B8F	0027ED1F2	3E7471BF3
13	3529922B1	0ECECBE04	1980B9B9E	38D60363F	18904BCED	108E3E5F1	34B95C446	338F51DAC
14	21FD50527	0EA2F7A31	1E294A159	114734A02	120B90BF3	3F3617C92	0129071E2	106640936
15	2B59354BB	275BF9761	39C6FF332	2004B3902	053F9DCB0	19D79A902	2B3125038	20649B43E
16	03A8A7A2B	091AE6721	18651FD9E	1F5415ECD	1B38EA62E	07FB0F422	3EB58896B	077FE4C7C
17	06A13CB38	340099B18	2AE6D6385	1669631F9	28E51A676	19A023391	261855F39	3E518F0BC
18	2A88F831B	09D295831	294C468DF	1477F0A13	37725C6EB	00E7DB222	27D610157	349A8FAB6
19	163E1C44D	3F98B6F4A	1805538DD	01EE3DB4A	22AA1797E	27568753E	16090F219	2C9838C01
20	34B0543DC	121B8EA82	00873B4A0	220FE7C05	2EDBEAE34	1104BDB93	0711E8C0E	0E1C107BD
21	226183AFF	15643DE71	04A4CDECB	2E67FDF8A	26D2A6D40	25E7695F1	1A99778F5	20FE0C1A3
22	0F7EAC09D	12BB72B2A	182E44301	2962EB85A	3477C1B69	3E3CF56F7	29C9D00C6	39788600C
23	31084BEB5	1DC90E345	391736CC1	3C8292AE1	38A0D515C	3977012F6	25D1F6055	36A7D3F8B

Table 6-173—SA Preamble for *n* = 2 (Segment 2) *(continued)*

24	229D3ABAC	1044BA05F	0C391B88A	0636A90A6	0B14322AB	21ADC33E4	2DC1A3BFE	0D7FF6D1F
25	33C85B393	37BFA31B6	134F872F0	0C5EA36E1	286956ED1	1632092FA	382B4BB10	23DC3EF14
26	38E8B9BF6	0A0CE666B	207D98054	23FF360AD	121BFDA4E	347D442FD	242922C07	23C6E4115
27	263EA8516	36138BD6A	0ED9C55E7	3F0937876	03232BC24	18E5FFF26	3530CF206	3981B7414
28	1D9AC2E79	051B220E9	3F3B09EC8	0D3F6C366	0201A7CB9	3D5477092	22185FF9F	1C5AA5348
29	208D85694	22104E7C5	14BCFD3DD	3592DF665	1F4EC3265	24358076A	2D20A8000	017F2D489
30	36B3A9A2C	3F8E0F162	13ACDCCF2	16951F727	271E73555	1B3EDCDE7	162B45352	1CAFA635A
31	2D30FE705	3EC9BFC8D	1B10F8349	34F973F31	1CA96A349	1A28B4543	1C5367CE6	2DFAB0AE7
32	21D93EB5A	0E49D6211	3C6FCF774	09F44CACF	2D8CD2BEA	037DDAD3D	3BBD06D1D	39CBB996F
33	159B1F948	0183E8DCD	3A484866C	21F8DF1A5	219A58193	2D1B3C399	2275F19BA	0EFF4C612
34	22EB93A82	15047E272	15428D77B	38FFC612E	20609BE54	3226C8254	3E5568DB2	159284EED
35	34529707C	2E84585F4	20DFFB4C5	28288AA00	10EFC1E07	3C4D211FC	379087C3F	25716A7DD
36	20106354F	22AEB9FD7	3A6BAC67D	3126294C6	0FBC874AC	2DFE5675A	391B1DDAA	06BAA74D8
37	348F831C5	2E44BF3C2	3D9F6F454	20746A30E	08D183029	35C6BFEA7	2729B552B	263BB2EBD
38	202D7F08F	0DBE1C144	132F4EC09	184CD9B93	2596F5884	2A55B8217	2BEAE02D8	235A19A43
39	2DDE3FF5F	23932555C	001ED92D7	22FCD3D60	2C0737593	0B27E62FF	0693CFBDC	284D5B33F
40	1DB9AB8E9	2995EE0A1	1ACFE9892	0D41BCB9D	2E3806507	25CCD5D60	3536DF04C	0BB0A5E3B
41	3FFD4DD82	3E69CC1C1	2BC30FB74	3462F70FC	164FAE762	09B83F8AD	1DF593F3C	2DB478034
42	16E24E9B6	0A9FCFBD2	3A018544C	1ED8E2855	0037681E4	05950E1F8	1107DA097	377A25C65
43	03C9318B8	0C70A7749	0D58708C2	0CA2808C4	219E02554	39315B2F2	2E089B00F	302E135C7
44	04DC211E8	1DD20A505	21A50649F	2CA438C04	39CAD66AE	2E1BD969F	002748760	069924211
45	2E84BCF09	226F5D43C	37BE7EB10	07CDC854A	06FB50D48	08966435B	01BA5E5D2	1D34057FA
46	2D8DFD565	0A30D633F	33F93B7C6	0B330E9D2	0E659B262	130669024	19A9D5F64	38059132D
47	17E4777AE	1308F9046	2F7C0483E	1859E0943	0982C9101	05453D92C	001F53877	388A571AB
48	00D29CC63	0A6D3BDED	1CA44D2AF	388C002CA	2A3D70EF7	2DD3F5A6F	39FEAF0B6	11DFE385F
49	3E3A6CEC4	122F5E8BE	360B96301	0632CF244	2E8985A9F	0FD256C87	0449C29D4	26B713C90
50	238150687	3D96F7F7B	0091E6D18	21802352A	02F7A466E	0A5BB6648	350DA85DB	1C97F4544
51	306BA76DE	379A88697	3F0DA31E1	0EBF48C71	27F8A46EB	3F75A19F6	277002F97	275B43715
52	24D946CC1	38DF102DC	3EFE1F5B3	3C316E148	2735B20CF	0688E430F	0316DC923	24919BEA1
53	0EEAF72D2	3C7248573	1087A7BD6	08EDA9BF6	2B5D97BF4	26733DC60	1190D275B	2EC7ABD30
54	37C6AB63E	2FFC9C790	02CAA37A7	1B34A3F84	0022CD5F6	3ECF891BF	193D545E2	0172C674E
55	0848A41C3	1D8150EE7	3D8A8549A	2595F707B	00640B276	2D44EBDAE	1CAF37453	377EF590A
56	16B7A5F7D	1F5AA7998	382300A8B	218916E53	19D00E728	1EDA11790	0BBDEF9C4	1DEB15796
57	3EFB3368D	392AA88AD	29CF3CACD	03F59ED8A	1042098CA	1721B8F3A	2B5DE9312	0CB5E6F23
58	1A8B0FB9E	3FBC09C8B	3D7F3E248	034C9BCB5	1BDD89300	3392476C0	0C10AED4B	23BECA42A
59	0EBC749B6	33453C7F6	304735F5C	334628143	1DAF6E7A9	11BB9C393	226C5E4FF	170372039
60	3F9262CBC	0693308C8	21B563415	09BDCC403	0112C79D4	2DA9F1134	36AA1CD7D	3A1608BFC
61	218AC590E	0FACC734D	02132C9A3	27087557E	076B3ECE7	2EA16BA3D	0E1D452F1	3F70B027A
62	004F9DC68	25BE3AD9C	2CBD3C07B	3F9DECD71	3E771E15A	11FF2F24D	2AEA5DF67	1E838955D

Table 6-173—SA Preamble for *n* = 2 (Segment 2) *(continued)*

63	3A04BC376	1D19254F1	00F92DD2B	3C57484F3	181D0973E	319F9CEEA	053ADEEDB	1A3C22150
64	0F78BA6BC	2DFE0E681	3035BD77D	0A0FFD148	275F50C66	2246E9053	27B2BF3E9	1741894F8
65	1ACCD0F79	22F0AEA4F	32796ADB5	134A4A876	183D989E3	204C4BF97	22300E86F	3F18744A3
66	3EB6E19EF	1B24EAB88	2E318F810	3F07B618E	26B4C0C87	31CC10EA8	169E1B650	017DF88ED
67	2BD9E8FED	0AB104122	30C9D81A0	09EA73C7F	141357B1D	000A7DB48	1DD06FD41	0AFA8EF72
68	19CA5678F	28A89AA43	1DB945917	262AF69C3	3145A4473	3742CBFF5	1BCD965E9	1B0E7FC84
69	077838B25	2BF7032F8	23DC2E014	028544277	37B411B5F	392FF6CDC	1D66F2BE9	011372DA0
70	39596216C	05A651F63	183A6AE26	0D1FCA203	0FF6F0D22	2FEB8364B	05A438ED8	32D045F13
71	3711AD513	290B237FF	20E2A9B26	0C72A0234	2F1ABBE93	19B505378	354ED915D	0C359F272
72	1D7786BA4	1CCDF053A	36828B333	0ED27AFB6	241326FC4	1A9C37F8B	0A9C3C372	05937E898
73	1053B9CDB	040B97B1D	0D4FF481D	23AD465A8	2906EBDE2	0C4F6C09D	2189C5FEA	2D90D305A
74	39073122B	35FEAA236	1B38B7A90	2E02AB9F7	219FEEA0A	36B3B2EF8	39A3F4C8B	15A42C9DD
75	2C6326A9E	33F7536C1	2A120C75F	37030CAA0	3A011882C	098C8504E	3B92D756B	175811CF9
76	38A0F736B	2BD9E9C32	3B989715A	2A646ADF4	2D02FE38C	11AC7E9E6	3F5464862	0F382B0D8
77	26897D80C	145B21D3E	143F5E320	30549707E	28126710C	122CA92BE	3AF47270C	0B544128F
78	00E931208	2E1E75EAA	374C36E5F	21724DFC5	1DFCD2028	1B3FF774E	3A826A68B	1781CDCA4
79	0C3D7268D	0B7A26BF9	1587CE5CD	1D04E1E60	36240C07D	1AC403449	0417F9622	02B9F8BED
80	1B569F488	08A3F3A46	377F03A18	2DE416045	1ED96E381	33F4F16DC	2C8DAAE4F	33E384AC7
81	13F709786	02A4E32CB	14C7F849E	09EA16987	06C849EA4	219E4B995	243CB7F07	253513BC6
82	09B83FDF2	119D60439	278290BFF	2483E6F2C	0EDEC175D	242A669C1	3EB639EF0	31EBB4CA0
83	22CAEF0E4	0B2FCDED0	19BA79607	343F81C7B	289AA213E	358AC9FFA	23956ADA1	00BC725E7
84	1186F95E3	2F95F4048	3CFBF41E2	1D1E4BE96	26B38BA65	2F715E590	2235C0029	2C89AF93F
85	33437ED6C	12F14DB69	2E70F5611	183752704	142BC8B34	3B90ECD86	1C11EB493	1022D4782
86	248457F60	05B9A28A5	0A2A5DD56	16002D9E7	34C87FB16	2E32BAE0C	21065BD64	1CCE92BB0
87	1DCE3941A	1D940ACE3	30D331B98	3D5A3BAB6	119791607	10FB0D788	2C78E9015	100B598E4
88	39C0BC811	1B886594E	27AF50C73	2DCEA05E6	0805EDCA9	3A5989B08	18AD24255	1683B7CF2
89	186A3D233	09E8B95DA	1ED9F3DBE	1B19A74F8	356CA7443	316C9FBE9	3F8A3162A	3A0BC11CC
90	02F039B63	2F02D3E75	0F5B5E89E	3D062255C	222C6AA4E	25DEA06FB	39488C071	139318BFB
91	27B5B6EE8	22154E0BD	3FF7729F1	1052B1947	3D477BF2B	3EDB6745A	1B30CF849	030F84AF4
92	27B2D40BC	01EE5E9B6	24B0ACF84	3370F65E0	067D8DFA9	1C01B9327	26FF8FDB5	3809C0CA6
93	11F581193	07B9B7A7D	1CA56B4A3	3D088CC6C	11D52C38A	344760F0A	3D3AA336D	0118CBD93
94	096990784	2960D1672	3BFD7D847	2BC297EEE	32168CF28	3912FFF6C	08ED9BAB1	34452C6E5
95	02CD48DC2	186403849	24C6EE1EA	12ED5268A	2718C00E9	27E8F18CF	145913E2D	0B09009BB
96	06B97DD08	2880C9B96	37EB87E03	14C4ED01D	17041E5DC	347A412CB	088CE591B	0BE926B22
97	116250DF7	1745B4329	1102B7093	1CA549C5A	25244AB6C	374E0F19B	274F76015	0FB738F16
98	12841B9E9	1F9C4AEEB	1445F0C98	39FFB6307	02AB688E7	0FD8B499E	28D533072	138F162EA
99	22BD9525E	2030E58C6	25F2CD033	157D93437	1442E92D2	3D6EE9DF3	3CA5B469D	0588A0FAE
100	0FDEC177D	2606157BE	2224E556C	0C6F33897	0F830DE1B	3C3F9C1D8	2AF576923	0D4173E27
101	376EF82C2	30E3C582E	0A82DE29A	1B8D454D9	079ACE6D9	2579984C6	392F28400	24CEAEDF1

Table 6-173—SA Preamble for *n* = 2 (Segment 2) *(continued)*

102	1CD4AA9D2	1DD6F4DA5	3485B7150	105DE02F9	22168E0FA	24F48AA6C	003771A39	306890843
103	1F8303786	2C981AAE4	0819F22E9	0A1D88D55	3B4C012FD	0214CDF52	19DF3BE8F	02364E19A
104	1364A15C0	16E9F9961	17E598810	2654E5A2C	09B43C7C8	3A5E2AF45	14FC71E26	2B4BA69F4
105	12E128BEF	19166342E	04A1404B7	283D17B66	014836F64	13BE0B4B5	2F8583C08	2B19A7FB4
106	19F83FDE2	361D25170	36354011B	3FF4EC74B	1B2128FF9	0C849EB1B	096B991D8	1CA7A74AA
107	32E0BEF35	11A61714D	34C56D40B	0742C52FE	00ED2F1C4	3997FC7B7	06E414374	180DCD64F
108	18399ED59	224E6C2FF	3450F1BB7	27A1CA959	21B5E00F8	13B67DAE8	0B14C022E	0E41BBEE2
109	318D94D05	2EBB53B17	331C3E6F4	0FBCD71ED	380FF18B8	3E3C75B26	0E0088A18	17553D2A2
110	37AC7E5D5	27C9EADFA	3FC47B5E4	38699BB57	1564F8B27	3579C7FEB	13401BD88	0DB519DE0
111	0FF4D6F22	3C84242F3	2DEAE40AD	305F320A5	244CB97B0	0892DA905	3F09D5CB5	332E7DB02
112	31479E580	1B6AD13E0	16A1CF9E2	33A0A119A	1AC8388E9	3D4105F37	226501835	27AF1310F
113	1CBDAFE39	3E5A30C1C	236E9A029	063430D97	0CD91A825	02F335D7E	1989FE0BE	13C4E2A20
114	10B393370	33CB79316	2CEB44FC0	236019420	248F95ACB	35034B6F0	365691771	34A8FBCB6
115	25463FC5F	082FC0ED2	038ACE1CC	3E959B49D	21B8C04F5	08633F3A0	3A5D18159	12B3EC4C7
116	167B32C3E	06FF88387	34C3F468B	3239005B2	121C913AF	21C90CE16	28B54D557	3811CB0A9
117	221BD0503	0AF619499	21F8D40C1	1B3DA7AEE	3FA2E3B05	348466C50	10F12A28D	0E70B26AB
118	1D79A57C5	315D2460F	1402B8222	28DC66FEA	1BCF748F9	2AD5D4227	0094D2CAD	25EA22A58
119	062B39CFB	310E8818D	0F2D0A235	3F6468866	33F86F342	39CAB5BBC	2E7D6A8BF	3E9218162
120	2FCDEA0E0	1BDD766A4	2827B99BB	0B5F04CC9	1C9E02A9A	1A6675ED4	033497A06	07D4ADD44
121	3CD46CD9D	311A64A85	24DDFE6FF	3411C6FE5	0D0613CDA	0E9276056	178ACC4F8	23DEA3CB0
122	2762D6A40	306FE3843	1402589C8	382B07654	160BA3DEA	3815B54C8	273960105	2076A15E5
123	1C593A744	1562487F6	0C38617B4	2CA68266A	071C4BF93	2593F0BDC	1562436E5	199BEEA49
124	35B8C7503	278F57EAA	34A804061	19C657A74	385734710	3FAC27628	0707BED4E	32F20F45E
125	34994C46C	1C6B99499	1AF24D850	11AD795D3	19288BFE9	1360C1B96	3B5D8DBC0	2554E72D6
126	22D7095A4	34B70502A	3F0CB27D2	04FC214E6	24C0B80C5	03D6F4DC8	1432A099E	26300D70E
127	21C33416F	18B894695	3AC062614	3537CF601	00A20A8B8	1CD10BAF5	394DF1DC0	0925851ED

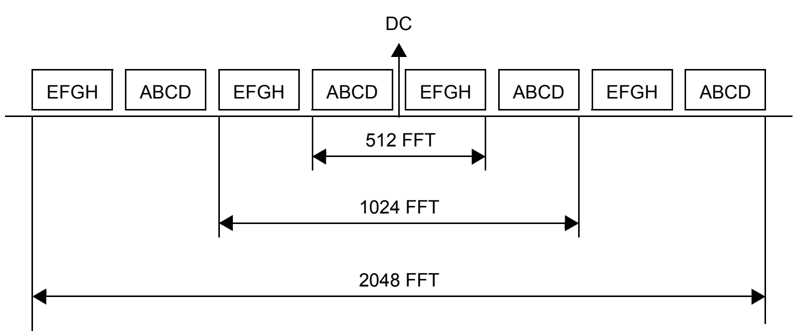


Figure 6-140—Allocation of sequence subblocks for each FFT

A circular shift is applied to more than three consecutive subcarriers after applying subcarrier mapping based on Equation (216). Each subblock has common offset. The circular shift pattern for each subblock is as follows:

[2,1,0…,2,1,0,…,2,1,0,2,1,0, DC, 1,0,2,1,0,2,…,1,0,2,…,1,0,2]

where the shift is circularly right shift.

For 512-FFT size, the subblocks (A, B, C, D, E, F, G, H) experience the following right circular shift (0, 2, 1, 0, 1, 0, 2, 1), respectively. Figure 6-141 depicts the symbol structure of SA-Preamble in the frequency domain for 512-FFT.

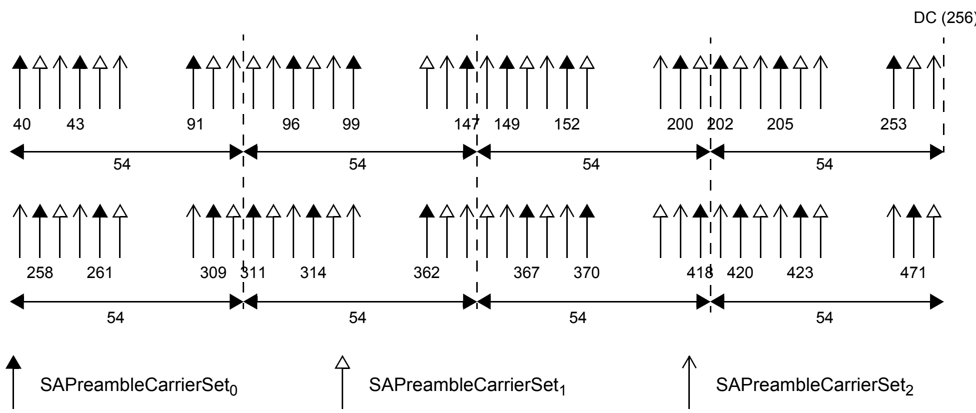


Figure 6-141—SA-Preamble symbol structure for 512-FFT

For multiple antenna systems, the SA-Preamble blocks or subblocks are interleaved on the number of antennas as follows. For 512-FFT size, Figure 6-142 depicts the SA-Preamble allocation for 2, 4, and 8 antennas.

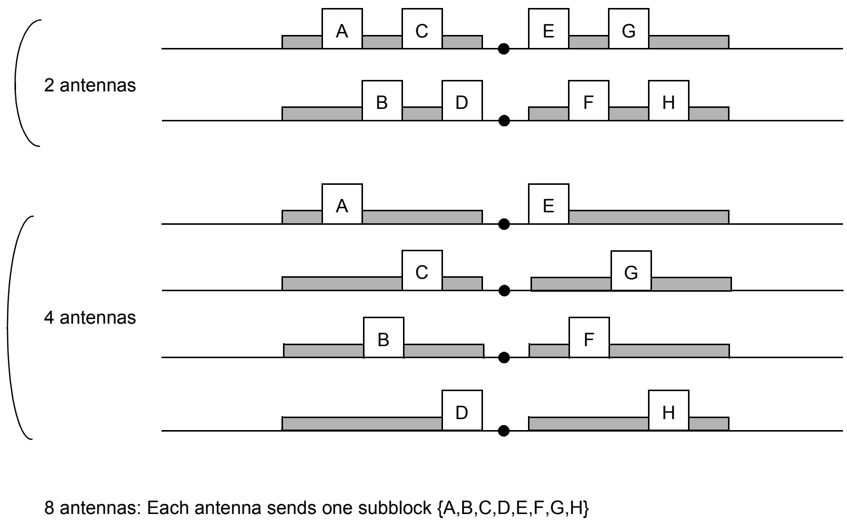


Figure 6-142—Multi-antenna example for 512-FFT

For 1024-FFT size, Figure 6-143 depicts the SA-Preamble allocation for 2, 4, and 8 antennas.

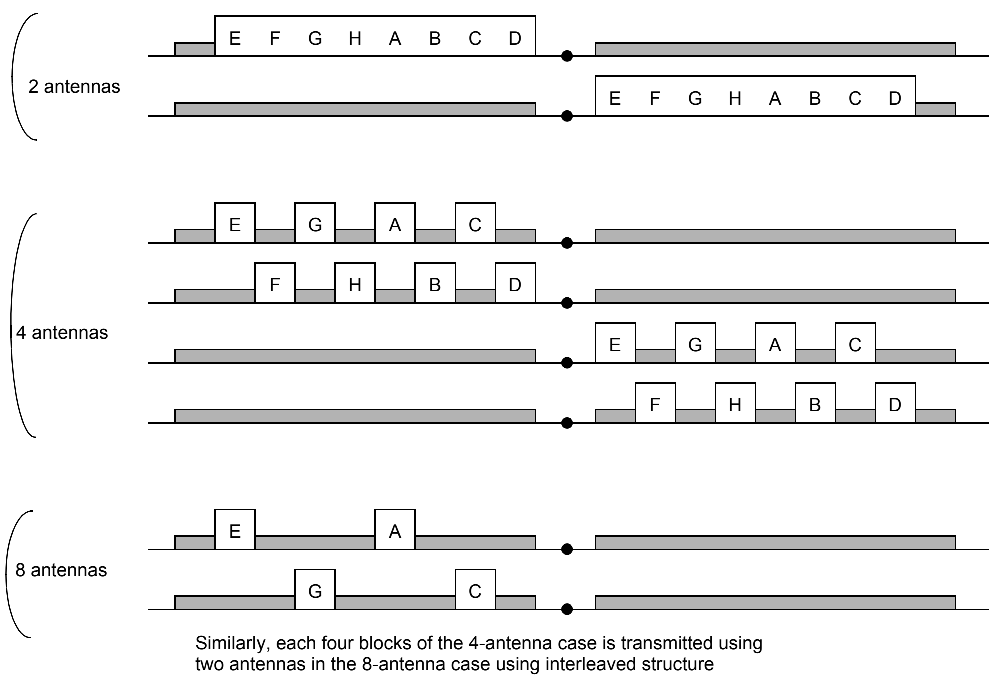


Figure 6-143—Multi-antenna example for 1024-FFT

For the 2048-FFT, Figure 6-144 depicts the SA-Preamble allocation for 2, 4, and 8 antennas.

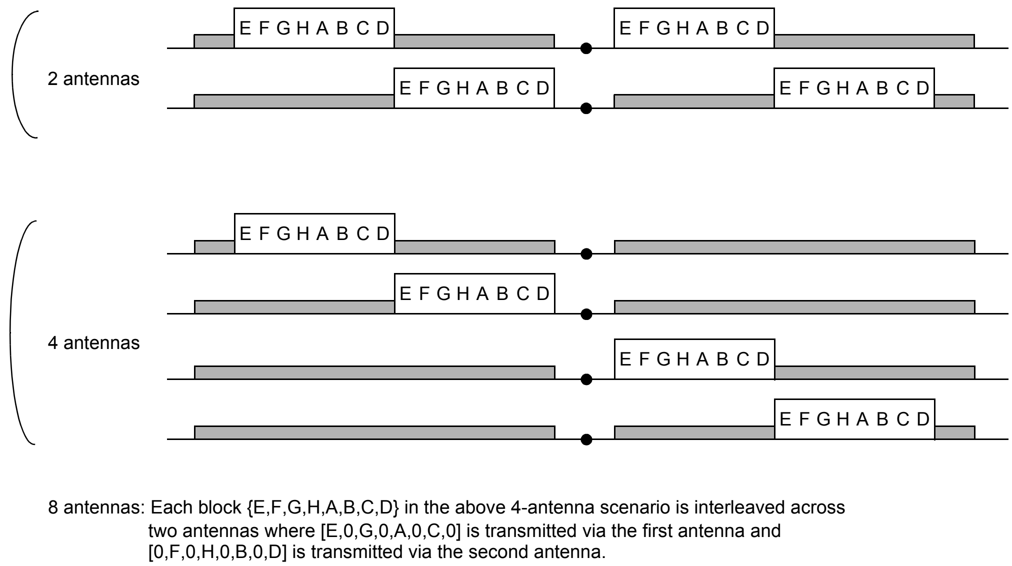


Figure 6-144—Multi-antenna example for 2048-FFT

Let "block" denote 8 consecutive subblocks {E, F, G, H, A, B, C, D}. For 512-FFT size, however, the positions of {E, F, G, H} shall be swapped with {A, B, C, D}, as shown in Figure 6-142. The algorithm to assign the preamble blocks to multiple transmit antennas where the tone dropping is not applied and the number of antennas is power of 2 can be described as follows. Let

N_t: number of transmit antennas

N_b: total number of blocks

N_s: total number of subblocks; $N_s = 8 \times N_b$

N_{bt}: number of blocks per antenna; $N_{bt} = N_b/N_t$

N_{st}: number of subblocks 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 antenna t is $t + p \times N_t$, where $t = 0, 1, \ldots, N_t–1$, $p = 0, 1, \ldots, N_{bt}–1$

Else

If ($N_{st} = 4$)

Interleave the 8 subblocks {E,F,G,H,A,B,C,D} across each 2 consecutive antennas

Block [E,0,G,0,A,0,C,0] is sent from antenna i at block position: floor(i/2)

Block [0,F,0,H,0,B,0,D] is sent from antenna $i + 1$ at block position: floor(($i + 1$)/2), where $i = 0$ for 512-FFT, $i = 0,2$ for 1024-FFT, and $i = 0,2,4,6$ for 2048-FFT

Else If ($N_{st} = 2$)

Interleave the 8 subblocks {E,F,G,H,A,B,C,D} across each 4 consecutive antennas

Block [E,0,0,0,A,0,0,0] is sent from antenna i at block position: floor(i/4)

Block [0,0,G,0,0,0,C,0] is sent from antenna $i + 1$ at block position: floor(($i + 1$)/4)

Block [0,F,0,0,0,B,0,0] is sent from antenna $i + 2$ at block position: floor(($i + 2$)/4)

Block [0,0,0,H,0,0,0,D] is sent from antenna $i + 3$ at block position: floor(($i + 3$)/4), where $i = 0$ for 512-FFT and $i = 0,4$ for 1024-FFT

Else If ($N_{st} = 1$)

Interleave the 8 subblocks {E,F,G,H,A,B,C,D} across each 8 consecutive antennas; i.e., send 1 subblock per antenna

Block [E,0,0,0,0,0,0,0] is sent from antenna i at block position: floor(i/8)

Block [0,F,0,0,0,0,0,0] is sent from antenna $i + 1$ at block position: floor(($i + 1$)/8)

Block [0,0,G,0,0,0,0,0] is sent from antenna $i + 2$ at block position: floor(($i + 2$)/8)

Block [0,0,0,H,0,0,0,0] is sent from antenna $i + 3$ at block position: floor(($i + 3$)/8)

Block [0,0,0,0,A,0,0,0] is sent from antenna $i + 4$ at block position: floor(($i + 4$)/8)

Block [0,0,0,0,0,B,0,0] is sent from antenna $i + 5$ at block position: floor(($i + 5$)/8)

Block [0,0,0,0,0,0,C,0] is sent from antenna $i + 6$ at block position: floor(($i + 6$)/8)

Block [0,0,0,0,0,0,0,D] is sent from antenna $i + 7$ at block position: floor(($i + 7$)/8), where $i = 0$ for 512-FFT.

At each time frame containing the SA-Preamble, the transmitted structures are rotated across the transmit antennas. For example, consider the 512-FFT system with 4 transmit antennas. At the f-th frame, the SA-Preamble structure [A,0,0,0,E,0,0,0] is sent via the first antenna, and structure [0,0,0,D,0,0,0,H] is sent via the fourth antenna. In the ($f + 2$)-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 sizes and number of antennas are shown in Table 6-174.

Table 6-174—SA-Preamble boosting levels

Ant\FFT	512	1k	2k
2	2.12	1.99	2.18
4	3.50	2.91	3.22
8	6.63	5.04	4.88

For two antennas and 512-FFT size case, the SA-Preamble is transmitted with a magnitude boost of 2.12. The boosted SA-Preamble at the k-th subcarrier can be written as

$$c_k = \frac{2.12}{\sqrt{N_t}} \times b_k$$

where b_k represents SA-Preamble before the boosting (+1, –1, +j, or –j) and N_t is the number of transmit antennas. The block cover sequence shall be applied to each subblock. Each bit {0, 1} of block cover sequence shown in Table 6-175 as a hexadecimal format is mapped to real number {+1, –1}, and then multiplied to all the subcarriers in the corresponding subblock in the structure depicted in Figure 6-140.

Table 6-175—SA-Preamble block cover sequence

(FFT, number of antennas)\Segment ID	0	1	2
(512,2)	22	22	37
(512,4)	09	01	07
(512,8)	00	00	00
(1024,2)	7373	3030	0000
(1024,4)	3333	2D2D	2727
(1024,8)	0F0F	0404	0606
(2048,2)	7F55AA42	4216CC47	3A5A26D9
(2048,4)	6F73730E	1F30305A	77000013
(2048,8)	2F333319	0B2D2D03	0127271F

SA-Preamble sequences for tone dropping support are obtained by dropping the farthest subblocks of the reference bandwidth from the DC subcarrier on both sides.

For support of irregular nominal channel bandwidth by tone dropping, the dropping unit of SA-Preamble is two subblocks. The granularity of nominal channel bandwidth is 1.25 MHz. Table 6-176 shows the allocation of sequence subblocks for SA-Preamble according to the different range of available nominal channel bandwidth, where N_{si} is the total number of subblocks in irregular nominal channel bandwidth.

Table 6-176—Allocation of sequence subblocks for tone dropping support

Irregular nominal channel bandwidth range, x (MHz)	N_{si}	Allocation of sequence subblocks
5 < x < 6.25	8	ABCD EFGH
6.25 ≤ x < 7.5	10	H ABCD EFGH A
7.5 ≤ x < 8.75	12	GH ABCD EFGH AB
8.75 ≤ x < 10	14	FGH ABCD EFGH ABC
10 < x < 11.25	16	EFGH ABCD EFGH ABCD
11.25 ≤ x < 12.5	18	D EFGH ABCD EFGH ABCD E
12.5 ≤ x < 13.75	20	CD EFGH ABCD EFGH ABCD EF
13.75 ≤ x < 15	22	BCD EFGH ABCD EFGH ABCD EFG
15 ≤ x < 16.25	24	ABCD EFGH ABCD EFGH ABCD EFGH
16.25 ≤ x < 17.5	26	H ABCD EFGH ABCD EFGH ABCD EFGH A

Table 6-176—Allocation of sequence subblocks for tone dropping support *(continued)*

Irregular nominal channel bandwidth range, x (MHz)	N_{si}	Allocation of sequence subblocks
17.5 ≤ x < 18.75	28	GH ABCD EFGH ABCD EFGH ABCD EFGH AB
18.75≤ x < 20	30	FGH ABCD EFGH ABCD EFGH ABCD EFGH ABC

In case of 5 < x < 6.25, the antenna configuration of 512-FFT size for the regular channel bandwidth 5 MHz is used. In case of 10 < x < 11.25, the antenna configuration of 1024-FFT size for the regular channel bandwidth 10 MHz is used. Except for these two cases, the algorithm to assign the SA-Preamble subblocks to multiple transmit antennas in the irregular system bandwidth is described as follows. Let $N_{st,k}$ be the number of subblocks for k-th antenna, where $k = 0, 1, ..., N_t - 1$. Then $N_{st,k}$ is defined by Equation (217).

$$N_{st,k} = \left\lfloor \frac{N_{si} + N_t - 1 - \mathrm{mod}(k - p, N_t)}{N_t} \right\rfloor \tag{217}$$

where

$$p = \left\lfloor \frac{N_t - \mathrm{mod}(N_{si}, N_t)}{2} \right\rfloor$$

The subblock position for the k-th antenna is $\left(t + \sum_{i=0}^{k-1} N_{st,i}\right)\ldots$, where $t = 0, 1, ..., N_{st,k} - 1$, and $N_{st,-1} = 0$.

Figure 6-145 shows the proposed SA-Preamble allocation at $11.25 \le x < 12.5$ as an example.

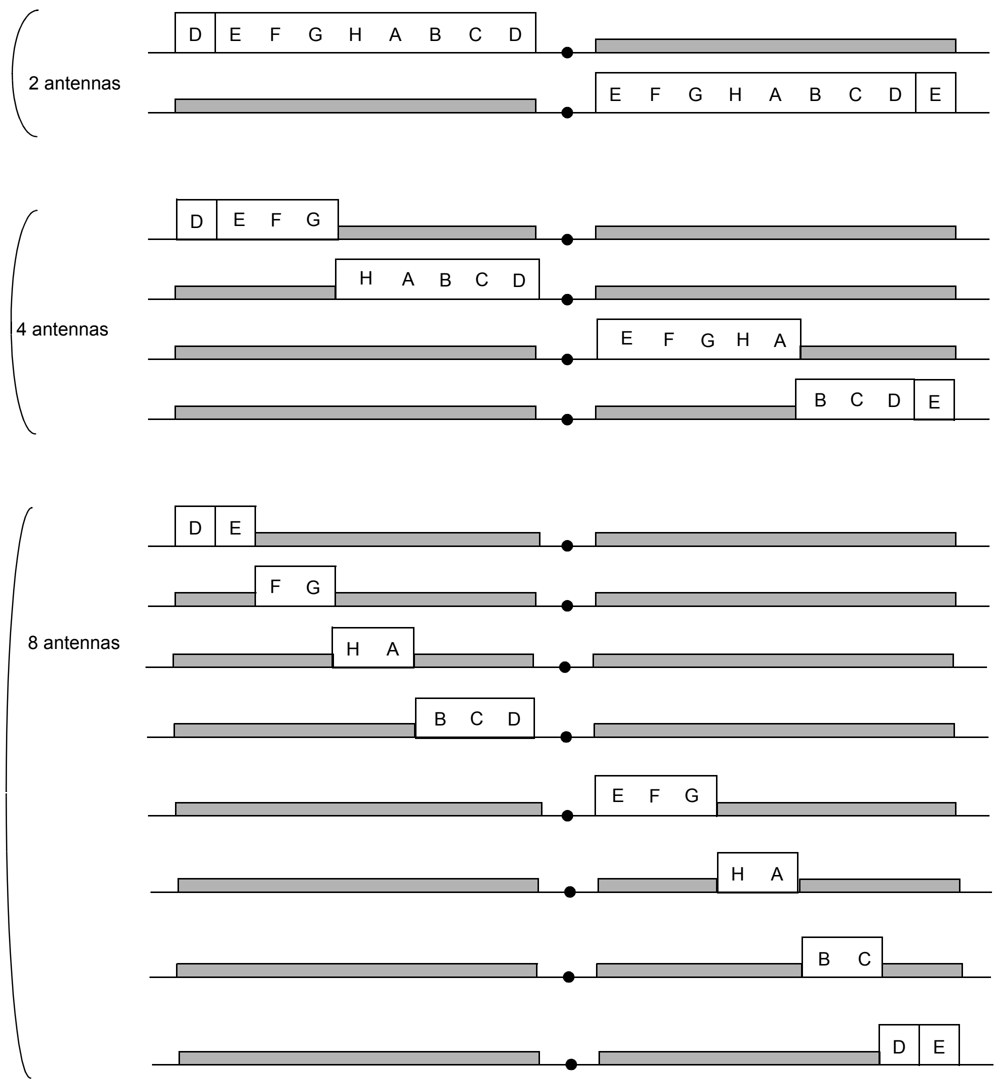


Figure 6-145—Proposed allocation of SA-Preamble at 11.25 ≤ *x* < 12.5

At each time frame containing SA-Preamble, the transmit structures are rotated across the transmit antennas. The rotating direction is same as the reference channel bandwidth.

The block cover sequence shall be applied to each subblock. Each bit {0, 1} of block cover sequence shown in Table 6-178 as a hexadecimal format is mapped to real number {+1, –1}, and then multiplied to all the subcarriers in the subblock structure corresponding to the tone dropping design. In Table 6-178, $BW_{\min}$ denotes the minimum value (MHz) of Irregular Nominal Channel Bandwidth Range as shown in Table 6-138. BCS for the range $5 < x < 6.25$ is the same as BCS of 512-FFT size for the regular channel bandwidth 5 MHz, and BCS for the range $10 < x < 11.25$ is the same as BCS of 1024-FFT size for the regular channel bandwidth 10 MHz as shown in Table 6-175.

The magnitude boosting levels for different $BW_{\min}$ and number of antennas are shown in Table 6-177.

Table 6-177—SA-Preamble boosting levels for tone dropping support

BW_{min}\Ant	2	4	8
6.25	2.22	3.09	4.26
7.5	2.27	3.54	4.92
8.75	2.20	3.06	5.24
11.25	2.34	3.04	5.18
12.5	2.43	3.31	5.66
13.75	2.44	3.08	5.83
15	2.52	3.33	6.32
16.25	2.59	3.16	5.39
17.5	2.71	3.38	5.78
18.75	2.66	3.26	5.94

Table 6-178—SA-Preamble block cover sequence based on subblock dropping

(BW_{min}, number of antennas)\ Segment ID	**0**	**1**	**2**
(6.25,2)	0f68	0650	0458
(6.25,4)	0300	0300	0908
(6.25,8)	0140	0000	0100
(7.5,2)	0C24	1558	0F58
(7.5,4)	1B08	030C	1904
(7.5,8)	0140	0400	0510
(8.75,2)	335A	146C	3C10
(8.75,4)	1320	0252	2406
(8.75,8)	0140	0404	1514
(11.25,2)	005A0F80	00000000	00000000
(11.25,4)	00AF6A80	00E65280	00A45900
(11.25,8)	00230000	00A30200	00090800
(12.5, 2)	000F7000	01FF0000	00000040
(12.5, 4)	00AF6A80	00E65040	00C45900
(12.5, 8)	015B0940	00030C40	01190540
(13.75, 2)	012C1BA0	030177A0	02266200

Table 6-178—SA-Preamble block cover sequence based on subblock dropping *(continued)*

(BW_{min}, number of antennas)\ Segment ID	0	1	2
(13.75, 4)	024C2400	03155920	01CF59A0
(13.75, 8)	009B0800	02830D20	02190420
(15, 2)	00CC5AB0	015411D0	020E0050
(15, 4)	038C2470	02D559C0	048F58D0
(15, 8)	009B0820	02830D10	06190420
(16.25, 2)	065A5AD0	06543808	080F4C50
(16.25, 4)	0D335A70	01146C70	053C10D8
(16.25, 8)	09932018	0D025248	00240640
(17.5, 2)	10C36614	1B553644	0F9A5524
(17.5, 4)	19B35A4C	13146C44	03BC1030
(17.5, 8)	1223234C	09525248	1B04042C
(18.75, 2)	2BA55AD4	029C6D58	13590072
(18.75, 4)	3D73734C	0F30306C	2B00000E
(18.75, 8)	05232312	21525272	04040414

6.3.5.2 DL control channels

DL control channels convey information essential for system operation. Information on DL control channels is transmitted hierarchically over different time scales from the superframe level to the AAI subframe level.

In mixed-mode operation (WirelessMAN-OFDMA R1 Reference System/WirelessMAN-Advanced Air Interface), an AMS can access the system without decoding WirelessMAN-OFDMA R1 Reference System FCH and MAP messages.

6.3.5.2.1 Superframe header

The Superframe header (SFH) carries essential system parameters and system configuration information. The SFH is located in the first AAI subframe within a superframe. The SFH uses the last 5 OFDM symbols, which form a Type 3 AAI subframe within the first AAI subframe.

All PRUs in the first AAI subframe of a superframe have the 2 stream pilot pattern in the Type 3 AAI subframe defined in 6.3.4. The resource mapping process in the first AAI subframe within a superframe is predefined as follows.

The AAI subframe where SFH is located always has one frequency partition FP_0. All N_{PRU} PRUs in the AAI subframe where SFH is located are permuted to generate the distributed LRUs. The permutation and frequency partition of the SFH AAI subframe can be described by $DSAC$ = 0 (all minibands without subband), $DFPC$ = 0 (reuse-1 only), $DCAS_{SB,0}$ = 0 (no subband CRU allocated), and $DCAS_{MB,0}$ = 0 (no miniband CRU allocated). Definitions of these parameters are given in 6.3.4.

The SFH occupies the first N_{SFH} distributed LRUs in the first AAI subframe of a superframe where N_{SFH} is no more than 24. The remaining distributed LRUs in the first AAI subframe of a superframe are used for other control and data transmission.

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

Table 6-179 includes the parameters and values for resource allocation of the SFH.

Table 6-179—Parameters and values for resource allocation of SFH

Parameters	Description	Value
N_{SFH}	The number of distributed LRUs which are occupied by SFH. Note that $N_{SFH} = N_{P\text{-}SFH} + N_{S\text{-}SFH}$	$N_{P\text{-}SFH} + N_{S\text{-}SFH}$
$N_{P\text{-}SFH}$	The number of distributed LRUs which are occupied by P-SFH	$ceil(N_{Rep,\ P\text{-}SFH} \times Size_{P\text{-}SFH} /40)$
$N_{S\text{-}SFH}$	The number of distributed LRUs which are occupied by S-SFH	$ceil(N_{Rep,\ S\text{-}SFH} \times Size_{S\text{-}SFH} /40)$

$N_{Rep,\ P\text{-}SFH}$ is the number of repetitions for P-SFH transmission. $N_{Rep,\ P\text{-}SFH}$ shall be set to 6.

$Size_{P\text{-}SFH}$ is the sum of the information bits in the P-SFH IE and 5-bit CRC. $Size_{P\text{-}SFH}$ shall be set to 26.

$N_{Rep,\ S\text{-}SFH}$ is the number of repetitions for S-SFH transmission and is indicated in P-SFH IE.

$Size_{S\text{-}SFH}$ is the sum of the information bits in the S-SFH IE and the 16-bit CRC. $Size_{S\text{-}SFH}$ varies according to the scheduled S-SFH SPx IEs, FFT size, and S-SFH size extension. When no S-SFH SPx IE is scheduled in the superframe, $Size_{S\text{-}SFH}$ is 0.

The factor of 1/40 is calculated by considering a code rate of 1/4 (excluding repetitions) and QPSK across 80 data subcarriers.

6.3.5.2.1.1 Primary Superframe header

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

The first $N_{P\text{-}SFH}$ distributed LRUs of the first AAI subframe shall be allocated for P-SFH transmission. $N_{P\text{-}SFH}$ shall be set to 4.

6.3.5.2.1.2 Secondary Superframe header

If the S-SFH is present, the S-SFH shall be mapped to the $N_{S\text{-}SFH}$ distributed LRUs following the $N_{P\text{-}SFH}$ distributed LRUs.

The information transmitted in S-SFH is divided into three subpackets.

The subpackets of S-SFH are transmitted periodically where each subpacket has a different transmission periodicity as illustrated in Figure 6-146.

The “SP scheduling periodicity information” field of S-SFH SP3 is used to indicate the transmission periodicity of the S-SFH SPs (1, 2, 3). Table 6-180 shows the transmission periodicity of different S-SFH SPs for different values of the “SP scheduling periodicity information” field.

Table 6-180—Transmission periodicity of S-SFH SPs

SP scheduling periodicity information	Transmission periodicity of S-SFH SP1	Transmission periodicity of S-SFH SP2	Transmission periodicity of S-SFH SP3
0000	40 ms	80 ms	160 ms
0001	40 ms	80 ms	320 ms
0010–1111: *Reserved*			

When the contents of any S-SFH SPx IE change, the ABS may additionally transmit the changed S-SFH SPx IE in superframes that carry the P-SFH only as illustrated in Figure 6-147. Such additional transmissions may only be scheduled in periods when the “S-SFH application hold indicator” is set to 1. Although the transmission frequency of the changed S-SFH SPx IE is increased due to one or multiple additional transmissions, these transmissions shall not affect the application time of the changed SPx IE or the transmissions determined by the original scheduling periodicity of the changed SPx IE.

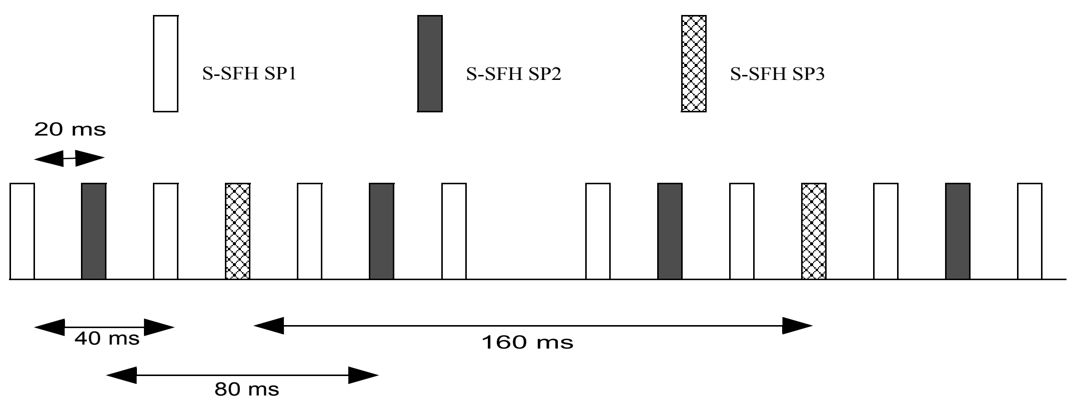


Figure 6-146—Illustration of periodic transmission of S-SFH SPs with example transmission periodicity of 40 ms, 80 ms, and 160 ms for SP1, SP2, and SP3, respectively

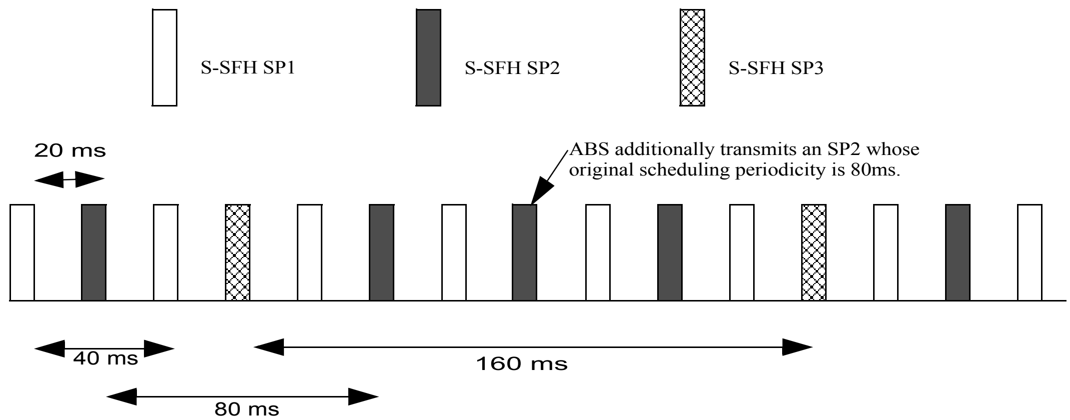


Figure 6-147—Illustration of additional transmission of S-SFH SP2

6.3.5.2.2 Advanced MAP (A-MAP)

The Advanced MAP (A-MAP) carries service control information. 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 present in all DL AAI subframes. DL and UL data allocations corresponding to an A-MAP region can occupy resources in any frequency partition within the AAI subframe or the AAI frame according to A-MAP relevance and HARQ timing defined in 6.2.14.2.2.

Figure 6-148 illustrates the location of A-MAP region in the TDD mode.

A-MAP	A-MAP	A-MAP	A-MAP				
DL SF0	DL SF1	DL SF2	DL SF3	UL SF0	UL SF1	UL SF2	UL SF3

Figure 6-148—Example of locations of A-MAP regions in a TDD system with a 4:4 DL/UL ratio

If FFR is used in a DL AAI subframe, both the reuse-1 partition and the power-boosted reuse-3 partition may contain an A-MAP region. In a DL AAI subframe, non-user specific, HARQ feedback, and power control A-MAPs are located in one frequency partition called the primary frequency partition. The primary frequency partition can be either the reuse-1 partition or the power-boosted reuse-3 partition, which is indicated by the ABS through S-SFH SP1 IE. Assignment A-MAPs can be located in one of the following: in the reuse-1 partition or the power-boosted reuse-3 partition or both. The number of assignment A-MAPs in each frequency partition is signaled through non-user specific A-MAP.

The structure of an A-MAP region within the primary frequency partition is illustrated in the example in Figure 6-149. The resource occupied by each A-MAP may vary depending on the system configuration and scheduler operation.

In DL AAI subframes other than the first AAI subframe of a superframe, an A-MAP region consists of the first L_{AMAP} distributed LRUs in a frequency partition and the LRUs are formed from PRUs with N_{sym} symbols. In the first DL AAI subframe of a superframe, the A-MAP region consists of the first L_{AMAP} distributed LRUs after N_{SFH} distributed LRUs occupied by SFH.

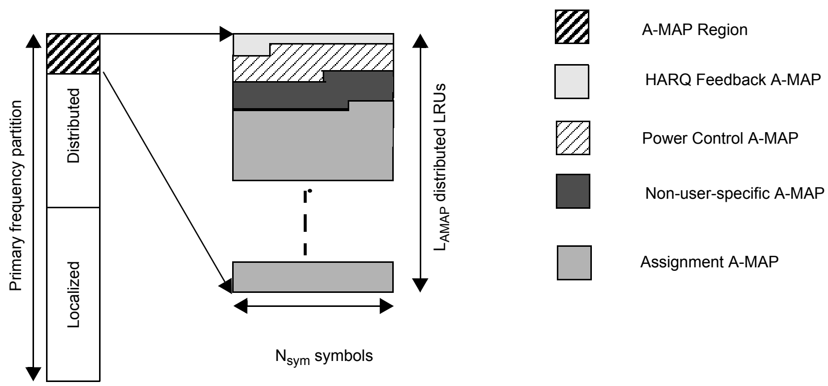


Figure 6-149—Structure of an A-MAP region

6.3.5.2.2.1 Non-user-specific A-MAP

Non-user-specific A-MAP consists of information that is not dedicated to a specific user or a specific group of users. The AMS should firstly decode the non-user-specific A-MAP in the primary frequency partition to obtain the information needed for decoding assignment A-MAPs and HF A-MAPs.

6.3.5.2.2.2 HARQ Feedback A-MAP

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

6.3.5.2.2.3 Power Control A-MAP

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

6.3.5.2.2.4 Assignment A-MAP

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

The minimum logical resource unit in the assignment A-MAP is called MLRU, consisting of $N_{MLRU} = 56$ data tones.

The assignment A-MAP IE shall be transmitted with one MLRU or multiple concatenated MLRUs in the A-MAP region. The number of logically contiguous MLRUs is determined based on the assignment A-MAP IE size and channel coding rate, where channel coding rate is selected based on the AMS's link condition.

Assignment A-MAP IEs with less than 40 bits are zero-padded to 40 bits. Assignment A-MAP IEs with more than 40 bits are divided into several segmented IE, each with 40 bits. Segments of an A-A-MAP IE should be separately coded with the same MCS and occupy a number of logically contiguous MLRUs. The process of assignment A-MAP IE segmentation is described in 6.3.5.5.2.4.15.

Assignment A-MAP IEs are grouped together based on channel coding rate. Assignment A-MAP IEs in the same group are transmitted in the same frequency partition with the same channel coding rate. Each assignment A-MAP group contains several logically contiguous MLRUs. The number of assignment A-MAP IEs in each assignment A-MAP group is signaled through a non-user-specific A-MAP in the same AAI subframe.

If two assignment A-MAP groups using two channel coding rates are present in an A-MAP region, assignment A-MAP group using lower channel coding rate is allocated first, followed by assignment A-MAP group using higher channel coding rate.

If a broadcast assignment A-MAP IE, i.e., the assignment A-MAP IE intended for all the AMSs, exists in a DL AAI subframe, it shall be present at the beginning of the assignment A-MAP group using the lower code rate in the primary frequency partition.

All the multicast assignment A-MAP IEs, i.e., all the assignment A-MAP IEs intended for a specific group of AMSs, present in any assignment A-MAP group, shall occupy a contiguous set of MLRUs starting from the beginning of the assignment A-MAP group. If the broadcast assignment A-MAP IE is present in the assignment A-MAP group, the multicast assignment A-MAP IEs are located right after the broadcast assignment A-MAP IE. The Group Resource Allocation A-MAP IE is an example of multicast assignment A-MAP IEs.

All the unicast assignment A-MAP IEs intended for a particular AMS shall be transmitted in the same assignment A-MAP group. The DL/UL Basic Assignment A-MAP IEs are an example of unicast assignment A-MAP IEs.

As an example, the structure of an assignment A-MAP for non-FFR configuration is illustrated in Figure 6-150.

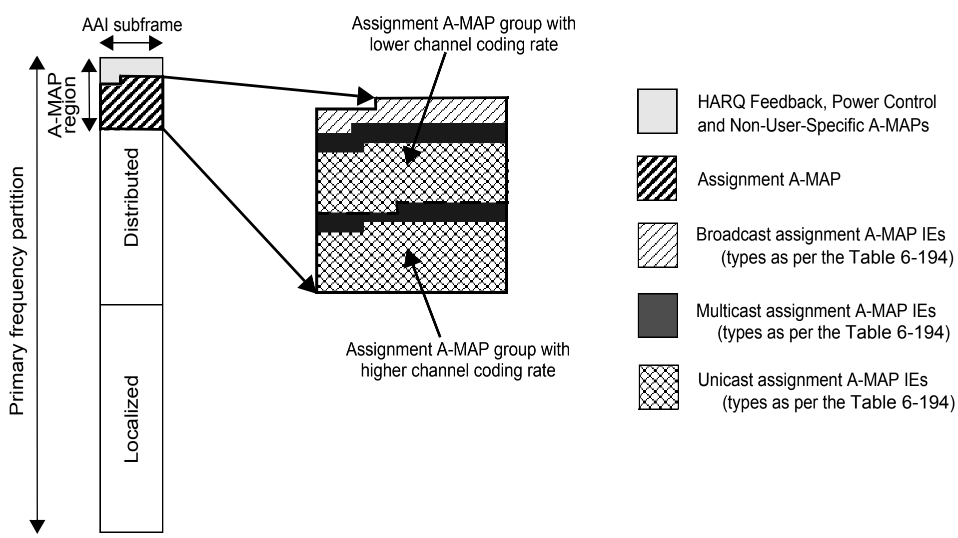


Figure 6-150—Structure of an assignment A-MAP for non-FFR configuration

The maximum number of assignment A-MAP IEs in one AAI subframe that the ABS may allocate to an AMS is 8. This number includes all of the assignment A-MAP IEs that are required to be considered by the AMS (its STID, group ID of GRA, Broadcast ID). For a segmentable assignment A-MAP IE, each segment is counted as 1 assignment A-MAP IE.

6.3.5.2.3 Enhanced multicast broadcast service MAP (E-MBS MAP)

The E-MBS MAP carries configuration information for enhanced multicast broadcast service for one E-MBS Zone. The E-MBS MAP is transmitted in the first several RUs of the E-MBS region in the beginning of the MSI. The parameters of the E-MBS region that include the SLRUs reserved for E-MBS are transmitted in the AAI-SCD message in 6.2.3.31, and the parameters required to decode the E-MBS MAP that includes the burst size of the E-MBS MAP aretransmitted in the AAI-E-MBS-CFG MAC control message described in 6.9.3.1. The first AAI subframe, excluded from the RUs of E-MBS, of each superframe is reserved for the superframe header to transmit.

Table 6-181—E-MBS MAP structure

Syntax	Size (bits)	Notes
E-MBS-MAP () {		
S-SFH SP2 update indicator	1	Indicates whether the changed S-SFH SP2 will be transmitted in this MSI. If this field is set to 1, the time offset that the changed S-SFH SP2 is transmitted will be included in this E-MBS MAP.
If (S-SFH SP2 update indicator == 1) {		
S-SFH SP2 transmission time offset	*variable*	Indicates the superframe offset at which the changed S-SFH SP2 is transmitted. The size of this field depends on MSI MSI == 0b00: 2 bits MSI == 0b01: 3 bits MSI == 0b10: 4 bits MSI == 0b11: 5 bits
}		
E-MBS_DATA_IE()	—	—
Padding	*variable*	Padding to reach byte boundary
}		

6.3.5.3 Resource mapping of DL control channels

6.3.5.3.1 Superframe header

6.3.5.3.1.1 Primary Superframe header

Figure 6-151 shows the physical processing block diagram for the P-SFH.

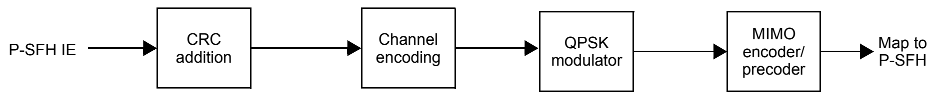


Figure 6-151—Physical processing block diagram for the P-SFH

The P-SFH IE shall be appended with a 5-bit CRC, per the ITU-T Recommendation G.704 CRC-5 with initialization to 0b00000 and no bitwise flipping of the polynomial output. The generating polynomial is $G(x) = x^5 + x^4 + x^2 + 1$.

The resulting sequence of bits shall be encoded by the TBCC described in 6.3.10.2 with parameters $M = N_{Rep,\,P-SFH}K_{bufsize}$ and $K_{bufsize} = 4L$, where L is the number of information bits and $N_{Rep,\,P-SFH}$ is the number of repetition for effective code rate of 1/24.

The encoded bit sequences shall be modulated using QPSK.

The modulated symbols shall be mapped to two transmission streams using SFBC as described in 6.3.6.1.1. The two streams using SFBC shall be precoded and mapped to the transmit antennas as described in 6.3.6.1.2.

Antenna specific symbols at the output of the MIMO /precoder shall be mapped to the resource elements described in 6.3.5.2.1.1. The mapping of data subcarriers across the resource elements is specified in 6.3.6.2.3.

6.3.5.3.1.2 Secondary Superframe header

Figure 6-152 shows the physical processing block diagram for the S-SFH.

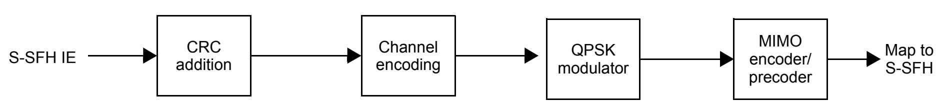


Figure 6-152—Physical processing block diagram for the S-SFH

The S-SFH IE shall be appended with a 16-bit CRC, per the CRC16-CCITT specification in ITU-T X.25. The number of bits including the 16-bit CRC is not larger than 128 bits.

The resulting sequence of bits shall be encoded by the TBCC described in 6.3.10.2 with parameters $M = N_{Rep,\,S-SFH}K_{bufsize}$ and $K_{bufsize} = 4L$, where L is the number of information bits.

The value of $N_{Rep,S\text{-}SFH}$ is indicated in P-SFH.

The encoded bit sequences shall be modulated using QPSK.

The modulated symbols shall be mapped to two transmission streams using SFBC as described in 6.3.6.1.1. The two streams using SFBC shall be precoded and mapped to the transmit antennas as described in 6.3.6.1.2.

Antenna specific symbols at the output of the MIMO precoder shall be mapped to the resource elements described in 6.3.5.2.1.2. The mapping of data subcarriers across the resource elements is specified in 6.3.7.2.3.

6.3.5.3.2 Advanced MAP (A-MAP)

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

6.3.5.3.2.1 Non-user-specific A-MAP

The coding chain for non-user-specific A-MAP IE to non-user-specific A-MAP symbols is shown in Figure 6-153.

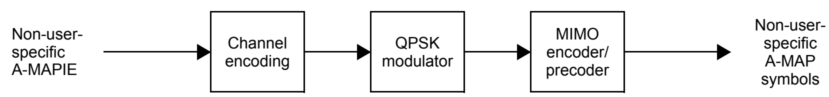


Figure 6-153—Chain of non-user-specific A-MAP IE to non-user-specific A-MAP symbols

The non-user-specific A-MAP IE is encoded by TBCC described in 6.3.10.2 with parameter $M = 3K_{bufsize}$ and $K_{bufsize} = 4L$ for 1/12 code, where L is the number of information bits. In FFR configurations, the non-user-specific A-MAP is also encoded with a code rate of 1/12 when it is in the frequency reuse-1 partition. When the non-user-specific A-MAP is in the power-boosted reuse-3 partition, it should be encoded with parameter $M = K_{bufsize} = 4L$ for 1/4 code rate. The encoded sequence is modulated using QPSK.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{NUS}[0]$ to $S_{NUS}[L_{NUS} - 1]$, are mapped to tone-pairs from RMP$[(L_{HF} + L_{PC})/2]$ to RMP$[(L_{HF} + L_{PC} + L_{NUS})/2 - 1]$, where RMP refers to the renumbered A-MAP tone-pairs described in 6.3.4.3.4 and L_{HF} is the number of tones required to transmit the entire HARQ feedback A-MAP; L_{PC} is the number of tones required to transmit the entire power control A-MAP; L_{NUS} is the number of tones required to transmit the non-user-specific A-MAP.

6.3.5.3.2.2 HARQ feedback A-MAP

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

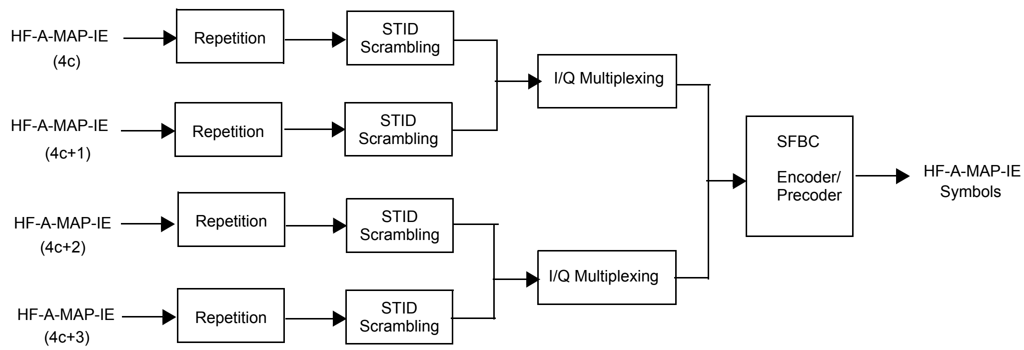


Figure 6-154—Chain of HF-A-MAP IE to HF-A-MAP symbols

Figure 6-154 shows the construction procedure of HF-A-MAP symbols from HF-A-MAP-IEs for constituting an HF-A-MAP group. An HF-A-MAP region has $N_{HF\text{-}A\text{-}MAP}/4$ HF-A-MAP groups, and each group consists of 4 HF-A-MAPs numbered $4c$, $4c + 1$, $4c + 2$, $4c + 3$, where c ($0 \leq c < N_{HF–A–MAP}/4$) is the HF-A-MAP group index. The HF-A-MAP IE resource index is then denoted as $4c+k$, where $0 \leq k < 4$. $N_{HF\text{-}A\text{-}MAP}$ is the maximum number of HF-A-MAP IEs configured per HF-A-MAP region and is signaled through the field “Number of DL HARQ feedback A-MAPs per HF-A-MAP region” in S-SFH SP1.

Each HF-A-MAP IE carries 1 bit information. First, this bit is repeated $N_{Rep\ HF\text{-}A\text{-}MAP}$ times, where $N_{Rep,\ HF\text{-}A\text{-}MAP}$ is 8. A bitwise XOR operation is then performed on the repeated HF-A-MAP IE bit with the $N_{Rep,\ HF\text{-}A\text{-}MAP}$ LSBs of the STID or the RA-ID of the AMS to which the HF-A-MAP IE is assigned. Following this operation, 0 is mapped to +1 and 1 is mapped to –1.

After scrambling, power scaling by $sqrt(P_i)$ ($0 \leq i < N_{HF–A–MAP}$) is applied to the sequence transmitted in the i-th HF-A-MAP resource, where $sqrt(P_i)$ is the value determined by the management entity to satisfy the link performance. Note that if the j-th HF-A-MAP resource is not allocated to any AMSs, P_j is set to 0.

Each power-scaled sequence is mapped to either the real part or the imaginary part in the signal constellation and multiplexed with other sequences, if they exist. As shown in Figure 6-154, HF-A-MAP IE $4c$ occupies the real part of the first symbol in each tone-pair, and HF-A-MAP IE $4c + 1$ occupies the imaginary part of the first symbol in each tone-pair. In the same way, HF-A-MAP IE $4c + 2$ occupies the real part of the second symbol in each tone-pair, and HF-A-MAP IE $4c + 3$ occupies the imaginary part of the second symbol in each tone-pair.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{HF}[0]$ to $S_{HF}[L_{HF} – 1]$, are directly mapped to tone-pairs from $RMP[0]$ to $RMP[L_{HF}/2 – 1]$ denoted by $RMP[p] = \{S_{HF}[2p], S_{HF}[2p + 1]\}$, where RMP refers to the renumbered A-MAP tone-pairs described in 6.3.4.3.4 and L_{HF} is the number of tones required to transmit one HF-A-MAP region. p is the integer value from 0 to $L_{HF}/2 – 1$.

In FDD, there is one HF-A-MAP region in each DL AAI subframe. In TDD, with notation in Table 6-140 in 6.2.14.2.2.2.2 for HF-A-MAP region in DL AAI subframe l, the associated UL subframes can start from a set of UL AAI subframe indices denoted by $M =\{m_0, m_1, ..., m_{K–1}\}$, where $m_0 < m_1 < ... < m_{K–1}$. The number of HF-A-MAP regions in an DL AAI subframe is equal to K according to the number of the associated UL subframes, i.e., the size of set M.

Within each HF-A-MAP region, the ABS allocates an HF-A-MAP resource index corresponding to an HARQ burst allocated to an AMS using the following rules.

For group resource allocation, the HF-A-MAP resource index for the l-th AMS in the GRA allocation is $(i_{start} + \lfloor l \cdot N_{HF-A-MAP} / N_{GRA} \rfloor) \bmod N_{HF-A-MAP}$, where i_{start} is the HFA Offset in the group resource allocation A-MAP IE for UL allocation, $N_{HF\text{-}A\text{-}MAP}$ is the maximum number of HF-A-MAP IEs configured per HF-A-MAP region, and N_{GRA} is the User Bitmap Size in the group resource allocation A-MAP IE for UL allocations.

For the BR-ACK A-MAP IE, the HF-A-MAP resource index for the l-th AMS grant in the BR-ACK bitmap is $(i_{start} + \lfloor l \cdot N_{HF-A-MAP} / N_{BR\text{-}ACK} \rfloor) \bmod N_{HF-A-MAP}$, where i_{start} is the HFA start offset in the BR-ACK A-MAP IE, $N_{HF\text{-}A\text{-}MAP}$ is the maximum number of HF-A-MAP IEs configured per HF-A-MAP region, and $N_{BR\text{-}ACK}$ is the number of AMSs with grants in the BR-ACK A-MAP IE.

For resource allocation using the UL Basic Assignment A-MAP IE, UL Subband Assignment A-MAP IE, CDMA Allocation A-MAP IE, Feedback Polling A-MAP IE, and the UL Persistent Allocation A-MAP IE, the HF-A-MAP resource index is $(M(j) + n) \bmod N_{HF-A-MAP}$, where n is a 3-bit HFA value in each assignment A-MAP IE, and $j \in \{0, 1\}$ is the value of the HF-A-MAP Index Parameter in the non-user-specific A-MAP IE that is transmitted in the subframe where n is signaled. $N_{HF\text{-}A\text{-}MAP}$ is the maximum number of HF-A-MAP IEs configured per HF-A-MAP region and is the value in S-SFH SP1 that corresponds to S-SFH change count applied in the subframe where n is signaled.

In order to determine a unique set of HARQ A-MAP resource indexes in a subframe, the ABS can set j to 0. In this case, $M(j)$ is set to the STID for the UL Basic Assignment A-MAP IE and UL Subband Assignment A-MAP IE and $M(j)$ is set to the RA-ID for CDMA Allocation A-MAP IE. Alternatively, a different set of HARQ A-MAP resource indexes can be obtained when $M(j)$ is set to the lowest LRU index of the corresponding UL transmission when $j = 1$. For the UL Persistent Allocation A-MAP IE and Feedback Polling A-MAP IE, $M(j)$ is always set to the STID regardless of the value of j.

6.3.5.3.2.3 Power Control A-MAP

Power Control A-MAP (PC-A-MAP) contains PC-A-MAP-IEs power correction of the uplink transmission. The ABS shall transmit PC-A-MAP-IE to every AMS that transmits FFBCH. The location of PC-A-MAP IE is specified in Table 6-192.

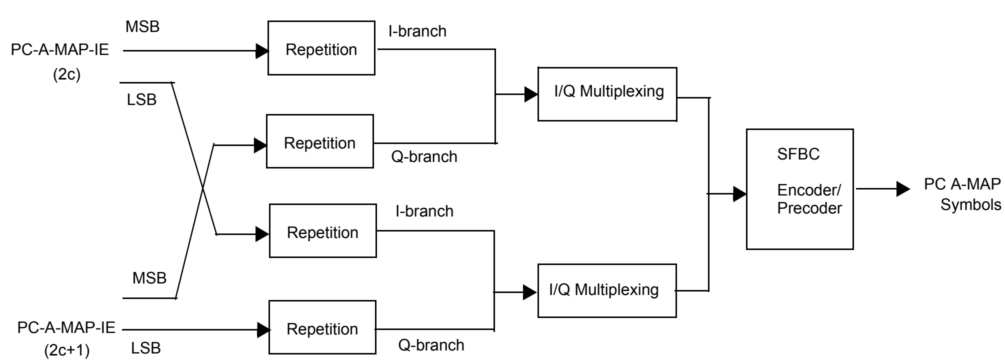


Figure 6-155—Chain of PC-A-MAP IE to PC-A-MAP symbols

Figure 6-155 shows the construction procedure of PC-A-MAP symbols from PC-A-MAP-IE. A PC-A-MAP region has $N_{PC\text{-}A\text{-}MAP}/2$ PC-A-MAP groups where a group consists of two contiguous PC-A-MAP IEs that are modulated together for PC-A-MAP symbols. Here, $N_{PC\text{-}A\text{-}MAP}$ is the total number of PC-A-MAP IEs per PC-A-MAP region.

Each group has two PC-A-MAP IEs numbered as $2c$ and $2c + 1$, and c ($0 \le c < N_{PC\text{-}A\text{-}MAP}/2$) is the PC-A-MAP group index. The PC-A-MAP resource index is then denoted as $2c+k$, where $0 \le k < 2$.

Each i-th PC-A-MAP-IE shall have the size of 2 bits according to the power correction value. From the PC-A-MAP IE, if the value is 0, it is mapped to +1 while the value 1 is mapped to –1. And then it is repeated $N_{Rep,\ PC\text{-}A\text{-}MAP}$ times, where $N_{Rep,\ PC\text{-}A\text{-}MAP}$ equals two if the A-A-MAP MCS selection field in SFH SP1 is 0b0, and four if the A-A-MAP MCS selection field is 0b1.

After repetition, power scaling by sqrt(P_i) ($0 \le i < N_{\text{PC-A-MAP}}$) shall be applied to the i-th PC-A-MAP-IE where sqrt(P_i) is the value determined by the management entity to satisfy the link performance. Note that if the j-th PC-A-MAP is not allocated to any AMSs, P_j is set to 0.

After being repeated and power scaled, the output is mapped to either the real part or the imaginary part in the signal constellation and multiplexed with other output, if it exists. As shown in Figure 6-155, PC-A-MAP IE $2c$ in the cluster occupies the real part of both symbols in each tone-pair before the SFBC encoder. PC-A-MAP IE $2c + 1$ occupies the imaginary part of both symbols in each tone-pair before the SFBC encoder.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{PC}[0]$ to $S_{PC}[L_{PC} - 1]$, are directly mapped to tone-pairs from RMP[L_{HF} /2] to RMP[($L_{HF} + L_{PC}$)/2 – 1] denoted by RMP[p+L_{HF}/2] = {$S_{PC}[2q]$, $S_{PC}[2q + 1]$}, where RMP refers to the renumbered A-MAP tone-pairs described in 6.3.4.3.4 and L_{HF} is the number of tones required to transmit an entire HF-A-MAP region; L_{PC} is the number of tones required to transmit an entire HF-A-MAP region; p and q are integer values from 0 to $L_{PC}/2 - 1$.

6.3.5.3.2.4 Assignment A-MAP

The Assignment A-MAP (A-A-MAP) shall include one or multiple A-A-MAP IEs and each A-A-MAP IE is encoded separately. Figure 6-156 describes the procedure for constructing A-A-MAP symbols.

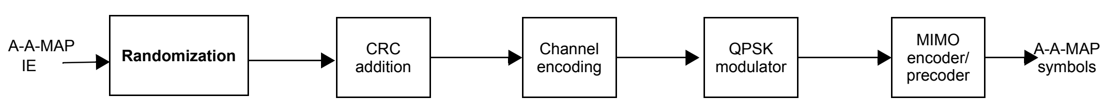


Figure 6-156—Chain of A-A-MAP IE to A-A-MAP symbols

The 40 bits of information contained in the A-A-MAP IE are masked by a sequence generated by a PRBS generator. The mask, when XOR'ed with the A-A-MAP IE, randomizes the A-A-MAP IE. When a MAPMask Seed is used to initialize the PRBS generator, the mask also conceals the contents of the A-A-MAP IE from unintended users. The PRBS generator and the randomization process are described in 6.3.10.1.3. When the 16-bit CRC Mask Type Indicator is 0b000, the 15-bit initial vector of the PRBS generator shall be the value of the MAPMask Seed that was transmitted to the AMS in the same MAC control message as the STID or TSTID value used as the 16-bit CRC Mask Masking Code. Otherwise, the 15-bit initial vector of the PRBS generator shall be the same as the 16-bit A-A-MAP CRC mask in Table 6-194 excluding the 1-bit masking prefix.

A 16-bit CRC, per the CRC16-CCITT specification in ITU-T X.25, is generated based on the randomized sequence of information bits of the assignment A-MAP IE. Denote the randomized assignment A-MAP IE by $m(x)$, the 16-bit CRC by $p(x)$, and the 16-bit CRC mask by $q(x)$ that is generated according to 6.3.5.5.2.4. The 16-bit CRC mask is applied to the 16-bit CRC by bitwise XOR operation. The masked CRC is then appended to the randomized sequence of information bits of the assignment A-MAP IE, resulting in a bit sequence of $m(x) \cdot x^{16} + p(x) \oplus q(x)$.

The resulting sequence of bits shall be encoded by the TBCC described in 6.3.10.2.

For a given system configuration, assignment A-MAP IEs can be encoded with two different effective code rates. The set of code rates shall be either (1/2, 1/4) or (1/2, 1/8) and is explicitly signaled in the S-SFH.

In case of FFR, the set of code rates in the reuse-1 partition is (1/2, 1/4) or (1/2, 1/8) and is signaled in the S-SFH. 1/2 or 1/4 code rate is used in the power-boosted reuse-3 partition and signaled in the S-SFH.

The parameters for TBCC are $M = K_{\mathrm{bufsize}} = 2L$ for 1/2 code rate, $M = K_{\mathrm{bufsize}} = 4L$ for 1/4 code rate, and $M = 2K_{\mathrm{bufsize}}$ and $K_{\mathrm{bufsize}} = 4L$ for 1/8 code rate, where L is the number of information bits. The encoded bit sequences shall be modulated using QPSK.

In the primary frequency partition, for each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_A[0]$ to $S_A[L_A - 1]$, are mapped to tone-pairs from $RMP[(L_{HF} + L_{PC} + L_{NUS})/2]$ to $RMP[(L_{HF} + L_{PC} + L_{NUS} + L_A)/2 - 1]$, where RMP refers to the renumbered A-MAP tone-pairs described in 6.3.4.3.4 and L_{HF} is the number of tones required to transmit the entire HARQ feedback A-MAP; L_{PC} is the number of tones required to transmit the entire power control A-MAP; L_{NUS} is the number of tones required to transmit the non-user specific-A-MAP; and L_A is the number of tones required to transmit the assignment A-MAP.

In the non-primary frequency partition, for each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_A[0]$ to $S_A[L_A - 1]$, are mapped to tone-pairs from RMP[0] to $RMP[L_A/2 - 1]$, where RMP refers to the renumbered A-MAP tone-pairs described in 6.3.4.3.4 and L_A is the number of tones required to transmit the assignment A-MAP.

6.3.5.3.3 Enhanced-Multicast Broadcast Services MAP (E-MBS MAP)

A 16-bit CRC is generated based on the contents of the E-MBS MAP. Following randomization, the resulting sequence of bits shall be encoded by the CTC described in 6.3.10.1. SFBC with precoding shall be used for transmitting the E-MBS MAP.

6.3.5.4 Downlink power control

The ABS should be capable of controlling the transmit power per AAI subframe and per user.

An ABS can exchange necessary information with a neighbor ABS through the backbone network to support downlink power control.

6.3.5.4.1 Power control for A-MAP

Downlink transmit power density of A-MAP transmission for an AMS may be set in order to satisfy the target error rate for the given MCS level that is used for the A-MAP transmission. A detailed algorithm is left to vendor-specific implementations.

6.3.5.5 DL control information elements

6.3.5.5.1 SFH control information elements

6.3.5.5.1.1 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 6-182.

Table 6-182—P-SFH IE format

Syntax	Size (bits)	Notes
P-SFH IE format () {		
LSB of superframe number	4	Part of superframe number
S-SFH change count	4	Indicates the value of S-SFH change count associated with the S-SFH SPx IE(s) transmitted in this S-SFH change cycle
S-SFH size extension	2	0b00: $Size_{SPx,extension} = 0$ 0b01: $Size_{SPx,extension} = 8$ 0b10: $Size_{SPx,extension} = 16$ 0b11: $Size_{SPx,extension} = 24$
Number of repetitions for S-SFH ($N_{Rep,S\text{-}SFH}$)	2	Indicates the number of repetitions used for S-SFH transmission. 0b00: *Reserved* 0b01: 6 0b10: 3 0b11: 1
S-SFH scheduling information	2	Indicates which S-SFH SP IE is included in S-SFH at this superframe 0b00: S-SFH SP1 IE 0b01: S-SFH SP2 IE 0b10: S-SFH SP3 IE 0b11: no S-SFH
S-SFH SP change bitmap	3	Indicates the change in the content of S-SFH SPx IE(s) between current SFH and previous SFH associated with the S-SFH change count If bit 0 (LSB) = 1, change in S-SFH SP1 IE. Otherwise, no change in SP1 IE. If bit 1 = 1, change in S-SFH SP2 IE. Otherwise, no change in SP2 IE. If bit 2 (MSB) = 1, change in S-SFH SP3 IE. Otherwise, no change in SP3 IE.
S-SFH application hold indicator	1	Indicates the S-SFH change count value used to determine the S-SFH SPx IE content to apply in this superframe: 0b0: Use S-SFH SPx IE content associated with the current S-SFH change count 0b1: Use S-SFH SPx IE content associated with (the current S-SFH change count – 1) modulo 16
Reserved	3	The reserved bits are for future extension
}		

LSB of superframe number (SFN)

This field indicates the 4 least significant bits of the superframe number in current superframe. The superframe number is represented by a total of 12 bits. The superframe number shall be synchronized among ABSs. The remaining 8 bits are carried in the S-SFH SP1 IE.

S-SFH change count

Incremented by one (modulo 16) by the ABS whenever any of the values (except MSB of superframe number in S-SFH SP1 IE) of the S-SFH IEs changes and maintained until the next increment. If the value of this count in a subsequent P-SFH IE remains the same, the AMS may assume that the S-SFH IEs have not changed and decide to disregard the following S-SFH IEs in this superframe.

S-SFH SP change bitmap

A bitmap indicating the S-SFH SPx IE changed in association with the current S-SFH change count. If any field of S-SFH SPx IE is changed (except MSB of Superframe Number in S-SFH SP1), the bit corresponding to the changed S-SFH SPx IE is set to 1. Other bits corresponding to the unchanged S-SFH SPxs are set to 0. The S-SFH change bitmap is maintained until the next superframe in which the S-SFH change count is incremented.

S-SFH application hold indicator

A 1-bit flag that indicates to AMSs which S-SFH content shall be applied in the current superframe—either the content corresponding to the value of S-SFH change count transmitted in the current superframe or the previously transmitted value. If the S-SFH application hold indicator is set to '0', the AMS shall use the S-SFH contents associated with the S-SFH change count transmitted in the current superframe. Otherwise, if the S-SFH application hold indicator is '1', the AMS shall use the S-SFH contents associated with the previous S-SFH change count (the current S-SFH change count – 1) modulo 16. In other words, when the S-SFH application hold indicator is '1', the previous contents of the S-SFH are held while new contents are being transmitted. If the desired S-SFH contents are not available, the AMS shall acquire the relevant S-SFH contents by decoding the S-SFHs carried in their corresponding scheduled superframes.

6.3.5.5.1.2 S-SFH IE

The S-SFH IE is mapped to the S-SFH. Essential system parameters and system configuration information belonging to the S-SFH are categorized into three S-SFH subpacket IEs such as SP1, SP2, and SP3. These SPs are transmitted in different timing and periodicity. The periodicity of SP (T_{SP}) is determined with $T_{SP1} < T_{SP2} < T_{SP3}$.The S-SFH IE format are shown in Table 6-183.

The size of the S-SFH subpacket IE, $Size_{SPx}$, is determined by the default size of S-SFH SPx IE, $Size_{SPx, default}$, and the value of the S-SFH size extension field, $Size_{SPx, extension}$. That is, $Size_{SPx} = Size_{SPx,default} + Size_{SPx,extension}$, where $Size_{SPx}$ is not larger than 112. The default size of S-SFH SPx IE is specified in Table 6-183, and the value of the S-SFH size extension is signaled via P-SFH IE.

Table 6-183—S-SFH IE format

Syntax	Size (bits)	Notes
S-SFH IE format () {		
if (S-SFH Scheduling information == 0b00) {		
S-SFH SP1 IE ()	$Size_{SP1}$	Includes S-SFH SP1 IE in Table 6-184. The size of S-SFH SP1 IE depends on FFT size. For 2048 FFT, $Size_{SP1,\ default} = 96$ For 1024 FFT, $Size_{SP1,\ default} = 90$ For 512 FFT, $Size_{SP1}$, default = 84
}		
else if (S-SFH Scheduling information == 0b01) {		
S-SFH SP2 IE ()	$Size_{SP2}$	Includes S-SFH SP2 IE in Table 6-185. The size of S-SFH SP2 IE depends on FFT size. For 2048 FFT, $Size_{SP2,\ default} = 96$ For 1024 FFT, $Size_{SP2,\ default} = 90$ For 512 FFT, $Size_{SP2,\ default} = 86$
}		
else if (S-SFH Scheduling information == 0b10) {		
S-SFH SP3 IE ()	$Size_{SP3}$	Includes S-SFH SP3 IE in Table 6-186. $Size_{SP3,\ default} = 77$
}		
}		

S-SFH SP1 IE contains information for network reentry, see Table 6-184.

Table 6-184—S-SFH SP1 IE format

Syntax	Size (bits)	Notes
S-SFH SP1 IE format () {		
MSB of superframe number	8	Remaining bit of SFN except LSB of SFN in P-SFH
LSBs of 48 bit ABS MAC ID	12	Specifies the 12 least significant bits of ABS ID

Table 6-184—S-SFH SP1 IE format *(continued)*

Syntax	Size (bits)	Notes
Number of UL HARQ feedback channels per HARQ feedback region	2	Describes L_{HFB} in 6.3.7.3.3.2. Channel numbers represented by the two bits (0, 1, 2, 3) are as follows: For 512 FFT size, 6, 12, 18, 24 For 1024 FFT size, 6, 12, 24, 30 For 2048 FFT size, 12, 24, 48, 60
Number of DL HARQ feedback A-MAPs per HF-A-MAP region	2	Channel numbers represented by the two bits (0, 1, 2, 3) are as follows: For 512 FFT size, 4, 8, 12, 16 For 1024 FFT size, 8, 16, 24, 32 For 2048 FFT size, 16, 32, 48, 64
Power control channel resource size indicator	2	Total number of PC-A-MAPs, $N_{PC\text{-}A\text{-}MAP}$ 0b00: 0 (No use of PC-A-MAP) 0b01: $2 \times \text{ceil}(7 \times U/D)$ 0b10: $2 \times \text{ceil}(14 \times U/D)$ 0b11: $2 \times \text{ceil}(24 \times U/D)$ Here, U and D are the number of AAI subframes per AAI frame on the uplink and downlink, respectively.
DL primary frequency partition location	1	0b0: Reuse-1 partition 0b1: Power-boosted reuse-3 partition
Frequency partition location for UL control channels	1	0b0: Reuse-1 partition 0b1: Power-boosted reuse-3 partition
A-MAP MCS selection	1	0b0: QPSK 1/2 and QPSK 1/4 can be used for assignment A-MAP in reuse-1 partition. QPSK 1/2 is used for assignment A-MAP in the power-boosted reuse-3 partition of FFR. 0b1: QPSK 1/2 and QPSK 1/8 can be used for assignment A-MAP in reuse-1 partition. QPSK 1/4 is used for assignment A-MAP in the power-boosted reuse-3 partition of FFR.
$DCAS_{SB0}$	5/4/3	Indicates the number of subband-based CRUs in FP0 in 6.3.4.3.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
$DCAS_{MB0}$	5/4/3	Indicates the number of miniband-based CRUs in FP0 in 6.3.4.3.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
DCAS-i	3/2/1	Indicates the number of total allocated subband and miniband CRUs, $DCAS_i$, in a unit of a subband, for FP_i ($i > 0$) in 6.3.4.3.1. For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bit
Frame configuration index	6	The mapping between value of this index and frame configuration is listed in Table 6-151, Table 6-152, and Table 6-153.

Table 6-184—S-SFH SP1 IE format *(continued)*

Syntax	Size (bits)	Notes
Uplink AAI subframes for sounding	3	This value represents the number of uplink AAI subframes with sounding symbols. 0b000: no sounding symbols 0b001: 1 AAI subframe 0b010: 2 AAI subframes 0b011: 3 AAI subframes 0b100: 4 AAI subframes 0b101–111: *Reserved* The sounding symbols shall be placed in AAI subframes in accordance to their type. First, sounding symbols shall be allocated in uplink AAI subframes of Type 2 starting from the first in time AAI subframe of Type 2. If the number of uplink AAI subframe of Type 2 is less than the number of AAI subframes for sounding, sounding symbols shall be allocated in the AAI subframes of other types in the following order: Type 1. For these types of uplink AAI subframes sounding symbols shall be allocated in the similar way as for Type 2. Type 3 uplink AAI subframes are not used for sounding. When frame structure is supporting the WirelessMAN-OFDMA R1 Reference System MSs in PUSC zone by FDM manner, this field means bitmap to indicate AAI subframes for sounding. Type 4 uplink AAI subframes are not used for sounding.
ABS EIRP	6	Unsigned integer from 1 to 64 in units of 1 dBm, where 0b000000 = 1 dBm and 0b111111 = 64 dBm.
Cell bar information	1	If Cell Bar bit = 0b1, this cell shall not be allowed for network entry or reentry.
UL_N_MAX_ReTx	1	Specifies the maximum retransmission number for UL HARQ 0b0: 4 0b1: 8
DL_N_MAX_ReTx	1	Specifies the maximum retransmission number for DL HARQ 0b0: 4 0b1: 8
$T_{UL\_Rx\_Processing}$	1	Specifies the ABS's Rx processing time for UL HARQ 0b0: 3 AAI subframes 0b1: 4 AAI subframes
Cell specific ranging configuration indicator	1	Indicates the ranging configuration type. 0b0: Ranging configuration type being the one for Femtocell 0b1: Ranging configuration type being the one for non-Femtocell

Table 6-184—S-SFH SP1 IE format *(continued)*

Syntax	Size (bits)	Notes
WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone support	1	Indicates whether frame configuration supports WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone systems or not 0b0: No support of WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone 0b1: Support of WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone This field is 0b1 if Frame configuration index is equal to – 5, 7, 9, 11, 13, 15, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, or 30 for 5/10 MHz channel bandwidth according to Table 6-151; – 4, 6, 8 or 10 for 8.75 MHz channel bandwidth according to Table 6-152; – 3 or 5 (with CP = 1/8) for 7 MHz channel bandwidth according to Table 6-153. This field is 0b0 if Frame configuration index is something else.
If (Support of WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone){		Indicates support of the WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone, when the WirelessMAN-OFDMA R1 Reference System support with FDM-based UL PUSC Zone is 0b1.
Allocation periodicity of the RCH	2	Indicates the periodicity of the RCH allocation according to Table 6-269.
Subframe offset of the RCH	2	Indicates the subframe offset (O_{SF}) of the RCH allocation related to Table 6-269. The range of values is $0 \le O_{SF} \le 3$.
Start RP code information of the RCH	4	Indicates the k_{ns}, which is the parameter for start of the RP code group (r_{ns0}). $r_{ns0}(k_{ns}) = 16 \times k_{ns} + 1$ The range of values is $0 \le k_{ns} \le 15$.
RP code partition information for the RCH	4	Indicates the number of the initial, handover and periodic RP codes (N_{IN}, N_{HO}, and N_{PE}) according to Table 6-273.
UL_Permbase	7	Indicates UL_Permbase used in WirelessMAN-OFDMA R1 Reference System system with FDM-based UL PUSC Zone.
Reserved	6/3	For 1024 FFT size, 6 bits For 512 FFT size, 3 bits
} else {		
if(Cell specific ranging configuration Indicator == 0b0) {		for AAI ranging configuration indicator being the one for Femtocell.
Allocation periodicity of the S-RCH	2	Indicates the periodicity of the S-RCH allocation according to Table 6-272.
Subframe offset of the S-RCH	2	Indicates the subframe offset (O_{SF}) of the S-RCH allocation related to Table 6-272. The range of values is $0 \le O_{SF} \le 3$.

Table 6-184—S-SFH SP1 IE format *(continued)*

Syntax	Size (bits)	Notes
Start RP code information of the S-RCH	4	Indicates the k_s that is the parameter controlling the start root index of the RP codes (r_{s0}). $r_{s0} = 6 \times k_s + 1$ The range of values is $0 \le k_s \le 15$.
RP code partition information for the S-RCH	4	Indicates the number of initial, handover and periodic codes (N_{IN}, N_{HO}, and N_{PE}) according to the Table 6-271.
Transmission timing offset of S-RCH	3	Indicates N_{RTO}, which is the parameter used for the calculation of the sample number, T_{RTO}, which is applied to advance the ranging signal transmission timing relative to the defined uplink transmission timing point based on the frame structure from the AMS perspective when the AMS conducts initial or handover ranging in a femtocell. $T_{RTO} = \lfloor N_{RTO} \times (T_g - 2) \times F_S \rfloor$ (samples) where $N_{RTO} = min(\lfloor RTD/(T_g - 2) \rfloor, 7)$, and RTD is the round-trip delay from the femto-ABS to the overlay macro-ABS. The range of values is $0 \le N_{RTO} \le 7$.
} else {		
Allocation periodicity of the NS-RCH	2	Indicates the periodicity of the NS-RCH allocation according to the Table 6-269.
Subframe offset of the NS-RCH	2	Indicates the subframe offset (O_{SF}) of the NS-RCH allocation related to the Table 6-269. The range of values is $0 \le O_{SF} \le 3$.
Start RP code information of the NS-RCH	4	Indicates the k_{ns} that is the parameter controlling the start root index of the RP codes (r_{ns0}). $r_{ns0}(k_{ns}) = 4 \times k_{ns} + 1$ for NS-RCH format 0. $r_{ns0}(k_{ns}) = 16 \times k_{ns} + 1$ for NS-RCH format 1. The range of values is $0 \le k_{ns} \le 15$
RP code partition information for the NS-RCH	4	Indicates the number of initial and handover RP codes (N_{IN} and N_{HO}) according to the Table 6-268.
Number of the cyclic shifted RP codes per root index for the NS-RCH	2	Indicates the number of cyclic shifted codes per root index (M_{ns}) for RP codes according to the Table 6-267.
NS-RCH formats	1	Indicates the NS-RCH formats number of Table 6-262.
}		
$UCAS_{SB0}$	5/4/3	Indicates the number of subband-based CRUs in FP_0 in 6.3.7.3.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits
$UCAS_{MB0}$	5/4/3	Indicates the number of miniband-based CRUs in FP_0 in 6.3.7.3.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits

Table 6-184—S-SFH SP1 IE format *(continued)*

Syntax	Size (bits)	Notes
$UCAS_i$	3/2/1	Indicates the number of total allocated CRUs, in a unit of a subband, for FP_i ($i \geq 0$) in 6.3.7.3.1 For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bits
}		
Reserved		
}		

S-SFH SP2 IE contains information for initial network entry and network discovery; see Table 6-185.

Table 6-185—S-SFH SP2 IE format

Syntax	Size (bits)	Notes
S-SFH SP2 IE format () {		
AAI MAC version	4	An unsigned 4-bit quantity equal to the value of the MAC version TLV (see 11.1.3 in IEEE Std 802.16), minus 10.
UL carrier frequency	16	Indicates the UL carrier frequency in unit of 100 KHz for FDD. If all bits are set to 0, the duplexing mode is TDD.
MSB of 48 bit ABS MAC ID	36	Remaining bits of ABS MAC ID except LSB of 48-bit ABS MAC ID in S-SFH SP1. Its MSB 24 bits are set by Operator ID.
Network Configuration	1	Indicates configuration of the network element to which the ABS is attached. 0b0: Advanced network mode 0b1: R1 network mode The definition for Advanced/R1 network mode is outside the scope of this standard.
OLRegion	1	Provides indication about the structure of the MIMO OL Region. Further details in 6.3.4.3.1.
DSAC	5/4/3	Indicates the number of subbands K_{SB} as defined in Table 6-154 to Table 6-156 in 6.3.4.2.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits

Table 6-185—S-SFH SP2 IE format *(continued)*

Syntax	Size (bits)	Notes
DFPC	4/3/3	Indicates the frequency partition configuration as defined in Table 6-157 to Table 6-159 in 6.3.4.2.3 For 2048 FFT size, 4 bits For 1024 FFT size, 3 bits For 512 FFT size, 3 bits
DFPSC	3/2/1	Indicates the number of subbands allocated to FP_i (i > 0) in 6.3.4.2.3 For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bit
USAC	5/4/3	Indicates the number of subbands K_{SB} as defined in Table 6-248 to Table 6-250 in 6.3.7.2.1 For 2048 FFT size, 5 bits For 1024 FFT size, 4 bits For 512 FFT size, 3 bits For support of WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone, all bits shall be set to zero.
UFPC	4/3/3	Indicate the frequency partition configuration as defined in Table 6-251 to Table 6-253 in 6.3.7.2.3 For 2048 FFT size, 4 bits For 1024 FFT size, 3 bits For 512 FFT size, 3 bits For support of WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone, all bits shall be set to zero.
UFPSC	3/2/1	Indicate the number of subbands allocated to FP_i (i > 0) in 6.3.7.2.3 For 2048 FFT size, 3 bits For 1024 FFT size, 2 bits For 512 FFT size, 1 bits For support of WirelessMAN-OFDMA R1 Reference System with FDM-based UL PUSC Zone, all bits shall be set to zero.
AMS Transmit Power Limitation Level	5	Unsigned 5-bit integer. Specifies the maximum allowed AMS transmit power. Values indicate power levels in 1 dB steps starting from 0 dBm.
$EIRxP_{IR,min}$	5	Unsigned integer from –133 to –102 in units of 1 dBm, where 0b00000 = –133 dBm and 0b11111 = –102 dBm.

Table 6-185—S-SFH SP2 IE format *(continued)*

Syntax	Size (bits)	Notes
The indicator of MIMO midamble in Relay Zone/The indicator of DL R-TTI	1	If serving station is the ABS: 0b0: Additional MIMO midamble is not transmitted in AAI DL Relay zone 0b1: Additional MIMO midamble is transmitted in AAI DL Relay zone (transmission location is defined in 6.3.7.2.3) If serving station is TTR ARS: 0b0: DL R-TTI = 0 0b1: DL R-TTI = T_s
AMSID Privacy Support	1	0b0: Not support 0b1: Support
Reserved		
}		

S-SFH SP3 IE contains remaining essential system information; see Table 6-186.

Table 6-186—S-SFH SP3 IE format

Syntax	Size (bits)	Notes
S-SFH SP3 IE format () {		
S-SFH change cycle	3	It is the minimum duration (unit: superframe) over which the contents of the S-SFH remain the same. 0b000: 16 0b001: 32 0b010: 64 0b011 ~ 0b111: *Reserved*
SA-Preamble sequence soft partitioning information	4	Specifies the partition information of SA-Preamble sequence for non-macro ABS as public and CSG femto BS as defined in Table 6-169.
IoT correction value for UL power control	10	The 10-bits IoT correct value is used to support the correction of 5 IoT values (IOT_Sounding, IOT_FP0, IOT_FP1, IOT_FP2, IOT_FP3) defined in the AAI-ULPC-NI message, each 2 bits are expressed as the correction value: 0b00: +1dB 0b01: +0.5dB 0b10: 0 dB 0b11: –0.5dB The correction value is accumulated on IoT values from the latest AAI-ULPC-NI message until the new AAI-ULPC-NI message received and applied.
UL_FEEDBACK_SIZE	4	Number of distributed LRUs for UL feedback channels per a UL AAI subframe (refer to 6.3.7.3.3.2). For 512/1024 FFT size, the size shall not result in more than 28 feedback channels.
# Tx antenna	2	0b00: 2 antennas 0b01: 4 antennas 0b10: 8 antennas 0b11: *Reserved*
SP scheduling periodicity information	4	Indicates transmission periodicity of S-SFH SPs according to the Table 6-180.
HO Ranging backoff start	4	Initial backoff window size for the AMS performing the handover ranging during the HO process, expressed as a power of 2. Values of *n* range 0–15 (the highest order bits shall be unused and set to 0).
HO Ranging backoff end	4	Final backoff window size for the AMS performing a handover ranging during the HO process, expressed as a power of 2. Values of *n* range 0–15.
Initial ranging backoff start	4	Initial backoff window size for initial ranging contention, expressed as a power of 2. Values of *n* range 0–15.

Table 6-186—S-SFH SP3 IE format *(continued)*

Syntax	Size (bits)	Notes
Initial ranging backoff end	4	Final backoff window size for initial ranging contention, expressed as a power of 2. Values of *n* range 0–15.
UL BW REQ channel information	3	Indicates the number and the location of UL AAI subframe where the UL BW REQ channels is allocated. The maximum number of UL BW REQ channel in a frame is four. 0b000: First UL AAI subframe in the first frame in every superframe 0b001: First UL AAI subframe in the first and second frame in every superframe 0b010: First UL AAI subframe in every frame 0b011: First 2 UL AAI subframes in every frame 0b100: First 4 UL AAI subframes in every frame 0b101~111: *Reserved* When frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM based uplink PUSC zone, 0b100 shall not be supported.
Bandwidth request backoff start	4	Initial backoff window size for contention BRs, expressed as a power of 2. Values of *n* range 0–15 (the highest order bits shall be unused and set to 0).
Bandwidth request backoff end	4	Final backoff window size for contention BRs, expressed as a power of 2. Values of *n* range 0–15.
fpPowerConfig	3	The power boosting/deboosting values are listed in Table 6-187.
D-LBS zone configuration	2	Provides indication of D-LBS zone transmission period. 0b00: D-LBS zone transmission is switched off 0b01: D-LBS zone periodicity = 4 (80 ms) 0b10: D-LBS zone periodicity = 16 (320 ms) 0b11: D-LBS zone periodicity = 32 (640 ms)
NSP Change Count	4	The value of NSP Change Count is programmable. NSP Change Count is an incrementing value. A change in NSP Change Count signals to an AMS that the contents of AAI-SII-ADV has changed.
SCD Count	4	Indicates Configuration Change Count that is associated with the system configuration of the AAI-SCD.
Reserved		
}		

Table 6-187—Power boosting/deboosting values

fpPower Config	*FPCT* = 3 or 4 and $FPS_i > 0$ for $1 \le i \le 3$			*FPCT* = 2 or 3 and $FPS3_i = 0$	
	FP1_Power (dB)	FP2_Power (dB)	FP3_Power (dB)	FP1_Power (dB)	FP2_Power (dB)
0b000	0.0	0.0	0.0	0.0	0.0
0b001	1.0	–0.5	–0.5	0.5	–0.5
0b010	2.0	–1.5	–1.5	1.0	–1.5
0b011	2.5	–2.0	–2.0	1.5	–2.5
0b100	3.0	–3.0	–3.0	2.0	–4.0
0b101	3.5	–4.5	–4.5	2.5	–6.5
0b110	4.0	–6.0	–6.0	3.0	–Inf
0b111	4.75	–Inf	–Inf	*Reserved*	*Reserved*

The power loading values of the power deboosted partition will be overwritten by fp2Power and fp3Power in the AAI-DL-IM message.

The power boosting/deboosting rule is defined in 6.2.21.1.

6.3.5.5.2 A-MAP control information elements

A-MAP IE is defined as the basic element of service control.

6.3.5.5.2.1 Non-user-specific A-MAP IE

A 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. Non-user-specific A-MAP IE also includes HF-A-MAP index parameter and HFBCH index parameter, which are used to indicate which transmission parameter is used to calculate HF-A-MAP index and HFBCH index, respectively. The non-user-specific A-MAP IE is shown in Table 6-188. A non-user-specific A-MAP IE has 12 bits in total.

The number of assignment A-MAPs in each assignment A-MAP group can be derived from the Assignment A-MAP size in the non-user-specific A-MAP IE through table look-up, and it determines the starting offset of each assignment A-MAP group in the A-MAP region. The actual number of assignment A-MAP IEs in each assignment A-MAP group can be equal to or less than the number indicated by the look-up tables. The look-up tables, each with 256 entries, can be generated by the following equations for a particular assignment A-MAP MCS set and FFR configuration.

For non-FFR configuration with Group 1 using QPSK 1/4 and Group 2 using QPSK 1/2, the look-up table can be generated using Equation (218) to Equation (221) and looping through all values of N_{total} and k.

Table 6-188—Non-user-specific A-MAP IE

Syntax	Size (bits)	Notes
Assignment A-MAP size	8	Indicate the number of assignment A-MAPs in each assignment A-MAP group using Equation (218) to Equation (235).
HF-A-MAP Index Parameter	1	Indicates which transmission parameter is used to calculate HF-A-MAP index.
HFBCH Index Parameter	1	Indicates which transmission parameter is used to calculate HFBCH index.
Non-user specific A-MAP extension flag	1	If non-user-specific A-MAP extension flag is set, it indicates that non-user specific A-MAP is extended. The extended non-user specific part has 12 bits and uses the same PHY structure, i.e., channel coding, modulation, and MIMO encoding, as the non-user-specific A-MAP described in 6.3.5.3.2.1.
Reserved	1	Reserved bits

$$G_1(I) = \begin{cases} k & k = 0, 1, \ldots, \lfloor N_{total}/2 \rfloor & 0 \le N_{total} \le 24 \\ N_{total} - 24 + 3 \times k, & k = 0, 1, 2, 3, & 25 \le N_{total} \le 29 \\ N_{total} - 29 + 4 \times k, & k = 0, 1, 2, 3, & 30 \le N_{total} \le 32 \\ N_{total} - 30 + 4 \times k, & k = 0, 1, 2, 3, & 33 \le N_{total} \le 34 \\ N_{total} - 32 + 3 \times k, & k = 0, 1, 2, 3, & 35 \le N_{total} \le 39 \\ N_{total} - 32 + 4 \times k, & k = 0, 1, 2, & 40 \le N_{total} \le 42 \\ N_{total} - 32 + 3 \times k, & k = 0, 1, 2, & 43 \le N_{total} \le 48 \end{cases} \tag{218}$$

$$G_2(I) = N_{total} - 2 \times G_1(I) \tag{219}$$

$$I = I_b(N_{total}) + k \tag{220}$$

$$I_b(N_{total}) = \begin{cases} 0, & N_{total} = 0 \\ I_b(N_{total} - 1) + \lfloor (N_{total} - 1)/2 \rfloor + 1, & 1 \le N_{total} \le 25 \\ I_b(N_{total} - 1) + 4, & 26 \le N_{total} \le 40 \\ I_b(N_{total} - 1) + 3, & 41 \le N_{total} \le 48 \\ 0, & \text{otherwise} \end{cases} \tag{221}$$

where

I is the 8-bit index for Assignment A-MAP size in non-user-specific A-MAP IE.

$G_i(I)$ is the number of assignment A-MAPs in group i for a given I.

N_{total} ($0 \le N_{total} \le 48$) is the total number of MLRUs for all A-A-MAP in an AAI subframe.

$I_b(N_{total})$ is the base index for a given N_{total} value.

For non-FFR configuration with Group 1 using QPSK 1/8 and Group 2 using QPSK 1/2, the look-up table can be generated using Equation (222) to Equation (225) and looping through all values of N_{total} and k.

$$G_1(I) = \begin{cases} k & k = 0, 1, ..., \lfloor N_{total}/4 \rfloor & 0 \le N_{total} \le 24 \\ k+1 & k = 0, 1, 2, 3, 4, 5, & 25 \le N_{total} \le 27 \\ k+1 & k = 0, 1, 2, 3, 4, 5, 6, & 28 \le N_{total} \le 32 \\ k + \lfloor N_{total}/3 \rfloor - 10 & k = 0, 1, 2, 3, 4, 5, 6, & 33 \le N_{total} \le 48 \end{cases} \tag{222}$$

$$G_2(I) = N_{total} - 4 \times G_1(I) \tag{223}$$

$$I = I_b(N_{total}) + k \tag{224}$$

$$I_b(N_{total}) = \begin{cases} 0, & N_{total} = 0 \\ I_b(N_{total} - 1) + \lfloor (N_{total} - 1)/4 \rfloor + 1, & 1 \le N_{total} \le 25 \\ I_b(N_{total} - 1) + 6, & 26 \le N_{total} \le 28 \\ I_b(N_{total} - 1) + 7, & 29 \le N_{total} \le 48 \\ 0, & \text{otherwise} \end{cases} \tag{225}$$

For FFR configuration with Group 1 using QPSK 1/8, Group 2 using QPSK 1/2, and Group 3 using QPSK 1/4, the look-up table can be generated using Equation (226) to Equation (230) and looping through all values of N_{total} and k.

$$G_1(I) = \begin{cases} k & k = 0, 1, ..., \lfloor N_{total}/4 \rfloor & 0 \le N_{total} \le 24 \\ k + \left\lfloor \frac{29 - N_{total}}{2} \right\rfloor - 1 & k = 0, 1, 2, 3, 4, 5, & 25 \le N_{total} \le 27 \\ k + \left\lfloor \frac{36 - N_{total}}{4} \right\rfloor - 1 & k = 0, 1, 2, 3, 4, 5, 6, & 28 \le N_{total} \le 32 \\ k + \left\lfloor \frac{56 - N_{total}}{8} \right\rfloor - 1 & k = 0, 1, 2, 3, 4, 5, 6, & 33 \le N_{total} \le 48 \end{cases} \tag{226}$$

$$G_2(I) = N_{total} - 4 \times G_1(I) - 2 \times G_3(I) \tag{227}$$

$$G_3(I) = \left\lfloor \frac{N_{total} - 4 \times G_1(I)}{3} \right\rfloor \tag{228}$$

$$I = I_b(N_{total}) + k \tag{229}$$

$$I_b(N_{total}) = \begin{cases} 0, & N_{total} = 0 \\ I_b(N_{total}-1) + \lfloor (N_{total}-1)/4 \rfloor + 1, & 1 \le N_{total} \le 25 \\ I_b(N_{total}-1) + 6, & 26 \le N_{total} \le 28 \\ I_b(N_{total}-1) + 7, & 29 \le N_{total} \le 48 \\ 0, & \text{otherwise} \end{cases} \tag{230}$$

For the FFR configuration with Group 1 using QPSK 1/4 and Group 2 using QPSK 1/2 for assignment A-MAP in the reuse-1 partition, and Group 3 using QPSK 1/2 for assignment A-MAP in the power-boosted reuse-3 partition, the look-up table can be generated using Equation (231) to Equation (235) and looping through all values of N_{total} and k.

$$G_1(I) = \begin{cases} k & k = 0, 1, ..., \lfloor N_{total}/2 \rfloor & 0 \le N_{total} \le 3 \\ k+1 & k = 0, 1, ..., \lfloor N_{total}/2 \rfloor - 2 & 4 \le N_{total} \le 24 \\ \lfloor (N_{total}-23)/2 \rfloor + 2 \times k, & k = 0, 1, 2, 3, 4, & 25 \le N_{total} \le 31 \\ \lfloor (N_{total}-28)/2 \rfloor + 3 \times k, & k = 0, 1, 2, 3, 4, & 32 \le N_{total} \le 33 \\ N_{total} - 32 + 2 \times k, & k = 0, 1, 2, 3, 4, 5, & 34 \le N_{total} \le 40 \\ N_{total} - 32 + k, & k = 0, 1, 2, 3, 4, 5, & 41 \le N_{total} \le 42 \\ N_{total} - 32 + 2 \times k, & k = 0, 1, 2, 3, 4, & 43 \le N_{total} \le 44 \\ N_{total} - 32 + k, & k = 0, 1, 2, 3, 4, & 45 \le N_{total} \le 48 \end{cases} \tag{231}$$

$$G_2(I) = \left\lfloor \frac{N_{total} - 2 \times G_1(I)}{2} \right\rfloor \tag{232}$$

$$G_3(I) = N_{total} - 2 \times G_1(I) - G_2(I) \tag{233}$$

$$I = I_b(N_{total}) + k \tag{234}$$

$$I_b(N_{total}) = \begin{cases} 0, & N_{total} = 0 \\ I_b(N_{total}-1) + \lfloor (N_{total}-1)/2 \rfloor + 1, & 1 \le N_{total} \le 4 \\ I_b(N_{total}-1) + \lfloor (N_{total}-1)/2 \rfloor - 1, & 5 \le N_{total} \le 25 \\ I_b(N_{total}-1) + 5, & 26 \le N_{total} \le 34 \\ I_b(N_{total}-1) + 6, & 35 \le N_{total} \le 43 \\ I_b(N_{total}-1) + 5, & 44 \le N_{total} \le 48 \\ 0 & \text{otherwise} \end{cases} \tag{235}$$

6.3.5.5.2.2 HARQ Feedback A-MAP IE

The HARQ Feedback A-MAP IE includes one bit, and the corresponding value for HARQ ACK/NACK information is shown in Table 6-189. If HF-A-MAP IE has the 0b0 or 0b1, it shall be interpreted as ACK information or NACK information, respectively.

Table 6-189—HF-A-MAP-IE

Syntax	Size (bits)	Notes
HF-A-MAP IE format {		
HF-A-MAP IE value	1	0b0: ACK feedback info. 0b1: NACK feedback info.
}		

6.3.5.5.2.3 Power Control A-MAP IE

The PC-A-MAP IE includes two bits, and the corresponding values for power correction are shown in Table 6-190; e.g., if the power correction value is 0b00, it shall be interpreted as tone power (power density) and should be reduced by 0.5 dB.

Table 6-190—PC-A-MAP IE format

Syntax	Size (bits)	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
}		

For FDD/H-FDD/TDD systems, when the AMS transmits the q-th FFBCH at the m-th uplink subframe inthe i-th frame, the corresponding PC-A-MAP IE to the AMS automatically follows the assignment location defined in Table 6-192.

N: total number of AAI subframes in an AAI frame. (In TDD systems, $N = D + U$. In FDD/H-FDD, $N = D = U$.)

D: total number of DL AAI subframes in an AAI frame.

U: total number of UL AAI subframes in an AAI frame.

Q: total number of FFBCH in an AAI frame, $Q = U \times Q_{max}$.

Q_{max}: the maximum FFBCH number among UL AAI subframes given by $Q_{max} = N_{fb} \times UL\_FEEDBACK\_SIZE - N_{HARQ\text{-}Region\text{-}min} \times L_{HFB}/6$, where N_{fb} is 3. When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with an FDM-based uplink PUSC zone, N_{fb} is 4. L_{HFB} is the number of UL HARQ channels per HARQ region defined in S-SFH SP1, and $N_{HARQ\text{-}Region\text{-}min}$ is the minimum value among number of HARQ regions in the UL AAI frame shown in Table 6-191.

Table 6-191—Number of HARQ regions in each UL AAI subframe

AAI DL subframe: AAI UL subframe	$N_{HARQ\text{-}Region\text{-}min}$
6:2	3
5:3	1
4:4	1
3:5	0
2:6	0

q: the feedback channel index specified in Feedback Allocation A-MAP IE ($0 \le q \le Q_{max} - 1$).
m: UL AAI subframe index ($0 \le m \le U - 1$) .
T: necessary number of PC-A-MAPs in a DL AAI subframe corresponding to the total number of FFBCH in any UL AAI subframe, which is defined by $T = ceil(Q/D)$.
s: the feedback channel index in an AAI frame, i.e., the q-th feedback channel in the m-th UL AAI subframe, $s = Q_{max} \times m+q$.

Table 6-192—PC-A-MAP IE location

	Frame index	Subframe index	Channel index
F-FBCH location	i	m	q
PC-A-MAP IE location for FDD/H-FDD systems	i + floor$\lceil (m + N/2)/N \rceil$	(floor(m+$N/2$)) mod N	q
PC-A-MAP IE location for TDD systems	$i + 1$	floor(s/T)	s mod T

6.3.5.5.2.4 Assignment A-MAP IE

Table 6-193 describes Assignment A-MAP IE Types.

Table 6-193—Assignment A-MAP IE types

A-MAP IE Type	Usage	Property
0b0000	DL Basic Assignment A-MAP IE	Unicast
0b0001	UL Basic Assignment A-MAP IE	Unicast
0b0010	DL Subband Assignment A-MAP IE	Unicast
0b0011	UL Subband Assignment A-MAP IE	Unicast
0b0100	Feedback Allocation A-MAP IE	Unicast
0b0101	UL Sounding Command A-MAP IE	Unicast
0b0110	CDMA Allocation A-MAP IE	Unicast
0b0111	DL Persistent Allocation A-MAP IE	Unicast
0b1000	UL Persistent Allocation A-MAP IE	Unicast
0b1001	Group Resource Allocation A-MAP IE	Multicast
0b1010	Feedback Polling A-MAP IE	Unicast
0b1011	BR-ACK A-MAP IE	Multicast
0b1100	Broadcast Assignment A-MAP IE	Broadcast/Multicast
0b1101	*Reserved*	N/A
0b1110	*Reserved*	N/A
0b1111	Extended Assignment A-MAP IE	N/A

CRC Mask

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

The 16-bit masked CRC is constructed using a 1-bit masking prefix, a 3-bit message type indicator, and a 12-bit Masking Code as described in Table 6-194.

Table 6-194—Description of CRC mask

Masking prefix (1-bit MSB)	Remaining 15-bit LSBs	
0b0	*Type Indicator*	*Masking Code*
	0b000	12-bit STID or TSTID
	0b001	Refer to Table 6-195
	0b010	Refer to Table 6-196
0b1	15-bit RA-ID: The RA-ID is derived from the AMS's random access attributes [i.e., superframe number (LSB 5bits), frame_index (2 bits), preamble code index for ranging or BR (6 bits) and opportunity index for ranging or BR (2 bits)] as defined below: RA-ID = (LSB 5 bits of superframe number | frame_index | preamble_code_index | opportunity_index)	

Table 6-195—Description of the masking code for type indicator 001

Decimal value	Description
0	Used to mask Broadcast Assignment A-MAP IE for broadcast or ranging channel assignment
1	Used to mask BR-ACK A-MAP IE
2–128	Used to mask Group Resource Allocation A-MAP IE (group ID)
Others	*Reserved*

Table 6-196—Description of the masking code for type indicator 010

Decimal value	Description
4095	Used to mask Broadcast Assignment A-MAP IE for multicast assignment
Others	*Reserved*

6.3.5.5.2.4.1 DL basic assignment A-MAP IE

Table 6-197 describes the fields in a DL Basic Assignment A-MAP IE used for resource assignment in the DL.

A-MAP IE Type: Defines the structure of the assignment A-MAP IE for the bits in the assignment A-MAP IE following the A-MAP IE type field. A-MAP IE Type distinguishes between assignment A-MAP IEs used for the UL/DL, and assignment A-MAP IEs used for resource allocation and control signaling. Additional A-MAP IE types are reserved for future use.

Table 6-197—DL Basic Assignment A-MAP IE[a]

Syntax	Size (bits)	Description/Notes
DL_Basic_Assignment_A-MAP_IE() {		
A-MAP IE Type	4	DL Basic Assignment A-MAP IE
$I_{SizeOffset}$	5	Offset used to compute burst size index
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Multi-layer encoding 0b11: CDR
if (MEF == 0b01){		Parameters for vertical encoding
M_t	3	Number of streams in transmission $M_t \le N_t$ N_t: Number of transmit antennas at the ABS 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
Reserved	2	Reserved bits
} else if(MEF == 0b10) {		Parameters for multi-layer encoding
if (N_t == 4)		Parameters for multi-layer encoding for the ABS with modulation constellation of paired user for up to 4 stream transmission.

Table 6-197—DL Basic Assignment A-MAP IE[a] (continued)

Syntax	Size (bits)	Description/Notes
Si	5	Index used to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO, and the modulation constellation of paired user 0b00000: 2 streams with PSI = stream 1 and other modulation = QPSK 0b00001: 2 streams with PSI = stream 1 and other modulation = 16QAM 0b00010: 2 streams with PSI = stream 1 and other modulation = 64QAM 0b00011: 2 streams with PSI = stream 1 and other modulation information not available 0b00100: 2 streams with PSI = stream 2 and other modulation = QPSK 0b00101: 2 streams with PSI = stream 2 and other modulation = 16QAM 0b00110: 2 streams with PSI = stream 2 and other modulation = 64QAM 0b00111: 2 streams with PSI = stream 2 and other modulation information not available 0b01000: 3 streams with PSI = stream 1 0b01001: 3 streams with PSI = stream 2 0b01010: 3 streams with PSI = stream 3 0b01011: 4 streams with PSI = stream 1 0b01100: 4 streams with PSI = stream 2 0b01101: 4 streams with PSI = stream 3 0b01110: 4 streams with PSI = stream 4 0b01111: 3 streams with PSI = stream 1 and stream 2 0b10000: 4 streams with PSI = stream 1 and stream 2 0b10001: 4 streams with PSI = stream 3 and stream 4 0b10010: 3 streams with PSI = stream 3 and other modulation = QPSK 0b10011: 3 streams with PSI = stream 3 and other modulation = 16QAM 0b10100: 3 streams with PSI = stream 3 and other modulation = 64QAM 0b10101: 3 streams with PSI = stream 1 and stream 2 and other modulation = QPSK 0b10110: 3 streams with PSI = stream 1 and stream 2 and other modulation = 16QAM 0b10111: 3 streams with PSI = stream 1 and stream 2 and other modulation = 64QAM 0b11000: 4 streams with PSI = stream 1 and stream 2 and other modulation = QPSK 0b11001: 4 streams with PSI = stream 1 and stream 2 and other modulation = 16QAM 0b11010: 4 streams with PSI = stream 1 and stream 2 and other modulation = 64QAM 0b11011: 4 streams with PSI = stream 3 and stream 4 and other modulation = QPSK 0b11100: 4 streams with PSI = stream 3 and stream 4 and other modulation = 16QAM 0b11101: 4 streams with PSI = stream 3 and stream 4 and other modulation = 64QAM 0b11110: reserved 0b11111: reserved

Table 6-197—DL Basic Assignment A-MAP IE[a] (continued)

Syntax	Size (bits)	Description/Notes
} else{		Parameters for multi-layer encoding for the ABS with modulation constellation of paired user for up-to 8 stream transmission.
Si	5	Index used to identify the combination of the number of streams and the allocated pilot stream index(PSI) in a transmission with MU-MIMO, and the modulation constellation of paired user in the case of 2 stream transmission 0b00000: 2 streams with PSI = stream 1 and other modulation = QPSK 0b00001: 2 streams with PSI = stream 1 and other modulation = 16QAM 0b00010: 2 streams with PSI = stream 1 and other modulation = 64QAM 0b00011: 2 streams with PSI = stream 1 and other modulation information not available 0b00100: 2 streams with PSI = stream 2 and other modulation = QPSK 0b00101: 2 streams with PSI = stream 2 and other modulation = 16QAM 0b00110: 2 streams with PSI = stream 2 and other modulation = 64QAM 0b00111: 2 streams with PSI = stream 2 and other modulation information not available 0b01000: 3 streams with PSI = stream 1 0b01001: 3 streams with PSI = stream 2 0b01010: 3 streams with PSI = stream 3 0b01011: 4 streams with PSI = stream 1 0b01100: 4 streams with PSI = stream 2 0b01101: 4 streams with PSI = stream 3 0b01110: 4 streams with PSI = stream 4 0b01111: 3 streams with PSI = stream 1 and stream 2 0b10000: 4 streams with PSI = stream 1 and stream 2 0b10001: 4 streams with PSI = stream 3 and stream 4 0b10010: 8 streams with PSI = stream 1 0b10011: 8 streams with PSI = stream 2 0b10100: 8 streams with PSI = stream 3 0b10101: 8 streams with PSI = stream 4 0b10110: 8 streams with PSI = stream 5 0b10111: 8 streams with PSI = stream 6 0b11000: 8 streams with PSI = stream 7 0b11001: 8 streams with PSI = stream 8 0b11010: 8 streams with PSI = stream 1 and stream 2 0b11011: 8 streams with PSI = stream 3 and stream 4 0b11100: 8 streams with PSI = stream 5and stream 6 0b11101: 8 streams with PSI = stream 7and stream 8 0b11110: reserved 0b11111: reserved
}		
}else{		
Reserved	5	Reserved bits
}		

Table 6-197—DL Basic Assignment A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
Resource Index	11	512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 DL AAI subframes for FDD or all DL AAI subframes for TDD
HFA	3	HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
ACID	4	HARQ channel identifier
SPID	2	HARQ subpacket identifier for HARQ IR 0b00: 0 0b01: 1 0b10: 2 0b11: 3
CRV	1	Constellation Rearrangement Version 0b0: 0 0b1: 1
Reserved	1	Reserved bit
}		

[a]A 16-bit CRC is generated based on the randomized contents of the DL Basic Assignment A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

$\boldsymbol{M_t}$**:** Number of streams in transmission. The DL pilot pattern with M_t streams shall be used in the allocated resource.

Si: Index used to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO, and the modulation constellation of paired user in the case of 2 stream transmission. For Co-MIMO transmission to two users, the ABS shall indicate to one AMS a total number of streams equal to 3 using one of the values 0b01000, 0b01001 or 0b01010, in order to ensure that the AMS will perform channel estimation using one stream of the non-interlaced pilot pattern with 3 streams.

Resource Index: Resource Index with starting LRU index and size of a single allocation spanning contiguous LRUs.

Resource Indexing in the DL/UL Basic Assignment A-MAP IE

The Resource Index in the DL/UL Basic Assignment A-MAP IE identifies a single allocation of a resource comprising a set of contiguous LRUs in a DL/UL AAI subframe. The index determines the size (S) of the allocated resource in number of contiguous LRUs in frequency within the subframe and the index (L) of the

LRU from where the scheduled allocation begins. The contiguous LRUs shall consist of the same type of LRU (i.e., DLRU, NLRU, or SLRU) within the same frequency partition except for the allocation over SLRU and NLRU within the same frequency partition. An allocation may span over contiguous SLRUs and NLRUs within the same frequency partition. Contiguous LRUs in an allocated resource shall be contained within the same frequency partition and cannot span multiple frequency partitions.

Multiple non-contiguous subbands are indexed using the DL/UL Subband Assignment A-MAP IEs and the SLRUs assigned for a burst shall belong to the same frequency partition.

For a given system bandwidth with N_{max} LRUs, the size of allocations comprising contiguous LRUs can be chosen from *1* to N_{max}. For each allocation size, resources can be allocated starting from different LRUs in the AAI subframe. Every possible allocation size *S*, from *1* to N_{max} can be assigned in any location starting at LRU *L*, provided $(S+L) \le 24$ and $(S+L) \le 48$ for 512 and 1024 FFT sizes, respectively.

For a 2048 FFT size, the number of assignable resource sizes is reduced, but there is no constraint on where these allocations may be made in the AAI subframe, as long as $(S+L) \le 96$. The assignable resource sizes are specified as follows:

- All resource sizes in increments of 1 LRU are assignable in the range of 1 to 12 LRUs.
- Only even resource sizes are assignable in increments of 2 LRUs in the range of 14 to 24 LRUs.
- Resource sizes are assignable in increments of 4 LRUs in the range of 28 to 48 LRUs.
- Resource sizes are assignable in increments of 8 LRUs in the range of 56 to 88 LRUs.
- All resource sizes in increments of 1 LRU are assignable in the range of 92 to 96 LRUs.

Derivation of the mapping between LRU index and physical PRU index:

For each frequency partition *i*, $TC_{LRU,i}$, the total number of CLRUs and DLRUs up to and including that partition is calculated as shown in Equation (236) and Equation (237).

$$TC_{LRU,i} = \sum_{m=0}^{i} FPS_m,\ 0 \le i \le 3 \tag{236}$$

$$LRU[k] = \begin{cases} DLRU_{FPi}[k - TC_{LRU,\,i-1}], \\ \quad \text{for } TC_{LRU,\,i-1} \le k < (LRU_{DRU,\,FPi} + TC_{LRU,\,i-1}) \\ NLRU_{FPi}[k - (LRU_{DRU,\,FPi} + TC_{LRU,\,i-1})], \\ \quad \text{for } ((LRU_{DRU,\,FPi} + TC_{LRU,\,i-1}) \le k < (LRU_{DRU,\,FPi} + LRU_{MB\text{-}CRU,\,FPi} + TC_{LRU,\,i-1})) \\ SLRU_{FPi}[k - (LRU_{DRU,\,FPi} + LRU_{MB\text{-}CRU,\,FPi} + TC_{LRU,\,i-1})], \\ \quad \text{for } ((LRU_{DRU,\,FPi} + LRU_{MB\text{-}CRU,\,FPi} + TC_{LRU,\,i-1}) \le k < TC_{LRU,\,i}) \end{cases} \tag{237}$$

with $0 \le i \le 3$, $0 \le k < \sum_{m=0}^{3} FPS_m$, and $TC_{LRU,\text{-}1} = 0$.

The mapping from $DLRU_{FP_i}$, $NLRU_{FP_i}$, and $SLRU_{FP_i}$ to the PRU indices (and vice-versa) is as specified in 6.3.4.3.5.

Determining the Resource Index for the Scheduled Resource at the ABS

For a given system bandwidth with N_{max} LRUs across all frequency partitions, the ABS maintains a vector I_a of length N_{max} in which the non-zero entries contain the starting index for each of the assignable resource sizes.

The S-th element of I_a, $1 \le S \le 96$ for 11 bit resource indexing in a DL/UL AAI subframe for a 2048 FFT size is defined as in Equation (238):

$$I_a(S) = \begin{cases} 0 & S = 1 \\ I_a(S-1) + (96 - (S-1) + 1) & 2 \le S \le 12 \\ I_a(S-2) + (96 - (S-2) + 1) & S = 2k,\ 7 \le k \le 12 \\ I_a(S-4) + (96 - (S-4) + 1) & S = 4k,\ 7 \le k \le 12 \\ I_a(S-8) + (96 - (S-8) + 1) & S = 8k,\ 7 \le k \le 11 \\ 2048 - \sum_{k=S}^{96} (96 - k + 1) & 92 \le S \le 96 \\ 0 & \text{otherwise} \end{cases} \tag{238}$$

The resource index RI for an allocation of size S LRUs beginning at LRU L is computed as

$$RI = \begin{cases} I_a(S) + L & \text{if } I_a(S) > 0 \text{ or } S = 1 \\ \text{not assignable} & \text{if } I_a(S) = 0 \text{ and } S > 1 \end{cases}$$

where $1 \le S \le 96$, $0 \le L \le 95$, and $(S + L) \le 96$.

The ABS first determines if the required resource size is assignable by checking if the S-th element in I_a has a non-zero value or S = 1. If the size S is assignable, then the 11 bit resource index is then determined by simply adding L to the value of the S-th element in I_a. If the required resource is not assignable, the next higher or lower non-zero element in I_a is selected based on the link adaptation scheme employed.

On the UL only, RI = 0b111 1111 1111 is reserved to indicate a skipped HARQ retransmission on the UL. When the AMS received this resource index in the UL, and it shall not be used for resource allocation. When the AMS receives this resource index in the UL Basic Assignment A-MAP IE, the AMS shall not transmit the HARQ subpacket for the ACID signaled in this IE. The retransmission number is incremented by one for the skipped retransmission.

The S-th element of I_a, for 11 bit resource indexing in a DL/UL AAI subframe for a 1024 FFT size is defined as

$$I_a(S) = \begin{cases} 0 & S = 1 \\ I_a(S-1) + (48 - (S-1) + 1) & 2 \le S \le 48 \end{cases}$$

The resource index RI for an allocation of size S LRUs beginning at LRU L is computed as

$$RI = I_a(S) + L,\ 1 \le S \le 48,\ 0 \le L \le 47 \text{ and } (S + L) \le 48$$

The S-th element of I_a, $1 \le S \le 24$ for 9 bit resource indexing in a DL/UL AAI subframe for a 512 FFT size is defined as:

$$I_a(S) = \begin{cases} 0 & S = 1 \\ I_a(S-1) + (24 - (S-1) + 1) & 2 \le S \le 24 \end{cases}$$

The resource index RI for an allocation of size S LRUs beginning at LRU L is computed as

$$RI = I_a(S) + L,\ 1 \le S \le 24,\ 0 \le L \le 23 \text{ and } S + L \le 24$$

Determining the Scheduled Resource from the Resource Index at the Receiver

At the receiver, the 11 bit resource index, RI, in the DL/UL Basic Assignment A-MAP IE is used to determine the assigned resource size S as described by Equation (239). The element in the vector I_a with the maximum possible value, $I_a(S)$, is found such that $I_a(S) \le RI$; then the value S is the assigned resource size.

$$S = \max_{s \in \{S_{assignable}\}} \{I_a(s) | I_a(s) \le RI\} \tag{239}$$

where $S_{assignable}$ = {1, 2, 3, ... N_{max} } for FFT sizes of 512 and 1024 and $S_{assignable}$ = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 20, 22, 24, 28, 32, 36, 40, 44, 48, 56, 64, 72, 80, 88, 92, 93, 94, 95, 96} for a FFT size of 2048. The starting LRU for the allocation is determined by subtracting the value of I_a corresponding to the assigned resource size S from the index RI in the DL/UL Basic Assignment A-MAP IE, i.e.,

$$L = RI - I_a(S)$$

6.3.5.5.2.4.2 UL basic assignment A-MAP IE

Table 6-198 describes the fields in a UL Basic Assignment A-MAP IE used for resource assignment in the UL.

Table 6-198—UL Basic Assignment A-MAP IE[a]

Syntax	Size (bits)	Description/Notes
UL_Basic_Assignment_A-MAP_IE() {	—	—
A-MAP IE Type	4	UL Basic Assignment A-MAP IE
$I_{SizeOffset}$	5	Offset used to compute burst size index
PMI Indicator	1	Flag to indicate if PMI is signaled explicitly 0b0: PMI not signaled explicitly 0b1: PMI signaled explicitly
CSM	1	Flag to indicate CSM 0b0: SU-MIMO 0b1: CSM
if(PMI Indicator == 0b0){	—	PMI not signaled

Table 6-198—UL Basic Assignment A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
TTI and Relevance	2	Indicates the TTI type and the location of UL subframe relevant to this A-MAP. 0b00: long TTI spanning 4 UL AAI subframes for FDD or all UL AAI subframes for TDD 0b01: default TTI, the first UL subframe relevant to this A-MAP 0b10: default TTI, the second UL subframe relevant to this A-MAP 0b11: default TTI, the third UL subframe relevant to this A-MAP 0b10 and 0b11 are only applicable if the number of DL AAI subframes is less than the number of UL AAI subframes in TDD mode.
if(CSM == 0b0){		SU-MIMO (Non- adaptive/ Adaptive precoding without PMI)
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding Non-adaptive precoding shall be used at the AMS with SFBC. M_t shall be ignored with SFBC
if(MEF == 0b1){	—	—
M_t	2	Number of streams in transmission $M_t \le N_t$, up to 4 streams per AMS supported N_t: Number of transmit antennas at the AMS 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
PF	1	Precoding flag for SU-MIMO when PMI is not signaled 0b0: Non-adaptive precoding 0b1: Adaptive precoding using the precoder of rank M_t of the AMS's choice
Reserved	3	Reserved bits
}else{	—	—
Reserved	6	Reserved bits
}	—	—
}else if(CSM == 0b1){		CSM (Non-adaptive/Adaptive precoding without PMI)

Table 6-198—UL Basic Assignment A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
CSM Format	6	For CSM modes the following combinations apply for up to 8 streams 0b000000: TNS = 2, M_t = 1, SI = 1 0b000001: TNS = 2, M_t = 1, SI = 2 0b000010: TNS = 3, M_t = 1, SI = 1 0b000011: TNS = 3, M_t = 1, SI = 2 0b000100: TNS = 3, M_t = 1, SI = 3 0b000101: TNS = 3, M_t = 2, SI = 1 0b000110: TNS = 3, M_t = 2, SI = 2 0b000111: TNS = 4, M_t = 1, SI = 1 0b001000: TNS = 4, M_t = 1, SI = 2 0b001001: TNS = 4, M_t = 1, SI = 3 0b001010: TNS = 4, M_t = 1, SI = 4 0b001011: TNS = 4, M_t = 2, SI = 1 0b001100: TNS = 4, M_t = 2, SI = 2 0b001101: TNS = 4, M_t = 2, SI = 3 0b001110: TNS = 4, M_t = 3, SI = 1 0b001111: TNS = 4, M_t = 3, SI = 2 0b010000: TNS = 8, M_t = 1, SI = 1 0b010001: TNS = 8, M_t = 1, SI = 2 0b010010: TNS = 8, M_t = 1, SI = 3 0b010011: TNS = 8, M_t = 1, SI = 4 0b010100: TNS = 8, M_t = 1, SI = 5 0b010101: TNS = 8, M_t = 1, SI = 6 0b010110: TNS = 8, M_t = 1, SI = 7 0b010111: TNS = 8, M_t = 1, SI = 8 0b011000: TNS = 8, M_t = 2, SI = 1 0b011001: TNS = 8, M_t = 2, SI = 2 0b011010: TNS = 8, M_t = 2, SI = 3 0b011011: TNS = 8, M_t = 2, SI = 4 0b011100: TNS = 8, M_t = 2, SI = 5 0b011101: TNS = 8, M_t = 2, SI = 6 0b011110: TNS = 8, M_t = 2, SI = 7 0b011111: TNS = 8, M_t = 3, SI = 1 0b100000: TNS = 8, M_t = 3, SI = 2 0b100001: TNS = 8, M_t = 3, SI = 3 0b100010: TNS = 8, M_t = 3, SI = 4 0b100011: TNS = 8, M_t = 3, SI = 5 0b100100: TNS = 8, M_t = 3, SI = 6 0b100101: TNS = 8, M_t = 4, SI = 1 0b100110: TNS = 8, M_t = 4, SI = 2 0b100111: TNS = 8, M_t = 4, SI = 3 0b101000: TNS = 8, M_t = 4, SI = 4 0b101001: TNS = 8, M_t = 4, SI = 5 0b101010~0b111111: *Reserved*
PF	1	Precoding flag for CSM when PMI is not signaled 0b0: Non-adaptive precoding 0b1: Adaptive precoding using the precoder of rank M_t of the AMS’s choice
}	—	—
} else {	—	PMI signaled

Table 6-198—UL Basic Assignment A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL AAI subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator= 0b1
if(CSM == 0b0){	—	SU-MIMO with PMI
M_t	2	Number of streams in transmission $M_t \leq N_t$, up to 4 streams per AMS supported N_t: Number of transmit antennas at the AMS 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
PMI	6	4 bits PMI for $N_t = 2$, first 2 MSB set to 0 6 bits PMI for $N_t = 4$
}else {	—	CSM with PMI
CSM Format	4	For CSM modes the following combinations apply for up to 4 streams 0b0000: TNS = 2, M_t= 1, SI = 1 0b0001: TNS = 2, M_t = 1, SI = 2 0b0010: TNS = 3, M_t = 1, SI = 1 0b0011: TNS = 3, M_t = 1, SI = 2 0b0100: TNS = 3, M_t = 1, SI = 3 0b0101: TNS = 3, M_t = 2, SI = 1 0b0110: TNS = 3, M_t = 2, SI = 2 0b0111: TNS = 4, M_t = 1, SI = 1 0b1000: TNS = 4, M_t = 1, SI = 2 0b1001: TNS = 4, M_t = 1, SI = 3 0b1010: TNS = 4, M_t = 1, SI = 4 0b1011: TNS = 4, M_t = 2, SI = 1 0b1100: TNS = 4, M_t = 2, SI = 2 0b1101: TNS = 4, M_t = 2, SI = 3 0b1110: TNS = 4, M_t = 3, SI = 1 0b1111: TNS = 4, M_t = 3, SI = 2
PMI	4	4 bit PMI
}	—	—
}	—	—
Resource Index	11	512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size
HFA	3	HARQ Feedback Allocation

Table 6-198—UL Basic Assignment A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
AI_SN	1	HARQ identifier sequence number
ACID	4	HARQ channel identifier
Reserved	1	Reserved bits
}	—	—

[a]A 16-bit CRC is generated based on the randomized contents of the UL Basic Assignment A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

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.

PMI Indicator: Flag to indicate if PMI is signaled.

CSM: Flag to indicate if CSM is signaled.

The Resource Index field in the UL Basic Assignment A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE, with ‘DL’ specific terminology replaced by ‘UL’ equivalents.

6.3.5.5.2.4.3 DL Subband Assignment A-MAP IE

The DL Subband Assignment A-MAP IE shall have an identical structure to the DL Basic Assignment A-MAP IE with the following exceptions. The MEF field shall be 1 bit long, with 0b0/0b1 indicating HE/VE. Following the MEF field shall be a 1-bit ModeIndicator field.

The “A-MAP IE Type” field shall be set to the value 0b0010.

In all cases, the ABS/AMS shall perform the following pre-processing steps to define some terms that are used in the indexing and in the interpretation of the RA field. The notation and terms in these steps, related to subchannelization, are defined in 6.3.4.

Pre-Processing

Derivation of the mapping between the subband logical resource unit (SLRU) index and the PRU index shall be done as follows. The total number of subbands over all partitions may be calculated as

$$Y_{SB} = \sum_{m=0}^{3} \frac{L_{SB-CRU,FP_m}}{N_1} \tag{240}$$

For each frequency partition i, the total number of subband-CRUs up-to and including that partition may be calculated as

$$X_i = \sum_{m=0}^{i} L_{SB-CRU, FP_m}, \ 0 \le i \le 3 \tag{241}$$

Then, the SLRUs are indexed as

$$\mathrm{SLRU}[k] = \mathrm{SLRU}_{FPi}[k - X_{i-1}], \ 0 \le X_{i-1} \le k < X_i < N_1 Y_{SB}, \text{ with } 0 \le i < 3, X_{-1} = 0 \tag{242}$$

The subbands are indexed as

$$\mathrm{SB}[m] = \left\{ \text{All SLRU[k]with indices k such that } \left\lfloor \frac{k}{N_1} \right\rfloor = m \right\}, \text{with } 0 \le m < Y_{SB} \tag{243}$$

The mapping from the SLRU_{FPi} to the PRU indices (and vice-versa) is as specified in 6.3.4.3.5.

Interpretation of the Resource Index when $Y_{SB} \le 4$

When the total number of subbands over all partitions, $Y_{SB} \le 4$:

a) A single instance of a resource allocation shall be made using a single IE.

b) A 12-bit Effective RA field (ERA field) shall be constructed by combining the ModeIndicator bit and the 11 RA bits, with the ModeIndicator forming the MSB of the ERA field. The AMS and the ABS shall interpret the ERA field as defined below.

   1) The four SLRUs in each subband are partitioned into three allocation units, consisting of the first two SLRUs, the third SLRU and the fourth SLRU, respectively. Each of the j bit positions in the ERA field, $0 \le j < 12$, indicates the allocation or non-allocation of specific SLRUs indices within a particular allocation unit using a bit-map method, as indicated by Table 6-199.

Table 6-199—ERA bit to SLRU index mapping when $Y_{SB} \le 4$

ERA bit *j*, ERA[*j*]	0 (LSB)	1	2	3	4	5	6	7	8	9	10	11
SLRU[*k*] indexed by ERA[*j*]	0,1	2	3	4,5	6	7	8,9	10	11	12,13	14	15

   2) Position j in the ERA field corresponds to the SLRUs with indices k as indicated in Table 6-199.

   Denoting ERA[j] as the j-th position in the ERA field, $0 \le j < 12$, with $j = 0$ being the LSB, $ERA[j] = 1 \ge$ the SLRUs with indices k corresponding to bit j, as indicated in Table 6-199, have been allocated.

   $ERA[j] = 0 \ge$ The SLRUs with indices k corresponding to bit j, as indicated in Table 6-199 have not been allocated.

Figure 6-157 pictorially illustrates the previous description of the interpretation of the ERA field when $Y_{SB} \le 4$.

Interpretation of the Resource Index when $5 \le Y_{SB} \le 10$

When the total number of subbands over all partitions, $5 \le Y_{SB} \le 10$, a single instance of a resource allocation shall be made using a single IE, and the ABS shall set the ModeIndicator to 0b0. Two interpretations of the RA field can be made via the MSB bit of the RA field, allowing different allocation granularities.

When the RA MSB bit is set to 0b0, the ABS and the AMS shall interpret the RA field as follows. This method allows a 1 subband granularity.

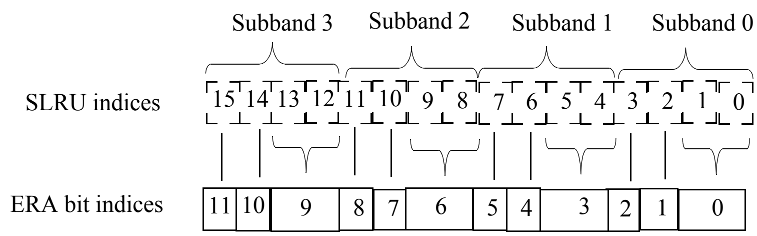


Figure 6-157—Interpretation of the ERA field when $Y_{SB} \le 4$,illustrated *for* $Y_{SB} = 4$

- Each of the j LSB bit positions in the RA field, $0 \le j < 10$, indicates the allocation or non-allocation of all 4 SLRUs within a particular subband, using a bit-map method.
- Position j corresponds to the 4 SLRUs with indices k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$.
- Denoting RA[j] as the j-th position in the RA field, $0 \le j < 10$, with $j = 0$ being the LSB,

RA[j] = 1 ≥ The 4 SLRUs with indices k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have been allocated.

RA[j] = 0 ≥ The 4 SLRUs with indices k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have not been allocated.

Figure 6-158 illustrates the above description of the interpretation of the RA field when $5 \le Y_{SB} \le 10$, and RA MSB bit = 0b0.

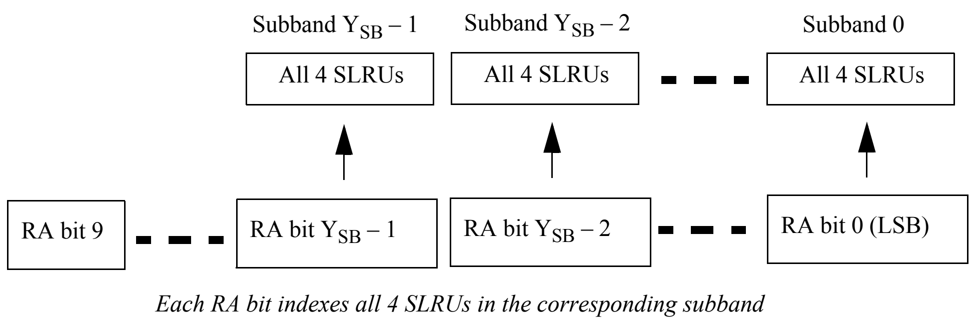


Figure 6-158—Interpretation of the RA field when $5 \le Y_{SB} \le 10$ and RA MSB = 0b0

When the RA MSB bit is set to 0b1, the ABS and the AMS shall interpret the RA field as follows:

— The RA field shall be partitioned as follows. Denoting the LSB bit as bit 0, bit positions 0 and 1 are referred to as PIF (Pattern Indication Field), bit position 2 as the LF (Location Field), and bit positions 3 to 9 as the RIF (Resource Indexing Field).

— The ABS and the AMS shall interpret the RA field as defined in Figure 6-159.

— The extended binomial coefficient $\left\{ \begin{matrix} n \\ k \end{matrix} \right\}$ used in interpretation is defined as follows:

For integers n and k, the extended binomial coefficient is defined as

$$\left\{ \begin{matrix} n \\ k \end{matrix} \right\} = \begin{cases} \binom{n}{k} \text{ for } (n \ge k) \\ 0 \text{ for } n < k \end{cases}$$

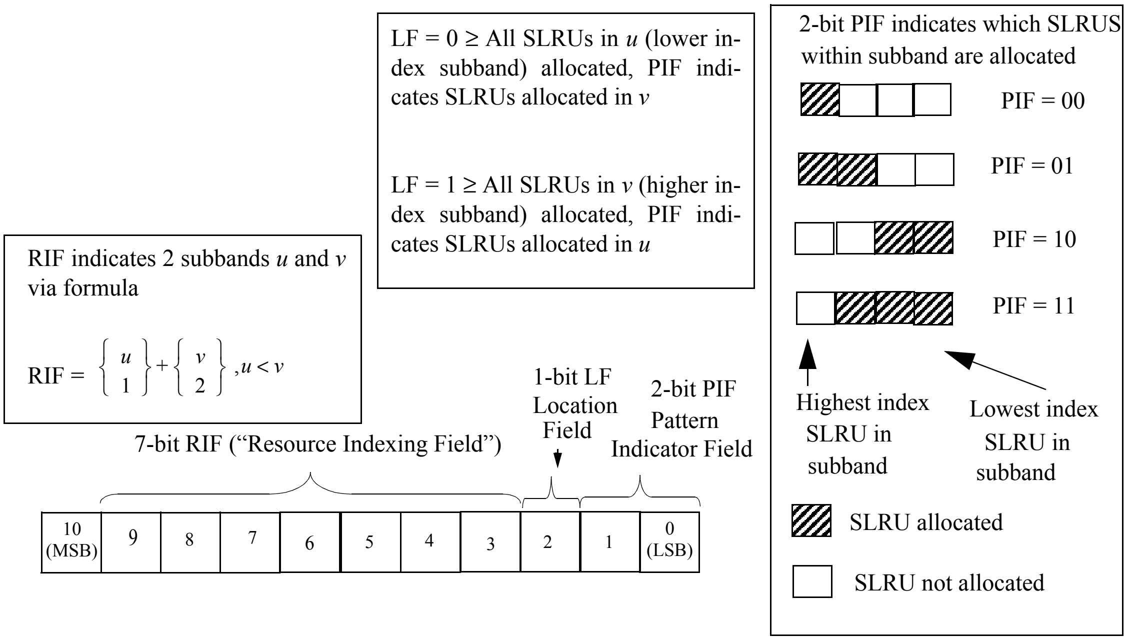


Figure 6-159—Interpretation of the RA field when $5 \le Y_{SB} \le 10$ and ModeIndicator = 0b1

Interpretation of the Resource Index when $11 \le Y_{SB} \le 21$

When the total number of subbands over all partitions, $11 \le Y_{SB} \le 21$, a single instance of a resource allocation may be made using a single or two IEs. The value of the ModeIndicator shall indicate whether a single or two IEs are being used.

— When an allocation is made using 2 IEs, the RA fields of the two IEs shall be concatenated to form a 22-bit field, referred to as the Concatenated-RA field (CRA field). The LSB of the RA field of the IE occurring last in the A-AMAP region shall be interpreted as the LSB of the CRA field. The ABS shall map the two IEs carrying a single instance of an allocation to MLRUs with contiguous logical indices, and shall set ModeIndicator to 0b1 in each of them. The AMS shall infer that two IEs refer to the same instance of a resource allocation from the values of the ModeIndicator, ACID and SPID fields. The ABS and the AMS shall interpret the CRA field in this case as defined as follows:

1) Each of the j bit positions in the C-RA field, $0 \le j < 22$, indicates the allocation or non-allocation of all 4 SLRUs within a particular subband, using a bit-map method.

2) Position j in the C-RA field corresponds to the 4 SLRUs with indices k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$

Denoting CRA[j] as the j-th position in the CRA field, $0 \le j < 22$, with $j = 0$ being the LSB,

CRA[j] = 1 ≥ The 4 SLRUs with indices k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have been allocated.

CRA[j] = 0 ≥ The 4 SLRUs with indices k such that $\left\lfloor \frac{\mathrm{SLRU}[k]}{N_1} \right\rfloor = j$ have not been allocated.

Figure 6-160 illustrates the above description of the interpretation of the CRA field when $11 \le Y_{SB} \le 21$ and ModeIndicator = 0b1, i.e., 2 IEs are used to make an allocation.

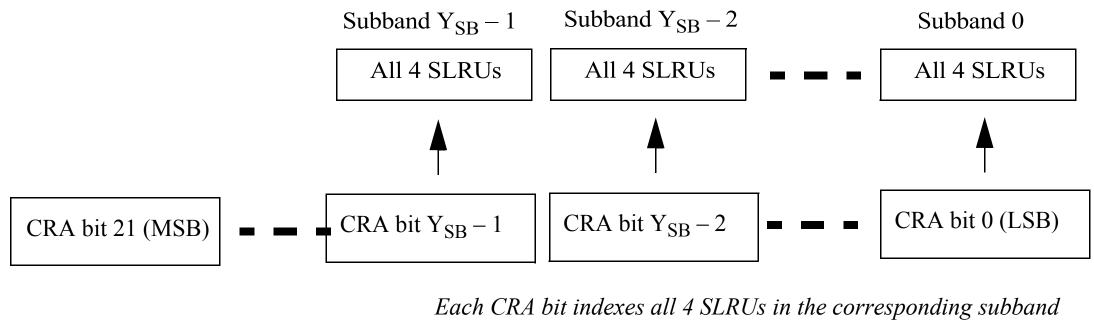


Figure 6-160—Interpretation of the CRA field when 11 ≤ Y_{SB} ≤ 21and ModeIndicator = 0b1

— When an allocation is made using a single IE, the ABS shall set ModeIndicator to 0b0, and the ABS and the AMS shall interpret the RA field as described as follows. This description defines the mapping of the RA field to all possible non-contiguous combination of indices of 2 or 3 subbands.

When the total number of subbands over all partitions, $Y_{SB} > 10$, a single IE may be used to make allocations of 2 or 3 subbands with arbitrary non-contiguous logical indices. This subclause defines the interpretation of the RA field in this case, allowing for the indication of all possible combinations of 2 or 3 subbands with non-contiguous logical indices. Allocations of contiguous subbands may be made using the DL Basic Assignment A-MAP IE.

The following definitions and associated terminology are used to make interpretations:

— A "Subband Pair" (*SBP*) contains a pair of subbands with contiguous indices. The indices of a subband pair and the corresponding subbands are related as follows: $SBP[j] \leftrightarrow \{SB[2j], SB[2j+1]\}$.

1) There are a maximum of 21 subbands in a 20 MHz system. The corresponding 11 subband pairs are indexed as: $SBP[0] \leftrightarrow \{SB[0], SB[1]\}$, $SBP[1] \leftrightarrow \{SB[2], SB[3]\}$,..., $SBP[9] \leftrightarrow \{SB[18], SB[19]\}$, while $SBP[10] \leftrightarrow \{SB[20]\}$.
2) The first 7 (MSB) bits of the RA field are referred to as the "Resource Indexing Field" (RIF), while the last 4 (LSB) bits are referred to as the "Indication Type Field" (ITF).

The mapping between the RA field and the allocated subband indices proceeds as follows. The Resource Indexing Field indicates the subband pair(s) being allocated, while the Indication Type Field further indicates the particular subbands within the subband pair that are being allocated.

Figure 6-161 illustrates the definitions of subband pairs, while Figure 6-162 depicts the partitioning and usage of the RA field.

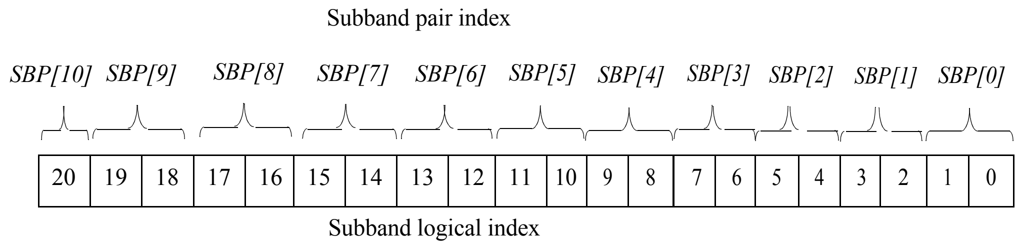


Figure 6-161—Definitions of subband pairs in the Y_{SB} > 10, single IE case

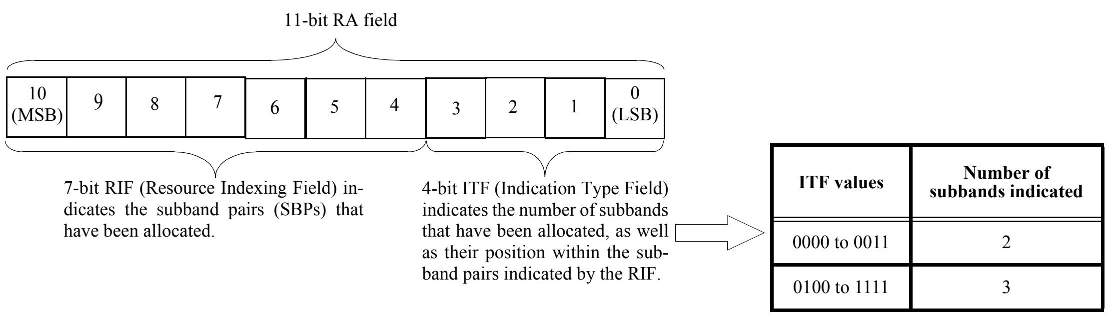


Figure 6-162—Partitioning and usage of the RA field in the Y_{SB} > 10, single IE case

The interpretations of the RIF and the ITF for the two- and three-subband allocation cases are described as follows in the next two subsections.

Allocation of two subbands

The values of the Indication Type Field (4 LSB bits of the RA field) from 0000 through 0011 indicate the assignment of 2 subbands. Denoting the assigned subbands as *SB[x]* and *SB[y]*, and further denoting *SB[x]*<-->*SBP[u]* and *SB[y]*<-->*SBP[v],* the values of the ITF from 0000 through 0011 shall be interpreted as follows:

— ITF = 0000 –> Both *SB[x]* and *SB[y]* are the lower SB indices in *SBP[u]* and *SBP[v*], respectively.

— ITF = 0001 –> *SB[x]* and *SB[y]* are the higher SB indices in *SBP[u]* and *SBP[v]*, respectively.

— ITF = 0010 –> *SB[x]* is the lower SB index in *SBP[u], SB[y]* is the higher SB index in *SBP[v]*.

— ITF = 0011 –> *SB[x]* is the higher SB index in *SBP[u], SB[y]* is the lower SB index in *SBP[v].*

In order to indicate the allocation {*SBP[u], SBP[v]*}, the ABS shall set the RIF to have the following decimal value:

$$RIF = \left\{\begin{matrix} u \\ 1 \end{matrix}\right\} + \left\{\begin{matrix} v \\ 2 \end{matrix}\right\}, u < v$$

where

$\begin{Bmatrix} n \\ k \end{Bmatrix}$ denotes the extended binomial coefficient defined previously.

This formula uniquely maps each distinct pair of SBP indices *{u, v}* to a distinct decimal value for the RIF.

Knowledge of the SBPs allocated, along with the information about the allocated subbands within the SBPs as indicated by the ITF, completes the allocation details for this case.

Allocation of three subbands

The values of the Indication Type Field (4 LSB bits of the RA field) from 0100 through 1111 indicate the assignment of three subbands. Denoting the assigned subbands as *SB[x], SB[y],* and *SB[z],* and further denoting *SB[x]<-->SBP[u], SB[y]<-->SBP[v],* and *SB[z]<-->SBP[w]*.

Allocation of three subbands, with two of them in the same Subband Pair

In this case of a three subband allocation, *SB[x]* and *SB[y]* belong to the same SBP, i.e., *SBP[u] = SBP[v]*. The ITF values 0100 and 0101 indicate these cases, and shall be interpreted as follows:

— ITF = 0100 –> *SB[z]* is the lower SB index in *SBP[w]*.

— ITF = 0101 –> *SB[z]* is the higher SB index in *SBP[w]*.

In order to indicate the allocation {*SBP[u], SBP[v], SBP[w]*}, with *u* = *v*, the ABS shall set the RIF to have the following decimal value:

$$RIF = \begin{cases} \begin{Bmatrix} u \\ 1 \end{Bmatrix} + \begin{Bmatrix} w \\ 2 \end{Bmatrix} & , u = v < w \\ \begin{Bmatrix} w \\ 1 \end{Bmatrix} + \begin{Bmatrix} u \\ 2 \end{Bmatrix} + 55 & , w < u = v \end{cases}$$

where

$\begin{Bmatrix} n \\ k \end{Bmatrix}$ denotes the extended binomial coefficient defined previously.

This formula uniquely maps each distinct triplet of SBP indices *{u, v, w},* with *u* = *v*, to a distinct decimal value for the RIF. Knowledge of the SBPs allocated, along with the information about the allocated subbands within the SBPs as indicated by the ITF, completes the allocation details for this case.

Allocation of three subbands, with all three in different Subband Pairs, not including SBP[10]

In this case of a three subband allocation, we have $SBP[u] \neq SBP[v] \neq SBP[w]$, and none of *SBP[u], SBP[v],* or *SBP[w]* equaling SBP[10].

The eight ITF values from 0110 through 1101 shall indicate this case, and these ITF values shall be interpreted as follows. They allow indication of all possible arrangements of the indicated three subbands *SB[x], SB[y],* and *SB[z]* within the three indicated subband pairs *SBP[u], SBP[v],* and *SBP[w]*, and shall be interpreted as in Table 6-200.

Table 6-200—Interpretation of the ITF from 0110 through 1101 (decimal 6 through 13)

ITF value	Position of *SB[x]* in *SBP[u]*(Higher index/ Lower index)	Position of *SB[y]* in *SBP[v]*(Higher index/ Lower index)	Position of *SB[z]* in *SBP[w]*(Higher index/ Lower index)
0110	Higher	Higher	Higher
0111	Higher	Higher	Lower
1000	Higher	Lower	Higher
1001	Higher	Lower	Lower
1010	Lower	Higher	Higher
1011	Lower	Higher	Lower
1100	Lower	Lower	Higher
1101	Lower	Lower	Lower

In order to indicate the allocation {*SBP[u], SBP[v], SBP[w]*}, with $u \neq v \neq w \neq 10$, the ABS shall set the RIF to have the following decimal value:

$$RIF = \left\{ \begin{matrix} u \\ 1 \end{matrix} \right\} + \left\{ \begin{matrix} v \\ 2 \end{matrix} \right\} + \left\{ \begin{matrix} w \\ 3 \end{matrix} \right\}, u < v < w$$

where

$\left\{ \begin{matrix} n \\ k \end{matrix} \right\}$ denotes the extended binomial coefficient defined previously.

This formula uniquely maps each distinct triplet of SBP indices *{u, v, w}*, with $u \neq v \neq w \neq 10$, to a distinct decimal value for the RIF. Knowledge of the SBPs allocated, along with the information about the allocated subbands within the SBPs as indicated by the ITF, completes the allocation details for this case.

Allocation of three subbands, with all three in different Subband Pairs, including SBP[10]

In this case of a three subband allocation, we have $SBP[u] \neq SBP[v] \neq SBP[w]$, with *SBP[w] = SBP[10]*. Hence, in this case, we have one of the allocated subbands, *SB[z] = SB[20]*.

The two ITF values 1110 and 1111 shall indicate this case, and these ITF values shall be interpreted as follows:

- ITF = 1110 ≥ *SB[x]* and *SB[y]* are both the higher SB indices in *SBP[u]* and *SBP[v]* or both the lower indices in *SBP[u]* and *SBP[v]*, respectively.
- ITF = 1111≥ Either *SB[x]* is the higher SB index in *SBP[u]* and *SB[y]* is the lower SB index in *SBP[v]*, or *SB[x]* is the lower SB index in *SBP[u]* and *SB[y]* is the higher SB index in *SBP[v]*.

The MSB bit of the RIF provides further indication about *SB[x]* and *SB[y]* as follows:

- MSB bit of RIF = 0 ≥ *SB[x]* is the higher SB index in *SBP[u]*.
- MSB bit of RIF = 1 ≥ *SB[x]* is the lower SB index in *SBP[u]*.

The values of the ITF and the MSB bit of the RIF, taken together, complete the information about *SB[x]* and *SB[y]*.

In order to indicate the allocation {*SBP[u], SBP[v], SBP[w]*}, with $u \neq v \neq 10$, $w = 10$,the ABS shall set the 6 LSB of RIF to have the following decimal value:

$$6 \text{ LSB of } RIF = \left\{ \begin{matrix} u \\ 1 \end{matrix} \right\} + \left\{ \begin{matrix} v \\ 2 \end{matrix} \right\}, u < v$$

where

$\left\{ \begin{matrix} n \\ k \end{matrix} \right\}$ denotes the extended binomial coefficient defined previously.

This formula uniquely maps each distinct triplet of SBP indices *{u, v, w}*, with $u \neq v \neq 10$, $w = 10$ to a distinct decimal value for the six LSB of the RIF.

6.3.5.5.2.4.4 UL Subband Assignment A-MAP IE

The UL Subband Assignment A-MAP IE shall have an identical structure to the UL Basic Assignment A-MAP IE. With the exception of "Resource Index" field, all of the other fields shall be interpreted in the same manner as defined for the UL Basic Assignment A-MAP IE.

The "IE Type" field shall be set to the value 0b0011.

For all bandwidths, the "Resource Allocation" field shall be 11 bits long.

The pre-processing steps to define some of the terms used in the RA field interpretation shall be as defined in 6.3.5.5.2.4.3 (DL Subband Assignment A-MAP IE), with all DL terms replaced by their UL equivalents.

For the UL Subband IE, a single IE shall be used to indicate a single instance of an allocation in all cases. The RA field interpretation in the case of the UL Subband IE shall be as follows.

— When the total number of subbands over all partitions, $0 \leq Y_{SB} \leq 3$, each of the *j* bit positions in the RA field, $0 \leq j < 11$, indicates the allocation or non-allocation of particular SLRU indices using a bit-map method, as indicated by Table 6-201.

Table 6-201—RA bit to SLRU index mapping when $Y_{SB} \leq 3$

RA bit *j*, RA[*j*]	0 (LSB)	1	2	3	4	5	6	7	8	9 and 10
SLRU[*k*] indexed by RA[*j*]	0,1	2	3	4,5	6	7	8,9	10	11	Not used

— When $4 \leq Y_{SB} \leq 10$, the AMS and the ABS shall interpret the RA field in the same manner as in the $5 \leq Y_{SB} \leq 10$ case in the DL Subband Assignment A-MAP IE.

— For the $11 \leq Y_{SB} \leq 21$ case, the AMS and the ABS shall interpret the RA field in the same manner as in the $11 \leq Y_{SB} \leq 21$, ModeIndicator = 0b0 case in the DL Subband Assignment A-MAP IE.

6.3.5.5.2.4.5 Feedback Allocation A-MAP IE

Table 6-202 describes the fields in a Feedback Allocation A-MAP IE used for dynamically allocating or deallocating UL fast feedback control channels (including both PFBCH and SFBCH) to an AMS. If an AMS has an existing fast feedback control channel for an active DL carrier and receives a new feedback channel allocation for the same active DL carrier, the original fast feedback channel is deallocated automatically.

Definitions of the fields in the Feedback Allocation A-MAP IE are listed in Table 6-202.

Table 6-202—Feedback Allocation A-MAP IE[a]

Syntax	Size (bits)	Notes
Feedback_Allocation_A-MAP_IE() {	—	—
A-MAP IE Type	4	Feedback Allocation A-MAP IE
Channel Index	6	Feedback channel index within the UL fast feedback control resource region (Dependent on $L_{FB,FPi}$ defined in 6.3.7.3.3.2)
Short-term feedback period (p)	3	Feedback is transmitted on the FFBCH every 2^p frames
Long-term feedback Period (q)	2	Long-term feedback is transmitted on the FFBCH every 2^q short-term feedback opportunities. If q = 0b00, either the short-term or the long-term feedback shall be reported by the AMS, depending on the feedback formats defined in 6.3.8.3.1.5.
Frame index	2	The AMS starts reporting at the frame which number in the superframe is equal to Frame index. If the current frame is specified, the AMS starts reporting in four frames. Frames are numbered from 0 to 3 in the superframe. MIMO feedback reported by an AMS in frame N pertains to measurements performed at least up to frame $N-1$. The first MIMO feedback report following the Feedback Allocation A-MAP IE as per the "Frame index" may contain invalid MIMO feedback information if the MIMO feedback is sent in the frame immediately following the frame in which the Feedback Allocation A-MAP IE was received.
Subframe index	3	Indicates the UL AAI subframe index in the UL portion of the frame.

Table 6-202—Feedback Allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Allocation Duration(*d*)	3	An FFBCH is transmitted on the FFBCH channels indexed by Channel Index for 8×2^d frames. If d = 0b000, the FFBCH is deallocated. If d = 0b111, the AM reports until the ABS command for the AMS to stop.
ACK allocation flag	1	Indicates if one HARQ feedback channel is allocated to acknowledge the successful detection of this IE.
if (ACK allocation flag == 0b1) {		
HFA	6	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of this A-MAP IE
}		
MFM	3	MIMO Feedback Mode as defined in Table 6-223
if (MFM ≠ 1) {		

Table 6-202—Feedback Allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
$MaxM_t$	*variable* 1 or 2	Variable number of bits—depends on number of transmit antennas N_t If N_t = 2: (Any MFM) 0b0: 1 0b1: 2 If N_t = 4: (Any MFM) 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If N_t = 8 (SU-MIMO, MFM 0,2,3,4) 0b00: 1 0b01: 2 0b10: 4 0b11: 8 If N_t = 8: (MU-MIMO, MFM 5,7) 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If N_t = 8: (MU-MIMO, MFM 6) 0b00:1 0b01:2 0b10:4 0b11:8
}		
if (MFM == 2,3,5,6) {		
Feedback Format	2	
}else if (MFM = 4, 7) {		
Feedback Format	1	
}		
if (MFM == 0,4,7 and FPCT >1) {		Diversity Permutation and FFR is enabled
if (FPCT == 2) {		

Table 6-202—Feedback Allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
FPI	1	Frequency partition indication: The ABS indicates to the AMS to send wideband CQI and STC rate of the frequency partition and reuse factor in the future: 0b0: Frequency partition index 1 0b1: Frequency partition index 2 ABS should set FPI to a value such that $FPS_{FPI} > 0$
}		
else {		
FPI	2	Frequency partition indication: The ABS indicates to the AMS to send wideband CQI and STC rate of the frequency partition and reuse factor in the future: 0b00: Frequency partition index 0 0b01: Frequency partition index 1 0b10: Frequency partition index 2 0b11: Frequency partition index 3 The ABS should set FPI to a value such that $FPS_{FPI} > 0$
}		
}		
if (MFM == 0 & *q*!= 0b00 & FPCT >1){		
if (FPCT == 2){		When FPCT= 2, Long-term FPI is implicitly signaled by FPI. The ABS indicates to the AMS to send wideband CQI and STC rate for the second frequency partition using long-term feedback.
Long-Short FPI Switch Flag	1	Used to inform the AMS to switch Short and Long-term reporting based on the FPI of the latest data allocation. 0b0: FPI for Long and Short-Term Period report remains constant for the Allocation Duration (*d*) 0b1: FPI for Long and Short-Term Period interchange after every update of FPI of latest data allocation at the subsequent Long-Term Feedback Opportunity.
} else {		

Table 6-202—Feedback Allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Long-term FPI	2	Frequency partition indication: The ABS indicates to the AMS to send wideband CQI and STC rate for the second frequency partition using long-term feedback: 0b00: Frequency partition index 0 0b01: Frequency partition index 1 0b10: Frequency partition index 2 0b11: Frequency partition index 3 The ABS should set Long-term FPI to a different value than FPI and $FPS_{Long\ term\ FPI} > 0$.
}		
}		
if (MFM == 3) {		CL SU MIMO
Codebook_mode	2	Codebook Feedback Mode and Codebook Coordination 0b00: base mode with codebook coordination disabled 0b01: transformation mode with codebook coordination disabled 0b10: differential mode with codebook coordination disabled 0b11: base mode with codebook coordination enabled
if (N_t == 4) {		
Codebook_subset	1	0b0: report PMI from the base codebook or transformed base codebook 0b1: report PMI from the codebook subset or transformed codebook subset
}		
}		
if (MFM == 6) {		CL MU MIMO
Codebook_mode	2	Codebook Feedback Mode and Codebook Coordination Enable 0b00: *Reserved* 0b01: transformation mode with codebook coordination disabled 0b10: differential mode with codebook coordination disabled 0b11: base mode with codebook coordination enabled

Table 6-202—Feedback Allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
if (N_t == 4) {		
Codebook_subset	1	0b0: report PMI from the base codebook or transformed base codebook 0b1: report PMI from the codebook subset or transformed codebook subset
}		
}		
if (MFM == 4,7) {		CL SU and MU MIMO
Codebook_coordination	1	Codebook Feedback Mode and Codebook Coordination 0b0: base mode with codebook coordination disabled 0b1: base mode with codebook coordination enabled
if (N_t == 4) {		
Codebook_subset	1	0b0: report PMI from the base codebook 0b1: report PMI from the codebook subset
}		
}		
if(MFM == 0,1,2,5) {		
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
Padding	*variable*	Padding to reach byte boundary
}	—	—

[a]A 16-bit CRC is generated based on the randomized contents of the Feedback Allocation A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

Channel Index: Uniquely identifies a fast feedback channel on which an AMS can transmit fast feedback information. With this allocation, a one-to-one relationship is established between channel index and the AMS.

ACK Allocation Flag: The ABS may set ACK Allocation Flag to 0b1 if Allocation Duration equals 0b000. The ABS may set ACK Allocation Flag to 0b1 if Allocation Duration is not equal to 0b000 and the channel index of the newly allocated FFBCH is the same as the channel index of the deallocated FFBCH.

Short-term Feedback Period (*p*): Short-term feedback is transmitted on the FFBCH every 2^p frames.

Long-term Feedback Period (*q*): Long-term feedback is transmitted on the FFBCH every 2^q short-term feedback opportunities.

Allocation duration (*d*): A FFBCH is transmitted on the FFBCH channels indexed by Channel Index for 8×2^d frames. If d = 0b000, the FFBCH is deallocated. If d = 0b111, the AMS shall report until the ABS command for the AMS to stop.

MFM: MIMO feedback mode, defined in Table 6-223.

Feedback Format: This field specifies the feedback format index when reporting fast feedback information in the FFBCH. Feedback format definitions for different MIMO feedback modes are described in 6.3.8.3.1.5.

FPI: The frequency partition over which the short-term period report shall be measured by the AMS.This field does not exist when FPCT = 1.

Long-term FPI: The frequency partition over which the long-term period report shall be measured by the AMS. This field does not exist when FPCT = 1 and is implicitly signaled using FPI when FPCT = 2.

Long-Short FPI Switch Flag: This field indicates whether AMS switches long- and short-term reporting based on the FPI of the latest data allocation. If set to 0, the long- and short-term feedback reports do not change during fast feedback allocation duration. If set to 1, FPI for Long- and Short-Term Period interchange after every update of FPI of data allocation. The Long-Short interchange takes effect in the immediate “long-term” FFB opportunity after sending the HARQ response to the data allocation.

MaxM$_t$: This field specifies the maximum rank to be fed back by the AMS if MFM = 0,2,3,4 (which indicates a SU MIMO feedback mode for SM), or it specifies the maximum number of users scheduled on each RU at the ABS if MFM = 5,6,7 (which indicates a MU MIMO feedback mode).

Codebook_coordination: When codebook coordination is enabled, if the AMS reports STC rate equal to 1, then the AMS shall find the rate-1 PMI from the codebook entries broadcasted in BC_SI in AAI-DL-IM Message.

Codebook_mode: This field specifies the codebook feedback mode. If codebook coordination is enabled by setting Codebook_mode to 0b11 and if the AMS reports STC rate equal to 1, then the AMS shall find the rate-1 PMI from the codebook entries broadcasted in BC_SI in AAI-DL-IM Message.

Measurement Method Indication: This field indicates the use of midamble or pilots for CQI measurement.

In the case of vertical encoding, the DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE and DL Persistent A-MAP IE sent by the ABS can indicate any value of M_t as long as it complies with $M_t \le min(N_t, N_r)$. There is no constraint on the assigned M_t relative to $MaxM_t$ for an allocation outside the open-loop region. M_t shall be equal to $MaxM_t$ for an allocation in the open-loop region with $MaxM_t$ streams.

$MaxM_t$ should be interpreted as a function of Measurement Method Indication and the MIMO Feedback Mode.

If Measurement Method Indication == 0b0:

— With an MFM supporting MU MIMO operation, $MaxM_t$ indicates the maximum number of users the AMS should assume will be scheduled in future MU MIMO allocations. Based on this information, the AMS may make a better estimation of the multi-user interference in the CQI. If $MaxM_t$ is set to one, then the AMS shall assume it will be paired with no other AMSs and feed back Rank 1 CL-SU-MIMO CQI. If MFM 5 is indicated in the Feedback Allocation A-MAP IE, $MaxM_t$ indicates the rank of the open-loop codebook subset to which belongs to the unitary matrix from which the AMS should feedback its preferred stream index on a given physical subband.

— With an MFM supporting SU MIMO operation, $MaxM_t$ indicates the maximum STC rate allowed in the feedback report of the AMS. The ABS also uses $MaxM_t$ to make sure that the STC rate feedback is in accordance to STC rate ≤ $min(N_t, N_r)$ for the AMS. For an MFM requesting OL MIMO feedback for operation with a diversity allocation, setting $MaxM_t = 2$ enforces feedback for DLRU, otherwise the AMS may feedback STC rate up to 4. With MFM 0, $MaxM_t = 1$, indicates that the AMS shall feedback the wideband CQI for SFBC.

If Measurement Method Indication == 0b1:

— $MaxM_t$ indicates the rank of the open-loop region for which the feedback shall be provided. The open-loop region type can be deduced from $MaxM_t$ and MFM. $MaxM_t$ indicates the pilot pattern used in the OL region in which CQI measurements should be taken by the AMS.

6.3.5.5.2.4.6 UL Sounding Command A-MAP IE

Table 6-203 specifies the fields of UL Sounding Command A-MAP IE used by the ABS to request sounding transmission by the AMS.

The number of UL sounding transmissions per frame that the ABS allocates to an AMS shall be less than or equal to one.

Table 6-203—UL Sounding Command A-MAP IE[a]

Syntax	Size (bits)	Notes
UL_Sounding_Command_A-MAP_IE() {	—	—
A-MAP IE type	4	UL Sounding Command A-MAP IE
Sounding AAI subframe	2	Indicates the sounding AAI subframe. AAI subframes with sounding symbol are renumbered in time starting from 0
Sounding subband bitmap	*variable* max. 24	FFT size dependant
If (multiplexingType == 0) {		multiplexingType is transmitted in the AAI-SCD message.
Decimation offset *d*	5	Unique decimation offset
} else {		
Cyclic time shift m	5	Unique cyclic shift
}		
Periodicity (*p*)	3	0b000 = Single command, not periodic, or terminate the periodicity. Otherwise, repeat sounding once per $2^{(p-1)}$ frames, where *p* is decimal value of the periodicity field

Table 6-203—UL Sounding Command A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Antenna switching	1	0b0: Antenna switching 0b1: No antenna switching
Power boosting	1	0b0: No power boosting 0b1: 3 dB power boosting
Padding	*variable*	Padding
}		

[a]A 16-bit CRC is generated based on the randomized contents of the UL Sounding Command A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

d: Sounding channel index indicates unique decimation offset.
n: Sounding channel index indicates unique cyclic time shift.

Table 6-203 specifies the fields of UL Sounding Command A-MAP IE used by the ABS to request sounding transmission by the AMS. Decimal equivalent of the sounding AAI subframe indicates the AAI subframe number with sounding symbol (the first AAI subframe in frame is indexed 0). The sounding subband bitmap field is used to indicate the sounding subbands used in the sounding allocation. For that purpose, the N_{used} contiguous subcarriers are divided into sounding subbands, where each sounding subband compromises $N_1 \times P_{sc}$ adjacent subcarriers with N_1= 4 and P_{sc} = 18 for N_{FFT} = 512, 1024, and 2048. The MSB of the Sounding subband bitmap field corresponds to the sounding subband with lowest subcarrier indexes. The three periodicity bits are used to indicate the AMS to periodically repeat the sounding transmission. Setting periodicity bits to 0b000 indicates a single sounding command or terminates the sounding if periodic sounding command is being performed.

If the antenna switching flag equals 0, the AMS sounds with antenna switching, while if the antenna switching flag equals 1, the AMS sounds all transmit antennas. If the antenna switching field equals 0, then the actual decimation offset $g = d$ for multiplexing Type 0 or the actual cyclic shift index $n = m$ for multiplexing Type 1. The AMS sounds a transmit antenna at the each sounding opportunity from AMS antenna 1 to AMS antenna N_t or N_r based on the value of antenna configuration for sounding antenna switching in the AAI-REG-RSP message, repeatedly. If the antenna switching field equals 1, then the i-th antenna of the AMS corresponds to the actual decimation offset $g = d + i – 1$ for multiplexing Type 0 or to the actual cyclic shift index $n = m + i – 1$ for multiplexing Type 1. The AMS transmit antennas are indexed starting from one.

If power boosting field is set 1, 3 dB tone power boosting is applied to each Tx antenna.

6.3.5.5.2.4.7 CDMA Allocation A-MAP IE

Table 6-204—CDMA Allocation A-MAP IE[a]

Syntax	Size (bits)	Notes
CDMA_Allocation_A-MAP IE() {	—	—
A-MAP IE Type	4	CDMA Allocation A-MAP IE
CDMA allocation indication	1	0b0: Bandwidth allocation in response to a received contention-based bandwidth request. 0b1: Bandwidth allocation in response to a received contention-based ranging request
If (CDMA allocation indication == 0b0){		
Resource Index	11	512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL AAI subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator = 0b1
HFA	3	HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
Reserved	19	Reserved bits
}		
Else if (CDMA allocation indication == 0b1) {		
Uplink/Downlink Indicator	1	Indicates whether the following fields are for resource assignment in the uplink or in the downlink. 0b0: Uplink 0b1: Downlink
Resource Index	11	512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size.
$I_{SizeOffset}$	5	Offset used to compute burst size index
HFA	3	HARQ Feedback Allocation

Table 6-204—CDMA Allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
If (Uplink/Downlink Indicator == 0b0) {		
iotFP	7	IoT value of Frequency Partition used for AMS resource assignment, quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB, detail reference to the 6.2.3.32 AAI-ULPC-NI message
offsetControl	6	offsetControl is the transmit power adjustment value transmitted by the ABS. It represents the value among –15.5 dB to 16 dB with 0.5 dB step
AI_SN	1	HARQ identifier sequence number
Long TTI Indicator	1	Indicates the number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL AAI subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator = 0b1
} Else {		
ACID	4	HARQ channel identifier
AI_SN	1	HARQ identifier sequence number
SPID	2	HARQ subpacket identifier for HARQ IR
Reserved	8	Reserved bits
}		
}		
}		

[a]A 16-bit CRC is generated based on the randomized contents of the CDMA Allocation A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

Table 6-204 specifies the fields of CDMA Allocation A-MAP IE used by the ABS for UL bandwidth allocation for bandwidth request or UL or DL bandwidth allocations for ranging procedures before a TSTID or STID has been assigned to the AMS. Through the CDMA Allocation A-MAP IE, the ABS allocates UL resources to a user that requested bandwidth using a random ranging preamble code or BR preamble code, i.e., the ABS grants UL bandwidth for the transmission of BR with STID header in the bandwidth request procedure, and for the transmission of the AAI-RNG-REQ message or the AAI-MSG-ACK message as an acknowledgment to the AAI-RNG-RSP message in the ranging procedure. Other MAC control messages or MAC signaling headers shall not be transmitted in an UL allocation signaled using CDMA Allocation A-MAP IE. Note that the AAI-MSG-ACK message shall be signaled via CDMA Allocation A-MAP IE only when the AMS has not acquired STID or TSTID yet.

The maximum number of UL HARQ retransmissions is set to the default value defined in 6.2.14.2.2. For the CDMA allocation for AAI-RNG-REQ transmission or BR without STID header (6.2.2.1.3.2) transmission, a HARQ burst for retransmission may be assigned using CDMA allocation A-MAP IE at the relevant downlink subframe with AI_SN maintained the same as the previous CDMA allocation A-MAP IE with the same

RAID within the time duration that the ranging attribute is valid. On the other hand, a HARQ burst for the transmission of a new initial HARQ subpacket containing the AAI-RNG-REQ message or BR without STID header may be assigned using the CDMA allocation A-MAP IE with the AI_SN toggled within the time duration that the RAID is sustained.

The UL HARQ burst signaled via the CDMA Allocation A-MAP IE is always transmitted using MIMO mode 1 with $M_t = 1$ as the MIMO encoder format and QPSK as the modulation scheme.

In addition to UL allocation, the ABS transmits the AAI-RNG-RSP message through a DL burst assigned by CDMA Allocation A-MAP IE to an AMS in contention-based random access ranging procedure, where neither STID nor TSTID is assigned to the AMS yet.

The maximum number of the DL HARQ retransmission is set to the default value defined in 6.2.14.2.1.

The DL HARQ burst signaled by the CDMA Allocation A-MAP IE is always transmitted using SFBC as the MIMO encoder format and QPSK as the modulation scheme.

6.3.5.5.2.4.8 DL persistent allocation A-MAP IE

The DL persistent allocation A-MAP IE is specified in Table 6-205.

Table 6-205—DL persistent allocation A-MAP IE[a]

Syntax	Size (bits)	Description/Notes
DL Persistent Allocation A-MAP_IE() {	—	—
A-MAP IE Type	4	DL Persistent Allocation A-MAP IE
Allocation Period	2	Period of persistent allocation. If (Allocation Period == 0b00), it indicates the deallocation of a persistently allocated resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 6 frames
if (Allocation Period == 0b00){	—	—
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 DL AAI subframes for FDD or all DL AAI subframes for TDD

Table 6-205—DL persistent allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
HFA	6	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
Reserved	16	Reserved bits
} else if (Allocation Period != 0b00){	—	—
$I_{SizeOffset}$	5	Offset used to compute burst size index
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Multi-layer encoding 0b11: CDR
if (MEF == 0b01){		Parameters for vertical encoding
M_t	3	Number of streams in transmission $M_t \le N_t$ N_t : Number of transmit antennas at the ABS 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
Reserved	1	
} else if(MEF == 0b10){		Parameters for multi-layer encoding

Table 6-205—DL persistent allocation A-MAP IE[a] (continued)

Syntax	Size (bits)	Description/Notes
Si	4	Index to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO, and the modulation constellation of paired user in the case of 2 stream transmission 0b0000: 2 streams with PSI = stream 1 and other modulation = QPSK 0b0001: 2 streams with PSI = stream 1 and other modulation = 16QAM 0b0010: 2 streams with PSI = stream 1 and other modulation = 64QAM 0b0011: 2 streams with PSI = stream 1 and other modulation information not available 0b0100: 2 streams with PSI = stream 2 and other modulation = QPSK 0b0101: 2 streams with PSI = stream 2 and other modulation = 16QAM 0b0110: 2 streams with PSI = stream 2 and other modulation = 64QAM 0b0111: 2 streams with PSI = stream 2 and other modulation information not available 0b1000: 3 streams with PSI = stream 1 0b1001: 3 streams with PSI = stream 2 0b1010: 3 streams with PSI = stream 3 0b1011: 4 streams with PSI = stream 1 0b1100: 4 stream with PSI = stream 2 0b1101: 4 streams with PSI = stream 3 0b1110: 4 streams with PSI = stream 4 0b1111: n/a
}	—	—
Resource Index	11	512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default) 0b1: 4 DL AAI subframes for FDD or all DL AAI subframes for TDD
HFA	3	HARQ Feedback Allocation
N_ACID	2	Number of ACIDs for implicit cycling of HARQ channel identifier. 0b00: 1 0b01: 2 0b10: 3 0b11: 4

Table 6-205—DL persistent allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
Initial_ACID	4	Initial value of HARQ channel identifier for implicit cycling of HARQ channel identifiers.
Reserved	2	Reserved bits
}	—	—
}	—	—

[a]A 16-bit CRC is generated based on the randomized contents of the DL Persistent Allocation A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

The Resource Index field in the DL Persistent Allocation A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE.

Long TTI Indicator: Indicates number of AAI subframes spanned by the allocated resource. When Long TTI Indicator is set to 1, DL HARQ burst shall not be assigned in the frame where the SFH is transmitted.

6.3.5.5.2.4.9 UL persistent allocation A-MAP IE

The UL persistent allocation A-MAP IE is specified in Table 6-206.

Table 6-206—UL persistent allocation A-MAP IE[a]

Syntax	Size (bits)	Description/Notes
UL Persistent Allocation A-MAP_IE() {	—	—
A-MAP IE Type	4	UL Persistent Allocation A-MAP IE
Allocation Period	2	Period of persistent allocation If (Allocation Period == 0b00), it indicates the deallocation of persistent resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 6 frames
If (Allocation Period == 0b00){	—	—
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size

Table 6-206—UL persistent allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
TTI and Relevance	2	Indicates the TTI type and the location of UL subframe relevant to this A-MAP. 0b00: long TTI spanning 4 UL AAI subframes for FDD or all UL AAI subframes for TDD 0b01: default TTI, the first UL subframe relevant to this A-MAP 0b10: default TTI, the second UL subframe relevant to this A-MAP 0b11: default TTI, the third UL subframe relevant to this A-MAP 0b10 and 0b11 are only applicable if the number of DL AAI subframes is less than the number of UL AAI subframes in TDD mode.
HFA	6	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
Reserved	15	Reserved bits
} else if (Allocation Period != 0b00){	—	—
$I_{SizeOffset}$	5	Offset used to compute burst size index
M_t	1	Number of streams in transmission $M_t \le N_t$ up to 2 streams per AMS supported N_t : Number of transmit antennas at the AMS 0b0: 1 stream 0b1: 2 streams
TNS	2	Total number of streams in the LRU for CSM 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
if(TNS >M_t){	—	—
SI	2	Indicates first pilot index for CSM with TNS = 2, 3 or 4 streams: 0b00: SI = 1 0b01: SI = 2 0b10: SI = 3 0b11: SI = 4 If TNS = 2 streams, 0b10 and 0b11 are not applicable. If TNS = 3 streams, 0b11 is not applicable.
}		
else if (TNS == Mt) {		

Table 6-206—UL persistent allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding
Reserved	1	Reserved bit
}	—	—
PF	1	Precoding Flag 0b0: non-adaptive precoding 0b1: adaptive precoding using the precoder of rank M_t of the AMS's choice
Resource Index	11	512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size
TTI and Relevance	2	Indicates the TTI type and the location of UL subframe relevant to this A-MAP. 0b00: long TTI spanning 4 UL AAI subframes for FDD or all UL AAI subframes for TDD 0b01: default TTI, the first UL subframe relevant to this A-MAP 0b10: default TTI, the second UL subframe relevant to this A-MAP 0b11: default TTI, the third UL subframe relevant to this A-MAP 0b10 and 0b11 are only applicable if the number of DL AAI subframes is less than the number of UL AAI subframes in TDD mode.
HFA	3	HARQ Feedback Allocation
N_ACID	2	Number of ACIDs for implicit cycling of HARQ channel identifier. 0b00: 1 0b01: 2 0b10: 3 0b11: 4
Initial_ACID	4	Initial value of HARQ channel identifier for implicit cycling of HARQ channel identifiers.
Reserved	1	Reserved bit
}	—	—
}	—	—

[a]A 16-bit CRC is generated based on the randomized contents of the UL Persistent Allocation A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

The Resource Index field in the UL Persistent Allocation A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE with ‘DL’ specific terminology replaced by ‘UL’ equivalents.

6.3.5.5.2.4.10 Group resource allocation A-MAP IE

Group control information is used to allocate resources to one or multiple AMSs within a user group. The Group Resource Allocation A-MAP IE is used for signaling group resource allocation in the DL or UL. The Group Resource Allocation A-MAP IE is shown in Table 6-207.

Group scheduling requires two operations

a) Assignment of a flow of an AMS to a group. In order to add a flow of an AMS to a group in the DL or UL, the ABS shall transmit a Group Configuration MAC control message.

Allocation of resources to AMSs within a group. In order to assign resources to one or more AMSs in a group, the ABS shall transmit the Group Resource Allocation A-MAP IE. The Group Resource Allocation A-MAP IE is included in user-specific resource assignment in an A-MAP region. The GRA A-MAP IE contains bitmaps to indicate scheduled AMSs and signal MIMO mode HARQ burst size and resource size.

Table 6-207—Group Resource Allocation A-MAP IE[a]

Syntax	Size (bits)	Description/Notes
Group_Resource_Allocation_A-MAP_IE() {	—	—
A-MAP IE Type	4	Group Resource Allocation A-MAP IE
Segment Flag	1	0b0: indicates the segment except the first segment 0b1: indicates the first segment
if (UL Allocation && *D* <*U*){		If group corresponds to UL allocations and the number of DL AAI subframes (*D*) is less than the number of UL AAI subframes (*U*)
Allocation Relevance	2	Indicates the location of UL subframe relevant to this A-MAP. 0b00: the first UL subframe relevant to this A-MAP 0b01: the second UL subframe relevant to this A-MAP 0b10: third UL subframe relevant to this A-MAP 0b11: N/A
}		
User Bitmap	*variable*	Bitmap to indicate scheduled AMSs in a group. The size of the bitmap is equal to the User Bitmap Size signaled to each AMS in the Group configuration MAC control message. 0b0: AMS not allocated in this AAI subframe 0b1: AMS allocated in this AAI subframe
Resource Offset	7	Indicates starting LRU for resource assignment to this group
HFA Offset	6	Indicates the start of the HARQ feedback channel index used for scheduled allocations.
if(Group MIMO mode set == 0b01){		

Table 6-207—Group Resource Allocation A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
MIMO Bitmap	*variable*	Bitmap to indicate MIMO mode for the scheduled AMSs. 0b0: Mode 0 0b1: Mode 1
}		
else if(Group MIMO mode set == 0b11 && UL Allocation){		
SI Bitmap	*variable*	Bitmap to indicate fist pilot index of UL OL MU-MIMO(CSM) for the scheduled AMSs. 0b0: SI = 1 0b1: SI = 2
}		
Resource Allocation Bitmap	*variable*	Bitmap to indicate burst size/resource size for each scheduled AMS
}	—	—

[a]Depending upon its size, the Group Resource Allocation A-MAP IE may have one segment or may be broken into multiple segments, each of which is coded separately. A 16-bit CRC shall be generated based on the randomized contents of each segment. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194. Knowledge of the "User Bitmap" field, which always appears in the first segment, is used to infer the sizes of the other variable length fields. Hence, the total size of the GRA A-MAP IE, as well as the number of segments it is partitioned into, can be inferred from the first segment.

Resource Offset: Signals the offset of the LRU where the allocation for the group starts. The offset is with respect to the start of the AAI subframe.

HFA Offset: Signals the starting HARQ feedback channel index for scheduled AMSs of the group (as identified by ones in the User bitmap). The exact HARQ feedback allocation for a given AMS is determined by using the mechanism described in 6.3.7.3.3.2 for DL GRA allocations and 6.3.5.3.2.2 for UL GRA allocations

User Bitmap: A bitmap that uses 1 bit per flow of the AMS of the group to signal whether the AMS has an allocation in that AAI subframe. The size of the bitmap is determined by BS and can be 4, 8, 16, or 32 bits. This size is signaled to each AMS in the Group configuration MAC control message when the flow of the AMS is added to the group. The AMSs for which the corresponding bit is set to 1 are referred to as scheduled AMSs in that subframe.

MIMO Bitmap: This bitmap is included in the group only when the group MIMO mode set is 0b01. The MIMO mode set is signaled to the AMS in the Group configuration MAC control message when the user is added to the group. The size of this bitmap is equal to the number of scheduled flows in the group in that subframe. For each scheduled AMS, the value of corresponding bit in this bitmap signals the MIMO mode (mode 0 or mode 1).

SI Bitmap: This bitmap is included in the group only when the group MIMO mode set is 0b11. The MIMO mode set is signaled to the AMS in the Group Configuration MAC control message when the user is added to the group. The size of this bitmap is equal to the number of scheduled flows in the group in that subframe.

For each scheduled AMS, the value of corresponding bit in this bitmap signals the first pilot index as the stream index (SI = 1 or SI = 2) of UL OL MU-MIMO.

Resource Allocation Bitmap: The resource allocation bitmap uses 5 bits per flow to signal the HARQ burst size and the resource size for the AMS's allocation in that subframe. The first 2 bits signal the HARQ burst size and the next 3 bits signal the resource size. The 2-bit codes for burst sizes associated with the FID and the 3-bit resource sizes associated with the group are based on the information in the Group Configuration MAC control message.

When Long TTI Indicator is set to 1 in AAI-GRP-CFG for DL allocation, the DL HARQ burst shall not be assigned in the frame where the SFH is transmitted.

6.3.5.5.2.4.11 Feedback Polling A-MAP IE

The information element shown in Table 6-208 is used by the ABS to schedule MIMO feedback transmission by the AMS. In response to Feedback Polling A-MAP IE, the AMS sends the MIMO feedback using the AAI-SBS-MIMO-FBK message, AAI-MBS-MIMO-FBK message, MIMO Feedback Header (MFH), or Correlation Matrix Feedback Header (CMFH), depending on the requested feedback content and the number of transmit antennas at the ABS.

In initial allocation, Feedback Polling A-MAP IE is transmitted with following rules. When the Polling_sub_type bit is set to 0b0, a dedicated UL allocation is included in this Feedback Polling A-MAP IE. The dedicated UL allocation shall be used by the AMS to transmit feedback at the designated feedback transmission frame defined by this Feedback Polling A-MAP IE. When the Polling_sub_type bit is set to 0b1, no dedicated UL allocation is included. Instead, the ABS shall transmit an additional Feedback Polling A-MAP IE with Polling_sub_type = 0b0 in the same AAI subframe for a dedicated UL allocation and the AMS shall compose the feedback using Feedback Polling A-MAP IE with Polling_sub_type = 0b0 or 0b1, and transmit feedback in a dedicated UL allocation assigned by Feedback Polling A-MAP IE with Polling_sub_type = 0b0 in the same AAI subframe.

In order to change the control information about UL resource or MIMO feedback mode without releasing the allocation, the ABS shall transmit the Feedback Polling A-MAP IE(s) in the same manner as initial allocation. If the AMS has an existing allocation in a particular AAI UL subframe and receives a new Feedback Polling A-MAP IE(s) with the same ACID as for the existing allocation in the relevant AAI DL subframe associated with the AAI UL subframe that the existing feedback allocation is transmitted as defined in HARQ timing, the new allocation shall replace the previous existing allocation.

When MIMO_feedback_IE_type bit is set to 0b0, the AMS shall send the feedback in MIMO Feedback Header when wideband information for any combinations of MIMO feedback modes 0, 4, and 7 with $q = 0$ is requested.

The AMS shall send the feedback for all other MFM combinations of the AAI-SBS-MIMO-FBK message. When MIMO_feedback_IE_type bit is set to 0b1, the AMS shall send the feedback in the AAI-MBS-MIMO-FBK message.

The coefficients of the quantized transmit correlation matrix shall be fed back in Correlation Matrix Feedback Header (CMFH) if no AAI-SBS-MIMO-FBK message is sent in the same AAI subframe designated by the Feedback Polling A-MAP IE and the ABS is equipped with 2 or 4 transmit antennas. Otherwise, the coefficients of the quantized transmit correlation matrix shall be fed back in the AAI-SBS-MIMO-FBK message. The coefficients of the quantized transmit correlation matrix shall be fed back in the AAI-SBS-MIMO-FBK message if the ABS is equipped with eight transmit antennas.

If the transmit correlation matrix is previously allocated and the ABS indicates to transmit the feedback content with $q > 0$, the feedback resources previously assigned for the transmit correlation matrix shall be deallocated with a Feedback Polling A-MAP IE.

In case of feedback for MIMO feedback mode 0 with Measurement Method Indication = 0b0, and MIMO feedback modes 4 or 7, the AMS shall feedback the CQI for FP_0 if $FPS_0 > 0$, or for FP_k if $FPS_0 = 0$, where FP_k is determined by k = SegmentID.

MIMO feedback reported by an AMS in frame N pertains to measurements performed at least up to frame N-1. The first MIMO feedback report following the Feedback Polling A-MAP IE may contain invalid MIMO feedback information if the MIMO feedback is sent in the frame immediately following the frame in which the Feedback Polling A-MAP IE was received.

Table 6-208—Feedback Polling A-MAP IE[a]

Syntax	Size (bits)	Notes
Feedback_Polling_A-MAP_IE(){		
A-MAP IE Type	4	Feedback Polling A-MAP IE
Polling_sub_type	1	0b0: uplink resource allocation or deallocation. 0b1: feedback mode allocation or deallocation.
if (Polling_sub_type == 0b0){		
Allocation Duration (*d*)	3	The allocation is valid for $2^{(d-1)}$ superframes starting from the superframe defined by allocation relevance. If d == 0b000, the pre-scheduled feedback transmission is released. If d == 0b111, the pre-scheduled feedback transmission shall be valid until the ABS commands to release it.
if (d == 0b000){		Feedback deallocation
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size
HFA	6	HARQ feedback channel allocation for Feedback Channel Deallocation confirmation
Reserved	15	
} else if (d != 0b000){		Feedback allocation
$I_{SizeOffset}$	5	Offset used to compute burst size index

Table 6-208—Feedback Polling A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size
MEF	1	MIMO encoder format for uplink feedback transmission Non-adaptive precoding shall be used at the AMS. 0b0: SFBC 0b1: VE with $M_t = 2$, or $M_t = 1$ if the AMS has 1 transmit antenna
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL AAI subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator = 0b1
HFA	3	HARQ feedback channel allocation
ACID	4	HARQ channel identifier
MFM_allocation_index	2	0b00: MFM 0 with Measurement Method Indication = 0b0 0b01: MFM 3 with all subbands 0b10: MFM 6 with all subbands 0b11: MFM is defined in Feedback Polling A-MAP IE with Polling_subtype = 0b1
$MaxM_t$	1	0b0: 1 0b1: 2 for MFM0, or min(N_t,N_r) for MFM3, or min(N_t,4) for MFM6. This field shall be ignored if MFM_allocation_index == 0b11

Table 6-208—Feedback Polling A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Period	4	Resource is allocated at frames designated by every short and long period. The short feedback period is p frames. The long feedback period is q superframes. The first allocation shall start two frames later. The AAI subframe index is defined as in 6.2.14.2.2 and the AAI frame index is given by $i + 2$, where i is the index of the frame where the Feedback Polling A-MAP IE is transmitted. The feedback of MIMO feedback modes in MFM_allocation_index is allocated on the short period. The feedback of the transmit correlation matrix is allocated on the long period if $q > 0$. Short and long period reports shall start at the first allocation. When short and long period feedback reports coincide in the same frame, long period feedback content shall be sent in the same burst. 0b0000: $p = 1$, $q = 0$ 0b0001: $p = 2$, $q = 0$ 0b0010: $p = 4$, $q = 0$ 0b0011: $p = 8$, $q = 0$ 0b0100: $p = 16$, $q = 0$ 0b0101: $p = 1$, $q = 1$ 0b0110: $p = 2$, $q = 1$ 0b0111: $p = 1$, $q = 2$ 0b1000: $p = 2$, $q = 2$ 0b1001: $p = 4$, $q = 2$ 0b1010: $p = 1$, $q = 4$ 0b1011: $p = 2$, $q = 4$ 0b1100: $p = 4$, $q = 4$ 0b1101: $p = 0$, $q = 1$ 0b1110: $p = 0$, $q = 4$ 0b1111: $p = 0$, $q = 16$
}		
}else{		Polling_sub_type == 0b1
ACK Allocation Flag	1	
if (ACK Allocation Flag == 0b1)		
HFA	6	HARQ feedback channel allocation to acknowledge the successful detection of this IE.
}		

Table 6-208—Feedback Polling A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Allocation Duration (*d*)	3	The allocation is valid for $2^{(d-1)}$ superframes starting from the superframe defined by allocation relevance. If *d* == 0b000, the pre-scheduled feedback transmission is released. If *d* == 0b111, the pre-scheduled feedback transmission shall be valid until the ABS commands to release it.
if (*d* == 0b000){		Feedback deallocation
Polling_deallocation_bitmap	3	
} else {		Feedback allocation
MIMO_feedback_IE_type	1	0b0: feedback allocation for single-BS MIMO operation 0b1: feedback allocation for multi-BS MIMO operation
if (MIMO_feedback_IE_type == 0b0){		Single-BS MIMO feedback request
MFM_bitmap	8	Maximum of three distinct concurrent MFM are allowed with MFM_bitmap. If a currently allocated MFM is indicated in the MFM_bitmap, it indicates a deallocation and reallocation of this MFM. ACK Allocation Flag shall be set to 0b1 in this case.

Table 6-208—Feedback Polling A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Period	4	Resource is allocated at frames designated by every short and long period. The short feedback period is p frames. The long feedback period is q superframes. The first allocation shall start two frames later. The AAI subframe index is defined as in 6.2.17.2.2 and the AAI frame index is given by $i + 2$, where i is the index of the frame where the Feedback Polling A-MAP IE is transmitted. The feedback of MIMO feedback modes in MFM_allocation_index is allocated on the short period. The feedback of the transmit correlation matrix is allocated on the long period if $q > 0$. Short and long period reports shall start at the first allocation. When short and long period feedback reports coincide in the same frame, long period feedback content shall be sent in the same burst. 0b0000: $p = 1$, $q = 0$ 0b0001: $p = 2$, $q = 0$ 0b0010: $p = 4$, $q = 0$ 0b0011: $p = 8$, $q = 0$ 0b0100: $p = 16$, $q = 0$ 0b0101: $p = 1$, $q = 1$ 0b0110: $p = 2$, $q = 1$ 0b0111: $p = 1$, $q = 2$ 0b1000: $p = 2$, $q = 2$ 0b1001: $p = 4$, $q = 2$ 0b1010: $p = 1$, $q = 4$ 0b1011: $p = 2$, $q = 4$ 0b1100: $p = 4$, $q = 4$ 0b1101: $p = 0$, $q = 1$ 0b1110: $p = 0$, $q = 4$ 0b1111: $p = 0$, $q = 16$
if (LSB #0 in MFM_bitmap == 1){		MFM 0
$MaxM_t$	1~2	
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
if (LSB #2 in MFM_bitmap == 1){		MFM 2
$MaxM_t$	1~2	

Table 6-208—Feedback Polling A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
If (LSB #3 in MFM_bitmap == 1){		MFM 3
$MaxM_t$	1~2	
}		
If (LSB #4 in MFM_bitmap == 1){		MFM 4
$MaxM_t$	1~2	
}		
If (LSB #5 in MFM_bitmap == 1){		MFM 5
$MaxM_t$	1~2	
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with $MaxM_t$ streams for CQI measurements
}		
If (LSB #6 in MFM_bitmap == 1){		MFM 6
$MaxM_t$	1~2	
}		
If (LSB #7 in MFM_bitmap == 1){		MFM7
$MaxM_t$	1~2	
}		
If ((LSB #2 in MFM_bitmap == 1) or (LSB #3 in MFM_bitmap == 1) or (LSB #5 in MFM_bitmap == 1) or (LSB #6 in MFM_bitmap == 1)){		MFM 2, 3, 5, 6
Num_best_subbands	2	0b00: report all subbands 0b01: 1 best subband 0b10: min{6, Y_{SB}} best subbands 0b11: min{12, Y_{SB}} best subbands 1≤ Num_best_subbands ≤ Y_{SB}
}		

Table 6-208—Feedback Polling A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
If ((LSB #3 in MFM_bitmap == 1) or (LSB #4 in MFM_bitmap == 1) or (LSB #6 in MFM_bitmap == 1) or (LSB #7 in MFM_bitmap == 1)){		MFM 3,4, 6,7
If (q = 0) {		
Codebook_coordination	1	0b0: base mode with codebook coordination disabled 0b1: base mode with codebook coordination enabled
}		
If (N_t == 4){		
Codebook_subset	1	0b0: report PMI from the base codebook or transformed base codebook 0b1: report PMI from codebook subset or transformed codebook subset
}		
}		
}else{		Multi-BS MIMO feedback request
Period (p)	3	
TRU	2	Target RU indicating which RUs or which type of RU to work on for feedback 0b00: Latest best subbands reported for single BS MIMO 0b01: Whole bandwidth 0b10: FFR partition 0 0b11: boosted FFR partition
ICT	2	0b00: PMI restriction for single-BS precoding 0b01: PMI recommendation for single-BS precoding 0b10: CL-MD for multi-BS precoding 0b11: Co-MIMO for multi-BS precoding
if (N_t == 4){		
Codebook_subset	1	0b0: report PMI from the base codebook 0b1: report PMI from codebook subset
}		
N_multiBS_reports	3	Indicates the number of reports
if (ICT== 0b11){		

Table 6-208—Feedback Polling A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
MaxUser	2	Maximum number of users supported in Co-MIMO in the same resource. 0b00: 2 users 0b01: 3 users 0b10: 4 users 0b11: *Reserved*
}		
}		
}		
Padding	*variable*	To reach 40-bit assignment A-MAP IE size
}		
}		

[a]A 16-bit CRC is generated based on the randomized contents of the Feedback Polling A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

Parameters in the Feedback Polling A-MAP IE should be interpreted as for the Feedback Allocation A-MAP IE.

MaxM$_t$: The possible values of *MaxM$_t$* follow the rules of the Feedback Allocation A-MAP IE when Polling_sub_type == 0b1.

ACID: HARQ channel identifier.

The ABS shall not allocate more than one Uplink HARQ burst for MIMO feedback to an AMS in an AAI subframe.

Uplink HARQ retransmission for MIMO feedback shall be done as described in 6.2.14.2.1.2. A UL Basic assignment A-MAP IE may be sent to signal control information for retransmission to the ACID assigned for the UL allocation made with the Feedback Polling A-MAP IE with the AI_SN set to the same value (i.e., not toggled) as that implicitly used for the ACID at the UL feedback period. Retransmissions shall obey the following rules:

— If the retransmission process for the previous HARQ burst is not finished before a new HARQ burst with the same ACID is transmitted, the retransmission process for the previous HARQ burst is terminated and the new HARQ burst overrides it.

When a Feedback Polling A-MAP IE with Polling_sub_type = 0b0 is transmitted to make a resource allocation for feedback, the initial AI_SN for the corresponding ACID is set to 0.

The AI_SN corresponding to the ACID is implicitly toggled in each and every short/long feedback period specified by the “Period” field in the Feedback Polling A-MAP IE (i.e., short feedback period for “Period” = 0b0000~0b1100, and long feedback period for “Period” = 0b1101~0b1111) when the UL resource allocation for the feedback was made with Feedback Polling A-MAP IE with Polling_sub_type = 0b0 until the “Allocation Duration” expires or the ABS explicitly commands to release this allocation or a new Feedback Polling A-MAP IE is transmitted to override the previous one.

Polling_deallocation_bitmap: An AMS supports a maximum of three distinct concurrent feedback allocations, including one or several MFMs, the transmit correlation matrix, and multiBS MIMO feedback. Ordering of concurrent allocations in the Polling_deallocation_bitmap shall follow the order MFM i, MFM j $(j > i)$, MFM k $(k > j)$, transmit correlation matrix, multiBS MIMO feedback, as shown in Table 6-209. Each row or Table 6-209 shows one possible configuration of the Polling_deallocation_bitmap. If the bit is set to 1, it means the deallocation for MFMs or transmit correlation matrix or multiBS MIMO feedback.

Table 6-209—Polling deallocation bitmap

Polling_deallocation_bitmap bit #2 (MSB)	Polling_deallocation_bitmap bit #1	Polling_deallocation_bitmap bit #0 (LSB)
MFM i	MFM j $(j > i)$	MFM $k(k > j)$
MFM i	MFM j $(j > i)$	Transmit correlation matrix
MFM i	MFM j $(j > i)$	MultiBS MIMO feedback
MFM i	Transmit correlation matrix	MultiBS MIMO feedback
MFM i	MFM j $(j > i)$	N/A
MFM i	Transmit correlation matrix	N/A
MFM i	MultiBS MIMO feedback	N/A
Transmit correlation matrix	MultiBS MIMO feedback	N/A
MFM i	N/A	N/A
Transmit correlation matrix	N/A	N/A
MultiBS MIMO feedback	N/A	N/A

Period: The setting of short and long periods p and q when Polling_sub_type = 0b0 or MIMO_feedback_IE_type = 0b0 shall obey the rules that follow.

For the single-BS MIMO operation, if an AMS is allocated multiple types of MIMO feedback mode by two Feedback Polling A-MAP IEs with Polling_sub_type = 0b0 and 0b1 in the same subframe, the values of short period (p) and long period (q) shall be consistent in the two IEs. In the two IEs, p and q shall only take one same value.

If the ABS transmits a Feedback Polling A-MAP IE to change only the feedback contents without reallocation of feedback resources and without changing the period of feedback, the ABS shall transmit the Feedback Polling A-MAP IE in the second AAI frame prior to the AAI frame designated by the previous IE.

For MFM 0: The wideband CQI and wideband STC rate shall be transmitted using short feedback period.

For MFM 1: The wideband CQI shall be transmitted using short feedback period.

For MFM 2: The Best_subbands_index, subband CQI and STC rate shall be transmitted using short feedback period.

For MFM 3: when $p > 0$, $q = 0$, the Best_subbands_index, STC_Rate, subband CQI and subband PMI from the base codebook shall be transmitted using short period. When $p = 0$, $q > 0$, only the correlation matrix shall be transmitted using long feedback period. When $p > 0$, $q > 0$, the Best_subbands_index, STC_Rate, subband CQI and subband PMI from the transformed codebook shall be transmitted using short period, while the correlation matrix shall be transmitted using long period.

For MFM 4: When $p > 0$ and $q = 0$, the wideband CQI, STC rate and PMI from the base codebook shall be transmitted using short feedback period. When $p > 0$ and $q > 0$, the wideband CQI and STC rate shall be transmitted using short feedback period, and the correlation matrix shall be transmitted using long feedback period. When $p = 0$ and $q > 0$, only the correlation matrix shall be transmitted using long feedback period.

For MFM 5: The Best_subbands_index, subband CQI and Stream index shall be transmitted using short feedback period.

For MFM 6: When $p > 0$, $q > 0$, the Best_subbands_index, subband CQI and subband PMI from the transformed codebook shall be transmitted using short period, while the correlation matrix shall be transmitted using long period. When $p = 0$ and $q > 0$, only the correlation matrix shall be transmitted using long feedback period. The ABS shall not set $p > 0$ and $q = 0$.

For MFM 7: When $p > 0$ and $q = 0$, the wideband CQI and PMI from the base codebook shall be transmitted using short feedback period. When $p > 0$ and $q > 0$, the wideband CQI shall be transmitted using short feedback period, and the correlation matrix shall be transmitted using long feedback period. When $p = 0$ and $q > 0$, only the correlation matrix shall be transmitted using long feedback period.

6.3.5.5.2.4.12 BR ACK A-MAP IE

The BR Acknowledgment A-MAP IE indicates the decoding status of the BR preamble sequences transmitted in the frame n through the BR channels (opportunities). All the successfully received preamble sequences, to which the ABS does not grant UL resources before or in the frame n + BR_ACK_Offset, shall be contained in a single or multiple BR-ACK A-MAP IEs. Those included preamble sequences shall be arranged in ascending order of the preamble sequence index within an opportunity in a BR-ACK A-MAP IE. The BR-ACK A-MAP IE is not segmentable and the maximum number of BR ACK A-MAP IEs in a subframe is 2.

In addition, the BR-ACK A-MAP IE includes the allocation information for the fixed sized BR header (refer to 6.2.2.1.3.1). The UL resource and HFA shall be allocated to the preamble sequence whose grant indicator is '1'. The allocations shall be ordered based on the index of preamble sequences arranged in an ascending order. If the preamble sequence has the grant indicator of '1' in the k-th ($k = 0, 1, ..., K–1$) place within a BR-ACK A-MAP IE, the starting LRU index, R_k, is calculated as $R_k = R_0 + k \times M$, where R_0 is the value of resource start offset, and M is the value of Allocation size. K is the total number of preamble sequences whose grant indicator is '1' within a BR-ACK A-MAP IE. For HARQ feedback allocation, HF-A-MAP resource index is defined in 6.3.5.3.2.2.

If UL resource for the BR header is not allocated through the BR-ACK A-MAP IE, CDMA Allocation A-MAP IE is used for the UL resource allocation. For the UL HARQ burst allocated through the BR-ACK A-MAP IE, the maximum number of the HARQ retransmissions is set to the default value defined in 6.2.14.2. Non-adaptive HARQ retransmission is used.

The UL HARQ burst signaled via the BR-ACK A-MAP IE is always transmitted using MIMO mode 1 with $M_t = 1$ as the MIMO encoder format and QPSK as the modulation scheme.

Table 6-210—BR-ACK A-MAP IE[a]

Syntax	Size (bits)	Notes
BR-ACK_A-MAP_ IE() {		
A-MAP IE Type	4	BR-ACK A-MAP IE
BR-ACK Bitmap	N_BR_Opportunities	Each bit indicates whether this BR-ACK A-MAP IE includes the decoding status of the BR preamble in the corresponding BR opportunity or not. The bitmap size is the number of BR opportunities in a frame, and the bitmap is encoded in ascending order of the BR opportunity index. 0b0: No BR preamble sequence is detected, 0b1: At least one preamble sequence is detected N_BR_Opportunities ≤ 4
MSB of resource start offset	2	0b00, 0b01, 0b10: 2-bit-MSB of the start offset of the resource allocation (LRU) 0b11: No grant exist in this BR ACK A-MAP IE.
if (MSB of resource start offset != 0b11) {		
LSB of resource start offset	5	This field is the LSB of the start offset of the Resource allocation (LRU) for BR Header
HFA start offset	6	This field is start offset of HARQ Feedback Allocation.
Allocation size	1	Resource size for each BR header 0b0: 1 LRU 0b1: 2 LRUs
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource for BR header. 0b0: 1 AAI subframe (default) 0b1: 4 UL AAI subframes for FDD or all UL subframes for TDD If number of DL AAI subframes, D, is less than number of UL AAI subframes, U, Long TTI Indicator = 0b1
}		
for (*i* = 0; *i* < N_BR_Opportunities ; *i*++) {		
if (BR-ACK Bitmap[*i*] == 1) {		

Table 6-210—BR-ACK A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Notes
Number of received preamble sequences (L)	2	The number of BR preamble sequence indices included in this ACK A-MAP IE. 0b00: 1 0b01: 2 0b10: 3 0b11: 4
for (*j* = 0; j < L; *j*++) {		
Preamble sequence index	5	Preamble sequence index received in the BR opportunity
MSG decoding indicator	1	To indicate the decoding status of quick access message 0b0: MSG not decoded 0b1: MSG decoded relevant to Preamble sequence index
If (MSB of resource start offset != 0b11) && (MSG decoding indicator == 0b0){		
Grant indicator	1	To indicate whether grant of BR Header for the BR preamble sequence index is included or not 0b0: No UL resource allocation 0b1: UL resource allocation for BR with STID header
}		
}		
}		
}		
Reserved	*variable*	To reach 40-bit assignment A-MAP IE size.
}		

[a]A 16-bit CRC is generated based on the randomized contents of the BR-ACK A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194.

6.3.5.5.2.4.13 Broadcast Assignment A-MAP IE

Broadcast assignment A-MAP allocates resource for a broadcast or multicast burst or NS-RCH. A broadcast burst contains one or more broadcast MAC control messages. Table 6-211 describes the fields in a broadcast assignment A-MAP IE.

Table 6-211—Broadcast Assignment A-MAP IE[a]

Syntax	Size (bits)	Description/Notes
Broadcast_Assignment_A-MAP_IE() {		
A-MAP IE Type	4	Broadcast Assignment A-MAP IE
Function Index	2	0b00: This IE carries broadcast assignment information 0b01: This IE carries handover ranging channel allocation information 0b10: This IE carries multicast assignment information 0b11: *Reserved*
If(Function Index == 0b00){		
Burst Size	6	Burst size as indicated in the first 39 entries in Table 6-305
Resource Index	11	512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default TTI) 0b1: 4 UL AAI subframes for FDD or all UL subframes for TDD (Long TTI)
Transmission Format	1	0b0: no time domain repetition 0b1: with time domain repetition
If (Transmission Format == 0b1){		
Repetition	2	0b00: no more repetition of the same burst 0b01: the same burst shall be transmitted one more time 0b10: the same burst shall be transmitted two more times 0b11: the same burst shall be transmitted three more times
Reserved	13	Reserved bits
}else{		
Reserved	15	Reserved bits
}		
} else if (Function Index == 0b01){		
Number of Ranging Opportunities (N)	1	0: one NS-RCH 1: two NS-RCHs
for (i = 0; i < N; i++) {		
Subframe Index	3	

Table 6-211—Broadcast Assignment A-MAP IE[a] *(continued)*

Syntax	Size (bits)	Description/Notes
Ranging opportunity index	1	Indicates 2-bit Opportunity index of the ranging channel specified in 6.2.15.3. 0b0: 0b01 0b1: 0b10
}		
Reserved	29/25	Reserved bits. If Number of Ranging Opportunities is set to 0b0, Size in bits is 29. Otherwise, Size in bits is 25.
} else if {Function Index == 0b10} {		
Multicast Group ID	12	ID of a group that receives multicast assignment
Burst Size	6	Burst size as indicated in the first 39 entries in Table 6-305
Resource Index	11	512 FFT size: 0 in first 2 MSB bits + 9 bits for resource index 1024 FFT size: 11 bits for resource index 2048 FFT size: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number of AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default TTI) 0b1: 4 DL AAI subframe for FDD or all DL AAI subframes for TDD (long TTI)
Reserved	4	Reserved bits
}		

[a]A 16-bit CRC is generated based on the randomized contents of the Broadcast Assignment A-MAP IE. The CRC is masked by the 16-bit CRC mask generated according to Table 6-194. If Function index == 0b00 or 0b01, the CRC is masked by the 16-bit CRC mask with masking prefix = 0b0 and message type indicator = 0b001. If Function index == 0b10, the CRC is masked by the 16-bit CRC mask with masking prefix = 0b0 and message type indicator = 0b010.

Multicast Group ID is the ID of a group that receives multicast burst and is unique to an ABS. Multicast Group ID is assigned by the AAI-DSA-REQ/RSP message and changed by the AAI-DSC-REQ message.

The broadcast and multicast bursts signaled by the Broadcast Assignment A-MAP IE are always transmitted using SFBC as the MIMO encoder format and QPSK as the modulation scheme.

AAI-TRF-IND, AAI-PAG-ADV, and PGID_Info messages shall not be transmitted with the time domain repetition. For other broadcast MAC control messages, the time domain repetition may be used.

The periodicity of the time domain repetition is one frame. During the period when a broadcast burst is transmitted repetitively in time, other broadcast bursts can only be transmitted without time domain repetition. For each broadcast burst transmission with time domain repetition, the ABS shall transmit a broadcast assignment A-MAP IE with decreasing the value of the remaining repetition number by 1 per each transmission. That is, if the ABS performs the first transmission at the k-th frame with signaling the remaining repetition number as $N - 1$, the transmission shall be completed at the $(k+N-1)$-th frame. The value of Repetition field shall be decreased by 1 per each transmission. For other fields, only the resource index can be changed during the period when the time domain repetition is performed. SPID is always 0 for broadcast burst transmission.

When both Long TTI Indicator and Transmission Format are set to 1, the broadcast burst shall not be assigned in the frame where the SFH is transmitted.

6.3.5.5.2.4.14 Extended Assignment A-MAP IE

The Extended Assignment A-MAP IE is defined in Table 6-212.

Table 6-212—Extended Assignment A-MAP IE

Syntax	Size (bits)	Description/Notes
Extended_Assignment_A-MAP_ IE() {		
A-MAP IE Type	4	Extended Assignment A-MAP IE
Extended Assignment A-MAP IE Type	4	Extended Assignment A-MAP IE Type reserved for future extension
Extended Assignment A-MAP IE Body	32	Reserved for contents of the Extended Assignment A-MAP IE
}		

6.3.5.5.2.4.15 Assignment A-MAP IE segmentation

An Assignment A-MAP IE is segmentable if its size can be larger than 40 bits. A segmentable Assignment A-MAP IE should be parsed and coded in the following steps:

a) The IE, without IE Type and Segment Flag, is divided into 35-bit segments one by one. If the last segment has less than 35 bits, zero padding is applied to obtain 35 bits.
b) At the beginning of each segment, a 4-bit A-A-MAP IE Type and a 1-bit flag are inserted to form 40-bit segments. The value of the 1-bit flag is 1 for the first segment and 0 for other segments.
c) For each segment, a 16-bit CRC created from the 40-bit segment is appended to the end to form a 56-bit segment.
d) All segments from the assignment A-MAP IE are coded with the same MCS and occupy a number of logically contiguous MLRUs in sequence.

6.3.5.5.3 E-MBS Control Information elements

The resource mapping for E-MBS allows are defined in E-MBS-DATA_IEs as defined in Table 6-213.

Table 6-213—E-MBS DATA information elements

Syntax	Size (bits)	Description/Notes
E-MBS-DATA_IE () {	—	—
No. of E-MBS IDs+FIDs	8	Total number of E-MBS streams in the IE
for (*i* = 0; *i* < No. of E-MBS IDs + FIDs, *i*++){	—	
E-MBS ID+FID	16	E-MBS ID + Flow ID of an E-MBS stream
$I_{SizeOffset}$	5	Depends on supported modes, 32 modes assumed as baseline
MEF	1	E-MBS MIMO Encoding Format 0b0: SFBC 0b1: Vertical Encoding with 2 streams
E-MBS AAI subframe offset	*variable*	Includes the index of the AAI subframe where the E-MBS data burst ends and the first AAI subframe of the first frame of each superframe is reserved to transmit superframe header, where any E-MBS data burst is not transmitted. MSI == 0b00: 7 bits MSI == 0b01: 8 bits MSI == 0b10: 9 bits MSI == 0b11: 10 bits The AAI subframe offset index begins at the beginning of the MSI.
E-MBS Resource Indexing	7	Includes the location of the SLRU index where the E-MBS data burst ends. The first E-MBS stream begins in the SLRU immediately after E-MBS MAP in the E-MBS region The E-MBS resource indexing field indexes SLRUs of a subframe in the E-MBS region as indicated in the Zone Allocation bitmap transmitted in the AAI-SCD message described in 6.2.3.31.
}	—	—
}	—	—

6.3.6 Downlink MIMO

6.3.6.1 Downlink MIMO architecture and data processing

The architecture of downlink MIMO at the transmitter side is shown in Figure 6-163.

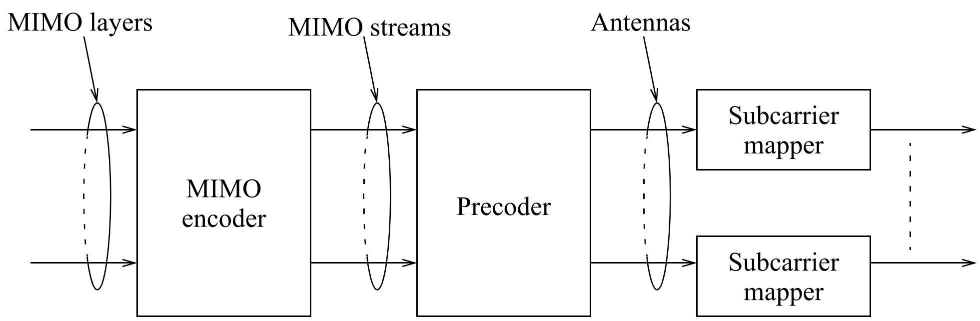


Figure 6-163—DL MIMO architecture

The MIMO encoder block maps L MIMO layers $L \geq 1$ onto M_t MIMO streams ($M_t \geq L$), which are fed to the Precoder block. MIMO layer is an information path fed to the MIMO encoder as an input. A MIMO layer represents one channel coding block. For the spatial multiplexing modes in SU-MIMO, “rank” is defined as the number of MIMO streams to be used for the user allocated to the Resource Unit (RU).

For SU-MIMO, only one user is scheduled in one = RU, and only one channel coding 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 channel coding blocks exist at the input of the MIMO encoder. The existence of multiple channel coding blocks at the input of the MIMO encoder can be caused by either using horizontal encoding or by using vertical encoding in several MIMO layers or by using a combination of vertical and horizontal encoding in several MIMO layers at the transmit side. Using multiple MIMO layers is called multi-layer encoding.

The precoder block maps MIMO stream(s) to antennas by generating the antenna-specific data symbols according to the selected MIMO mode.

The subcarrier mapping blocks map antenna-specific data to the OFDM symbol.

6.3.6.1.1 MIMO layer to MIMO stream mapping

MIMO layer to MIMO stream mapping is performed by the MIMO encoder. The MIMO encoder first maps L layers to M_t input symbols using serial to parallel mapping. The M_t input symbols construct $M_t \times 1$ vector, **s**, at a time as specified in Equation (244). In case of SU-MIMO, there is only one layer (L = 1). In case of MU-MIMO transmissions, depending on the allocated number of streams per each AMS, one or maximum two consecutive symbols belong to a single MIMO layer. The indexing order is followed by the Si field in DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, and DL Persistent Allocation A-MAP IE.

The input to the MIMO encoder is represented by an $M_t \times 1$ vector as specified in Equation (244).

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \cdots \\ s_{M_t} \end{bmatrix} \tag{244}$$

where s_i is the i-th input symbol within a batch. In case of MU-MIMO transmissions, the M_t symbols belong to different AMSs. Two consecutive symbols may belong to a single MIMO layer. One AMS shall have at most one MIMO layer.

MIMO layer to MIMO stream mapping of the input symbols is done in the space dimension first. The output of the MIMO encoder is an $M_t \times N_F$ MIMO STC matrix as given in Equation (245), which serves as the input to the precoder.

$$\mathbf{x} = S(\mathbf{s}) \tag{245}$$

where

- M_t is the number of MIMO streams.
- N_F is the number of subcarriers occupied by one MIMO block.
- $\mathbf{x}$ is the output of the MIMO encoder.
- $\mathbf{s}$ is the input MIMO layer vector.
- $S()$ is a function that maps an input MIMO layer vector to an STC matrix.
- $S(\mathbf{s})$ is an STC matrix.

The STC matrix $\mathbf{x}$ can be expressed as in Equation (246):

$$\mathbf{x} = \begin{bmatrix} x_{1,1} & x_{1,2} & \cdots & x_{1,N_F} \\ x_{2,1} & x_{2,2} & \cdots & x_{2,N_F} \\ \cdots & \cdots & \cdots & \cdots \\ x_{M_t,1} & x_{M_t,2} & \cdots & x_{M_t,N_F} \end{bmatrix} \tag{246}$$

The four MIMO encoder formats (MEF) are SFBC, vertical encoding (VE), multi-layer encoding (ME), and CDR. For SU-MIMO transmissions, the STC rate is defined as in Equation (247).

$$R = \frac{M_t}{N_F} \tag{247}$$

For MU-MIMO transmissions, the STC rate per user (R) is equal to 1 or 2 depending on the allocated number of streams per each AMS.

6.3.6.1.1.1 SFBC encoding

The input to the MIMO encoder is represented by a 2x1 vector.

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \tag{248}$$

The MIMO encoder generates the SFBC matrix.

$$\mathbf{x} = \begin{bmatrix} s_1 & -s_2{}^* \\ s_2 & s_1{}^* \end{bmatrix} \tag{249}$$

where **x** is a 2x2 matrix.

The SFBC matrix, **x**, occupies two consecutive subcarriers.

6.3.6.1.1.2 Vertical encoding

The input and the output of MIMO encoder is represented by an $M_t \times 1$ vector.

$$\mathbf{x} = \mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \ldots \\ s_{M_t} \end{bmatrix} \tag{250}$$

where s_i is the i-th input symbol within a batch.

For vertical encoding, $s_1 \ldots s_{M_t}$ belong to the same MIMO layer. The encoder is an identity operation.

6.3.6.1.1.3 Multi-layer encoding

The input and output of the MIMO encoder is represented by an $M_t \times 1$ vector.

$$\mathbf{x} = \mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \ldots \\ s_{M_t} \end{bmatrix} \tag{251}$$

where s_i is the i-th input symbol within a batch.

For multi-layer encoding, $s_1 \ldots s_{M_t}$ belong to different MIMO layers, where two consecutive symbols may belong to a single MIMO layer.

Multi-layer encoding is only used for MU-MIMO mode. The encoder is an identity operation.

6.3.6.1.1.4 CDR encoding

The input to the MIMO encoder is represented by a 1x1 vector.

$$s = s_1 \tag{252}$$

The MIMO encoder generates the CDR matrix.

$$\mathbf{x} = \begin{bmatrix} s_1 & s_1^* \end{bmatrix} \tag{253}$$

The CDR matrix, **x**, occupies two consecutive subcarriers.

6.3.6.1.2 MIMO stream to antenna mapping

MIMO stream to antenna mapping is performed by the precoder. The output of the MIMO encoder is multiplied by an $N_t \times M_t$ precoder, **W**. The output of the precoder is denoted by an $N_t \times N_F$ matrix, **z**. The mapping can be defined in Equation (254).

$$\mathbf{z} = \mathbf{W}\mathbf{x} = \begin{bmatrix} z_{1,1} & z_{1,2} & \cdots & z_{1,N_F} \\ z_{2,1} & z_{2,2} & \cdots & z_{2,N_F} \\ \cdots & \cdots & \cdots & \cdots \\ z_{N_t,1} & z_{N_t,2} & \cdots & z_{N_t,N_F} \end{bmatrix} \tag{254}$$

where

N_t is the number of transmit antennas.

$z_{j,k}$ is the output symbol to be transmitted via the *j*-th physical antenna on the *k*-th subcarrier.

Pilots within PRU are precoded in the same way as the data subcarriers.

6.3.6.1.2.1 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 number of MIMO streams, and k is the physical index of the subcarrier where $\mathbf{W}(k)$ is applied. The matrix **W** is selected from the base codebook or from a subset of size N_w precoders of the base codebook for a given rank. **W** belongs to the base codebook or to one of the subsets of the base codebook, according to the type of allocation, MEF, N_t, $MaxM_t$ and M_t, as specified in Table 6-214 and Table 6-215. The notation $\mathbf{C}_{\mathrm{DL,OL,SU}}(N_t, M_t, N_w)$ denotes a DL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t. The base codebook and the codebook subsets are defined in 6.3.6.2.5.5.

Table 6-214—Codebook subsets used for non-adaptive precoding in DL DLRU and NLRU

MEF	RU with M_t pilot MIMO streams outside OL region	RU in OL region with $MaxM_t$ MIMO streams
SFBC	$N_t = 2$: $C_{DL,OL,SU}$ (2, M_t, 1), $M_t = 2$ $N_t = 4$: $C_{DL,OL,SU}$ (4, M_t, 4), $M_t = 2$ $N_t = 8$: $C_{DL,OL,SU}$ (8, M_t, 4), $M_t = 2$	$N_t = 2$: $C_{DL,OL,SU}$ (2,$MaxM_t$, 1), $MaxM_t = 2$ $N_t = 4$: $C_{DL,OL,SU}$ (4,$MaxM_t$, 4), $MaxM_t = 2$ $N_t = 8$: $C_{DL,OL,SU}$ (8,$MaxM_t$, 4), $MaxM_t = 2$
VE	$N_t = 2$: $C_{DL,OL,SU}$ (2, M_t, N_w), $M_t = 1,2$ $N_t = 4$: $C_{DL,OL,SU}$ (4, M_t, N_w), $M_t = 1,2,3,4$ $N_t = 8$: $C_{DL,OL,SU}$ (8, M_t, N_w), $M_t = 1,2,3,4$ N_w depends on M_t	$N_t = 2$: $C_{DL,OL,SU}$ (2,$MaxM_t$, 1), $MaxM_t = 2$ $N_t = 4$: $C_{DL,OL,SU}$ (4,$MaxM_t$, 4), $MaxM_t = 2$ $N_t = 8$: $C_{DL,OL,SU}$ (8,$MaxM_t$, 4), $MaxM_t = 2$
ME	N/A	N/A
CDR	N/A	$N_t = 2$: $C_{DL,OL,SU}$ (2, $MaxM_t$, 2), $MaxM_t = 1$ $N_t = 4$: $C_{DL,OL,SU}$ (4, $MaxM_t$, 4), $MaxM_t = 1$ $N_t = 8$: $C_{DL,OL,SU}$ (8, $MaxM_t$, 8), $MaxM_t = 1$

Table 6-215—Codebook subsets used for non-adaptive precoding in DL SLRU

MEF	RU with M_t pilot MIMO streams outside OL region	RU in OL region with $MaxM_t$ MIMO streams
SFBC	$N_t = 2$: $C(2, M_t, 3)$, $M_t = 2$ $N_t = 4$: $C(4, M_t, 4)$, $M_t = 2$ $N_t = 8$: $C(8, M_t, 4)$, $M_t = 2$	N/A
VE	$N_t = 2$: $C(2, M_t, 3)$, $M_t = 1, \ldots, MaxM_t$ $N_t = 4$: $C(4, M_t, 4)$, $M_t = 1, \ldots, MaxM_t$ $N_t = 8$: $C(8, M_t, 4)$, $M_t = 1, \ldots, MaxM_t$	$N_t = 2$: $C(2, MaxM_t, 3)$, $MaxM_t = 2$ $N_t = 4$: $C(4, MaxM_t, 4)$, $MaxM_t = 2$ $N_t = 8$: $C(8, MaxM_t, 4)$, $MaxM_t = 2$
ME	$N_t = 2$: $C(2, M_t, 3)$, $M_t = 2, \ldots, MaxM_t$ $N_t = 4$: $C(4, M_t, 4)$, $M_t = 2, \ldots, MaxM_t$ $N_t = 8$: $C(8, M_t, 4)$, $M_t = 2, \ldots, MaxM_t$	$N_t = 2$: $C(2, MaxM_t, 3)$, $MaxM_t = 2$ $N_t = 4$: $C(4, MaxM_t, 4)$, $MaxM_t = 2$ $N_t = 8$: $C(8, MaxM_t, 4)$, $MaxM_t = 2$
CDR	N/A	$N_t = 2$: $C(2,MaxM_t, 3)$, $MaxM_t = 1$ $N_t = 4$: $C(4,MaxM_t, 4)$, $MaxM_t = 1$ $N_t = 8$: $C(8,MaxM_t, 4)$, $MaxM_t = 1$

The notation $C(N_t, M_t, NB)$ for the base codebooks is defined in 6.3.6.2.5.5. The notation $C(4, M_t, 4)$ in Table 6-215 refers to the CL SU-MIMO codebook subset of rank M_t for four transmit antennas defined in Table 6-237.

Non-adaptive precoding outside the OL region

In a RU allocated outside the OL region, with MEF using SFBC or VE and non-adaptive precoding, the matrix **W** changes every $N_1 P_{SC}$ contiguous physical subcarriers according to Equation (255), and it does not depend on the AAI subframe number. The $N_t \times M_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in physical subband s is selected as the codeword of index i in the codebook of rank M_t specified in Table 6-214 or Table 6-215, where i is given by Equation (255).

$$i = s \bmod N_w, \qquad s = 0 \ldots N_{sub}-1 \tag{255}$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

In a RU allocated outside the OL region, with MEF using ME and non-adaptive precoding, the matrix **W** changes every N_1 PRUs according to Equation (255), and it does not depend on the AAI subframe number. The $N_t \times M_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in subband s is selected as any M_t unordered columns of the codeword of index i in the codebook of rank $MaxM_t$ specified in Table 6-215, where i is given by Equation (255),and $MaxM_t$ is specified in Feedback Allocation A-MAP IE or Feedback Polling A-MAP IE. The AMS shall assume $M_t = MaxM_t$ in the codebook of Table 6-215 for its feedback of stream index.

Non-adaptive precoding inside the OL region
In a RU allocated in the $MaxM_t$ MIMO streams OL Region, the matrix W changes every N PRUs.

$N = N_1$ in all OL regions except in the OL region of Type 1 with NLRU. The $N_t \times MaxM_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in physical subband s is selected as the codeword of index i in the codebook of rank $MaxM_t$ specified in Table 6-214 or Table 6-215, where i is given by Equation (256).

$$i = s \bmod N_w, \qquad s = 0 \ldots N_{sub}-1 \tag{256}$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

In the OL region of Type 1 with NLRU, $N = N_2$, and the $N_t \times 1$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in PRU m in AAI subframe number t is selected as the codeword of index i in the codebook of rank $MaxM_t = 1$ specified in Table 6-214, where i is given by Equation (257).

$$i = (m + (t \bmod 2)) \bmod N_w, \qquad m = 0 \ldots N_{PRU}-1 \tag{257}$$

where N_{PRU} denotes the number of physical PRUs across the entire system bandwidth.

The values of N_w used for non-adaptive precoding in DL DLRU and NLRU are given in Table 6-216. The values of N_w used for non-adaptive precoding in DL SLRU are given in Table 6-216.

Table 6-216—Values of N_w for non-adaptive precoding in DL DLRU and NLRU

Rank	1	2	3	4	5	6	7	8
$N_t = 2$	2	1	N/A	N/A	N/A	N/A	N/A	N/A
$N_t = 4$	4	4	2	1	N/A	N/A	N/A	N/A
$N_t = 8$	8	4	4	2	2	2	2	1

Table 6-217—Values of N_w for non-adaptive precoding in DL SLRU

Rank	1	2	3	4	5	6	7	8
$N_t = 2$	8	4	N/A	N/A	N/A	N/A	N/A	N/A
$N_t = 4$	16	16	16	6	N/A	N/A	N/A	N/A
$N_t = 8$	16	16	16	16	16	16	16	2

6.3.6.1.2.2 Adaptive precoding

With adaptive precoding, the precoder **W** is derived from the feedback of the AMS.

For codebook-based adaptive precoding (codebook feedback), there are three feedback modes: base mode, transformation mode, and differential mode.

For TDD sounding-based adaptive precoding, the value of **W** is derived from the AMS sounding feedback.

6.3.6.1.3 Downlink MIMO modes

There are six MIMO transmission modes for unicast DL MIMO transmission as listed in Table 6-218.

Table 6-218—Downlink MIMO modes

Mode index	Description	MIMO encoding format (MEF)	MIMO precoding
Mode 0	OL SU-MIMO (Tx diversity)	SFBC	non-adaptive
Mode 1	OL SU-MIMO (SM)	VE	non-adaptive
Mode 2	CL SU-MIMO (SM)	VE	adaptive
Mode 3	OL MU-MIMO (SM)	ME	non-adaptive
Mode 4	CL MU-MIMO (SM)	ME	adaptive
Mode 5	OL SU-MIMO (Tx diversity)	CDR	non-adaptive

The allowed values of the parameters for each DL MIMO mode are shown in Table 6-219.

Table 6-219—DL MIMO parameters

	Number of transmit antennas	**STC rate per MIMO layer**	**Number of MIMO streams**	**Number of subcarriers**	**Number of MIMO layers**
	N_t	R	M_t	N_F	L
MIMO mode 0	2	1	2	2	1
	4	1	2	2	1
	8	1	2	2	1
MIMO mode 1 and MIMO mode 2	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1
	4	4	4	1	1
	8	1	1	1	1
	8	2	2	1	1
	8	3	3	1	1
	8	4	4	1	1
	8	5	5	1	1
	8	6	6	1	1
	8	7	7	1	1
	8	8	8	1	1
MIMO mode 3 and MIMO mode 4	2	1	2	1	2
	4	1	2	1	2
	4	1	3	1	3
	4	1	4	1	4
	8	1	2	1	2
	8	1	3	1	3
	8	1	4	1	4

Table 6-219—DL MIMO parameters *(continued)*

	Number of transmit antennas	STC rate per MIMO layer	Number of MIMO streams	Number of subcarriers	Number of MIMO layers
	N_t	R	M_t	N_F	L
MIMO mode 4	4	2 and 1[a]	3	1	2
	4	2 and 1[b]	4	1	3
	4	2	4	1	2
	8	2 and 1[a]	3	1	2
	8	2 and 1[b]	4	1	3
	8	2	4	1	2
	8	1	8	1	8
	8	2 and 1[c]	8	1	7
	8	2 and 1[d]	8	1	6
	8	2 and 1[e]	8	1	5
	8	2	8	1	4
MIMO mode 5	2	1/2	1	2	1
	4	1/2	1	2	1
	8	1/2	1	2	1

[a]2 streams to one AMS and 1 stream to another AMS, with 1 layer each.
[b]2 streams to one AMS and 1 stream each to the other two AMSs, with 1 layer each.
[c]2 streams to one AMS and 1 stream each to the other six AMSs, with 1 layer each.
[d]2 streams each to two AMSs and 1 stream each to the other four AMSs, with 1 layer each.
[e]2 streams each to three AMSs and 1 stream each to the other two AMSs, with 1 layer each.

M_t refers to the number of MIMO streams transmitted to one AMS with MIMO modes 0, 1, 2, and 5.

M_t refers to the total number of MIMO streams transmitted to multiple AMSs on the same RU with MIMO modes 3 and 4.

6.3.6.2 Transmission schemes for data channels

6.3.6.2.1 Encoding and precoding of SU-MIMO

6.3.6.2.1.1 Encoding of SU-MIMO modes

- **MIMO mode 0**: SFBC encoding of 6.3.6.1.1.1 shall be used with MIMO mode 0.
- **MIMO mode 1**: Vertical encoding of 6.3.6.1.1.2 shall be used with MIMO mode 1. The number of MIMO streams is $M_t \leq min(N_t, N_r)$ where N_r is the number of receive antennas and M_t is no more than 8.
- **MIMO mode 2**: Vertical encoding of 6.3.6.1.1.2 shall be used with MIMO mode 2. The number of MIMO streams is $M_t \leq min(N_t, N_r)$ where M_t is no more than 8.

— **MIMO mode 5**: CDR encoding of 6.3.6.1.1.4 shall be used with MIMO mode 5.

6.3.6.2.1.2 Precoding of SU-MIMO modes

— **MIMO mode 0**: Non-adaptive precoding of 6.3.6.1.2.1 with $M_t = 2$ MIMO streams shall be used with MIMO mode 0.

— **MIMO mode 1**: Non-adaptive precoding of 6.3.6.1.2.1 with M_t MIMO streams shall be used with MIMO mode 1.

— **MIMO mode 2**: Adaptive precoding of 6.3.6.1.2.2 shall be used with MIMO mode 2.

— **MIMO mode 5**: Non-adaptive precoding of 6.3.6.1.2.1 with $M_t = 1$ steam shall be used with MIMO mode 5.

6.3.6.2.2 Encoding and precoding of MU-MIMO

Multi-user MIMO schemes are used to enable a resource allocation to communicate data to two or more AMSs. Multi-user transmission with one or two MIMO streams per AMS is supported for MU-MIMO.

MU-MIMO includes the MIMO configuration of 2 Tx antennas to support up to two AMSs, and 4 Tx or 8 Tx antennas to support up to four AMSs, with one MIMO stream per AMS.

Both OL MU-MIMO (mode 3) and CL MU-MIMO (mode 4) are supported.

6.3.6.2.2.1 Encoding of MU-MIMO modes

— **MIMO mode 3**: Multi-layer encoding of 6.3.6.1.1.3 shall be used with MIMO mode 3.

— **MIMO mode 4**: Multi-layer encoding of 6.3.6.1.1.3 shall be used with MIMO mode 4.

6.3.6.2.2.2 Precoding of MU-MIMO modes

— MIMO mode 3

Non-adaptive precoding of 6.3.6.1.2.1 shall be used with MIMO mode 3.

With OL MU MIMO inside the OL region, the precoder **W** with two MIMO streams is predefined and fixed over time. With OL MU MIMO outside the OL region, the precoder **W** is an $N_t \times M_t$ sub-matrix of a predefined $N_t \times MaxM_t$ matrix.

The precoding matrix **W** used by the ABS is represented in Equation (258).

$$\boldsymbol{W}(k) = [v_1(k) \quad v_2(k) \quad \ldots \quad v_{M_t}(k)] \tag{258}$$

where $v_i(k)$ is the precoding vector for the i-th AMS on the k-th subcarrier.

$v_i(k)$ shall be used for precoding the pilot symbols on the i-th pilot MIMO stream on the k-th subcarrier.

— MIMO mode 4

Adaptive precoding of 6.3.6.1.2.2 shall be used with MIMO mode 4.

In CL MU MIMO, the precoder **W** is an $N_t \times M_t$ matrix for each subcarrier. It is used to communicate to up to M AMSs simultaneously. The form and derivation of the precoding matrix does not need to be known at the AMS. The ABS determines the precoding matrix based on the feedback received from the AMS.

The ABS shall construct the precoding matrix **W** as represented in Equation (259).

$$\boldsymbol{W}(k) = \left[\boldsymbol{v}_1(k)\ \boldsymbol{v}_2(k)\ \ldots\ \boldsymbol{v}_{M_t}(k)\right] \tag{259}$$

where, $\boldsymbol{v}_i(k)$ is the precoding vector for the i-th MIMO stream on the k-th subcarrier.

$v_i(k)$ shall be used for precoding the pilot symbols on the i-th pilot MIMO stream on the k-th subcarrier.

6.3.6.2.3 Mapping of data and pilot subcarriers

Consecutive symbols for each antenna at the output of the MIMO precoder are mapped in a frequency domain first order across LRUs of the allocation, starting from the data subcarrier with the smallest OFDM symbol index and smallest subcarrier index, and continuing to subcarrier index with increasing subcarrier index. When the edge of the allocation is reached, the mapping is continued on the next OFDM symbol.

6.3.6.2.4 Usage of MIMO modes

Table 6-220 shows permutations supported for each MIMO mode outside the OL region. The definitions of DLRU, NLRU, and SLRU are in 6.3.4.

Table 6-220—Supported permutation for each DL MIMO mode outside the OL region

	DLRU	NLRU	SLRU
MIMO mode 0	Yes	Yes	Yes
MIMO mode 1	Yes, with $M_t = 2$	Yes, with $2 \le M_t \le 4$	Yes
MIMO mode 2	No	Yes, with $M_t \le 4$	Yes
MIMO mode 3	No	No	Yes
MIMO mode 4	No	Yes	Yes
MIMO mode 5	No	No	No

Table 6-221 shows permutations supported for each MIMO mode inside the OL region with $MaxM_t$ streams.

Table 6-221—Supported permutation for each DL MIMO mode in the OL region

	DLRU	NLRU	SLRU
MIMO mode 0	Yes, with $MaxM_t = 2$	No	No
MIMO mode 1	Yes, with $MaxM_t = 2$	No	Yes, with $MaxM_t = 2$
MIMO mode 2	No	No	No
MIMO mode 3	No	No	Yes, with $MaxM_t = 2$
MIMO mode 4	No	No	No
MIMO mode 5	No	Yes, with $MaxM_t = 1$	Yes, with $MaxM_t = 1$

All pilots are precoded regardless of the number of transmit antennas and allocation type.

6.3.6.2.5 Feedback mechanisms and operation

6.3.6.2.5.1 Open-loop region

An open-loop region with $MaxM_t$ MIMO streams is defined as a time-frequency resource using the $MaxM_t$ MIMO streams pilot pattern and a given open-loop MIMO mode with $M_t = MaxM_t$ without rank adaptation. The open-loop region allows base stations to coordinate their open-loop MIMO transmissions, in order to offer a stable interference environment where the precoders and numbers of MIMO streams are not time-varying. The LRUs used for the open-loop region are indicated in the AAI-SCD message. These LRUs shall be aligned across cells.

Only a limited set of open-loop MIMO modes are allowed for transmission in the open-loop region, as specified in Table 6-221. All open-loop MIMO modes can also be used outside the open-loop region except for MIMO mode 5, as specified in Table 6-220.

An open-loop region is associated with the following specific set of parameters:

- — Type (number of MIMO streams $MaxM_t$, MIMO mode, MIMO feedback mode, type of permutation)
- — LRUs

There are three types of open-loop regions, as specified in Table 6-222.

Table 6-222—Types of open-loop regions

	MaxM$_t$	MIMO mode	MIMO feedback mode	Supported permutation
OL region Type 0	2 MIMO streams	MIMO mode 0 MIMO mode 1 (M_t = 2 MIMO streams)	MFM 0	DLRU
OL region Type 1	1 MIMO stream	MIMO mode 5 (M_t = 1 MIMO stream)	MFM 1	NLRU
			MFM 2	SLRU
OL region Type 2	2 MIMO streams	MIMO mode 1 (M_t = 2 MIMO streams for one AMS) MIMO mode 3 (M_t = 2 total number of MIMO streams for two AMSs)	MFM 5	SLRU

Dynamic switching between MIMO mode 1 and MIMO mode 3 in downlink transmissions in OL region Type 2 is allowed. The rank-2 precoders for transmission with MIMO mode 1 or MIMO mode 3 in OL region Type 2 are the same on a given subband.

The OL region Type 0 is present if olRegionType0On equals 0b1 inthe AAI-SCD message. All DRUs in frequency partition 0 will be in OL region Type 0.

The OL region Type 1 NLRU is present if olRegionType1NLRUSize is greater than 0 in the AAI-SCD message. The PRUs allocated to Type 1 OL region NLRU are the first (4 × olRegionType1NLRUSize) PRUs obtained by the mapping Equation (194), i.e., $PRU_{FP0}(j)$, where j = $L_{SB,FP0}$ to $L_{SB,FP0}$ + (4 × olRegionType1NLRUSize) – 1.

The OL region Type 1 SLRU is present if olRegionType1SLRUSize is greater than 0 in the AAI-SCD message. The PRUs allocated to Type 1 OL region SLRU are the (4 × olRegionType1SLRUSize) PRUs obtained by the mapping Equation (194), i.e., $PRU_{FP0}(j)$, where j = (4 × EMBS-SLRU-Size) to (4 × EMBS-SLRU-Size) + (4 × olRegionType1SLRUSize) – 1. EMBS-SLRU-Size is calculated from Zone_Allocation Bit-Map defined in 6.2.3.60.

The OL region Type 2 SLRU is present if olRegionType2SLRUSize is greater than 0 in the AAI-SCD message. The PRUs allocated to Type 2 OL region are the (4 × olRegionType2SLRUSize) PRUs obtained by the mapping Equation (194), i.e., $PRU_{FP0}(j)$, where j = (4 × EMBS-SLRU-Size) + (4 × olRegionType1SLRUSize) to (4 × EMBS-SLRU-Size) + (4 × olRegionType1SLRUSize) + (4 × olRegionType2SLRUSize) – 1.

All base stations that are coordinated over the same open loop region should use the same number of MIMO streams, in order to guarantee low interference fluctuation and thus improve the CQI prediction at the AMS. All pilots are precoded by non-adaptive precoding with *MaxM*$_t$ MIMO streams in the open-loop region. CQI measurements should be taken by the AMS on the precoded demodulation pilots rather than on the downlink midamble.

The *MaxM*$_t$ precoded pilots streams shall be transmitted in all the LRUs in the OL region even if data is not being transmitted by the ABS on some or all of the LRUs.

6.3.6.2.5.2 MIMO feedback mode selection

An AMS may send an unsolicited event-driven report to indicate its preferred MIMO feedback mode to the ABS. Event-driven reports for MIMO feedback mode selection may be sent on the P-FBCH during any allowed transmission interval for the allocated P-FBCH. The P-FBCH codewords allocated to event-driven reports are specified in 6.3.8.3.

6.3.6.2.5.3 MIMO feedback modes

Each MIMO transmission mode can be supported by one or several MIMO feedback modes. When allocating a feedback channel, the MIMO feedback mode shall be indicated to the AMS, and the AMS will feedback information accordingly.

The description of MIMO feedback modes and corresponding supported MIMO transmission modes is shown in Table 6-223.

The feedback of the quantized wideband correlation matrix shall be requested by the ABS for operation with transformation codebook-based feedback mode using the Feedback Polling A-MAP IE. The ABS may request the feedback of the quantized wideband correlation matrix independently of the MIMO feedback mode requested in the Feedback Allocation A-MAP IE. The quantized wideband correlation matrix may be used for wideband beamforming.

Table 6-223—MIMO feedback modes

MIMO Feedback Mode	Description and type of RU	Feedback content	Supported MIMO transmission mode outside the OL region (when Measurement Method Indication = 0b0)	Supported MIMO transmission mode inside the OL region (when Measurement Method Indication = 0b1)
0	OL SU MIMO SFBC/SM (Diversity: DLRU, NLRU) Sounding based CL SU and MU MIMO	1. STC Rate 2. Wideband CQI	MIMO mode 0 and MIMO mode 1. Flexible adaptation between the two modes STC Rate = 1: SFBC CQI 2 ≤ STC Rate ≤ 4: SM CQI In DLRU: M_t = 2 for SM. In NLRU: 2 ≤ M_t ≤ 4 for SM For sounding based CL SU MU MIMO, STC Rate = 1: SFBC CQI	MIMO mode 0 and MIMO mode 1. Flexible adaptation between the two modes STC Rate = 1: SFBC CQI STC Rate = 2: SM CQI In DLRU only.
1	OL SU MIMO CDR (Diversity: NLRU)	1. Wideband CQI	N/A	MIMO mode 5 STC Rate = 1/2
2	OL SU MIMO SM (localized: SLRU)	1. STC Rate 2. Subband CQI 3. Subband Selection	MIMO mode 1 1 ≤ STC Rate ≤ 8	MIMO mode 5 STC Rate = 1/2

Table 6-223—MIMO feedback modes *(continued)*

MIMO Feedback Mode	Description and type of RU	Feedback content	Supported MIMO transmission mode outside the OL region (when Measurement Method Indication = 0b0)	Supported MIMO transmission mode inside the OL region (when Measurement Method Indication = 0b1)
3	CL SU MIMO (localized: SLRU)	1. STC Rate 2. Subband CQI 3. Subband PMI 4.Subband selection 5. Wideband correlation matrix	MIMO mode 2 $1 \leq$ STC Rate ≤ 8	N/A
4	CL SU MIMO (Diversity: NLRU)	1. STC Rate 2. Wideband CQI 3. Wideband PMI 4. Wideband correlation matrix	MIMO mode 2 ($M_t \leq 4$)	N/A
5	OL MU MIMO (localized: SLRU)	1. Subband CQI 2. Subband Selection 3. MIMO stream indicator	MIMO mode 3	MIMO mode 3
6	CL MU MIMO (localized: SLRU)	1. Subband CQI 2. Subband PMI 3. Subband Selection 4. Wideband correlation matrix	MIMO mode 4	N/A
7	CL MU MIMO (Diversity: NLRU)	1. Wideband CQI 2. Wideband PMI 3. Wideband correlation matrix	MIMO mode 4	N/A

MIMO feedback mode 0 is used for the OL-SU SFBC and SM adaptation in diversity permutation. The AMS estimates the wideband CQI for both SFBC and SM, and reports the CQI and STC Rate. STC Rate 1 means SFBC with precoding and STC Rate 2 means rank-2 SM with precoding. MIMO feedback mode 0 may also be used for CQI feedback for sounding based beamforming defined in 6.3.6.2.5.6. The AMS shall estimate the wideband CQI for SFBC mode ($MaxM_t$ = 0b00), and report the CQI.

MIMO feedback mode 1 is used for the OL-SU CDR with STC rate 1/2 in diversity permutation.

MIMO feedback mode 2 is used for the OL-SU SM in localized permutation for frequency selective scheduling. The STC Rate indicates the preferred number of MIMO streams for SM. The subband CQI shall correspond to the selected rank.

MIMO feedback mode 3 is used for the CL-SU SM in localized permutation for frequency selective scheduling. The STC Rate indicates the preferred number of MIMO streams for SM. The subband CQI shall correspond to the selected rank.

The MIMO feedback mode 4 is used for the CL SU MIMO using wideband beamforming. In this mode, the AMS shall feedback the wideband CQI. The wideband CQI shall be estimated at the AMS assuming short-term or long-term precoding at the ABS, according to the feedback period. The channel state information may be obtained at the ABS via the feedback of the correlation matrix, or via the feedback of the wideband PMI.

The MIMO feedback mode 5 is used for OL MU MIMO in localized permutation with frequency selective scheduling. In this mode, the AMS shall feedback the subband selection, MIMO stream indicator, and corresponding CQI.

The MIMO feedback mode 6 is used for CL MU MIMO in localized permutation with frequency selective scheduling. In this mode, the AMS shall feedback the subband selection, corresponding CQI, and subband PMI. The subband CQI refers to the CQI of the best PMI in the subband. The rank-1 codebook (or its subset) is used to estimate the PMI in one subband.

The MIMO feedback mode 7 is used for CL MU MIMO in diversity permutation using wideband beamforming. In this mode, the AMS shall feedback the wideband CQI. The wideband CQI shall be estimated at the AMS assuming short-term or long-term precoding at the ABS, according to the feedback period. The channel state information may be obtained at the ABS via the feedback of the correlation matrix, or via the feedback of the wideband PMI.

An AMS supports a maximum of four distinct concurrent feedback allocations, including one or several MFMs, the transmit correlation matrix, and multiBS MIMO feedback. One feedback allocation may be assigned using the Feedback Allocation A-MAP IE and up to three may be assigned using the Feedback Polling A-MAP IE. Any or all feedback modes assigned to an AMS using the Feedback Polling A-MAP IE can be deallocated using the Polling deallocation_bitmap included in the Feedback Polling A-MAP IE. For details of the Polling_deallocation_bitmap operation, refer to 6.3.5.5.2.4.11. Feedback modes assigned to an AMS using the Feedback Allocation A-MAP IE are deallocated using the Allocation Duration field of this IE, found in 6.3.5.5.2.4.5.

6.3.6.2.5.4 Downlink signaling support of DL-MIMO modes

The ABS shall send some parameters necessary for DL MIMO operation in a broadcast message. The broadcast information is carried in the S-SFH SP3 IE or in the additional broadcast information such as AAI-SCD or AAI-DL-IM messages.

The BS shall send some parameters necessary for DL MIMO operation in a unicast message. The unicast information is carried in the DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent A-MAP IE, Feedback Polling A-MAP IE, and Feedback Allocation A-MAP IE.

Table 6-224 specifies the DL control parameters required for MIMO operation.

Table 6-224—DL MIMO control parameters

Parameter	Description	Value	Notes
		Broadcast Information	
N_t	Number of transmit antennas at the BS	2, 4, 8	Indicated in S-SFH (system information) SP3 IE
OL_Region	OL MIMO region, which signaling is used to indicate MS where is the predefined OL MIMO region and number of MIMO streams (1 or 2)	Refer to the AAI-SCD message (6.2.3.31)	Indicated in AAI-SCD Message
BC_SI	Rank-1 base codebook subset indication for interference mitigation with PMI coordination	BitMAP: 8 bits if $N_t = 2$ 16 bits if $N_t = 4, 8$	Rank-1 codebook element restriction or recommendation information It shall be ignored if Codebook_mode = 0b00, 0b01 or 0b10 It is indicated in AAI-DL-IM Message Its usage is enabled by Codebook_mode or Codebook_coordination
		Unicast Information	
MEF	MIMO encoder format	SFBC Vertical encoding Multilayer encoding CDR	MIMO encoder format. Indicated in DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent Allocation A-MAP IE
M_t	Number of MIMO streams in transmission	1 to 8	Number of MIMO streams in the transmission. Indicated in DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent Allocation A-MAP IE
PSI	Index of allocated pilot MIMO stream	1 to 8	PSI shall be indicated if MEF is ME (Multi-layer Encoding). Indicated in DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, DL Persistent Allocation A-MAP IE

Table 6-224—DL MIMO control parameters *(continued)*

Parameter	Description	Value	Notes
MFM	MIMO feedback mode	Refer to Table 6-223	To decide the feedback content and related MS processing Indicated in Feedback Allocation A-MAP IE, Feedback Polling A-MAP IE
$MaxM_t$	Maximum number of MIMO streams	If N_t = 2 (any MFM): 0b0: 1 0b1: 2 If N_t = 4 (any MFM): 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If N_t = 8 (SU-MIMO MFM 0, 2, 3, 4): 0b00: 1 0b01: 2 0b10: 4 0b11: 8 If N_t = 8 (MU-MIMO MFM 5, 7): 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If N_t = 8 (MU-MIMO MFM 6): 0b00:1 0b01:2 0b10:4 0b11:8	If MFM indicates a SU feedback mode: the maximum STC rate scheduled for each user If MFM indicates a MU feedback mode: the maximum number of total streams for all users scheduled on each RU Indicated in Feedback Allocation A-MAP IE, Feedback Polling A-MAP IE
Codebook_ subset	Codebook subset type for CL MIMO modes 2 and 4	Base codebook or codebook subset	Depending on the MFM and Codebook_subset, the MS shall feedback a PMI from the SU or MU base codebook, or from a subset of the SU or MU of the base codebook Indicated in Feedback Allocation A-MAP IE, Feedback Polling A-MAP IE

Table 6-224—DL MIMO control parameters *(continued)*

Parameter	Description	Value	Notes
Codebook_mode	Codebook feedback mode for CL MIMO modes 2 and 4	0b00: base mode with codebook coordination disabled 0b01: transformation mode with codebook coordination disabled 0b10: differential mode with codebook coordination disabled 0b11: base mode with codebook coordination enabled	This field specifies the codebook feedback mode. If codebook coordination is enabled by setting Codebook_mode to 0b11 or by setting Codebook_coordination to 0b1, and if the AMS reports STC rate equal to 1, then the AMS shall find the rate-1 PMI from the codebook entries broadcasted in BC_SI in AAI-DL-IM Message

When Codebook_subset indicates the use of a codebook subset and MFM indicates a CL SU MIMO mode (MFM = 3 and 4), the MS shall use the SU base codebook subset of Table 6-237 when $N_t = 4$. When Codebook_subset indicates the use of a codebook subset and MFM indicates a CL MU MIMO mode (MFM = 6 and 7), the MS shall use the MU base codebook subset of Table 6-237 when $N_t = 4$.

6.3.6.2.5.5 Quantized MIMO feedback for closed-loop transmit precoding

Quantized feedback modes

An AMS feedbacks a Preferred Matrix Index (PMI) to support DL precoding.

There are three types of codebook feedback modes.

The operation of the codebook feedback modes for the PMI is summarized as follows:

1) **The base mode**: the PMI feedback from an AMS shall represent an entry of the base codebook. It shall be sufficient for the ABS to determine a new precoder.

2) **The transformation mode**: the PMI feedback from an AMS shall represent an entry of the transformed base codebook according to long-term channel information.

3) **The differential mode**: the PMI feedback from an AMS shall represent an entry of the differential codebook or an entry of the base codebook at PMI reset times. The feedback from an AMS provides a differential knowledge of the short-term channel information. This feedback represents information that is used along with other feedback information known at the ABS for determining a new precoder.

The mobile station shall support the base and transformation mode and may support the differential mode.

The transformation and differential feedback modes are applied to the base codebook or to a subset of the base codebook.

Base mode for codebook-based feedback

The base codebook is a unitary codebook. A codebook is a unitary codebook if each of its matrices consists of columns of a unitary matrix.

The AMS selects its preferred matrix from the base codebook based on the channel measurements. The AMS sends back the index of the preferred codeword, and the ABS computes the precoder **W** according to the index. Both the ABS and the AMS use the same codebook for correct operation.

For the base mode, the PMI feedback from a mobile station shall represent an entry of the base codebook, where the base codebooks are defined as follows for two, four, and eight transmit antennas at the ABS.

The notation $C(N_t, M_t, NB)$ denotes the codebook, which consists of 2^{NB} complex matrices of dimension N_t by M_t, and M_t denotes the number of MIMO streams.

The notation $C(N_t, M_t, NB, i)$ denotes the i-th codebook entry of $C(N_t, M_t, NB)$.

Base codebook for two transmit antennas

SU-MIMO base codebook

The base codebook of SU-MIMO with two transmit antennas consists of rank-1 codebook $C(2,1,3)$ and rank-2 codebook $C(2,2,3)$, as illustrated in Table 6-225 and Table 6-226, respectively.

Table 6-225—$C(2,1,3)$

Index	m	$C(2, 1, 3, m) = [c_1; c_2]$	
		c_1	c_2
000	0	0.7071	–0.7071
001	1	0.7071	–0.5000 – 0.5000i
010	2	0.7071	–0.7071i
011	3	0.7071	0.5000 – 0.5000i
100	4	0.7071	0.7071
101	5	0.7071	0.5000 + 0.5000i
110	6	0.7071	0.7071i
111	7	0.7071	–0.5000 + 0.5000i

Table 6-226—*C*(2,2,3)

Index	*m*	$C(2,2,3,m) = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}^T$	
		c_{11} c_{21}	c_{12} c_{22}
000	0	0.7071 0.7071	–0.7071 0.7071
001	1	0.7071 0.7071	–0.5000 – 0.5000i 0.5000 + 0.5000i
010	2	0.7071 0.7071	–0.7071i 0.7071i
011	3	0.7071 0.7071	0.5000 – 0.5000i –0.5000 + 0.5000i
100~111	4~7	—	—

MU-MIMO base codebook

The base codebook for MU-MIMO is the same as the rank-1 base codebook for SU-MIMO.

Base codebook for four transmit antennas

SU-MIMO base codebook

The base codebooks of SU-MIMO with four transmit antennas consist of rank-1 codebook *C*(4,1,6), rank-2 codebook *C*(4,2,6), rank-3 codebook *C*(4,3,6), and rank-4 codebook *C*(4,4,6). Table 6-227, Table 6-228, Table 6-229, and Table 6-230 are included to illustrate the rank-1,2,3,4 base codebooks.

Table 6-227—*C*(4,1,6)

Binary index	*m*	$C(4, 1, 6, m) = [c_1; c_2; c_3; c_4]$			
		c_1	c_2	c_3	c_4
000000	0	0.5000	–0.5000	0.5000	–0.5000
000001	1	–0.5000	–0.5000	0.5000	0.5000
000010	2	–0.5000	0.5000	0.5000	–0.5000
000011	3	0.5000	–0.5000i	0.5000	–0.5000i
000100	4	–0.5000	–0.5000i	0.5000	0.5000i
000101	5	–0.5000	0.5000i	0.5000	–0.5000i
000110	6	0.5000	0.5000	0.5000	0.5000

Table 6-227—*C*(4,1,6) *(continued)*

Binary index	*m*	$C(4, 1, 6, m) = [c_1; c_2; c_3; c_4]$			
		c_1	c_2	c_3	c_4
000111	7	0.5000	0.5000i	0.5000	0.5000i
001000	8	0.5000	0.5000	0.5000	-0.5000
001001	9	0.5000	0.5000i	-0.5000	0.5000i
001010	10	0.5000	-0.5000	0.5000	0.5000
001011	11	0.5000	–0.5000i	–0.5000	–0.5000i
001100	12	0.5000	0.3536 + 0.3536i	0.5000i	–0.3536 + 0.3536i
001101	13	0.5000	–0.3536 + 0.3536i	–0.5000i	0.3536 + 0.3536i
001110	14	0.5000	–0.3536 – 0.3536i	0.5000i	0.3536 – 0.3536i
001111	15	0.5000	0.3536 – 0.3536i	–0.5000i	–0.3536 – 0.3536i
010000	16	0.5000	–0.4619 – 0.1913i	0.3536 + 0.3536i	–0.1913 – 0.4619i
010001	17	0.3117	0.6025 + 0.1995i	–0.4030 – 0.4903i	–0.1122 – 0.2908i
010010	18	0.3117	–0.6025 – 0.1995i	–0.1122 – 0.2908i	0.4030 + 0.4903i
010011	19	0.3058	0.1901 – 0.6052i	0.1195 + 0.2866i	0.4884 – 0.4111i
010100	20	0.5000	–0.1913 + 0.4619i	–0.3536 – 0.3536i	0.4619 – 0.1913i
010101	21	0.5000	0.1913 – 0.4619i	–0.3536 – 0.3536i	–0.4619 + 0.1913i
010110	22	0.5000	0.4619 + 0.1913i	0.3536 + 0.3536i	0.1913 + 0.4619i
010111	23	0.3082	0.0104 + 0.3151i	0.4077 + 0.4887i	–0.4783 + 0.4145i
011000	24	0.3117	0.3573 – 0.2452i	0.6025 – 0.1995i	–0.1578 + 0.5360i
011001	25	0.3117	0.2452 + 0.3573i	–0.6025 + 0.1995i	0.5360 + 0.1578i
011010	26	0.3082	–0.3666 + 0.2426i	0.6092 – 0.1842i	0.1615 – 0.5298i
011011	27	0.3117	–0.2452 – 0.3573i	–0.6025 + 0.1995i	–0.5360 – 0.1578i
011100	28	0.3117	0.4260 + 0.0793i	0.1995 + 0.6025i	0.2674 + 0.4906i
011101	29	0.3117	–0.0793 + 0.4260i	–0.1995 – 0.6025i	0.4906 – 0.2674i
011110	30	0.3117	–0.4260 – 0.0793i	0.1995 + 0.6025i	–0.2674 – 0.4906i
011111	31	0.3117	0.0793 – 0.4260i	–0.1995 – 0.6025i	–0.4906 + 0.2674i
100000	32	0.5636	–0.3332 – 0.2672i	0.1174 + 0.5512i	–0.3308 – 0.2702i
100001	33	0.5587	0.3361 + 0.2735i	–0.3361 – 0.2735i	–0.1135 – 0.5471i
100010	34	0.5587	–0.3361 – 0.2735i	–0.1135 – 0.5471i	0.3361 + 0.2735i
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

Table 6-227—*C*(4,1,6) *(continued)*

Binary index	*m*	$C(4, 1, 6, m) = [c_1; c_2; c_3; c_4]$			
		c_1	c_2	c_3	c_4
100111	39	0.5587	–0.2990 + 0.0880i	0.3361 + 0.2735i	–0.5216 + 0.3616i
101000	40	0.5587	0.0880 – 0.2990i	0.3361 – 0.2735i	–0.3616 + 0.5216i
101001	41	0.5587	0.2990 + 0.0881i	–0.3362 + 0.2735i	0.5216 + 0.3616i
101010	42	0.5587	–0.0880 + 0.2990i	0.3361 – 0.2735i	0.3616 – 0.5216i
101011	43	0.5587	–0.2990 – 0.0880i	–0.3361 + 0.2735i	–0.5216 – 0.3616i
101100	44	0.5636	0.2741 – 0.1559i	0.2672 + 0.3332i	0.1081 + 0.6236i
101101	45	0.5636	0.1559 + 0.2741i	–0.2672 – 0.3332i	0.6236 – 0.1081i
101110	46	0.5587	–0.2737 + 0.1492i	0.2735 + 0.3361i	–0.1132 – 0.6245i
101111	47	0.5587	–0.1492 – 0.2737i	–0.2735 – 0.3361i	–0.6245 + 0.1132i
110000	48	0.5000	–0.4619 + 0.1913i	0.3536 – 0.3536i	–0.1913 + 0.4619i
110001	49	0.3117	0.4030 + 0.4903i	–0.6025 – 0.1995i	–0.1122 – 0.2908i
110010	50	0.3117	–0.4029 – 0.4904i	–0.1184 – 0.2883i	0.6067 + 0.1865i
110011	51	0.3082	0.4887 – 0.4077i	0.1205 + 0.2837i	0.1842 – 0.6092i
110100	52	0.5000	0.1913 + 0.4619i	–0.3536 + 0.3536i	–0.4619 – 0.1913i
110101	53	0.5000	–0.1913 – 0.4619i	–0.3536 + 0.3536i	0.4619 + 0.1913i
110110	54	0.5000	0.4619 – 0.1913i	0.3536 – 0.3536i	0.1913 – 0.4619i
110111	55	0.3117	–0.2452 + 0.3573i	0.6025 + 0.1995i	–0.5360 + 0.1578i
111000	56	0.3117	0.3117	0.4030 – 0.4903i	–0.4030 + 0.4903i
111001	57	0.3117	0.3117i	–0.4030 + 0.4903i	0.4903 + 0.4030i
111010	58	0.3082	–0.3152 – 0.0036i	0.4076 – 0.4888i	0.4040 – 0.4872i
111011	59	0.3082	0.0036 – 0.3152i	–0.4076 + 0.4888i	–0.4872 – 0.4040i
111100	60	0.3117	0.2204 + 0.2204i	0.4903 + 0.4030i	0.0618 + 0.6317i
111101	61	0.3117	–0.2204 + 0.2204i	–0.4903 – 0.4030i	0.6317 – 0.0618i
111110	62	0.3082	–0.2154 – 0.2302i	0.4887 + 0.4077i	–0.0451 – 0.6313i
111111	63	0.3082	0.2254 – 0.2204i	–0.4888 – 0.4076i	–0.6302 + 0.0588i

Table 6-228—*C(*4,2,6)

Index	m	$C(4,2,6,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \end{bmatrix}^T$			
		c_{11} c_{21}	c_{12} c_{22}	c_{13} c_{23}	c_{14} c_{24}
000000	0	0.5000 0.5000	0.5000 –0.5000	0.5000 0.5000	0.5000 –0.5000
000001	1	0.5000 –0.5000	0.5000 –0.5000	0.5000 0.5000	0.5000 0.5000
000010	2	0.5000 –0.5000	0.5000 0.5000	0.5000 0.5000	0.5000 –0.5000
000011	3	0.5000 –0.5000	–0.5000 –0.5000	0.5000 0.5000	–0.5000 0.5000
000100	4	0.5000 –0.5000	–0.5000 0.5000	0.5000 0.5000	–0.5000 –0.5000
000101	5	–0.5000 –0.5000	–0.5000 0.5000	0.5000 0.5000	0.5000 –0.5000
000110	6	0.5000 –0.5000	0.5000i – 0.5000i	0.5000 0.5000	0.5000i 0.5000i
000111	7	0.5000 –0.5000	0.5000i 0.5000i	0.5000 0.5000	0.5000i – 0.5000i
001000	8	0.5000 –0.5000	– 0.5000i – 0.5000i	0.5000 0.5000	– 0.5000i 0.5000i
001001	9	0.5000 –0.5000	– 0.5000i 0.5000i	0.5000 0.5000	– 0.5000i – 0.5000i
001010	10	0.5000 –0.5000	0.5000 – 0.5000i	0.5000 0.5000	0.5000 0.5000i
001011	11	0.5000 –0.5000	0.5000 0.5000i	0.5000 0.5000	0.5000 – 0.5000i
001100	12	0.5000 –0.5000	0.5000i –0.5000	0.5000 0.5000	0.5000i 0.5000
001101	13	0.5000 –0.5000	0.5000i 0.5000	0.5000 0.5000	0.5000i –0.5000
001110	14	0.5000 0.5000	0.5000 –0.5000	0.5000 0.5000	–0.5000 0.5000
001111	15	0.5000 0.5000	–0.3536 + 0.3536i 0.3536 – 0.3536i	– 0.5000i – 0.5000i	0.3536 + 0.3536i –0.3536 – 0.3536i
010000	16	0.5000 –0.5000	–0.5000 – 0.5000i	0.5000 0.5000	–0.5000 0.5000i
010001	17	0.5000 –0.5000	–0.5000 0.5000i	0.5000 0.5000	–0.5000 – 0.5000i

Table 6-228—*C*(4,2,6) *(continued)*

Index	m	$C(4,2,6,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \end{bmatrix}^T$			
		c_{11} c_{21}	c_{12} c_{22}	c_{13} c_{23}	c_{14} c_{24}
010010	18	0.5000 0.5587	–0.5000 0.3361 + 0.2735i	0.5000 –0.3361 – 0.2735i	–0.5000 –0.1135 – 0.5471i
010011	19	–0.5000 0.5000	–0.5000 – 0.5000i	0.5000 0.5000	0.5000 – 0.5000i
010100	20	–0.5000 0.5587	–0.5000 –0.3361 – 0.2735i	0.5000 –0.1135 – 0.5471i	0.5000 0.3361 + 0.2735i
010101	21	–0.5000 0.3117	–0.5000 –0.2452 + 0.3573i	0.5000 0.6025 + 0.1995i	0.5000 –0.5360 + 0.1578i
010110	22	–0.5000 0.5000	0.5000 – 0.5000i	0.5000 0.5000	–0.5000 – 0.5000i
010111	23	0.5000 0.5000	0.5000 0.5000i	0.5000 –0.5000	–0.5000 0.5000i
011000	24	–0.5000 0.5587	0.5000 –0.2990 + 0.0880i	0.5000 0.3361 + 0.2735i	–0.5000 –0.5216 + 0.3616i
011001	25	0.5000 0.5000	0.5000 – 0.5000i	0.5000 –0.5000	–0.5000 – 0.5000i
011010	26	0.5000 0.3117	0.5000 –0.2452 – 0.3573i	0.5000 –0.6025 + 0.1995i	–0.5000 –0.5360 – 0.1578i
011011	27	0.5000 0.5000	0.5000i –0.5000	–0.5000 0.5000	0.5000i 0.5000
011100	28	0.5000 0.5587	0.5000i –0.0880 + 0.2990i	–0.5000 0.3361 – 0.2735i	0.5000i 0.3616 – 0.5216i
011101	29	0.5000 0.5000	–0.5000 – 0.5000i	0.5000 –0.5000	0.5000 – 0.5000i
011110	30	0.5000 0.5587	–0.5000 –0.2990 – 0.0880i	0.5000 –0.3361 + 0.2735i	0.5000 –0.5216 – 0.3616i
011111	31	0.5000 0.5000	0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000i – 0.5000i	–0.3536 + 0.3536i 0.3536 + 0.3536i
100000	32	0.5000 0.5000	0.3536 + 0.3536i –0.3536 – 0.3536i	0.5000i 0.5000i	–0.3536 + 0.3536i 0.3536 – 0.3536i
100001	33	0.5000 0.5000	0.3536 + 0.3536i 0.3536 – 0.3536i	0.5000i – 0.5000i	–0.3536 + 0.3536i –0.3536 – 0.3536i
100010	34	0.5000 0.3117	0.3536 + 0.3536i 0.0793 – 0.4260i	0.5000i –0.1995 – 0.6025i	–0.3536 + 0.3536i –0.4906 + 0.2674i
100011	35	0.5000 0.5000	–0.3536 + 0.3536i –0.3536 – 0.3536i	– 0.5000i 0.5000i	0.3536 + 0.3536i 0.3536 – 0.3536i
100100	36	–0.5000 0.3082	0.5000i 0.0104 + 0.3151i	0.5000 0.4077 + 0.4887i	– 0.5000i –0.4783 + 0.4145i

Table 6-228—*C*(4,2,6) *(continued)*

Index	m	$C(4, 2, 6, m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \end{bmatrix}^T$			
		c_{11} c_{21}	c_{12} c_{22}	c_{13} c_{23}	c_{14} c_{24}
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 –0.5000i	–0.4030 – 0.4903i 0.5000	–0.1122 – 0.2908i –0.5000i
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

Table 6-228—*C*(4,2,6) *(continued)*

Index	*m*	$C(4, 2, 6, m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \end{bmatrix}^T$			
		c_{11} c_{21}	c_{12} c_{22}	c_{13} c_{23}	c_{14} c_{24}
111000	56	0.5000 0.5000	0.1913 + 0.4619i –0.1913 – 0.4619i	–0.3536 + 0.3536i –0.3536 + 0.3536i	–0.4619 – 0.1913i 0.4619 + 0.1913i
111001	57	0.3117 0.5000	0.3117 –0.5000	0.4030 – 0.4903i 0.5000	–0.4030 + 0.4903i 0.5000
111010	58	0.3117 0.3082	0.3117 –0.3152 – 0.0036i	0.4030 – 0.4903i 0.4076 – 0.4888i	–0.4030 + 0.4903i 0.4040 – 0.4872i
111011	59	0.3117 0.5000	0.3117i – 0.5000i	–0.4030 + 0.4903i –0.5000	0.4903 + 0.4030i – 0.5000i
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 6-229—*C*(4,3,6)

Binary index	*m*	$C(4,3,6,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \end{bmatrix}^T$			
		c_{11} c_{21} c_{31}	c_{12} c_{22} c_{32}	c_{13} c_{23} c_{33}	c_{14} c_{24} c_{34}
000000	0	0.5000 0.5000 –0.5000	0.5000 –0.5000 –0.5000	0.5000 0.5000 0.5000	0.5000 –0.5000 0.5000
000001	1	0.5000 0.5000 –0.5000	0.5000 –0.5000 0.5000	0.5000 0.5000 0.5000	0.5000 –0.5000 –0.5000
000010	2	0.5000 –0.5000 –0.5000	0.5000 –0.5000 0.5000	0.5000 0.5000 0.5000	0.5000 0.5000 –0.5000

Table 6-229—*C*(4,3,6) *(continued)*

Binary index	*m*	$C(4,3,6,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \end{bmatrix}^T$			
		c_{11} c_{21} c_{31}	c_{12} c_{22} c_{32}	c_{13} c_{23} c_{33}	c_{14} c_{24} c_{34}
000011	3	0.5000 –0.5000 –0.5000	–0.5000 –0.5000 0.5000	0.5000 0.5000 0.5000	–0.5000 0.5000 –0.5000
000100	4	0.5000 0.5000 –0.5000	0.5000i –0.5000i –0.5000i	0.5000 0.5000 0.5000	0.5000i –0.5000i 0.5000i
000101	5	0.5000 0.5000 –0.5000	0.5000i –0.5000i 0.5000i	0.5000 0.5000 0.5000	0.5000i –0.5000i –0.5000i
000110	6	0.5000 –0.5000 –0.5000	0.5000i –0.5000i 0.5000i	0.5000 0.5000 0.5000	0.5000i 0.5000i –0.5000i
000111	7	0.5000 –0.5000 –0.5000	–0.5000i –0.5000i 0.5000i	0.5000 0.5000 0.5000	–0.5000i 0.5000i –0.5000i
001000	8	0.5000 0.5000 –0.5000	0.5000 –0.5000 –0.5000i	0.5000 0.5000 0.5000	0.5000 –0.5000 0.5000i
001001	9	0.5000 –0.5000 –0.5000	0.5000 –0.5000i 0.5000i	0.5000 0.5000 0.5000	0.5000 0.5000i –0.5000i
001010	10	0.5000 0.5000 –0.5000	0.5000i –0.5000i –0.5000	0.5000 0.5000 0.5000	0.5000i –0.5000i 0.5000
001011	11	0.5000 –0.5000 –0.5000	0.5000i –0.5000 0.5000	0.5000 0.5000 0.5000	0.5000i 0.5000 –0.5000
001100	12	0.5000 0.5000 0.5000	0.5000 0.5000i –0.5000	0.5000 –0.5000 0.5000	–0.5000 0.5000i 0.5000
001101	13	0.5000 0.5000 0.5000	0.5000 –0.5000 –0.5000i	0.5000 0.5000 –0.5000	–0.5000 0.5000 –0.5000i

Table 6-229—*C*(4,3,6) *(continued)*

Binary index	*m*	$C(4,3,6,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \end{bmatrix}^T$			
		c_{11} c_{21} c_{31}	c_{12} c_{22} c_{32}	c_{13} c_{23} c_{33}	c_{14} c_{24} c_{34}
001110	14	0.5000 0.5000 0.5000	0.3536+0.3536i – 0.3536+0.3536i 0.3536–0.3536i	0.5000i –0.5000i –0.5000i	– 0.3536+0.3536i 0.3536+0.3536i –0.3536– 0.3536i
001111	15	0.5000 0.5000 0.5000	– 0.3536+0.3536i –0.3536– 0.3536i 0.3536–0.3536i	–0.5000i 0.5000i –0.5000i	0.3536+0.3536i 0.3536–0.3536i –0.3536– 0.3536i
001111 ≈ 111111	16 ≈ 63	N/A			

The indexes from 16 to 63 are not used in 6-bits downlink PMI feedback for $M_t = 3$ codebook.

Table 6-230—*C*(4,4,6)

Binary index	*m*	$C(4,3,4,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \\ c_{41} & c_{42} & c_{43} & c_{44} \end{bmatrix}^T$			
		c_{11} c_{21} c_{31} c_{41}	c_{12} c_{22} c_{32} c_{42}	c_{13} c_{23} c_{33} c_{43}	c_{14} c_{24} c_{34} c_{44}
000000	0	0.5000 0.5000 –0.5000 –0.500	0.5000 –0.5000 –0.5000 0.5000	0.5000 0.5000 0.5000 0.5000	0.5000 –0.5000 0.5000 –0.5000
000001	1	0.5000 0.5000 –0.5000 –0.5000	0.5000i –0.5000i –0.5000i 0.5000i	0.5000 0.5000 0.5000 0.5000	0.5000i –0.5000i 0.5000i –0.5000i
000010	2	0.5000 0.5000 –0.5000 –0.5000	0.5000 –0.5000 –0.5000i 0.5000i	0.5000 0.5000 0.5000 0.5000	0.5000 –0.5000 0.5000i –0.5000i

Table 6-230—*C*(4,4,6) *(continued)*

000011	3	0.5000 0.5000 –0.5000 –0.5000	0.0000+0.5000i 0.0000–0.5000i –0.5000 0.5000	0.5000 0.5000 0.5000 0.5000	0.5000i –0.5000i 0.5000 –0.5000
000100	4	0.5000 0.5000 0.5000 0.5000	0.5000 0.0000+0.5000i –0.5000 0.0000–0.5000i	0.5000 –0.5000 0.5000 –0.5000	–0.5000 0.5000i 0.5000 0.000–0.5000i
000101	5	0.5000 0.5000 0.5000 0.5000	0.3536+0.3536i – 0.3536+0.3536i –0.3536–0.3536i 0.3536–0.3536i	0.5000i –0.5000i 0.5000i –0.5000i	– 0.3536+0.3536i 0.3536+0.3536i 0.3536–0.3536i –0.3536– 0.3536i
000110 ≈ 111111	6 ≈ 63	N/A			

The indexes from 6 to 63 are not used in 6-bits downlink PMI feedback for M_t = 4 codebook.

MU-MIMO base codebook

The base codebook for MU-MIMO is same as the rank-1 base codebook for SU-MIMO.

Base codebook for eight transmit antennas

SU-MIMO base codebook

The base codebooks of SU-MIMO with eight transmit antennas consist of rank-1 codebook *C*(8,1,4), rank-2 codebook *C*(8,2,4), rank-3 codebook *C*(8,3,4), rank-4 codebook *C*(8,4,4), rank-5 codebook *C*(8,5,4), rank-6 codebook *C*(8,6,4), rank-7 codebook *C*(8,7,4), and rank-8 codebook *C*(8,8,4). Table 6-231 illustrates the rank-1 base codebook, and Table 6-232 illustrates the ranks-2,3,4,5,6,7,8 base codebooks.

Table 6-231—*C*(8,1,4)

Binary index	***m***	$C(8, 1, 4, m) = [c_1; c_2; c_3; c_4; c_5; c_6; c_7; c_8]$							
		c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8
0000	0	0.3536	–0.3051 – 0.1786i	0.1732 + 0.3082i	0.0062 – 0.3535i	–0.1839 + 0.3020i	0.3112 – 0.1677i	–0.3533 – 0.0124i	0.2987 + 0.1892i
0001	1	0.3536	–0.2514 – 0.2486i	0.0041 + 0.3535i	0.2456 – 0.2543i	–0.3535 + 0.0082i	0.2571 + 0.2427i	–0.0123 – 0.3533i	–0.2397 + 0.2599i
0010	2	0.3536	–0.1697 – 0.3102i	–0.1907 + 0.2977i	0.3527 + 0.0244i	–0.1479 – 0.3211i	–0.2107 + 0.2839i	0.3502 + 0.0486i	–0.1254 – 0.3306i
0011	3	0.3536	–0.0614 – 0.3482i	–0.3322 + 0.1210i	0.1768 + 0.3062i	0.2708 – 0.2273i	–0.2709 – 0.2272i	–0.1767 + 0.3062i	0.3323 + 0.1208i

Table 6-231—*C*(8,1,4) *(continued)*

Binary index	m	$C(8, 1, 4, m) = [c_1; c_2; c_3; c_4; c_5; c_6; c_7; c_8]$							
		c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8
0100	4	0.3536	0.0638 – 0.3478i	–0.3306 – 0.1254i	–0.1830 + 0.3025i	0.2646 + 0.2345i	0.2784 – 0.2180i	–0.1642 – 0.3131i	–0.3376 + 0.1050i
0101	5	0.3536	0.1881 – 0.2994i	–0.1534 – 0.3185i	–0.3513 – 0.0395i	–0.2204 + 0.2764i	0.1168 + 0.3337i	0.3447 + 0.0786i	0.2499 – 0.2501i
0110	6	0.3536	0.2892 – 0.2034i	0.1196 – 0.3327i	–0.0936 – 0.3409i	–0.2727 – 0.2251i	–0.3525 – 0.0272i	–0.3040 + 0.1805i	–0.1449 + 0.3225i
0111	7	0.3536	0.3461 – 0.0721i	0.3241 – 0.1412i	0.2885 – 0.2044i	0.2407 – 0.2590i	0.1828 – 0.3026i	0.1172 – 0.3336i	0.0467 – 0.3505i
1000	8	0.3536	0.3461 + 0.0721i	0.3241 + 0.1412i	0.2885 + 0.2044i	0.2407 + 0.2590i	0.1828 + 0.3026i	0.1172 + 0.3336i	0.0467 + 0.3505i
1001	9	0.3536	0.2892 + 0.2034i	0.1196 + 0.3327i	–0.0936 + 0.3409i	–0.2727 + 0.2251i	–0.3525 + 0.0272i	–0.3040 – 0.1805i	–0.1449 – 0.3225i
1010	10	0.3536	0.1881 + 0.2994i	–0.1534 + 0.3185i	–0.3513 + 0.0395i	–0.2204 – 0.2764i	0.1168 – 0.3337i	0.3447 – 0.0786i	0.2499 + 0.2501i
1011	11	0.3536	0.0638 + 0.3478i	–0.3306 + 0.1254i	–0.1830 – 0.3025i	0.2646 – 0.2345i	0.2784 + 0.2180i	–0.1642 + 0.3131i	–0.3376 – 0.1050i
1100	12	0.3536	–0.0614 + 0.3482i	–0.3322 – 0.1210i	0.1768 – 0.3062i	0.2708 + 0.2273i	–0.2709 + 0.2272i	–0.1767 – 0.3062i	0.3323 – 0.1208i
1101	13	0.3536	–0.1697 + 0.3102i	–0.1907 – 0.2977i	0.3527 – 0.0244i	–0.1479 + 0.3211i	–0.2107 – 0.2839i	0.3502 – 0.0486i	–0.1254 + 0.3306i
1110	14	0.3536	–0.2514 + 0.2486i	0.0041 – 0.3535i	0.2456 + 0.2543i	–0.3535 – 0.0082i	0.2571 – 0.2427i	–0.0123 + 0.3533i	–0.2397 – 0.2599i
1111	15	0.3536	–0.3051 + 0.1786i	0.1732 – 0.3082i	0.0062 + 0.3535i	–0.1839 – 0.3020i	0.3112 + 0.1677i	–0.3533 + 0.0124i	0.2987 – 0.1892i

The four rank-8 matrices used for rank-2 to rank-8 transmission for SU-MIMO are as follows:

$$V1 = \begin{bmatrix} 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & 0.25+0.25i & -0.25-0.25i & -0.25+0.25i & 0.25-0.25i \\ 0.3536 & 0.3536 & -0.3536 & -0.3536 & 0.3536i & 0.3536i & -0.3536i & -0.3536i \\ 0.3536 & -0.3536 & -0.3536i & 0.3536i & -0.25+0.25i & 0.25-0.25i & 0.25+0.25i & -0.25-0.25i \\ 0.3536 & 0.3536 & 0.3536 & 0.3536 & -0.3536 & -0.3536 & -0.3536 & -0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & -0.25-0.25i & 0.25+0.25i & 0.25-0.25i & -0.25+0.25i \\ 0.3536 & 0.3536 & -0.3536 & -0.3536 & -0.3536i & -0.3536i & 0.3536i & 0.3536i \\ 0.3536 & -0.3536 & -0.3536i & 0.3536i & 0.25-0.25i & -0.25+0.25i & -0.25-0.25i & 0.25+0.25i \end{bmatrix}$$

$$V2 = \begin{bmatrix} 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & 0.25+0.25i & -0.25-0.25i & -0.25+0.25i & 0.25-0.25i \\ 0.25+0.25i & 0.25+0.25i & -0.25-0.25i & -0.25-0.25i & -0.25+0.25i & -0.25+0.25i & 0.25-0.25i & 0.25-0.25i \\ 0.25+0.25i & -0.25-0.25i & 0.25-0.25i & -0.25+0.25i & -0.3536 & 0.3536 & 0.3536i & -0.3536i \\ 0.3536i & 0.3536i & 0.3536i & 0.3536i & -0.3536i & -0.3536i & -0.3536i & -0.3536i \\ 0.3536i & -0.3536i & -0.3536 & 0.3536 & 0.25-0.25i & -0.25+0.25i & 0.25+0.25i & -0.25-0.25i \\ -0.25+0.25i & -0.25+0.25i & 0.25-0.25i & 0.25-0.25i & 0.25+0.25i & 0.25+0.25i & -0.25-0.25i & -0.25-0.25i \\ -0.25+0.25i & 0.25-0.25i & 0.25+0.25i & -0.25-0.25i & 0.3536i & -0.3536i & 0.3536 & -0.3536 \end{bmatrix}$$

$$V3 = \begin{bmatrix} 0.5 & 0.5 & 0.5 & 0.5 & 0 & 0 & 0 & 0 \\ 0.5 & -0.5 & 0.5i & -0.5i & 0 & 0 & 0 & 0 \\ 0.5 & 0.5 & -0.5 & -0.5 & 0 & 0 & 0 & 0 \\ 0.5 & -0.5 & -0.5i & 0.5i & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0 & 0 & 0 & 0 & 0.5 & -0.5 & 0.5i & -0.5i \\ 0 & 0 & 0 & 0 & 0.5 & 0.5 & -0.5 & -0.5 \\ 0 & 0 & 0 & 0 & 0.5 & -0.5 & -0.5i & 0.5i \end{bmatrix}$$

$$V4 = \begin{bmatrix} 0.5 & 0.5 & 0.5 & 0.5 & 0 & 0 & 0 & 0 \\ a+ai & -a-ai & -a+ai & a-ai & 0 & 0 & 0 & 0 \\ 0.5i & 0.5i & -0.5i & -0.5i & 0 & 0 & 0 & 0 \\ -a+ai & a-ai & a+ai & -a-ai & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0 & 0 & 0 & 0 & a+ai & -a-ai & -a+ai & a-ai \\ 0 & 0 & 0 & 0 & 0.5i & 0.5i & -0.5i & -0.5i \\ 0 & 0 & 0 & 0 & -a+ai & a-ai & a+ai & -a-a \end{bmatrix}, \quad \text{where } a = 0.3536$$

The 4-bit 8Tx base codebook for ranks-2 to -8 is constructed from the four 8x8 base matrices and is specified in Table 6-232. Note that only the column indices of the corresponding base matrices are shown in Table 6-232 for brevity.

Table 6-232—Ranks-2 to -8 of SU MIMO 4-bit 8Tx base codebook

Codebook matrix index (CMI)	Base matrix	*C*(8,2,4)	Base matrix	*C*(8,3,4)	*C*(8,4,4)	*C*(8,5,4)	*C*(8,6,4)	*C*(8,7,4)	*C*(8,8,4)
0	*V1*	1 5	*V1*	1 3 5	1537	12357	123567	1234567	12345678
1		2 6		2 4 6	2648	12468	124568	1234568	N/A
2		3 7		2 3 7	3726	23467	234678	1234678	N/A
3		4 8		1 4 8	4815	13458	134578	1234578	N/A
4		5 3		3 5 7	5372	23567	234567	2345678	N/A
5		4 6		4 6 8	6481	14568	134568	1345678	N/A
6		2 7		2 6 7	7264	24678	124678	1245678	N/A
7		8 1		1 5 8	8153	13578	123578	1235678	N/A
8	*V3*	1 5	*V2*	1 2 3	1234	12345	123456	1234567	12345678
9		2 6		1 2 4	1246	12456	124567	1245678	N/A
10		3 7		2 3 4	2437	23478	123478	1234578	N/A
11		4 8		1 3 4	1348	13478	134678	1234678	N/A
12	*V4*	1 5		5 7 8	3578	23578	235678	1235678	N/A
13		2 6		6 7 8	4678	14678	145678	1345678	N/A
14		3 7		5 7 6	5678	35678	345678	2345678	N/A
15		4 8		5 6 8	1568	13568	123568	1234568	N/A

The indexes from 1 to 7 and 9 to 15 are not used in 4-bit downlink PMI feedback for M_t = 8 codebook.

MU-MIMO base codebook

The base codebook for MU-MIMO is the same as the rank-1 base codebook for SU-MIMO.

Codebook subset selection

In codebook-based precoding with CL MIMO operation, the precoding matrix **W**(*k*) shall be derived from a PMI within the base codebook or a subset thereof. Subset information is transmitted in BC_SI and Codebook_subset indication.

The Base Codebook Subset Indication (BC_SI) field determines which elements of the rank-1 codebook are restricted or recommended for PMI feedback in case of MIMO mode 2 and 4. If the *i*-th element of BC_SI is set to 0, then the *i*-th element of the rank-1 codebook, $C(N_t, 1, N_B, i)$, is restricted for PMI feedback. This field shall be ignored when Codebook_mode is not set to 0b11. If Codebook_mode is set to 0b11 or Codebook_coordination is set to 0b1 when the ABS has four transmit antennas, then Codebook_subset shall be set to 0b1. Codebook_mode and Codebook_coordination are transmitted in the Feedback Allocation A-MAP IE or Feedback Polling A-MAP IE. If codebook coordination is enabled by Codebook_mode = 0b11 or Codebook_coordination 0b1 while the AMS did not receive an AAI-DL-IM message, then the AMS assumes that all BC_SI bit field are ones.

Codebook subsets

OL MIMO subset

The OL SU-MIMO codebook subset shall be used for non-adaptive precoding with MIMO mode 0, MIMO mode 1, and MIMO mode 5 in DLRU and NLRU.

The notation $C_{\mathrm{DL,OL,SU}}(N_t, M_t, N_w)$ denotes the DL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t, and M_t denotes the number of MIMO streams. The notation $C_{\mathrm{DL,OL,SU}}(N_t, M_t, N_w, i)$ denotes the i-th codebook entry of $C_{\mathrm{DL,OL,SU}}(N_t, M_t, N_w)$.

OL SU-MIMO subset for two transmit antennas

The codewords of the OL SU-MIMO codebook subset for two transmit antennas are given in Table 6-233 for each rank. The corresponding codewords of the DL base codebook for two transmit antennas are also given in Table 6-233.

Table 6-233—$C_{\mathrm{DL,OL,SU}}$(2,1,2) and $C_{\mathrm{DL,OL,SU}}$(2,2,1)

$C_{\mathrm{DL,OL,SU}}(2, 1, 2, n)$		$C_{\mathrm{DL,OL,SU}}(2, 2, 1, n)$	
n	**$C(2,1,3,m)$ in downlink base codebook**	***n***	**$C(2,2,3,m)$ in downlink base codebook**
0	$C(2,1,3,2)$	0	$C(2,2,3,2)$
1	$C(2,1,3,6)$		

OL SU-MIMO subset for four transmit antennas

The codewords of the OL SU-MIMO codebook subset for four transmit antennas are given in Table 6-234 for each rank. The corresponding codewords of the DL base codebook for four transmit antennas are given in Table 6-234.

Table 6-234—$C_{\mathrm{DL,OL,SU}}$(4,1,4), $C_{\mathrm{DL,OL,SU}}$(4,2,4), $C_{\mathrm{DL,OL,SU}}$(4,3,2), and $C_{\mathrm{DL,OL,SU}}$(4,4,1)

$C_{\mathrm{DL,OL,SU}}(4, 1, 4, n)$		$C_{\mathrm{DL,OL,SU}}(4, 2, 4, n)$		$C_{\mathrm{DL,OL,SU}}(4, 3, 2, n)$		$C_{\mathrm{DL,OL,SU}}(4, 4, 1, n)$	
n	**$C(4,1,6,m)$ in base codebook**	***n***	**$C(4,2,6,m)$ in base codebook**	***n***	**$C(4,3,6,m)$ in base codebook**	***n***	**$C(4,4,6,m)$ in base codebook**
0	$C(4,1,6,8)$	0	$C(4,2,6,23)$	0	$C(4,3,6,12)$	0	$C(4,4,6,4)$
1	$C(4,1,6,10)$	1	$C(4,2,6,29)$	1	$C(4,3,6,13)$		
2	$C(4,1,6,9)$	2	$C(4,2,6,27)$				
3	$C(4,1,6,11)$	3	$C(4,2,6,25)$				

OL SU-MIMO subset for eight transmit antennas

The codewords of the OL SU-MIMO codebook subset for eight transmit antennas are given in Table 6-235 and Table 6-236 for each rank. The corresponding codewords of the DL base codebook for eight transmit antennas are given in Table 6-235 and Table 6-236.

Table 6-235—$C_{DL,OL,SU}(8,1,8)$, $C_{DL,OL,SU}(8,2,4)$, $C_{DL,OL,SU}(8,3,4)$, and $C_{DL,OL,SU}(8,4,2)$

$C_{DL,OL,SU}(8, 1, 8, n)$		$C_{DL,OL,SU}(8, 2, 4, n)$		$C_{DL,OL,SU}(8, 3, 4, n)$		$C_{DL,OL,SU}(8, 4, 2, n)$	
n	***C*(8,1,4,*m*) in base codebook**	***n***	***C*(8,2,4,*m*) in base codebook**	***n***	***C*(8,3,4,*m*) in base codebook**	***n***	***C*(8,4,4,*m*) in base codebook**
0	*C*(8,1,4,0)	0	*C*(8,2,4,0)	0	*C*(8,3,4,0)	0	*C*(8,4,4,0)
1	*C*(8,1,4,3)	1	*C*(8,2,4,1)	1	*C*(8,3,4,1)	1	*C*(8,4,4,1)
2	*C*(8,1,4,5)	2	*C*(8,2,4,2)	2	*C*(8,3,4,2)		
3	*C*(8,1,4,7)	3	*C*(8,2,4,3)	3	*C*(8,3,4,5)		
4	*C*(8,1,4,9)						
5	*C*(8,1,4,11)						
6	*C*(8,1,4,13)						
7	*C*(8,1,4,15)						

Table 6-236—$C_{DL,OL,SU}(8,5,2)$, $C_{DL,OL,SU}(8,6,2)$, $C_{DL,OL,SU}(8,7,2)$, and $C_{DL,OL,SU}(8,8,1)$

$C_{DL,OL,SU}(8, 5, 2, n)$		$C_{DL,OL,SU}(8, 6, 2, n)$		$C_{DL,OL,SU}(8, 7, 2, n)$		$C_{DL,OL,SU}(8, 8, 1, n)$	
n	***C*(8,5,4,*m*) in base codebook**	***n***	***C*(8,6,4,*m*) in base codebook**	***n***	***C*(8,7,4,*m*) in base codebook**	***n***	***C*(8,8,4,*m*) in base codebook**
0	*C*(8,5,4,0)	0	*C*(8,6,4,0)	0	*C*(8,7,4,0)	0	*C*(8,8,**4**,0)
1	*C*(8,5,4,1)	1	*C*(8,6,4,1)	1	*C*(8,7,4,1)		

CL SU-MIMO subset for four transmit antennas

Codebook subset selection for four transmit antennas is specified in Table 6-237.

Table 6-237—Subset selection of the base codebook for four transmit antennas

Rank	One	Two	Three	Four
Subset selection	$C(4,1,6,m)$ m = 0 to15	$C(4,2,6,m)$ m = 0 to15	$C(4,3,6,m)$ m = 0 to15	$C(4,4,6,m)$ m = 0 to5

CL MU-MIMO subset for four transmit antennas

The base codebook subset for MU-MIMO is the same as the rank 1 of the base codebook subset for SU-MIMO, defined in Table 6-237.

6.3.6.2.5.5.1 Transformation codebook based feedback mode

The base codebooks and their subsets of rank 1 for SU and MU MIMO can be transformed as a function of the ABS transmit correlation matrix. A quantized representation of the ABS transmit correlation matrix shall be fed back by the AMS as instructed by the ABS.

For the transformation mode, the PMI feedback from a mobile station shall represent an entry of the transformed base codebook according to long-term channel information.

In transformation mode, both the ABS and the AMS transform the rank-1 base codebook to a rank-1 transformed codebook using the correlation matrix.

The transformation for codewords of rank-1 is of the form in Equation (260).

$$\tilde{\boldsymbol{v}}_i = \frac{\boldsymbol{R}\boldsymbol{v}_i}{\|\boldsymbol{R}\boldsymbol{v}_i\|} \tag{260}$$

where

$\boldsymbol{v}_i$ is the i-th codeword of the base codebook.

$\tilde{\boldsymbol{v}}_i$ is the i-th codeword of the transformed codebook.

$\mathbf{R}$ is the $N_t \times N_t$ transmit correlation matrix.

After obtaining the transformed codebook, both the AMS and the ABS shall use the transformed codebook for the feedback and precoding process of rank-1. The codebooks of rank > 1 shall be used without transformation when the AMS is operating with transformation codebook-based feedback mode.

The correlation matrix **R** shall be fed back to support the transformation mode of codebook-based precoding.

R is fed back periodically, and one correlation matrix is valid for whole band.

During some time period and in the whole band, the correlation matrix is measured as

$$\mathbf{R} = \mathrm{E}(\mathbf{H}_{ij}^{H}\mathbf{H}_{ij}) \tag{261}$$

where $\mathbf{H}_{ij}$ is the correlated channel matrix in the i-th OFDM symbol period and j-th the subcarriers.

The measured correlation matrix has the format of

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} \\ \mathrm{conj}(r_{12}) & r_{22} \end{bmatrix} \qquad (N_t = 2) \tag{262}$$

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} \\ \mathrm{conj}(r_{12}) & r_{22} & r_{23} & r_{24} \\ \mathrm{conj}(r_{13}) & \mathrm{conj}(r_{23}) & r_{33} & r_{34} \\ \mathrm{conj}(r_{14}) & \mathrm{conj}(r_{24}) & \mathrm{conj}(r_{34}) & r_{44} \end{bmatrix} \qquad (N_t = 4) \tag{263}$$

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} & r_{16} & r_{17} & r_{18} \\ \mathrm{conj}(r_{12}) & r_{22} & r_{23} & r_{24} & r_{25} & r_{26} & r_{27} & r_{28} \\ \mathrm{conj}(r_{13}) & \mathrm{conj}(r_{23}) & r_{33} & r_{34} & r_{35} & r_{36} & r_{37} & r_{38} \\ \mathrm{conj}(r_{14}) & \mathrm{conj}(r_{24}) & \mathrm{conj}(r_{34}) & r_{44} & r_{45} & r_{46} & r_{47} & r_{48} \\ \mathrm{conj}(r_{15}) & \mathrm{conj}(r_{25}) & \mathrm{conj}(r_{35}) & \mathrm{conj}(r_{45}) & r_{55} & r_{56} & r_{57} & r_{58} \\ \mathrm{conj}(r_{16}) & \mathrm{conj}(r_{26}) & \mathrm{conj}(r_{36}) & \mathrm{conj}(r_{46}) & \mathrm{conj}(r_{56}) & r_{66} & r_{67} & r_{68} \\ \mathrm{conj}(r_{17}) & \mathrm{conj}(r_{27}) & \mathrm{conj}(r_{37}) & \mathrm{conj}(r_{47}) & \mathrm{conj}(r_{57}) & \mathrm{conj}(r_{67}) & r_{77} & r_{78} \\ \mathrm{conj}(r_{18}) & \mathrm{conj}(r_{28}) & \mathrm{conj}(r_{38}) & \mathrm{conj}(r_{48}) & \mathrm{conj}(r_{58}) & \mathrm{conj}(r_{68}) & \mathrm{conj}(r_{78}) & r_{88} \end{bmatrix} \qquad (N_t = 8) \tag{264}$$

where the diagonal entries are positive and the non-diagonal entries are complex. Because of the symmetry of the correlation matrix, only the upper triangular elements shall be fed back after quantization.

The **R** matrix is normalized by the maximum element amplitude, and then quantized to reduce the feedback overhead.

The equation of normalization is

$$\bar{R} = \frac{R}{\max(\mathrm{abs}(r_{ij}))} \qquad (i, j = 1, \ldots, N_t) \tag{265}$$

The normalized diagonal elements are quantized by 1 bit, and the normalized complex elements are quantized by 4 bits.

The equation for quantization is

$$q = a \cdot e^{(j \cdot b \cdot 2\pi)} \tag{266}$$

a = [0.6 0.9] and b = 0 for diagonal entries

Table 6-238—Quantization parameters for diagonal entries of *R*

Diagonal entries	Binary encoding	*a*	*b*	*q*
q_1	0	0.6	0	0.6000
q_2	1	0.9	0	0.9000

a = [0.1 0.5] and b = [0 1/8 1/4 3/8 1/2 5/8 3/4 7/8] for non-diagonal upper triangular entries.

Table 6-239—Quantization parameters for non-diagonal entries of *R*

Non-diagonal entries	Binary encoding	*a*	*b*	*q*
q_1	0000	0.1	0	0.1000
q_2	0001	0.1	1/8	0.0707 + 0.0707i
q_3	0010	0.1	1/4	0.1000i
q_4	0011	0.1	3/8	–0.0707 + 0.0707i
q_5	0100	0.1	1/2	–0.1000
q_6	0101	0.1	5/8	–0.0707 – 0.0707i
q_7	0110	0.1	3/4	–0.1000i
q_8	0111	0.1	7/8	0.0707 – 0.0707i
q_9	1000	0.5	0	0.5000
q_{10}	1001	0.5	1/8	0.3536 + 0.3536i
q_{11}	1010	0.5	1/4	0.5000i
q_{12}	1011	0.5	3/8	–0.3536 + 0.3536i
q_{13}	1100	0.5	1/2	–0.5000
q_{14}	1101	0.5	5/8	–0.3536 – 0.3536i
q_{15}	1110	0.5	3/4	–0.5000i
q_{16}	1111	0.5	7/8	0.3536 – 0.3536i

The value of q represents an element of $\bar{R}$, as described in Table 6-238 and Table 6-239. The total number of bits of feedback is 6 bits for 2 transmit antennas, 28 bits for 4 transmit antennas, and 120 bits for 8 transmit antennas. The AMS and the ABS shall use the same transformation based on the correlation matrix fed back by the AMS.

6.3.6.2.5.5.2 Differential codebook-based feedback mode

The differential feedbacks exploit the correlation between precoding matrixes adjacent in time or frequencies. The feedback shall start initially and restart periodically by sending a one-shot feedback that fully depicts the precoder by itself. At least one differential feedback shall follow the start and restart feedback. The start and restart feedback employs the codebook defined for the base mode and is sent through long-term report defined in Feedback Allocation A-MAP IE for MFM 3 and 6. The differential feedback is sent through the short-term report defined in Feedback Allocation A-MAP IE for MFM 3 and 6.

Denote the feedback index, the corresponding feedback matrix, and the corresponding precoder by t, $\boldsymbol{D}(t)$, and $\boldsymbol{V}(t)$, respectively. The sequential index is reset to 0 at $T_{max} + 1$. The index for the start and restart feedbacks are 0. Let $\boldsymbol{A}$ be a vector or a matrix and $\boldsymbol{Q}_{\boldsymbol{A}}$ be the rotation matrix determined by $\boldsymbol{A}$. The indexes of the subsequent differential feedbacks are 1, 2, ..., T_{max} and the corresponding precoders are

$\boldsymbol{V}(t) = \boldsymbol{Q}_{\boldsymbol{V}(t-1)}\boldsymbol{D}(t)$, for $t = 0,1, 2, ..., T_{max}$

where the rotation matrix $\boldsymbol{Q}_{\boldsymbol{V}(t-1)}$ is a unitary $N_t \times N_t$ matrix computed from the previous precoder $\boldsymbol{V}(t-1)$; N_t is the number of transmit antennas. The dimension of the feedback matrix $\boldsymbol{D}(t)$ is $N_t \times M_t$, where M_t is the number of spatial streams.

$\boldsymbol{Q}_{\boldsymbol{V}(t-1)}$ has the form $\boldsymbol{Q}_{V(t-1)} = \left[\boldsymbol{V}(t-1)\ \boldsymbol{V}^{\perp}(t-1)\right]$, where $\boldsymbol{V}^{\perp}(t-1)$ consists of columns each of which has a unit norm and is orthogonal to the other columns of $\boldsymbol{Q}_{\boldsymbol{V}(t-1)}$. For $M_t = 1$, where $\boldsymbol{V}(t-1)$ is a vector,

$$\boldsymbol{Q}_{V(t-1)} = \begin{cases} \boldsymbol{I} - \dfrac{2}{\|\omega\|^2}\omega\omega^H, \text{ for } \|\omega\| > 0 \\ \boldsymbol{I}, \text{ otherwise} \end{cases}$$

where $\|\boldsymbol{V}(t-1)\| = 1$ and $\omega = e^{-j\theta}\boldsymbol{V}(t-1) - \boldsymbol{e}_1$; θ is the phase of the first entry of $\boldsymbol{V}(t-1)$, and $\boldsymbol{e}_1 = [1\ 0\ ...\ 0]^T$. For $M_t > 1$, let $L = N_t - M_t$. For computing $\boldsymbol{Q}_{\boldsymbol{V}(t-1)}$, L columns are appended to $\boldsymbol{V}(t-1)$ forming a square matrix $\boldsymbol{M} = [\boldsymbol{V}(t-1)\ \boldsymbol{E}]$ and the appended columns are

$$\boldsymbol{E} = \left[\boldsymbol{e}_{\tau_1} \ \dots \ \boldsymbol{e}_{\tau_L}\right]$$

where $\boldsymbol{e}_{\tau_j}$ is the $N_t \times 1$ vector whose entry on the τ_j-th row is one and whose other entries are zeros. $\boldsymbol{Q}_{\boldsymbol{V}(t-1)}$ is computed by orthogonalizing and normalizing the columns of $\boldsymbol{M}$. The indexes τ_j for $j = 1, ..., L$ are selected for the numerical stability of the orthogonalization and normalization process. Let

$$\boldsymbol{g} = (|\mathrm{Re}(\boldsymbol{V}(t-1))| + |\mathrm{Im}(\boldsymbol{V}(t-1))|)\boldsymbol{a}$$

where $\boldsymbol{a}$ is the $1 \times M_t$ vector with all entries equal to one; Re() and Im() take the real and imaginary parts of the input matrix, respectively; | | takes the absolute values of the input matrix entry by entry. The i-th row of the vector $\boldsymbol{g}$ has the sum of the absolute values of all the real and imaginary parts of $\boldsymbol{V}(t-1)$ on the same row. The entries of $\boldsymbol{g}$ are stored in an increasing order. If $\boldsymbol{g}_i = \boldsymbol{g}_j$ and $i < j$, then $\boldsymbol{g}_i < \boldsymbol{g}_j$ is used in the order list. The order list is

$$\boldsymbol{g}_{k_1} < \dots < \boldsymbol{g}_{k_{N_t}}$$

where k_i for $i = 1, ..., \boldsymbol{N}_t$ are row indexes of $\boldsymbol{g}$. The first L indexes in the list are assigned to the indexes τ_j in $\boldsymbol{E}$ as

$$\tau_j = k_j, \text{ for } j = 1, \dots, L$$

The Gram-Schmidt orthogonalization and a normalization process are applied to the last L columns of $\boldsymbol{M}$ column by column and result in $\boldsymbol{Q}_{\boldsymbol{V}(t-1)}$ as

For $j = 1$: L

For $k = 1$: $j + M_t - 1$

$$\boldsymbol{m}_{j+M_t} = \boldsymbol{m}_{j+M_t} - \boldsymbol{m}^*_{\tau_j,k}\boldsymbol{m}_k$$

End

$$\boldsymbol{m}_{j+M_t} = \frac{\boldsymbol{m}_{j+M_t}}{\|\boldsymbol{m}_{j+M_t}\|}$$

End

$$\boldsymbol{Q}_{V(t-1)} = M$$

where $\boldsymbol{m}^*_{\tau_j, k}$ is the conjugate of $\boldsymbol{M}$'s entry on the τ_j -th row and k-th column.

The feedback matrix $\boldsymbol{D}(t)$ is selected from a differential codebook. Denote the codebook by $D(N_t, M_t\, N_w)$, where N_w is the number of codewords in the codebook. The codebooks $D(2,1,4)$, $D(2,2,4)$, $D(4,1,16)$, $D(4,2,16)$, $D(8,1,16)$, $D(8,2,16)$, $D(8,3,16)$, and $D(8,4,16)$ are listed in Table 6-240 through Table 6-247. Denote $\boldsymbol{D}_i(N_t,M_t,N_w)$ the i-th codeword of $D(N_t, M_t\, N_w)$. The rotation matrixes $\boldsymbol{Q}_{D_i(N_t, M_t, N_w)}$s of the $\boldsymbol{D}_\mathrm{i}(N_t,M_t,N_w)$s comprise a set of N_t by N_t matrixes that are denoted by $\boldsymbol{Q}_{D(N_t, M_t, N_w)}$.

The differential codebook $D(4,3,N_w)$ is computed from $\boldsymbol{Q}_{D(4,\,1,\,N_w)}$. The i-th codeword of $D(4,3,N_w)$ denoted by $\boldsymbol{D}_i(4,3,N_w)$ is computed as

$$\boldsymbol{D}_i(4,3,N_w) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} \tilde{\boldsymbol{Q}}_i(4,1,N_w)$$

where $\tilde{Q}_i(4,1,N_w)$ consists of the last three columns of the i-th matrix in $\boldsymbol{Q}_{D(4,\,1,\,N_w)}$. The differential codebook $D(4,4,N_w)$ is computed from $\boldsymbol{Q}_{D(4,\,2,\,N_w)}$. The i-th codeword of $D(4,4,N_w)$ is the i-th matrix in $\boldsymbol{Q}_{D(4,\,2,\,N_w)}$. The differential codebooks $D(8,5,N_w)$, $D(8,6,N_w)$, and $D(8,7,N_w)$ are computed from $D(8,3,N_w)$, $D(8,2,N_w)$, and $D(8,1,N_w)$, respectively. The i-th codewords $\boldsymbol{D}_i(8,5,N_w)$, $\boldsymbol{D}_i(8,6,N_w)$, and $\boldsymbol{D}_i(8,7,N_w)$ of $D(8,5,N_w)$, $D(8,6,N_w)$, and $D(8,7,N_w)$ are computed, respectively, as

$$\boldsymbol{D}_i(8,5,N_w) = \begin{bmatrix} 0&0&0&1&0&0&0&0 \\ 0&0&0&0&1&0&0&0 \\ 0&0&0&0&0&1&0&0 \\ 0&0&0&0&0&0&1&0 \\ 0&0&0&0&0&0&0&1 \\ 1&0&0&0&0&0&0&0 \\ 0&1&0&0&0&0&0&0 \\ 0&0&1&0&0&0&0&0 \end{bmatrix} \tilde{\boldsymbol{Q}}_i(8,3,N_w)$$

$$\boldsymbol{D}_i(8,6,N_w) = \begin{bmatrix} 0&0&1&0&0&0&0&0 \\ 0&0&0&1&0&0&0&0 \\ 0&0&0&0&1&0&0&0 \\ 0&0&0&0&0&1&0&0 \\ 0&0&0&0&0&0&1&0 \\ 0&0&0&0&0&0&0&1 \\ 1&0&0&0&0&0&0&0 \\ 0&1&0&0&0&0&0&0 \end{bmatrix} \tilde{\boldsymbol{Q}}_i(8,2,N_w)$$

$$\boldsymbol{D}_i(8,7,N_w) = \begin{bmatrix} 0&1&0&0&0&0&0&0 \\ 0&0&1&0&0&0&0&0 \\ 0&0&0&1&0&0&0&0 \\ 0&0&0&0&1&0&0&0 \\ 0&0&0&0&0&1&0&0 \\ 0&0&0&0&0&0&1&0 \\ 0&0&0&0&0&0&0&1 \\ 1&0&0&0&0&0&0&0 \end{bmatrix} \tilde{\boldsymbol{Q}}_i(8,1,N_w)$$

where $\tilde{\boldsymbol{Q}}_i(8,k,N_w)$ consists of the last 8-k columns of the i-th matrix in $\boldsymbol{Q}_{D(8,k,Nw)}$. The differential codebook $D(8,8,N_w)$ is computed from $D(8,4,N_w)$. The i-th code word of $D(8,8,N_w)$ is the i-th matrix in $\boldsymbol{Q}_{D(8,4,Nw)}$.

Table 6-240—*D*(2,1,4) codebook

Index	Codeword	Index	Codeword
1	$\begin{bmatrix}1 & 0\end{bmatrix}^T$	3	$\begin{bmatrix}\cos(15°) & \sin(15°)\exp(j120°)\end{bmatrix}^T$
2	$\begin{bmatrix}\cos(15°) & \sin(15°)\end{bmatrix}^T$	4	$\begin{bmatrix}\cos(15°) & \sin(15°)\exp(-j120°)\end{bmatrix}^T$

Table 6-241—*D*(2,2,4) codebook

Index	Codeword	Index	Codeword
1	$\begin{bmatrix}1 & 0 \\ 0 & 1\end{bmatrix}$	3	$\begin{bmatrix}\cos(15°) & \sin(15°)\exp(j120°) \\ \sin(15°)\exp(j120°) & -\cos(15°)\end{bmatrix}$
2	$\begin{bmatrix}\cos(15°) & \sin(15°) \\ \sin(15°) & -\cos(15°)\end{bmatrix}$	4	$\begin{bmatrix}\cos(15°) & \sin(15°)\exp(-j120°) \\ \sin(15°)\exp(-j120°) & -\cos(15°)\end{bmatrix}$

Table 6-242—*D*(4,1,16) codebook

Index	Codeword	Index	Codeword
1	[1 0 0 0]^T	9	[cos(20^o) 0.2553 + 0.1430i 0.0282 + 0.0897i 0.1469 + 0.0308i]^T
2	[cos(20^o) 0.2062 – 0.0657i 0.0485 – 0.2038i – 0.0885 + 0.1358i]^T	10	[cos(20^o) 0.0507 – 0.3289i 0.0276 + 0.0448i 0.0508 – 0.0297i]^T
3	[cos(20^o) – 0.0531 – 0.0765i 0.0806 – 0.1811i – 0.1432 – 0.2203i]^T	11	[cos(20^o) –0.0352 + 0.2445i 0.0560 + 0.1197i – 0.1178 – 0.1569i]^T
4	[cos(20^o) -0.0762 - 0.1024i -0.2492 - 0.1865i 0.0616 + 0.0028i]^T	12	[cos(20^o) –0.0505 – 0.0233i –0.1061 + 0.3140i 0.0505 + 0.0382i]^T
5	[cos(20^o) – 0.0475 – 0.0535i 0.0266 – 0.0109i 0.1997 + 0.2668i]^T	13	[cos(20^o) – 0.3407 – 0.0014i 0.0280 + 0.0108i 0.0021 + 0.0020i]^T
6	[cos(20^o) – 0.0478 – 0.0010i –0.0229 + 0.0325i 0.2359 – 0.2397i]^T	14	[cos(20^o) – 0.0180 – 0.0100i 0.3300 + 0.0502i 0.0685 – 0.0205i]^T
7	[cos(20^o) 0.0030 + 0.1854i –0.1733 –0.1136 + 0.1992i]^T	15	[cos(20^o) – 0.0401 – 0.0885i 0.0946 + 0.1084i – 0.2792 + 0.0942i]^T
8	[cos(20^o) 0.1926 – 0.0378i – 0.1914 + 0.0534i – 0.1467 – 0.1320i]^T	16	[cos(20^o) – 0.0436 + 0.2160i 0.0596 – 0.2318i 0.1057 + 0.0002i]^T

Table 6-243—*D*(4,2,16) codebook

Index	Codeword	Index	Codeword
1	[1 0 0 0 0 1 0 0]^T	9	[0.9770 0.1518 + 0.0929i 0.0606 – 0.0773i 0.0063 – 0.0647i –0.0507 – 0.1011i – 0.0981 + 0.8703i –0.1618 – 0.0957i – 0.3914 + 0.1776i]^T
2	[0.9571 – 0.0238 + 0.0314i –0.0454 – 0.2541i –0.0790 + 0.0977i –0.0965 + 0.0299i 0.9114 + 0.0872i –0.0431 – 0.3386i –0.1023 + 0.1567i]^T	10	[–0.6295 – 0.5472 – 0.3123i –0.0136 – 0.1891i 0.2222 – 0.3486i 0.5496 – 0.3201i –0.7539 – 0.0022i 0.0440 + 0.0657i –0.0189 + 0.1434i]^T
3	[–0.0262 0.7460 – 0.6224i 0.2085 + 0.1061i 0.0104 – 0.0226i 0.6933 + 0.5709i 0.1217 + 0.0055i –0.1479 – 0.3702i –0.1061 – 0.0917i]^T	11	[0.3622 – 0.8103 – 0.3554i 0.0797 – 0.2550i –0.1050 + 0.0596i – 0.8270 + 0.3289i –0.2410 – 0.0429i –0.1349 – 0.3222i –0.0937 + 0.1311i]^T
4	[0.9990 0.0386 – 0.0212i 0.0035 – 0.0023i 0.0002 + 0.0019i –0.0343 – 0.0200i 0.8730 + 0.0488i 0.3473 – 0.1714i 0.2857 – 0.0483i]^T	12	[–0.4402 –0.8115 – 0.0841i 0.0434 + 0.1299i –0.1636 + 0.3083i –0.7666 + 0.1113i 0.5535 + 0.0180i 0.0170 + 0.1186i –0.1660 + 0.2268i]^T

Table 6-243—*D*(4,2,16) codebook *(continued)*

Index	Codeword	Index	Codeword
5	[0.9556 0.1479 – 0.0806i –0.0215 + 0.1307i –0.0706 – 0.1894i –0.0844 + 0.0610i 0.8284 – 0.3568i 0.1996 – 0.1472i –0.1478 + 0.3037i]^T	13	[1 0 0 0 0 –0.8741 + 0.0445i 0.3194 – 0.1760i 0.3172 – 0.0173i]^T
6	[–0.8726 0.1100 – 0.0735i –0.4250 – 0.1821i –0.0795 + 0.0325i 0.1648 + 0.1221i 0.9722 – 0.0007i –0.0410 – 0.1039i 0.0018 + 0.0180i]^T	14	[–0.8851 –0.3025 + 0.3449i 0.0049 + 0.0437i –0.0340 – 0.0557i 0.2630 + 0.2692i –0.7941 – 0.0049i 0.2671 – 0.0632i –0.2947 + 0.2561i]^T
7	[–0.6845 –0.0048 – 0.7234i 0.0310 – 0.0167i 0.0831 + 0.0006i 0.0085 + 0.6243i 0.6200 + 0.0054i –0.3294 – 0.2343i 0.2292 – 0.0994i]^T	15	[0.8990 –0.1582 – 0.1183i 0.1246 – 0.0775i –0.3616 – 0.0214i 0.0035 + 0.2203i –0.8650 + 0.3492i –0.0464 + 0.0693i 0.2338 + 0.1398i]^T
8	[0.5617 0.8043 + 0.1719i –0.0617 – 0.0099i 0.0607 – 0.0241i 0.7006 – 0.1414i –0.5130 – 0.0152i –0.1561 + 0.2422i 0.3191 + 0.2023i]^T	16	[0.5212 0.3746 + 0.7570i 0.0670 + 0.1016i –0.0085 – 0.0003i 0.3025 – 0.7018i –0.4381 + 0.0708i –0.2495 – 0.2784i 0.2622 – 0.1028i]^T

Table 6-244—*D*(8,1,16) codebook

Index	Codeword	Index	Codeword
1	[cos(20^o) 0 –0.1449 – 0.1483i 0.0019 + 0.0060i 0.0336 + 0.0253i –0.0242 – 0.1235i –0.2259 + 0.0069i 0.0409 – 0.0598i]^T	9	[cos(20^o) 0 0.1314 + 0.0144i 0.0509 + 0.0237i 0.0301 + 0.0390i 0.0311 + 0.0019i –0.0091 + 0.0202i 0.2958 + 0.0708i]^T
2	[cos(20^o) 0 –0.0005 + 0.0004i 0.0334 + 0.0152i 0.0022 + 0.0207i –0.0651 + 0.1824i 0.0153 + 0.2095i –0.0093 – 0.1830i]^T	10	[cos(20^o) 0 0.0292 + 0.0247i –0.3217 + 0.1076i –0.0073 + 0.0175i 0.0049 + 0.0013i 0.0048 – 0.0017i –0.0004 – 0.0001i]^T
3	[cos(20^o) 0.3402 – 0.0352i 0 0 0 0 0 0]^T	11	[cos(20^o) 0 0.0702 – 0.0699i 0.0279 – 0.0024i 0.0380 + 0.0396i –0.0493 – 0.0118i –0.0215 + 0.1480i –0.1441 + 0.2401i]^T
4	[cos(20^o) 0 –0.0264 – 0.0267i 0.0602 + 0.0858i 0.0281 + 0.0282i 0.2700 + 0.1283i –0.0290 – 0.0870i –0.0700 + 0.0173i]^T	12	[cos(20^o) 0 –0.1352 + 0.2709i 0.0727 + 0.1069i –0.0037 – 0.0066i –0.0406 – 0.0670i –0.0100 + 0.0186i –0.0156 + 0.0413i]^T
5	[cos(20^o) –0.2005 – 0.2771i 0 0 0 0 0 0]^T	13	[cos(20^o) 0 –0.1771 – 0.1261i 0.0068 + 0.0073i 0.0303 – 0.0033i –0.0678 + 0.0243i 0.2320 – 0.0669i 0.0581 + 0.0424i]^T

Table 6-244—*D*(8,1,16) codebook *(continued)*

Index	Codeword	Index	Codeword
6	[cos(20°) 0 –0.0368 + 0.0937i –0.0494 – 0.3041i 0.0844 + 0.0300i 0.0619 + 0.0044i 0.0004 – 0.0052i –0.0043 – 0.0018i]^T	14	[cos(20°) 0 0.0091 – 0.0155i 0.0183 – 0.0622i –0.3302 + 0.0486i 0.0145 – 0.0213i 0.0072 – 0.0162i –0.0063 + 0.0050i]^T
7	[cos(20°) 0 0.1291 – 0.0176i 0.0518 + 0.0286i 0.0540 + 0.0451i 0.0479 – 0.2164i 0.1215 + 0.0023i –0.0800 – 0.1457i]^T	15	[cos(20°) 0 0.0473 – 0.0160i 0.0085 – 0.0123i 0.0046 – 0.3373i 0.0003 – 0.0018i –0.0172 – 0.0097i –0.0070 – 0.0022i]^T
8	[cos(20°) 0 0.1048 + 0.0160i 0.0387 – 0.0003i 0.0357 + 0.0531i –0.1838 + 0.0992i –0.0685 – 0.2188i –0.0579 – 0.0243i]^T	16	[cos(20°) –0.1397 + 0.3122i 0 0 0 0 0 0]^T

Table 6-245—*D*(8,2,16) codebook

Index	Codeword	Index	Codeword
1	[0.7331 0.5926 – 0.0231i –0.0036 – 0.1045i –0.0006 + 0.2627i 0.0545 + 0.1414i –0.0320 – 0.0143i 0.0665 – 0.0168i 0.0219 – 0.0397i 0.5425 + 0.1393i –0.7031 – 0.2625i 0.0237 + 0.0141i –0.1884 + 0.1499i –0.2074 – 0.0770i 0.0188 + 0.0326i 0.0117 – 0.0680i –0.0831 + 0.0480i]^T	9	[0.4805 0.4783 + 0.6827i 0.0742 – 0.1408i –0.0160 – 0.1621i 0.0606 + 0.1005i –0.0429 – 0.0279i 0.0086 – 0.0629i 0.0331 – 0.0307i 0.4265 – 0.6231i –0.5197 + 0.0132i –0.2630 – 0.1531i –0.1293 – 0.0967i 0.0014 + 0.1463i –0.0259 – 0.0655i 0.0028 + 0.0110i –0.1108 – 0.0468i]^T
2	[0.9982 –0.0307 + 0.0185i 0.0165 – 0.0095i –0.0101 + 0.0149i 0.0172 + 0.0310i –0.0025 + 0.0122i –0.0153 + 0.0006i 0.0036 + 0.0045i 0.0119 + 0.0176i 0.8584 + 0.1763i 0.2087 + 0.1178i 0.0105 + 0.1397i 0.0008 + 0.1248i 0.1068 – 0.0086i –0.2813 + 0.0375i –0.2150 – 0.0270i]^T	10	[0.7753 –0.3773 + 0.3664i 0.1663 – 0.0282i –0.0184 – 0.0221i –0.0261 + 0.0896i 0.0229 + 0.0120i –0.1158 + 0.1945i 0.1034 + 0.1477i –0.3397 – 0.3554i –0.8030 – 0.0429i 0.0130 – 0.1029i –0.0238 + 0.1384i 0.0673 – 0.0364i –0.1714 + 0.1669i 0.0240 – 0.0733i 0.0818 – 0.0731i]^T
3	[0.7810 –0.3012 – 0.4935i –0.0369 + 0.0117i 0.0702 + 0.0235i 0.0389 – 0.1200i –0.0083 + 0.0028i –0.0039 – 0.0031i 0.0042 – 0.1812i –0.2917 + 0.4051i –0.7501 – 0.1000i 0.0137 – 0.2081i 0.0161 + 0.0871i –0.0084 – 0.0017i –0.1035 + 0.1564i –0.1068 + 0.0323i 0.0652 + 0.2736i]^T	11	[0.3182 –0.2057 – 0.8830i –0.2196 + 0.0726i 0.0033 – 0.0454i –0.0636 + 0.0583i –0.1093 + 0.0243i –0.0271 + 0.0176i –0.0090 – 0.0040i –0.1635 + 0.8561i –0.2843 + 0.0466i –0.1400 + 0.0865i 0.0591 – 0.0841i 0.0559 – 0.0177i 0.0486 + 0.0383i –0.0666 + 0.0772i 0.1809 – 0.2632i]^T
4	[0.8043 0.3748 + 0.3648i –0.0533 – 0.0589i –0.0633 + 0.1438i 0.0348 – 0.0730i 0.0961 – 0.0319i –0.1343 + 0.0879i –0.0682 – 0.0365i 0.3215 – 0.3635i –0.7751 + 0.0967i 0.1544 – 0.0618i 0.0828 – 0.1355i –0.0084 – 0.0067i 0.0014 – 0.2908i –0.0191 + 0.0942i –0.0372 – 0.0792i]^T	12	[–0.3234 0.7888 – 0.3649i 0.0076 + 0.0156i 0.0357 – 0.1612i 0.0339 – 0.2275i 0.0959 + 0.0443i 0.0004 + 0.0168i 0.0497 + 0.2136i 0.8260 + 0.3813i 0.2801 + 0.0005i 0.0038 + 0.0874i 0.0225 – 0.0316i 0.1892 – 0.1231i –0.1147 – 0.0750i 0.0119 – 0.0018i 0.1037 + 0.0647i]^T

Table 6-245—*D*(8,2,16) codebook *(continued)*

Index	Codeword	Index	Codeword
5	[0.5906 0.6836 + 0.3391i 0.0254 – 0.0522i –0.0033 – 0.0064i –0.0742 – 0.0233i 0.0578 + 0.2084i 0.0648 + 0.0566i 0.0582 – 0.0438i 0.6312 – 0.3373i –0.5667 + 0.0404i 0.0895 – 0.0844i –0.0327 + 0.1047i 0.2891 + 0.0104i 0.0371 + 0.0600i 0.1394 – 0.1392i –0.0530 – 0.0871i]^T	13	[0.3656 0.8256 + 0.4141i –0.0588 – 0.0494i 0.0423 + 0.0338i 0.0143 + 0.0201i 0.0300 + 0.0266i –0.0221 – 0.0407i 0.0002 – 0.0009i 0.7251 – 0.3787i –0.3311 + 0.0195i 0.0826 + 0.1751i 0.2469 – 0.2065i 0.0006 + 0.1599i –0.0584 + 0.0225i –0.0095 – 0.1962i 0.0985 + 0.0436i]^T
6	[0.7608 –0.3305 – 0.4863i 0.0327 – 0.0252i 0.0042 + 0.0409i 0.1037 – 0.1133i –0.0175 + 0.0343i –0.0551 – 0.2083i –0.0130 + 0.0173i –0.3420 + 0.4389i –0.7238 – 0.0889i –0.0077 – 0.0605i 0.2502 – 0.0639i –0.0380 – 0.0235i –0.1133 + 0.0376i 0.0260 + 0.0954i –0.1004 – 0.2282i]^T	14	[0.8383 0.3273 – 0.3389i –0.1469 + 0.0138i 0.0247 – 0.1717i 0.0374 + 0.0834i –0.1073 + 0.0159i 0.0011 + 0.0009i –0.0285 + 0.0499i 0.2951 + 0.4061i –0.7403 – 0.2034i 0.1478 – 0.0082i –0.0665 + 0.1009i 0.1452 – 0.2706i 0.1000 – 0.1133i 0.0176 + 0.0080i 0.0547 – 0.0409i]^T
7	[0.8091 –0.0679 + 0.4526i –0.1428 + 0.0777i 0.0297 + 0.0645i 0.0349 – 0.0672i 0.1223 – 0.1543i 0.0695 – 0.1274i 0.0416 + 0.1928i –0.0559 – 0.5020i –0.8029 – 0.0460i –0.0144 + 0.0600i 0.0463 + 0.1478i 0.1112 + 0.1072i –0.0349 – 0.0328i 0.1677 + 0.0966i –0.0813 + 0.0025i]^T	15	[0.5673 –0.7044 – 0.1966i 0.0361 – 0.0742i –0.0432 – 0.1203i –0.0975 + 0.0120i 0.1570 + 0.1415i 0.0797 – 0.0941i 0.0535 + 0.2187i –0.7468 + 0.1299i –0.5644 – 0.1277i 0.0756 – 0.0076i 0.0581 – 0.0054i 0.0732 + 0.2159i 0.0866 – 0.0548i –0.1056 – 0.0838i 0.0239 – 0.0117i]^T
8	[0.4004 –0.0626 + 0.9120i 0.0169 + 0.0173i 0.0287 – 0.0063i 0.0118 – 0.0260i 0.0212 – 0.0010i 0.0001 + 0.0000i 0.0036 + 0.0353i –0.0445 – 0.8045i –0.3473 – 0.0162i –0.0098 + 0.0361i 0.0631 – 0.0504i 0.0326 – 0.0490i 0.3000 + 0.1502i 0.1134 + 0.3039i –0.0242 + 0.0144i]^T	16	[0.7254 0.3107 – 0.5519i 0.1002 – 0.1052i 0.0985 – 0.0160i –0.0267 + 0.0652i 0.0733 + 0.0504i 0.0221 – 0.1643i –0.0161 – 0.0314i 0.3179 + 0.5933i –0.6201 – 0.0324i –0.2257 + 0.0442i –0.0206 – 0.0281i 0.0571 – 0.0204i 0.0177 – 0.2066i –0.2054 + 0.0506i –0.0695 + 0.1044i]^T

Table 6-246—*D*(8,3,16) codebook

Index	Codeword	Index	Codeword
1	[0.0623 0.1129 – 0.5018i 0.8368 + 0.1673i –0.0478 – 0.0049i 0.0014 + 0.0129i –0.0019 – 0.0002i 0.0079 + 0.0269i 0.0003 + 0.0028i –0.1646 + 0.3583i 0.7292 – 0.1312i –0.0792 – 0.4633i –0.0540 – 0.0072i –0.0122 – 0.1037i 0.0510 + 0.0261i 0.0304 + 0.1643i –0.1684 + 0.0353i –0.2248 + 0.7132i –0.3654 + 0.0609i 0.0484 + 0.1682i –0.2036 – 0.0051i –0.0259 + 0.1150i –0.2556 + 0.1771i 0.0827 + 0.1981i –0.2471 – 0.1172i]^T	9	[0.7649 0.3205 – 0.0211i 0.4153 + 0.1314i 0.2189 – 0.1860i 0.0114 – 0.0216i –0.0591 + 0.0580i 0.0881 – 0.1073i 0.0818 + 0.0783i 0.0433 – 0.0716i 0.7711 + 0.1015i –0.5195 – 0.2159i 0.0542 + 0.1110i –0.0109 + 0.0316i –0.0634 – 0.1481i –0.1228 + 0.0577i 0.0534 – 0.0890i –0.6047 + 0.1834i 0.4269 – 0.0363i 0.5060 – 0.0612i 0.1320 – 0.2992i 0.0146 + 0.0117i –0.1467 + 0.0661i 0.0274 – 0.1175i 0.0839 + 0.0509i]^T
2	[0.9444 0.0451 + 0.0621i –0.1710 – 0.1408i –0.0372 – 0.1402i 0.0058 – 0.0476i 0.0289 + 0.0006i 0.1531 + 0.0643i 0.0265 + 0.0255i –0.1452 + 0.0054i 0.7877 + 0.1580i –0.1993 – 0.3990i –0.2059 – 0.1390i –0.0455 + 0.1035i 0.1068 + 0.0248i –0.1816 + 0.0824i 0.0408 – 0.0812i 0.1620 + 0.1411i 0.4152 + 0.0123i 0.4263 + 0.6605i –0.0451 – 0.0270i –0.1498 + 0.0377i 0.1237 – 0.0730i 0.0116 – 0.1950i 0.1459 – 0.2379i]^T	10	[0.1626 –0.3784 + 0.5088i –0.6973 + 0.1601i 0.0820 – 0.0051i –0.0966 – 0.0036i –0.0536 – 0.1617i –0.1011 + 0.0023i 0.0483 – 0.0450i 0.1615 – 0.1424i 0.6698 – 0.1625i –0.5284 – 0.3342i –0.1095 – 0.0522i 0.0093 + 0.0938i –0.0986 – 0.1179i 0.1195 – 0.1129i –0.1081 + 0.0421i 0.8287 + 0.1736i –0.0376 – 0.1688i 0.1016 + 0.1985i –0.1190 – 0.0607i –0.0126 + 0.0011i 0.3017 + 0.0170i 0.0026 – 0.1741i –0.1258 – 0.2192i]^T
3	[0.6233 0.3116 – 0.5557i –0.2372 + 0.2738i 0.0849 + 0.0743i –0.1592 – 0.1101i 0.0482 + 0.0168i 0.0044 – 0.0966i –0.0984 – 0.0499i –0.1445 – 0.1013i 0.5635 – 0.1294i 0.7616 – 0.0079i 0.1523 + 0.0460i 0.0261 – 0.0154i 0.1047 – 0.1106i 0.0352 – 0.0366i –0.0252 – 0.0422i 0.2570 + 0.6345i –0.3767 – 0.0482i 0.3817 + 0.1385i 0.0660 + 0.1481i –0.0911 + 0.0578i 0.1511 – 0.0914i –0.0112 + 0.0803i 0.2612 + 0.2798i]^T	11	[0.5185 –0.2285 + 0.6623i 0.3636 + 0.0405i 0.0078 + 0.0787i –0.0052 – 0.0770i –0.1586 + 0.1123i 0.2355 – 0.0028i –0.0217 + 0.0219i 0.0846 – 0.2347i 0.2266 – 0.2278i 0.5401 + 0.6248i –0.0321 – 0.0359i 0.2265 + 0.1207i 0.1348 + 0.0184i –0.1527 + 0.0586i –0.1406 + 0.1384i –0.6968 – 0.3143i –0.2364 + 0.4102i –0.0008 + 0.3152i –0.0810 + 0.0232i –0.1986 + 0.0099i 0.0221 – 0.0360i 0.1266 – 0.0178i 0.1305 + 0.1018i]^T
4	[0.6374 –0.1498 + 0.0607i –0.1408 + 0.6914i 0.0761 + 0.0183i 0.0350 + 0.0642i –0.0805 + 0.1466i –0.0971 + 0.1408i –0.0055 + 0.0325i –0.4748 + 0.4760i 0.0273 + 0.2762i 0.2106 + 0.4471i 0.2757 – 0.1364i 0.0699 + 0.0025i 0.2155 – 0.1142i –0.0094 + 0.1743i –0.1700 – 0.0918i 0.1273 + 0.0052i –0.6189 + 0.6553i –0.0051 – 0.3419i 0.0826 – 0.1341i 0.0049 + 0.0494i –0.1083 – 0.0427i –0.0074 + 0.0725i –0.0863 + 0.0285i]^T	12	[0.3208 –0.4724 – 0.5827i 0.0569 – 0.5034i 0.1230 – 0.2071i 0.0171 – 0.0017i 0.0907 – 0.0061i –0.0177 + 0.0117i 0.0909 + 0.0492i –0.6005 + 0.4090i 0.0543 – 0.2307i –0.5085 – 0.1488i 0.0152 – 0.1414i –0.2251 – 0.1175i –0.0424 + 0.0148i –0.1367 – 0.1070i 0.0909 + 0.1003i –0.4689 + 0.0911i –0.5511 – 0.0486i 0.4621 + 0.3378i 0.0997 – 0.0133i 0.1922 – 0.0990i 0.0061 – 0.0216i –0.0024 – 0.2627i –0.0747 – 0.0775i]^T

Table 6-246—*D*(8,3,16) codebook *(continued)*

Index	Codeword	Index	Codeword
5	[0.7116 0.1098 – 0.1420i –0.4070 – 0.4459i –0.0617 – 0.1544i 0.1110 – 0.1449i 0.0058 + 0.0464i –0.1114 + 0.0924i 0.0863 – 0.0731i 0.4453 – 0.3348i 0.0342 + 0.3467i 0.6196 + 0.1892i –0.1520 + 0.1149i 0.0936 – 0.1814i –0.0510 + 0.0551i –0.1728 – 0.0188i 0.1861 – 0.0133i –0.0632 – 0.0713i –0.8608 – 0.1798i 0.0977 – 0.3203i –0.0148 + 0.1692i 0.0050 – 0.0433i –0.0621 + 0.1089i –0.1588 – 0.1010i 0.1444 – 0.0514i]^T	13	[0.2897 –0.4685 – 0.0591i 0.5619 – 0.4945i 0.0934 – 0.0930i –0.1566 + 0.1616i 0.1164 + 0.0406i 0.0956 + 0.2012i –0.0010 + 0.0015i 0.0053 + 0.1052i 0.8080 + 0.0699i 0.3344 – 0.3716i –0.0605 + 0.0326i –0.1045 + 0.0988i 0.0039 – 0.1072i –0.0685 – 0.0204i –0.0368 + 0.1945i –0.5489 – 0.7016i –0.0039 – 0.2045i 0.1641 – 0.0288i –0.0655 – 0.0561i –0.2975 – 0.1380i –0.0073 – 0.0844i 0.0624 + 0.0671i –0.0782 + 0.0142i]^T
6	[0.2614 –0.1370 + 0.5858i 0.1097 + 0.6460i 0.0177 – 0.0575i 0.1146 – 0.0620i 0.0608 – 0.0818i –0.1700 + 0.0766i 0.0103 + 0.2732i –0.5352 + 0.2236i 0.3268 + 0.4659i –0.4239 – 0.1265i 0.0426 + 0.0915i –0.1397 – 0.2335i –0.0117 + 0.0842i 0.0362 + 0.0620i 0.0903 + 0.1980i 0.2966 + 0.6434i –0.1531 + 0.3473i 0.2742 – 0.4608i –0.0174 + 0.1615i –0.0097 + 0.1606i –0.0665 – 0.0428i –0.0047 + 0.0425i –0.0486 – 0.0612i]^T	14	[0.8373 –0.0367 – 0.1572i 0.3562 + 0.1839i –0.0490 + 0.1270i –0.0017 – 0.0040i –0.2275 – 0.0826i –0.0470 + 0.1656i 0.0509 + 0.0525i –0.1455 + 0.1112i 0.7103 – 0.1155i 0.4911 – 0.2546i –0.1153 + 0.0862i 0.0657 – 0.0736i –0.1471 + 0.0674i 0.0643 – 0.1407i –0.0876 – 0.2332i 0.4214 + 0.1331i 0.1834 + 0.5492i –0.2700 – 0.5480i –0.0180 + 0.0210i –0.0267 + 0.0821i 0.2553 – 0.0716i 0.1072 – 0.0287i –0.0727 – 0.0078i]^T
7	[0.7413 –0.4689 – 0.3009i –0.2631 – 0.0569i –0.0549 – 0.0272i 0.0898 + 0.0299i –0.1226 – 0.1509i –0.0405 – 0.1002i 0.0633 + 0.0379i 0.2595 + 0.0303i 0.5407 + 0.3566i –0.6573 – 0.0578i 0.0957 + 0.1435i –0.0209 + 0.1006i –0.0772 + 0.0252i 0.1666 + 0.0158i 0.0439 + 0.0047i 0.4311 – 0.3220i 0.3708 – 0.0513i 0.5058 – 0.3286i 0.0712 + 0.1456i –0.3255 + 0.1288i –0.0164 + 0.1743i –0.1206 – 0.0812i –0.0617 + 0.0456i]^T	15	[0.7950 0.3058 – 0.1929i –0.3777 – 0.1081i 0.1373 – 0.0379i 0.0086 – 0.0471i –0.0500 + 0.0732i –0.1767 – 0.0332i 0.1397 + 0.0239i 0.3852 + 0.1401i 0.2130 + 0.1535i 0.5181 + 0.6151i –0.2271 + 0.0412i –0.0029 – 0.0262i 0.1315 – 0.1187i 0.1463 + 0.0761i –0.0220 – 0.0572i –0.1151 + 0.3849i 0.0022 – 0.8198i 0.0921 + 0.0792i 0.0853 – 0.0361i 0.1365 – 0.1593i –0.0165 + 0.1069i 0.2159 + 0.1546i –0.0589 – 0.1160i]^T
8	[0.8019 –0.2979 + 0.3746i –0.2344 – 0.1283i –0.0178 + 0.0426i –0.1032 – 0.0078i –0.0415 – 0.1073i –0.0212 – 0.0520i –0.0874 – 0.1401i –0.1877 – 0.4626i –0.4474 – 0.3408i –0.3370 – 0.4130i 0.1179 + 0.1355i 0.0712 – 0.0044i 0.1632 – 0.0970i 0.1706 + 0.0835i 0.0673 – 0.1906i 0.0137 – 0.2336i –0.5159 – 0.0224i 0.6560 + 0.3227i 0.0766 + 0.0025i –0.1502 + 0.1952i –0.1497 – 0.2203i 0.0690 – 0.0061i 0.0423 – 0.0082i]^T	16	[0.1591 –0.1981 + 0.3209i –0.8341 + 0.3484i 0.0567 + 0.0176i –0.0559 + 0.0073i –0.0039 + 0.0324i 0.0119 – 0.0857i –0.0060 – 0.0043i –0.3398 – 0.4595i 0.6623 + 0.0214i –0.3295 – 0.2138i –0.0669 – 0.0500i 0.0724 + 0.0674i 0.0937 – 0.0889i 0.0583 + 0.1206i 0.0071 + 0.1692i –0.3365 – 0.5480i –0.5606 – 0.0625i 0.0799 + 0.0796i –0.2330 – 0.0567i 0.0395 + 0.2882i 0.0848 + 0.2292i 0.1172 – 0.0988i 0.0806 + 0.1540i]^T

Table 6-247—*D*(8,4,16) codebook

Index	Codeword	Index	Codeword
1	[0.4681 0.0162 – 0.0499i 0.0845 + 0.1896i 0.7535 – 0.2741i –0.0161 – 0.0022i –0.0920 – 0.1711i 0.0626 – 0.1573i –0.1422 – 0.0726i –0.3778 + 0.1850i 0.5134 – 0.0411i –0.0459 – 0.6095i 0.2602 – 0.1834i –0.1178 – 0.0337i –0.0273 – 0.1778i –0.0512 + 0.0912i –0.1565 + 0.0009i –0.1567 + 0.1463i –0.0921 + 0.7413i –0.4705 + 0.1808i –0.0346 – 0.2501i –0.0897 – 0.0700i –0.0053 – 0.1725i 0.0726 – 0.1359i –0.0996 – 0.0422i –0.5246 – 0.3717i 0.1408 – 0.1536i –0.2346 + 0.4128i 0.3202 – 0.0216i 0.1447 + 0.2814i 0.1175 + 0.1721i 0.1625 + 0.1685i 0.0083 + 0.1278i]^T	9	[0.5744 0.2016 – 0.2475i –0.2441 + 0.2734i –0.5093 + 0.2849i –0.1351 + 0.1452i –0.0010 + 0.0012i 0.1562 + 0.0448i 0.1522 + 0.0667i 0.1263 + 0.1821i 0.3519 – 0.0128i 0.0879 + 0.6611i 0.4627 – 0.2616i 0.1069 + 0.1412i 0.0173 + 0.1092i –0.1726 + 0.0766i 0.0952 + 0.1067i –0.2624 – 0.5040i 0.2127 – 0.3820i –0.4695 + 0.0516i –0.0286 – 0.3182i –0.1628 – 0.0452i 0.0784 + 0.0251i –0.1701 + 0.1382i –0.1146 – 0.2535i –0.3880 + 0.0127i 0.6716 + 0.0412i 0.3069 – 0.0014i –0.1780 + 0.3955i –0.0306 – 0.2290i –0.1657 + 0.0777i 0.0075 + 0.1506i –0.0367 – 0.0569i]^T
2	[0.7710 –0.0391 – 0.2436i 0.0566 – 0.2808i 0.3547 – 0.1960i 0.0521 – 0.0951i –0.2212 – 0.0036i 0.0944 – 0.0284i –0.0580 + 0.1571i –0.4304 + 0.0154i 0.3932 – 0.4551i 0.2774 – 0.3351i 0.0827 – 0.3953i 0.1221 + 0.0238i 0.0367 + 0.2192i 0.0883 – 0.0997i 0.0732 + 0.1118i –0.0679 + 0.0192i –0.6031 + 0.0756i 0.6821 + 0.0757i 0.0297 – 0.1369i –0.1600 + 0.0574i 0.0954 – 0.0158i 0.2833 – 0.1220i 0.0403 – 0.0034i 0.0720 + 0.3526i 0.0805 + 0.3719i –0.1308 + 0.3319i 0.1544 – 0.6639i 0.0179 – 0.0900i 0.2288 + 0.0458i –0.1123 + 0.0174i 0.2103 + 0.1179i]^T	10	[0.2903 –0.0452 – 0.2873i –0.3908 – 0.7921i 0.0090 – 0.1659i –0.0117 + 0.0020i 0.0616 + 0.0857i 0.1041 – 0.0258i –0.0107 – 0.0203i 0.1425 + 0.0628i 0.4357 + 0.0617i –0.0510 + 0.2129i –0.0838 – 0.7602i 0.1845 – 0.1039i –0.0525 + 0.0494i 0.1210 – 0.1036i 0.0023 – 0.2717i –0.2872 + 0.7606i –0.3242 – 0.2050i –0.1539 + 0.0834i –0.0668 – 0.0881i 0.1774 – 0.2077i –0.1659 + 0.1490i 0.0314 + 0.0614i –0.1234 + 0.0686i –0.3408 + 0.0822i –0.1413 + 0.6338i 0.0048 – 0.3175i –0.4275 – 0.1600i –0.2443 + 0.0022i 0.1535 – 0.1516i 0.0174 + 0.1009i –0.0391 – 0.1675i]^T
3	[0.8029 –0.3042 + 0.0521i –0.0674 – 0.3480i 0.0355 – 0.2275i 0.0395 – 0.1708i 0.0530 – 0.0432i –0.1567 + 0.1413i 0.0103 + 0.0379i –0.1918 + 0.2392i 0.3048 + 0.4199i –0.3435 – 0.4540i 0.4022 – 0.1852i –0.1267 + 0.1453i 0.0518 + 0.1367i 0.0603 + 0.2122i –0.0950 + 0.0179i 0.2076 + 0.3797i 0.0919 + 0.6106i 0.1819 + 0.3312i –0.3495 + 0.1688i –0.0150 – 0.0403i –0.1273 – 0.0804i 0.1914 + 0.2661i –0.0421 – 0.0660i 0.1696 + 0.1246i –0.1856 – 0.0249i –0.5531 + 0.1969i 0.2601 + 0.6136i –0.1118 – 0.0557i 0.0930 – 0.0200i 0.0296 – 0.1801i –0.1142 – 0.2465i]^T	11	[0.4643 –0.5194 – 0.4287i 0.0702 – 0.2408i –0.3517 – 0.1887i –0.2283 + 0.0446i –0.0033 – 0.1952i 0.0272 + 0.0242i 0.0627 + 0.1057i –0.3338 + 0.3960i 0.2473 + 0.1169i –0.2613 – 0.1217i –0.6924 + 0.0126i –0.1830 + 0.0569i 0.0013 – 0.1585i –0.0527 – 0.0129i 0.1696 – 0.0253i –0.0664 + 0.5044i –0.2981 + 0.3297i 0.5439 – 0.3380i 0.0348 + 0.1336i 0.0735 – 0.0980i –0.1873 + 0.0970i –0.0550 – 0.0388i –0.2034 – 0.0958i –0.3407 + 0.2657i –0.3034 – 0.2311i –0.4672 – 0.2766i 0.4697 – 0.0453i –0.0095 + 0.1137i –0.2069 – 0.0222i –0.0769 + 0.1834i 0.2295 – 0.0442i]^T

Table 6-247—*D*(8,4,16) codebook *(continued)*

Index	Codeword	Index	Codeword
4	[0.5481 –0.1069 – 0.3964i –0.2595 – 0.4355i 0.3975 – 0.0779i –0.1128 + 0.0024i –0.0284 + 0.0093i 0.2860 – 0.0007i 0.1034 – 0.0616i –0.0047 + 0.3999i 0.4310 + 0.0905i –0.2821 + 0.4415i 0.3849 – 0.3975i –0.0423 + 0.0598i 0.2123 + 0.0030i 0.1007 – 0.0196i –0.0603 + 0.0297i –0.2857 + 0.6050i –0.3651 – 0.3189i –0.2968 – 0.0570i –0.3222 – 0.0277i 0.0702 + 0.0076i –0.1065 – 0.0600i 0.1150 – 0.1548i –0.2071 – 0.1463i 0.1905 + 0.1028i 0.3912 + 0.3276i –0.2220 – 0.4390i –0.4776 – 0.2271i 0.0586 + 0.2070i –0.0755 + 0.2823i –0.0602 – 0.1556i 0.1042 + 0.0270i]^T	12	[0.8084 0.2334 + 0.1928i –0.0226 + 0.3112i –0.1853 – 0.0576i –0.1212 – 0.2131i 0.1366 + 0.0531i –0.1855 + 0.0194i 0.0583 – 0.0072i 0.3711 – 0.0001i 0.2420 – 0.3733i –0.4158 – 0.4229i 0.4450 + 0.1192i 0.1215 + 0.0593i 0.0527 – 0.0448i 0.2612 + 0.0523i –0.0585 – 0.0547i 0.2976 + 0.1603i –0.5239 – 0.3294i 0.5202 – 0.0261i 0.1678 – 0.1223i 0.1322 + 0.2226i 0.2782 + 0.0601i –0.0727 + 0.0589i –0.0758 – 0.1607i –0.0480 – 0.0720i 0.2016 + 0.3748i 0.3281 + 0.1399i 0.7540 – 0.2376i –0.0517 – 0.1442i –0.1050 + 0.1090i 0.0781 – 0.0021i –0.0736 + 0.0369i]^T
5	[–0.1145 –0.7399 – 0.4223i –0.0152 – 0.0274i –0.1625 + 0.4493i 0.0317 + 0.0218i 0.0129 – 0.0024i –0.0918 – 0.0510i –0.1069 + 0.0881i –0.4708 + 0.3985i 0.3533 + 0.0861i –0.0133 + 0.0157i –0.1260 + 0.5341i 0.2119 – 0.1205i –0.1454 – 0.2100i 0.0814 – 0.1505i 0.1785 – 0.0021i –0.0118 + 0.2967i –0.2027 + 0.0290i 0.8063 + 0.0162i –0.1477 – 0.2563i 0.1807 + 0.0934i –0.0771 + 0.0885i 0.1569 – 0.0608i 0.1805 – 0.1263i 0.4886 – 0.2539i 0.1601 + 0.1723i 0.2460 + 0.4552i –0.2529 + 0.4377i 0.1786 – 0.1530i –0.0621 + 0.1120i –0.1029 + 0.0988i –0.1583 + 0.0342i]^T	13	[0.1343 0.2346 + 0.4950i –0.1357 – 0.3848i –0.6727 + 0.0688i 0.0762 + 0.0182i 0.0055 + 0.1005i 0.1342 – 0.0879i 0.0780 – 0.1004i 0.1776 – 0.4037i 0.5019 + 0.0078i –0.2502 – 0.1460i 0.2639 – 0.5741i –0.0359 – 0.0007i –0.1237 – 0.0605i –0.1633 – 0.0398i 0.1462 + 0.0203i –0.3624 + 0.6139i 0.1279 + 0.3034i –0.4505 + 0.2464i 0.0971 – 0.1836i –0.0267 + 0.1311i 0.0063 – 0.1959i –0.1033 – 0.0110i 0.0682 – 0.0693i –0.3472 – 0.1653i 0.3018 + 0.3529i 0.4939 + 0.3554i –0.0567 – 0.0098i –0.3034 – 0.3221i 0.0013 + 0.0168i –0.1103 – 0.2170i –0.0809 + 0.0321i]^T

Table 6-247—*D*(8,4,16) codebook *(continued)*

Index	Codeword	Index	Codeword
6	[0.2755 –0.1482 + 0.4541i 0.3150 – 0.6512i 0.2816 + 0.2597i 0.0123 + 0.0859i –0.1116 – 0.0496i –0.0199 – 0.0338i 0.0164 + 0.0406i 0.2379 – 0.1765i 0.5344 – 0.1852i 0.0102 + 0.0167i –0.2585 + 0.6599i 0.1352 + 0.1457i 0.0402 – 0.0000i 0.0346 + 0.1149i –0.1523 + 0.1047i 0.3554 + 0.4813i 0.3734 – 0.1837i 0.1413 + 0.1028i 0.3620 – 0.1641i –0.0672 + 0.2124i 0.2214 – 0.0329i –0.0685 – 0.3971i 0.0210 – 0.1338i –0.4320 – 0.0777i 0.4116 – 0.2453i 0.4938 – 0.3972i –0.1551 – 0.2833i –0.1000 – 0.1466i –0.0855 – 0.0253i 0.1409 – 0.0647i –0.0913 – 0.0094i]^T	14	[0.7755 –0.4092 + 0.1933i 0.0340 + 0.1979i –0.2508 – 0.0735i 0.1223 + 0.1079i –0.0355 – 0.0901i 0.0467 + 0.0973i –0.0034 + 0.1937i 0.0967 + 0.0588i 0.0849 + 0.0238i 0.7218 + 0.1724i 0.4424 – 0.3768i 0.0755 + 0.0490i –0.0060 + 0.2240i –0.0919 + 0.0974i 0.0653 – 0.1023i 0.2793 – 0.2710i 0.0099 – 0.7202i –0.0247 – 0.1517i 0.2675 + 0.0810i 0.0425 – 0.1991i –0.2862 – 0.2233i –0.0376 + 0.0603i 0.2125 + 0.0679i 0.2014 + 0.0977i –0.0648 + 0.4039i –0.2215 – 0.4748i 0.6583 + 0.1046i –0.0636 + 0.0359i –0.0240 – 0.1358i 0.1308 + 0.0818i –0.1135 – 0.0520i]^T
7	[0.7811 –0.4244 – 0.1198i 0.0607 + 0.0057i 0.2210 – 0.3018i –0.0895 + 0.1509i –0.0345 – 0.0831i –0.0276 – 0.0367i –0.0088 + 0.1035i –0.4041 + 0.2043i –0.3532 + 0.1749i 0.6207 – 0.1381i 0.1909 – 0.3159i 0.1746 + 0.1310i 0.1335 – 0.0517i –0.1042 + 0.0514i –0.1167 + 0.0619i 0.1250 + 0.1343i 0.3987 – 0.0736i 0.3833 + 0.4478i –0.3750 – 0.4499i –0.0675 – 0.0284i –0.0862 – 0.0801i 0.1790 – 0.0098i 0.1278 – 0.2092i 0.3263 – 0.0791i 0.3210 + 0.4369i 0.3774 + 0.0716i 0.2260 + 0.4348i –0.0100 – 0.0025i 0.4238 – 0.0756i 0.1110 + 0.0725i –0.0097 + 0.0504i]^T	15	[0.3775 0.7059 + 0.4102i 0.1520 – 0.3368i –0.0680 – 0.1728i 0.0292 + 0.0815i –0.0004 – 0.0324i –0.0794 + 0.0366i 0.0158 + 0.0589i 0.0518 – 0.0147i 0.1590 – 0.0174i 0.1448 – 0.0307i 0.4950 + 0.7803i –0.0444 + 0.0889i –0.0020 + 0.0504i –0.0849 – 0.1368i 0.2379 + 0.0290i 0.7864 + 0.0570i –0.1268 – 0.2526i 0.1516 + 0.4064i 0.0015 – 0.0990i –0.1399 – 0.0453i –0.0171 + 0.0751i 0.0708 + 0.1044i 0.2376 + 0.0229i 0.3060 + 0.2074i –0.3789 – 0.0027i –0.2630 – 0.5826i –0.1656 + 0.1788i 0.0543 + 0.1477i –0.1058 + 0.1281i –0.2509 + 0.1682i 0.0165 – 0.3285i]^T
8	[0.3343 –0.6511 – 0.4260i –0.0414 – 0.0479i 0.2028 – 0.4232i –0.0384 – 0.0202i –0.1068 + 0.0353i 0.1152 – 0.0420i –0.1454 + 0.0886i –0.3713 + 0.3790i 0.1843 + 0.1331i –0.1978 – 0.2772i 0.0418 – 0.6803i 0.0470 – 0.0367i –0.0504 + 0.1593i –0.0963 + 0.2050i 0.0578 + 0.0131i 0.5969 – 0.1579i 0.3344 + 0.1591i 0.2926 – 0.4724i 0.0231 – 0.2180i 0.1365 + 0.1733i 0.0515 + 0.0484i –0.0054 – 0.1132i –0.0533 – 0.2355i 0.2311 – 0.1081i 0.1602 + 0.2906i –0.5570 + 0.3705i 0.4111 – 0.1001i –0.1839 – 0.1143i –0.0538 + 0.0635i 0.0917 – 0.1108i –0.1149 – 0.3326i]^T	16	[0.8972 –0.0244 + 0.0245i –0.2142 – 0.2167i –0.1533 + 0.2114i –0.0685 + 0.0046i 0.0648 + 0.0254i –0.0190 + 0.0135i 0.1176 + 0.0938i 0.1690 + 0.0059i 0.9082 – 0.0388i 0.1429 + 0.2136i –0.0324 – 0.1111i 0.0925 – 0.0127i –0.1655 + 0.0804i –0.0729 + 0.0140i –0.0866 – 0.1005i 0.1011 + 0.0414i –0.1505 + 0.1226i 0.6742 + 0.2873i 0.0566 + 0.5795i –0.0460 + 0.0690i –0.0743 + 0.1149i –0.0393 + 0.1314i 0.0566 – 0.1629i 0.2734 + 0.1941i –0.1614 – 0.2031i –0.0078 + 0.3565i 0.5286 – 0.3442i –0.1402 – 0.1657i 0.0839 – 0.2928i –0.1511 + 0.2129i 0.0024 – 0.2954i]^T

6.3.6.2.5.6 Unquantized MIMO feedback for closed-loop transmit precoding

To assist the ABS in determining the precoding matrix to use for SU-MIMO or MU-MIMO, the ABS may request the AMS transmit a sounding signal in an UL sounding channel. The ABS may translate the measured UL channel response to an estimated DL channel response. The transmitter and receiver hardware of the ABS may be calibrated to assist the channel response translation.

The derived precoding matrix shall be the same for all subcarriers within a PRU.

6.3.6.3 Transmission schemes for control channels

SFH and A-MAP shall be transmitted using SFBC defined in 6.3.6.1.1.1. The two-stream pilot pattern defined in 6.3.4.4.1 is used for SFH and A-MAP transmission.

6.3.6.4 MIMO transmission schemes for E-MBS

MIMO modes 0 and 1 specified in Table 6-218 shall be used for MIMO transmissions in E-MBS. When MIMO mode 1 is used for E-MBS, the number of MIMO streams shall be no more than 2.

6.3.7 Uplink physical structure

Each uplink AAI subframe is divided into four or fewer frequency partitions; each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the AAI subframe. Each frequency partition can include contiguous (localized) and/or non-contiguous (distributed) physical resource units. Each frequency partition can be used for different purposes such as fractional frequency reuse (FFR). Figure 6-164 illustrates the uplink physical structure in the example of two frequency partitions with frequency partition 2 including both contiguous and distributed resource allocations, where Sc stands for Subcarrier.

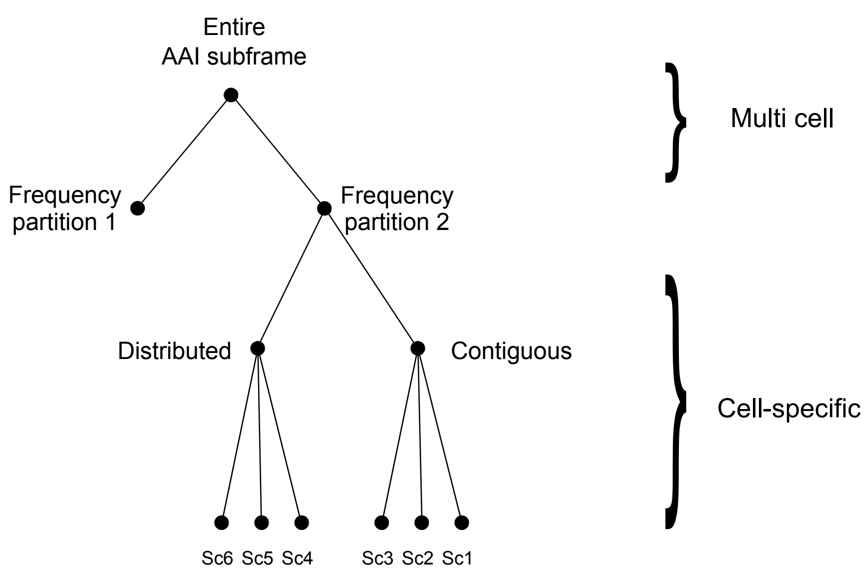


Figure 6-164—Example of uplink physical structure

6.3.7.1 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, 7, 5, and 9 OFDMA symbols for Type 1, Type 2, Type 3, and Type 4 AAI subframes, respectively. A logical resource unit (LRU) is the basic logical unit for distributed and contiguous resource allocations.

The LRU size for control channel transmission should be the same as for data transmission. Multiple users are allowed to share one control LRU.

6.3.7.1.1 Distributed logical resource unit

The uplink distributed logical resource unit (DLRU) contains subcarriers from three tiles that are spread across the distributed resource allocations within a frequency partition. The minimum unit for forming the uplink DLRU is a tile. The uplink tile size is $6 \times N_{sym}$, where the value of N_{sym} depends on the AAI subframe type.

6.3.7.1.2 Contiguous logical resource unit

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

6.3.7.2 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.

6.3.7.2.1 Subband partitioning

The PRUs are first divided into subbands and minibands; 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 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 $L_{SB} = N_1 \times K_{SB}$. A 5-, 4-, or 3-bit field called Uplink Subband Allocation Count (*USAC*) determines the value of K_{SB} depending on FFT size. The *USAC* is transmitted in the SFH. The remaining PRUs are allocated to minibands. The number of minibands in an allocation is denoted by K_{MB}. The number of PRUs allocated to minibands is $L_{MB} = N_2 \times K_{MB}$. The total number of PRUs is $N_{PRU} = L_{SB} + L_{MB}$. The maximum number of subbands that can be formed is denoted as N_{sub} where $N_{sub} = \lfloor N_{PRU}/N_1 \rfloor$. Mappings between *USAC* and K_{SB} are shown in Table 6-248 through Table 6-250 for FFT sizes of 2048, 1024, and 512, respectively.

For system bandwidths between 10 MHz and 20 MHz, the relation between the system bandwidth and supported N_{PRU} is listed in Table 6-148. The mapping between *USAC* and K_{SB} is based on Table 6-248, the maximum valid value of K_{SB} is $N_{PRU}/4 - 3$.

For those system bandwidths in range of [5, 10], the relation between the system bandwidth and supported N_{PRU} is listed in Table 6-149. The mapping between *USAC* and K_{SB} is based on Table 6-249 the maximum valid value of K_{SB} is $N_{PRU}/4 - 2$.

Table 6-248—Mapping between *USAC* and K_{SB} for 2048 FFT size

USAC	Number of subbands allocated (K_{SB})	*USAC*	Number of subbands allocated (K_{SB})
0	0	16	16
1	1	17	17
2	2	18	18
3	3	19	19
4	4	20	20
5	5	21	21
6	6	22	N/A
7	7	23	N/A
8	8	24	N/A
9	9	25	N/A
10	10	26	N/A
11	11	27	N/A
12	12	28	N/A
13	13	29	N/A
14	14	30	N/A
15	15	31	N/A

Table 6-249—Mapping between *USAC* and K_{SB} for 1024 FFT size

USAC	Number of subbands allocated (K_{SB})	*USAC*	Number of subbands allocated (K_{SB})
0	0	8	8
1	1	9	9
2	2	10	10
3	3	11	N/A
4	4	12	N/A
5	5	13	N/A
6	6	14	N/A
7	7	15	N/A

Table 6-250—Mapping between *USAC* and K_{SB} for 512 FFT size

USAC	Number of subbands allocated (K_{SB})	*USAC*	Number of subbands allocated (K_{SB})
0	0	4	4
1	1	5	N/A
2	2	6	N/A
3	3	7	N/A

The PRUs are partitioned and reordered into two groups: subband PRUs (PRU_{SB}) and miniband PRUs (PRU_{MB}). The set of PRU_{SB} is numbered from 0 to (L_{SB} – 1) and the set of PRU_{MB} from 0 to (L_{MB} – 1).

Equation (267) defines the mapping of PRUs into PRU_{SB}s. Equation (268) defines the mapping of PRUs to PRU_{MB}s. Figure 6-165 illustrates the PRUs to PRU_{SB}s and PRU_{MB}s mapping for a 10 MHz bandwidth with K_{SB} equal to 7.

$$PRU_{SB}[j] = PRU[i]; \qquad 0 \le j \le L_{SB} - 1 \tag{267}$$

where

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

$$PRU_{MB}[k] = PRU[i]; \quad k = 0, 1, \ldots, L_{MB} - 1 \tag{268}$$

where

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

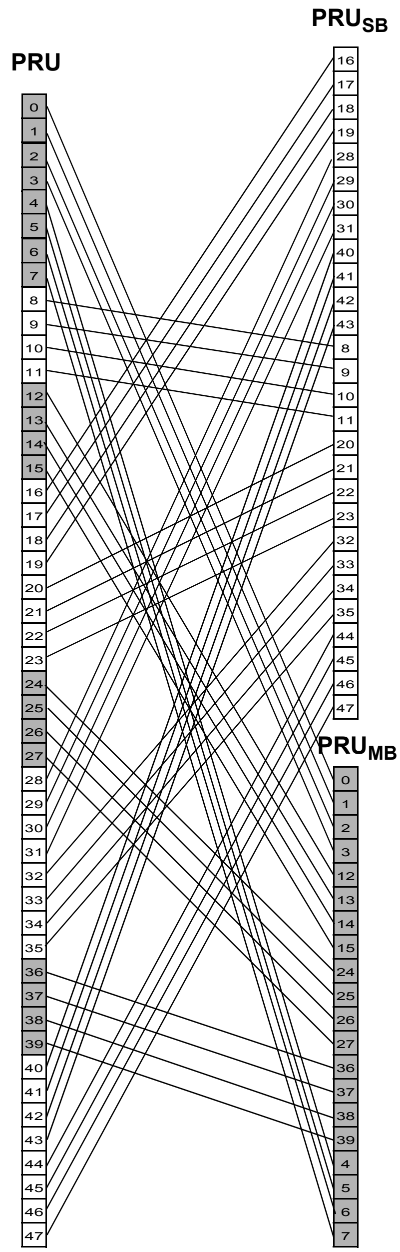


Figure 6-165—PRU to PRU_{SB} and PRU_{MB} mapping for BW = 10 MHz, K_{SB} = 7

6.3.7.2.2 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 (269) describes the mapping from PRU_{MB}s to $PPRU_{MB}$s.

$$PPRU_{MB}[j] = PRU_{MB}[i]; \qquad 0 \le j \le L_{MB} - 1 \tag{269}$$

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 6-166 illustrates the mapping from PRU to PRU_{SB} and PRU_{MB}.

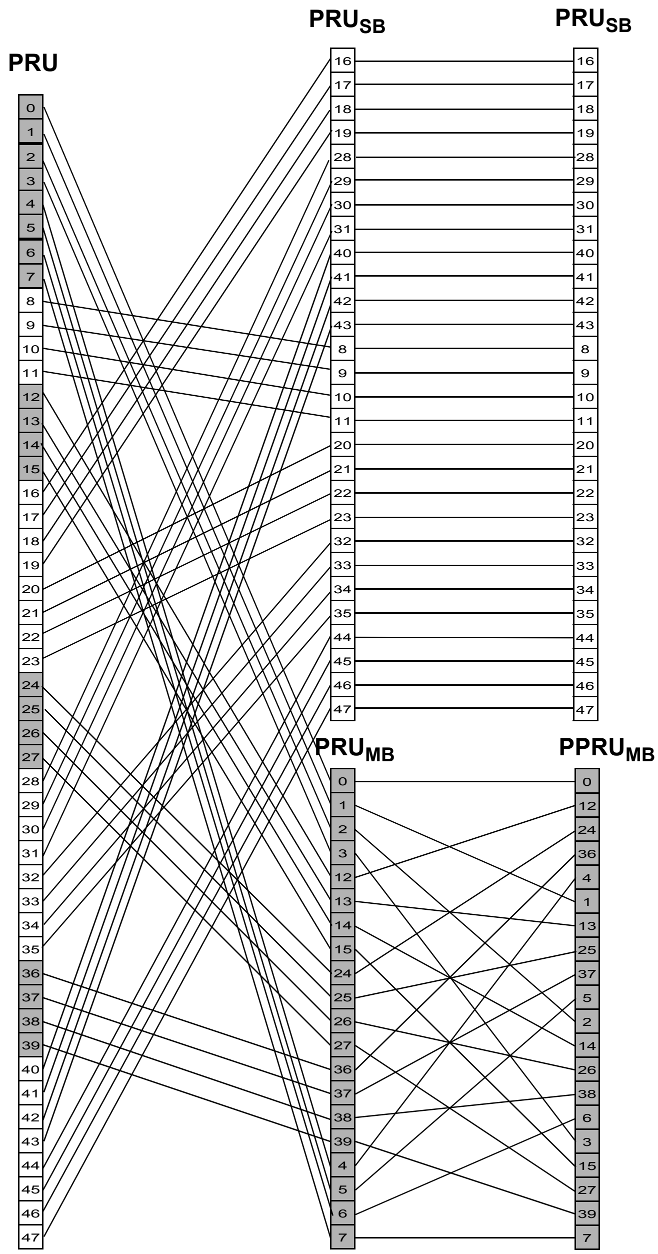


Figure 6-166—Mapping from PRUs to PRU_{SB} and $PPRU_{MB}$ mapping for BW = 10 MHz, K_{SB} = 7

6.3.7.2.3 Frequency partitioning

The PRU_{SB}s and $PPRU_{MB}$s are allocated to one or more frequency partitions. By default, only one partition is present. The maximum number of frequency partitions is 4. The frequency partition configuration is transmitted in the S–SFH SP2 in a 4- or 3-bit composite field called the Uplink Frequency Partition Configuration (*UFPC*), depending on FFT size. The Frequency Partition Count (*FPCT*) defines the number of frequency partitions. The Frequency Partition Size (FPS_i) defines the number of PRUs allocated to FP_i. *FPCT* and FPS_i are determined from *UFPC* as shown in Table 6-251 through Table 6-253.

A field of length 1, 2, or 3 bits, called the Uplink Frequency Partition Subband Count (*UFPSC*), defines the number of subbands allocated to FP_i, for $i > 0$. When *UFPC* = 0, *UFPSC* is equal to 0.

Table 6-251—Mapping between *UFPC* and frequency partitioning for 2048 FFT size

UFPC	Freq. partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i ($i > 0$)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$FPS_1 = N_{PRU} - 2 \times \text{floor}(N_{PRU}/3)$ $FPS_2 = \text{floor}(N_{PRU}/3)$ $FPS_3 = \text{floor}(N_{PRU}/3)$
2	1 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/4)$	$\text{floor}(N_{PRU}/4)$
3	3 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/6)$	$\text{floor}(N_{PRU}/6)$
4	5 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/8)$	$\text{floor}(N_{PRU}/8)$
5	9 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/12)$	$\text{floor}(N_{PRU}/12)$
6	9 : 5 : 5 : 5	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU} \times 5/24)$	$\text{floor}(N_{PRU} \times 5/24)$
7	0 : 1 : 1 : 0	2	0	$N_{PRU}/2$ for $i = 1,2$ 0 for $i = 3$
8	1 : 1 : 1 : 0	3	$N_{PRU} - 2 \times \text{floor}(N_{PRU}/3)$	$\text{floor}(N_{PRU}/3)$ for $i = 1,2$ 0 for $i = 3$
9–15	*Reserved*			

Table 6-252—Mapping between *UFPC* and frequency partitioning for 1024 FFT size

UFPC	Freq. partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i $(i > 0)$
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$FPS_1 = N_{PRU} - 2 \times \text{floor}(N_{PRU}/3)$ $FPS_2 = \text{floor}(N_{PRU}/3)$ $FPS_3 = \text{floor}(N_{PRU}/3)$
2	1 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/4)$	$\text{floor}(N_{PRU}/4)$
3	3 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/6)$	$\text{floor}(N_{PRU}/6)$
4	5 : 1 : 1 : 1	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU}/8)$	$\text{floor}(N_{PRU}/8)$
5	9 : 5 : 5 : 5	4	$N_{PRU} - 3 \times \text{floor}(N_{PRU} \times 5/24)$	$\text{floor}(N_{PRU} \times 5/24)$
6	0 : 1 : 1 : 0	2	0	$N_{PRU}/2$ for $i = 1,2$ 0 for $i = 3$
7	1 : 1 : 1 : 0	3	$N_{PRU} - 2 \times \text{floor}(N_{PRU}/3)$	$\text{floor}(N_{PRU}/3)$ for $i = 1,2$ 0 for $i = 3$

Table 6-253—Mapping between *UFPC* and frequency partitioning for 512 FFT size

UFPC	Freq. partitioning (FP_0:FP_1:FP_2:FP_3)	*FPCT*	FPS_0	FPS_i $(i > 0)$
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$N_{PRU}/3$
2	1 : 1 : 1 : 1	4	$N_{PRU}/4$	$N_{PRU}/4$
3	3 : 1 : 1 : 1	4	$N_{PRU}/2$	N_{PRU} 1/6
4	9 : 5 : 5 : 5	4	$N_{PRU} \times 3/8$	$N_{PRU} \times 5/24$
5	0 : 1 : 1 : 0	2	0	$N_{PRU}/2$ for $i = 1,2$ 0 for $i = 3$
6	1 : 1 : 1 : 0	3	$N_{PRU}/3$	$N_{PRU}/3$ for $i = 1,2$ 0 for $i = 3$
7	*Reserved*			

The number of subbands in the i-th frequency partition is denoted by $K_{SB,FPi}$, as shown in Equation (270).

$$K_{SB,FP_i} = \begin{cases} K_{SB} - (FPCT-1)\cdot UFPSC & i = 0, FPCT = 4 \\ UFPSC & i > 0, FPCT = 4 \\ UFPSC & i > 0, FPCT = 3, UFPC = 1 \\ K_{SB} - (FPCT-1)\cdot UFPSC & i = 0, FPCT = 3, UFPC \neq 1 \\ UFPSC & i = 1,2, FPCT = 3, UFPC \neq 1 \\ UFPSC & i = 1,2, FPCT = 2 \\ K_{SB} & i = 0, FPCT = 1 \\ 0 & \text{Otherwise} \end{cases} \quad (270)$$

When FPCT = 2, *UFPSC* shall be $K_{SB}/2$.

The number of minibands in the *i*-th frequency partition is denoted by $K_{MB,FPi}$ as shown in Equation (271).

$$K_{MB,FPi} = (FPS_i - K_{SB,FPi} \cdot N_1)/N_2 \qquad 0 \le i < 4 \quad (271)$$

The numbers of subband PRUs and miniband PRUs in each frequency partition are $L_{SB,FPi} = N_1 \times K_{SB,FPi}$ and $L_{MB,FPi} = N_2 \times K_{MB,FPi}$, respectively.

The mapping of subband PRUs and miniband PRUs to the frequency partition *i* is given by the following equations:

$$PRU_{FPi}(j) = \begin{cases} PRU_{SB}(k_1) & 0 \le j < L_{SB,FPi} \\ PPRU_{MB}(k_2) & L_{SB,FPi} \le j < (L_{SB,FPi} + L_{MB,FPi}) \end{cases} \quad (272)$$

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 6-167 depicts the frequency partitioning for BW of 10 MHz, K_{SB} = 7, FPCT = 4, $FPS_0 = FPS_i$ = 12, and *UFPSC* = 2.

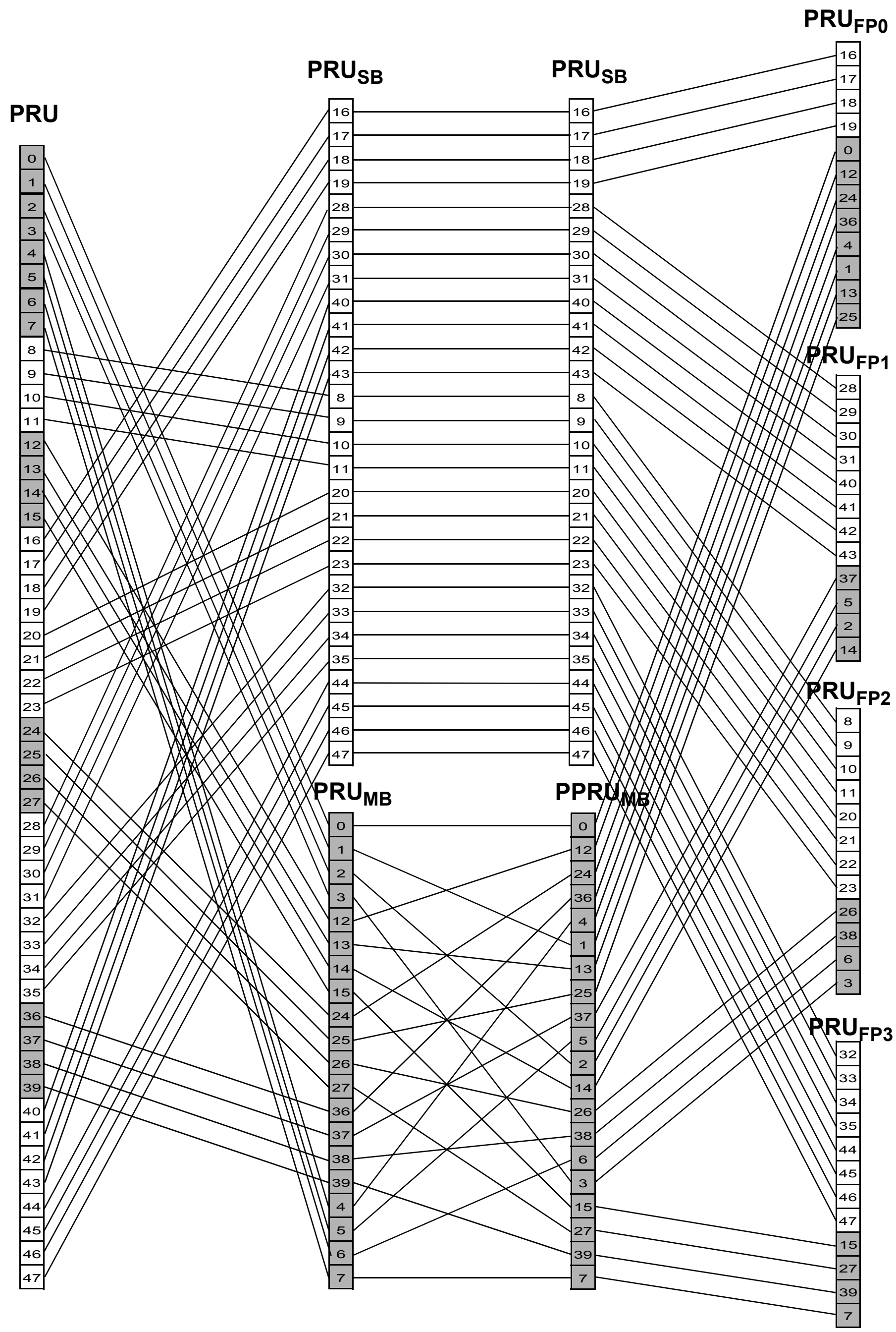


Figure 6-167—Frequency partition for *BW* = 10 MHz, K_{SB} = 7, *FPCT* = 4, $FPS_0 = FPS_i$ = 12, and *UFPSC* = 2

6.3.7.3 Cell-specific resource mapping

PRU_{FPi}s are mapped to LRUs. All further PRUs and tile permutations are constrained to the PRUs within a frequency partition.

6.3.7.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector-specific basis. Let $L_{SB\text{-}CRU,FPi}$ and $L_{MB\text{-}CRU,FPi}$ denote the number of allocated subband CRUs and miniband CRUs for FP_i ($i \geq 0$). The number of total allocated CRUs, in units of a subband (i.e., N_1 PRUs), for FP_i (for $i \geq 0$) is given by uplink CRU allocation size, $UCAS_i$. The numbers of subband-based and miniband-based CRUs in FP_0 are given by $UCAS_{SB,0}$ and $UCAS_{MB,0}$, in units of a subband and miniband, respectively.

For FP_0, the value of $UCAS_{SB,0}$ is explicitly signaled in the SFH as a 5-, 4-, or 3-bit field to indicate the number of subbands in unsigned-binary format. $UCAS_{SB,0} \leq K_{SB,FP_0}$. A 5-, 4-, or 3-bit uplink miniband-based CRU allocation size ($UCAS_{MB,0}$) is sent in the SFH only for FP_0, depending on FFT size. The number of subband-based CRUs for FP_0 is given by the Equation (273).

$$L_{SB-CRU,FP_0} = N_1 \cdot UCAS_{SB,0} \tag{273}$$

The mapping between $UCAS_{MB,0}$ and the number of miniband-based CRUs for FP_0 is shown in the Table 6-254 through Table 6-256 for FFT sizes of 2048, 1024, and 512, respectively.

For those system bandwidths between 10 MHz and 20 MHz, the mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 is based on Table 6-254, the maximum valid value of $L_{MB\text{-}CRU,FP0}$ is less than floor($88 \times N_{PRU}/96$).

For those system bandwidths in the range of [5, 10], the mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 is based on Table 6-255, the maximum valid value of $L_{MB\text{-}CRU,FP0}$ is less than floor($42 \times N_{PRU}/48$).

Table 6-254—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 2048 FFT size

$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)	$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)
0	0	16	28
1	2	17	32
2	4	18	36
3	6	19	40
4	8	20	44
5	10	21	48
6	12	22	52
7	14	23	56
8	16	24	60
9	18	25	64
10	19	26	68
11	20	27	72

Table 6-254—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 2048 FFT size *(continued)*

$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)	$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)
12	21	28	76
13	22	29	80
14	23	30	84
15	24	31	88

Table 6-255—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 1024 FFT size

$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)	$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)
0	0	8	16
1	2	9	18
2	4	10	20
3	6	11	22
4	8	12	24
5	10	13	38
6	12	14	40
7	14	15	42

Table 6-256—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 512 FFT size

$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)	$UCAS_{MB,0}$	Number of miniband-based CRU for FP_0 ($L_{MB\text{-}CRU,FP0}$)
0	0	4	8
1	2	5	10
2	4	6	18
3	6	7	20

For $FP_i(i > 0, FPCT \neq 2)$, only one value for $UCAS_i$ is explicitly signaled for all $i > 0$, in the SFH as a 3-, 2-, or 1-bit field to signal the same numbers of allocated CRUs for $FP_i(i > 0, FPCT \neq 2)$. When $UFPC = 0$, $UCAS_i = 0$. For $FP_i(i > 0, FPCT \neq 2)$, the number of subband CRUs ($L_{SB\text{-}CRU,FPi}$) and miniband CRUs ($L_{MB\text{-}CRU,FPi}$) are derived using Equation (274) and Equation (275), respectively.

$$L_{SB-CRU,FPi} = N_1 \cdot \min\{UCAS_i, K_{SB,FPi}\} \tag{274}$$

$$L_{MB-CRU,FPi} = \begin{cases} 0, & UCAS_i \le K_{SB,FPi} \\ (UCAS_i - K_{SB,FPi}) \cdot N_1 & UCAS_i > K_{SB,FPi} \end{cases} \tag{275}$$

When $FPCT$ =2, $UCAS_{SB,i}$ and $UCAS_{MB,i}$ for i = 1 and 2 are signaled using the $UCAS_{SB,0}$ and $UCAS_{MB,0}$ fields in the SFH. Since FP_0 and FP_3 are empty, $L_{SB\text{-}CRU,FP0} = L_{MB\text{-}CRU,FP0} = L_{DRU,FP0}$ =0 and $L_{SB\text{-}CRU,FP3} = L_{MB\text{-}CRU,FP3} = L_{DRU,FP3} = 0$. For i = 1 and 2, $L_{SB\text{-}CRU,FPi} = N_1 \times UCAS_{SB,0}$ and $L_{MB\text{-}CRU,FPi}$ is obtained from $UCAS_{MB,0}$ using the mapping in Table 6-254 through Table 6-256 for system bandwidths of 20 MHz, 10 MHz, and 5 MHz, respectively.

The total number of CRUs in frequency partition FP_i, for $0 \le i < 4$, is denoted by $L_{CRU,FPi}$, calculated as shown in Equation (276).

$$L_{CRU,FPi} = L_{SB-CRU,FPi} + L_{MB-CRU,FPi} \tag{276}$$

The number of DRUs in each frequency partition is denoted by $L_{DRU,FPi}$, calculated as shown in Equation (277).

$$L_{DRU,FPi} = FPS_i - L_{CRU,FPi} \qquad \text{for } 0 \le i < FPCT \tag{277}$$

The mapping from PRU_{FPi} to CRU_{FPi} (for $0 \le i < FPCT$) is given by Equation (278):

$$CRU_{FPi}[j] = \begin{cases} PRU_{FPi}[j], & 0 \le j < L_{SB-CRU,FPi} \\ PRU_{FPi}[k + L_{SB-CRU,FPi}], & L_{SB-CRU,FPi} \le j < L_{CRU,FPi} \end{cases} \tag{278}$$

where
$k = s[j - L_{SB\text{-}CRU,FPi}]$

$s[\,]$ is the CRU/DRU allocation sequence defined in Equation (279) and $0 \le s[j] < FPS_i - L_{SB-CRU,FPi}$.

$$s[j] = \{\mathrm{PermSeq}(j) + \mathrm{UL\_PermBase}\} \bmod (FPS_i - L_{SB-CRU,FPi}) \tag{279}$$

where PermSeq() is the permutation sequence of length ($FPS_i - L_{SB\text{-}CRU,FPi}$) and is determined by $SEED = \{IDcell \times 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in 6.3.4.3.3. The UL_PermBase is set to preamble *IDcell*.

The mapping of PRU_{FPi} to DRU_{FPi} is given by Equation (280):

$$DRU_{FPi}[j] = PRU_{FPi}[k + L_{SB-CRU,FPi}], \quad 0 \le j < L_{DRU,FPi} \tag{280}$$

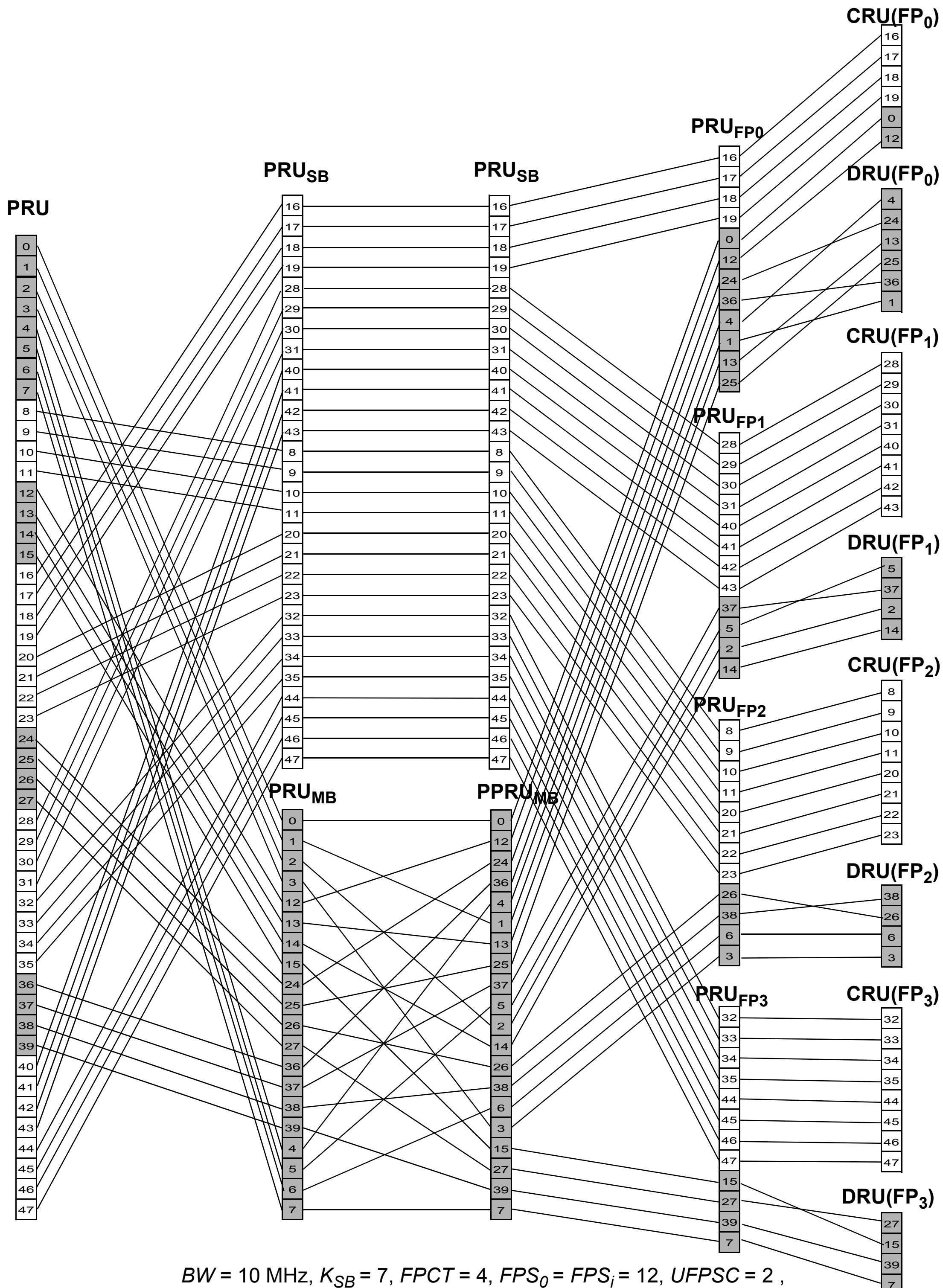
where
$k = s[j + L_{CRU,FPi} - L_{SB\text{-}CRU,FPi}]$

Figure 6-168 presents an example to illustrate the various steps of subband partitioning, miniband permutation, frequency partitioning, and cell-specific resource mapping (CRU/DRU allocation) for the case of a 10 MHz system bandwidth. For this example, $K_{SB} = USAC = 7$, $FPCT = 4$, $FPS_i = 12$ (for $i \geq 0$), $UFPSC = 2$, $UCAS_{SB,0} = 1$, $UCAS_{MB,0} = 1$, $UCAS_i = 2$, and $IDcell = 0$.

Table 6-257 presents a summary of the parameters used to configure the UL PHY structure.

Table 6-257—UL PHY structure—Summary of parameters

	Operation procedure	Related signaling field (FFT size 2048/1024/ 512)	Channel for signaling	Parameters calculated from signaled fields	Definition	Units
Sector Com-mon	Subband Partitioning Mini-band Partitioning	*USAC* (5/4/3 bits)	SFH –SP2	K_{SB}	Number of subbands	Sub-bands
				$L_{SB} = N_1 \times K_{SB}$	Number of PRUs assigned to subbands	PRUs
				$L_{MB} = N_2 \times K_{MB}$	Number of PRUs assigned to minibands	PRUs
	Frequency Partitioning	*UFPC* (4/3/3 bit)		*FPCT*	Number of frequency partitions	Fre-quency parti-tions
				FPS_i	Number of PRUs in FP_i	PRUs
		UFPSC (3/2/1 bit)		$K_{SB,\ FPi}$	Number of subbands assigned to FP_i	Sub-bands
				$K_{MB,\ FPi}$	Number of minibands assigned to FP_i	Miniban ds
				$L_{SB,FPi} = N_1 \times K_{SB,\ FPi}$	Number of PRUs assigned to subbands in FP_i	PRUs
				$L_{MB,FPi} = N_2 \times K_{MB,\ FPi}$	Number of PRUs assigned to be minibands in FP_i	PRUs
Sector Specific	CRU/DRU Allocation	$UCAS_{SB,0}$ (5/4/3 bit) $UCAS_{MB,0}$ (5/4/3 bit) $UCAS_i$ (3/2/1 bit)	SFH – SP1	$L_{SB\text{-}CRU,\ FPi}$	Number of subband-based CRUs in FP_i	CRUs
				$L_{MB\text{-}CRU,\ FPi}$	Number of miniband-based CRUs in FP_i	CRUs
				$L_{CRU,FPi} = L_{SB\text{-}CRU,\ FPi} + L_{MB\text{-}CRU,\ FPi}$	Number of CRUs in FP_i	CRUs
				$L_{DRU,FPi} = FPS_i - L_{CRU,FPi}$	Number of DRUs in FP_i	DRUs
	Tile Permuta-tion	*IDcell* (10 bit)	Obtained from SA-Preamble			



BW = 10 MHz, K_{SB} = 7, $FPCT$ = 4, $FPS_0 = FPS_i$ = 12, $UFPSC$ = 2 ,
$UCAS_{SB,0}$ = 1, $UCAS_{MB,0}$ = 1, $UCAS_i$ = 2, and $IDcell$ = 0.

Figure 6-168—Frequency partition for *BW* = 10 MHz

6.3.7.3.2 Tile permutation

Each of the DRUs of an UL frequency partition is divided into three tiles of six 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:

$$Tile(s, n, t) = L_{DRU, FPi} \cdot n + g(PermSeq(), s, n, t) \tag{281}$$

where

$Tiles(s,n,t)$ is the tile index of the n-th tile in the s-th distributed LRU of the t-th AAI subframe.

n is the tile index, 0 to 2, in a distributed LRU.

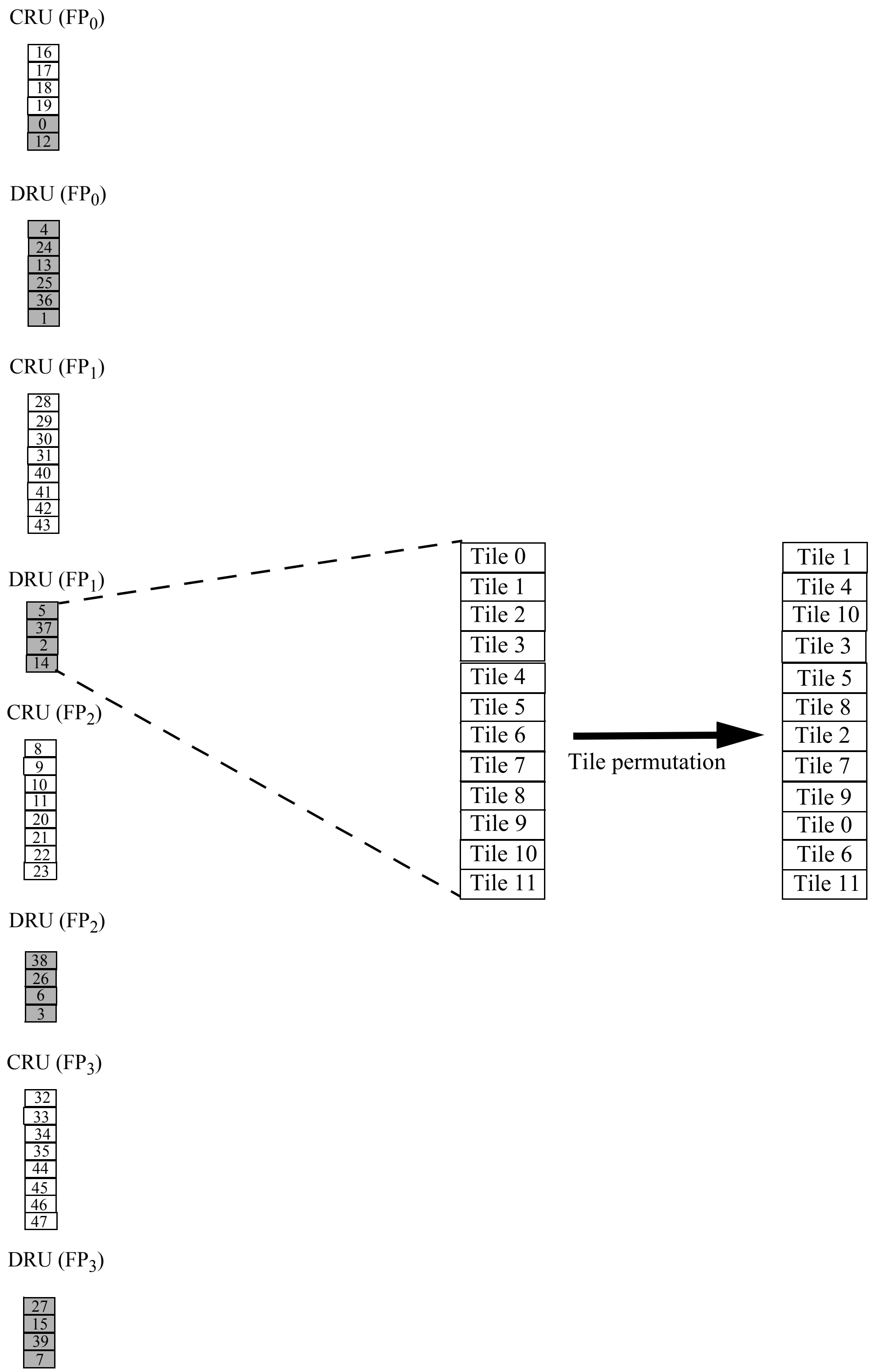
t is the AAI subframe index with respect to the frame.

s is the distributed LRU index, 0 to $L_{DRU, FPi} - 1$.

$PermSeq()$ is the permutation sequence of length $L_{DRU,FPi}$ and is determined by SEED = $\{IDcell \times 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in 6.3.4.3.3.

$g(PermSeq(),s,n,t) = \{PermSeq[(n + 107 \times s + 1213 \times t) \bmod L_{DRU,FPi}] + UL\_PermBase\} \bmod L_{DRU,FPi}$, where the $UL\_PermBase$ is set to preamble $IDcell$.

Figure 6-169 presents the tile permutation for BW = 10 MHz, $K_{SB} = 7$, $FPCT = 4$, $FPS_0 = FPS_i = 12$, $UFPSC = 2$, $UCAS_{SB,0} = 1$, $UCAS_{MB,0} = 1$, $UCAS_i = 2$, $IDcell = 0$, and AAI subframe index = 0.



$K_{SB} = 7$, $FPCT = 4$, $FPS_0 = FPS_i = 12$, $UFPSC = 2$, $UCAS_{SB,0} = 1$, $UCAS_{MB,0} = 1$, $UCAS_i = 2$, $IDcell = 0$, and AAI subframe index = 0.

Figure 6-169—Tile partition for *BW* = 10 MHz

6.3.7.3.3 Resource allocation and tile permutation for control channels

The distributed LRUs in an uplink frequency partition may be further divided into data, bandwidth request, and feedback regions. A feedback region consists of feedback channels that can be used for both HARQ ACK/NACK and fast feedback. In a multicarrier system with active DL-only secondary carriers, the primary UL carrier contains multiple feedback regions for the primary DL carrier and the active DL-only secondary carriers. The primary UL carrier contains one feedback region corresponding to the primary DL carrier and each active DL-only secondary carrier. The allocation order of data channels and UL control channels are UL HARQ feedback channels, UL fast feedback channels, UL bandwidth request channels, and UL data channels as shown in Figure 6-171.

When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, the ranging channel is located in the lowest DLRU index, which is followed by UL HARQ feedback channels, UL fast feedback channels, UL bandwidth request channels, and UL data channels as shown in Figure 6-170. If there is no regular ranging channel in a subframe, the uplink control channel starts from lowest index as shown in Figure 6-171. If there is a UL dynamic ranging channel in a frame, it is located right after the UL control channels.

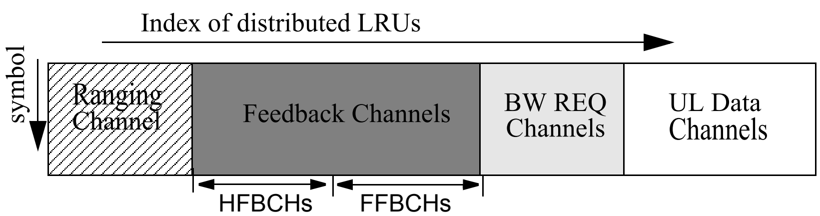
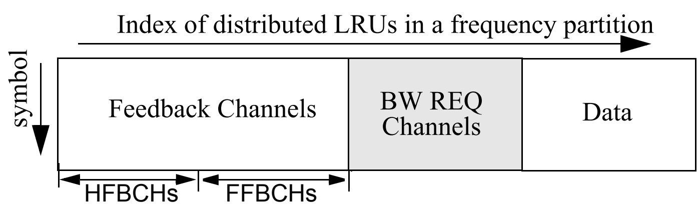


Figure 6-170—Allocation order of UL channels in the FDM-based UL PUSC zone



Allocation of UL control and data channels in the distributed LRUs of a frequency partition of an UL AAI subframe.

Figure 6-171—Allocation of channels in the UL frequency partition

If FFR is used in an UL AAI subframe, the UL control channels are used in the reuse-1 partition or the power-boosted reuse-3 partition. The frequency partition where the UL control channels are located is indicated by the ABS through S-SFH SP1 IE, and it is referred to as a frequency partition location for UL control channels.

6.3.7.3.3.1 Bandwidth request channels

If the UL AAI subframe contains a bandwidth request channel, the number of bandwidth request channels in an UL AAI subframe is N_{bwr}, which is 1. When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, N_{bwr} is 2. The UL AAI subframe containing bandwidth request channel is indicated by S-SFH SP3.

The index of the bandwidth request channel is the same as the UL subframe index where the channel is located. When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, the index of bandwidth request channels starts from zero at the first subframe that includes the channels and increases within a subframe first. The index continues to increase along UL subframe.

The bandwidth request channel is of the same size as a LRU, i.e., three 6x6 tiles. The bandwidth request channel uses an LRU constructed from the tile permutation specified in 6.3.7.3.2.

When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, the bandwidth request channels consist of three 4x6 tiles. A DLRU consists of two bandwidth request channels, and the DLRU is constructed from 6.3.7.3.5.3. A bandwidth request channel is formed by three consecutive tiles. One bandwidth request channel is formed by tile (0), tile (1), and tile (2). Another bandwidth request channel is formed by tile (3), tile (4), and tile (5).

6.3.7.3.3.2 Feedback channels

Let UL_FEEDBACK_SIZE be the number of distributed LRUs in an UL AAI subframe reserved for feedback channels. The number of feedback channels in an UL AAI subframe is L_{FB}.

$$L_{FB} = N_{fb} \cdot UL\_FEEDBACK\_SIZE \tag{282}$$

where N_{fb} is 3. When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, N_{fb} is 4.

The feedback channels are formed by three permuted 2x6 mini-tiles. The mini-tile reordering process applied to each distributed LRU is described as follows:

a) The uplink tiles in the distributed LRUs reserved for feedback channels are divided into 2x6 feedback mini-tiles (FMTs). The FMTs so obtained are numbered from 0 to $3 \times L_{FB} - 1$.

b) A mini-tile reordering is applied to the available 2x6 FMTs as specified by Equation (283) and Equation (284) to obtain the reordered FMTs (RFMTs).

c) Each group of three consecutive RFMTs forms a feedback channel.

The closed form expression for the FMT reordering function used in step b) above is as Equation (283).

$$MiniTile(s, n) = 9 \cdot \mathrm{floor}\left(\frac{s}{3}\right) + \mathrm{mod}(s, 3) + 3 \cdot n \tag{283}$$

When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, the closed form expression is as Equation (284).

$$MiniTile(s, n) = 6 \cdot \mathrm{floor}\left(\frac{s}{2}\right) + \mathrm{mod}(s, 2) + 2 \cdot n \tag{284}$$

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 $L_{FB} - 1$.

HARQ feedback channels

Each feedback channel constructed according to 6.3.7.3.3.2 can be used to transmit six HARQ feedback channels. The number of HARQ feedback channels per HARQ feedback region is denoted by L_{HFB}, which is signaled through the field "Number of UL HARQ feedback channels per HARQ feedback region" in S-SFH SP1.

A pair of HARQ feedback channels is formed by three 2x2 reordered HARQ mini-tiles (RHMT). The HMTs reordering process and the construction of HARQ feedback channel are described as follows and illustrated in Figure 6-193.

1) Each 2x6 RFMT is divided into three consecutively indexed 2x2 HMTs. The HMTs so obtained are numbered from 0 to $3 \times L_{FB}/2 - 1$.
2) A HMT reordering is applied to the HMTs as specified by Equation (285) to obtain the RHMTs.
3) Each group of three consecutive RHMTs forms a pair of HARQ feedback channels.

The closed form expression for the HMT reordering function used in step 2) above is as Equation (285).

$$HMT(k, m) = 9 \cdot \text{floor}\left(\frac{k'}{3}\right) + \text{mod}(k' + m, 3) + 3 \cdot m \tag{285}$$

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 $L_{HFB} - 1$.
$k' = \lfloor k/2 \rfloor$	

In FDD, there is one HARQ feedback region in each UL AAI subframe. In TDD, with notation in Table 6-99 in 6.2.14.2.2.2.1, for HARQ feedback region in UL AAI subframe n, the associated DL subframes can start from a set of DL AAI subframe indices denoted by $M = \{m_0, m_1, ..., m_{R-1}\}$, where $m_0 < m_1 < ... m_{R-1}$. The number of HARQ feedback regions in an UL AAI subframe is equal to R according to the number of the associated DL subframes, i.e,. the size of set M. For DL bursts starting at AAI subframe m_r, the index of the associated HARQ Feedback region is the order of m_r in set M, with index 0 corresponding to the first HARQ feedback region. Within each HARQ feedback region, the index for HARQ feedback channel is calculated as follows.

For the deallocation of a persistent allocation, index k is specified in HFA of the DL Persistent Allocation A-MAP IEs.

For the deallocation of fast feedback channel allocation and feedback polling allocation, index k may be specified in HFA of the Feedback Allocation A-MAP IE and Feedback Polling A-MAP IE, respectively.

For group resource allocation, index k for the l-th AMS in GRA allocation is $(i_{start} + \lfloor l \cdot L_{HFB}/N_{GRA} \rfloor) mod N_{HFB}$, where i_{start} is the HFA Offset in the Group Resource Allocation A-MAP IE, L_{HFB} is the total number of HFBCH configured per HARQ feedback region, and N_{GRA} is the Use Bit Map Size in the Group Resource Allocation A-MAP IE for DL allocations.

For resource allocation using the DL Basic Assignment A-MAP IE, DL Subband Assignment A-MAP IE, CDMA Allocation A-MAP IE, and DL Persistent Allocation A-MAP IE, the index k is $(M(j) + n) \text{mod} L_{HFB}$, where n is a 3-bit HFA value signaled in each Assignment A-MAP IEs, $j \in \{0, 1\}$ is the value of the HFBCH Index Parameter in the non-user-specific A-MAP IE that is transmitted in the subframe where n is signaled. L_{HFB} is the total number of HFBCH configured per HARQ feedback region, and is the value in S-SFH SP1 that corresponds to S-SFH change count applied in the subframe where n is signaled.

In order to determine a unique set of HFBCH resource indexes in a subframe, the ABS can set j to 0. In this case, $M(j)$ is set to the STID for the DL Basic Assignment A-MAP IE and DL Subband Assignment A-MAP IE, and $M(j)$ is set to the RA-ID for CDMA Allocation A-MAP IE. Alternatively, a different set of HFBCH resource indexes can be obtained when $M(j)$ is set to the lowest LRU index of the corresponding DL transmission when $j = 1$. For the DL Persistent Allocation A-MAP IE, $M(j)$ is always set to the STID regardless of the value of j.

Fast feedback channels

A fast feedback channel consists of one feedback channel. It is allocated after HARQ feedback regions and the total number of the fast feedback channels is $L_{FB} - R \times \text{floor}(L_{HFB}/6)$, where R is the number of HARQ feedback regions in an UL AAI subframe.

6.3.7.3.4 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 6.3.7.3.2 to form distributed LRUs.

6.3.7.3.5 WirelessMAN-OFDMA R1 Reference System systems support

When the frame structure is supporting the R1 MSs in PUSC zone by FDM manner as defined in 6.3.3.5, a new symbol structure and subchannelization defined in the subclause are used.

6.3.7.3.5.1 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 6-258, Table 6-259, and Table 6-260.

Table 6-258—512 FFT OFDMA UL subcarrier allocations for DRU

Parameters	Value	Comments
Number of DC subcarriers	1	Index 256 (counting from 0)
$N_{g,left}$	52	Number of left guard subcarriers
$N_{g,right}$	51	Number of right guard subcarriers
N_{used}	409	Number of all subcarriers used in WirelessMAN-OFDMA R1 Reference System PUSC zone within a symbol, including DC carrier

Table 6-259—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 R1 Reference System PUSC zone within a symbol, including DC carrier

Table 6-260—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 R1 Reference System PUSC zone within a symbol, including DC carrier

6.3.7.3.5.2 Resource block for FDM based UL PUSC zone support

When supporting FDM-based UL PUSC zone, a tile consists of four consecutive subcarriers and six OFDMA symbols, as shown in Figure 6-172.

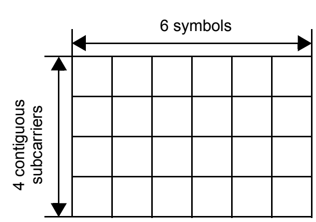


Figure 6-172—Resource block for FDM based UL PUSC zone support

6.3.7.3.5.3 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 R1 Reference System system bandwidth, all usable subcarriers given in Table 6-258, Table 6-259, and Table 6-260 are divided into PUSC tiles.
2) UL PUSC subchannelization is performed as described in 8.4.6.2.2 in IEEE Std 802.16.
3) All PUSC tiles of subchannels from step 2) are extended in time domain from 3 OFDM symbols to N_{sym} OFDM symbols, where N_{sym} is dependent of AAI subframe type.
4) Based on subchannels of step 3) with symbol extension tiles, DRUs for Advanced Air Interface are made up.
5) Repeat step 3) and step 4) for remained OFDMA symbols of every uplink AAI subframe.
6) Renumber the DLRU index in reverse order of PUSC subchannel index.

Overall process of subcarrier to subchannel mapping is shown in Figure 6-173.

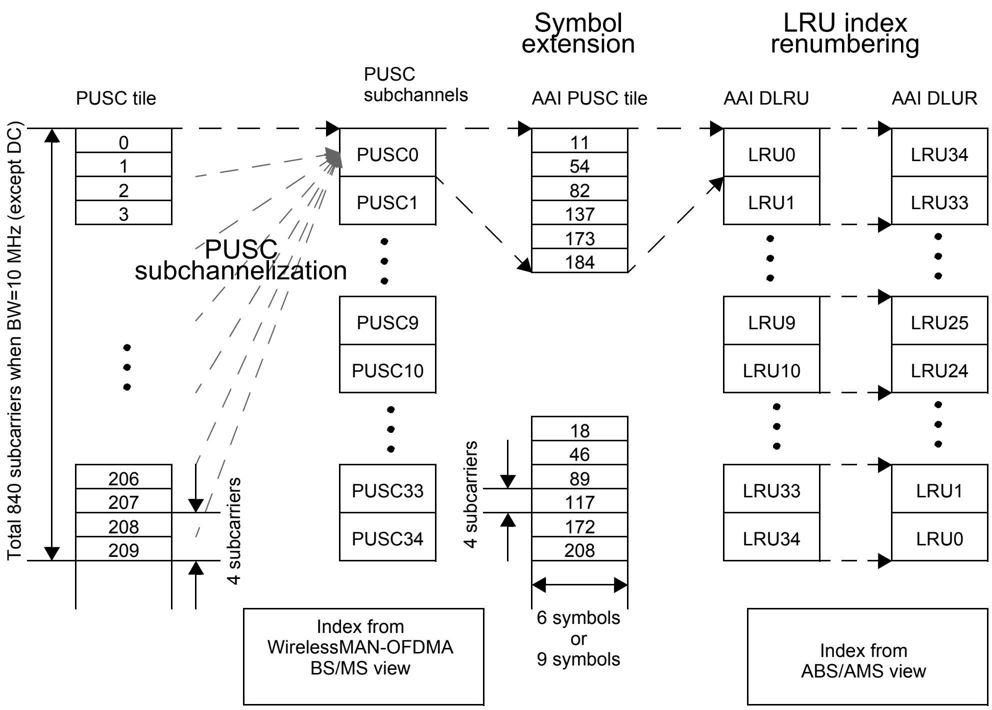


Figure 6-173—Example of subchannelization for FDM base UL PUSC zone support

When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, an LRU consists of six tiles and the tile indexing is the same as the Wireless MAN-OFDMA.

6.3.7.4 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 four transmission streams for SU-MIMO and for up to eight transmission streams for CSM.

The pilot pattern may support variable pilot boosting. When pilots are boosted, each data subcarrier should have the same Tx power across all OFDM symbols in a resource block.

Figure 6-174 and Figure 6-175 show the pilot structure for distributed LRUs where the number of streams is one or two, respectively. Figure 6-176 and Figure 6-177 contain the one and two-stream pilot patterns for the distributed PUSC LRU. Figure 6-178, Figure 6-179, Figure 6-180, and Figure 6-181 show the pilot structure for contiguous LRUs where the number of streams is one, two, three, or four. Figure 6-182 shows the pilot structure for contiguous LRUs with eight streams. Note that the pilot patterns for UL contiguous LRUs are the same as in the downlink case.

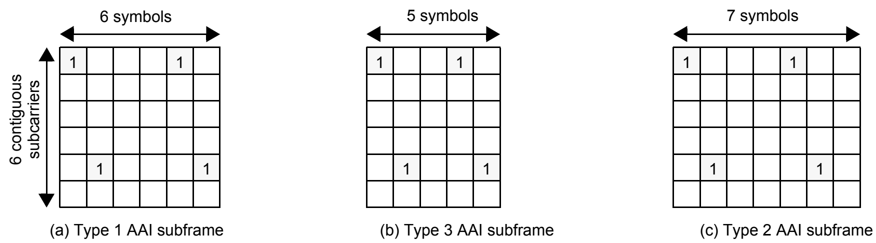


Figure 6-174—Pilot patterns of 1-Tx stream for distributed LRUs

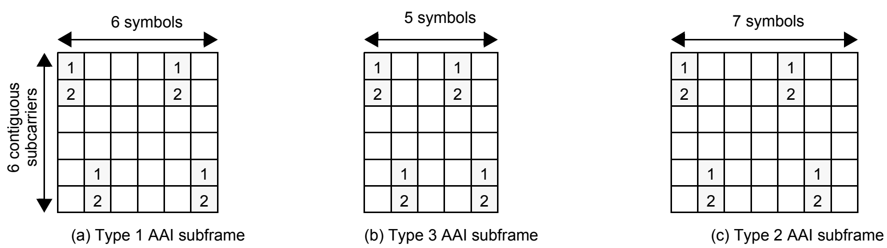


Figure 6-175—Pilot patterns of 2-Tx streams for distributed LRUs

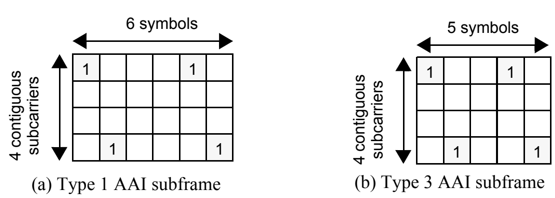
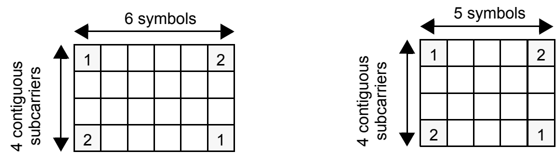


Figure 6-176—Pilot pattern of 1-Tx stream for distributed PUSC LRUs



(a) Type 1 AAI subframe (b) Type 3 AAI subframe

Figure 6-177—Pilot pattern of 2-Tx stream for distributed PUSC LRUs

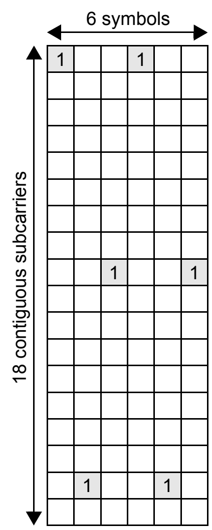


Figure 6-178—Pilot patterns for contiguous LRUs for 1-Tx stream

The 1 stream uplink pilot patterns of Type 2 and Type 3 AAI subframes is the same as 1 stream downlink pilot patterns of Type 2 and Type 3 AAI subframes with pilot pattern set 0 and stream set 0 defined in 6.3.4.4.1.

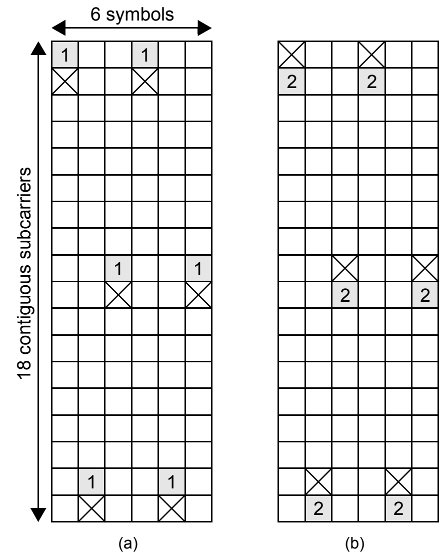


Figure 6-179—Pilot patterns for contiguous LRUs for 2-Tx streams

The 2-stream uplink pilot patterns of Type 2 and Type 3 AAI subframes is the same as 2-stream downlink pilot patterns of Type 2 and Type 3 AAI subframes with pilot pattern set 0 defined in 6.3.4.4.1.

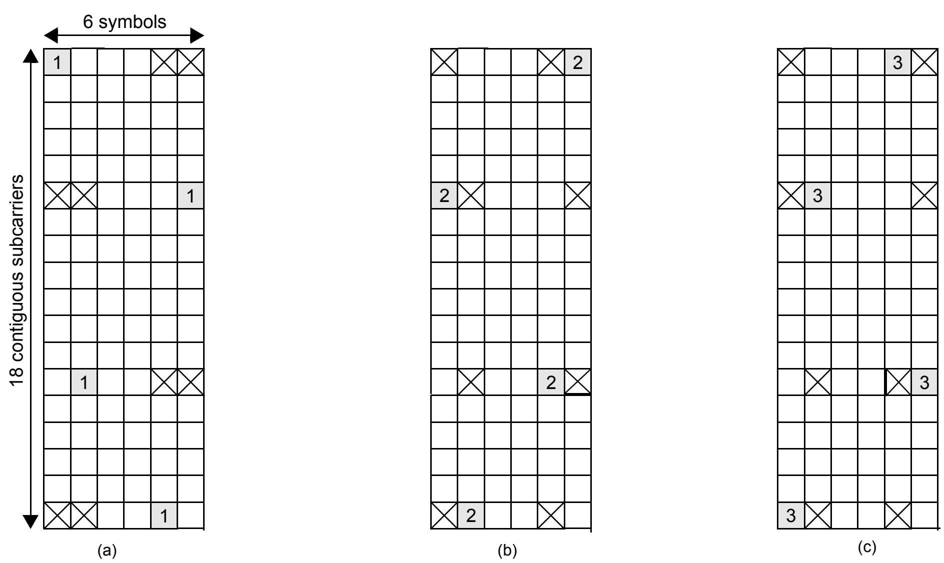


Figure 6-180—Pilot patterns for contiguous LRUs for 3-Tx streams

For 3-stream MIMO transmissions, the first three of the four pilot streams will be used and the unused pilot stream is allocated for data transmission.

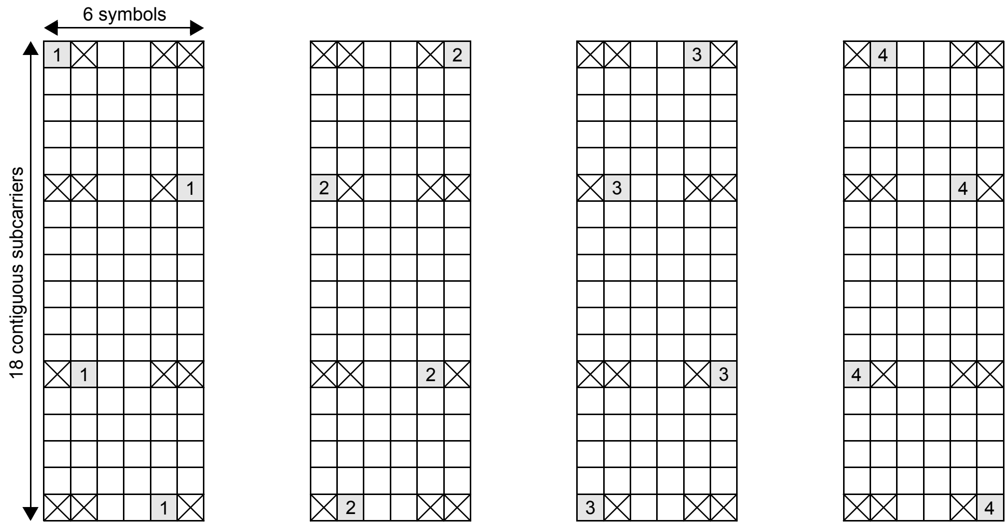


Figure 6-181—Pilot patterns for contiguous LRUs for 4-Tx streams

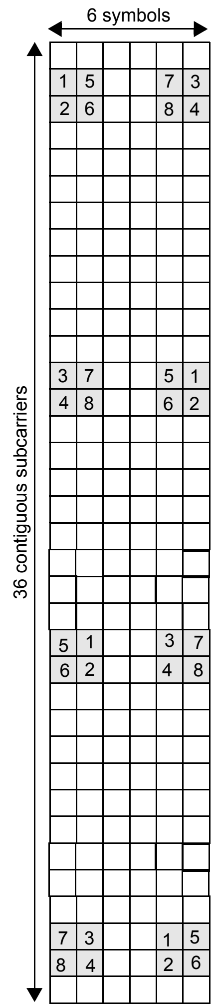


Figure 6-182—Pilot patterns for contiguous LRUs for 8-Tx streams

The uplink pilot patterns of Type 2 and Type 3 AAI subframe for 3 and 4 streams are the same as downlink pilot patterns of Type 2 and Type 3 AAI subframe for 3 and 4 streams defined in 6.3.4.4.1.

The pilot patterns of Type 4 AAI subframe are derived from the Type 2 AAI subframe patterns. The first seven symbols of Type 4 AAI subframe pilot patterns are identical to the Type 2 AAI subframe patterns. In case of one stream, the last two symbols of Type 4 AAI subframe pilot patterns are generated by appending the first two symbols of Type 2 AAI subframe pilot patterns. In case of two streams, the last symbol of Type 4 AAI subframe pilot pattern copies the first symbol of the Type 2 AAI subframe pilot pattern and the eighth symbol does not include pilot.

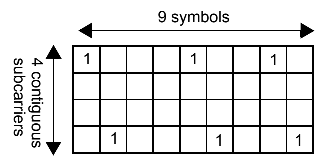


Figure 6-183—Pilot patterns of 1-Tx stream for Type 4 AAI subframe distributed PUSC LRUs

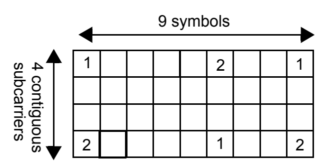


Figure 6-184—Pilot patterns of 2-Tx stream for Type 4 AAI subframe distributed PUSC LRUs

6.3.7.5 Uplink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRU is the same as the structure defined in 6.3.7.1. The guard PRUs are used as miniband CRUs at partition FP_0 for data transmission only. The number of usable guard subcarriers is predefined and should be known to both the AMS and the ABS based on carrier bandwidth.The number of guard PRUs in the left and right edge of each carrier are shown in Table 6-261. Denote the number of guard PRUs in the left (right) edge of carrier by N_{LGPRU} (N_{RGPRU}). The total number of guard PRUs are $N_{\mathrm{GPRU}} = N_{\mathrm{LGPRU}} + N_{\mathrm{RGPRU}}$.

Table 6-261—Number of guard PRUs

BW	Number of guard PRUs in the left edge of carrier[a]	Number of guard PRUs in the right edge of carrier[b]
5 MHz	0	0
10 MHz	1	1
20 MHz	2	2
7 MHz	0	0
8.75 MHz	0	0

[a]When a carrier occupies the leftmost spectrum among multiple contiguous carriers, the number of guard PRUs in the left edge of carrier is zero.
[b]When a carrier occupies the rightmost spectrum among multiple contiguous carriers, the number of guard PRUs in the right edge of carrier is zero.

Denote left guard PRUs and right guard PRUs by $GPRU_L[0]$, ..., $GPRU_L[N_{LGPRU} – 1]$ and $GPRU_R[0]$, ..., $GPRU_R[N_{RGPRU} – 1]$ from the lowest frequency. Then, guard PRUs are indexed by interleaving $GPRU_L$ and $GPRU_R$ one by one. That is, $GPRU[i] = GPRU_L[i/2]$, for i is an even number and $GPRU[i] = GPRU_R[(i–1)/2]$, for i is an odd number. If $N_{LGPRU} = 0$, then $GPRU[i] = GPRU_R[i]$. If $N_{RGPRU} = 0$, then $GPRU[i] = GPRU_L[i]$.

The N_{GPRU} guard PRUs are used as mini-band LRUs, i.e., NLRUs at frequency partition FP0 without any permutation for data transmission only. In detail, i-th guard NLRU, i.e., GNLRU[i], is always allocated along with the i-th last NLRU at partition FP0. In other words, when an allocation including the i-th last NLRU at partition FP0 is made to an AMS for multicarrier support, the i-th guard NLRU, i.e., GNLRU[i], is allocated together. The mapping to the GNLRU[i] is made after mapping to the i-th NLRU at partition FP0.

When an adjacent carrier is not an active carrier of the AMS, the guard subcarriers in between active and non-active carriers shall not be utilized for data transmission for that AMS.

When the overlapped guard subcarriers are not aligned in the frequency domain, they shall not be used for data transmission.

6.3.8 Uplink control channel

6.3.8.1 Physical uplink control channel

Feedback channels and bandwidth request channels are allocated in first six symbols of any AAI subframe when the sounding channel is not allocated.

6.3.8.1.1 Fast feedback control channel

The DRUs are permuted by UL tile permutation as described in 6.3.7.3.2 to form distributed LRUs for both data and control resource/channel. A UL feedback mini-tile (FMT) is defined as two contiguous subcarriers by six 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 three RFMTs. The details of feedback mini-tile permutation and the subchannelization of fast feedback are described in 6.3.7.3.3.2.

6.3.8.1.1.1 Primary fast feedback channel

The primary fast feedback channel is comprised of three RFMTs. The construction process of primary fast feedback channels is described in 6.3.7.3.3.2.

6.3.8.1.1.2 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 three RFMTs. The construction process of secondary fast feedback is described in 6.3.7.3.3.2.

6.3.8.1.2 HARQ feedback control channel

Each UL HARQ feedback resource consists of three RHMTs. A total resource of three 2x6 RFMTs supports six UL HARQ feedback channels. The 2x6 RFMTs are further divided into three UL HARQ mini-tiles (HMT). Each HMT has a structure of two subcarriers by two OFDM symbols.

6.3.8.1.3 Sounding channel

Uplink sounding channel 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, the ABS can translate the measured UL channel response to an estimated DL channel response when the transmitter and receiver hardware of the ABS are appropriately calibrated.

6.3.8.1.3.1 Sounding PHY structure

The sounding signal occupies a single OFDMA symbol in the UL subframe. The sounding symbol in the UL subframe is located in the first symbol. Each UL subframe can contain only one sounding symbol. For the Type 1 AAI subframe, the sounding signal shall not be transmitted in the LRU that contains other control channels. For the Type 2 AAI subframe, the sounding signal can be transmitted in any resource unit. For the six-symbol PRU case, the remaining five consecutive symbols are formed to be a five-symbol PRU used for data transmission, as shown in Figure 6-185. For the seven-symbol PRU case, the remaining six consecutive symbols are formed to be a six-symbol PRU for data transmission and other control channels, as shown in Figure 6-185. Multiple UL AAI subframes in a 5-ms radio frame can be used for sounding. The number of subcarriers for the sounding in a PRU is 18 adjacent subcarriers.

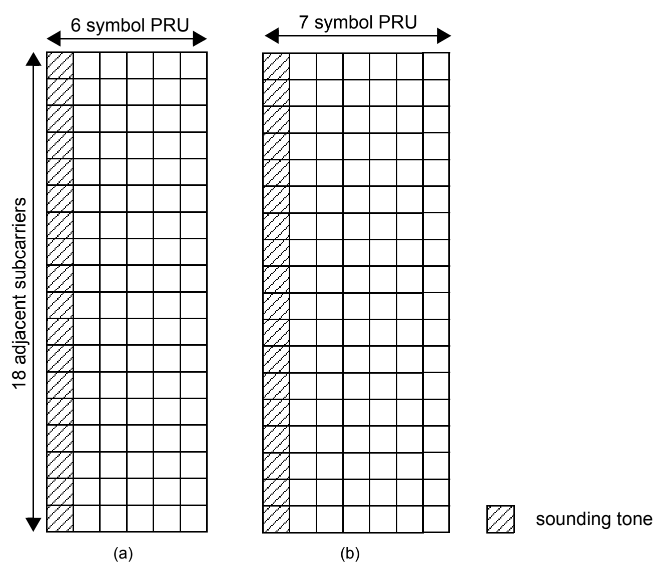


Figure 6-185—Sounding PHY structures for (a) 6-symbol PRU and (b) 7-symbol PRU cases

When the frame structure is supporting the WirelessMAN-OFDMA R1 Reference System MSs in PUSC zone by FDM manner, the sounding channels of both LZone and MZone are allocated in a symbol based on the unit of sounding subband, i.e., continuous 4x18 subcarriers by UL Sounding Command IE (8.4.5.4.24 in IEEE Std 802.16) and UL Sounding Command A-MAP IE (6.3.5.5.2.4.6), respectively.

6.3.8.1.4 Ranging channel

The UL ranging channel (RCH) is used for UL synchronization. The UL RCH can be further classified into non-synchronized ranging channel (NS-RCH) and synchronized ranging channel (S-RCH) for non-synchronized and synchronized AMSs, respectively. The S-RCH is used for periodic ranging. The NS-RCH is used for initial access and handover. An AMS shall not transmit any other uplink burst or uplink control channel signal in the AAI subframe where it transmits a ranging signal by using the NS-RCH.

6.3.8.1.4.1 Ranging channel structure for non-synchronized AMSs

The NS-RCH is used for initial network entry and association and for ranging against a target BS during handover.

The physical NS-RCH 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 NS-RCH occupies a localized bandwidth corresponding to 1 subband.

Power control operation described in 6.3.8.4.4 applies to ranging signal transmission.

Table 6-262 contains formats and parameters for the NS-RCH.

Table 6-262—Formats and parameters for the NS-RCH

Format No.	T_{RCP}	T_{RP}	Δf_{RP}
0	$k_1 \times T_g + k_2 \times T_b$	$2 \times T_b$	$\Delta f/2$
1	$3.5 \times T_g + 7 \times T_b$	$8 \times T_b$	$\Delta f/8$

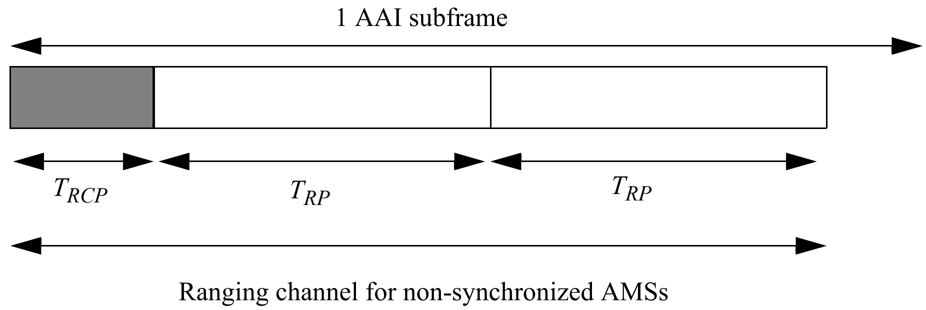
where T_b, T_g, and Δf are defined in 6.3.2.4.

The T_{RCP} for Formats 0 depends on OFDMA parameters, and AAI subframe types as:

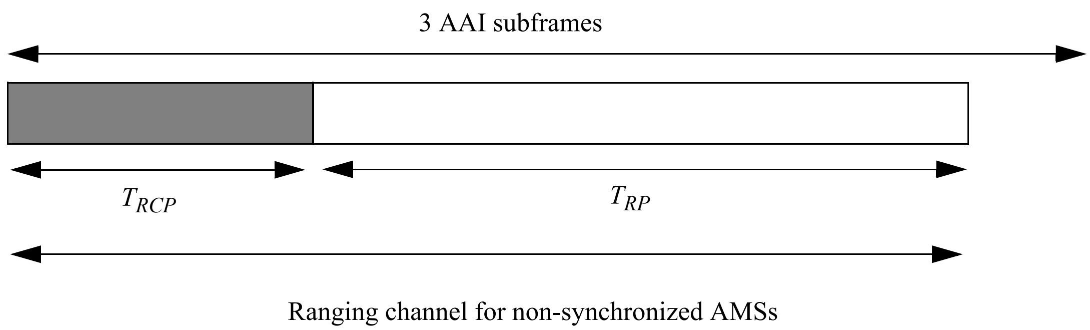
$$k_1 = (N_{sym} + 1)/2 \quad \text{and} \quad k_2 = (N_{sym} - 4)/2$$

where N_{sym} is the number of OFDMA symbols in a AAI subframe as defined in 6.3.7.1.

The NS-RCH is allocated in one or three UL AAI subframes for Format 0 or Format 1, respectively. Format 0 has a repeated structure as shown in Figure 6-186. RCP is the copy of the rear part of RP, without phase discontinuity between RCP and RP. The transmission start time of the NS-RCH is aligned with the corresponding UL AAI subframe start time at the DL synchronized AMS. The remaining time duration of the AAI subframes is reserved to prevent interference between the adjacent AAI subframes.



(a) Format 0



(b) Format 1

Figure 6-186—NS-RCH allocation in AAI subframe(s)

6.3.8.1.4.2 Ranging channel structure for synchronized AMSs

The S-RCH is used for periodic ranging. The AMSs that are already synchronized to the T-ABS are allowed to transmit the periodic ranging signal. In a femtocell, AMSs shall perform initial ranging, handover ranging, and periodic ranging by using the S-RCH.

The physical structure of S-RCH occupies 72 subcarriers by 6 OFDMA symbols starting from the first OFDMA symbol within a subframe, where there are two repeated signal waveforms and each signal waveform as a basic unit is generated by the ranging preamble code over 72 subcarriers by 3 OFDMA symbols.

Figure 6-187 illustrates the physical structure with a basic unit of S-RCH structure in the time domain where T_g and T_b are defined in 6.3.2.4.

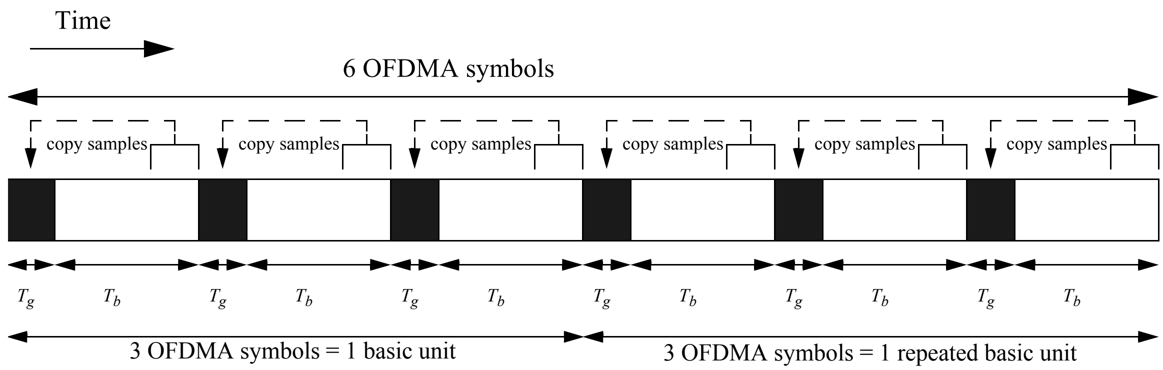


Figure 6-187—S-RCH structure in the time domain

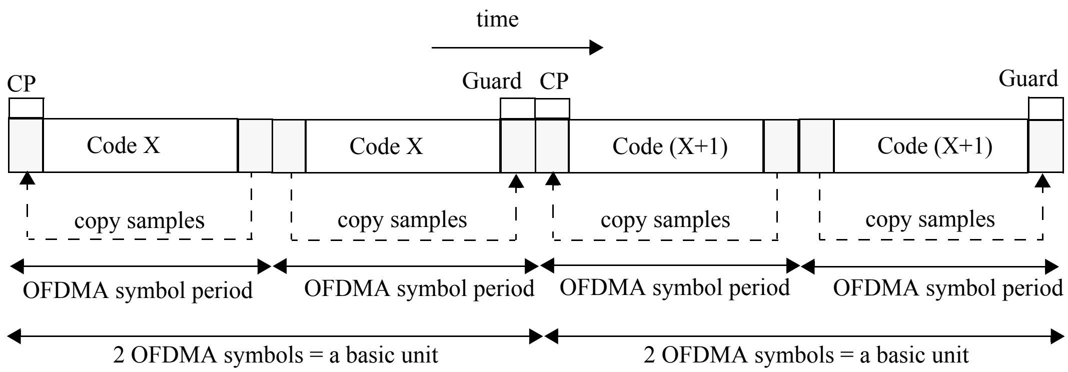
The power control operation described in 6.3.8.4.2 applies to periodic ranging signal transmission. In the femtocell, the power control operation described in 6.3.8.4.4 applies to initial/handover ranging signal transmission.

6.3.8.1.4.3 Ranging channels for FDM-based UL PUSC zone support

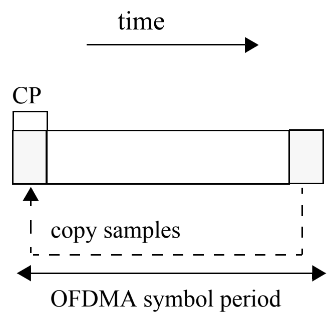
The RCHs for FDM-based UL PUSC zone support is composed of six distributed LRUs by using the symbol structure defined in 6.3.7.3.5.1.

A signal transmission of NS-RCH shall be performed during four consecutive symbols with two basic units, in which the basic unit consists of two OFDMA symbols as shown in Figure 6-188(a). Within a basic unit, the same ranging code is transmitted on the ranging channel during each symbol, with no phase discontinuity between the two symbols. Onto two basic units, the AMS shall transmit the two consecutive RP codes, as illustrated in Figure 6-188(b). A time-domain illustration of the NS-RCH is shown in Figure 6-188(a). The RP code index for random selection and its response is determined as the first RP code index between the two consecutive RP codes. If the first code (Code X) is selected as the last one in the code set, then Code (X+1) is the first one in the corresponding code set.

A signal transmission of S-RCH shall be performed during a symbol same as Figure 6-188(b). A time-domain illustration of the S-RCH is shown in Figure 6-188(b).



(a) NS-RCH structure



(b) S-RCH structure

Figure 6-188—RCH structures for FDM-based UL PUSC zone support

For the NS-RCH, the transmitted signal is according to 6.3.2.5, Equation (185), except that $0 \le t \le 2T_s$.

The NS-RCH and S-RCH are allocated in a UL AAI subframe. Within the allocated ranging AAI subframe, first four symbols in an UL AAI subframe are occupied for the NS-RCH. The last symbol in the same UL AAI subframe is occupied for the S-RCH. A time-domain illustration of the ranging AAI subframe is shown in Figure 6-189. The transmission start time of the NS-RCH is aligned with the corresponding UL subframe start time at the DL synchronized AMS.

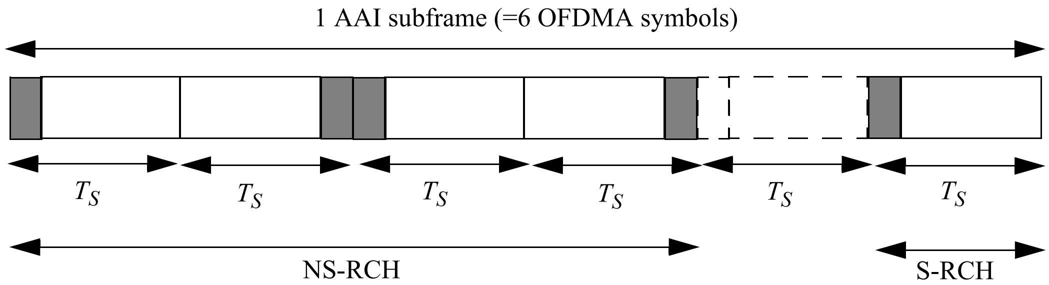


Figure 6-189—RCH structures and allocations for FDM based UL PUSC zone support

Power control operation described in 6.3.8.4.4 or 6.3.8.4.2, applies to initial/handover or periodic ranging signal transmission, respectively.

6.3.8.1.5 Bandwidth request channel

Bandwidth request information is transmitted using contention-based random access on this control channel.The bandwidth request (BR) channel contains resources for the AMS to send a BR preamble and an optional quick access message.

A BR tile is defined as six contiguous subcarriers by six OFDMA symbols. Each BR channel consists of three distributed BR tiles. Within a BR channel, each BR tile carries the same BR preamble and a part of a quick access message. The AMS may transmit the BR preamble only and leave the resources for the quick access message unused.

When frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, a BR tile is defined as four contiguous subcarriers by six OFDMA symbols. The number of BR tiles per BR channel is three. Each BR tile carries a BR preamble only.

6.3.8.2 Uplink control channels physical resource mapping

6.3.8.2.1 Fast feedback control channel (FFBCH)

There are two types of UL fast feedback control channels: primary fast feedback channel (PFBCH) and secondary fast feedback channels (SFBCH).

6.3.8.2.1.1 Primary fast feedback control channel

The primary fast feedback channels are comprised of three distributed FMTs. Figure 6-190 illustrates the mapping of the PFBCH.

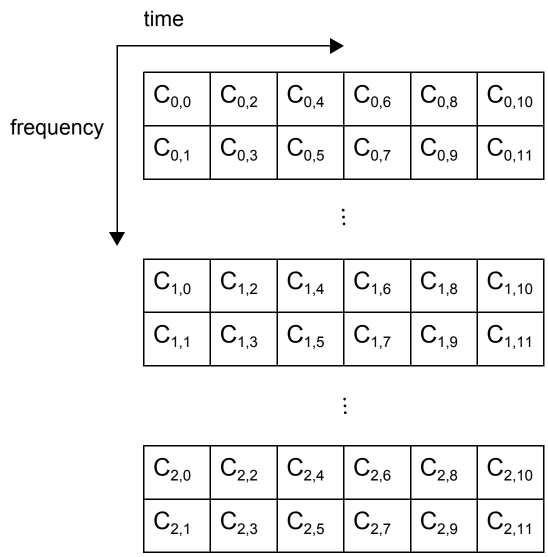


Figure 6-190—PFBCH comprised of three distributed 2x6 UL FMTs

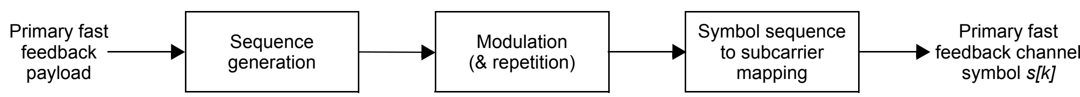


Figure 6-191—Mapping of information in the PFBCH

The process of composing the PFBCH is illustrated in Figure 6-191. The l PFBCH payload bits are used to generate the PFBCH sequence according to Table 6-263. The resulting bit sequence is modulated, repeated, and mapped to uplink PFBCH symbol $s[k]$ (0 mapped to +1 and 1 mapped to –1). The mapping of primary fast feedback channel symbol $s[k]$ to the UL FMTs is given by Equation (286). This set of sequences can carry up to six information bits.

$$C_{i,j} = s[K_i[j]] \text{, for } i = 0, 1, 2 \text{, } 0 \le j \le 11 \tag{286}$$

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 6-263—Sequences for PFBCH

Index	Sequence	Index	Sequence
0	111111111111	32	101011001001
1	101111010110	33	111011100000
2	011010111101	34	001110001011
3	001010010100	35	011110100010
4	101010101010	36	100111111010
5	111010000011	37	110111010011
6	001111101000	38	000010111000
7	011111000001	39	010010010001
8	110011001100	40	111110011100
9	100011100101	41	101110110101
10	010110001110	42	011011011110
11	000110100111	43	001011110111
12	100110011001	44	101010011111
13	110110110000	45	111010110110
14	000011011011	46	001111011101
15	010011110010	47	011111110100
16	101011111100	48	111111001010
17	111011010101	49	101111100011
18	001110111110	50	011010001000
19	011110010111	51	001010100001
20	111110101001	52	110010101111
21	101110000000	53	100010000110
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

6.3.8.2.1.2 Secondary fast feedback control channel

The SFBCH is comprised of three distributed FMTs with two pilots allocated in each FMT. Pilot sequence $p_0p_1p_2p_3p_4p_5$ is modulated as [1 1 1 1 1 1] with 3 dB pilot boosting.

The SFBCH symbol generation procedure is as follows. First, the SFBCH payload information bits $a_0a_1a_2\ldots a_{l-1}$ are encoded to M bits $b_0b_1b_2\ldots b_{M-1}$ using the TBCC encoder described in 6.3.10.2.1.

The values of parameters L and M are set to l and 60, respectively. The value of $K_{bufsize}$ should be set as Equation (287).

$$K_{bufsize} = \begin{cases} 30 & (l = 7, 8, 9) \\ 5l & (l = 10, 11) \\ 60 & (12 \le l \le 24) \end{cases} \tag{287}$$

The coded sequence $b_0b_1b_2\ldots b_{M-1}$ is then modulated to M/2 symbols $c_0c_1c_2\ldots c_{M/2-1}$ using QPSK. The modulated symbols are mapped to the data subcarriers of the SFBCH FMTs as shown in Figure 6-192.

When the length of the feedback message is less than 7 bits, ones are padded at the end of feedback message to ensure that length reaches a 7-bit boundary.

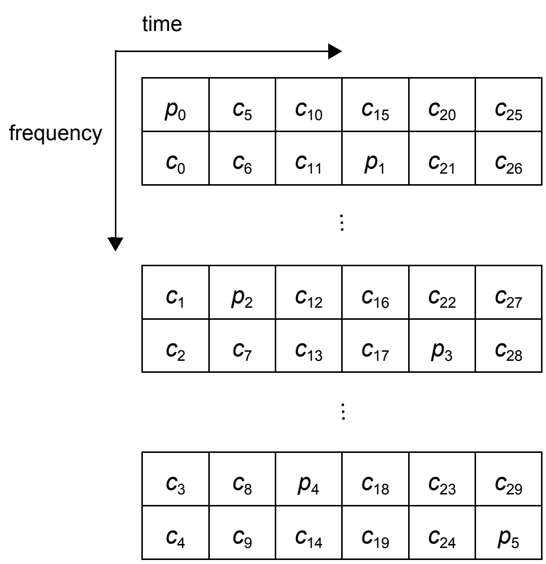


Figure 6-192—SFBCH comprising of three distributed 2x6 UL FMTs

6.3.8.2.2 HARQ feedback control channel

The HARQ feedback control channel resource of three RFMTs shall be further divided into nine HARQ mini-tiles (HMTs), each having a structure of two subcarriers by two OFDMA symbols. Each pair of HARQ feedback channels are allocated in three HMTs, identified by similar patterns in the structure shown in Figure 6-193. 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 6-264 is mapped to each HMT to form HARQ feedback channels, where i denotes the HMT index. Each group of three RFMTs can therefore support six HARQ feedback channels.

Each HARQ feedback channel shall carry one bit of HARQ feedback, and two 4-bit sequences shall be assigned to carry ACK or NACK information for each channel. CDM is used to multiplex two HARQ channels in one unit and two 4-bit orthogonal sequences, each carrying ACK or NACK information for one HARQ channel can be transmitted simultaneously. The sequences and mapping of HARQ feedback are defined in Table 6-264.

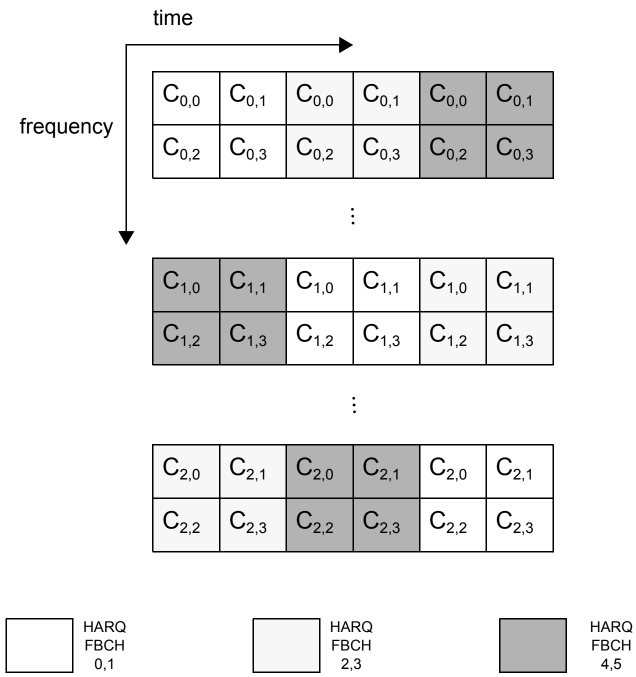


Figure 6-193—2x2 HMT structure

Table 6-264—Orthogonal sequences for UL HARQ feedback channel

Sequence index	Orthogonal sequence	1-bit feedback
0	[+1 +1 +1 +1]	Even numbered channel ACK
1	[+1 –1 +1 –1]	Even numbered channel NACK
2	[+1 +1 –1 –1]	Odd numbered channel ACK
3	[+1 –1 –1 +1]	Odd numbered channel NACK

6.3.8.2.3 Sounding channel

6.3.8.2.3.1 Sounding sequence

Define b_k as the complex coefficients modulating all subcarriers in the sounding symbol, $0 \le k \le N_{used} - 1$ (N_{used} is used a number of used subcarriers dependent on FFT size), such that the signal transmitted by the AMS is defined by Equation (288).

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{\substack{k=0 \\ k \neq \frac{N_{used}-1}{2}}}^{k=N_{used}-1} b_k \cdot e^{j2\pi\left(k - \frac{N_{used}-1}{2}\right)\Delta f(t - T_g)} \right\} \tag{288}$$

For decimation separation (multiplexing Type 0), the occupied subcarriers are decimated (where D is a subcarrier decimation value transmitted in the AAI-SCD message) starting with offset g relative to the first used subcarrier ($k = 0$). The occupied subcarriers for each transmit device (AMS or AMS antenna) shall be modulated by BPSK symbols extracted from the Golay sequence according to Equation (289).

$$b_k = \begin{cases} 2 \cdot \sqrt{D} \cdot \left(\frac{1}{2} - G([k + u + offset_D(fft)] \bmod 2048)\right), & k \in B, k \neq \frac{N_{used}-1}{2}, k \bmod D = g \\ 0, & \text{otherwise} \end{cases} \tag{289}$$

where

k	is the subcarrier index ($0 \le k \le N_{used} - 1$).
N_{used}	is the number of used subcarriers in the sounding symbol.
$G(x)$	is the Golay sequence defined in Table 6-265 $0 \le x \le 2047$.
fft	is the FFT size used.
u	is a shift value, where the actual value of u is transmitted in AAI-SCD.
$offset_D(fft)$	is an FFT size specific offset as defined in Table 6-266.
B	is the group of all allocated subcarriers according to the sounding instructions.
D	is the decimation value.
g	is the actual decimation offset.

For cyclic shift separation (multiplexing Type 1), the sequence used by a Tx device (AMS or AMS antenna) associated with the n-th cyclic shift index is determined according to Equation (290).

$$b_k = \begin{cases} 2 \cdot \left(\frac{1}{2} - G([k + u + offset_D(fft)] \bmod 2048)\right) \cdot e^{-j2\pi \frac{k}{P} n}, & k \in B, k \neq \frac{N_{used}-1}{2} \\ 0, & \text{otherwise} \end{cases} \tag{290}$$

where

k	is the subcarrier index $0 \le k \le N_{used} - 1$.
N_{used}	is the number of used subcarriers in the sounding symbol.
$G(x)$	is the Golay sequence defined in Table 6-265 ($0 \le x \le 2047$).
P	is the max cyclic shift index (transmitted in the AAI-SCD message).
n	is the cyclic time shift index, which ranges from 0 to P–1.
B	is the group of allocated subcarriers according to the sounding instructions.
u	is a shift value transmitted in AAI-SCD.
fft	is the FFT size used.
$offset_D(fft)$	is an FFT size specific offset as defined in Table 6-266.

Table 6-265—Golay sequence of length 2048 bits

0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0x121D,	0x12E2,	0x121D,	0xED1D,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D

NOTE—Hexadecimal series should be read, left-to-right, as a sequence of bits where each 16-bit word is started at the MSB and ends at the LSB where the second word MSB follows. First bit of sequence is referenced as offset 0.

Table 6-266—Sounding sequence offset values

FFT size	$offset_D$
2048	30
1024	60
512	542

6.3.8.2.3.2 Multiplexing for multi-antenna and multi-AMS

The uplink sounding channels of multiple AMS and multiple antennas per AMS can be multiplexed through decimation separation or cyclic shift separation in each sounding allocation. Also, in case of multiple UL AAI subframes for sounding, time division separation can be applied by assigning different AMSs to different UL AAI subframe. For cyclic shift separation, each AMS occupies all subcarriers within sounding allocation and uses the different sounding waveform. For frequency decimation separation each AMS uses decimated subcarrier subset from the sounding allocation set with different frequency offset.

For antenna switching capable AMS and multi-antenna AMS, the 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 AMS antenna (1, **…**, N_t or N_r based on the value of antenna configuration for sounding antenna switching in the AAI-REG-RSP message) on frames $t = j \times 2^{(p-1)} + i - 1$, where $t = 0$ corresponds to the frame where UL Sounding Command A-MAP IE is received, p is periodicity in UL Sounding Command A-MAP IE, and j is a running index ($j = 0, 1, 2, \ldots$ for $p \neq 0$ and $j = 0$ for $p = 0$). For sounding with antenna switching and periodical sounding allocation ($p \neq 0$), the assigned periodicity $2^{(p-1)}$ shall be larger or equal to AMS antenna N_t, or N_r based on the value of Antenna configuration for Sounding antenna switching in the AAI-REG-RSP message.

6.3.8.2.4 Ranging channel

6.3.8.2.4.1 Ranging channel for non-synchronized AMSs

Ranging preamble codes

The ranging preamble (RP) codes are classified into initial ranging and handover ranging preamble codes. The initial RP codes shall be used for initial network entry and association. The handover RP codes shall be used for ranging against a T-ABS during handover. For a ranging code opportunity, each AMS randomly chooses one of the RP codes from the available RP codes set in a cell, except that in the handover ranging case where a dedicated ranging code is assigned, the AMS shall use the assigned dedicated RP code.

The Zadoff-Chu sequences with cyclic shifts are used for the RP codes. The p-th RP code $x_p(k)$ is defined by Equation (291).

$$x_p(k) = \exp\left(-j \cdot \pi \cdot \frac{r_p \cdot k(k+1) + 2 \cdot k \cdot s_p \cdot N_{CS}}{N_{RP}}\right), k = 0, 1, \ldots, N_{RP} - 1 \tag{291}$$

where

p is the index for the p-th RP code which is made as the s_p-th cyclic shifted sequence from the root index r_p of Zadoff-Chu sequence.

$$r_p = \mathrm{mod}((1 - 2 \cdot \mathrm{mod}(\lfloor p/M_{ns} \rfloor, 2)) \cdot (\lfloor p/M_{ns}/2 \rfloor + r_{ns0}) + N_{RP}, N_{RP}),$$

$$p = 0,1,\ldots N_{cont} - 1, N_{cont},\ldots,N_{cont} + N_{dedi} - 1 \tag{292}$$

$$s_p = \mathrm{mod}(p, M_{ns}), p=0,1,\ldots N_{cont} - 1, N_{cont},\ldots,N_{cont} + N_{dedi} - 1 \tag{293}$$

where

r_{ns0} is broadcasted in the S-SFH.

M_{ns} is the number of cyclic shifted codes per ZC root index according to Table 6-267.

N_{cont} is the total number of initial ($0 \sim N_{IN} - 1$) and handover RP codes ($N_{IN} \sim N_{IN} + N_{HO} - 1$) per sector for contention-based approach.

N_{dedi} is the total number of dedicated handover RP code ($N_{cont} \sim N_{cont} + N_{dedi} - 1$) per sector where maximum possible N_{dedi} per sector is 32.

N_{CS} is the unit of cyclic shift according to the cell size. It is defined by $N_{CS} = N_{RP}/M_{ns}$, where M_{ns} is the number of cyclic shifted codes per ZC root index according to Table 6-267.

N_{RP} is the length of RP codes defined as N_{RP} = 139 for the NS-RCH Format 0 in Table 6-262 and N_{RP} = 557 for the NS-RCH Format 1 in Table 6-262.

The number of cyclic shifted codes per root index (M_{ns}), the start root index of ZC code (r_{ns0}), and the RP code partition information are broadcasted by S-SFH SP1. The number of cyclic shifted codes per root index is defined in Table 6-267. The start root index of ZC code is defined by $r_{ns0} = 4 \times k_{ns}+1$ and $r_{ns0} = 16 \times k_{ns}+1$ for the NS-RCH Format 0 and Format 1, respectively, where k_{ns} (= 0, 1, 2, …, or 15) is a cell specific value broadcasted through S-SFH SP1. The RP code partition information indicates the number of the initial and handover RP codes and is defined in Table 6-268.

Table 6-267—Number of cyclic shifted codes per ZC root index, M_{ns}, for the NS-RCH

index	0	1	2	3
M_{ns}	1	2	4	8

Table 6-268—RP code partition information table, N_{IN} and N_{HO}, for the NS-RCH

Partition Index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of the initial RP codes, N_{IN}	8	8	8	8	16	16	16	16	24	24	24	24	32	32	32	32
Number of the handover RP codes, N_{HO}	8	16	24	32	8	16	24	32	8	16	24	32	8	16	24	32

Ranging channel configurations

The information for ranging time resource allocation is indicated by the S-SFH in a regular allocation. The information of the NS-RCH allocation consists of the ranging configuration with AAI subframe-offset (O_{SF}) for ranging resource allocation in the time domain. The information for ranging frequency resource allocation, i.e., the subband index for ranging resource allocation is determined by the *IDcell* and the allocated number of subbands R_{SB} according to the Equation (294), where *IDcell* is defined in 6.3.5.1.2 and R_{SB} is $L_{SB\text{-}CRU,FPi}/4$, where L_{SB-CRU,FP_i} is the number of allocated subband CRUs in 6.3.7.3 for FP_i corresponding to reuse-1 partition or power-boosted reuse-3 only if there is no reuse-1 partition.

$$I_{SB} = \mathrm{mod}(\, IDcell, R_{SB}) \tag{294}$$

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

Table 6-269 shows the information of the NS-RCH allocation in a regular allocation, which is indicated by the S-SFH.

Table 6-269 indicates the AAI subframe allocating the NS-RCH for Format 0 and Format 1. For Format 1, it indicates the starting AAI subframe for allocating the NS-RCH AAI subframe in contiguous three AAI subframes.

Table 6-269—Periodicity of the NS-RCH allocations by S-SFH

Configurations	AAI subframe allocating the NS-RCH
0	O_{SF}-th UL AAI subframe in every frame
1	O_{SF}-th UL AAI subframes in the first frame in every superframe
2	O_{SF}-th UL AAI subframe in the first frame in every even numbered superframe, i.e., mod(superframe number, 2) = 0
3	O_{SF}-th UL AAI subframe of the first frame in every 4th superframe, i.e., mod(superframe number, 4) = 0

The NS-RCH for handover ranging can also be allocated by the Broadcast Assignment A-MAP IE based on ABS scheduling decision in any AAI subframe, except the AAI subframe that has already been used for a regular allocation.

Ranging signal transmission

Equation (295) specifies the transmitted signal voltage to the antenna, as a function of time, during the NS-RCH format 0 or 1.

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_C t} \sum_{k=-(N_{RP}-1)/2}^{(N_{RP}-1)/2} x_p(k+(N_{RP}-1)/2) \cdot e^{j2\pi(k+K_{offset})\Delta f_{RP}(t-T_{RCP})} \right\} \tag{295}$$

where

t is the elapsed time since the beginning of the subject NS-RCH, with $0 < t < (T_{RCP} + 2 \times T_{RP})$ for Format 0 or $0 < t < (T_{RCP} + T_{RP})$ for Format 1.

N_{RP} is the length of the RP code in frequency domain.

$x_p(n)$ is the p-th RP code with length N_{RP}.

K_{offset} is the parameter related to the frequency position and is defined by

$$K_{offset} = -\{P_{SC} \cdot (k_0 + 2 - N_{PRU}/2) - 1/2 + \lfloor 2 \cdot k_0/N_{PRU} \rfloor\} \cdot \Delta f/\Delta f_{RP}\,.$$

N_{PRU} is the total number of PRUs as defined in 6.3.7.2.1.

k_0 is the lowest PRU index of the assigned NS-RCH.

P_{sc} is the number of the consecutive subcarriers within a PRU in frequency domain as defined in 6.3.7.1.

Δf_{RP} is the ranging subcarrier spacing.

6.3.8.2.4.2 Ranging channel for synchronized AMSs

Ranging preamble codes

The Padded Zadoff-Chu codes with cyclic shifts are used for the RP codes. The p-th RP code $x_p(n,k)$ for the n-th OFDMA symbol within a basic unit is defined by Equation (296).

$$x_p(n, k) = \exp\left(-j \cdot \pi\left(\frac{r_p \cdot (n \cdot 71 + k) \cdot (n \cdot 71 + k + 1)}{211} + \frac{2 \cdot k \cdot s_p \cdot N_{TCS}}{N_{FFT}}\right)\right), \quad k = 0, 1, \ldots, N_{RP} - 1; n = 0,1,2 \tag{296}$$

where

p is the index for the p-th RP code within a basic unit that is made as the s_p-th cyclic shifted sequence from the root index r_p of the Zadoff-Chu sequence.

$r_p = \mathrm{mod}((1 - 2 \cdot \mathrm{mod}(\lfloor p/M_s \rfloor, 2)) \cdot (\lfloor p/M_s/2 \rfloor + r_{s0}) + 211, 211)$

$p = 0,1,\ldots N_{cont} - 1, N_{cont},\ldots,N_{cont} + N_{dedi} - 1$

$s_p = \mathrm{mod}(p, M_s), p=0,1,\ldots N_{cont} - 1, N_{cont},\ldots,N_{cont} + N_{dedi} - 1$

r_{s0} is the start root index.

M_s is the number of cyclic shift per ZC root index and defined by $M_s = 1/G$.

N_{cont} is the number of periodic RP codes per sector ($0 \sim N_{PE} - 1$), which is defined by Table 6-270 for contention-based approach. For femtocell, N_{cont} is the total number of initial ($0 \sim N_{IN} - 1$), handover ($N_{IN} \sim N_{IN} + N_{HO} - 1$) and periodic RP codes ($N_{IN} + N_{HO} \sim N_{IN} + N_{HO} + N_{PE} - 1$) per sector, which is defined by Table 6-271 for contention-based approach.

N_{dedi} is the total number of dedicated handover RP codes ($N_{cont} \sim N_{cont} + N_{dedi} - 1$) per sector where maximum possible N_{dedi} per sector is 32.

N_{TCS} is the unit of time domain cyclic shift per OFDMA symbol according to the CP length and defined by $N_{TCS} = G \cdot N_{FFT}$, where G and N_{FFT} are the CP ratio and FFT size defined in Table 6-146, respectively.

N_{RP} is the length of the RP codes per OFDMA symbol, i.e., $N_{RP} = 72$.

The start root index of the ZC code (r_{s0}) and the RP code information are broadcasted by the AAI-SCD message for periodic ranging in non-femto deployment and S-SFH SP1 for initial, handover, and periodic ranging in femtocell deployment. The start root index of the ZC code is defined by $r_{s0} = 6 \times k_s + 1$, where k_s (= 0, 1, 2, …, or 15) is a cell specific value. The RP code information indicates the number of periodic RP codes, and is defined by Table 6-270. For femtocell, the RP code partition information indicate the number of initial, handover and periodic RP codes and is defined in Table 6-271.

Table 6-270—Ranging preamble code information table, N_{PE}, for the S-RCH

Index	Number of periodic ranging preamble codes, N_{PE}
0	8
1	16
2	24
3	32

Table 6-271—The RP code partition information table for Femtocell, N_{IN}, N_{HO}, and N_{PE}, for the S-RCH

Partition index	Number of initial RP codes, N_{IN}	Number of handover RP codes, N_{HO}	Number of periodic RP codes, N_{PE}
0	4	4	4
1	4	8	4
2	4	16	4
3	4	24	4
4	8	4	8
5	8	8	8
6	8	16	8
7	8	24	8
8	16	4	16
9	16	8	16
10	16	16	16
11	16	24	16
12	24	4	24
13	24	8	24
14	24	16	24
15	24	24	16

Ranging channel configurations

The information of the S-RCH allocation consists of the ranging configuration with AAI subframe-offset (O_{SF}) for ranging resource allocation in the time domain where O_{SF} is the same AAI subframe-offset of the NS-RCH defined in 6.3.8.2.4.1. The information for ranging frequency resource allocation, i.e., the subband index for ranging resource allocation is determined by the *IDcell* and the allocated number of subbands R_{SB} according to the Equation (297) where *IDcell* is defined in 6.3.5.1.2 and R_{SB} is $L_{SB\text{-}CRU,FPi}/4$, where $L_{SB\text{-}CRU,FPi}$ is the number of allocated subband CRUs as defined in 6.3.7.3 for FP_i corresponding to reuse-1 partition or power-boosted reuse-3 partition only if there is no reuse-1 partition.

$$I_{SB,s} = \begin{cases} \mathrm{mod}(IDcell, R_{SB}), & \text{when NS-RCH is configured as Format 0 with } N_{UL} > 1 \\ \mathrm{mod}(IDcell + 1, R_{SB}), & \text{otherwise} \end{cases} \tag{297}$$

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

Table 6-272 shows the information of the S-RCH allocation where N_{UL} is the number of UL AAI subframe per frame.

When Y_{SB} = 1 and N_{UL} = 1, the configuration 0 shall be not used for the S-RCH allocation.

Table 6-272—Periodicity of the S-RCH allocations

Configurations	AAI subframe allocating the S-RCH
0	mod(O_{SF} + 1, N_{UL})th UL AAI subframe in every frame
1	mod(O_{SF} + 1, N_{UL})th UL AAI subframe in the second frame in every superframe
2	mod(O_{SF} + 1, N_{UL})th UL AAI subframe in the second frame in every 4th superframe, i.e., mod(superframe number, 4) = 0
3	mod(O_{SF} + 1, N_{UL})th UL AAI subframe in the second frame in every 8th superframe, i.e., mod(superframe number, 8) = 0

6.3.8.2.4.3 Ranging channel for FDM-based UL PUSC zone support

Ranging preamble codes

When the frame structure is supporting the R1 MSs in UL PUSC zone by FDM manner as defined in 6.3.7.3.5, the ranging codes for WirelessMAN-OFDMA R1 Reference System in 8.4.7.3 in IEEE Std 802.16 are used for AMSs.

The binary codes are the pseudonoise codes produced by the PRBS described in Figure 6-194, which implements the polynomial generator $1+X^1+X^4+X^7+X^{15}$. The PRBS generator shall be initialized by the seed b14...b0 = 0,0,1,0,1,0,1,1,s0,s1,s2,s3,s4,s5,s6, where s6 is the LSB of the PRBS seed, and s6:s0 = UL_PermBase, where s6 is the MSB of the UL_PermBase.

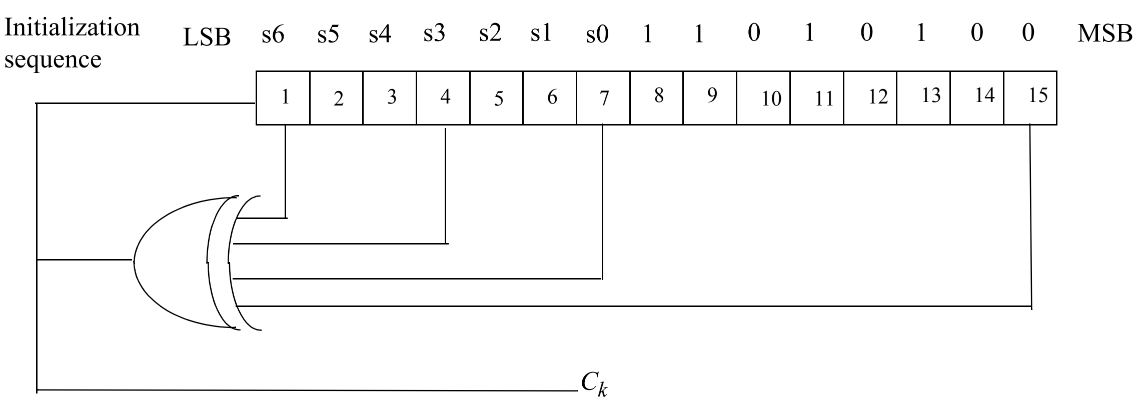


Figure 6-194—PRBS generator for ranging code generation

The binary RP codes are subsequences of the pseudonoise sequence appearing at its output C_k. The length of each RP code is 144 bits. These bits are used to modulate the subcarriers in a group of six adjacent distributed LRUs, where distributed LRUs are considered adjacent if they have successive LRU numbers. The bits are mapped to the subcarriers in increasing frequency order of the subcarriers so that the lowest indexed bit modulates the subcarrier with the lowest frequency index and the highest indexed bit modulates the subcarrier with the highest frequency index. The six distributed LRUs are called a ranging LRU.

The number of available RP codes is 256, numbered 0, ... , 255. Each ABS uses a subgroup of these RP codes, where the start index of subgroup is defined by a number r_{ns0}, $r_{ns0} = 16 \times k_{ns} + 1$, where k_{ns} (= 0, 1, 2, …, or 15) is a cell-specific value broadcasted by S-SFH SP1. The group of RP codes shall be between r_{ns0} and $((N_{IN} + N_{HO} + N_{PE} + N_{dedi}) \bmod 256)$.

— The first N_{IN} RP codes produced are for contention-based initial ranging. Clock the PRBS generator $144 \times (r_{ns0} \bmod 256)$ times to $144 \times ((r_{ns0} + N_{IN}) \bmod 256) - 1$ times.

— The next N_{HO} RP codes produced are for contention-based handover ranging. Clock the PRBS generator $144 \times ((r_{ns0} + N_{IN}) \bmod 256)$ times to $144 \times ((r_{ns0} + N_{IN} + N_{HO}) \bmod 256) - 1$ times.

— The next N_{PE} RP codes produced are for contention-based periodic ranging. Clock the PRBS generator $144 \times ((r_{ns0} + N_{IN} + N_{HO}) \bmod 256)$ times to $144 \times ((r_{ns0} + N_{IN} + N_{HO} + N_{PE}) \bmod 256) - 1$ times.

— The next N_{dedi} RP codes produced are for dedicated handover ranging where maximum possible number of dedicated RP codes per sector is 32. Clock the PRBS generator $144 \times ((r_{ns0} + N_{IN} + N_{HO}+N_{PE}) \bmod 256)$ times to $144 \times ((r_{ns0} + N_{IN} + N_{HO} + N_{PE} + N_{dedi}) \bmod 256) - 1$ times.

The UL_PermBase, start index of subgroup (r_{ns0}) and the number of RP code in each group (N_{IN}, N_{HO}, and N_{PE}) are broadcasted by S-SFH SP1. The number of initial, handover and periodic RP codes is defined in Table 6-273.

Table 6-273—RP code partition information table for FDM-based UL PUSC zone support, N_{IN}, N_{HO}, and N_{PE}

Partition index	Number of initial ranging codes, N_{IN}	Number of handover ranging codes, N_{HO}	Number of periodic ranging codes, N_{PE}
0	8	8	8
1	8	16	8
2	8	24	8
3	8	32	8
4	16	8	16
5	16	16	16
6	16	24	16
7	16	32	16
8	24	8	24
9	24	16	24
10	24	24	24
11	24	32	24
12	32	8	32
13	32	16	32
14	32	24	32
15	32	32	32

Ranging channel configurations

The information for the RCHs time/frequency resource allocation with Figure 6-189 is indicated by the S-SFH. The information of the RCHs allocation consists of the ranging configuration with subframe-offset (O_{SF}) for ranging resource allocation in the time domain. The frequency resource allocation of the RCHs is described in 6.3.7.3.3.

The periodicity of the RCHs allocation with Figure 6-189 is the same as that of the NS-RCH defined in Table 6-269.

6.3.8.2.5 Bandwidth request channel

Each BR channel shall comprise of three distributed BR tiles for frequency diversity. A BR tile in the M-Zone is defined as six contiguous subcarriers by six OFDMA symbols. As shown in Figure 6-195, the BR tile is made up of two parts—a preamble portion and a data portion. The preamble portion transmits the BR preamble on a resource that spans four subcarriers by six OFDMA symbols. The data portion of the BR tile spans two contiguous subcarriers by six OFDMA symbols and transmits the quick access message for the three-step BR. The procedure for the formation of BR channel is defined in 6.3.7.3.3.1.

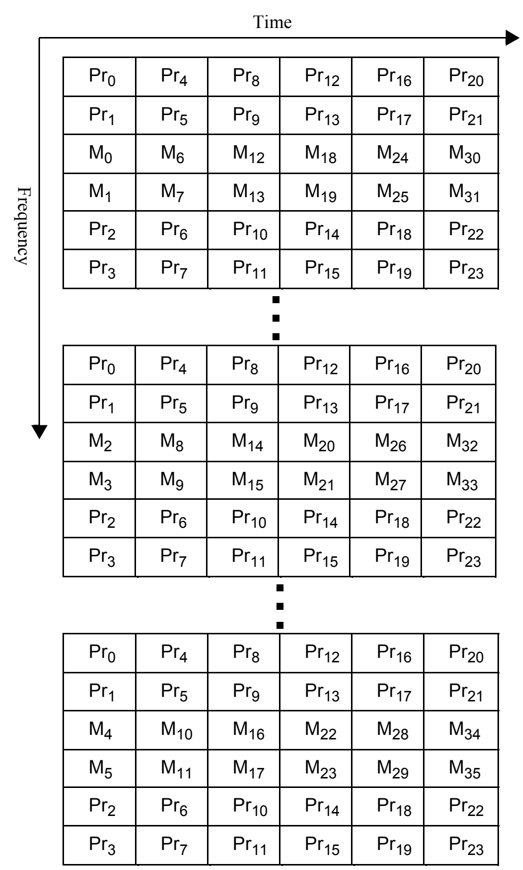


Figure 6-195—6x6 BR tile structure in the advance air interface

For the three-step BR, 16 bits of BW request information is constructed from 12 bits of STID and 4 bits of pre-defined BR information described in 6.3.10.1.5.1. Let $s_0s_1s_2s_3s_4s_5s_6s_7s_8s_9s_{10}s_{11}$ and $s_{12}s_{13}s_{14}s_{15}$

denote the STID and pre-defined BR information respectively. By reordering the bits of STID and pre-defined BR information, 16 bits of BW request information is formed as shown in Equation (298).

$$b_0 b_1 b_2 b_3 b_4 b_5 b_6 b_7 b_8 b_9 b_{10} b_{11} b_{12} b_{13} b_{14} b_{15} = s_0 s_1 s_2 s_3 s_4 s_5 s_6 s_7 s_8 s_9 s_{10} s_{11} s_{12} d_0 d_1 d_2 \tag{298}$$

where

$$d_i = \mathrm{mod}(s_i + s_{i+3} + s_{i+6} + s_{i+9} + s_{i+13}, 2) \qquad 0 \le i < 3$$

3 bits of the 16 information bits shall be carried in the BR preamble using the preamble index. The combined resource in the data portions of the three tiles that form the BR channel shall be used to transmit the remaining 13 bits of information. The frame number and 16 bits of the bandwidth request message shall be used to select a sequence of length 24 from Table 6-274. The selected preamble sequence is transmitted in the preamble portion of all the three BW REQ tiles.

Table 6-274—BR channel preamble sequences

u	$P_u(k)$, $0 \le k < 24$																							
0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
1	1	0	1	0	1	1	1	0	0	0	1	0	1	0	1	0	1	1	1	0	0	0	1	0
2	1	0	0	1	0	1	1	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0	1
3	1	1	0	0	1	0	1	1	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0
4	1	0	1	0	0	1	0	1	1	1	0	0	1	0	1	0	0	1	0	1	1	1	0	0
5	1	0	0	1	0	0	1	0	1	1	1	0	1	0	0	1	0	0	1	0	1	1	1	0
6	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1
7	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1	1
8	1	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1
9	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0
10	1	0	1	1	1	0	0	0	1	0	0	1	1	0	1	1	1	0	0	0	1	0	0	1
11	1	1	0	1	1	1	0	0	0	1	0	0	1	1	0	1	1	1	0	0	0	1	0	0
12	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
13	1	0	1	0	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1

Table 6-274—BR channel preamble sequences *(continued)*

u	$P_u(k), 0 \le k < 24$																						
14	1	0	0	1	0	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	1	1	1	0
15	1	1	0	0	1	0	1	1	1	0	0	0	0	0	1	1	0	1	0	0	0	1	1	1
16	1	0	1	0	0	1	0	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	1	1
17	1	0	0	1	0	0	1	0	1	1	1	0	0	1	1	0	1	1	0	1	0	0	0	1
18	1	0	0	0	1	0	0	1	0	1	1	1	0	1	1	1	0	1	1	0	1	0	0	0
19	1	1	0	0	0	1	0	0	1	0	1	1	0	0	1	1	1	0	1	1	0	1	0	0
20	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	0
21	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0	1	1	0	1
22	1	0	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0
23	1	1	0	1	1	1	0	0	0	1	0	0	0	0	1	0	0	0	1	1	1	0	1	1

The preamble sequences transmitted in the three BR tiles of a BR channel are defined as in Equation (299).

$$P_u(k),\ 0 \le k < 24 \tag{299}$$

where k is symbol index, and u is sequence index.

The mapping between the combination of the frame number and the 16 bits of the bandwidth request message $b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11}b_{12}b_{13}b_{14}b_{15}$ to the physical preamble index u is as in Equation (300).

$$u = \mathrm{mod}(q + \mathrm{bin2dec}(b_{13}b_{14}b_{15}) + 8r, 24) \tag{300}$$

where

$$r = \mathrm{mod}\left(\sum_{i=0}^{4} \mathrm{bin2dec}(b_{3i}b_{3i+1}b_{3i+2}), 3\right)$$

$$q = \lfloor \mathrm{bin2dec}(b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11})/24 \rfloor \times t$$

and t is the frame index calculated as four times superframe number plus frame index within a superframe (in range of 0 to 3).

The selected preamble sequence $P_u(0)$, $P_u(1)$, …, $P_u(23)$ shall be BPSK modulated (0 mapped to +1 and 1 mapped to –1) and mapped to Pr_0, Pr_1, …, Pr_{23}.

The 16-bit information in the quick access message transmitted in the BR channel shall be used to generate 5 bits CRC $r_0r_1r_2r_3r_4$, per the ITU-T G.704 CRC-5 with initialization to 0b00000 and no bitwise flipping of the polynomial output using generating polynomial $G(x) = x^5 + x^4 + x^2 + 1$. The 13 bits of information together with the 5 CRC bits, $b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11}b_{12}r_0r_1r_2r_3r_4$, shall be encoded into 72 bits $c_0, c_1, c_2, ..., c_{71}$ using the TBCC code with parameters $L = 18$, $K_{bufsize} = 72$ and $M = 72$. The 72 coded bits shall then be QPSK modulated to generate 36 data symbols $M_0, M_1, ..., M_{35}$. The combined resource of the data portion in the three distributed BR tiles that form the BR channel shall be used to transmit these data symbols.

To calculate 5 bits CRC the following procedure is applied:

a) The first bit s_0 corresponds to the x^{15} term and the last bit s_{15} corresponds to the x^0 term of the information polynomial
b) The information polynomial multiplied by x^5 is divided by polynomial $G(x) = x^5+x^4+x^2+1$
c) The 5 bits of the CRC are set so that the first bit of r_0 corresponds to x^4 term of the remainder polynomial and the last bit r_4 corresponds to x^0 term of the remainder polynomial

When frame structure is supporting the WirelessMAN-OFDMA R1 Reference System with FDM-based uplink PUSC zone, a BR tile shall be defined as four contiguous subcarriers by 6 OFDMA symbols. As shown in Figure 6-196, only the BR preamble shall be transmitted in all 24 subcarriers that form the BR tile. In this case, the preamble index u shall be randomly selected from 0 to 23.

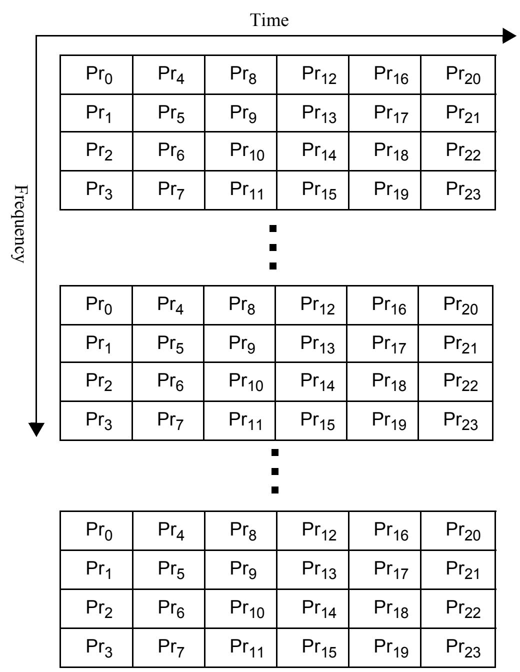


Figure 6-196—4x6 BR tile structure

For the AMS with multiple transmission antennas, the multi-antenna transmission of BR shall be limited to 1-stream mode 1 uplink MIMO scheme defined in 6.3.9.

6.3.8.3 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:

— Channel quality feedback
— MIMO feedback
— HARQ feedback (ACK/NACK)
— Uplink synchronization signals

— Bandwidth requests
— Frequency partition selection (for MFM 0, 4, and 7)

6.3.8.3.1 Fast feedback control channel

The UL fast feedback channel shall carry channel quality feedback and MIMO feedback. There are two types of UL fast feedback control channels: primary fast feedback channel (PFBCH) and secondary fast feedback channels (SFBCH). The UL fast feedback channel starts at a pre-determined location, with the size defined in a DL broadcast control message. Fast feedback allocations to an AMS can be periodic and the allocations are configurable. The number of UL fast feedback channels that the ABS allocates to an AMS shall be less than or equal to one per active carrier. This allocation may include requests for interleaved PFBCH and SFBCH reports.

6.3.8.3.1.1 Primary fast feedback control channel

The UL PFBCH carries 6 bits of information, providing feedback contents in Table 6-275.

Table 6-275—PFBCH feedback content

PFBCH feedback content	Related MIMO feedback mode	Description/Notes
CQI	0,1,2,3,4,5,6,7	1) Wideband CQI 2) Subband CQI for best-1 subband
STC Rate Indicator	0,2,3,4	
Subband index	2,3,5,6	Subband selection for best-1 subband
PMI	3,4,6,7	1) Wideband PMI 2) Subband PMI for best-1 subband
EDI Type 0	N/A	Event-driven indicator to request to switch MIMO feedback mode between distributed and localized allocations
EDI Type 1	N/A	Event-driven indicator to request UL bandwidth. 2 sequences (two services)
EDI Type 2	N/A	Event-driven indicator in order that the AMS informs the ABS about the frequency partition index (for MIMO feedback modes 0,4,7)
EDI Type 3	N/A	Event-driven indicator to indicate occupancy status of HARQ soft buffer

Event-driven indicator (EDI) shall not be transmitted in two consecutive feedback reports.

For PFBCH transmission, four encoding types are defined. Encoding type corresponding to MFM and feedback format in Feedback Allocation A-MAP IE is used.

PFBCH Encoding Type 0: Encoding Type 0 in PFBCH is used for CQI and STC rate or EDI reporting. Details can be found in Table 6-276.

Table 6-276—Contents encoding Type 0 in PFBCH

Index	Content (value)	Description/Notes
0	STC rate = 1, MCS = 0000	
1	STC rate = 1, MCS = 0001	
2	STC rate = 1, MCS = 0010	
3	STC rate = 1, MCS = 0011	
4	STC rate = 1, MCS = 0100	
5	STC rate = 1, MCS = 0101	
6	STC rate = 1, MCS = 0110	
7	STC rate = 1, MCS = 0111	
8	STC rate = 1, MCS = 1000	
9	STC rate = 1, MCS = 1001	
10	STC rate = 1, MCS = 1010	
11	STC rate = 1, MCS = 1011	
12	STC rate = 1, MCS = 1100	
13	STC rate = 1, MCS = 1101	
14	STC rate = 1, MCS = 1110	
15	STC rate = 1, MCS = 1111	
16	STC rate = 2, MCS = 0000	
17	STC rate = 2, MCS = 0001	
18	STC rate = 2, MCS = 0010	
19	STC rate = 2, MCS = 0011	
20	STC rate = 2, MCS = 0100	
21	STC rate = 2, MCS = 0101	
22	STC rate = 2, MCS = 0110	
23	STC rate = 2, MCS = 0111	
24	STC rate = 2, MCS = 1000	
25	STC rate = 2, MCS = 1001	
26	STC rate = 2, MCS = 1010	
27	STC rate = 2, MCS = 1011	
28	STC rate = 2, MCS = 1100	
29	STC rate = 2, MCS = 1101	
30	STC rate = 2, MCS = 1110	

Table 6-276—Contents encoding Type 0 in PFBCH *(continued)*

Index	Content (value)	Description/Notes
31	STC rate = 2, MCS = 1111	
32	STC rate = 3, MCS = 0100	
33	STC rate = 3, MCS = 0101	
34	STC rate = 3, MCS = 0110	
35	STC rate = 3, MCS = 0111	
36	STC rate = 3, MCS = 1000	
37	STC rate = 3, MCS = 1001	
38	STC rate = 3, MCS = 1010	
39	STC rate = 3, MCS = 1011	
40	STC rate = 3, MCS = 1100	
41	STC rate = 3, MCS = 1101	
42	STC rate = 3, MCS = 1110	
43	STC rate = 3, MCS = 1111	
44	STC rate = 4, MCS = 1000	
45	STC rate = 4, MCS = 1001	
46	STC rate = 4, MCS = 1010	
47	STC rate = 4, MCS = 1011	
48	STC rate = 4, MCS = 1100	
49	STC rate = 4, MCS = 1101	
50	STC rate = 4, MCS = 1110	
51	STC rate = 4, MCS = 1111	
52	*Reserved*	
53	*Reserved*	
54	*Reserved*	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven indicator for buffer management
56	Event-driven Indicator (EDI) for Buffer management (overflow)	
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations

Table 6-276—Contents encoding Type 0 in PFBCH *(continued)*

Index	Content (value)	Description/Notes
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	The AMS informs the ABS about the frequency partition index (for MIMO feedback modes 0,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request
63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	

PFBCH Encoding Type 1: Encoding Type 1 in PFBCH is used for best subband index or EDI reporting. Details can be found in Table 6-277.

PFBCH Encoding Type 2: Encoding Type 2 in PFBCH is used for PMI reporting. The PMI of the *i*-th codebook entry, $C(N_t, M_t, N_B, i)$, is mapped into sequence index i in PFBCH.

PFBCH Encoding Type 3: Encoding Type 3 in PFBCH is used for CQI or EDI reporting. Details can be found in Table 6-278.

6.3.8.3.1.2 Secondary fast feedback control channel

The UL SFBCH carries wideband/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. The feedback contents in Table 6-279 are carried in order of Feedback Fields in Feedback formats.

6.3.8.3.1.3 Channel quality indicator (CQI) definition

The CQI feedback together with the STC rate feedback (when applicable) composes the spectral efficiency value reported by the AMS. This value corresponds to the measured block error rate which is the closest, but not exceeding, a specific target error rate.

Table 6-277—Contents encoding Type 1 in PFBCH

Index	Content (Value)	Description/Notes
0	Subband index 0	Subband index for Best-1 subband (see 6.3.8.3.1.4)
1	Subband index 1	
2	Subband index 2	
3	Subband index 3	
4	Subband index 4	
5	Subband index 5	
6	Subband index 6	
7	Subband index 7	
8	Subband index 8	
9	Subband index 9	
10	Subband index 10	
11	Subband index 11	
12	Subband index 12	
13	Subband index 13	
14	Subband index 14	
15	Subband index 15	
16	Subband index 16	
17	Subband index 17	
18	Subband index 18	
19	Subband index 19	
20	Subband index 20	
21	Subband index 21	
22	Subband index 22	
23	Subband index 23	
24	*Reserved*	*Reserved*
25~53	*Reserved*	
54	*Reserved*	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven for buffer management
56	Event-driven Indicator (EDI) for Buffer management (full)	
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations

Table 6-277—Contents encoding Type 1 in PFBCH *(continued)*

Index	Content (Value)	Description/Notes
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	The AMS informs the ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request
63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	

Table 6-278—Contents encoding Type 3 in PFBCH

Index	Content (Value)	Description/Notes
0	STC rate = 1/2, MCS = 0000	
1	STC rate = 1/2, MCS = 0001	
2	STC rate = 1/2, MCS = 0010	
3	STC rate = 1/2, MCS = 0011	
4	STC rate = 1/2, MCS = 0100	
5	STC rate = 1/2, MCS = 0101	
6	STC rate = 1/2, MCS = 0110	
7	STC rate = 1/2, MCS = 0111	
8	STC rate = 1/2, MCS = 1000	
9	STC rate = 1/2, MCS = 1001	
10	STC rate = 1/2, MCS = 1010	
11	STC rate = 1/2, MCS = 1011	
12	STC rate = 1/2, MCS = 1100	
13	STC rate = 1/2, MCS = 1101	
14	STC rate = 1/2, MCS = 1110	
15	STC rate = 1/2, MCS = 1111	

Table 6-278—Contents encoding Type 3 in PFBCH *(continued)*

Index	Content (Value)	Description/Notes
16~54	*Reserved*	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven for buffer management
56	Event-driven Indicator (EDI) for Buffer management (full)	
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	The AMS informs the ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request
63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	

Table 6-279—SFBCH feedback content

SFBCH feedback content	Related MIMO feedback mode	Description/Notes
Subband CQI	2,3,5,6	Reporting of average and differential CQI of selected subbands.
Subband index	2,3,5,6	Indicating the selected subbands.
Subband PMI	3,6	Preferred Matrix Index of one subband for CL MIMO.
Stream Indicator	5	It is needed for OL MU MIMO only and used to indicate which spatial stream to estimate CQI.
STC Rate Indicator	2,3,4,5,6,7	
PFBCH Indicator	2,3,4,5,6,7	One bit indicator used for indicating the transmission of PFBCH in the next SFBCH opportunity. In the transmission of PFBCH, encoding Type 0 shall be used and an EDI shall be transmitted.
Wideband CQI and PMI	4,7	

The AMS reports the CQI by selecting a nominal MCS index from Table 6-280. MCS index should be selected assuming 4 LRUs in Type 1 AAI subframe as a resource allocation, and 10% as a target error rate for the first HARQ transmission and considering varying channel conditions during the delay from the reference signal that the CQI measurement is made on and to the point of time that the CQI is reported. That is, the reported CQI in frame N measured from the reference signal(s) at least up to frame $N – 1$ corresponds to an appropriate MCS index for the frame N. In order to allocate the AMS with MCS level and rank appropriate for the actual requirements, the ABS should make further adjustments to the AMS reported spectral efficiency, by considering parameters values different from the reference ones and by adapting to delay and mobility conditions.

The nominal MCS for CQI feedback shall be selected from Table 6-280.

Table 6-280—MCS table for CQI

MCS index	Modulation	Code rate
0000	QPSK	31/256
0001	QPSK	48/256
0010	QPSK	71/256
0011	QPSK	101/256
0100	QPSK	135/256
0101	QPSK	171/256
0110	16QAM	102/256
0111	16QAM	128/256
1000	16QAM	155/256
1001	16QAM	184/256
1010	64QAM	135/256
1011	64QAM	157/256
1100	64QAM	181/256
1101	64QAM	205/256
1110	64QAM	225/256
1111	64QAM	237/256

For MU-MIMO feedback modes with codebook-based feedback, the CQI is calculated at the AMS assuming there are ($MaxM_t – 1$) interfering users and that the interfering users are scheduled by the S-ABS using rank-1 precoders orthogonal to each other and orthogonal to the rank-1 precoder represented by the reported PMI. If $MaxM_t = 1$, the AMS feeds back rank-1 CL SU-MIMO CQI.

6.3.8.3.1.4 Representation of subband indices

For the AMS selected subband feedback, the AMS shall report the M selected subband logical indices using a combinatorial index r defined as

$$r = \sum_{i=1}^{M} \left\langle {S_i \atop i} \right\rangle$$

where

the set $\{S_i, i = 1, 2, \ldots, M\}, (0 \le S_i \le Y_{SB} - 1, S_i < S_{i+1})$ contains the M selected subband logical indices.

$\left\langle {x \atop y} \right\rangle = \begin{cases} \binom{x}{y}, x \ge y \\ 0, x < y \end{cases}$ is the extended binomial coefficient.

resulting in a unique label in the range: $r \in \left\{0, \ldots, \binom{Y_{SB}}{M} - 1\right\}$.

The term Y_{SB} and the logical subband indexing are defined in 6.3.5.5.2.4.3.

6.3.8.3.1.5 Feedback formats

Feedback formats define the information content carried by the fast feedback channels. The format of the content of the PFBCH is determined by the PFBCH encoding type. The SFBCH payload information bits may carry subbands index (Best_subbands_index), STC rate, wideband STC rate, PFBCH indicator, subband CQI, subband avg_CQI, differential CQI, stream index, wideband PMI, subband PMI, base PMI, and differential PMI. The SFBCH payload information bits $a_0a_1 \ldots a_{23}$ are defined in the order specified in Table 6-281 to Table 6-289.

STC rate and wideband STC rate shall be encoded with 1, 2, or 3 bits when the ABS has 2, 4, or 8 transmit antennas, respectively.

Subband CQI and subband avg_CQI shall be encoded with 4 bits corresponding to the nominal MCS of Table 6-280.

Differential CQI shall be encoded with 2 bits indicating values, 0b00: –1, 0b01: 0, 0b10: +1, 0b11: +2.

Wideband PMI, subband PMI, and base PMI shall be encoded with 3, 4, or 6 bits according to the codebook size.

Differential PMI shall be encoded with 2, 4, or 4 bits when the ABS has 2, 4, or 8 transmit antennas, respectively.

When the AMS estimates PMI by using the midamble, the AMS should consider channel variation and report the PMI with reference to the frame the PMI is reported. That is, the reported PMI in frame N measured from the midamble(s) at least up to frame $N - 1$ corresponds to an appropriate value of PMI estimated for the frame N.

Stream index shall be encoded with ceil($\log_2(MaxM_t)$) bits.

Best_subbands_index shall be encoded with $\left\lceil \log_2 \binom{Y_{SB}}{M} \right\rceil$ bits, where $\binom{x}{y}$ is the combination operation.

The total number of subbands Y_{SB} available for feedback is shown in Equation (301).

$$Y_{SB} = \sum_{m=0}^{3} \frac{L_{SB-CRU,FP_m}}{N_1} \tag{301}$$

where L_{SB-CRU,FP_m} is the number of allocated subband CRUs for FP_m.

Feedback format for MFM 0,1,4,7

Feedback formats for MFM 0, 4, and 7 are listed in Table 6-281. Short-term report happens in every reporting period as defined in feedback allocation A-MAP IE, long-term report will puncture short-term report according to long-term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. When $q = 0$, only the short period reports shall be sent. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding Type 0. If MFM = 4 or 7 and $q = 0$ for feedback format = 0b0, the ABS should allocate the feedback of the transmit correlation matrix using Feedback Polling A-MAP IE before allocating MFM 4 or 7 to the AMS, where q is defined in the Feedback Allocation A-MAP IE. If MFM = 4 or 7 for feedback format = 0b1, the ABS shall set $q = 0$, and only the short period reports shall be sent.

The wideband CQI is one average CQI corresponding to the MIMO mode signaled by the combination MFM and STC rate, with averaging over the whole band. In the case where the number of DL frequency partitions FPCT > 1, the wideband CQI is one average CQI over the corresponding frequency partition.

When MFM = 4 or 7 and $q > 0$, the AMS should calculate CQI assuming that the ABS will calculate the beamforming matrix utilizing the latest PMI which is fed back to the ABS. When MFM = 4 or 7 and $q = 0$ for feedback format = 0b0, the AMS should calculate CQI assuming that the ABS will calculate the beamforming matrix utilizing the latest successfully received transmit correlation matrix that is fed back to the ABS. For MFM 0, the calculated CQI should account for the non-adaptive precoder to be used by the ABS.

Table 6-281 shows feedback formats for MIMO feedback mode 0, 4, and 7 when Measurement Method Indication = 0b0 in Feedback Allocation A-MAP IE (operation outside the open-loop region).

Table 6-281—Feedback formats for MFM 0, 4, and 7 (outside OL region)

MFM	Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/Notes
0	0	PFBCH	2	Short	Wideband CQI and STC rate or any type of EDI	Encoding Type 0
				Long	Wideband CQI and STC rate	Encoding Type 0 Long-term FPI for FFR No long-term report when $q = 0$

Table 6-281—Feedback formats for MFM 0, 4, and 7 (outside OL region) *(continued)*

MFM	Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/Notes
4	0	PFBCH	2	Short	Wideband CQI and STC rate or any type of EDI	Encoding Type 0
				Long	Wideband PMI	PMI Encoding Type 2 No long-term report when $q = 0$
	1	SFBCH	1	Short	Wideband CQI Wideband STC rate Wideband PMI PFBCH indicator	
7	0	PFBCH	2	Short	Wideband CQI or any type of EDI	STC rate = 1 Encoding Type 0
				Long	Wideband PMI	PMI for rank 1 Encoding Type 2 No long-term report when $q = 0$
	1	SFBCH	1	Short	Wideband CQI Wideband PMI PFBCH indicator	

Table 6-282 shows feedback formats for MIMO feedback mode 0 and 1 when Measurement Method Indication = 0b1 in Feedback Allocation A-MAP IE (operation inside the open-loop region). When $q > 0$, the AMS shall not send a feedback report on the short period, except when it coincides with the long period.

Table 6-282—Feedback formats for MFM 0 and 1 (inside OL region)

MFM	FFBCH	Number of Reports	Report Period	Feedback Fields	Description/Notes
0	PFBCH	1	Long	Wideband CQI and STC rate or any type of EDI	Encoding Type 0
1	PFBCH	1	Long	Wideband CQI or any type of EDI	Encoding Type 3

Feedback format for MFM 2

The detailed format is listed in Table 6-283. Short-term report happens in every reporting period as defined in feedback allocation A-MAP IE, long-term report will puncture short-term report according to long-term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. If the PFBCH indicator in SFBCH is set to ‘1’, PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding Type 0. When $q = 0$, only the long period reports shall be sent. $q = 0$ shall not be set if Measurement Method Indication = 0b1.

The CQI of subband *m* shall be computed as follows: (Subband *m* CQI index) = (Subband avg CQI index) + (Subband *m* differential CQI), using the latest available reports of Subband avg CQI and Subband differential CQI. Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are {–1, 0, +1, +2}, which is index of the MCS level. The AMS shall ensure that the reported differential CQI will produce a value of subband *m* CQI in the range of 0 to 15.

Table 6-283 shows feedback formats for MIMO feedback mode 2 when Measurement Method Indication = 0b0 in Feedback Allocation A-MAP IE (operation outside the open-loop region).

Table 6-283—Feedback formats for MFM 2 (outside OL region)

Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/Notes
0 (M = 1)	PFBCH	2	Short	Subband CQI and STC rate or any type of EDI	Encoding Type 0 No short-term report when $q = 0$
			Long	Best_subbands_ index	Encoding Type 1
1 (M = 1)	SFBCH	1	Long	Best_subbands_ index, Subband CQI, STC rate, PFBCH indicator	Support of STC rate 1 to 8

2 ($M = \min\{5, Y_{SB}\}$)	SFBCH	2	Short	Subband avg CQI,
				For (m = 1:M){
				Subband differential CQI
				}
					No short-term report when $q = 0$

			Long	Best_subbands_ index, Wideband STC rate, PFBCH indicator	Support of STC rate 1 to 8

3 ($M = \min\{10, Y_{SB}\}$)	SFBCH	2	Short	Subband avg CQI,
				For (m = 1:M){
				Subband differential CQI
				}
					No short-term report when $q = 0$

			Long	Best_subbands_ index, Wideband STC rate, PFBCH indicator	Support of STC rate 1 to 8

Table 6-284 shows Feedback formats for MIMO feedback mode 2 when Measurement Method Indication = 0b1 in Feedback Allocation A-MAP IE (operation inside the open-loop region).

Table 6-284—Feedback formats for MFM 2 (inside OL region)

Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/Notes
0 (M = 1)	PFBCH	2	Short	Subband CQI for STC rate = 1/2 or any type of EDI	Encoding Type 3
			Long	Best_subbands_ index	Encoding Type 1
1 (M = 1)	SFBCH	1	Long	Best_subbands_ index, Subband CQI, PFBCH indicator	STC rate = 1/2

2 (M = min{5,Y_{SB}}	SFBCH	2	Short	Subband avg CQI,
				For (m = 1:M){
				Subband differential CQI
				}
					STC rate = 1/2

			Long	Best_subbands_ index, PFBCH indicator	

3 (M = min{10,Y_{SB}}	SFBCH	2	Short	Subband avg CQI,
				For (m = 1:M){
				Subband differential CQI
				}	

			Long	Best_subbands_ index, PFBCH indicator	

Feedback format for MFM 3

The detailed format is listed in Table 6-285. Short-term report happens in every reporting period as defined in feedback allocation A-MAP IE, long-term report will puncture short-term report according to long-term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. For feedback format 0 with 3 reports using the PFBCH, Subband PMI shall be transmitted first followed by report of Best_subbands_index. Subband CQI and subband PMI are then transmitted alternately and Best_subbands_index is transmitted in the long-term period. If the PFBCH indicator in SFBCH is set to ‘1’, PFBCH is transmitted using encoding Type 0 by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback. When q = 0, only the long period reports shall be sent. q = 0 shall not be set with the differential feedback mode.

The CQI of subband m shall be computed as follows for the first short period report following a long period report: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI). Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are {–1, 0, +1, +2}, which is the unit of the MCS level. The AMS shall ensure that the reported differential CQI will produce a value of subband m CQI in the range of 0 to 15.

If the ABS has four transmit antennas and assigns MFM3 with feedback format 3, then it shall set Codebook_subset = 0b1 except if Codebook_mode indicates the differential codebook-based feedback mode.

The detailed format for MIMO feedback mode 3 with differential codebook is in Table 6-286. Short-term report happens in every reporting period as defined in Feedback Allocation A-MAP IE. For $M > 1$, two long-term reports will puncture two short-term reports continuously according to long-term feedback period in Feedback Allocation A-MAP IE. The long-term feedback that conveys Best_subband_index shall be transmitted first. For $M = 1$, the long-term report will puncture one short-term report according to long-term feedback period in Feedback Allocation A-MAP IE.

Table 6-285—Feedback formats for MFM 3

Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/Notes
0 ($M = 1$)	PFBCH	3	Short	Subband CQI or any type of EDI	Encoding Type 0 No short-term report when $q = 0$
			Short	Subband PMI	Encoding Type 2 STC rate = 1 No short-term report when $q = 0$
			Long	Best_subband_index	Encoding Type 1

1 ($M = 2$)	SFBCH	2	Short	For ($m = 1{:}M$){
				Subband differential CQI,
				Subband PMI
				}
					No short-term report when $q = 0$

			Long	Best_subband_index, Wideband STC rate, Subband avg CQI, PFBCH indicator	

2 ($M = 3$)	SFBCH	2	Short	For ($m = 1{:}M$){
				Subband differential CQI,
				Subband PMI
				}
					No short-term report when $q = 0$

			Long	Best_subband_index, Wideband STC rate, Subband avg CQI, PFBCH indicator	

3 ($M = 4$)	SFBCH	2	Short	For ($m = 1{:}M$){
				Subband differential CQI,
				Subband PMI
				}
					No short-term report when $q = 0$

			Long	Best_subband_index, Wideband STC rate, Subband avg CQI, PFBCH indicator	

Table 6-286—Feedback formats for MFM 3 for differential codebook

Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/Notes
0 (M = 1)	SFBCH	2	Short	Subband CQI, Subband differential PMI, Padding	Padding 1 bit: if N_t = 2 0 bit: otherwise
			Long	Best_subbands_ index, STC rate, Base PMI, PFBCH indicator	PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

1 (M = 2)	SFBCH	3	Short	For (m = 1:M){
				Subband differential CQI,
				Subband differential PMI
				}	

			Long	Best_subbands_ index, Subband avg_CQI, PFBCH indicator	
			Long	For (m = 1:M){ Base PMI }, Wideband STC rate	PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

2 (M = 3)	SFBCH	3	Short	For (m = 1:M){
				Subband differential CQI,
				Subband differential PMI
				}	

			Long	Best_subbands_ index, Wideband STC rate, Subband avg_CQI, PFBCH indicator	

			Long	For (m= 1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

3 (M = 4)	SFBCH	3	Short	For (m = 1:M){
				Subband differential CQI,
				Subband differential PMI
				}	

			Long	Best_subbands_ index, Wideband STC rate, Subband avg_CQI, PFBCH indicator	

			Long	For (m = 1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

Feedback format for MFM 5

The detailed format is listed in Table 6-287. Short-term report happens in every reporting period as defined in Feedback Allocation A-MAP IE, long-term report will puncture short-term report according to long-term feedback period in Feedback Allocation A-MAP IE. The long period report shall start by puncturing the first short period report. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding Type 0. When $q = 0$, only the long period reports shall be sent. $q = 0$ shall not be set if Measurement Method Indication = 0b1.

The CQI of subband m shall be computed as follows: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI), using the latest available reports of Subband avg CQI and Subband differential CQI. Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are {–1, 0, +1, +2}, which is the unit of the MCS level. The AMS shall ensure that the reported differential CQI will produce a value of subband m CQI in the range of 0 to 15.

The feedback formats for MIMO feedback mode 5 are the same for operation inside or outside the open-loop region.

Table 6-287—Feedback formats for MFM 5

Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/ Notes
0 (M = 1)	SFBCH	1	Long	Best_subbands_index, Subband CQI, Stream Index, PFBCH indicator	

1 (M = 2)	SFBCH	2	Short	Subband avg_CQI,
				For (m = 1:M){
				Subband differential CQI,
				Stream Index
				}
					No short-term report when q = 0

			Long	Best_subbands_index, PFBCH indicator	

2 (M = 3)	SFBCH	2	Short	Subband avg_CQI,
				For (m = 1:M){
				Subband differential CQI,
				Stream Index
				}
					No short-term report when q = 0

			Long	Best_subbands_index, PFBCH indicator	

3 (M = 5)	SFBCH	2	Short	Subband avg_CQI,
				For (m = 1:M){
				Subband differential CQI,
				Stream Index
				}
					No short-term report when q = 0

			Long	Best_subbands_index, PFBCH indicator	

Feedback format for MFM 6

The detailed format is listed in Table 6-288. Short-term report happens in every reporting period as defined in feedback allocation A-MAP IE, long-term report will puncture short-term report according to long-term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. For feedback format 0 with 3 reports using the PFBCH, Subband PMI shall be transmitted first after every report of Best_subbands_index. Subband CQI and subband PMI are then transmitted alternately and Best_subbands_index is transmitted in the long-term period. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted using encoding Type 0 by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback. When $q = 0$, only the long-term reports shall be sent. $q = 0$ shall not be set with the differential feedback mode.

The CQI of subband m shall be computed as follows: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI), using the latest available reports of Subband avg CQI and Subband differential CQI. Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are {–1, 0, +1, +2}, which is the unit of the MCS level. The AMS shall ensure that the reported differential CQI will produce a value of subband m CQI in the range of 0 to 15.

If the ABS has four transmit antennas and assigns MFM six with feedback format 3, then it shall set Codebook_subset = 0b1 except if Codebook_mode indicates the differential codebook-based feedback mode.

The detailed format for MIMO feedback mode 6 with differential codebook is in Table 6-289. Short-term report happens in every reporting period as defined in feedback allocation A-MAP IE. For $M > 1$, two long-term reports will puncture two short-term reports continuously according to long-term feedback period in Feedback Allocation A-MAP IE. For $M = 1$, the long-term report will puncture one short-term report according to long-term feedback period in Feedback Allocation A-MAP IE.

Table 6-288—Feedback formats for MFM 6

Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/Notes
0 (M = 1)	PFBCH	3	Short	Subband CQI or any type of EDI	Encoding Type 0 No short-term report when q = 0
			Short	Subband PMI	Encoding Type 2 No short-term report when q = 0
			Long	Best_subbands_index	Encoding Type 1

1 (M = 2)	SFBCH	2	Short	For (m = 1:M){
				Subband differential CQI,
				Subband PMI
				}
					No short-term report when q = 0

			Long	Best_subbands_index, Subband avg CQI, PFBCH indicator	

2 (M = 3)	SFBCH	2	Short	For (m = 1:M){
				Subband differential CQI,
				Subband PMI
				}
					No short-term report when q = 0

			Long	Best_subbands_index, Subband avg CQI, PFBCH indicator	

3 (M = 4)	SFBCH	2	Short	For (m = 1:M){
				Subband differential CQI,
				Subband PMI
				}
					No short-term report when q = 0

			Long	Best_subbands_index, Subband avg CQI, PFBCH indicator	

Table 6-289—Feedback formats for MFM 6 for differential codebook

Feedback format	FFBCH	Number of reports	Report period	Feedback fields	Description/Notes
0 (M = 1)	SFBCH	2	Short	Subband CQI, Differential PMI, Padding	Padding 1 bit: if N_t = 2 0 bit: otherwise
			Long	Best_subbands_index, Base PMI, PFBCH indicator	PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

1 (M = 2)	SFBCH	3	Short	For (m = 1:M){
				Subband differential CQI,
				Subband differential PMI
				}	

			Long	Best_subbands_index, subband avg_CQI, PFBCH indicator	

			Long	For (m = 1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

2 (M = 3)	SFBCH	3	Short	For (m = 1:M){
				Subband differential CQI,
				Subband differential PMI
				}	

			Long	Best_subbands_index, subband avg_CQI, PFBCH indicator	

			Long	For (m = 1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

3 (M = 4)	SFBCH	3	Short	For (m = 1:M){
				Subband differential CQI,
				Subband differential PMI
				}	

			Long	Best_subbands_index, subband avg_CQI, PFBCH indicator	

			Long	For (m = 1:M){
				Base PMI
				}
					PMI for reset. Base PMI is a PMI from the base codebook or the base codebook subset.

6.3.8.3.1.6 Operation of EDI for request for switching MFM

The 57th codeword in PFBCH is defined for transition of MFM between distributed and localized permutations, where MFM 0, 1, 4, and 7 are corresponding to the distributed permutation, and MFM 2, 3, 5, and 6 are corresponding to the localized permutation. Based on the measurements such as the channel variation, the speed of the AMS, and so on, the AMS triggers transition to the appropriate permutation by transmitting the codeword. The transmission of the codeword means the request from an AMS for transition to another permutation from the current permutation corresponding to MFM, which was assigned by Feedback allocation A-MAP IE. If PFBCH is being used according to the feedback format, the AMS transmits the codeword at any feedback opportunity. If SFBCH is being used according to the feedback format, the AMS transmits SFBCH with setting the 'PFBCH indicator' to '1' first, and then transmits the codeword through PFBCH in the next feedback opportunity. When the ABS receives the codeword, the ABS may send Feedback allocation A-MAP IE to the AMS to assign the appropriate MFM that the ABS determines based on the request from the AMS. In order to determine the appropriate MFM, the ABS may transmit Feedback polling A-MAP IE to the AMS to obtain more MIMO feedback information before sending Feedback allocation A-MAP IE. When the ABS does not send the Feedback allocation A-MAP IE and/or the AMS does not receive the Feedback allocation A-MAP IE, the AMS shall keep reporting the feedback information. When the ABS sends the Feedback allocation A-MAP IE and the AMS receives the Feedback allocation A-MAP IE, the previous fast feedback channel is automatically deallocated and the AMS shall report the new feedback information through the newly allocated fast feedback channel.

6.3.8.3.2 Bandwidth request channel

The quick access message contains a 12-bit MSID and 4-bit predefined BR information defined in 6.2.11.1.5.1.

6.3.8.4 Uplink power control

Uplink power control is supported for both an initial calibration and a periodic adjustment on transmit power without loss of data. The uplink power control algorithm determines the transmission power of an OFDM symbol to compensate for the pathloss, shadowing, and fast fading. Uplink power control shall intend to control inter-cell interference level.

A transmitting AMS shall maintain the transmitted power density, unless the maximum power level is reached. In other words, when the number of active LRUs allocated to a user is reduced, the total transmitted power shall be reduced proportionally by the AMS, as long as there is no additional change of parameters for power control. When the number of LRU is increased, the total transmitted power shall also be increased proportionally. However, the transmitted power level shall not exceed the maximum levels dictated by signal integrity considerations and regulatory requirements.

An AMS shall report the maximum available power of the carrier for initial network entry by MAX Tx Power field when the AMS transmits AAI-SBC-REQ, and shall report the maximum power of available carriers when the AMS sends AAI-MC-REQ.

For interference level control, the current interference level of each ABS may be shared among ABSs.

The power per subcarrier and per stream shall be calculated according to Equation (302).

$$P(dBm) = L + SINR_{Target} + NI + Offset \tag{302}$$

where

$SINR_{Target}$ is the target uplink SINR received by the ABS.

P	is the Tx power level (dBm) per stream and per subcarrier for the current transmission.
L	is the estimated average current DL propagation loss calculated by the AMS. It shall include the AMS's Tx antenna gain and path loss.
NI	is the estimated average power level (dBm) of the noise and interference per subcarrier at the ABS, as indicated in the AAI-ULPC-NI message.
Offset	is a correction term for the AMS-specific power offset. It is controlled by the ABS through power control messages. There are two kinds of Offset values that are used for data and control, respectively. Further details are given in the following subclauses (6.3.8.4.1, 6.3.8.4.2, and 6.3.8.4.3).

The estimated average current DL propagation loss, L, shall be calculated based on the total power received on the active subcarriers of the frame preamble.

6.3.8.4.1 Power control for data channel

For data channel transmission, the $SINR_{Target}$ term in Equation (302) is calculated according to Equation (303).

$$SINR_{Target} = 10\log 10\left(\max\left(10^{\wedge}\left(\frac{SINR_{MIN}(dB)}{10}\right), \gamma_{IoT} \times SIR_{DL} - \alpha\right)\right) - \beta \times 10\log 10(TNS) \tag{303}$$

where Equation (303) is the target SINR value for IoT control and tradeoff between overall system throughput and cell edge performance, decided by the control parameter γ_{IoT} and $SINR_{MIN}$(dB). The parameters used in Equation (303) are broadcasted in the AAI-SCD message unless otherwise noted. The explanation for the parameters is as follows:

— $SINR_{MIN}$(dB) is the SINR requirement (*dataSinrMin*) for the minimum rate expected by the ABS.

— γ_{IoT} is the fairness and IoT control factor broadcasted.

— SIR_{DL} is the linear ratio of the downlink signal to interference power, measured by the AMS.

— α is the factor according to the number of receive antennas at the ABS.

— β is set to be zero or one to determine the influence of TNS on $SINR_{Target}$..

— TNS is the Total Number of Streams in the LRU indicated by UL A-MAP IE. In case of SU-MIMO, this value shall be set to M_t where M_t is the number of streams for the AMS. In case of CSM, TNS is the aggregated number of streams.

When calculated data channel $SINR_{Target}$ is higher than *dataSinrMax* defined in the AAI-SCD message, $SINR_{Target}$ shall be set to *dataSinrMax*.

For a data channel transmission, the *Offset* in Equation (302) shall be set to the value $Offset_{Data}$ conveyed in an AAI-UL_POWER_ADJ message. The value used shall be taken from the most recent message that preceded the first uplink subframe of the frame by more than $T_{DL\_Rx\_Processing}$. An AMS shall set initial $Offset_{Data}$ as $Offset_{Initial}$ after the AMS succeeds for initial ranging process. Here $Offset_{Initial}$ is calculated by an AMS during initial ranging process according to 6.3.8.4.4.

6.3.8.4.2 Power control for control channels

In the case of control channel transmission, except for initial ranging and sounding transmission, $SINR_{Target}$ in Equation (302) is set according to Table 6-290. The parameters in Table 6-290 are conveyed in the AAI-SCD message.

Table 6-290—$SINR_{Target}$ parameters for control channels

Control channel type	$SINR_{Target}$ parameters
HARQ Feedback	*targetHarqSinr*
Synchronized Ranging	*targetSyncRangingSinr*
P-FBCH	*targetPfbchSinr*
S-FBCH	*targetSfbchBaseSinr*
	targetSfbchDeltaSinr
Bandwidth Request	*targetBwRequestSinr*

For HARQ Feedback, Synchronized Ranging, P-FBCH and Bandwidth Request, the $SINR_{Target}$ values are indicated directly in Table 6-290. For the S-FBCH channel, the $SINR_{Target}$ value is defined in Equation (304).

$$SINR_{Target}(SFBCH) = SFBCH_{Base} + (l - l_{min}) \times SFBCH_{Delta} \tag{304}$$

where

$SFBCH_{Base}$ is base $SINR_{Target}$ value signaled by *targetSfbchBaseSinr*.

$SFBCH_{Delta}$ is differential $SINR_{Target}$ value signaled by *targetSfbchDeltaSinr*.

l is S-FBCH payload information bits number defined in 6.3.8.2.1.2.

l_{min} is the minimum S-FBCH payload information bits number (l_{min} = 7) defined in 6.3.8.2.1.2.

For a control channel transmission, the *Offset* in Equation (302) shall be set to the value $Offset_{Control}$ conveyed as offsetControl in an AAI-UL_POWER_ADJ message. The value used shall be taken from the most recent message that preceded the first uplink subframe of the frame by more than $T_{DL\_Rx\_Processing}$. An AMS shall set initial $Offset_{Control}$ as $Offset_{Initial}$ + offsetControl after the AMS succeeds for initial ranging process. Here $Offset_{Initial}$ is calculated by an AMS during initial ranging process according to 6.3.8.4.4 and offsetControl is included in CDMA Allocation A-MAP IE (6.3.8.4.8).

If an AMS does not receive any BR-ACK A-MAP IE at the (*n*+*BR_ACK_Offset*)-th frame who transmitted a Bandwidth Request preamble sequence at the *n*-th frame, the AMS considers it as an implicit-NACK and may restart BR procedure. If it has continuously failed to receive BR-ACK A-MAP IE with *N* time(s) and if it restarts the (N +1)-th BR procedure, it shall increase Tx Power by $N \times P_{IR,\,Step}$ dB from the BR preamble transmission power which is decided by Equation (302), where $P_{IR,Step}$ is the step size to ramp up, which is 2 dB.

6.3.8.4.3 Power correction using PC-A-MAP

The ABS may change the AMS's Tx power through direct power adjustment by PC-A-MAP. When the AMS receives its PC-A-MAP IE from the ABS, it shall modify its $Offset_{Control}$ value according to Equation (305).

$$Offset_{Control} = Offset_{Control} + \Delta_{PowerAdjust} \tag{305}$$

where $\Delta_{PowerAdjust}$ is the power correction value indicated by the ABS through PC-A-MAP.

If the AMS receives the AAI-UL_POWER_ADJUST message at *i*-th frame, the AMS's $Offset_{Control}$ shall be replaced by offsetControl indicated by the message from the (i + 1)-th frame. Also PC-A-MAP IE from (i + 1)-th frame is effective on this new value.

6.3.8.4.4 Initial ranging channel power control

For initial ranging, the AMS sends an initial ranging code at a randomly selected ranging channel. The initial transmission power is decided according to measured RSS. If the AMS does not receive a response, it may increase its power level by $P_{\mathrm{IR,Step}}$ and may send a new initial ranging code, where $P_{\mathrm{IR,Step}}$ is the step size to ramp up, which is 2 dB. The AMS could further increase the power until maximum transmit power is reached.

The initial transmission power of the AMS is calculated as shown in Equation (306).

$$P_{TX\_IR\_MIN} = EIRxP_{IR,\,min} + BS\_EIRP - RSS \tag{306}$$

where $EIRxP_{IR,min}$ is the minimum targeting receiving power and *BS_EIRP* is the transmission power of the BS, which are obtained from S-SFH SP2 and SP1, respectively, and *RSS* is the received signal strength measured by the AMS.

In the case that the Rx and Tx gain of the AMS antenna are different, the AMS shall use Equation (307).

$$P_{TX\_IR\_MIN} = EIRxP_{IR,\,min} + BS\_EIRP - RSS + (G_{Rx\_MS} - G_{Tx\_MS}) \tag{307}$$

where G_{Rx_MS} is the antenna gain of the AMS Rx, and G_{Tx_MS} is the antenna gain of the AMS Tx.

If the AMS receives RNG-ACK for continue mode without power adjustment (power level adjustment indication bit equals 0) as response to the corresponding ranging code transmitted by the AMS, the AMS shall use its latest ranging transmission power as the initial power level for next continued ranging transmission. The power ramping up will be performed for the next ranging transmission if there is no response within the given time.

If RNG-ACK has a power level adjustment indication bit with 1, transmission power for continue mode shall be based on the power used for the latest ranging and the AMS shall adjust it by the amount of power level adjustment field of RNG-ACK. The adjusted power level will be used as the power level for next continued ranging transmission, and the power ramping up will be performed for the next ranging transmission if there is no response within the given time.

After an AMS completes the initial ranging process successfully with *N* times ramping up and *M* times RNG-ACK, initial offset value $Offset_{Initial}$ is determined as Equation (308).

$$Offset_{Initial} = P_{TX\_IR\_Final} - (L + SINR_{InitialRanging} + NI) - 10\log 10(RangingSubcarrierNum) \tag{308}$$

where

L and *NI* are defined in 6.3.8.4.

$SINR_{InitialRanging}$ is defined as Equation (309).

$$SINR_{InitialRanging} = offsetControl + targetInitialRangingSinr \tag{309}$$

where

offsetControl is included in CDMA Allocation A-MAP IE (6.3.8.4.8).

targetInitialRangingSinr is the default initial ranging target SINR defined in Table 6-291.

RangingSubcarrierNum is the number of initial ranging subcarrier number, as 72 defined in 6.3.8.1.4.1.

$P_{TX\_IR\_Final}$ is the final initial ranging transmission power defined in Equation (310).

$$P_{TX\_IR\_Final} = P_{TX\_IR\_MIN} + N \times P_{IR,\,Step} + \sum P_{RNG-ACK}(m) \tag{310}$$

where $P_{RNG\text{-}ACK}(m)$ is the power level adjustment value of the m-th received RNG-ACK message (m = 1, ..., M) during the ranging process, and $P_{IR,Step}$ is the step size to ramp up, which is 2 dB.

$Offset_{Initial}$ shall be included in the AAI-RNG-REQ message to be sent to the serving the ABS right after the initial ranging process.

6.3.8.4.5 Sounding channel power control

Power control for the UL sounding channel is supported to manage the sounding quality. The AMS's transmit power for UL sounding channel is controlled separately according to its sounding channel target SINR value. The transmission power per subcarrier shall be determined by multiplying the modulation coefficient b_k, calculated as per Equation (289) or Equation (290), by the linear scale factor corresponding to *P(dBm)* derived from Equation (302).

In Equation (302), $SINR_{Target}$ is the sounding channel target SINR, which is set according to the DL SIR of the AMS defined by parameter SIR_{DL}. In order to maintain the UL sounding quality, the different target SINR values are assigned according to the DL SIR of each AMS; the AMS with high DL SIR applies relatively high target SINR, and the AMS with low DL SIR applies relatively low target SINR.

The $SINR_{Target}$ for sounding channel shall be calculated from Equation (302) using the following parameter settings: $SINR_{MIN}$ is the minimum SINR requirement expected by the ABS that is set to *soundingSinrMin*, γ_{IoT} is set to the IoT control factor for sounding channel *gammaIotSounding*, SIR_{DL} is the ratio of the downlink signal versus interference power, measured by the AMS, α is set to 0, β is set to 0 or 1 by the AAI-SCD message, TNS is set to 1 when antenna switching field equals 0, and TNS is set to the number of Tx antenna when antenna switching field equals 1.

When calculated sounding $SINR_{Target}$ is higher than *soundingSinrMax*, the $SINR_{Target}$ shall be set to *soundingSinrMax*.

Offset for sounding channel in Equation (302) is set to 0.

If power boosting field in UL Sounding Command A-MAP IE is set 1, 3 dB tone power boosting is applied to each Tx antenna.

All parameters necessary for sounding channel power control are transmitted through the AAI-SCD message in 6.2.3.30.

6.3.8.4.6 Concurrent transmission of uplink control channel and data

In case of simultaneous transmission among control channels, uplink transmission power of assigned channels is determined based on the channel list in Table 6-291 in descending order until the total transmission power reaches maximum power limitation of the AMS.

If the AMS has not sufficient power to transmit an assigned channel, compared to the power level determined by Equation (302), then the AMS shall transmit this channel with the remaining power, even if it is insufficient to meet the requirements of Equation (302).

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Table 6-291—Priority of uplink transmit channels

Channel type
HARQ feedback
PFBCH/SFBCH
Synchronized Ranging
Sounding
DATA
Bandwidth Request

6.3.8.4.7 Uplink power status reporting

6.3.8.4.7.1 Power status reporting information

There are two key parameters for power status reporting: the base uplink transmission PSD and the SIR_{DL} defined in 6.3.8.4.1.

The base uplink transmission PSD is derived from Equation (302) by setting $SINR_{Target} = 0$ and $Offset = 0$:

$$PSD(base) = L + NI \tag{311}$$

The parameter is reported in dBm and is coded using 8 bits in 0.5 dBm steps ranging from –74 dBm (coded 0x00) to 53.5 dBm (coded 0xFF). The NI value used here is the most recent NI value of the frequency partition with UL control channel.

The reported SIR_{DL} value is coded using 10 bits in 1/16 dB steps ranging from –12 dB (coded 0x000) to 51.9375 dB (coded 0x3ff).

After the ABS has received $PSD(base)$ and SIR_{DL} from the AMS, the PSD for all uplink channels can be estimated in the ABS.

6.3.8.4.7.2 Status transmission condition

The AMS shall send the status reporting message Uplink Power Status Report header (defined in 6.2.2.1.3.6) to the ABS when the conditions are as listed in Equation (312) through Equation (314).

$$|M(n_{last}) - M(n)| \geq \text{txPowerReportThreshold} \tag{312}$$

and

$$n - n_{last} \geq \text{txPowerReportMinimumInterval} \tag{313}$$

or

$$n - n_{last} \geq \text{txPowerReportPeriodicalInterval} \tag{314}$$

where M is defined in Equation (315):

$$M = L + SINR_{Target}\,(Reported) \tag{315}$$

L	is the pathloss defined in Equation (302).
$SINR_{Target}$	is defined in Equation (303) with beta = 0 and $SINR_{Target}$ (Reported) is the value measured at the moment of 'Reported'.
n_{last}	is the frame when the last AMS status reporting message was sent.
n	is the current frame.

The status reporting configuration parameters txPowerReportThreshold, txPowerReportMinimumInterval, and txPowerReportPeriodicalInterval are sent from the ABS to the AMS in the AAI-UL_PSR_CFG message (defined in 6.2.3.34).

The AMS shall send the first power status report right after the AMS receives the first AAI-UL_PSR_CFG message with uplinkPowerStatusReport = 1.

6.3.8.4.8 Uplink power control in initial network entry and reentry

During initial network entry and reentry, after a successful initial ranging process, the ABS needs to send CDMA Allocation A-MAP IE to the AMS as shown in Figure 6-73.

The key power control parameters NI and offsetControl, which are signaled by CDMA Allocation A-MAP IE, directly belong to the FP of assigned data burst when multi-FPs are used.

When the AMS has only successfully received the CDMA Allocation A-MAP IE, the AMS will set NI and offsetControl by the values from CDMA Allocation A-MAP IE. Other uplink power control parameters are set by the default value listed in Table 6-292.

Table 6-292—Default ULPC parameters

Type	Parameters	Default value
Data Channel Control Parameters	Alpha	1/2
	Beta	0
	Gamma	0.5
	dataSinrMin	3 dB
	dataSinrMax	40 dB

Table 6-292—Default ULPC parameters *(continued)*

Type	Parameters	Default value
Control Channel Target SINR Value	targetHarqSinr	2 dB
	targetInitialRangingSinr	0 dB
	targetSyncRangingSinr	–3 dB
	targetPfbchSinr	0 dB
	targetSfbchBaseSinr	1.5 dB
	targetSfbchDeltaSinr	0.24 dB
	targetBwRequestSinr	0.5 dB
Offset Initialization	offsetData	0

Whenever the AMS successfully receives AAI-SCD, AAI-ULPC-NI, and AAI-UL_POWER_ADJ messages, the signaled uplink power control parameters will be updated accordingly.

6.3.8.4.9 Uplink power control in handover

During the handover processing, if CDMA_RNG_FLAG in the AAI-HO-CMD message is set to 0, CDMA-based ranging will be skipped and the power offset values for the T-ABS will be included in the AAI-HO-CMD, as shown in Table 6-40. Other uplink power control parameters for the T-ABS are set by using the S-ABS value.

If CDMA_RNG_FLAG in the AAI-HO-CMD message is set to 1 and dedicated CDMA ranging code is not present, CDMA based ranging shall be performed, and the power control parameters of the T-ABS will be determined using the process defined in 6.3.8.4.8.

Before the handover procedure has been finished, two sets of uplink power control parameters are kept in the AMS to support uplink transmission to the S-ABS and the T-ABS separately.

If CDMA_RNG_FLAG in the AAI-HO-CMD message is set to 1 and dedicated CDMA ranging code is present, CDMA based ranging shall be performed, and iotFP and offsetControl for the T-ABS will be included in the AAI-HO-CMD, as shown in Table 6-34. In this case, the AMS sets iotFP and offsetControl by the values from AAI-HO-CMD. All other power control parameters of the T-ABS are determined according to 6.3.8.4.8.

After handover, whenever the AMS successfully receives AAI-SCD, AAI-ULPC-NI, and AAI-UL-POWER-ADJ messages from the T-ABS, the signaled uplink power control parameters will be updated accordingly.

In case of zone switch from LZone to MZone, power control parameters (i.e., iotFP, offsetControl) for the MZone of the S-ABS shall be included in the Zone Switch TLV if TSTID is also included. In such a case, CDMA-based ranging will be skipped and the AMS will perform a bandwidth request procedure in MZone using the power offset values included in the Zone Switch TLV. Other uplink power control parameters for the T-ABS are set by using the S-ABS value.

6.3.8.4.10 Uplink power control in multicarrier operation

In multicarrier operation mode, the pathloss reference of uplink power control for a given carrier shall be the same (downlink) carrier in case of TDD mode. In FDD mode, the pathloss reference shall be the paired downlink carrier.

6.3.8.5 Uplink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRU is the same as the structure defined in 6.3.7.1. The guard PRUs are used as miniband CRUs at partition FP_0 for data transmission only. The number of usable guard subcarriers is predefined and should be known to both the AMS and the ABS based on carrier bandwidth.

6.3.9 Uplink MIMO

6.3.9.1 Uplink MIMO architecture and data processing

The architecture of uplink MIMO at the transmitter side is shown in Figure 6-197.

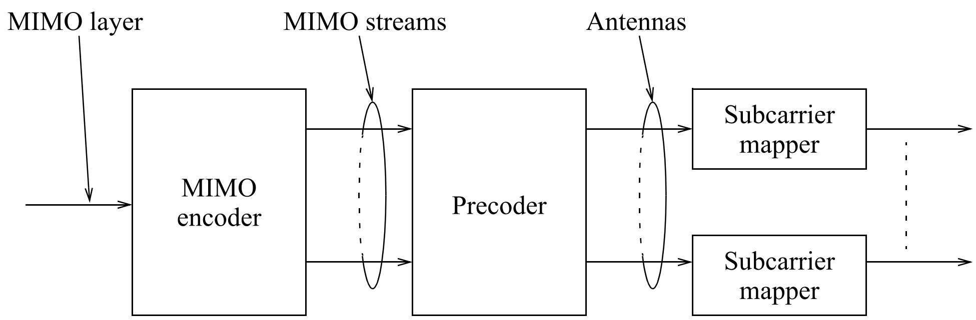

Figure 6-197—UL MIMO architecture

The MIMO encoder block maps a single MIMO layer (L = 1) onto M_t $(M_t \geq L)$ MIMO streams, which are fed to the Precoder block.

For SU-MIMO and collaborative spatial multiplexing (MU-MIMO), only one channel coding block exists in the allocated RU (vertical MIMO encoding at transmit side).

The precoder block maps MIMO stream(s) to antennas by generating the antenna-specific data symbols according to the selected MIMO mode.

The MIMO encoder and precoder blocks shall be omitted when the AMS has one transmit antenna.

The subcarrier mapping blocks map antenna-specific data to the OFDM symbol.

6.3.9.1.1 MIMO layer to MIMO stream mapping

MIMO layer to MIMO stream mapping is performed by the MIMO encoder. The uplink MIMO encoder is identical to the downlink MIMO encoder described in 6.3.6.1.1 but with only a single MIMO layer (L = 1).

Multilayer encoding (MEF = 0b10) is not supported for uplink transmissions. Collaborative spatial multiplexing (CSM) is achieved with vertical encoding (MEF = 0b01) at the AMS. The STC rate per AMS for uplink SU-MIMO and MU-MIMO (CSM) transmissions is defined as $R = M_t/N_F$.

An AMS with 1 transmit antenna shall use vertical encoding (MEF = 0b01) for uplink transmissions.

6.3.9.1.1.1 SFBC encoding

Uplink SFBC encoding is identical to the downlink SFBC encoding described in 6.3.6.1.1.1.

SFBC encoding format shall not be allocated to an AMS with 1 transmit antenna.

6.3.9.1.1.2 Vertical encoding

Uplink vertical encoding is identical to the downlink vertical encoding described in 6.3.6.1.1.2.

Vertical encoding with 1 MIMO stream (M_t = 1) format shall be allocated to an AMS with 1 transmit antenna.

6.3.9.1.2 MIMO stream to antenna mapping

MIMO stream to antenna mapping is performed by the precoder. The uplink mapping is identical to the downlink mapping described in 6.3.6.1.2.

6.3.9.1.2.1 Non-adaptive precoding

There is no precoding if there is only one transmit antenna at the MS.

With non-adaptive precoding, the precoding matrix is an $N_t \times M_t$ matrix $\mathbf{W}(k)$, where N_t is the number of transmit antennas, M_t is the numbers of MIMO streams, and k is the physical index of the subcarrier where $\mathbf{W}(k)$ is applied. The matrix $\mathbf{W}$ is selected from a subset of size N_w precoders of the base codebook for a given rank. $\mathbf{W}$ belongs to one of the subsets of the base codebook specified in 6.3.9.4.1 or the base codebook in 6.3.9.3.1.1 and 6.3.9.3.2.1, according to the type of allocation, MEF, N_t and M_t, as specified in Table 6-293 and Table 6-294.

Table 6-293—Codebook subsets used for non-adaptive precoding in UL DLRU and NLRU

MEF	RU with M_t pilot streams
SFBC	$C_{UL,OL,SU}(N_t, M_t, N_w)$, $M_t = 2$
VE	$C_{UL,OL,SU}(N_t, M_t, N_w)$, $M_t = 1, ..., 4$ N_w depends on M_t

The notation $C_{UL,OL,SU}$ (N_t, M_t, N_w) and the values of N_w for the open-loop codebook subsets are defined in 6.3.9.4.1.

The notation $C_{base,SU}$ (N_t, M_t, NB) for the base codebooks is defined in 6.3.9.3.

In a RU allocated in a AAI subframe with MEF = 0b00 (SFBC) or 0b01 (VE) and non-adaptive precoding, the matrix $\mathbf{W}$ changes every N_1P_{SC} contiguous physical subcarriers according to Equation (316), and it does not depend on the AAI subframe number. When supporting FDM based UL PUSC zone, the matrix W for non-adaptive precoding changes every N_1P_{SC} contiguous physical subcarriers that start from physical subcarrier index = 0. 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 Equation (316).

Table 6-294—Codebook subsets used for non-adaptive precoding in UL SLRU

MEF	RU with M_t pilot streams
SFBC	$N_t = 2$: $C_{base,UL}(2, 2, 3)$ $N_t = 4$: $C_{base,UL}(4, 2, 6)$
VE	$N_t = 2$: $C_{base,UL}(2, 1, 4)$ if $M_t = 1$ or $C_{base,UL}(2, 2, 3)$ if $M_t = 2$ $N_t = 4$: $C_{base,UL}(4, M_t, 6)$, $M_t = 1,2,3,4$

$$i = s \bmod N_w, \qquad s = 0 \ldots N_{sub}-1 \tag{316}$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

The values of N_w used for non-adaptive precoding in UL DLRU and NLRU are given in Table 6-295. The values of N_w used for non-adaptive precoding in UL SLRU are given in Table 6-296.

Table 6-295—Values of N_w for non-adaptive precoding in UL DLRU and NLRU

Rank	1	2	3	4
$N_t = 2$	2	1	N/A	N/A
$N_t = 4$	4	4	4	4

Table 6-296—Values of N_w for non-adaptive precoding in UL SLRU

Rank	1	2	3	4
$N_t = 2$	8	4	N/A	N/A
$N_t = 4$	64	64	64	64

6.3.9.1.2.2 Adaptive precoding

There is no precoding if there is only one transmit antenna at the AMS.

With adaptive precoding, the precoder **W** is derived at the ABS or at the AMS, as instructed by the ABS.

With 2-Tx or 4-Tx at the AMS in FDD and TDD systems, unitary codebook based adaptive precoding is supported. In this mode, an AMS transmits a sounding signal on the uplink to assist the precoder selection at the ABS. The ABS then signals the uplink precoding matrix index to be used by the AMS in the UL Basic Assignment A-MAP IE and UL Subband Assignment A-MAP IE.

With 2-Tx or 4-Tx at the AMS in TDD systems, adaptive precoding based on the measurements of downlink reference signals is supported. The AMS chooses the precoder based on the downlink measurements. The form and derivation of the precoding matrix does not need to be known at the ABS.

6.3.9.1.3 Uplink MIMO transmission modes

There are five MIMO transmission modes for UL MIMO transmission as listed in Table 6-297.

Table 6-297—Uplink MIMO modes

Mode index	Description	MIMO encoding format (MEF)	MIMO precoding
Mode 0	OL SU-MIMO	SFBC	Non-adaptive
Mode 1	OL SU-MIMO (SM)	VE	Non-adaptive
Mode 2	CL SU-MIMO (SM)	VE	Adaptive
Mode 3	OL Collaborative spatial multiplexing (MU-MIMO)	VE	Non-adaptive
Mode 4	CL Collaborative spatial multiplexing (MU-MIMO)	VE	Adaptive

The allowed values of the parameters for each UL MIMO mode are shown in Table 6-298.

Table 6-298—UL MIMO parameters

	Number of transmit antennas	STC rate per MIMO layer	Number of MIMO streams	Number of subcarriers	Number of MIMO layers
	N_t	R	M_t	N_F	L
MIMO mode 0	2	1	2	2	1
	4	1	2	2	1
MIMO mode 1	1	1	1	1	1

Table 6-298—UL MIMO parameters *(continued)*

	Number of transmit antennas	STC rate per MIMO layer	Number of MIMO streams	Number of subcarriers	Number of MIMO layers
	N_t	R	M_t	N_F	L
MIMO mode 1 and MIMO mode 2	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1
	4	4	4	1	1
MIMO mode 3 and MIMO mode 4	1	1	1	1	1
	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1
	4	4	4	1	1

M_t refers to the number of MIMO streams transmitted from one AMS.

In mode 3 and 4, N_t refers to the number of transmit antennas at one AMS involved in CSM.

6.3.9.2 Transmission schemes for data channels

6.3.9.2.1 Encoding and precoding of SU-MIMO modes

6.3.9.2.1.1 Encoding of SU-MIMO modes

- **MIMO mode 0:** SFBC encoding of 6.3.9.1.1.1 shall be used with MIMO mode 0.
- **MIMO mode 1:** Vertical encoding of 6.3.9.1.1.2 shall be used with MIMO mode 1. The number of MIMO streams is $M_t \le \min(N_t, N_r)$, where N_r is the number of receive antennas and M_t is no more than 4.
- **MIMO mode 2:** Vertical encoding of 6.3.9.1.1.2 shall be used with MIMO mode 2. The number of MIMO streams is $M_t \le \min(N_t, N_r)$, where M_t is no more than 4.

6.3.9.2.1.2 Precoding of SU-MIMO modes

- **MIMO mode 0:** Non-adaptive precoding with $M_t = 2$ MIMO streams shall be used with MIMO mode 0.
- **MIMO mode 1:** Non-adaptive precoding with M_t MIMO streams shall be used with MIMO mode 1.
- **MIMO mode 2:** Adaptive precoding shall be used with MIMO mode 2.

6.3.9.2.2 Encoding and precoding of collaborative spatial multiplexing (MU-MIMO)

AMSs can perform collaborative spatial multiplexing onto the same RU. In this case, the ABS assigns different pilot patterns for each AMS.

6.3.9.2.2.1 Encoding of MU-MIMO modes

— **MIMO mode 3:** Vertical encoding shall be used with MIMO mode 3.

— **MIMO mode 4:** Vertical encoding shall be used with MIMO mode 4.

6.3.9.2.2.2 Precoding of MU-MIMO modes

— **MIMO mode 3:** Non-adaptive precoding shall be used with MIMO mode 3.

— **MIMO mode 4:** Adaptive precoding shall be used with MIMO mode 4.

6.3.9.2.3 Mapping of data subcarriers

Consecutive symbols for each antenna at the output of the MIMO precoder are mapped in a frequency domain first order across LRUs of the allocation, starting from the data subcarrier with the smallest OFDM symbol index and smallest subcarrier index, and continuing to subcarrier index with increasing subcarrier index. When the edge of the allocation is reached, the mapping is continued on the next OFDM symbol.

6.3.9.2.4 Usage of MIMO modes

Table 6-299 shows the permutations supported for each MIMO mode.

Table 6-299—Supported permutation for each UL MIMO mode

	DLRU	NLRU	SLRU
MIMO mode 0	Yes	Yes	Yes
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

6.3.9.2.5 Downlink signaling support of UL-MIMO modes

6.3.9.2.5.1 Broadcast information

The ABS shall send parameters necessary for UL MIMO operation in a unicast message. The parameters may be transmitted depending on the type of operation. The unicast information is carried in the UL basic Assignment A-MAP IE, UL Subband Assignment A-MAP IE, and UL Persistent A-MAP IE.

Table 6-300 specifies the DL control parameters required for UL MIMO operation.

Table 6-300—UL MIMO control parameters

Parameter	Description	Value	Notes
MEF	MIMO Encoding Format	SFBC Vertical encoding	MIMO encoding format
CSM	Collaborative Spatial Multiplexing	Disabled or enabled	SU MIMO if CSM is disabled. MU MIMO if CSM is enabled.
M_t	Number of MIMO streams	1 to 4	Number of MIMO streams in the AMS transmission.
TNS	Total number of MIMO streams in the LRU	1 to 8	Enabled when CSM is enabled. Indication of the total number of MIMO streams in the LRU.
SI	First pilot index	1 to 8	Enabled when CSM is enabled.
PF	Precoding flag	No-adaptive precoding or adaptive codebook precoding	Cannot be applied to the AMS with 1 transmit antenna.
PMI Indicator	PMI indicator	0b0: the AMS shall use the precoder of rank M_t of its choice 0b1: the indicated PMI of rank M_t shall be used by the AMS for precoding	This field is relevant only when PF indicates adaptive codebook precoding. PMI indication = 0b0 may be used in TDD When PMI indication = 0b1, the ABS selects the precoder to use at the AMS.
PMI	Precoding matrix index in the UL base codebook	0 to 9 when $N_t = 2$ 0 to 63 when $N_t = 4$	Enabled when PF indicates adaptive codebook precoding, and PMI indication = 0b1.

6.3.9.3 Codebook for closed-loop transmit precoding

The notation $C_{base,\,UL}(N_t, M_t, NB)$ denotes the rank-M_t uplink base codebook, which consists of 2^{NB} complex matrices of dimension N_t by M_t, and M_t denotes the number of MIMO streams.

The notation $C_{base,\,UL}(N_t, M_t, NB, i)$ denotes the i-th codebook entry of $C_{base,\,UL}(N_t, M_t, NB)$.

6.3.9.3.1 Base codebook for two transmit antenna

6.3.9.3.1.1 SU-MIMO base codebook

The base codebooks of SU-MIMO with two transmit antennas consist of rank-1 codebook $C_{base,UL}(2,1,4)$ and rank-2 codebook $C_{base,UL}(2,2,3)$. Table 6-301 is included to illustrate the rank-1 base codebooks.

Table 6-301—$C_{base,UL}(2,1,4)$

Binary index	m	$C_{base,UL}(2, 1, 4, m) = [c_1; c_2]$	
		c_1	c_2
0000	0	0.7071	–0.7071
0001	1	0.7071	–0.5000 – 0.5000i
0010	2	0.7071	–0.7071i
0011	3	0.7071	0.5000 – 0.5000i
0100	4	0.7071	0.7071
0101	5	0.7071	0.5000 + 0.5000i
0110	6	0.7071	0.7071i
0111	7	0.7071	–0.5000 + 0.5000i
1000	8	1	0
1001	9	0	1
1010–1111	10–15	—	—

The rank-2 base codebook $C_{base,UL}(2,2,3)$ for uplink 2-Tx is the same as the downlink 2-Tx rank-2 base codebook.

6.3.9.3.1.2 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 6.3.9.3.1.1.

6.3.9.3.2 Base codebook for four transmit antennas

6.3.9.3.2.1 SU-MIMO base codebook

The uplink base codebook of SU-MIMO with four transmit antennas consist of rank-1 codebook $C_{base,UL}(4,1,6)$, rank-2 codebook $C_{base,UL}(4,2,6)$, rank-3 codebook $C_{base,UL}(4,3,6)$, and rank-4 codebook $C_{base,UL}(4,4,6)$. Rank-1 codebook entry $C_{base,UL}(4,1,6,m)$ consists of the first column of $C_{base,UL}(4,4,6,m)$. Rank-2 codebook entry $C_{base,UL}(4,2,6,m)$ consists of the first two columns of $C_{base,UL}(4,4,6,m)$. Rank-3 codebook entry $C_{base,UL}(4,3,6,m)$ consists of the first three columns of $C_{base,UL}(4,4,6,m)$. Table 6-302 specifies the rank-4 base codebook.

6.3.9.3.2.2 MU-MIMO base codebook

The base codebook for UL collaborative spatial multiplexing MIMO is a 4-bit subset of the base codebook for UL SU-MIMO, defined in 6.3.9.3.2.1. The codebook is defined in Table 6-303 for rank-1, -2, and -3.

Table 6-302—$C_{base,UL}(4,4,6)$

Binary Index	m	$C_{base,UL}(4,4,6,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \\ c_{41} & c_{42} & c_{43} & c_{44} \end{bmatrix}$			
		c_{11} c_{21} c_{31} c_{41}	c_{12} c_{22} c_{32} c_{42}	c_{13} c_{23} c_{33} c_{43}	c_{14} c_{24} c_{34} c_{44}
000000	0	0.5000 0.5000i –0.5000 – 0.5000i	0.5000 –0.5000 0.5000 –0.5000	0.5000 – 0.5000i –0.5000 0.5000i	0.5000 0.5000 0.5000 0.5000
000001	1	0.5000 0.2357 – 0.4410i –0.4619 – 0.1913i –0.4619 – 0.1913i	0.5000 0.4410 + 0.2357i 0.4619 + 0.1913i –0.1913 + 0.4619i	0.5000 –0.2357 + 0.4410i –0.4619 – 0.1913i 0.4619 + 0.1913i	0.5000 –0.4410 – 0.2357i 0.4619 + 0.1913i 0.1913 – 0.4619i
000010	2	0.5000 –0.4157 + 0.2778i –0.3536 – 0.3536i –0.3536 + 0.3536i	0.5000 –0.2778 – 0.4157i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.4157 – 0.2778i –0.3536 – 0.3536i 0.3536 – 0.3536i	0.5000 0.2778 + 0.4157i 0.3536 + 0.3536i –0.3536 – 0.3536i
000011	3	0.5000 0.4976 – 0.0490i –0.1913 – 0.4619i 0.1913 + 0.4619i	0.5000 0.0490 + 0.4976i 0.1913 + 0.4619i 0.4619 – 0.1913i	0.5000 –0.4976 + 0.0490i –0.1913 – 0.4619i –0.1913 – 0.4619i	0.5000 –0.0490 – 0.4976i 0.1913 + 0.4619i –0.4619 + 0.1913i
000100	4	0.5000 –0.4619 – 0.1913i – 0.5000i 0.5000	0.5000 0.1913 – 0.4619i 0.5000i – 0.5000i	0.5000 0.4619 + 0.1913i – 0.5000i –0.5000	0.5000 –0.1913 + 0.4619i 0.5000i 0.5000i
000101	5	0.5000 0.3172 + 0.3865i 0.1913 – 0.4619i 0.1913 – 0.4619i	0.5000 –0.3865 + 0.3172i –0.1913 + 0.4619i –0.4619 – 0.1913i	0.5000 –0.3172 – 0.3865i 0.1913 – 0.4619i –0.1913 + 0.4619i	0.5000 0.3865 – 0.3172i –0.1913 + 0.4619i 0.4619 + 0.1913i
000110	6	0.5000 –0.0975 – 0.4904i 0.3536 – 0.3536i –0.3536 – 0.3536i	0.5000 0.4904 – 0.0975i –0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000 0.0975 + 0.4904i 0.3536 – 0.3536i 0.3536 + 0.3536i	0.5000 –0.4904 + 0.0975i –0.3536 + 0.3536i 0.3536 – 0.3536i
000111	7	0.5000 –0.1451 + 0.4785i 0.4619 – 0.1913i –0.4619 + 0.1913i	0.5000 –0.4785 – 0.1451i –0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 0.1451 – 0.4785i 0.4619 – 0.1913i 0.4619 – 0.1913i	0.5000 0.4785 + 0.1451i –0.4619 + 0.1913i –0.1913 – 0.4619i

Table 6-302—$C_{base,UL}$(4,4,6) *(continued)*

001000	8	0.5000 0.3536 – 0.3536i 0.5000 0.5000i	0.5000 0.3536 + 0.3536i –0.5000 0.5000	0.5000 –0.3536 + 0.3536i 0.5000 – 0.5000i	0.5000 –0.3536 – 0.3536i –0.5000 –0.5000
001001	9	0.5000 –0.4785 + 0.1451i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 –0.1451 – 0.4785i –0.4619 – 0.1913i 0.1913 – 0.4619i	0.5000 0.4785 – 0.1451i 0.4619 + 0.1913i –0.4619 – 0.1913i	0.5000 0.1451 + 0.4785i –0.4619 – 0.1913i –0.1913 + 0.4619i
001010	10	0.5000 0.4904 + 0.0975i 0.3536 + 0.3536i 0.3536 – 0.3536i	0.5000 –0.0975 + 0.4904i –0.3536 – 0.3536i –0.3536 – 0.3536i	0.5000 –0.4904 – 0.0975i 0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000 0.0975 – 0.4904i –0.3536 – 0.3536i 0.3536 + 0.3536i
001011	11	0.5000 –0.3865 – 0.3172i 0.1913 + 0.4619i –0.1913 – 0.4619i	0.5000 0.3172 – 0.3865i –0.1913 – 0.4619i –0.4619 + 0.1913i	0.5000 0.3865 + 0.3172i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 –0.3172 + 0.3865i –0.1913 – 0.4619i 0.4619 – 0.1913i
001100	12	0.5000 0.1913 + 0.4619i 0.5000i –0.5000	0.5000 –0.4619 + 0.1913i – 0.5000i 0.5000i	0.5000 –0.1913 – 0.4619i 0.5000i 0.5000	0.5000 0.4619 – 0.1913i – 0.5000i – 0.5000i
001101	13	0.5000 0.0490 – 0.4976i –0.1913 + 0.4619i –0.1913 + 0.4619i	0.5000 0.4976 + 0.0490i 0.1913 – 0.4619i 0.4619 + 0.1913i	0.5000 –0.0490 + 0.4976i –0.1913 + 0.4619i 0.1913 – 0.4619i	0.5000 –0.4976 – 0.0490i 0.1913 – 0.4619i –0.4619 – 0.1913i
001110	14	0.5000 –0.2778 + 0.4157i –0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 –0.4157 – 0.2778i 0.3536 – 0.3536i 0.3536 – 0.3536i	0.5000 0.2778 – 0.4157i –0.3536 + 0.3536i –0.3536 – 0.3536i	0.5000 0.4157 + 0.2778i 0.3536 – 0.3536i –0.3536 + 0.3536i
001111	15	0.5000 0.4410 – 0.2357i –0.4619 + 0.1913i 0.4619 – 0.1913i	0.5000 0.2357 + 0.4410i 0.4619 – 0.1913i –0.1913 – 0.4619i	0.5000 –0.4410 + 0.2357i –0.4619 + 0.1913i –0.4619 + 0.1913i	0.5000 –0.2357 – 0.4410i 0.4619 – 0.1913i 0.1913 + 0.4619i
010000	16	0.5000 –0.5000 –0.5000 – 0.5000i	0.5000 – 0.5000i 0.5000 –0.5000	0.5000 0.5000 –0.5000 0.5000i	0.5000 0.5000i 0.5000 0.5000
010001	17	0.5000 0.4410 + 0.2357i –0.4619 – 0.1913i –0.4619 – 0.1913i	0.5000 –0.2357 + 0.4410i 0.4619 + 0.1913i –0.1913 + 0.4619i	0.5000 –0.4410 – 0.2357i –0.4619 – 0.1913i 0.4619 + 0.1913i	0.5000 0.2357 – 0.4410i 0.4619 + 0.1913i 0.1913 – 0.4619i
010010	18	0.5000 –0.2778 – 0.4157i –0.3536 – 0.3536i –0.3536 + 0.3536i	0.5000 0.4157 – 0.2778i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.2778 + 0.4157i –0.3536 – 0.3536i 0.3536 – 0.3536i	0.5000 –0.4157 + 0.2778i 0.3536 + 0.3536i –0.3536 – 0.3536i
010011	19	0.5000 0.0490 + 0.4976i –0.1913 – 0.4619i 0.1913 + 0.4619i	0.5000 –0.4976 + 0.0490i 0.1913 + 0.4619i 0.4619 – 0.1913i	0.5000 –0.0490 – 0.4976i –0.1913 – 0.4619i –0.1913 – 0.4619i	0.5000 0.4976 – 0.0490i 0.1913 + 0.4619i –0.4619 + 0.1913i
010100	20	0.5000 0.1913 – 0.4619i – 0.5000i 0.5000	0.5000 0.4619 + 0.1913i 0.5000i – 0.5000i	0.5000 –0.1913 + 0.4619i – 0.5000i –0.5000	0.5000 –0.4619 – 0.1913i 0.5000i 0.5000i

Table 6-302—$C_{base,UL}$(4,4,6) *(continued)*

010101	21	0.5000 –0.3865 + 0.3172i 0.1913 – 0.4619i 0.1913 – 0.4619i	0.5000 –0.3172 – 0.3865i –0.1913 + 0.4619i –0.4619 – 0.1913i	0.5000 0.3865 – 0.3172i 0.1913 – 0.4619i –0.1913 + 0.4619i	0.5000 0.3172 + 0.3865i –0.1913 + 0.4619i 0.4619 + 0.1913i
010110	22	0.5000 0.4904 – 0.0975i 0.3536 – 0.3536i –0.3536 – 0.3536i	0.5000 0.0975 + 0.4904i –0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000 –0.4904 + 0.0975i 0.3536 – 0.3536i 0.3536 + 0.3536i	0.5000 –0.0975 – 0.4904i –0.3536 + 0.3536i 0.3536 – 0.3536i
010111	23	0.5000 –0.4785 – 0.1451i 0.4619 – 0.1913i –0.4619 + 0.1913i	0.5000 0.1451 – 0.4785i –0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 0.4785 + 0.1451i 0.4619 – 0.1913i 0.4619 – 0.1913i	0.5000 –0.1451 + 0.4785i –0.4619 + 0.1913i –0.1913 – 0.4619i
011000	24	0.5000 0.3536 + 0.3536i 0.5000 0.5000i	0.5000 –0.3536 + 0.3536i –0.5000 0.5000	0.5000 –0.3536 – 0.3536i 0.5000 –0.5000i	0.5000 0.3536 – 0.3536i –0.5000 –0.5000
011001	25	0.5000 –0.1451 – 0.4785i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 0.4785 – 0.1451i –0.4619 – 0.1913i 0.1913 – 0.4619i	0.5000 0.1451 + 0.4785i 0.4619 + 0.1913i –0.4619 – 0.1913i	0.5000 –0.4785 + 0.1451i –0.4619 – 0.1913i –0.1913 + 0.4619i
011010	26	0.5000 –0.0975 + 0.4904i 0.3536 + 0.3536i 0.3536 – 0.3536i	0.5000 –0.4904 – 0.0975i –0.3536 – 0.3536i –0.3536 – 0.3536i	0.5000 0.0975 – 0.4904i 0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000 0.4904 + 0.0975i –0.3536 – 0.3536i 0.3536 + 0.3536i
011011	27	0.5000 0.3172 – 0.3865i 0.1913 + 0.4619i –0.1913 – 0.4619i	0.5000 0.3865 + 0.3172i –0.1913 – 0.4619i –0.4619 + 0.1913i	0.5000 –0.3172 + 0.3865i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 –0.3865 – 0.3172i –0.1913 – 0.4619i 0.4619 – 0.1913i
011100	28	0.5000 –0.4619 + 0.1913i 0.5000i –0.5000	0.5000 –0.1913 – 0.4619i – 0.5000i 0.5000i	0.5000 0.4619 – 0.1913i 0.5000i 0.5000	0.5000 0.1913 + 0.4619i –0.5000i –0.5000i
011101	29	0.5000 0.4976 + 0.0490i –0.1913 + 0.4619i –0.1913 + 0.4619i	0.5000 –0.0490 + 0.4976i 0.1913 – 0.4619i 0.4619 + 0.1913i	0.5000 –0.4976 – 0.0490i –0.1913 + 0.4619i 0.1913 – 0.4619i	0.5000 0.0490 – 0.4976i 0.1913 – 0.4619i –0.4619 – 0.1913i
011110	30	0.5000 –0.4157 – 0.2778i –0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.2778 – 0.4157i 0.3536 – 0.3536i 0.3536 – 0.3536i	0.5000 0.4157 + 0.2778i –0.3536 + 0.3536i –0.3536 – 0.3536i	0.5000 –0.2778 + 0.4157i 0.3536 – 0.3536i –0.3536 + 0.3536i
011111	31	0.5000 0.2357 + 0.4410i –0.4619 + 0.1913i 0.4619 – 0.1913i	0.5000 –0.4410 + 0.2357i 0.4619 – 0.1913i –0.1913 – 0.4619i	0.5000 –0.2357 – 0.4410i –0.4619 + 0.1913i –0.4619 + 0.1913i	0.5000 0.4410 – 0.2357i 0.4619 – 0.1913i 0.1913 + 0.4619i
100000	32	0.5000 – 0.5000i –0.5000 – 0.5000i	0.5000 0.5000 0.5000 –0.5000	0.5000 0.5000i –0.5000 0.5000i	0.5000 –0.5000 0.5000 0.5000
100001	33	0.5000 –0.2357 + 0.4410i –0.4619 – 0.1913i –0.4619 – 0.1913i	0.5000 –0.4410 – 0.2357i 0.4619 + 0.1913i –0.1913 + 0.4619i	0.5000 0.2357 – 0.4410i –0.4619 – 0.1913i 0.4619 + 0.1913i	0.5000 0.4410 + 0.2357i 0.4619 + 0.1913i 0.1913 – 0.4619i

Table 6-302—$C_{base,UL}$(4,4,6) *(continued)*

100010	34	0.5000 0.4157 – 0.2778i –0.3536 – 0.3536i –0.3536 + 0.3536i	0.5000 0.2778 + 0.4157i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 –0.4157 + 0.2778i –0.3536 – 0.3536i 0.3536 – 0.3536i	0.5000 –0.2778 – 0.4157i 0.3536 + 0.3536i –0.3536 – 0.3536i
100011	35	0.5000 –0.4976 + 0.0490i –0.1913 – 0.4619i 0.1913 + 0.4619i	0.5000 –0.0490 – 0.4976i 0.1913 + 0.4619i 0.4619 – 0.1913i	0.5000 0.4976 – 0.0490i –0.1913 – 0.4619i –0.1913 – 0.4619i	0.5000 0.0490 + 0.4976i 0.1913 + 0.4619i –0.4619 + 0.1913i
100100	36	0.5000 0.4619 + 0.1913i – 0.5000i 0.5000	0.5000 –0.1913 + 0.4619i 0.5000i – 0.5000i	0.5000 –0.4619 – 0.1913i –0.5000i –0.5000	0.5000 0.1913 – 0.4619i 0.5000i 0.5000i
100101	37	0.5000 –0.3172 – 0.3865i 0.1913 – 0.4619i 0.1913 – 0.4619i	0.5000 0.3865 – 0.3172i –0.1913 + 0.4619i –0.4619 – 0.1913i	0.5000 0.3172 + 0.3865i 0.1913 – 0.4619i –0.1913 + 0.4619i	0.5000 –0.3865 + 0.3172i –0.1913 + 0.4619i 0.4619 + 0.1913i
100110	38	0.5000 0.0975 + 0.4904i 0.3536 – 0.3536i –0.3536 – 0.3536i	0.5000 –0.4904 + 0.0975i –0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000 –0.0975 – 0.4904i 0.3536 – 0.3536i 0.3536 + 0.3536i	0.5000 0.4904 – 0.0975i –0.3536 + 0.3536i 0.3536 – 0.3536i
100111	39	0.5000 0.1451 – 0.4785i 0.4619 – 0.1913i –0.4619 + 0.1913i	0.5000 0.4785 + 0.1451i –0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 –0.1451 + 0.4785i 0.4619 – 0.1913i 0.4619 – 0.1913i	0.5000 –0.4785 – 0.1451i –0.4619 + 0.1913i –0.1913 – 0.4619i
101000	40	0.5000 –0.3536 + 0.3536i 0.5000 0.5000i	0.5000 –0.3536 – 0.3536i –0.5000 0.5000	0.5000 0.3536 – 0.3536i 0.5000 –0.5000i	0.5000 0.3536 + 0.3536i –0.5000 –0.5000
101001	41	0.5000 0.4785 – 0.1451i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 0.1451 + 0.4785i –0.4619 – 0.1913i 0.1913 – 0.4619i	0.5000 –0.4785 + 0.1451i 0.4619 + 0.1913i –0.4619 – 0.1913i	0.5000 –0.1451 – 0.4785i –0.4619 – 0.1913i –0.1913 + 0.4619i
101010	42	0.5000 –0.4904 – 0.0975i 0.3536 + 0.3536i 0.3536 – 0.3536i	0.5000 0.0975 – 0.4904i –0.3536 – 0.3536i –0.3536 – 0.3536i	0.5000 0.4904 + 0.0975i 0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000 –0.0975 + 0.4904i –0.3536 – 0.3536i 0.3536 + 0.3536i
101011	43	0.5000 0.3865 + 0.3172i 0.1913 + 0.4619i –0.1913 – 0.4619i	0.5000 –0.3172 + 0.3865i –0.1913 – 0.4619i –0.4619 + 0.1913i	0.5000 –0.3865 – 0.3172i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 0.3172 – 0.3865i –0.1913 – 0.4619i 0.4619 – 0.1913i
101100	44	0.5000 –0.1913 – 0.4619i 0.5000i –0.5000	0.5000 0.4619 – 0.1913i – 0.5000i 0.5000i	0.5000 0.1913 + 0.4619i 0.5000i 0.5000	0.5000 –0.4619 + 0.1913i –0.5000i –0.5000i
101101	45	0.5000 –0.0490 + 0.4976i –0.1913 + 0.4619i –0.1913 + 0.4619i	0.5000 –0.4976 – 0.0490i 0.1913 – 0.4619i 0.4619 + 0.1913i	0.5000 0.0490 – 0.4976i –0.1913 + 0.4619i 0.1913 – 0.4619i	0.5000 0.4976 + 0.0490i 0.1913 – 0.4619i –0.4619 – 0.1913i
101110	46	0.5000 0.2778 – 0.4157i –0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.4157 + 0.2778i 0.3536 – 0.3536i 0.3536 – 0.3536i	0.5000 –0.2778 + 0.4157i –0.3536 + 0.3536i –0.3536 – 0.3536i	0.5000 –0.4157 – 0.2778i 0.3536 – 0.3536i –0.3536 + 0.3536i

Table 6-302—$C_{base,UL}$(4,4,6) *(continued)*

101111	47	0.5000 –0.4410 + 0.2357i –0.4619 + 0.1913i 0.4619 – 0.1913i	0.5000 –0.2357 – 0.4410i 0.4619 – 0.1913i –0.1913 – 0.4619i	0.5000 0.4410 – 0.2357i –0.4619 + 0.1913i –0.4619 + 0.1913i	0.5000 0.2357 + 0.4410i 0.4619 – 0.1913i 0.1913 + 0.4619i
110000	48	0.5000 0.5000 –0.5000 –0.5000i	0.5000 0.5000i 0.5000 –0.5000	0.5000 –0.5000 –0.5000 0.5000i	0.5000 –0.5000i 0.5000 0.5000
110001	49	0.5000 –0.4410 – 0.2357i –0.4619 – 0.1913i –0.4619 – 0.1913i	0.5000 0.2357 – 0.4410i 0.4619 + 0.1913i –0.1913 + 0.4619i	0.5000 0.4410 + 0.2357i –0.4619 – 0.1913i 0.4619 + 0.1913i	0.5000 –0.2357 + 0.4410i 0.4619 + 0.1913i 0.1913 – 0.4619i
110010	50	0.5000 0.2778 + 0.4157i –0.3536 – 0.3536i –0.3536 + 0.3536i	0.5000 –0.4157 + 0.2778i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 –0.2778 – 0.4157i –0.3536 – 0.3536i 0.3536 – 0.3536i	0.5000 0.4157 – 0.2778i 0.3536 + 0.3536i –0.3536 – 0.3536i
110011	51	0.5000 –0.0490 – 0.4976i –0.1913 – 0.4619i 0.1913 + 0.4619i	0.5000 0.4976 – 0.0490i 0.1913 + 0.4619i 0.4619 – 0.1913i	0.5000 0.0490 + 0.4976i –0.1913 – 0.4619i –0.1913 – 0.4619i	0.5000 –0.4976 + 0.0490i 0.1913 + 0.4619i –0.4619 + 0.1913i
110100	52	0.5000 –0.1913 + 0.4619i – 0.5000i 0.5000	0.5000 –0.4619 – 0.1913i 0.5000i – 0.5000i	0.5000 0.1913 – 0.4619i –0.5000i –0.5000	0.5000 0.4619 + 0.1913i 0.5000i 0.5000i
110101	53	0.5000 0.3865 – 0.3172i 0.1913 – 0.4619i 0.1913 – 0.4619i	0.5000 0.3172 + 0.3865i –0.1913 + 0.4619i –0.4619 – 0.1913i	0.5000 –0.3865 + 0.3172i 0.1913 – 0.4619i –0.1913 + 0.4619i	0.5000 –0.3172 – 0.3865i –0.1913 + 0.4619i 0.4619 + 0.1913i
110110	54	0.5000 –0.4904 + 0.0975i 0.3536 – 0.3536i –0.3536 – 0.3536i	0.5000 –0.0975 – 0.4904i –0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000 0.4904 – 0.0975i 0.3536 – 0.3536i 0.3536 + 0.3536i	0.5000 0.0975 + 0.4904i –0.3536 + 0.3536i 0.3536 – 0.3536i
110111	55	0.5000 0.4785 + 0.1451i 0.4619 – 0.1913i –0.4619 + 0.1913i	0.5000 –0.1451 + 0.4785i –0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 –0.4785 – 0.1451i 0.4619 – 0.1913i 0.4619 – 0.1913i	0.5000 0.1451 – 0.4785i –0.4619 + 0.1913i –0.1913 – 0.4619i
111000	56	0.5000 –0.3536 – 0.3536i 0.5000 0.5000i	0.5000 0.3536 – 0.3536i –0.5000 0.5000	0.5000 0.3536 + 0.3536i 0.5000 –0.5000i	0.5000 –0.3536 + 0.3536i –0.5000 –0.5000
111001	57	0.5000 0.1451 + 0.4785i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 –0.4785 + 0.1451i –0.4619 – 0.1913i 0.1913 – 0.4619i	0.5000 –0.1451 – 0.4785i 0.4619 + 0.1913i –0.4619 – 0.1913i	0.5000 0.4785 – 0.1451i –0.4619 – 0.1913i –0.1913 + 0.4619i
111010	58	0.5000 0.0975 – 0.4904i 0.3536 + 0.3536i 0.3536 – 0.3536i	0.5000 0.4904 + 0.0975i –0.3536 – 0.3536i –0.3536 – 0.3536i	0.5000 –0.0975 + 0.4904i 0.3536 + 0.3536i –0.3536 + 0.3536i	0.5000 –0.4904 – 0.0975i –0.3536 – 0.3536i 0.3536 + 0.3536i
111011	59	0.5000 –0.3172 + 0.3865i 0.1913 + 0.4619i –0.1913 – 0.4619i	0.5000 –0.3865 – 0.3172i –0.1913 – 0.4619i –0.4619 + 0.1913i	0.5000 0.3172 – 0.3865i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 0.3865 + 0.3172i –0.1913 – 0.4619i 0.4619 – 0.1913i

Table 6-302—$C_{base,UL}(4,4,6)$ (continued)

111100	60	0.5000 0.4619 – 0.1913i 0.5000i –0.5000	0.5000 0.1913 + 0.4619i – 0.5000i 0.5000i	0.5000 –0.4619 + 0.1913i 0.5000i 0.5000	0.5000 –0.1913 – 0.4619i –0.5000i – 0.5000i
111101	61	0.5000 –0.4976 – 0.0490i –0.1913 + 0.4619i –0.1913 + 0.4619i	0.5000 0.0490 – 0.4976i 0.1913 – 0.4619i 0.4619 + 0.1913i	0.5000 0.4976 + 0.0490i –0.1913 + 0.4619i 0.1913 – 0.4619i	0.5000 –0.0490 + 0.4976i 0.1913 – 0.4619i –0.4619 – 0.1913i
111110	62	0.5000 0.4157 + 0.2778i –0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 –0.2778 + 0.4157i 0.3536 – 0.3536i 0.3536 – 0.3536i	0.5000 –0.4157 – 0.2778i –0.3536 + 0.3536i –0.3536 – 0.3536i	0.5000 0.2778 – 0.4157i 0.3536 – 0.3536i –0.3536 + 0.3536i
111111	63	0.5000 –0.2357 – 0.4410i –0.4619 + 0.1913i 0.4619 – 0.1913i	0.5000 0.4410 – 0.2357i 0.4619 – 0.1913i –0.1913 – 0.4619i	0.5000 0.2357 + 0.4410i –0.4619 + 0.1913i –0.4619 + 0.1913i	0.5000 –0.4410 + 0.2357i 0.4619 – 0.1913i 0.1913 + 0.4619i

Table 6-303—$C_{UL,CL,CSM}(4,1,4)$, $C_{UL,CL,CSM}(4,2,4)$, and $C_{UL,CL,CSM}(4,3,4)$

UL CSM codebook	Rank	Indices of base codebook $C_{base,UL}$
$C_{UL,CL,CSM}(4,1,4,m)$ m=0 to 15	1	0, 5, 10, 15, 20, 25, 30, 35, 40, 44, 45, 49, 50, 54, 55,59
$C_{UL,CL,CSM}(4,2,4,m)$ m=0 to 15	2	0,6, 9, 11, 14, 16, 19, 24, 33, 38, 41, 43, 46, 48, 51, 56
$C_{UL,CL,CSM}(4,3,4,m)$ m=0 to 15	3	0, 5, 10, 15, 20, 25, 30, 35, 40, 44, 45, 49, 50, 54, 55, 59

6.3.9.4 Codebook subsets for open-loop transmit precoding

6.3.9.4.1 OL SU-MIMO subset

The UL OL SU-MIMO codebook subset shall be used for non-adaptive precoding with MIMO mode 0 and MIMO mode 1 in DLRU and NLRU.

The notation $C_{UL,OL,SU}(N_t, M_t, N_w)$ denotes the UL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t, and M_t denotes the number of MIMO streams. The notation $C_{UL,OL,SU}(N_t, M_t, N_w, i)$ denotes the i-th codebook entry of $C_{UL,OL,SU}(N_t, M_t, N_w)$.

$C_{UL,OL,SU}(N_t, M_t, N_w)$ shall be used for precoding with N_t transmit antennas and M_t MIMO streams with MIMO mode 0 and MIMO mode 1.

6.3.9.4.1.1 OL SU-MIMO subset for two transmit antennas

The UL OL SU-MIMO codebook subset for 2-Tx is the same as the DL OL SU-MIMO codebook subset for 2-Tx. $C_{UL,OL,SU}(2, M_t, N_w) = C_{DL,OL,SU}(2, M_t, N_w)$, and it shall be used for precoding with 2 transmit antennas and M_t MIMO streams with MIMO mode 0 and MIMO mode 1.

6.3.9.4.1.2 OL SU-MIMO subset for four transmit antennas

The codewords $C_{UL,\,OL,\,SU}(4, M_t, 4, n)$ of the OL SU-MIMO codebook subset for four transmit antennas, $C_{UL,\,OL,\,SU}(4, M_t, 4)$ are given in Table 6-304 for each rank M_t. The corresponding codewords $C_{base,\,UL}(4, M_t, 6, m)$ of the uplink base codebook for four transmit antennas $C_{base,\,UL}(4, M_t, 6)$ are given in Table 6-304.

Table 6-304—$C_{UL,OL,SU}$(4,1,4), $C_{UL,OL,SU}$(4,2,4), $C_{UL,OL,SU}$(4,3,4), and $C_{UL,OL,SU}$(4,4,4)

$C_{UL,OL,SU}(4, 1, 4, n)$		$C_{UL,OL,SU}(4, 2, 4, n)$		$C_{UL,OL,SU}(4, 3, 4, n)$		$C_{UL,OL,SU}(4, 4, 4, n)$	
n	$C_{base,\,UL}(4, 1, 6, m)$	n	$C_{base,\,UL}(4, 2, 6, m)$	n	$C_{base,\,UL}(4, 3, 6, m)$	n	$C_{base,\,UL}(4, 4, 6, m)$
0	$C_{base,\,UL}(4, 1, 6, 9)$	0	$C_{base,\,UL}(4, 2, 6, 9)$	0	$C_{base,\,UL}(4, 3, 6, 9)$	0	$C_{base,\,UL}(4, 4, 6, 9)$
1	$C_{base,\,UL}(4, 1, 6, 15)$	1	$C_{base,\,UL}(4, 2, 6, 15)$	1	$C_{base,\,UL}(4, 3, 6, 15)$	1	$C_{base,\,UL}(4, 4, 6, 15)$
2	$C_{base,\,UL}(4, 1, 6, 49)$	2	$C_{base,\,UL}(4, 2, 6, 49)$	2	$C_{base,\,UL}(4, 3, 6, 49)$	2	$C_{base,\,UL}(4, 4, 6, 49)$
3	$C_{base,\,UL}(4, 1, 6, 55)$	3	$C_{base,\,UL}(4, 2, 6, 55)$	3	$C_{base,\,UL}(4, 3, 6, 55)$	3	$C_{base,\,UL}(4, 4, 6, 55)$

6.3.9.4.2 OL MU-MIMO subset

The UL OL MU-MIMO codebook subset is same as the UL OL SU-MIMO codebook subset.

6.3.10 Channel coding and HARQ

6.3.10.1 Channel coding for the data channel

Channel coding procedures for downlink and uplink data channels are shown in Figure 6-198.

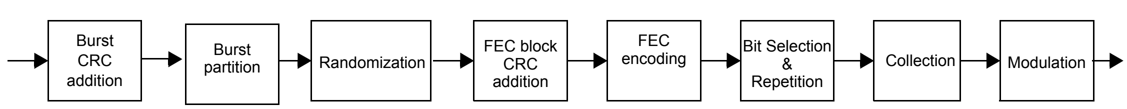

Figure 6-198—Channel coding procedure for data channel

6.3.10.1.1 Burst CRC encoding

Cyclic Redundancy Code (CRC) bits are used to detect errors in the received packets. A 16-bit burst CRC, per the CRC16-CCITT specification in Rec. ITU-T X.25, shall be appended to the data burst using the cyclic generator polynomial in Equation (317) if the number of FEC block partitions K_{FB} is larger than 1:

$$g_{DB-CRC}(D) = D^{16} + D^{12} + D^{5} + 1 \tag{317}$$

As an example, if the input data of 4 bytes in hexadecimal is 0x1234ABCD, the burst CRC encoding above yields 16-bit burst CRC of 0x5DF0. Note that this is just for the purpose of giving an example for the burst CRC encoding itself and the burst CRC shall be appended only when the data burst is partitioned into multiple FEC blocks (or $K_{FB} > 1$).

The data burst, including the CRC if appended when $K_{FB} > 1$, is further processed by the burst partition as described in 6.3.10.1.2.

6.3.10.1.2 Burst partition

Only the burst sizes N_{DB} listed in Table 6-305 are supported in the PHY layer. These sizes include the addition of CRC (per burst and/or per FEC block), when applicable. Other sizes require padding (refer to 6.2.4.7) to the next burst size excluding FEC CRC and burst CRC. When the burst size including 16 CRC bits for a data burst and/or FEC blocks exceeds the maximum FEC block size, N_{FB_MAX}, the burst is partitioned into K_{FB} FEC blocks.

Table 6-305—Burst size

idx	N_{DB} (byte)	K_{FB}	*idx*	N_{DB} (byte)	K_{FB}	*idx*	N_{DB} (byte)	K_{FB}
1	6	1	23	90	1	45	1200	2
2	8	1	24	100	1	46	1416	3
3	9	1	25	114	1	47	1584	3
4	10	1	26	128	1	48	1800	3
5	11	1	27	144	1	49	1888	4
6	12	1	28	164	1	50	2112	4
7	13	1	29	180	1	51	2400	4
8	15	1	30	204	1	52	2640	5
9	17	1	31	232	1	53	3000	5
10	19	1	32	264	1	54	3600	6
11	22	1	33	296	1	55	4200	7
12	25	1	34	328	1	56	4800	8

Table 6-305—Burst size *(continued)*

idx	N_{DB} (byte)	K_{FB}	*idx*	N_{DB} (byte)	K_{FB}	*idx*	N_{DB} (byte)	K_{FB}
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

$$idx = I_{MinimalSize} + I_{SizeOffset}$$

where $I_{SizeOffset} \in \{0, 1, \ldots, 31\}$ is a 5 bits index in A-MAP IE, and $I_{MinimalSize}$ is calculated based on the allocation size as shown in Table 6-306. The allocation size is defined as the number of LRUs multiplied by the STC rate allocated for the burst. In the case of long TTI, the number of LRUs is calculated as the number of AAI subframes in TTI multiplied by the number of LRUs per AAI subframe. For allocation size 185~192, $I_{SizeOffset}$ = 31 is invalid.

Table 6-306—Minimal size index as a function of the allocation size

Allocation size	$I_{MinimalSize}$	Allocation size	$I_{MinimalSize}$	Allocation size	$I_{MinimalSize}$
1 ~ 3	1	16 ~ 18	15	58 ~ 64	26
4	2	19 ~ 20	16	65 ~ 72	27
5	4	21 ~ 22	17	73 ~ 82	28
6	6	23 ~ 25	18	83 ~ 90	29
7	8	26 ~ 28	19	91 ~ 102	30
8	9	29 ~ 32	20	103 ~ 116	31
9	10	33 ~ 35	21	117 ~ 131	32
10 ~ 11	11	36 ~ 40	22	132 ~ 145	33
12	12	41 ~ 45	23	146 ~ 164	34
13	13	46 ~ 50	24	165 ~ 184	35
14 ~ 15	14	51 ~ 57	25	185 ~ 192	36

The modulation order N_{mod} (2 for QPSK, 4 for 16-QAM and 6 for 64-QAM) depends on the parameter $I_{SizeOffset}$ and AAI subframe type according to Table 6-307 or Table 6-308. Allocation size of 1 or 2 are special cases (separate columns in the table). For allocation size of at least 3, the modulation order depends only on $I_{SizeOffset}$. The allocation size and the value of $I_{SizeOffset}$ are set by the ABS scheduler, which takes into account the resulting modulation order and effective code rate, and according to the link adaptation.

Table 6-307—Rules for modulation order (for default TTI burst transmitted other than Type 3 subframe or long-TTI burst transmitted over subframes not including Type 3 subframe)

$I_{SizeOffset}$	N_{mod} (allocation size > 2)	N_{mod} (allocation size = 2)	N_{mod} (allocation size = 1)
0 ~ 9	2	2	2
10 ~ 15	2	2	4
16 ~18	2	4	6
19 ~ 21	4	4	6
22 ~ 23	4	6	6
24 ~ 31	6	6	6

Table 6-308—Rules for modulation order (for default TTI burst transmitted in Type 3 subframe or long-TTI burst transmitted over subframes including Type 3 subframe)

$I_{SizeOffset}$	N_{mod} (allocation size > 2)	N_{mod} (allocation size = 2)	N_{mod} (allocation size = 1)
0 ~ 7	2	2	2
8 ~ 13	2	2	4
14 ~16	2	4	6
17 ~ 19	4	4	6
20 ~ 21	4	6	6
22 ~ 31	6	6	6

In broadcast assignment A-MAP IE, the burst size index is directly signaled as 'Burst Size' instead of being indirectly derived using $I_{SizeOffset}$ and $I_{Minimalsize}$. When the uplink BW for BR header is granted through CDMA allocation A-MAP IE, neither $I_{SizeOffset}$ nor burst size index is signaled, but the value of burst size index is predetermined as 2 (i.e., 8 bytes). In both cases, the burst size index and the modulation order are not dependent on the allocation size, where the modulation order N_{mod} is fixed to 2 (i.e., QPSK).

In GRA A-MAP IE, the Resource Allocation Bitmap is used to inform both the burst size and the resource size as specified in 6.3.5.5.2.4.10. The burst size is the one among the four burst sizes predefined in the AAI-

GRP-CFG message. The resource size is the one among the eight resource sizes predefined in the AAI-GRP-CFG message. The modulation order N_{mod} is dependent on the burst size and the resource size signaled in GRA A-MAP IE. The burst size index is found in Table 6-304 for the signaled burst size and $I_{Minimalsize}$ is found in Table 6-305 after calculating the allocation size for the signaled resource size. $I_{SizeOffset}$ is calculated as subtracting $I_{Minimalsize}$ from the burst size index, and N_{mod} is found in Table 6-306.

If a burst is partitioned into more than one FEC block, each partitioned FEC block has the same size. The size of the FEC encoder input is denoted by N_{FB}. The set of supported FEC encoder input sizes including FEC block CRC, when applicable, is the subset of the burst size table, i.e., N_{DB} of *idx* from 1 to 39 in Table 6-305.

The burst size N_{DB} including burst CRC and FEC block CRC is defined by Equation (318).

$$N_{DB} = K_{FB} \times N_{FB} \tag{318}$$

The payload size excluding burst CRC and FEC block CRC is defined by Equation (319).

$$N_{PL} = N_{DB} - I_{MFB} \times N_{DB-CRC} - K_{FB} \times N_{FB-CRC} \tag{319}$$

where

I_{MFB}	equals 0 when $K_{FB} = 1$, 1 when $K_{FB} > 1$.
$N_{FB\text{-}CRC}$	equals 16, which is the size of the FEC block CRC.
$N_{DB\text{-}CRC}$	equals 16, which is the size of the burst CRC.

The burst partition block generates K_{FB} FEC blocks, with each FEC block processed by the randomization block as described in 6.3.10.1.3.

6.3.10.1.3 Randomization

The randomization bits are generated using a PRBS generator as shown in Figure 6-199. The generator polynomial of the PRBS generator is $1 + X^{14} + X^{15}$. The initial vector of the PRBS generator shall be designated [0 1 1 0 1 1 1 0 0 0 1 0 1 0 1] from LSB to MSB.

The data byte to be transmitted shall enter sequentially into the randomization, MSB first. The data bits are XOR-ed with the output of the PRBS generator, with the MSB of the data burst XOR-ed with the first bit of the PRBS generator output.

The randomization is initialized with the initial vector for each FEC block.

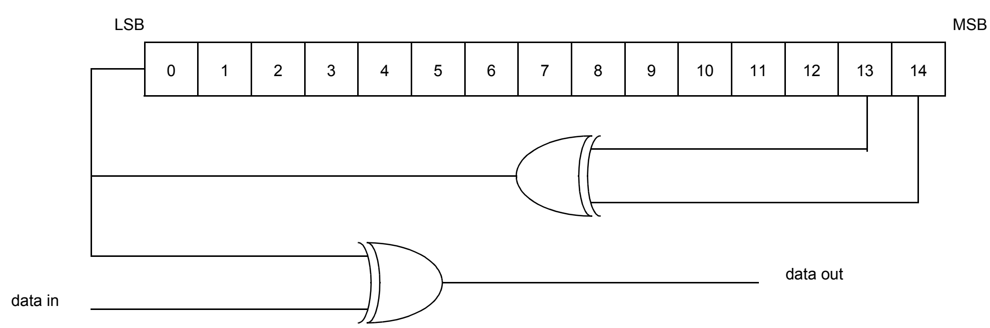

Figure 6-199—Data randomization with a PRBS generator

The output of the data randomization is further processed by FEC block CRC addition block as described in 6.3.10.1.4.

6.3.10.1.4 FEC block CRC encoding

The burst partition procedure generates K_{FB} FEC blocks for each burst. The FEC block CRC generator appends a 16-bit FEC block CRC for each FEC block. For the 16-bit FEC block CRC, CRC16-ANSI is used with the CRC register preset to all-zeros but without post-inversion of the CRC encoding result. The cyclic generator for FEC block CRC encoding is shown in Equation (320).

$$g_{FB-CRC}(D) = D^{16} + D^{15} + D^{2} + 1 \quad (320)$$

Denote the bits of FEC encoder input by $d_1, d_2, ..., d_{N_{FB}}$ with d_1 being the MSB and N_{FB} being the size of the FEC encoder input, including the 16-bit FEC block CRC. Denote the parity bits produced by the FEC block CRC generator by $p_1, p_2, ..., p_{16}$. The FEC block CRC encoding is performed in a systematic form, which means that in GF(2), the polynomial in Equation (321).

$$d_1 D^{N_{FB}-1} + d_2 D^{N_{FB}-2} + \ldots + d_{N_{FB}-16} D^{16} + p_1 D^{15} + p_2 D^{14} + \ldots + p_{15} D^{1} + p_{16} \quad (321)$$

yields a remainder equal to 0 when divided by $g_{FB-CRC}(D)$.

As an example, if the input data of 4 bytes in hexadecimal is 0x1234ABCD, the FEC block CRC encoding above yields 16-bit CRC of 0x9332.

6.3.10.1.5 FEC encoding

Each FEC block shall be encoded using the convolutional turbo codes specified in 6.3.10.1.5.1.

6.3.10.1.5.1 Convolutional turbo codes

CTC encoder

The CTC encoder, including its constituent encoder, is depicted in Figure 6-200.

It uses a double binary CRSC (Circular Recursive Systematic Convolutional) code.

The bits of the data to be encoded are alternatively fed to A and B, starting with the MSB of the first byte being fed to A, followed by the next bit being fed to B. The encoder is fed by blocks of N_{FB} bits or N couples ($N_{FB} = 2N$ bits).

The polynomials defining the connections are described in octal and symbol notations as follows:

For the feedback branch: 13, equivalently $1 + D + D^3$ (in octal notation)

For the Y parity bit: 15, equivalently $1 + D^2 + D^3$

For the W parity bit: 11, equivalently $1 + D^3$

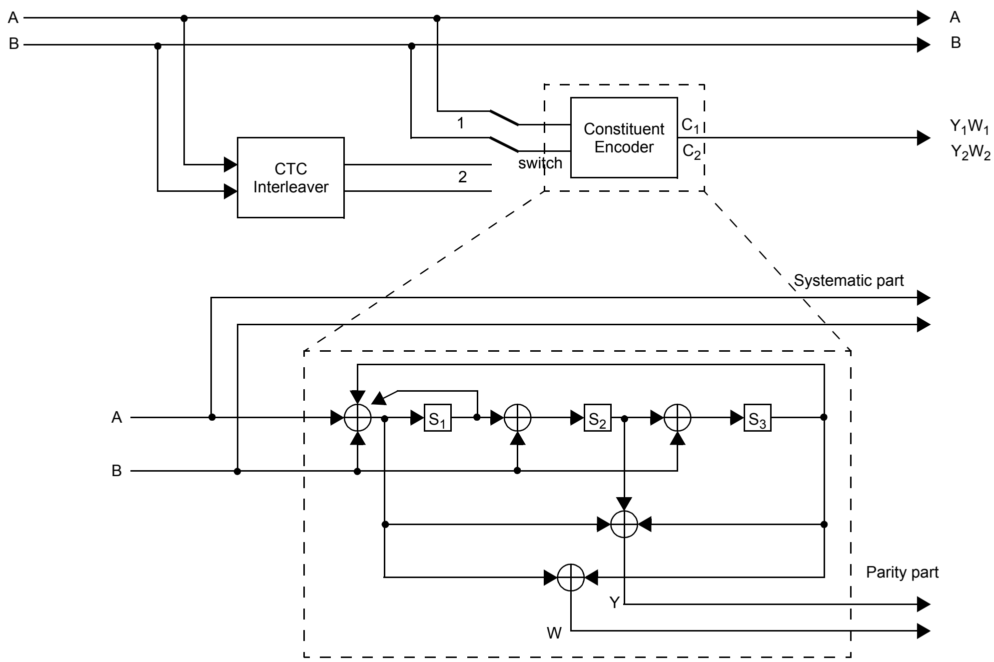

Figure 6-200—CTC encoder

First, the encoder (after initialization by the circulation state S_c; see 8.4.9.2.3 in IEEE Std 802.16) is fed the sequence in the natural order (switch 1 in Figure 6-200) with incremental address $i = 0, 1, \ldots, N-1$. This first encoding is called C_1 encoding.

Next, the encoder (after initialization by the circulation state S_c; see 8.4.9.2.3.3 in IEEE Std 802.16) is fed by the interleaved sequence (switch 2 in Figure 6-200) with incremental address $i = 0, 1, \ldots, N-1$. This second encoding is called C_2 encoding.

The order in which the encoded bits shall be fed into the bit separation block (see 8.4.9.2.3.4 in IEEE Std 802.16) is as follows:

$$\mathrm{A, B, Y_1, Y_2, W_1, W_2} =$$
$$A_0, A_1, A_2 \ldots, A_{N\text{-}1}, B_0, B_1, B_2, B_{N-1}, Y_{1,0}, Y_{1,1}, Y_{1,2}, \ldots Y_{1,N-1},$$
$$Y_{2,0}, Y_{2,1}, Y_{2,2}, \ldots Y_{2,N\text{-}1}, W_{1,0}, W_{1,1}, W_{1,2}, \ldots W_{1,N-1}, W_{2,0}, W_{2,1}, W_{2,2}, \ldots W_{2,N-1}$$

CTC interleaver

The CTC interleaver requires the parameters P_0, P_1, P_2, and P_3 shown in Table 6-309, where the value of N_{FB} is shown in bit.

The detailed interleaver structures except table for interleaver parameters correspond to 8.4.9.2.3.2 in IEEE Std 802.16.

Table 6-309—Interleaver parameters

Index	N_{FB} (bits)	P_0	P_1	P_2	P_3	*Index*	N_{FB} (bits)	P_0	P_1	P_2	P_3
1	48	5	0	0	0	21	568	19	102	140	226
2	64	11	12	0	12	22	640	23	84	296	236
3	72	11	18	0	18	23	720	23	130	156	238
4	80	7	4	32	36	24	800	23	150	216	150
5	88	13	36	36	32	25	912	29	14	264	94
6	96	13	24	0	24	26	1024	29	320	236	324
7	104	7	4	8	48	27	1152	31	534	372	246
8	120	11	30	0	34	28	1312	31	214	160	506
9	136	13	58	4	58	29	1440	41	288	556	672
10	152	11	38	12	74	30	1632	29	334	564	66
11	176	17	52	68	32	31	1856	47	576	212	728
12	200	11	76	0	24	32	2112	43	96	720	980
13	216	11	54	56	2	33	2368	47	228	440	724
14	248	13	6	84	46	34	2624	47	378	1092	1250
15	288	17	74	72	2	35	2944	41	338	660	646
16	320	17	84	108	132	36	3328	37	258	28	1522
17	352	17	106	56	50	37	3776	53	772	256	408
18	400	19	142	0	142	38	4224	59	14	668	1474
19	456	17	184	0	48	39	4800	53	66	24	2
20	512	19	64	52	124						

Determination of CTC circulation states

Correspond to 8.4.9.2.3.3 in IEEE Std 802.16.

Bit separation

Correspond to 8.4.9.2.3.4.1 in IEEE Std 802.16.

Subblock interleaving

The subblock interleaver requires the parameters *m* and *J* shown in Table 6-310.

The detailed subblock interleaver structures except table for subblock interleaver parameters correspond to 8.4.9.2.3.4.2 in IEEE Std 802.16.

Table 6-310—Parameters for the subblock interleavers

Index	N_{FB}	*m*	*J*	*Index*	N_{FB}	*m*	*J*	*Index*	N_{FB}	*m*	*J*	*Index*	N_{FB}	*m*	*J*
1	48	3	3	11	176	5	3	21	568	7	3	31	1856	9	2
2	64	4	2	12	200	5	4	22	640	7	3	32	2112	9	3
3	72	4	3	13	216	5	4	23	720	7	3	33	2368	9	3
4	80	4	3	14	248	6	2	24	800	7	4	34	2624	9	3
5	88	4	3	15	288	6	3	25	912	8	2	35	2944	9	3
6	96	4	3	16	320	6	3	26	1024	8	2	36	3328	9	4
7	104	4	4	17	352	6	3	27	1152	8	3	37	3776	10	2
8	120	5	2	18	400	6	4	28	1312	8	3	38	4224	10	3
9	136	5	3	19	456	7	2	29	1440	8	3	39	4800	10	3
10	152	5	3	20	512	7	2	30	1632	8	4				

Bit grouping

The interleaved subblocks shall be multiplexed into four blocks. Those four blocks consist of an interleaved A subblock; an interleaved B subblock; a bit-by-bit multiplexed sequence of the interleaved Y_1 and Y_2 subblock sequences, which is referred to as Y; and a bit-by-bit multiplexed sequence of the interleaved W_2 and W_1 subblock sequences, which is referred to as W. Information subblocks, A and B, are bypassed, while parity subblocks are multiplexed bit by bit. The bit-by-bit multiplexed sequence of interleaved Y_1 and Y_2 subblock sequences shall consist of the first output bit from the Y_1 subblock interleaver, the first output bit from the Y_2 subblock interleaver, the second output bit from the Y_1 subblock interleaver, the second output bit from the Y_2 subblock interleaver, and so on. The bit-by-bit multiplexed sequence of interleaved W_2 and W_1 subblock sequences shall consist of the first output bit from the W_2 subblock interleaver, the first output bit from the W_1 subblock interleaver, the second output bit from the W_2 subblock interleaver, the second output bit from the W_1 subblock interleaver, and so on.

After multiplexing subblocks into four blocks, Subblock B and Subblock W are circularly left-shifted by k bits. Subblock Y is circularly left-shifted by 1 bit. When the FEC block size N_{FB} is equal to the multiple of the modulation order, k is set as 1. Otherwise, let k be 0. Figure 6-201 shows the interleaving scheme as explained above.

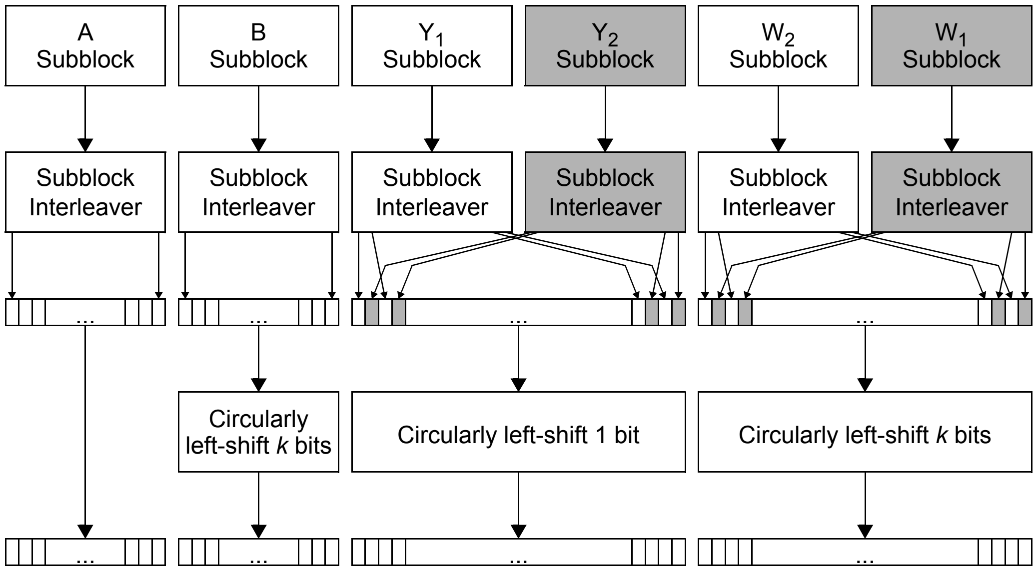

Figure 6-201—Block diagram of the interleaving scheme

Resource segmentation

The N_{RE} data tones allocated for the subpacket are segmented into K_{FB} blocks, one for each FEC block. The number of data tones for the k-th FEC block is defined by Equation (322) where the MIMO stream is determined by the AMS Rx/Tx perspective.

$$N_{RE,k} = K_{RS} \cdot \left\lfloor \frac{\frac{N_{RE}}{K_{RS}} + (K_{FB} - k - 1)}{K_{FB}} \right\rfloor, 0 \le k < K_{FB} \tag{322}$$

where
K_{RS} = 1 for MIMO stream = 1.
K_{RS} = 2 for MIMO stream > 1.

6.3.10.1.6 Bit selection and repetition

Bit selection and repetition are performed to generate the subpacket.

Let $N_{CTC,k}$ be the number of coded bits that shall be transmitted for the k-th FEC block. The value of $N_{CTC,k}$ is calculated by Equation (323).

$$N_{CTC,k} = N_{RE,k} \cdot N_{SM} \cdot N_{mod} \tag{323}$$

where N_{SM} is equal to the STC rate allocated for the burst.

The index in the HARQ buffer for the j-th bit transmitted for the k-th FEC block $u_{k,j,i}$ shall be

$$N_{shift,i} = i \cdot N_{mod}$$

$$index_{k,j,i} = (j - N_{shift,i}) \bmod N_{CTC,k}$$

$$u_{k,j,i} = (P_{i,k} + index_{k,j,i}) \bmod N_{FB\_Buffer,k}$$

for $k = 0, \ldots, K_{FB} - 1$, and $j = 0, 1, \ldots, N_{CTC,k} - 1$,where i is the subpacket ID of the subpacket (SPID = i), $P_{i,k}$ is the starting position for subpacket i of the k-th FEC block as specified in 6.3.10.4.1, and $N_{FB\_Buffer,k} = 3 \cdot N_{FB,k}$ is the buffer size for the k-th FEC block of a burst.

6.3.10.1.7 Bit collection

The selected bits from each FEC block are collected in the order of FEC block for the HARQ transmission.

6.3.10.1.8 Modulation

Corresponds to 8.4.9.4.2 in IEEE Std 802.16.

6.3.10.2 Channel coding for control channel

Tail-biting convolutional codes (TBCC) are used for most of uplink and downlink control channels. The structure of TBCC encoder is depicted in Figure 6-202. The output encoded bits of the rate-1/5 TBCC encoder are separated into five subblocks, and each subblock goes through its subblock interleaver. In the bit selection block, the rate-matching mechanism is implemented by puncture or repetition operation.

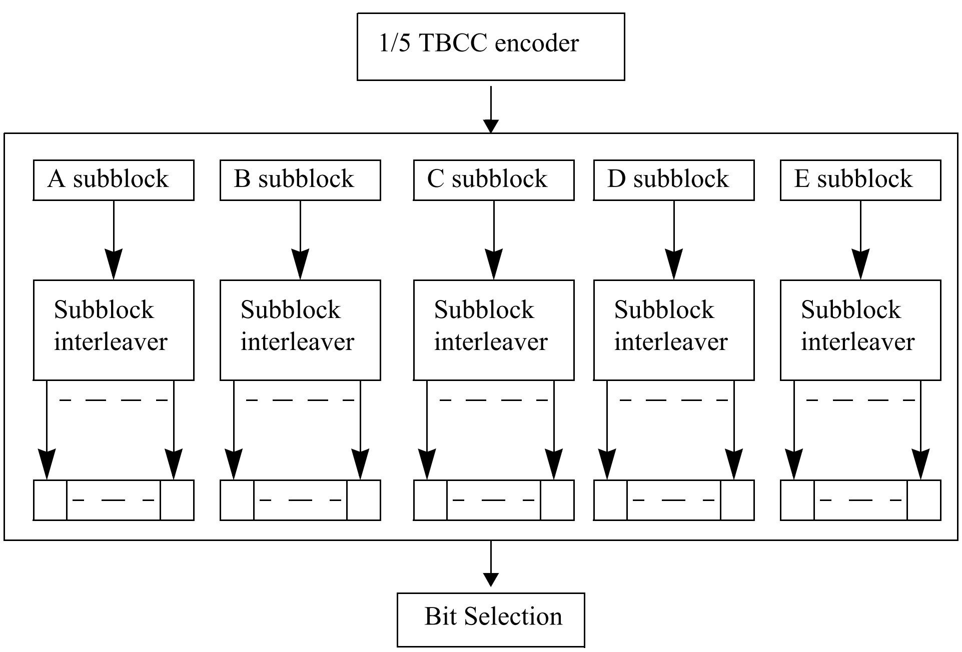

Figure 6-202—Block diagram of TBCC structure

6.3.10.2.1 TBCC encoder

The binary TBCC shall have a mother code rate of 1/5, a constraint length equal to $K = 7$, and shall use the generator polynomials in Equation (324) to derive its five code bits.

$$\begin{aligned} G_1 &= 171_{\mathrm{OCTAL}} && \text{for A} \\ G_2 &= 133_{\mathrm{OCTAL}} && \text{for B} \\ G_3 &= 165_{\mathrm{OCTAL}} && \text{for C} \\ G_4 &= 117_{\mathrm{OCTAL}} && \text{for D} \\ G_5 &= 127_{\mathrm{OCTAL}} && \text{for E} \end{aligned} \tag{324}$$

The TBCC encoder using above generator polynomials is depicted in Figure 6-203.

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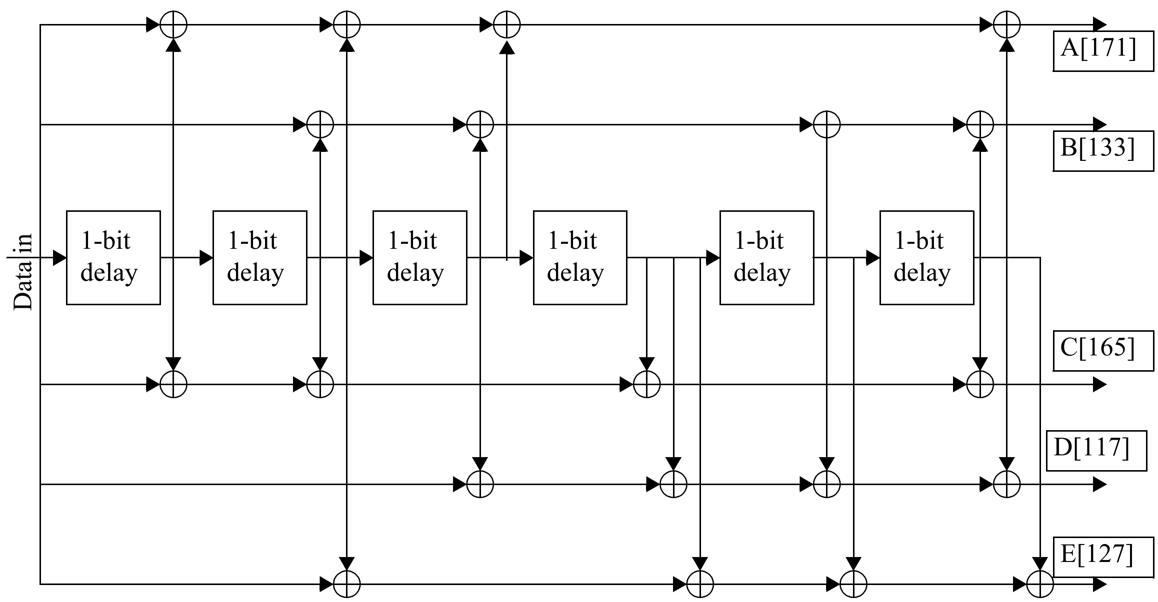

Figure 6-203—TBCC encoder of rate 1/5

6.3.10.2.2 Bit separation

All of the encoded bits shall be demultiplexed into five subblocks denoted A, B, C, D, and E. Suppose L information bits are input to the encoder. The encoded bits $u[i]$ with $i = 0, \ldots, 5L-1$ shall be distributed into five subblocks with $y^A[k] = u[5k]$, $y^B[k] = u[5k+1]$, $y^C[k] = u[5k+2]$, $y^D[k] = u[5k+3]$, and $y^E[k] = u[5k+4]$, where $k = 0, \ldots, L-1$.

6.3.10.2.3 Subblock interleaver

The five subblocks shall be interleaved separately. The interleaving is performed by the unit of bits. The output of the subblock interleaver $z^j[k]$ with $j = \mathrm{A,B,C,D,E}$ and $k = 0, \ldots, L-1$ is related to the input sequence $y^j[k]$. It can be expressed as $z^j[k] = y^j[\Pi_k]$, where Π_k is the interleaver index. It can be calculated by the following four steps:

a) Initialize x and k to 0.

b) Form a tentative output address $T[x]$ according to the following formula: $T[x] = (15(x+1) + 32(x+1)^2) \bmod 128$.

c) If $T[x]$ is less than L, $\Pi_k = T[x]$ and increment x and k by 1. Otherwise, discard $T[x]$ and increment x only.

d) Repeat steps b) and c) until all L interleaver output addresses are obtained.

The maximum value of L must be not greater than 128.

6.3.10.2.4 Bit grouping

The output sequence of the subblock interleaver shall consist of the interleaved A, B, C, D, and E subblock sequences. Let the bit grouping output denoted by $w[i]$ with $i = 0, \ldots, 5L-1$. It can be expressed as $w[k] = z^A[k]$, $w[k+L] = z^B[k]$, $w[k+2L] = z^C[k]$, $w[k+3L] = z^D[k]$, and $w[k+4L] = z^E[k]$ with $k = 0, \ldots, L-1$.

6.3.10.2.5 Bit selection

Suppose the desired number of the output bits is M. The output sequence $c[n]$ can be expressed as $c[n] = w[n \bmod K_{bufsize}]$, $n = 0, \ldots, M-1$, where $K_{bufsize} \le 5L$ is the size of buffer used for repetition.

6.3.10.3 Subcarrier randomization

6.3.10.3.1 PRBS for subcarrier randomization

The PRBS generator depicted on Figure 6-204 shall be used to produce a bit sequence w_k. The polynomial for the PRBS generator shall be $x^{15} + x^{11} + 1$.

The initialization vector of the PRBS generator for both DL and UL shall be designated $b_{14}...b_0$ so that

$b_0 \ldots b_9$ = 10 bits of *IDcell*, where b_0 and b_9 are the MSB and LSB of *IDcell,* respectively, and *IDcell* corresponds to SA-Preamble (in the range 0 to 767).

$b_{10} \ldots b_{14} = 1$, the values of these bits are always set to 1 for avoiding the initial state of all zeros.

The value of the subcarrier randomization sequence, on subcarrier k, is derived from bit w_{k+n}, where $n = \mathrm{mod}(7 \times m + f,\ 64)$, m = OFDMA symbol number within a frame (the first symbol in the AAI downlink/uplink frame is indexed 0. Note that the indexing only considers symbols that belong to the AAI portion in the AAI/WirelessMAN-OFDMA R1 Reference System mixed mode.) and f = frame index within a superframe (in the range 0 to 3). The subcarrier randomization sequence shall be generated for every subcarrier up to the highest numbered usable subcarrier, in order of physical subcarriers, including the DC subcarrier and usable subcarriers that are not allocated. The first usable subcarrier is indexed 0. The output bits of PRBS shall be counted from zero.

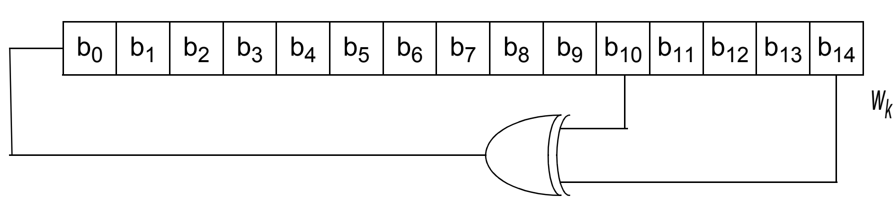

Figure 6-204—PRBS generator for subcarrier randomization

The subcarrier randomization sequence shall not be applied to the subcarriers belonging to the PA- and SA-Preamble, MIMO midamble, uplink sounding, Initial/HO ranging region, Periodic Ranging, and data and pilot subcarriers of CDR allocations.

For data and pilot subcarriers belonging to the E-MBS allocation, an alternative subcarrier randomization sequence is applied. The sequence is generated as described above, but 7 bits of E-MBS Zone ID shall be used as $b_0 \ldots b_6$ and $b_7 \ldots b_9 = 1$ in the PRBS initialization vector instead of *IDcell*.

6.3.10.3.2 Data subcarrier randomization

The constellation-mapped data z_k after precoding shall be subsequently modulated onto the allocated data subcarriers for each antenna. The data subcarrier symbols z_k of each transmit antenna shall be modulated according to the subcarrier physical index k using Equation (325).

$$c_k = \sqrt{B_d}(1 - 2w_{k+n})z_k \tag{325}$$

where the B_d value shall be set according to the number of streams as indicated in Table 6-311 and Table 6-312 for downlink and uplink, respectively.

Table 6-311—Downlink data and pilot subcarriers power

Number of streams M_t	Per stream power on data subcarriers B_d	Per stream pilot power B_p	Per stream pilot boosting level, dB
1–2	$1 / M_t$	1.5849	$2 + 10 \times \log10(M_t)$
3–4		1	$10 \times \log10(M_t)$
5–8		1	$10 \times \log10(M_t)$

Table 6-312—Uplink data and pilot subcarriers power

	Number of streams M_t	Per stream power on data subcarriers B_d	Per stream pilot power B_p	Per stream pilot boosting level, dB
SU-MIMO	1	1	$1.5849 \times M_t$	$2 + 10 \times \log10(M_t)$
	2–4		M_t	$10 \times \log10(M_t)$
UL CSM	1–4		M_t	$10 \times \log10(M_t)$

The operation shall be also applied for the subcarriers for the fast-feedback and ACK channels with $B_d = 1$.

6.3.10.3.3 Pilot subcarrier randomization

The pilot subcarriers, z_k, of each stream shall be modulated after precoding according to Equation (326).

$$c_k = \sqrt{B_p}(1-2w_{k+n})z_k \tag{326}$$

where k corresponds to the physical subcarrier index, the pilot boosting value B_p shall be set according to number of streams as indicated in Table 6-311 and Table 6-312 for downlink and uplink, respectively.

For uplink SU-MIMO mode with $M_t = 1$ in SLRU, NLRU, and DLRU allocations, B_p shall be set to 1.5849.

For UL CSM (collaborative spatial multiplexing) mode, the pilot subcarriers shall be further amplified by $\sqrt{\frac{TNS}{M_t}}$ after applying Equation (326), where TNS is a total number of streams in CSM mode.

The per stream pilot boosting provided in Table 6-311 and Table 6-312 is defined as power of pilot subcarrier relative to average power of data subcarrier on corresponding data stream.

In the Type 1 OL MIMO region, the pilot sequence used to modulate the CoFIP pilot subcarriers shall be obtained from the set of pilot modulation sequences defined in Table 6-313. The sequence index used for modulation of PRU pilot subcarriers is derived from $i = \text{mod}(s + t + \text{mod}(\text{mod}(IDcell, 256), 7), 7)$, where s is the physical PRU index and t is the physical subframe index.

In the Type 1 OL MIMO region, the pilot subcarriers within the PRU of allocation are modulated using symbols obtained from the pilot modulation sequence with sequence index i, $0 \le i \le 6$, shown in Table 6-312. The symbols of the pilot modulation sequence with sequence index i starting from left to right are mapped to pilot subcarriers in the PRU of allocation in a time domain first and frequency domain second order. The example shown in Figure 6-205 illustrates one such mapping of the pilot modulation sequence corresponding to sequence index 0 on to the pilot subcarriers of the PRU in AAI subframes having 5, 6, and 7 OFDMA symbols. Note that for the AAI subframes with 7 OFDMA symbols, pilot mapping is done for the first 6 OFDMA symbols using the same procedure as that of AAI subframes with 6 OFDMA symbols, and the pilot values for the seventh OFDMA symbol are same as that of the pilot values of the first OFDMA symbol.

Table 6-313—Pilot modulation sequences for CoFIP

Sequence index	Pilot modulation sequence
0	[–1 –1 1 1 1 –1]
1	[–1 1 –1 –1 1 1]
2	[–1 1 1 1 –1 1]
3	[1 –1 –1 1 1 1]
4	[1 –1 1 –1 –1 1]
5	[1 1 –1 1 –1 –1]
6	[1 1 1 –1 1 –1]

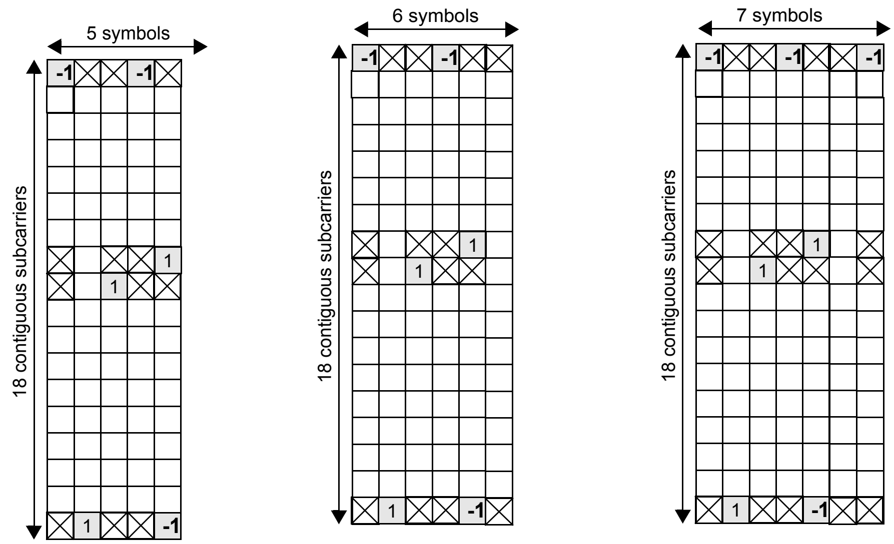

Figure 6-205—Mapping of pilot modulation sequence to pilot subcarriers of CoFIP

6.3.10.4 HARQ

6.3.10.4.1 IR HARQ

IR HARQ 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 6.3.10.1.6 is determined as a function of SPID using Table 6-314.

Table 6-314—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	$(-N_{CTC,k}/2) \bmod (N_{FB\_Buffer,k})$

For uplink HARQ, the starting position for the bit selection algorithm as described in 6.3.10.1.6 is determined as a function of SPID for Equation (327).

$$P_{i,k} = (\mathrm{SPID} \cdot N_{CTC,k}) \bmod N_{FB\_Buffer,k} \tag{327}$$

For uplink HARQ, the SPID of a subpacket shall be initiated to 0 when the AMS receives the UL Basic Assignment A-MAP IE and UL Subband Assignment A-MAP IE regardless of the transmission number.

The SPID of a subpacket shall be increased in cyclic order of SPIDs (i.e., 0 -> 1 -> 2 -> 3 -> 0 -> ...)

6.3.10.4.2 Constellation rearrangement

Two constellation rearrangement (CoRe) versions shall be supported. The constellation rearrangement only applies to 16QAM and 64QAM. In case of QPSK, it is transparent.

Table 6-315 and Table 6-316 describe the operations that produce two different CoRe versions for 16QAM and 64QAM according to the number of MIMO streams from the AMS Rx/Tx perspective, respectively, so that the four bits in a 16QAM symbol (the six bits in a 64QAM) 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 6-315—Constellation rearrangement version (MIMO stream = 1)

Constellation	N_{mod}	CRV	Mapping rule					
16QAM	4	0	b_0	b_1	b_2	b_3	—	—
16QAM	4	1	b_3	b_2	b_1	b_0	—	—
64QAM	6	0	b_0	b_1	b_2	b_3	b_4	b_5
64QAM	6	1	b_5	b_4	b_3	b_2	b_1	b_0

Table 6-316—Constellation rearrangement version (MIMO stream > 1)

Constellation	N_{mod}	CRV	Mapping rule											
			Even symbol						Odd symbol					
16QAM	4	0	b_0	b_1	b_2	b_3	-	-	b_4	b_5	b_6	b_7	—	—
16QAM	4	1	b_1	b_4	b_3	b_6	-	-	b_5	b_0	b_7	b_2	—	—
64QAM	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}
64QAM	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

For the *k*-th FEC block, $N_{CTC,k}$ coded bits are mapped onto $N_{QAM,k}$ QAM symbols applying CoRe mapping rule in Table 6-315 and Table 6-316. In Table 6-316, a pair of two QAM symbols uses the same value of CRV when the number of MIMO stream is larger than 1. For a QAM symbol index j, an "even symbol" has its index j mod 2 = 0 and an "odd symbol" has its index j mod 2 = 1 where $j = 0, 1, 2, \ldots, N_{QAM,k} - 1$. The QAM symbol index j represents its transmit order.

In the DL HARQ operation, CRV is signaled for each subpacket to an AMS as a starting value for CRV. For data initially transmitted using persistent allocated resources, the value of the CRV indicated by DL Persistent Allocation A-MAP IE shall be zero. In UL HARQ operation, the information on CRVs is implicitly known at the AMS and the ABS and the starting value for CRV of the subpacket i shall be $\lfloor (i \cdot N_{CTC,k})/N_{FB\_Buffer,k} \rfloor \bmod 2$.

In the DL and UL HARQ operations, the value of CRV is determined assuming $N_{shift,i}$ is 0 for all subpacket i while the coded bits are mapped on to the QAM symbols in their transmit order considering $N_{shift,i}$.

The CRV shall be changed to the other version of CoRe in DL and UL HARQ operations whenever the transmitted bits wrap around at the end of circular buffer per SPID.

Let $CRV_{j,k}$ be the value of CRV for the j-th QAM symbol for the k-th FEC block. The value $CRV_{j,k}$ is calculated by Equation (328) where the MIMO stream is determined by the AMS Rx/Tx perspective.

$$CRV_{j,k} = \left(CRV_{starting,k} + \left\lfloor \frac{\left\lfloor \frac{P_{i,k}/N_{mod}}{K_{RS}} \right\rfloor \cdot K_{RS} + n}{N_{\mathrm{FB\_Buffer},k}/N_{mod}} \right\rfloor \right) \bmod 2 \quad (328)$$

where

$CRV_{starting,k}$ is the starting value for the CRV

$$n = \left(N_{QAM,k} - \left\lfloor \frac{SPID}{K_{RS}} \right\rfloor \cdot K_{RS} + j \right) \bmod N_{QAM,k}$$

$$K_{RS} = \begin{cases} 1 & \text{if MIMO stream} = 1 \\ 2 & \text{otherwise} \end{cases}$$

6.3.11 Link adaptation

This subclause introduces the link adaptation scheme, which adaptively adjusts radio link transmission formats in response to change of radio channel for both downlink and uplink.

6.3.11.1 DL link adaptation

The S-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 S-ABS may adapt the MIMO mode, according to CQI reports from the AMS and considering system parameters, such as traffic load, number of users, ACK/NACK, CQI variation, preferred MFM, and so on.

The AMS shall measure the DL channel quality and report back to the ABS. The exact measurement method used to derive the CQI feedback is implementation specific.

6.3.11.2 UL link adaptation

Adaptive modulation and channel coding scheme for UL transmission shall be supported.

The S-ABS may adapt the MCS level based on the UL channel quality estimation, allocated resource size, and maximum transmission power of the AMS. UL control channel (excluding initial ranging channel) transmit power should be adapted based on UL power control.

6.3.12 Error vector magnitude (EVM) and requirements

6.3.12.1 EVM definition

The EVM is calculated using Equation (329):

$$EVM = 10\log 10\left(\frac{1}{N_f}\sum_{i=1}^{N_f}\frac{\sum_{j-1}^{L_S}\sum_{k\in S\oplus S_u}[(I(i,j,k)-I_0(i,j,k))^2+(Q(i,j,k)-Q_0(i,j,k))^2]}{\sum_{j=1}^{L_S}\sum_{k\in S}[I_0(i,j,k)^2+Q_0(i,j,k)^2]}\right) \quad (329)$$

where

N_f	is the number of frames used for the measurement.
L_S	is the number of symbols used for the measurement.
S	is the group of modulated data subcarriers.
S_u	is the group of unmodulated data subcarriers. It includes all subcarriers in the range 0 … N_{used} – 1, except the DC and the modulated subcarriers (in S).
$(I_0(i,j,k), Q_0(i,j,k))$	denotes the ideal symbol point of the i-th frame, j-th OFDMA symbol,and k-th subcarrier in the complex plane. It is set as (0, 0) in the un-modulated data subcarriers.
$(I(i,j,k), Q(i,j,k))$	denotes the observed point of the i-th frame, j-th OFDMA symbol, and k-th subcarrier in the complex plane.

By using Equation (329), the EVM noise in both modulated and unmodulated tones are summed.

6.3.12.2 EVM requirements

To ensure that the system performance does not degrade obviously due to EVM noise, the relative basic EVM measurement, averaged over subcarriers, symbols, and frames, shall not exceed the values in Table 6-317.

Table 6-317—EVM requirements

Modulation	Required EVM level (dB)
QPSK	–14
16QAM	–19
64QAM	–24

6.3.13 Channel quality measurements

6.3.13.1 Introduction

RSSI, CINR, and SIR measurements and associated statistics may be used for characterizing signal quality, assisting the ABS in selection/assignment of frequency partition, HO, scan, and UL power control. As channel behavior is time variant, both mean and variance are required to be defined.

6.3.13.2 RSSI mean and standard deviation

When a collection of RSSI measurements is mandated by the ABS, an AMS shall obtain an RSSI measurement from the DL SA-preamble. From a succession of RSSI measurements, the AMS shall derive and update estimates of the mean of the RSSI, and report them through a proper message (e.g., AAI-HO-REQ or AAI-SCN-REP message).

RSSI mean shall be reported in units of decibels relative to 1 mW, following the quantization requirement in each message.

The method used to estimate the RSSI of a single measurement is left to individual implementation.

The mean RSSI statistics (in dBm), derived from a multiplicity of single measurement, shall be updated using Equation (330).

$$\hat{\mu}_{RSSI}[k] = \begin{cases} R[0]_{dB} & k = 0 \\ (1-\alpha_{avg})^{n+1}\hat{\mu}_{RSSI}[k-1] + (1-(1-\alpha_{avg})^{n+1}) \cdot R[k]_{dB} & k > 0 \end{cases} \text{ dBm} \quad (330)$$

where

k is the time index for the measurement; and n is the number of consecutive frames in which no measurement is made.

$R[k]_{\mathrm{dB}}$ is the RSSI in dBm measured during message k, and α_{avg} is an averaging parameter specified by the ABS per the specific usage case.

6.3.13.3 CINR mean and variance

When CINR measurements are mandated by the ABS, an AMS shall obtain a CINR measurement from the SA-preamble for HO, scan and AAI-FFR-REP. From a succession of these measurements, the AMS shall derive and update estimates of the mean and variance of the CINR, and report them through a proper message (e.g., AAI-FFR-REP, AAI-HO-REQ, and AAI-SCN-REP messages).

Mean and variance statistics for CINR shall be reported in units of dB, following the quantization requirement in each message.

The method used to estimate the CINR of a single measurement is left to individual implementation.

The estimated CINR may be formulated without loss of generality as follows in Equation (331).

$$CINR[k] = \sum_{j=1}^{N_r} CINR[k]_j = \sum_{j=1}^{N_r} \frac{P_{signal}[k]_j}{P_{interference}[k]_j + P_{noise}[k]_j} \quad (331)$$

where

$CINR[k]$ is the CINR for measurement k .

$CINR[k]_j$ is the CINR for measurement k at j-th received antenna.

$P_{signal}[k]_j$ is the signal power for measurement k at j-th received antenna excluding SA-pre amble boosting .

$P_{interference}[k]_j$ is the interference power for measurement k at j-th received antenna excluding SA-preamble boosting.

$P_{noise}[k]_j$ is the noise power for measurement k at j-th received antenna.

N_r is the number of receive antennas at the AMS.

The estimation of the noise power that could be measured from the interference-free region is MS implementation specific.

The estimation of the interference power is described in Equation (332).

$$P_{interference}[k]_j = P_{Seg0} \times P_{interference\_T_0}[k]_j + P_{Seg1} \times P_{interference\_T_1}[k]_j + P_{Seg2} \times P_{interference\_T_2}[k]_j \tag{332}$$

where T_s is a set of measurement indices derived from the SA-preamble tone indices of segment s; $P_{interference\_Ts}[k]j$ is the interference power level of segment s at j-th received antenna calculated from SA-preamble measurement. P_{segi} is the linear power boosting or deboosting level for segment i. For example, in reuse-1 deployment, $P_{seg0} = P_{seg1} = P_{seg2} = 1$. For segment 0 of reuse-3 deployment, $P_{seg0} = 1$ and $P_{seg1} = P_{seg2} = 0$. For the power boosting reuse-3 partition of segment 0 in FFR deployment, $P_{seg0} = FP1\_Power$, $P_{seg1} = FP2\_Power$, $P_{seg2} = FP3\_Power$ where $FP1\_Power$ is the linear power boosting level and $FP2\_Power$ and $FP3\_Power$ are linear power deboosting levels.

The measured signal power for boosted reuse-3 FP shall be multiplied by $P_{seg0} = FP1\_Power$ to obtain $P_{signal}[k]j$.

The mean CINR statistics (in decibels) shall be derived from a multiplicity of single measurement using Equation (333).

$$\hat{\mu}_{CINR}[k] = \begin{cases} CINR[0]_{dB} & k = 0 \\ (1-\alpha_{avg})^{n+1}\hat{\mu}_{CINR}[k-1] + (1-(1-\alpha_{avg})^{n+1}) \cdot CINR[k]_{dB} & k > 0 \end{cases} \text{ dBm} \tag{333}$$

where

$CINR[k]_{\mathrm{dB}} = 10\log 10(CINR[k])$.

α_{avg} is an averaging parameter specified by the ABS as per the specific usage case.

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

To obtain the variance, the expectation-squared statistic shall be updated using Equation (334)

$$.\hat{x}^2_{CINR}[k] = \begin{cases} \left|CINR[0]_{dB}\right|^2 & k = 0 \\ (1-\alpha_{avg})^{n+1}\hat{x}^2_{CINR}[k-1] + (1-(1-\alpha_{avg})^{n+1}) \cdot \left|CINR[k]_{dB}\right|^2 & k > 0 \end{cases} \text{ dBm} \tag{334}$$

and

$$\hat{\sigma}^2_{CINR}[k] = \left|\hat{x}^2_{CINR}[k] - \hat{\mu}^2_{CINR}[k]\right| \tag{335}$$

6.3.13.4 SIR mean

When SIR measurements are mandated by the ABS, an AMS shall obtain a SIR measurement from the SA-preamble for UL power control. From a succession of these measurements, the AMS shall derive and update estimates of the SIR mean, and report them through Uplink Power Status Report Header.

Mean statistics for SIR shall be reported in units of dB, following the quantization requirement in Uplink Power Status Report Header.

The method used to estimate the SIR of a single measurement is left to individual implementation.

The estimated SIR may be formulated without loss of generality as follows in Equation (336).

$$SIR_{Inst}[k] = \sum_{j=1}^{N_r} SIR[k]_j = \sum_{j=1}^{N_r} \frac{P_{signal}[k]_j}{P_{interference}[k]_j} \tag{336}$$

where

$SIR[k]$	is the SIR for measurement k .
$SIR[k]j$	is SIR for measurement k at j-th received antenna.
$P_{signal}[k]_j$	is the signal power for measurement k at j-th received antenna excluding SA-pre amble boosting.
$P_{interference}[k]_j$	is the interference power for measurement k at j-th received antenna excluding SA-preamble boosting as described in Equation (332).
N_r	is the number of receive antennas at the AMS.

The mean SIR statistics (in decibels) shall be derived from a multiplicity of single measurement using Equation (337).

$$SIR_{DL}[k]_{dB} = \begin{cases} SIR_{Inst}[0]_{dB} & k = 0 \\ (1-\alpha_{avg})^{n+1} SIR_{DL}[k-1]_{dB} + (1-(1-\alpha_{avg})^{n+1}) \cdot SIR_{Inst}[k]_{dB} & k > 0 \end{cases} \tag{337}$$

where

$SIR_{Inst}[k]_{\mathrm{dB}} = 10\log_{10}(SIR_{Inst}[k])$.

α_{avg}	is an averaging parameter specified by the ABS as per the specific usage case.
n	is the number of consecutive frames in which no measurement is made.

6.3.13.5 Downlink noise and interference level mean and variance

For downlink noise and interference (DL NI) level, report through FFR-REP,which responds to FFR-CMD instructed by the ABS, an AMS shall obtain DL NI measurement from the SA-preamble for downlink FFR operation. From a succession of these measurements, the AMS shall derive and update estimates of the DL NI mean and variance, and report them through the FFR-REP message.

The method used to estimate the DL NI of a single measurement is left to individual implementation.

The estimated DL NI may be formulated without loss of generality as follows in Equation (338).

$$NI[k] = \frac{1}{N_r}\sum_{j=1}^{N_r} NI[k]_j = \frac{1}{N_r}\sum_{j=1}^{N_r} (P_{interference}[k]_j + P_{noise}[k]_j) \tag{338}$$

where

$NI[k]$	is the NI for measurement k .
$NI[k]_j$	is NI for measurement k at j-th received antenna.
$P_{interference}[k]_j$	is the interference power for measurement k at j-th received antenna excluding SA-preamble boosting as described in Equation (332).
$P_{noise}[k]_j$	is the noise power for measurement k at j-th received antenna.
N_r	is the number of receive antennas at the AMS.

The estimation of the noise power that could be measured from the interference-free region is MS implementation specific.

The mean NI statistics (in decibels) shall be derived from a multiplicity of single measurement using Equation (339).

$$\hat{\mu}_{NI}[k] = \begin{cases} NI[0]_{dB} & k = 0 \\ (1-\alpha_{avg})^{n+1}\hat{\mu}_{NI}[k-1] + (1-(1-\alpha_{avg})^{n+1}) \cdot NI[k]_{dB} & k > 0 \end{cases} \tag{339}$$

where

$NI[k]_{\mathrm{dB}} = 10\log_{10}(NI[k])$.

α_{avg} is an averaging parameter specified by the ABS as per the specific usage case.

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

To obtain the variance, the expectation-squared statistic shall be updated using Equation (340).

$$\hat{x}^2_{NI}[k] = \begin{cases} |NI[0]_{dB}|^2 & k = 0 \\ (1-\alpha_{avg})^{n+1}\hat{x}^2_{NI}[k-1] + (1-(1-\alpha_{avg})^{n+1}) \cdot |NI[k]_{dB}|^2 & k > 0 \end{cases} \tag{340}$$

and

$$\hat{\sigma}^2_{NI}[k] = \left|\hat{x}^2_{NI}[k] - \hat{\mu}^2_{NI}[k]\right| \tag{341}$$

6.3.14 Receiver requirements

The ABS and the AMS receiver requirements are the same as those listed in 8.4.14 in IEEE Std 802.16.

6.4 Support for Femto ABS

6.4.1 General description

A Femto ABS is an ABS with low transmit power, typically installed by a subscriber in the home or SOHO to provide the access to closed or open groups of users as configured by the subscriber and/or the access provider. A Femto ABS is typically connected to the service provider's network via one (or multiple) wired and/or wireless broadband connection (cable, DSL, WirelessMAN-OFDMA R1 Reference systems, WirelessMAN-Advanced Air Interface systems, etc.)

Femto ABSs operate in licensed spectrum and may use the same or different frequency as macro ABSs. Their coverage may overlap with a macro ABS.

Femto ABS is intended to serve public users like an Open Subscriber Group (OSG), or to serve a Closed Subscriber Group (CSG), which is a set of subscribers authorized by the Femto ABS owner or the network service provider. CSG can be modified by the service level agreement between the subscriber and the network service provider.

6.4.2 Femto base station subscription types

A Femto ABS may belong to one of the following subscription types:

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

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

c) OSG (Open Subscriber Group) Femto ABS: An OSG Femto ABS is accessible to any AMS.

6.4.3 Femto ABS state diagram

A Femto ABS transitions through multiple states during its operation, as illustrated in Figure 6-206. On Power-On, it enters the Initialization State. In this state, procedures like configuration of radio interface parameters and time/frequency synchronization should be performed. After attachment to service provider's core network, which may include synchronization to the Macro ABS, it enters the Operational State. In the Operational State, if the Femto ABS becomes unattached to the service providers network or if it fails to meet operational requirements (may include failed synchronization), it reverts to the Initialization State.

In the Operational State, normal and low-duty operation modes are supported. In low-duty mode, the Femto ABS reduces radio interface activity in order to reduce interference to neighbor cells. In the low-duty mode, the Femto ABS alternates between available and unavailable interval (i.e., low-duty operation cycle). A further functional description of low-duty operation mode of Femto ABS can be found in 6.4.10.

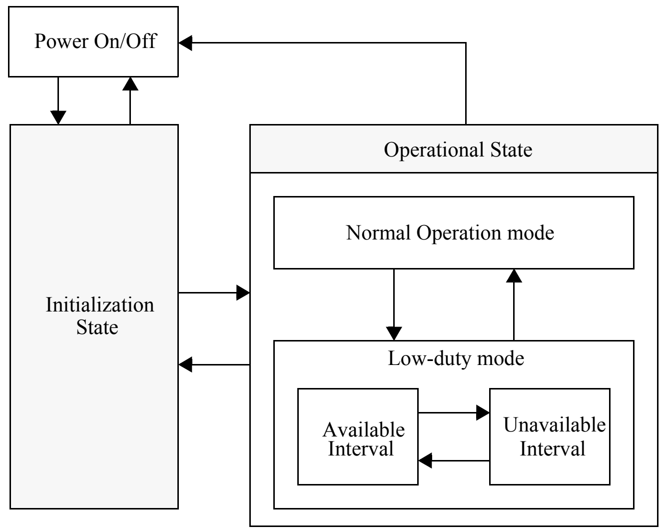

Figure 6-206—Functional overview of Femto ABS states and operational modes

6.4.4 PHY and MAC level identifier

Femto ABSs are distinguished from Macro ABSs by the use of different SA-Preambles sequences in order to enable early distinction of Femto from the Macro, which helps the AMS to avoid unnecessary network (re)entry and handovers to/from a Femto ABS.

A large number of Femto ABSs may be configured with the same CSG, which has the same group of authorized AMSs. A common identifier may be assigned to all CSG Femto ABSs that are part of the same CSG. An AMS may use this identifier for accessibility check for the CSG Femto ABSs.

The common identifier, CSG ID, is used to identify the BSs belonging to the same CSG. CSG ID shall be unique within the same operator ID. The CSG ID, as a part of the BS ID, may be derived from the full BS ID or may be provided by the CSG Femto ABS during initial network entry in the AAI-REG-RSP or may be pre-provisioned by the network. How to derive the CSG ID from BS ID is out of scope. If the CSGID is sent by the ABS then its length, which can be up to 24 bits, shall be specified in the AAI-REG-RSP message. The AMS's CSG white list may contain the identifiers of allowable Femto ABSs.

6.4.4.1 PHY level cell identifier

The indication of a Femto ABS type, i.e., whether it is CSG/OSG is in the SA-Preamble (see 6.3.5.1.2) partitioning of the preamble code space. This partitioning information is broadcasted in the AAI-SCD and SP3 of S-SFH.

6.4.4.2 CSG white list

The CSG white list, is a list of Femto ABSs to which the AMS is subscribed and can access. These Femto ABSs are identified based on the common identifier defined in 6.4.4.

The AMS's local white list may contain the allowable BS IDs or common identifiers of CSGs and relevant information to help derivation of the allowable BS IDs from common identifier. Besides this the whitelist may include absolute/relative location information of CSG Femto ABS, such as GPS information and overlay Macro ABS BSID.

An AMS subscribed to CSG(s) should be configured with a CSG White List for its accessibility check. The CSG white list may be provided to the AMS by the Femto service provider through the network using messaging that is outside the scope of this standard.

6.4.5 Femto ABS initialization and de-attachment

The Femto ABS shall perform Femto ABS initialization procedures to register itself to the network and to configure itself through the backhaul connection.

6.4.5.1 Femto ABS attachment to the Macro ABS

For a Femto ABS that uses air interface connection with the overlaid Macro ABS for exchanging control messages, the Femto ABS shall perform the following additional initialization procedure during the Femto ABS initialization procedure:

a) Scan for DL channel and establish synchronization with the Macro ABS

b) Perform ranging

The details of Femto ABS initialization procedure including obtaining and configuring Femto ABS air interfaces operation parameters through the backhaul connection are out of scope of this specification.

6.4.5.2 Femto ABS deattachment from network

The Femto ABS deregistration procedure is performed through the backhaul network.

In the case of power down of the Femto ABS, the Femto ABS may send out-of-service information to its associated AMSs. Before powering down or changing to the initialization state, the Femto ABS may request its associated AMSs to perform handover to neighbor cell. When the backhaul link of the Femto ABS is down or the connection with the service provider network is lost for a configurable pre-defined time, the Femto ABS shall consider itself de-attached from the network. In such a case, the Femto ABS shall follow the procedure described in 6.4.13 before transitioning to the Initialization or Power Down State.

6.4.6 Network synchronization

A Femto ABS shall be synchronized with the overlay ABS network at least in all cases where interference in UL or DL can occur, where the synchronization means the aligned frame boundary, and the aligned DL / UL split in TDD systems. The network synchronization may be achieved by Femto ABS scanning the A-Preamble transmitted by the Macro ABSs. For this option, if the Femto ABS can successfully detect the Macro ABS A-Preamble, it shall synchronize its downlink transmission with the received A-Preamble signal from Macro ABSs. The Macro ABS A-Preamble scanning for Femto ABS network synchronization may be performed before Femto ABS activation or during the unavailability interval of low-duty mode. The Femto ABS may also achieve network synchronization from GPS or backhaul network (e.g., IEEE Std 1588™ [B5][11]) or from AMS that is either attached to it or to the overlaid macro in which case the overlaid macro indicates the time difference via the backhaul to the Femto ABS.

6.4.7 Network entry

The network entry procedure shall be the same as described as in 6.2.15 with the exception of procedures described in this subclause.

[11]The numbers in brackets correspond to those of the bibliography in Annex A.

6.4.7.1 Femto ABS detection, identification, and selection

Figure 6-207 shows the procedure AMS may follow for discovery of and association with Femto ABS. The figure only serves as an illustration of the procedure inside AMS.

An AMS may prefer its subscribed CSG Femto ABS, while other ABSs may also be chosen as candidates.

If the detected Cell_ID belongs to the set of CSG-open Femto ABSs and the AMS is not a member of any CSG, the AMS may continue the network entry with this ABS, if the AMS cannot be served by other neighboring macro or OSG Femto ABSs.

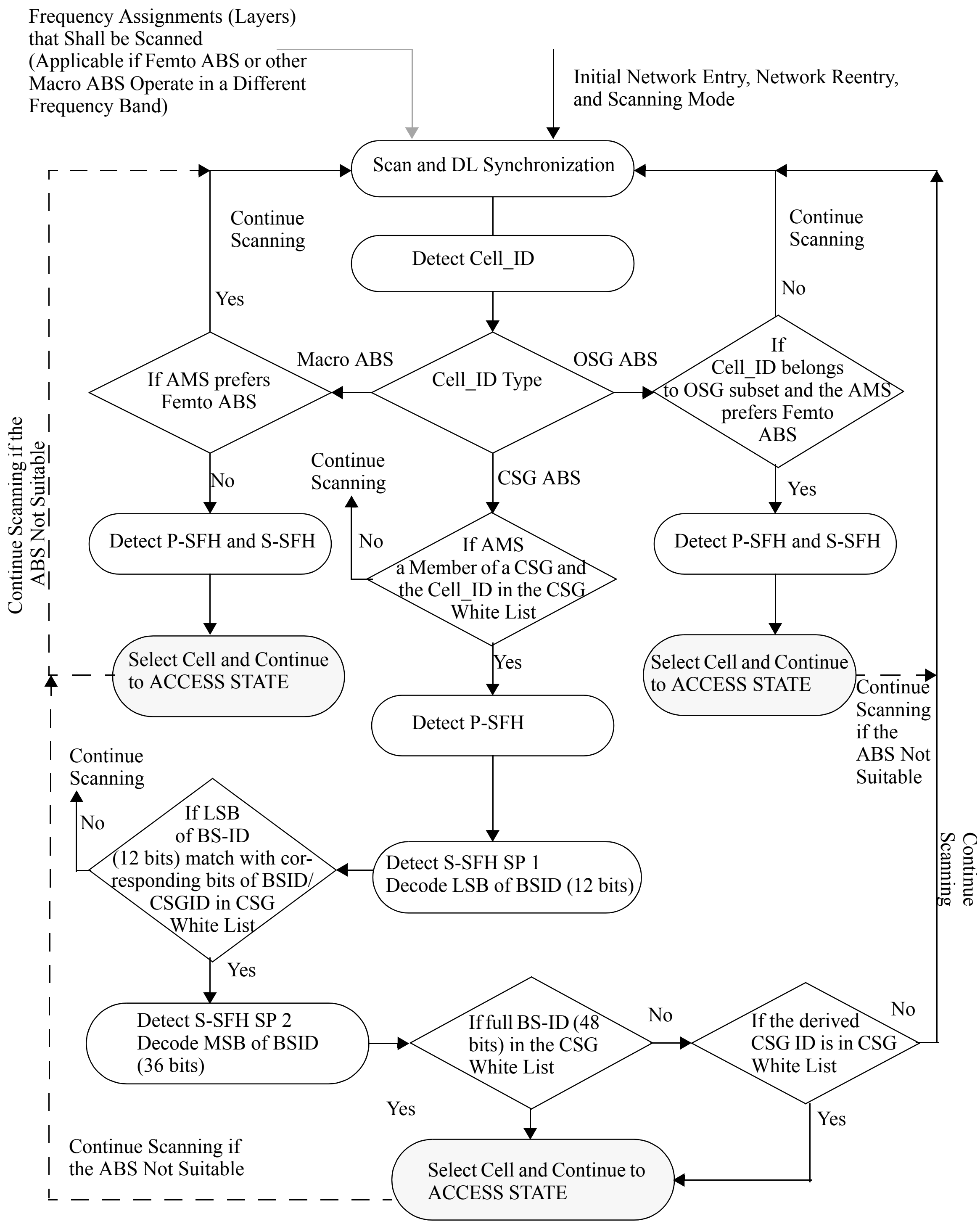

Figure 6-207—Procedure for Femto ABS discovery and association

During network entry, the AMS shall acquire the DL PHY synchronization by A-Preamble. The AMS identifies the type of ABS based on the detected Cell_ID and the Cell_ID partitioning information. The AMS may select the ABS depending on the Cell Type, Cell ID, Received Signal Level, Nearness to a cell, Service Continuity/Services Offered, Capability of the neighbor cell like MIMO configuration, MC configuration etc. Cell_ID and associated carrier index, and the LSB of BS-ID (or the MSB of BS-ID if SP2 is decoded early prior to SP1) may help the AMS to quickly exclude the CSG Femto ABSs to which it is not subscribed. Full BSID (48 bits) or the derived CSGID is the exact identifier for the AMS to determine whether it is authorized to access to the T-ABS. The AMS has the common identifiers in its *White List* (i.e., a local table in the AMS containing the identities of all the CSG Femto base stations to which the AMS is subscribed and is authorized to access) in order to be authorized to access to the target Femto ABS. If the Femto ABS is excluded, the AMS should continue the scanning until a suitable ABS is detected.

The procedure illustrated in Figure 6-207, provides the procedures that the AMS may follow to complete cell selection/re-selection when Femto and Macro base stations are deployed on the same or a different FA. If the Femto base stations are deployed in a different FA (inter-FA), the same procedure may be applicable except that the AMS scans a different frequency band and conducts RF measurements during scanning in that frequency. The other procedures remain intact and the detected Cell_IDs will only belong to open and/or closed subscriber group Femto base stations.

If the Femto and Macro base stations are deployed in the same FA (intra-FA), the same procedure may be applicable and the AMS conducts RF measurements during scanning in the same frequency. Combination of the inter-FA and intra-FA scanning is also possible where the neighbor macro base stations operate in the same frequency band and Femto base stations operate in a different frequency band(s).

6.4.7.2 Manual Femto ABS selection

Manual Femto ABS selection enables a human user to select a Femto ABS and override automatic selection. In manual Femto ABS selection, the AMS may scan neighbor Femto ABSs and report the list of scanned Femto ABSs to the user.

An AMS may attempt to access a Femto ABS not contained in the CSG white list based on manual selection provided the access credentials can be obtained. Based on the AAI-REG-RSP message from the Femto ABS, the AMS's CSG white list may be updated.

An AMS with CSG white list may update the white list by manual operation in idle mode.

6.4.7.3 Femto ABS access restrictions

The AMS shall not attempt to access or initiate handover to a CSG-closed Femto ABS, which is not contained in the CSG whitelist, except in case of emergency call or manual Femto BS selection (see 6.4.7.2).

6.4.7.4 Ranging

6.4.7.4.1 Ranging channel configuration

S-RCH is used for initial ranging, handover ranging, and periodic ranging of a femtocell. BW REQ is done in exactly the same manner as in a regular Macro cell.

6.4.7.4.2 Ranging channel transmission

The AMS shall advance the transmission timing of S-RCH based on the S-RCH transmission timing offset broadcasted by the Femto ABS in S-SFH SP1 for the S-RCH transmissions before receiving AAI-RNG-ACK during the uplink initial/handover ranging in a femtocell.

6.4.7.5 Femto ABS reselection by the AMS

When the AMS performs initial network entry or network reentry with a Femto ABS, it first performs initial ranging by sending the AAI-RNG-REQ message. The AMS may include one or more CSGID(s) as part of the AAI-RNG-REQ message to the Femto ABS, if one or more CSGID(s) is(are) provisioned in the AMS. If the Femto ABS is a CSG Femto ABS, it may have one or more CSGID(s) provisioned in it as well. If it is an OSG Femto ABS, then there shall be no CSGID provisioned for it.

If the Femto ABS is an OSG Femto ABS, then the Femto ABS ignores the CSGID(s) (if sent by the AMS) in the AAI-RNG-REQ and goes ahead with the next steps. If the Femto ABS is a CSG Femto ABS, the Femto ABS receives the AAI-RNG-REQ and, if needed, it looks at the received CSGID(s) and checks if it matches with at least one of its CSGID(s). If there is match of the CSGID, then the Femto ABS knows that the AMS is a member of the Femto ABS and goes ahead with the next steps.

If the received CSGID(s) from the AMS does not match any of the CSGID(s) of the Femto ABS itself, and the Femto ABS is a CSG-Closed Femto ABS, the Femto ABS shall send a AAI-RNG-RSP and in the AAI-RNG-RSP it indicates the rejection of access for this AMS. In order to help the AMS to attach to nearby Femto ABSs, the Femto ABS provides "Redirection Info" to the AMS in the AAI-RNG-RSP message. The "Redirection Info" consists of the ABSID, preamble index, and center frequency of other nearby cells. Since the Femto ABS cannot be sure that the AMS is not its member as the AMS may not have included all the CSGIDs in its white list in AAI-RNG-REQ, the Femto ABS provides its CSGID(s) and sets the Ranging Abort bit=1 with the Ranging Abort Timer = 65535 in the AAI-RNG-RSP in this case so that the AMS can perform the accessibility check for the Femto ABS.

If there are no CSGIDs included in the AAI-RNG-REQ, then the normal network entry procedure as in 6.2.15 applies.

If the Femto ABS has CSGID info of nearby Femto ABSs, then it may filter the "Redirection Info" based on the CSGID(s) provided by the AMS in the AAI-RNG-REQ message and only provide the OSG Femto ABSs as well as CSG Femto ABSs with matching CSGID(s) to the AMS in the "Redirection Info". After receiving the "Redirection Info", the AMS may attach to the other candidate ABSs.

In case the AMS does not support CSG white-list capability or does not have any CSGID(s) provisioned in its CSG white list, the "Redirection Info" may be provided in the AAI-REG-RSP message.

Figure 6-208 shows the procedure.

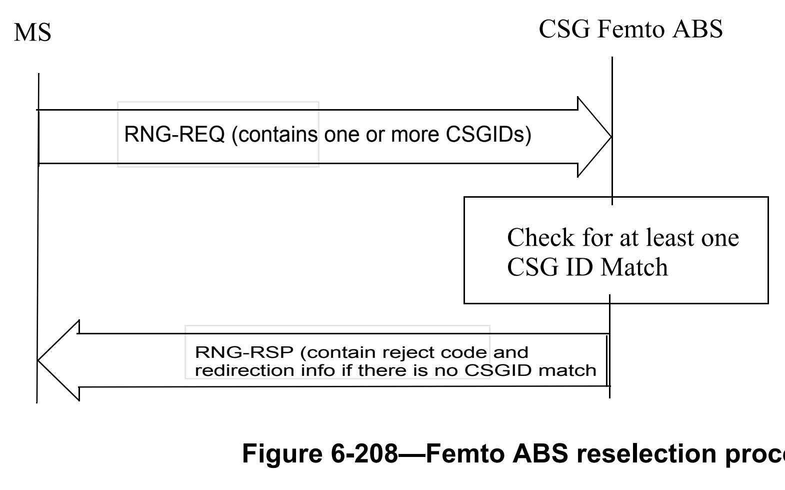

Figure 6-208—Femto ABS reselection procedure

6.4.8 Handover (HO)

The handover process of an AMS between a Femto ABS and a Macro ABS or between two Femto ABSs will follow the same procedure as described in 6.2.6 with the exception of procedures described in this subclause. The handover process of an AMS between a Femto ABS and a R1 system BS will follow the same procedure as described in 6.2.6.4 with the exception of procedures described in this subclause. For Femto ABSs that support the R1 MSs, they shall follow the same procedure as described in 6.3.20 in IEEE Std 802.16 for the WirelessMAN-OFDMA R1 Reference System.

6.4.8.1 Network topology acquisition

6.4.8.1.1 Network topology advertisement

Femto ABS shall broadcast a list of neighboring macro ABSs, and may broadcast OSG Femto ABSs and/or macro hot-zone ABSs via AAI-NBR-ADV.

After the AMS associates with Femto ABS, the Femto ABS may unicast a list of accessible neighboring Femto ABSs. The accessible Femto ABS list may contain CSG-closed Femto ABSs serving CSGs to which the AMS belongs, and CSG-open Femto ABSs. An AMS may request the accessible Femto ABS list from the Femto ABS by sending the AAI-SCN-REP message.

The macro ABS may broadcast system information of OSG Femto ABSs in the AAI-NBR-ADV message.

6.4.8.1.2 AMS scanning neighbor Femto ABSs

For neighbor Femto ABSs, an AMS performs the scanning procedure as per 6.2.6.1.2 with exceptions described in this subclause. An AMS may scan Femto ABSs according to the FAs included in the broadcast AAI-NBR-ADV message. An AMS may scan Femto ABSs that are not included in AAI-NBR-ADV based on SA-preamble partitioning information (see 6.4.4). In addition, an AMS may scan allowed Femto ABSs based on the CSG white list, which may include the absolute or relative location information of the CSG Femto ABS, such as the GPS information or the overlay macro ABS BSID, respectively. Based on location information and/or speed, the AMS may initiate the scanning procedure (see 6.2.6.1.2). For example, the AMS may use the absolute or relative location information of the CSG Femto ABS to initiate scanning when the distance between the AMS and the CSG Femto ABS is less than a pre-configured threshold or the AMS detects the overlay macro ABS. Details of the threshold configuration are vendor specific and outside the scope of this specification. The AMS may request an additional scanning opportunity by sending AAI-SCN-REQ including the detected SA-preamble index and FA information. Upon reception of the AAI-SCN-REQ, the ABS shall respond with an AAI-SCN-RSP, which may include a neighbor-accessible Femto ABS list based on the SA-preamble index.

When the AMS performs network entry with the macro ABS, it may include CSGID(s) in AAI-RNG-REQ. If the overlay macro ABS receives the CSGID(s) from the AMS, it may recommend CSG Femto ABS to monitor UL signaling of its member AMS, which is served by the Macro ABS. The serving Macro ABS should further select a set of the accessible CSG Femto ABS for an AMS based on AMS location information, or base station information reported by the AMS, if such information is available, before the serving Macro ABS recommends the CSG Femto ABS to monitor UL signaling. If the set of the accessible CSG Femto ABS selected by the serving Macro ABS is empty, the serving Macro ABS shall not recommend any CSG Femto ABS to monitor UL signaling. If CSG Femto ABS is in low-duty mode, the CSG Femto ABS can try to receive A-MAP information from overlay Macro ABS and then monitor its member AMS’s UL signaling in associated allocations. If CSG Femto ABS is not in low-duty mode, overlapped Macro ABS may trigger dedicated periodic ranging for the AMS. A CSG Femto ABS can monitor the ranging preamble at the dedicated ranging slot of Macro ABS. When the received signaling quality satisfies certain conditions to indicate its proximity to the Femto BS, CSG Femto ABS can request overlapped Macro ABS to send unsolicited AAI-SCN-RSP for the AMS to scan the CSG Femto ABS. In particular, Macro BS informs the current uplink transmission power of the AMS to the Femto BS so that Femto BS may estimate AMS's proximity based on calculated path loss.

When the AMS has to scan the Femto ABSs belonging to a CSG, the AMS can provide the desired CSGID(s) in the AAI-SCN-REQ message to the S-ABS. The ABS can respond with a list of ABSs, addressed by BSID belonging to the requested CSGID(s), with ABS's FA, A-preamble index, in the AAI-SCN-RSP message.

The ABS may send an unsolicited AAI-SCN-RSP for the AMS to scan the Femto ABS.

After scanning and identifying the existence of any Femto ABSs, the AMS may report FA, A-Preamble index or BS IDs and measurement results according to the Trigger conditions included in the AAI-SCD message by sending AAI-SCN-REP. The AAI-SCN-REP may contain the neighbor request indication and it may additionally contain Neighbor_Request_BS_Type, to which the ABS may unicast an AAI-NBR-ADV that includes a list of Femto ABSs that is formed based on the reported FA, A-preamble index or BSIDs, or the reported measurement. When AAI-SCN-REP indicates it is for the neighbor request, it can include AMS desired CSGID(s) of the subscribed CSG Femto BSs, and the ABS can response with a list of ABSs belonging to the requested CSGID(s) in the AAI-SCN-REP message.

If the AMS decides to perform HO to any Femto ABS, it may request more detailed system information of the detected neighbor Femto ABSs to the S-ABS using an AAI-SCN-REP message. For that purpose, AAI-SCN-REP includes the detected 12-bit LSB of the BSID of neighbor Femto ABS(s).

6.4.8.2 Trigger condition definitions

Per BS type, an AMS and a ABS may apply different trigger condition for scanning and handover.

6.4.8.3 HO decision

An AMS should prioritize target subscribed CSG Femto ABSs according to their order in AAI-HO-CMD provided by the S-ABS, with the first CSG Femto ABS in the list being the most preferred HO target.

An AMS may access unsubscribed CSG-Open Femto ABSs if no candidate ABSs are available at the AMS after scanning macro and accessible Femto ABSs.

After the decision of HO to a Femto ABS, the AMS shall follow the HO procedures as described in 6.2.6.

6.4.8.4 HO from Macro ABS to Femto ABS

When an AMS hands over from a Macro ABS to a Femto ABS, the AMS shall follow the procedure in 6.2.6.

6.4.8.5 HO from Femto ABS to Macro ABS or other Femto ABS

The handover procedures from a serving Femto ABS to a target macro ABS shall be the same as defined per 6.2.6 with the exceptions as defined in this subclause.

6.4.8.6 HO between Femto ABS and R1 system BS

An AMS served by an R1 BS may discover an AAI only Femto ABS through blind scanning and decide to directly HO to the Femto ABS. In this case, the AMS performs the direct HO procedure per 6.2.6.4.1.2.2.

An AMS served by an AAI only Femto ABS may discover an R1 BS through blind scanning or scanning directed by indication information in AAI-NBR-ADV.

6.4.9 Idle mode

A Femto ABS shall support idle mode.

The Femto ABSs support Idle mode by use of the same procedures as specified for macro ABSs with the exceptions given in this subclause.

An AMS with CSG white list shall not attach to an unsubscribed CSG-Closed Femto ABS in Idle mode.

A CSG-Closed Femto ABS shall not broadcast paging for a non-member AMS.

6.4.10 Low-duty operation mode

6.4.10.1 General description

Besides the normal mode, Femto ABSs may support low-duty mode, in order to reduce interference to neighbor cells.

The low-duty mode consists of available intervals (AI) and unavailable intervals (UAI). During an AI, the Femto ABSs may become active on the air interface for activities such as paging, transmitting system information, and ranging, or for data traffic transmission. During a UAI, it does not transmit on the air interface. A UAI may be used for synchronization with the overlay macro BS or for measuring the interference from neighbor cells.

The Femto ABS may enter low-duty mode if there are no AMSs attached to the Femto ABS and there are no AMSs in the process of network entry.

The Femto ABS in low-duty mode schedules an AI whenever there is an operational requirement for this. This means that the AIs at the Femto ABS comprise at least all AIs of the paging cycle and of the Default LDM pattern. Figure 6-209 provides an example with one AMS in idle mode.

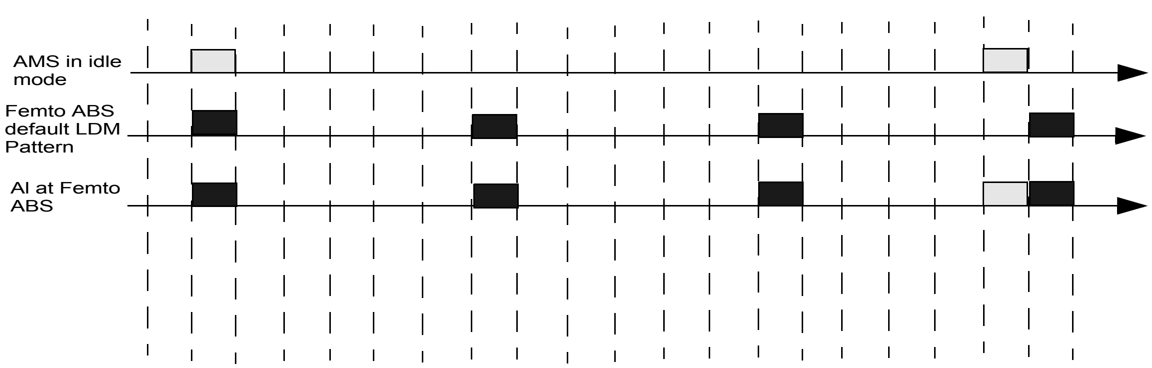

Figure 6-209—Example of operation in low-duty mode

6.4.10.2 Default LDM pattern(s)

A sequence of availability and unavailability intervals forms an LDM pattern. The default LDM pattern is the iteration of one available interval and one unavailable interval. An available interval for the default LDM pattern begins with the frame including the PA-Preamble. The default LDM pattern is a subset of the available intervals at the Femto ABS.

The default LDM pattern parameters include the following:
- Available interval (in units of four frames)
- Unavailable interval (in units of four frames)
- Start Superframe offset

The AI starts at the Superframe number "N",

where

N modulo (AI + UAI) == Start Superframe Offset

Once a Femto ABS enters low-duty mode, the default LDM pattern of the Femto ABS may be activated.

There may be one or more default LDM patterns in a Femto ABS deployment. The default LDM pattern(s) parameters can be pre-provisioned or unicasted to the AMS during initial network entry with the Femto ABS in the AAI-REG-RSP message. The LDM parameters can be broadcasted in the AAI-SON-ADV message, by the ABS when they are changed, for certain duration of time as decided by the network.

6.4.11 Interference avoidance and interference mitigation

Large interference from an inaccessible Femto ABS may trigger a nearby AMS to report the interference to the S-ABS, and the report information should include system information of the inaccessible Femto ABS (e.g., BS_ID of the Femto ABS).

An AMS may initiate or be requested to report the signal strength measurements of its neighbor ABSs to its S-ABS. The reported information can be used by the S-ABS to coordinate interference mitigation with its neighbor ABSs. Upon receiving the interference coordination sent by the S-ABS, the interfering ABS (e.g., CSG-closed Femto ABS or the Femto ABS that the AMS is unable to enter due to mobility) may perform interference mitigation.

If the AMS is connected to S-ABS and the AMS is interfered by a CSG-Closed Femto ABS where it is not a member, it may indicate this problem to the S-ABS by sending an AAI-SCN-REP.

If an AMS is placed into outage by an inaccessible Femto ABS (e.g., the CSG-closed Femto ABS of which it is not a member) and only if the AMS has no connection with a neighbor ABS, it may indicate this problem to that Femto ABS by sending an AAI-RNG-REQ with the Ranging Purpose Indication code 0b1100, to request interference mitigation.

Upon inaccessible Femto ABS receiving an AAI-RNG-REQ with the Ranging Purpose Indication code 0b1100 from the AMS, the Femto ABS may perform interference mitigation based on the measurement and legitimacy of the AMS. The Femto ABS may either reduce its transmit power locally or communicate with the network entity to cooperate on the interference mitigation process.

Upon communication with the network entity, the CSG-Closed Femto ABS may convert to a CSG-Open Femto ABS or reduce its transmit power as directed by the network entity or refrain from transmitting on certain resource regions as indicated by the network entity. In case CSG-Closed Femto ABS converts to

CSG-Open Femto ABS, the interfered AMS served by macro ABS may perform handover to the CSG-Open Femto ABS.

Upon receiving an AAI-RNG-REQ with the Ranging Purpose Indication code 0b1100, or an interference indication from the overlay macro ABS, and if there are no AMSs attached to the CSG-Closed Femto ABS and there are no AMSs in network (re)entry process, the CSG-Closed Femto ABS may operate in LDM for a time interval to reduce interference.

The interference between Femto and/or macro can be mitigated by static or semi-static radio resource reservation and resource sharing using FDM and/or TDM manner and/or DL power control. While using the TDM manner, Femto ABS may disable some of its subframes and announce the disabled subframes via AAI-SON-ADV. The operation of resource reservation shall not contradict with the FFR operation defined in 6.2.21. Femto ABSs shall also utilize FFR partitions in the DL and UL using the same signaling and procedures as used by the macro ABSs. FFR partitions used by the Femto ABSs may be different in terms of size, subchannel assignment, and transmit power level than those used on macro ABSs. One or more FFR partitions may be used as the radio resource region where Femto ABSs are not allowed to transmit. The blocked region size may increase if the number of AMSs interfered by Femto ABS becomes larger; and the blocked region size may decrease if the number of AMSs interfered by Femto ABS becomes smaller. A Femto ABS may detect and reserve the resources autonomously, or in cooperation with the overlay macro ABS.

A Femto ABS may select the carrier frequency, or frequency partition to avoid the mutual interference between macro/micro and Femto ABSs or among Femto ABSs based on the measurement result of surrounding reception power.

Femto ABS may measure the signal strength for the carrier frequency, or frequency partition of the neighbor macro/micro/femtocells. In addition, the Femto ABS may receive A-Preamble from the neighbor macro/micro/femtocells and obtain information on cell type. The Femto ABS may select its carrier frequency, or frequency partition based on signal strength and the cell type information of its neighbors.

The AMS may scan inaccessible ABS blindly or based on instruction. The S-ABS may request the AMS to report the scanning result of an inaccessible ABS via AAI-SCN-REP. The AMS may report an inaccessible ABS to the S-ABS via AAI-SCN-REP, without the request from the S-ABS. The S-ABS may initiate IM with the interfering Femto ABS via backhaul.

The S-ABS may send the interfering BS_ID(s) for which the resource reservation is coordinated via AAI-SCN-RSP to the AMS, and it may request the AMS to scan the Femto ABS that performed coordinated IM via unsolicited AAI-SCN-RSP. The scan can be periodical. The AMS may scan and report the scanning result to the S-ABS via AAI-SCN-REP, if certain predefined conditions are met. The report may be sent periodically. Based on the scan report from the AMS, the S-ABS may request the interfering Femto ABS to stop the operation for interference mitigation (resource reservation, transmit power reduction, ABS type change, etc.) via backhaul. This is referred to as IM termination.

The Femto ABS may scan and measure the interference level from neighboring femtocells at startup time, then be configured with the desired *IDcell* by network entity, e.g., SON server with the best interference condition to transmit A-MAP in corresponding frequency partitions. When the A-MAP is transmitted by a Femto ABS, it follows the same rule as macro ABSs.

Based on interference condition, Femto ABS may switch primary frequency partition between reuse 1 partition and power- boosted reuse 3 partition.

The Femto ABS may be semi-statically reconfigured to a different *IDcell* by network entity, e.g., SON server based on interference condition (e.g., via entering the initialization state) in order to change its power-boosted reuse 3 partition

6.4.11.1 Interference mitigation trigger condition definitions

IM-termination trigger definitions are encoded using the description in Table 6-318.

Table 6-318—IM-termination trigger; type/function/action description

Name	Length (bits)	Value
Type/Function/Action	3	See Table 6-319 for description
Trigger value	8	Trigger value is the value used in comparing measured metric for determining a trigger condition

Table 6-319—IM-termination trigger; type/function/action description

Name	Size (bits)	Value
Type	1	Trigger metric type: 0x0: RSSI metric 0x1: CINR metric
Function	1	Computation defining trigger condition: 0x0: Metric of neighbor ABS is less than absolute value 0x1: *Reserved*
Action	1	0x0: Respond on trigger with AAI-SCN-REP to terminate IM. 0x1: *Reserved*

6.4.12 Power control

Both uplink and downlink power control should be supported by the Femto ABSs.

6.4.12.1 Downlink power control

The Femto ABS shall set the maximum downlink transmit power and should take into account building penetration losses.

6.4.13 Femto ABS reliability

The Femto ABS shall disable the air interface to its subordinated AMSs as soon as the connection with the service provider network is lost. Before disabling the air interface, the Femto ABS shall broadcast the AAI-SON-ADV message. In such a case, the Femto ABS should support the mechanisms to ensure service continuity of the AMSs prior to disabling air interface. For example, the BS initiated handover depicted in 6.2.6. When a Femto ABS is going to disable the air interface, it shall set the Cell Bar bit to 1 in order to prevent AMS (re)entry and should broadcast that the air interface is going down through AAI-SON-ADV with Action type 3 with the appropriate Reason bit 0b00 and 0b11, as specified in 6.2.3.7, repeatedly until it disables the air interface. If handover is to be performed, the indicator may also inform whether the handover will be coordinated or not for AMS to decide what handover procedure it will perform. The AMS may initiate HO to a BS based on the recommended list given by the AAI-SON-ADV message or any previously cached neighbor BS list of its preference.

The Femto ABS may store MAC context information of the serving AMSs (basic capabilities, security capabilities, etc.). Such context information allows AMS to perform optimized network reentry when returning back to the Femto ABS upon its recovery.

At the expected uptime, if provided, the AMS may scan the previous Femto ABS if not directed by the network to decide whether to return to it via HO or not.

In the case of Femto ABS resource adjustment due to interference mitigation which may affect some AMS that are originally connected with the Femto ABS, the Femto ABS may send resource-adjustment information to the subordinated AMSs to prevent MSs from out of service using the AAI-SON-ADV with Action type 3 of Reason bit 01 or 10.

Before executing resource adjustment, the Femto ABS may request some subordinated AMSs to perform handover to neighbor cell if required. The MAC message AAI-SON-ADV may be unicast/multicast to the AMSs. The Femto ABS should finish HO initiation and HO preparation phases before it does resource adjustment.

When supporting the Femto ABS reliability improvement functions, the Femto ABS is assumed to equipped with backup power buffer to ensure the functions can be performed in a period of time when normal power supply is not available. It is also assumed that Femto ABS is capable to learn the backhaul connection status from the modem (e.g., xDSL or DOCSIS) and configure the message/signaling to support the functions identified in this subclause.

If the Femto ABS recovers from failure of backhaul, or power down, or it regains resources from interference coordination, it may inform network or notify the current S-ABS of the AMS through the backhaul network interface. Based on the cell types of current S-ABS and the Femto ABS and associated mobility management policy, the current S-ABS may then initiate AMS handover back to the Femto ABS according to 6.4.8, in which the recovered Femto ABS should be listed in the first priority.

6.5 Multi-BS MIMO

6.5.1 DL Multi-BS MIMO

Multi-BS MIMO techniques improve sector throughput and cell-edge throughput through multi-BS cooperative signaling. These include single-BS precoding with multi-BS coordination and multi-BS joint processing.

6.5.1.1 DL/UL signaling

Table 6-320—Control parameters for DL Multi-BS MIMO

Parameter	Description	Value	Control channel (IE)	Notes
ICT	Interference coordination type	0b00: PMI restriction 0b01: PMI recommendation 0b10: CL-MD 0b11: Co-MIMO	Feedback Polling A-MAP IE	Indicates which Multi-BS MIMO mode
TRU	Target resource unit	0b00: Latest best subbands reported for single BS MIMO 0b01: Whole bandwidth 0b10: FFR partition 0 0b11: boosted FFR partition	Feedback Polling A-MAP IE	Indicates resource units for feedback measurements
MaxUser	Maximum number of users supported in Co-MIMO	0b00: MaxUser = 2 0b01: MaxUser = 3 0b10: MaxUser = 4 0b10: *Reserved*	Feedback Polling A-MAP IE	Maximum number of users supported for MU-MIMO transmission with Co-MIMO
NIP_th_1	NIP threshold for Single BS precoding with Multi-BS Coordination trigger	4 bits	AAI-DL-IM	
NIP_th_2	NIP threshold for DL Multi-BS Joint MIMO Processing trigger	4 bits	AAI-DL-IM	
CINR_th	CINR threshold for single BS precoding with Multi-BS Coordination and Multi-BS Joint MIMO Processing trigger	4 bits	AAI-DL-IM	Used together with NIP_th_1 or NIP_th_2 for requesting Multi-BS MIMO by the AMS

Sounding based Co-MIMO and CL-MD can be supported as instructed by the BS in the UL Sounding Command A-MAP IE.

Table 6-321—Feedback information for DL Multi-BS MIMO supported by codebook-based feedback

	Feedback information type	Description
Periodic feedback	Base station ID	Report BS_ID using Temp_BSID. Temp_BSID is diversity set member ID assigned to this ABS
	PMI report for serving and neighboring cell	For PMI coordination among multiple ABSs
	PMI_coordination_subset indication	Indicating one correlation level or two correlation levels associated with the PMI report for neighboring cells
	Additional measurement metric	SINR gain assuming the reported PMI set is coordinated. This can be used for resolving conflict from multiple AMSs
	Normalized interference power (NIP)	Ratio of average interference power (with or without transmitter precoder) from the ABS with BS-ID, to the total interference power plus noise received by the AMS, which serves as an indicator of severity of interference
	CPMI for neighboring cell	Concatenating PMI for neighboring cell
	RelativeAmp	Relative channel amplitude (Normalized by the largest channel amplitude of collaborative ABS)
Event-driven feedback	Requesting Multi-BS MIMO	For the AMS reporting of its preference on single BS precoding with Multi-BS MIMO coordination or multi-BS joint MIMO processing using the AAI-MBS-MIMO-REQ control message

Uplink sounding can be used to support sounding based Co-MIMO and CL-MD.

For multi-BS MIMO joint processing mode (i.e., CL-MD or Co-MIMO), an ABS shall inform the corresponding AMS of the set of ABSs participating in multi-BS MIMO using the AAI-MBS-MIMO-RSP control message.

6.5.1.2 Single-BS precoding with multi-BS coordination

This subclause describes interference mitigation techniques applicable with DL MIMO modes 2 and 4 with codebook-based feedback mode, with additional inter-ABS coordination mechanisms and interference measurement support. The inter-ABS coordination mechanisms in this subclause do not require data forwarding between different ABSs.

6.5.1.2.1 Operation procedure

Two types of single-BS precoding techniques with multi-BS coordination may be supported in AAI. One is PMI coordination, supported by codebook-based feedback, and the other is interference nulling, supported by codebook-based feedback or by uplink sounding.

Single-BS precoding with multi-BS coordination may be enabled by the ABS for one or several AMSs when CL MIMO precoding with DL MIMO mode 2 or 4 is applied in the serving and neighboring cells. The inter-cell interference can be mitigated by coordinating the precoders applied in neighboring cells via higher layer signaling, based on feedback from AMSs to their respective S-ABSs.

With codebook-based feedback, PMI coordination can be applied as either PMI recommendation or PMI restriction, as instructed by the ABS in Feedback Polling A-MAP IE.

If ICT is set to 0b00 in Feedback Polling A-MAP IE, then the AMS finds the PMI that acts as the strongest interference to the AMS by the neighboring cell in the frequency resource unit indicated by TRU indicated in Feedback Polling A-MAP IE.

If ICT is set to 0b01 in Feedback Polling A-MAP IE, then the AMS finds the PMI that acts as the weakest interference to the AMS by the neighboring cell in the frequency resource unit indicated by TRU indicated in Feedback Polling A-MAP IE.

Restricting or recommending the usage of rank-1 codebook elements as a response to the neighboring cell's request is done by the BS transmission of BC_SI in AAI-DL-IM message. Details are in 6.3.6.2.5.5.

The operation procedure of PMI coordination follows the steps below:

1) Once an AMS receives a Feedback Polling A-MAP IE, it shall send AAI-MBS-MIMO-FBK periodically with the requested information. This information may include a PMI or a set of PMIs, Temp_BSID (diversity member ID) and additional measurements.

   For reporting a set of PMIs, the following procedure shall be performed at the AMS after determining the recommended (or restricted) PMI w_k:

   —Considering all PMIs (w_0, w_1, …, w_m) in the rank-1 DL base codebook $C(2, 1, 3, m)$ for $m = 0$ to 8 with 2Tx, or in the rank-1 DL base codebook subset $C(4,1,6,m)$ for $m = 0$ to 15 with 4Tx, or in the rank-1 DL base codebook $C(8, 1, 4, m)$ for $m = 0$ to 15 with 8Tx, the AMS calculates the cross correlation of each PMI to the recommended (or restricted) PMI w_k. The cross-correlation between PMIs i and k is defined in Equation (339), with superscript ^{H} indicating conjugate transpose.

$$\rho_{i,k} = \left|w_i^H \times w_k\right| \qquad i = 1, \ldots, N \tag{339}$$

   Assume that the N correlation values $\rho_{1,k} \ldots \rho_{N,k}$ are sorted in descending order and then renamed as $r_1 \ldots r_N$ such that

$$r_1 = \rho_{k,k} = 1 > r_2 = \ldots = r_{n_1} > r_{n_1+1} = \ldots = r_{n_2} > r_{n_2+1} = \ldots = r_{n_3} > r_{n_3+1} \ldots > r_N \tag{340}$$

   The AMS determines the size of the subset of PMIs to be jointly recommended (or restricted), based on two correlation levels determined by n_1 and n_2 in Equation (340). The AMS indicates the selection of n_1 or n_2 via pmiCoordinationSubset in an AAI-MBS-MIMO-FBK. The value of pmiCoordinationSubset is specified in Table 6-322.

Table 6-322—pmiCoordinationSubset

pmiCoordinationSubset	Value
0b0	n_1
0b1	n_2

2) Upon receiving feedback from multiple AMSs, an ABS should communicate with neighboring ABSs to coordinate their usage of PMIs via higher layer signaling. The ABS should then broadcast codebook subset information in BC_SI in AAI-DL-IM message to all AMSs in its cell. BC_SI is indicated by a bitmap.

3) The ABS may send a Feedback Allocation A-MAP IE with Codebook_mode set to 0b11 to selected AMS. Consequently, these AMSs should feedback their desired PMI in the codebook subset broadcasted in BC_SI.

Inter-cell interference nulling can be done using PMI, which acts as a strongest interference for the neighboring cell by codebook-based feedback or overhearing neighboring cell's sounding signal to generate the precoding matrix that nulls the interference to neighboring cells.

6.5.1.3 DL multi-BS joint MIMO processing

This subclause introduces interference mitigation techniques based on joint MIMO transmission across multiple ABSs. The ABS and AMS may optionally support one or both adaptive precoding-based multi-BS joint processing techniques, e.g., Closed-loop Macro-Diversity (CL-MD) and Collaborative MIMO (Co-MIMO) transmission. CL-MD is used with DL MIMO mode 2, while Co-MIMO is used with DL MIMO mode 4. multi-BS joint MIMO processing may be enabled by the ABS for one or several AMSs when adaptive precoding is applied in the serving and neighboring cells and user data is shared among multiple cells.

6.5.1.3.1 Operation procedure

With adaptive precoding, the precoder matrix **W** is derived from the feedback of the AMS, with codebook-based feedback or sounding-based feedback. Two types of adaptive precoding based multi-BS joint processing are supported, CL-MD and Co-MIMO. When CL-MD is enabled, a single AMS is served jointly by multiple coordinating ABSs. When Co-MIMO is enabled, several AMSs are served jointly by the multiple coordinating ABSs through MU-MIMO scheduling and precoding.

For codebook-based feedback, the AMS(s) choose the PMIs for the serving cell and the neighboring cells based on the respective estimated channel state information. The S-ABS should also instruct the AMS(s) to feedback a 3-bit uniformly quantized phase information for each neighboring cell, such that ABS can form a concatenated precoder by applying phase adjustments to PMIs for neighboring cells to further improve the system performance. The equation for phase adjustment is $p = e^{j2\pi b}$, where b corresponds to a 3-bit CPMI value that is defined in Table 6-323.

Table 6-323—Quantization parameters for *b*

CPMI value	*b*
0b000	0
0b001	1/8
0b010	2/8
0b011	3/8
0b100	4/8
0b101	5/8
0b110	6/8
0b111	7/8

The concatenated precoder for the *i*-th neighboring cell is constructed as

$$\tilde{\boldsymbol{W}}_i = \boldsymbol{W}_i \exp(j2\pi b_i) \tag{341}$$

where

$\boldsymbol{W}_i$ is the precoding matrix corresponding to the PMI chosen from base codebook for the *i*-th neighboring cell.

b_i is the CPMI value selected from Table 6-323.

When DL Multi-BS joint processing is enabled, radio resource allocation, data mapping, and pilot pattern allocation should be aligned among coordinating ABSs. The same data packet is transmitted by the coordinating ABSs on the same time and frequency resources. The same pilot patterns without interlacing shall apply to the coordinating BSs.

The operation procedure of DL multi-BS joint processing follows the steps below:

1) Once an AMS receives a Feedback Polling A-MAP IE, it shall send AAI-MBS-MIMO-FBK periodically with the requested information in case of codebook feedback, or send UL sounding as instructed by UL Sounding Command A-MAP IE in case of sounding feedback.
2) Upon receiving feedback from multiple AMSs, in case of codebook feedback, the ABS shall forward the PMIs and CPMI to neighboring ABSs to coordinate the usage of PMIs. In case of sounding feedback, each involved ABS can perform precoding based on the received sounding signal(s) from single AMS for CL-MD or from multiple AMSs for Co-MIMO.

The Collaborative MIMO Zone (Co-MIMO Zone) is defined to facilitate inter-ABS coordination for supporting Co-MIMO transmission. Co-MIMO Zone is a radio resource region composed by LRUs and subframes, where the Co-MIMO Zone utilized by neighboring ABSs for Co-MIMO transmission will associate to the same LRU and subframes. The permutation of the Co-MIMO Zone for these ABSs shall be the same.

For UL sounding based DL CL-MD and Co-MIMO operation, the sounding sequence can be used for the calibration of Tx/Rx RF phase mismatch caused by the hardware or over the air (OTA) UL/DL channel phase mismatch caused by the non-ideal channel reciprocity of UL and DL channels involved in DL Multi-BS joint MIMO processing. The calibration process is triggered and setup by AAI-MBS-SOUNDING-CAL.

Upon receiving AAI-MBS-SOUNDING-CAL with calibration mode=0, the AMS shall send the calibration sounding sequence obtained by replacing b_k in Equation (288) by $b_k \exp(-j(\theta_k^{DL,x}))$, where $\theta_k^{DL,x}$ is the phase of downlink channel on the k-th subcarrier of the x-th collaborative ABS (from the first antenna at ABS to the first antenna at AMS) measured via downlink midamble.

ABS uses phases of the received UL calibration sounding sequence as Tx and Rx RF phase mismatch (i.e., $\theta_k^{UL,x} - \theta_k^{DL,x}$, with $\theta_k^{UL,x}$ being UL channel phase). Each collaborative ABS compensates Tx and Rx RF phase mismatch.

For the purpose of DL/UL OTA channel phase calibration, upon receiving AAI-MBS-SOUNDING-CAL with calibration mode = 1, the AMS shall send the calibration sounding sequence obtained by replacing b_k in Equation (277) by $b_k \exp(-j(\theta_k^{DL,a} - \theta_k^{DL,s}))$, where $\theta_k^{DL,a}$ is the phase of downlink channel of the a-th adjacent ABS (other than the S-ABS) involved in DL Multi-BS joint MIMO processing on the k-th subcarrier, and $\theta_k^{DL,s}$ is the phase of the S-ABS's downlink channel on the k-th subcarrier. The adjacent ABSs (other than the S-ABS) use the phase of the received UL calibration sounding sequence to get the phase difference of OTA UL and OTA DL channel phase plus the S-ABS OTA DL channel phase (i.e., $\theta_k^{UL,a} - \theta_k^{DL,a} + \theta_k^{DL,s}$).

The Co-MIMO transmission is activated by the backhaul network, which includes the determination of the ABSs involved in Co-MIMO transmission. When activating sounding-based Co-MIMO transmission, each Co-MIMO Zone will be allocated for serving one or multiple AMS, and each ABS can have multiple Co-MIMO Zones to different AMS. The associated LRUs, permutation, and subframes for each Co-MIMO Zone will be negotiated by the ABSs involved in Co-MIMO transmission through the backhaul network before the allocation.

6.5.1.4 Multi-BS MIMO trigger mechanism

ABS broadcasts normalized interference power (NIP) thresholds for two types of multi-BS MIMO schemes and one common CINR threshold. The NIP is defined as ratio of average interference power (with or without transmitter precoder) from one dominant interference BS to the total interference power plus noise received by AMS. The AMS may accordingly request the preferred multi-BS MIMO scheme. The operation procedure of the multi-BS MIMO trigger follows the steps below:

a) AMS in normal process of Single-Cell CL MIMO feeds back information for CL MIMO operation.

b) ABS selects a NIP threshold NIP_th_1 for single-BS precoding with multi-BS coordination, a threshold NIP_th_2 for multi-BS joint MIMO processing and a common CINR_th based on network measurements. NIP_th_1 is threshold for per-ABS NIP of one adjacent ABS and NIP_th_2 is threshold for sum NIP of several adjacent ABSs whose per-ABS NIP is larger than NIP_th_1. Then the ABS broadcasts the NIP thresholds NIP_th_1, NIP_th_2, and CINR_th in AAI-DL-IM message.

c) AMS computes per-ABS NIP of adjacent ABSs listed in AAI-DL-IM message, calculates sum NIP when per-ABS NIP is higher than NIP_th_1, and checks the trigger conditions. If per-ABS NIP ≥ NIP_th_1 and sum NIP < NIP_th_2 and CINR<CINR_th AMS may request operation with single-BS precoding with multi-BS coordination using the AAI-MBS-MIMO-REQ message.

    1) AMS feedback its event-driven request to operate single-BS precoding with multi-BS coordination to its serving BS through AAI-MBS-MIMO-REQ, which includes a NIP difference measurement with respect to NIP_th_1.

    2) Once an AMS receives a Feedback Polling A-MAP IE, the procedure outlined in 6.5.1.2.1 will be followed.

d) If per-ABS NIP ≥ NIP_th_1 and Sum NIP ≥ NIP_th_2 and CINR < CINR_th, AMS may request operation with multi-BS joint MIMO processing using the AAI-MBS-MIMO-REQ message.

    1) AMS feedback its event-driven request to operate with multi-BS joint MIMO processing to its serving BS through AAI-MBS-MIMO-REQ, which includes a NIP difference measurement with respect to NIP_th_2. Also, an 8-bit bitmap is included indicating which adjacent ABSs are involved in multi-BS joint MIMO processing. This 8-bit bitmap represents strongest 8 adjacent

ABS in the AAI-DL-IM message based on a measurement metric such as RSSI or CINR, which is reported in the AAI-SCN-REP message. In case both RSSI and CINR are reported, the order shall be based on RSSI.

2) Once an AMS receives a Feedback Polling A-MAP IE, the procedure outlined in 6.5.1.3.1 will be followed.

6.5.2 UL multi-BS MIMO

6.5.2.1 Single-BS precoding with multi-BS coordination

This subclause describes interference mitigation techniques applicable to UL MIMO modes 2 and 4 of adaptive codebook precoding with rank-1, with additional inter-ABS coordination mechanisms and interference measurement support. The inter-ABS coordination mechanisms in this subclause do not require data forwarding between different ABSs.

6.5.2.1.1 DL signaling

Table 6-324 shows the control parameters for UL multi-BS MIMO.

Table 6-324—Control parameters for UL multi-BS MIMO

Parameter	Description	Value	Control channel (IE)	Notes
$PMI_{min,j}$	PMI minimizing interference to the *j*-th neighboring ABS.	4 bits if N_t=2 6 bits if N_t=4	AAI-MBS-MIMO-SBP	Selected from the rank-1 base codebook defined in 6.3.10.3
λ_j	Interference sensitivity level of the *j*-th neighboring ABS.	0b00: 1 0b01: 2 0b10: 3 0b11: 4	AAI-MBS-MIMO-SBP	
PCR	PMI combination ratio.	0b00: 0.125 0b01: 0.375 0b10: 0.625 0b11: 0.875	AAI-MBS-MIMO-SBP	

6.5.2.1.2 Operation procedure

Single-BS precoding with multi-BS Coordination is performed by combining multiple PMIs in TDD or FDD UL transmission for mitigating inter-cell interference (ICI) when CL MIMO precoding is applied for the serving and neighboring cells. One of PMIs maximizes the transmission power of the serving cell; the others respectively minimize interference generated to each of the N_{nbr} neighboring cells.

The operation procedure of PMI combination follows the steps below:

a) PMI combination may be triggered by an ABS in an unsolicited manner. By using UL sounding signals, the serving and neighboring ABSs may measure channels of AMSs. Upon the channel measurements, the S-ABS and the *j*-th (j = 1..N_{nbr}) neighboring ABS may determine PMI maximizing transmission power and $PMI_{min,j}$ (j = 1..N_{nbr}) minimizing interference, respectively. Each of the N_{nbr} neighboring ABSs should also determine its own interference sensitivity level (ISL), λ . The *j*-th neighboring ABS provides the information of its $PMI_{min,j}$ and ISL (λ_j)to the S-ABS through the backhaul network.

The correspondent precoders of those PMIs $\mathbf{W}_{PMI}$ and $\mathbf{W}_{PMI_{Min},j}$ (j = 1..N_{nbr}) should be selected based on Equation (342).

$$\begin{aligned} PMI &= \arg\max_i \|(\mathbf{H}_s \mathbf{v}_i)\|^2 \\ PMI_{min,j} &= \arg\min_i \|(\mathbf{H}_{I,j} \mathbf{v}_i)\|^2 \end{aligned} \qquad (342)$$

where $\mathbf{H}_s$ and $\mathbf{H}_{I,j}$ denote information of channels from the AMS to its serving and the j-th neighboring ABS, respectively, and $\mathbf{v}_\mathrm{i}$ is the i-th codeword of the base codebook.

b) The S-ABS shall inform the PMI in UL Basic Assignment A-MAP IE or UL Subband Assignment A-MAP IE and $\mathrm{PMI}_{min,j}$, λ_j (interference sensitivity level of the j-th neighboring ABS) and PCR in the AAI-MBS-MIMO-SBP message to the AMS.

The transmitted precoder $\mathbf{W}$ combining multiple precoders ($\mathbf{W}_{PMI}$, $\mathbf{W}_{PMI_{min},1}$, $\ldots\mathbf{W}_{PMI_{min},N_{nbr}}$) should be generated as shown in Equation (343).

$$\mathbf{W} = \frac{PCR \cdot \mathbf{W}_{PMI} + (1-PCR) \cdot \sum_{j=1}^{N_{nbr}} \left(\lambda_j \Big/ \sum_{n=1}^{N_{nbr}} \lambda_n\right) \cdot W_{PMI_{min},j}}{\left\| PCR \cdot \mathbf{W}_{PMI} + (1-PCR) \cdot \sum_{j=1}^{N_{nbr}} \left(\lambda_j \Big/ \sum_{n=1}^{N_{nbr}} \lambda_n\right) \cdot W_{PMI_{min},j} \right\|} \qquad (343)$$

where $PCR \in \{0.125, 0.375, 0.625, 0.875\}$ and $\lambda \in \{1, 2, 3, 4\}$

6.5.2.2 UL multi-BS joint MIMO processing

The Advanced Air Interface may support uplink multi-BS MIMO to allow joint reception by multiple ABSs, e.g., macro-diversity combining and cooperative beamforming.

— *Collaborative zone initialization:* A common radio resource allocation shall be allocated as a collaborative zone among those BSs involved in uplink multi-BS MIMO operation. Uplink sounding signals shall be allocated orthogonally among MSs in the collaborative zone.

— *Inter-BS information exchanging and joint processing:* With macro-diversity combining enabled, soft decision information in the form of log-likelihood ratios are generated at neighboring BSs, transmitted to anchor BS accompanied with scheduling information through M-SAP/C-SAP primitives over backhaul network, and combined at anchor BS. With cooperative beamforming enabled, quantized versions of received signals are generated at neighboring BSs, transmitted to anchor BS accompanied with channel state information and scheduling information through M-SAP/C-SAP primitives over backhaul network, and jointly processed at anchor BS.

6.6 Support for relay

6.6.1 Relay modes and general description

In the Advanced WirelessMAN-OFDMA R1 Reference System, support for relay is an optional feature. The AMSs may associate either with an ARS or an ABS and receive services from the ARS or the ABS to which they are attached.

Relaying in the Advanced WirelessMAN-OFDMA R1 Reference System is performed using a decode and forward paradigm. Both TDD and FDD modes for duplexing the DL and UL are supported. ARSs operate either in time-division-transmit and receive (TTR) mode, whereby the access and relay link communications are multiplexed using time division multiplexing within a single RF carrier, or Simultaneous transmit and receive (STR) mode, whereby the access and relay link communications are performed simultaneously if the access and relay links are isolated enough. Relay mode is decided by ARS capability negotiation phase of ARS network entry.

In the Advanced WirelessMAN-OFDMA R1 Reference System, the ARSs operate in non-transparent mode, which essentially means that

a) The ARSs compose the SFH and the A-MAPs for the subordinate stations
b) The ARSs transmit the A-Preamble, SFH, and A-MAPs for the subordinate stations

In the Advanced WirelessMAN-OFDMA R1 Reference System deployment supporting relay, a distributed scheduling model is used where in each infrastructure station (ABS or ARS) schedules the radio resources on its subordinate link. The ABS notifies the ARSs and AMSs of the frame structure configuration.

In TTR mode, the radio frame is divided into AAI Access and AAI Relay zones as described in 6.6.3.1. In the AAI Access zone, the ABS and the the ARS transmit to, or receive from, the AMSs. In the AAI Relay zone, the ABS transmits to the ARSs and the AMSs, or receives from the ARSs and AMSs. The start times of the frame structures of the ABS and ARSs are aligned in time. The ABS and ARSs transmit A-Preamble, SFH, and A-MAPs to the AMSs at the same time.

6.6.2 Medium access control

6.6.2.1 Addressing

6.6.2.1.1 Station identifier (STID)

The ABS assigns an STID to the ARS during network entry. The STID uniquely identifies the ARS within the domain of the ABS. The structure of the STID is described in 6.2.1.2.1.

The ARS manages and assigns the STID for the AMS during the AMS initial network entry into the ARS.

6.6.2.1.2 Flow identifier (FID)

The ARS assigns and manages the FID for the AMS during the AMS DSA procedure with the ARS. The ABS manages and assigns the FID for the ARS on the relay link.

6.6.2.2 MAC PDU formats

AMS data traffic for AMSs sent on the relay connections on the relay link shall be encapsulated into a relay MAC PDU. The format of the relay MAC PDU is illustrated in Figure 6-210.

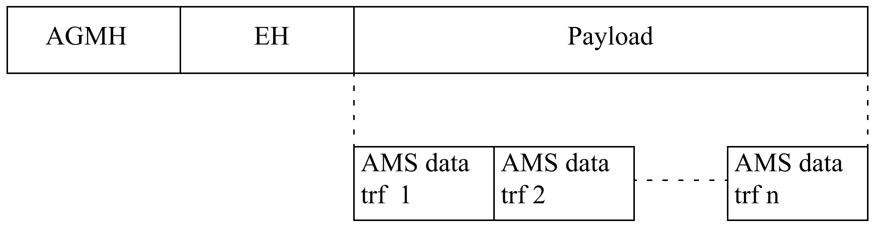

Figure 6-210—Relay MAC PDU format

Each relay MAC PDU shall begin with an Advanced Generic MAC header (AGMH). The format of AGMH is same as defined in 6.2.2.1.1. The AGMH may be followed by one or more extended headers. The relay MAC PDU shall also contain a payload. The payload consists of one or more AMSs' AMS data traffic.

MAC PDUs for the ARS sent on the control connections on the relay link shall follow the same format as shown in Figure 6-2.

6.6.2.3 Construction and transmission of MPDUs

6.6.2.3.1 Data forwarding scheme

For DL transmission via an ARS, when an ABS transmits data to AMSs via the ARS, the ABS shall encapsulate AMS data traffic of one or multiple target AMSs into a relay MAC PDU of the ARS where the advanced relay forwarding extended header (ARFEH) may be appended to identify the AMS data traffic. The ARS shall decode the DL basic assignment A-MAP IE to receive relay MAC PDUs. The ARS shall de-encapsulate received relay MAC PDU and transmit the AMS data traffic to target AMSs in the format of MAC PDU.

For UL transmission via an ARS, the ARS shall encapsulate the AMS data traffic from one or multiple AMSs into a relay MAC PDU where the ARFEH may be appended to identify the AMS data traffic.

6.6.2.3.2 Forwarding control messages between the ARS and the ASN

Upon the ABS receiving the downlink control messages from the ASN, it performs classification to recognize that it is an ARS related control message from the ASN. Then the ABS translates the control message between the two interfaces by means of encapsulating the control message in a "AAI-L2-XFER" MAC control message securely and sends it to the target ARS. In order to optimize the message size, the ABS may remove ASN transport network headers of the control message before transmitting the same to the ARS—the details of which are outside the scope of this standard.

On the uplink, the ARS sends the control message using the AAI-L2-XFER message.

6.6.2.4 Security

An ARS shall use the same security architecture and procedures as an AMS to provide privacy, authentication, and confidentiality between itself and an ABS on the relay link.

An ARS shall operate in distributed security mode. The AK established between an AMS and an authenticator is derived as follows:

AK = Dot16KDF(PMK, MS addressing|ARSID“AK”, 160)

where MS Addressing depends on the operation mode.

If AMSID privacy is disabled, MS addressing shall be 48-bit AMSID. Otherwise, it shall be AMSID*.

As shown in Figure 6-211, after authorization for an AMS completes, the authenticator shall transfer the relevant Authorization Key (AK) context associated with the AMS to its ARS and the MSK for the AMS is established. On obtaining AK context, the ARS derives necessary security keys such as CMAC keys and TEK from the AK and the ARS shall start key agreement 3-way handshake with the AMS. The ARS is responsible for key management of AK, CMAC keys, and TEK, and interacts with the AMS as if it were an ABS in the AMS’s perspectives. Especially AK is derived based on the ARSID in place of ABSID and NONCE_ABS in key agreement 3-way handshake is replaced with NONCE_ARS, which the ARS generates randomly.

During the key agreement, similarly to macro ABS, the Security Association shall be established between an AMS and an ARS. The ARS uses the set of active keys shared with the AMS to perform encryption/decryption and integrity protection on the access link.

The ARS runs a secure encapsulation protocol with the ABS based on the primary SA, which is established between the ARS and the ABS. The access ARS uses the set of active keys shared with the ABS to perform encryption/decryption and integrity protection on the relay link.

MPDUs are encapsulated into one relay MAC PDU and encrypted/decrypted at once by primary SA, which is established between the ARS and the ABS.

The security context used for relay link (between an ABS and an ARS) and access links (between an ARS and an AMS) are different and maintained independently. The key management follows the same method as a macro ABS defined in 6.2.5.2.

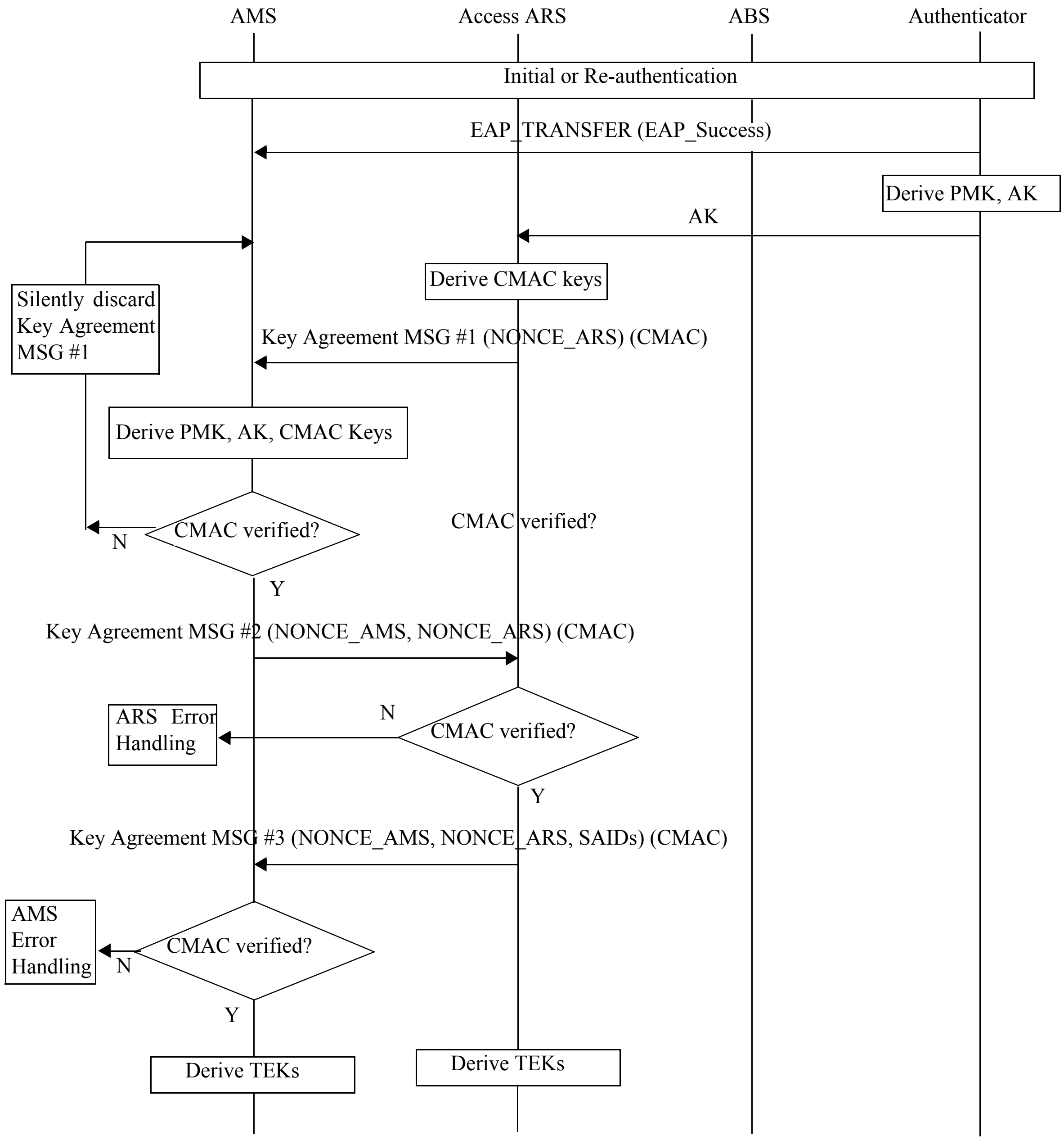

Figure 6-211—Key agreement procedure

6.6.2.5 Handover

6.6.2.5.1 Network topology advertisement

The ARS shall broadcast information about the neighbor ABSs/ARSs that are present in the network using the AAI-NBR-ADV message defined in 6.2.3.13. The ARS may obtain the information to be included in the AAI-NBR-ADV message from its management plane. Each ARS can broadcast a different AAI-NBR-ADV message that is suitable for its service area.

6.6.2.5.2 AMS scanning of neighbor ABSs/ARSs

The scanning follows the same procedure as described in 6.2.6.1.2, with the exception that when the serving station is an ARS, the ARS defines the corresponding trigger/action, controls the scanning procedure, and initiates handover based on received scanning report.

6.6.2.5.3 AMS handover process

The handover process follows the same procedure as described in 6.2.6, with every instance of ABS replaced by ARS.

During handover, serving station (ABS or ARS) may exchange AMS context with the target station (ABS or ARS) for handover optimization using AAI-L2-XFER messages carrying ASN control messages. The target station shall allocate the STID for the AMS, during handover.

6.6.2.6 Scheduling and QoS

The ABS may use persistent allocations (as described in 6.2.7) and group resource allocations (as described in 6.2.9) on the relay link. ARSs shall support the use of persistent scheduling and group resource allocations on the relay link.

The ARS shall schedule air link resources on the access link for communications with its associated AMSs. Frame-by-frame scheduling decisions are made by the ARS.

6.6.2.6.1 Connection management

The ARS controls the connection management for the associated AMS; i.e., AAI-DSx messages shall be terminated at the ARS. The ARS performs FID assignments for the AMS. The ARS communicates with the other network entities in the data path (ABS, ASN entities, etc.) using AAI-L2-XFER messages carrying ASN control messages to complete the data path setup for this FID of the AMS. Besides these messages, after receiving DSx messages from AMSs, the ARSs may send DSA or DSC messages to the ABS to reflect the changed QoS requirements on the relay link.

6.6.2.7 Bandwidth request and grant management

ARSs directly handle the bandwidth requests that they receive from associated AMSs. An ARS may receive bandwidth requests from its associated AMSs via any of the mechanisms described in 6.2.11.1.1. ARSs shall handle all bandwidth requests from AMSs locally, using the same protocol as ABSs (as described in 6.2.11).

ARSs may request uplink bandwidth from the ABS using one of the BW request mechanisms defined in 6.2.11.1. An ARS shall request bandwidth using the FID of one of the connections established between itself and the ABS. The ARS may request bandwidth for multiple connections using a single bandwidth request.

The bandwidth grant messages and procedures defined in 6.2.11.1 shall be used by the ARS and the AMS on the access link and between the ABS and the ARS on the relay link.

6.6.2.8 ARQ

The ARS performs the ARQ operation independently with an ABS on the relay link and an AMS on the access link. The two ARQ instances on two links have independent fragmentation/reassembly state maintenance. In fact, it is not necessary that both flows use ARQ. For example, an access link flow may use ARQ, but this flow's data may be multiplexed on a relay flow that is non-ARQ.

6.6.2.9 HARQ

HARQ subpacket generation and transmission between the ABS and the ARS as well as between the ARS and the AMS shall follow procedures described in 6.2.14.1.

An ARS shall perform HARQ operation with an ABS in the relay link and an AMS in the access link independently.

6.6.2.9.1 Generic HARQ signaling and timing

The HARQ signaling and timing protocol between the ABS and its AMS follows the generic procedure described in 6.2.14.2.

For TTR mode, the HARQ signaling protocol between ABS and ARS stations and between ARS and AMS stations follows the procedure in 6.2.14.2. The HARQ timing for transmissions between ARS and AMS stations is described in 6.6.2.9.1.1. The HARQ timing for transmissions between ABS and ARS stations is described in 6.6.2.9.1.2.

For STR mode, the HARQ signaling and timing protocol between ABS and ARS stations and between ARS and AMS stations shall follow the generic procedure in 6.2.14.2.

The following notations are used in this subclause:

- D_{AZ} is the number of AAI subframes in the AAI DL Access zone.
- D_{RZ} is the number of AAI subframes in the AAI DL Relay zone.
- U_{AZ} is the number of AAI subframes in the AAI UL Access zone.
- U_{RZ} is the number of AAI subframes in the AAI UL Relay zone.

6.6.2.9.1.1 A-MAP relevance and HARQ timing between the ARS and the AMS for TTR mode

The transmissions of a DL Assignment A-MAP IE, a DL HARQ subpacket, a HARQ feedback in UL and an UL Assignment A-MAP IE, an UL HARQ subpacket, as well as a HARQ feedback in DL between ARS and AMS stations shall be done in the AAI DL and the AAI UL Access zones of ARS frames.

6.6.2.9.1.1.1 FDD

The A-MAP relevance and HARQ timing for FDD defined in 6.2.14.2.2.1 shall be applied to the transmissions between ARS and AMS stations in the case of FDD frame structures supporting the relays described in 6.6.3.2.1. The same equations and rules defined in Table 6-137 and Table 6-138 shall be applied for HARQ timing operation between ARS and AMS stations.

The meaning of the following parameters that are used for calculation of DL HARQ timing shall be redefined as described below:

l	is the reference to the DL subframe of AAI DL Access zone, starting from 0 for the first downlink subframe of this zone and numbering up to $D_{AZ} - 1$, where the A-MAP is transmitted.
m	is the reference to the DL subframe of AAI DL Access zone, starting from 0 for the first downlink subframe of this zone and numbering up to $D_{AZ} - 1$, where HARQ subpacket begins its transmission.
n	is the reference for the UL subframe of AAI UL Access zone, starting from U_{RZ} for the first uplink subframe of this zone and numbering up to $(U_{RZ} + U_{AZ} - 1)$, where the HARQ acknowledgment is sent.

N_{TTI}	is the number of AAI subframes that a HARQ subpacket spans; i.e., 1 for the default TTI and D_{AZ} for long TTI in FDD DL.
$T_{DL\ Rx\ Processing}$	is the data burst Rx processing time required by the AMS and measured in subframes.

The definition of remaining parameters used for DL HARQ timing description shall be the same as defined in Table 6-130.

The meaning of the following parameters that are used for calculation of UL HARQ timing shall be redefined as described below:

l	is the reference to the DL subframe of the AAI DL Access zone, starting from 0 for the first downlink subframe of this zone and numbering up to $D_{AZ} - 1$, where the A-MAP is transmitted or the HARQ acknowledgment is sent.
m	is the reference to the UL subframe of the AAI UL Access zone, starting from U_{RZ} for the first uplink subframe of this zone and numbering up to $(U_{RZ} + U_{AZ} - 1)$, where HARQ subpacket begins its transmission.
N_{TTI}	is the number of AAI subframes that a HARQ subpacket spans; i.e., 1 for the default TTI and D_{AZ} for long TTI in FDD UL.
$T_{UL\ Tx\ Processing}$	is the data burst Tx processing time required by the AMS and measured in sub frames.
$T_{UL\ Rx\ Processing}$	is the data burst Rx processing time required by the ARS and measured in sub frames.

The definition of remaining parameters used for UL HARQ timing description shall be the same as defined in Table 6-131.

Figure 6-212 shows an example of the timing relationship between a DL Assignment A-MAP IE, a DL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in DL/UL Access zones of FDD frame, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, the duration of the AAI DL Access zone D_{AZ} and the duration of the AAI UL Access zone U_{AZ} are 4 AAI subframes and $T_{DL\_RX\_Processing}$ is 3 AAI subframes.

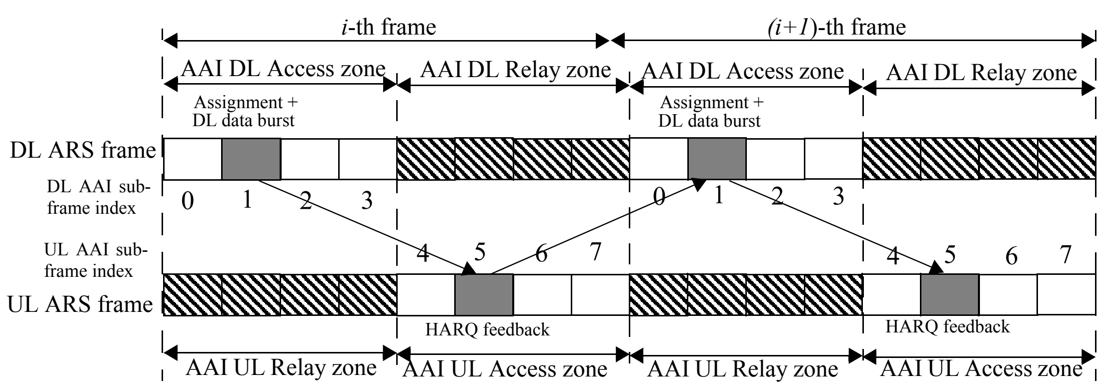

Figure 6-212—Example of FDD DL HARQ timing of ARS-AMS link

Figure 6-213 shows an example of the timing relationship between a UL Assignment A-MAP IE, a UL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in DL/UL Access zone of FDD frame, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, the duration of the AAI DL Access zone D_{AZ} and the duration of the AAI UL Access zone U_{AZ} are 4 AAI subframes and $T_{UL\_TX\_Processing}$ and $T_{UL\_RX\_Processing}$ is 3 AAI subframes.

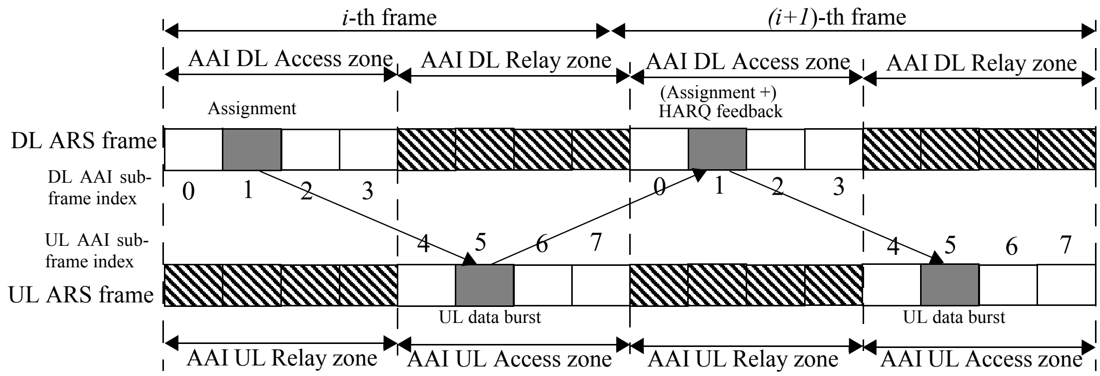

Figure 6-213—Example of FDD UL HARQ timing of ARS-AMS link

6.6.2.9.1.1.2 TDD

The A-MAP relevance and HARQ timing for TDD defined in 6.2.14.2.2.2 shall be applied to the transmissions between ARS and AMS stations in the case of TDD frame structures supporting the Relays described in 6.6.3.2.2.

The same equations and rules defined in Table 6-139 and Table 6-140 shall be applied for HARQ timing operation between ARS and AMS stations.

The meaning of the following parameters that are used for calculation of DL HARQ timing shall be redefined as described below:

l	is the reference to the DL subframe of AAI DL Access zone, starting from 0 for the first downlink subframe of this zone and numbering up to $D_{AZ} - 1$, where the A-MAP is transmitted.
m	is the reference to the DL subframe of AAI DL Access zone, starting from 0 for the first downlink subframe of this zone and numbering up to $D_{AZ} - 1$, where HARQ subpacket begins its transmission.
n	is the reference for the UL subframe of AAI UL Access zone, starting from 0 for the first uplink subframe of this zone and numbering up to $U_{AZ} - 1$, where the HARQ acknowledgment is sent.
N_{TTI}	is the number of AAI subframes that an HARQ subpacket spans; i.e., 1 for the default TTI and D_{AZ} for long TTI in TDD DL.
$T_{DL\_Rx\_Processing}$	is the data burst Rx processing time required by the AMS and measured in sub frames.

The definition of remaining parameters used for DL HARQ timing description shall be the same as defined in Table 6-132.

The meaning of the following parameters that are used for calculation of UL HARQ timing shall be redefined as described below:

l	is the reference to the DL subframe of AAI DL Access zone, starting from 0 for the first downlink subframe of this zone and numbering up to $D_{AZ} - 1$, where the A-MAP is transmitted or the HARQ acknowledgment is sent.

m	is the reference to the UL subframe of AAI UL Access zone, starting from 0 for the first uplink subframe of this zone and numbering up to $U_{AZ} - 1$, where HARQ subpacket begins its transmission.
N_{TTI}	is the number of AAI subframes that an HARQ subpacket spans; i.e., 1 for the default TTI and U_{AZ} for long TTI in TDD UL.
$T_{UL\_Tx\_Processing}$	is the data burst Tx processing time required by the AMS and measured in sub frames.
$T_{UL\_Rx\_Processing}$	is the data burst Rx processing time required by the ARS and measured in sub frames.

The definition of remaining parameters used for UL HARQ timing description shall be the same as defined in Table 6-133.

Figure 6-214 shows an example of the DL timing relationships between a DL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. Figure 6-215 shows an example of the UL timing relationships between an UL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. The ratio of the whole number of DL AAI subframes to the whole number of UL AAI subframes is 5:3. In these examples, D_{AZ} is 3 AAI subframes and U_{AZ} is 2 AAI subframes, $T_{UL\_RX\_Processing}$ is 3 AAI subframes.

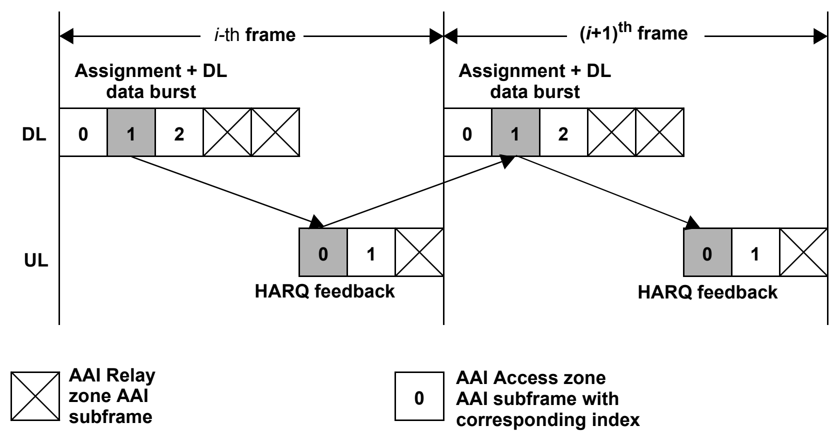

Figure 6-214—Example of TDD DL HARQ timing between ARS and AMS stations

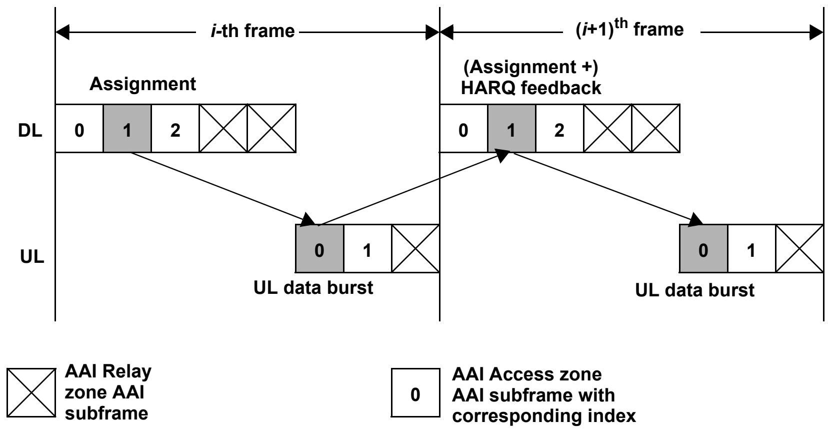

Figure 6-215—Example of TDD UL HARQ timing between ARS and AMS stations

6.6.2.9.1.2 A-MAP relevance and HARQ timing between the ABS and the ARS for TTR mode

The transmissions of a DL Assignment A-MAP IE, a DL HARQ subpacket, a HARQ feedback in UL and an UL Assignment A-MAP IE, an UL HARQ subpacket, a HARQ feedback in DL between ABS and ARS stations takes place in the AAI DL and the AAI UL Relay zones of ABS and ARS frames.

6.6.2.9.1.2.1 FDD

The A-MAP relevance and HARQ timing for FDD defined in 6.2.14.2.2.1 shall be applied to the transmissions between ABS and ARS stations in the case of FDD frame structures supporting the relays described in 6.6.3.2.1. The same equations and rules in Table 6-139 and Table 6-140 shall be applied for deciding HARQ timing between ABS and ARS stations.

The meaning of the following parameters that are used for calculation of DL HARQ timing shall be redefined as described below:

l	is the reference to the DL subframe of AAI DL Relay zone, starting from D_{AZ} for the first downlink subframe of this zone and numbering up to $(D_{RZ} + D_{AZ} - 1)$, where the A-MAP is transmitted.
m	is the reference to the DL subframe of AAI DL Relay zone, starting from D_{AZ} for the first downlink subframe of this zone and numbering up to $(D_{RZ} + D_{AZ} - 1)$, where HARQ subpacket begins its transmission.
n	is the reference for the UL subframe of AAI UL Relay zone, starting from 0 for the first uplink subframe of this zone and numbering up to $(U_{RZ} - 1)$, where the HARQ acknowledgment is sent.
N_{TTI}	is the number of AAI subframes that a HARQ subpacket spans; i.e., 1 for the default TTI and D_{RZ} for long TTI in FDD DL.
$T_{DL\_Rx\_Processing}$	is the data burst Rx processing time required by the ARS and measured in sub frames.

The definition of remaining parameters used for DL HARQ timing description shall be the same as defined in Table 6-130.

The meaning of the following parameters that are used for calculation of UL HARQ timing shall be redefined as described in the following:

l	is the reference to the DL subframe of AAI DL Relay zone, starting from D_{AZ} for the first downlink subframe of this zone and numbering up to $(D_{RZ} + D_{AZ} - 1)$, where the A-MAP is transmitted or the HARQ acknowledgment is sent.
m	is the reference to the UL subframe of AAI UL Relay zone, starting from 0 for the first uplink subframe of this zone and numbering up to $(U_{RZ} - 1)$, where HARQ subpacket begins its transmission.
N_{TTI}	is the number of AAI subframes that a HARQ subpacket spans; i.e., 1 for the default TTI and U_{RZ} for long TTI in FDD UL.
$T_{UL\_Tx\_Processing}$	is the data burst Tx processing time required by the ARS and measured in sub frames.
$T_{UL\_Rx\_Processing}$	is the data burst Rx processing time required by the ARS and measured in sub frames.

The definition of remaining parameters used for UL HARQ timing description shall be the same as defined in Table 6-131.

Figure 6-216 shows an example of the timing relationship between a DL Assignment A-MAP IE, a DL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in DL/UL Relay zone of FDD frame, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, the duration of the AAI DL Relay zone D_{RZ} and the duration of the AAI UL Relay zone U_{RZ} are 4 AAI subframes and $T_{DL\_RX\_Processing}$ is 3 AAI subframes.

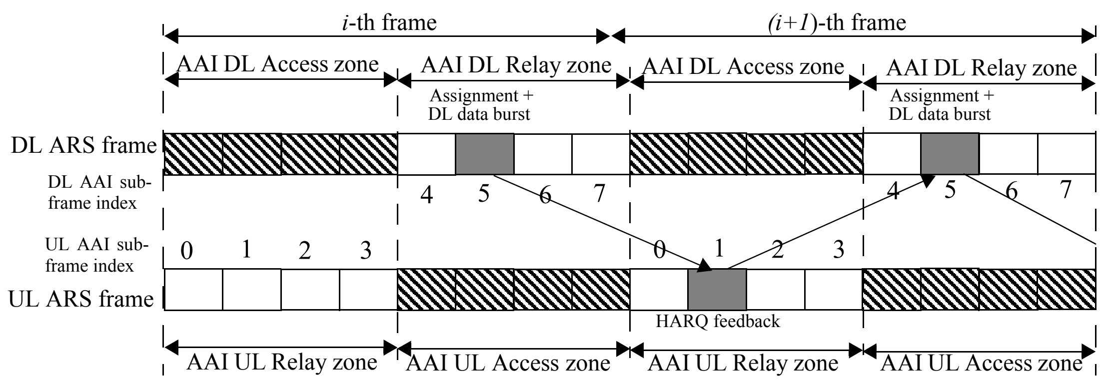

Figure 6-216—Example of FDD DL HARQ timing of ABS-ARS link

Figure 6-217 shows an example of the timing relationship between a UL Assignment A-MAP IE, a UL HARQ subpacket with the default TTI, corresponding HARQ feedback, and retransmission in DL/UL Relay zone of FDD frame, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. In this example, the duration of the AAI DL Relay zone D_{RZ} and the duration of the AAI UL Relay zone U_{RZ} are 4 AAI subframes and $T_{UL\_TX\_Processing}$ and $T_{UL\_RX\_Processing}$ is 3 AAI subframes.

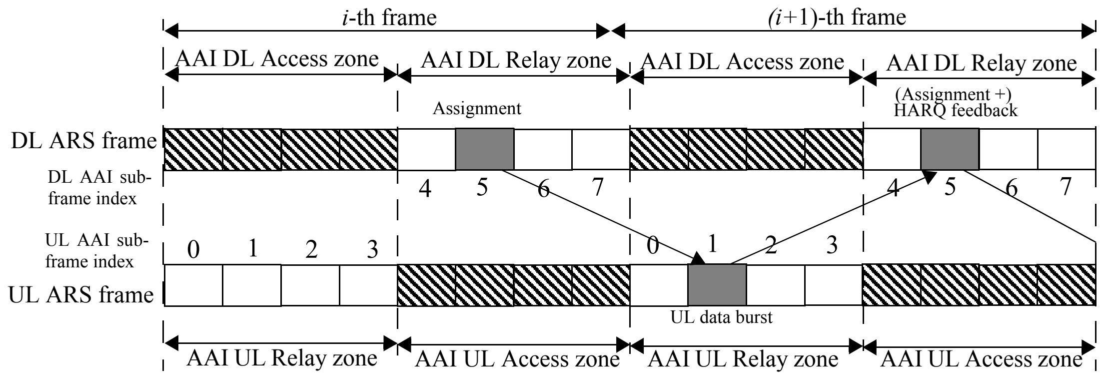

Figure 6-217—Example of FDD UL HARQ timing of ABS-ARS link

6.6.2.9.1.2.2 TDD

The A-MAP relevance and HARQ timing for TDD defined in 6.2.14.2.2.2 shall be applied to the transmissions between ABS and ARS stations in the case of TDD frame structures supporting the Relays described in 6.6.3.2.2.

The same equations and rules defined in Table 6-139 and Table 6-140 shall be applied for HARQ timing operation between ABS and ARS stations.

The meaning of the following parameters that are used for calculation of DL HARQ timing shall be redefined as described below:

l — is the reference to the DL subframe of AAI DL Relay zone, starting from D_{AZ} for the first downlink subframe of this zone and numbering up to $(D_{AZ} + D_{RZ} - 1)$, where the A-MAP is transmitted.

m — is the reference to the DL subframe of AAI DL Relay zone, starting from $\mathrm{D_{AZ}}$ for the first downlink subframe of this zone and numbering up to $(D_{AZ} + D_{RZ} - 1)$, where HARQ subpacket begins its transmission.

n — is the reference for the UL subframe of AAI UL Relay zone, starting from U_{AZ} for the first uplink subframe of this zone and numbering up to $(U_{AZ} + U_{RZ} - 1)$, where the HARQ acknowledgment is sent.

N_{TTI} — is the number of AAI subframes that an HARQ subpacket spans; i.e., 1 for the default TTI and D_{RZ} for long TTI in TDD DL.

$T_{DL\_Rx\_Processing}$ — is the data burst Rx processing time required by the ARS and measured in subframes.

The definition of remaining parameters used for DL HARQ timing description shall be the same as defined in Table 6-132.

The meaning of the following parameters that are used for calculation of UL HARQ timing shall be redefined as described below:

l — is the reference to the DL subframe of AAI DL Relay zone, starting from D_{AZ} for the first downlink subframe of this zone and numbering up to $(D_{AZ} + D_{RZ} - 1)$, where the A-MAP is transmitted or the HARQ acknowledgment is sent.

m	is the reference to the UL subframe of AAI UL Relay zone, starting from U_{AZ} for the first uplink subframe of this zone and numbering up to $(U_{AZ} + U_{RZ} - 1)$, where HARQ subpacket begins its transmission.
$NTTI$	is the number of AAI subframes that an HARQ subpacket spans; i.e., 1 for the default TTI and U_{RZ} for long TTI in TDD UL.
$T_{UL\_Tx\_Processing}$	is the data burst Tx processing time required by the ARS and measured in sub frames.
$T_{UL\_Rx\_Processing}$	is the data burst Rx processing time required by the ABS and measured in sub frames.

The definition of remaining parameters used for UL HARQ timing description shall be the same as defined in Table 6-133.

Figure 6-218 shows an example of the DL timing relationships between a DL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. Figure 6-219 shows an example of the UL timing relationships between an UL Basic Assignment A-MAP IE, a HARQ subpacket with the default TTI, corresponding HARQ feedback and retransmission, for 5 MHz, 10 MHz, and 20 MHz channel bandwidths. The ratio of the whole number of DL AAI subframes to the whole number of UL AAI subframes is 5 : 3. In these examples, D_{RZ} is 3 AAI subframes and U_{RZ} is 2 AAI subframes, $T_{UL\_RX\_Processing}$ is 3 AAI subframes.

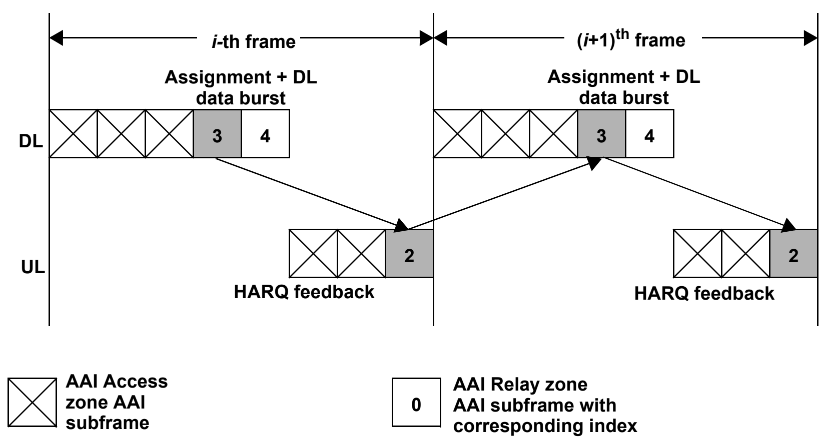

Figure 6-218—Example of TDD DL HARQ timing between ABS and ARS stations

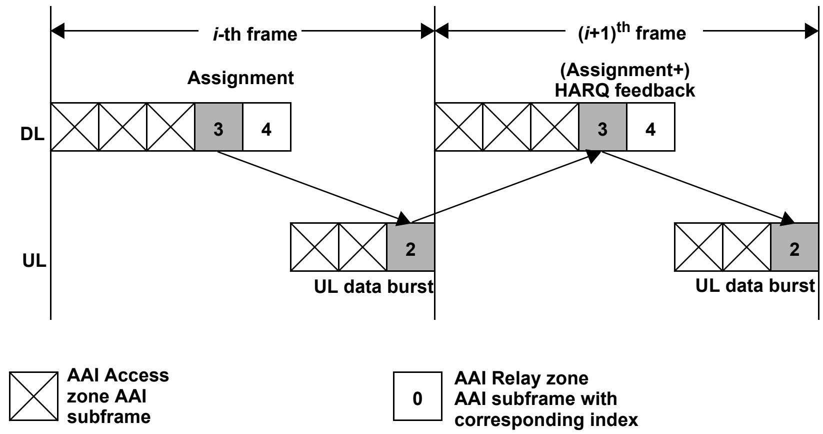

Figure 6-219—Example of TDD UL HARQ timing between ABS and ARS stations

6.6.2.9.2 Group resource allocation HARQ signaling and timing at ARS

An ARS shall perform group resource allocation with an ABS in the relay link and an AMS in the access link independently. The HARQ signaling and timing protocol between with adjacent stations (ABS and ARS or ARS and AMS) follows the procedure in 6.2.14.3.

6.6.2.9.3 Persistent allocation HARQ signaling and timing at ARS

An ARS shall perform persistent resource allocation with an ABS in the relay link and an AMS in the access link independently. The HARQ signaling and timing protocol between with adjacent stations (ABS and ARS or ARS and AMS) follows the procedure in 6.2.14.4.

6.6.2.10 Network entry

6.6.2.10.1 AMS network entry

In the DL channel scanning phase, an AMS may select an ARS as its access station. The AMS shall establish synchronization with the ARS and obtain DL/UL parameters by reading SFHs and an AAI-SCD message from the ARS.

After the ranging procedure described in 6.2.15.3, the ARS and AMS shall finish capability negotiation, authentication/key agreement, and registration procedures including default service flow setup. The ARS communicates with the ASN entities using AAI-L2-XFER messages carrying ASN control messages, during the AMS network entry. The ARS assigns the STID to the AMS.

6.6.2.10.2 ARS network entry

An ARS shall perform network entry with pre-configured ABS only. How the pre-configured ABS information is provided to the ARS is beyond the scope of this standard.

6.6.2.10.2.1 Relay station network entry

The network entry and initialization for relay station follows the procedures defined in 6.2.15. In addition, after the registration phase, the ARS shall perform configuration of the operational parameters as follows:

a) Scan for DL channel and establish synchronization with the ABS
b) Obtain DL/UL parameters (from SuperFrameHeader)
c) Perform ranging
d) Basic capability negotiation
e) Authorization, authentication, and key exchange
f) Registration with the ABS
g) Configure operational parameters

The procedure for initialization of an ARS shall be as shown in Figure 6-220.

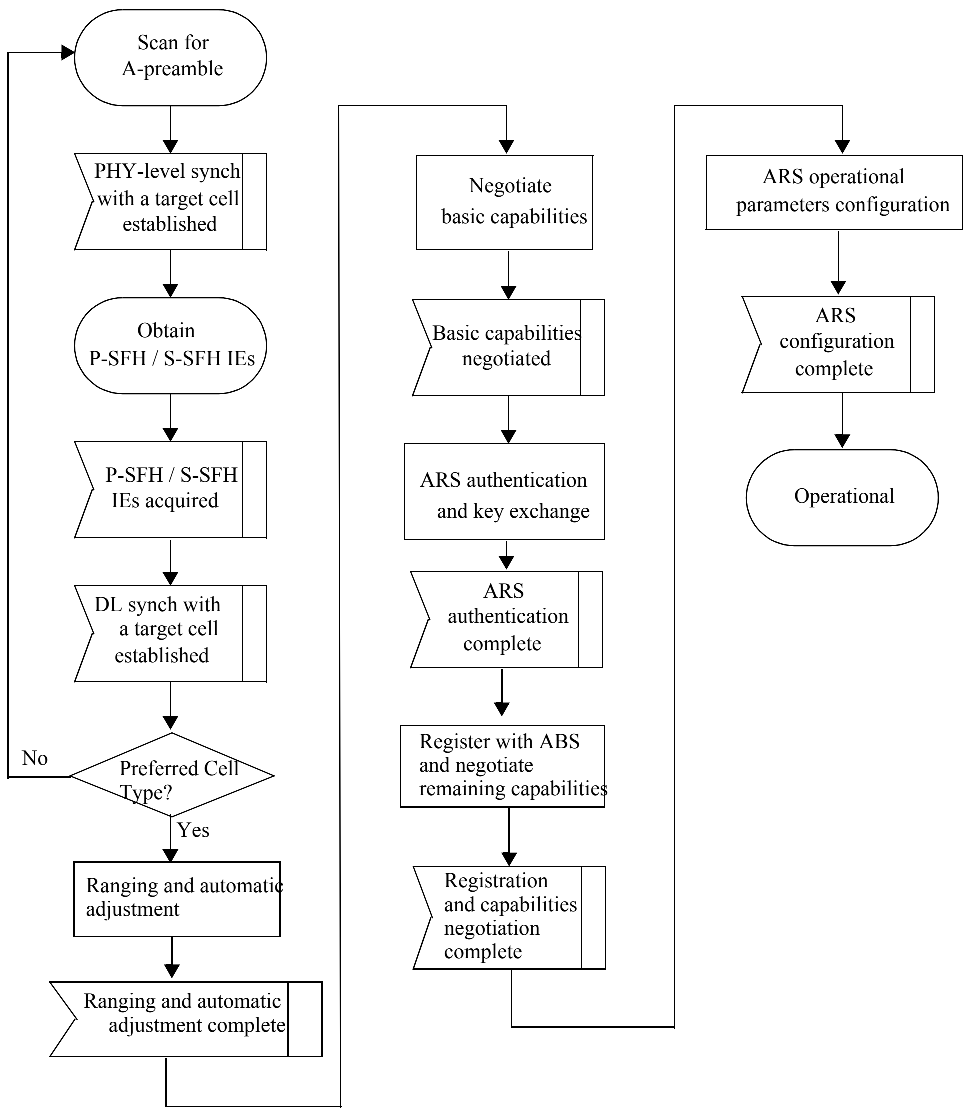

Figure 6-220—ARS initialization overview

6.6.2.10.2.2 Handling of the AMS initial ranging by the ARS

The ARS allocates its own ranging opportunities, and the ARS ranging channel configuration is carried in ARS's SFH. The ARS handles the ranging procedure.

When the ARS detects a ranging sequence on the access link, the adjustments related to the physical ARS-AMS link, if necessary, are performed by the ARS directly with the AMS (without any interaction with the ABS).

When the ARS receives the AAI-RNG-REQ message associated with initial network entry of the AMS, it assigns the TSTID to the AMS and responds back with the AAI-RNG-RSP message to the AMS.

6.6.2.11 Ranging

6.6.2.11.1 ARS initial ranging

When an ARS wishes to perform initial ranging with an ABS, the ARS shall follow the same steps as an AMS would, when the AMS performs initial ranging with the ABS as described in 6.2.15.3.

6.6.2.11.2 Handling of the AMS and ARS periodic ranging

When an ARS detects a periodic ranging sequence on the access link, it shall perform adjustments directly with the AMS with no interaction with the ABS. The ARS decides on the appropriate adjustments if required.

When an ARS initiates a periodic ranging on the relay link to the ABS, the ARS shall perform the same tasks as an AMS performs with the ABS.

The ranging channel for synchronized AMSs, as described in 6.3.8.1.4.2, is also used for ARS periodic ranging.

6.6.2.12 Sleep mode

When an AMS is attached to an ARS for sleep mode operation, the procedures are as defined in 6.2.17, where each instance of the ABS is replaced by the ARS.

6.6.2.13 Idle mode

When an AMS is attached to an ARS for idle mode operation, the procedures are as defined in 6.2.18, where each instance of the ABS is replaced by the ARS.

6.6.2.14 ARS configuration

In TTR mode, the ARS configuration is based on the transmission of a specific AAI-ARS-CONFIG-CMD message and is described in 6.6.2.14.1 and 6.6.2.14.2.

In STR mode, ARS configuration is not necessary after ARS registration.

6.6.2.14.1 Parameter configuration during TTR ARS network entry

After ARS registration, the ABS shall send an AAI-ARS-CONFIG-CMD message to configure the PHY layer operational parameters for relay operation. When an ARS receives an AAI-ARS-CONFIG-CMD message, it shall transmit an AAI-MSG-ACK message. The ARS shall start the RS operation and apply the

PHY operational parameters from the time specified by "Superframe Number Action" in AAI-ARS-CONFIG-CMD.

6.6.2.14.2 Parameter configuration update for TTR ARS operational mode

During ARS operation mode, when the PHY layer operational parameters for relay operation are changed, an ABS shall send an AAI-ARS-CONFIG-CMD message. When an ARS receives an AAI-ARS-CONFIG-CMD message, it shall transmit an AAI-MSG-ACK message. The ARS can use the Message ACK Extended Header as well as the AAI-MSG-ACK message. The ARS shall apply the system information in SFH or the configuration parameters from the time specified by "Superframe Number Action" in AAI-ARS-CONFIG-CMD.

6.6.2.15 ARS deregistration

An ARS may end its service and be removed from the networks. During the ARS deregistration process, all subordinate AMSs of the ARS shall be transferred to another ARS or ABS prior to ARS deregistration. An ARS may transmit an AAI-DREG-REQ message to an ABS so that it initiates the deregistration procedure and requests handover of all its subordinate AMSs. Upon receiving the AAI-DREG-REQ message, the ABS decides whether it allows the ARS deregistration. If the request is accepted, the ABS may transmit the AAI-DREG-RSP message to inform the acceptance and start the ABS-initiated handover process for the requested AMSs. After handover procedures between the ABS and ARS's subordinate AMSs are completed, the ABS informs the ARS that handover is completed by transmitting an AAI-DREG-RSP message. Upon receiving the AAI-DREG-RSP message, the ARS starts the deregistration process. If the ABS rejects the request, the ABS informs the ARS of the rejection of the request by transmitting the AAI-DREG-RSP message. Upon receiving the AAI-DREG-RSP message with rejection information, the ARS continues normal operation. After REQ-duration expires, the ARS retransmits an AAI-DREG-REQ message to the ABS.

The deregistration process may be initiated by an ABS through transmitting an unsolicited AAI-DREG-RSP message.

After deregistration, all the connections and resources are released between the ABS and the ARS.

6.6.2.16 Update of SFH

6.6.2.16.1 Update of SFH information during ARS network entry

An ARS performs an update of SFH as described in 6.2.24.

6.6.2.16.2 Update of SFH information during ARS operational mode

In TTR mode, the ABS shall notify an ARS of SFH information change via an AAI-ARS-ESI control message in 6.2.3.58. When the essential system information in SFH is changed, an ABS shall send the information through an AAI-ARS-ESI control message in the AAI DL Relay Zone. If an ARS receives the AAI-ARS-ESI message, it shall transmit the AAI-MSG-ACK message. The ARS shall apply the information from the superframe specified by "Superframe Number Action" in the AAI-ARS-ESI.

6.6.3 Physical layer for TTR relay mode

6.6.3.1 Basic frame structure supporting ARS

The Advanced Air Interface supports two hop data transmission between an ABS and an AMS using an intermediate ARS. Figure 6-221 shows an example of the basic frame structure for system supporting ARSs. When an ARS is deployed, it shall use the same OFDMA signal parameters (defined in Table 6-131) as its serving ABS. The ABS and ARS superframes shall be time aligned and shall consist of the same number of frames and AAI subframes. Every ARS superframe shall contain a superframe header (SFH). The SFH transmitted by the ARS shall have the same location and format as the SFH transmitted by the ABS. The ARS preambles (SA-Preamble and PA-Preamble) shall be transmitted synchronously with superordinate ABS preambles.

The ARS shall follow the basic AAI frame structure (Figure 6-221). The ABS-ARS frame and AMS frame shall be multiplexed in time separated.

When ARSs are supported, the ABS frame is divided into AAI Access zone and AAI Relay zone. The AAI Access zone position precedes the AAI Relay zone position inside the TDD frame and FDD DL frame. The AAI Relay zone position precedes the AAI Access zone position inside the FDD UL frame. The duration of the AAI Access zone and AAI Relay zone may be different in DL and UL directions.

The ABS frame AAI Access zone shall consist of AAI DL Access zone and AAI UL Access zone, and AAI Relay zone shall consist of AAI DL Relay zone and AAI UL Relay zone. The ABS frame AAI Access zone shall be used for communication with AMSs only. The ABS frame AAI Relay zone shall be used for communication with ARSs and may be used for communication with AMSs. In the AAI DL Relay zone, the ABS shall transmit to its subordinate ARS and in the AAI UL Relay zone the ABS shall receive transmissions from its subordinate ARS.

The ARS frame AAI Access zone shall consist of AAI DL Access zone and AAI UL Access zone and AAI Relay zone shall consist of AAI DL Relay zone and AAI UL Relay zone. The ARS frame AAI Access zone shall be used for communication with AMSs only. In the AAI DL Relay zone the ARS shall receive transmissions from its superordinate ABS and in the AAI UL Relay zone the ARS shall transmit to its superordinate ABS.

The frame configuration of AAI DL/UL Access zone and Relay zone in the frame is decided when ARS or AMS receives frame configuration index in S-SFH SP1. Some frame configurations defined for basic communication between ABS and AMS are not supported for ARS operation. Frame structures supporting the WirelessMAN-OFDMA R1 Reference System are not supported for ARS operation. The possible frame configurations and corresponding ratio of AAI DL/UL Access zone and Relay zone for ARS operation are shown in Table 6-325 (see 6.6.3.2.3).

In each ARS frame, the relay transmit to receive transition interval (R-TTI) may be inserted in order to make allowances for ARSTTG and RTD between the ARS and its superordinate station.

In each ARS frame, the relay receive to transmit transition interval (R-RTI) may be inserted in order to make allowances for ARSRTG and RTD between the ARS and its superordinate station.

The calculation of duration and the positions of R-TTI and R-RTI at the ARS frame in FDD and TDD modes are provided in 6.6.3.2.1 and 6.6.3.2.2 respectively. To share the same value for ARSTTG and ARSRTG, the ARS reports the ARSTTG and ARSRTG values during capability negotiation (see Table 6-33) during the ARS network entry phase.

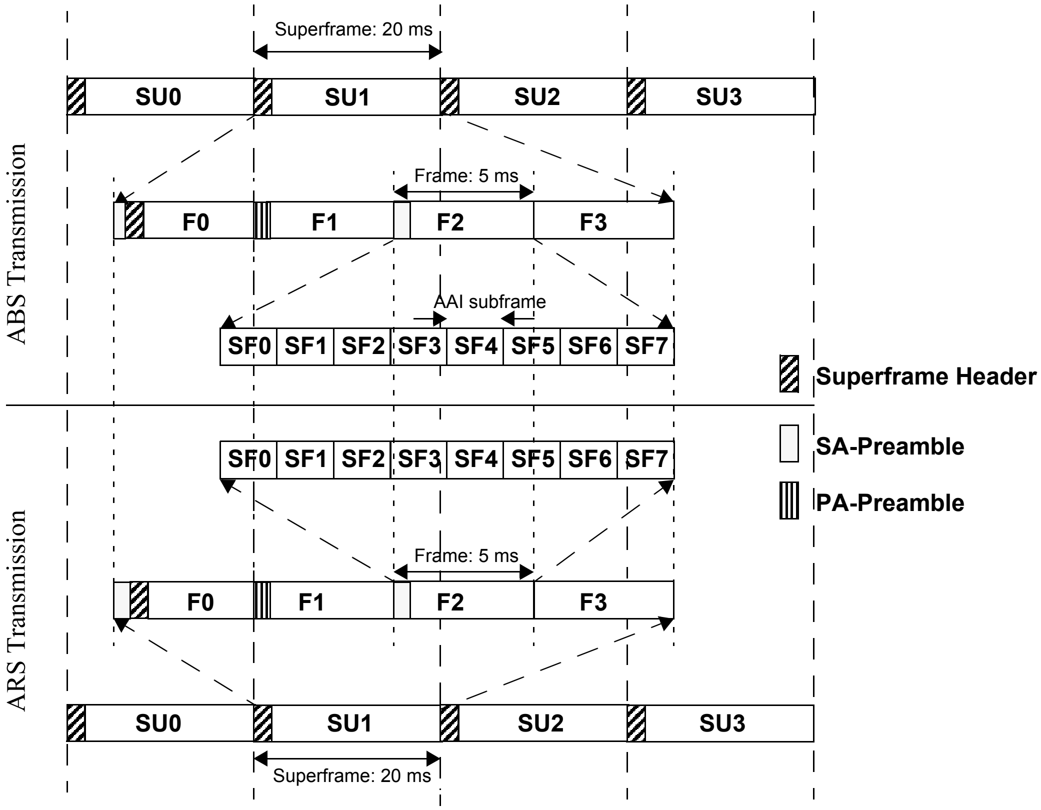

Figure 6-221—Superframe structure for system with ARS support

When an ARS is supported, the long TTI allocations in the ABS-ARS link shall span the entire AAI Relay zone in any DL or UL directions and the long TTI allocations in ARS-AMS link shall span the entire AAI Access zone in any DL or UL directions. Whenthe *AAI_Relay_zone_AMS_allocation_indicator* signaled in the AAI-SCD message is equal to 0, the long TTI allocations in the ABS-AMS link shall not be supported. Whenthe *AAI_Relay_zone_AMS_allocation_indicator* is equal to 1, the long TTI allocations in the ABS-AMS link shall span the entire DL or UL subframes in a TDD frame or occupy 4 AAI subframes for both DL and UL in a FDD frame.

6.6.3.2 Frame structure

6.6.3.2.1 FDD frame structure

The FDD frame shall be constructed on the basis of the basic frame structure defined in 6.3.3.

An ARS supporting FDD mode shall communicate with the ABS using full duplex FDD mode, and it shall be able to simultaneously support half duplex and full duplex AMSs operating on the same RF carrier.

An ARS in FDD systems shall use the DL carrier frequency (F_{DL}) for receiving from the ABS in the AAI DL Relay zone and shall use the UL carrier frequency (F_{UL}) for transmission to the ABS in the AAI UL Relay zone.

In ARS radio frame, the ARS idle state time interval (R_IdleTime) shall be inserted between two ARS frames. In the ARS DL frame, R_IdleTime shall be the same as IdleTime of the ABS. In the ARS UL frame, the duration of R_IdleTime shall be less than or equal to the duration of IdleTime of the ABS. The duration of the R_IdleTime for the ARS UL frame is signaled by the ABS to the ARS through AAI-ARS-CONFIG-CMD during ARS network entry. The ARS UL frame may be time-retreated for a T_{adv} interval referring to the start of the ABS UL frame. The duration of T_{adv} is calculated according to Equation (344).

$$T_{adv} = \text{IdleTime} - \text{R\_IdleTime} \tag{344}$$

When an ARS switches transceiver states from transmit to receive or from receive to transmit, a DL ARS radio frame in the FDD system may have an R-TTI between the AAI Access zone and AAI Relay zone and an R-RTI between the AAI Relay zone and AAI Access zone in the next DL ARS frame. The location of the R-TTI is the last OFDM symbol of the last AAI subframe of the AAI Access zone and the location of the R-RTI is the last OFDM symbol of the last AAI subframe of the AAI Relay zone. The duration of R-TTI and R-RTI in DL for each ARS shall be calculated by Equation (345) and Equation (346).

$$\text{R-TTI} = \begin{cases} 0 & \text{if } RTD/2 \geq ARSTTG \\ T_s & \text{if } RTD/2 < ARSTTG \end{cases} \tag{345}$$

$$\text{R-RTI} = \begin{cases} 0 & \text{if IdleTime} - RTD/2 \geq ARSRTG \\ T_s & \text{if IdleTime} - RTD/2 < ARSRTG \end{cases} \tag{346}$$

where the RTD is the round-trip delay between the ARS and its superordinate station and T_s is defined in Table 6-153.

If the R-TTI is present (i.e., its duration is equal to T_s), then the ARS AAI DL Access zone AAI subframe with the R-TTI is formed by the Type 3 or Type 1 AAI subframe when the corresponding ABS AAI DL Access zone AAI subframe is the Type 1 or Type 2 AAI subframe, respectively. If there is no R-TTI (i.e., its duration is equal to zero), the AAI subframes in the DL Access zone at the ARS are the same as those at the ABS.

When an ARS switches transceiver states from receive to transmit or from transmit to receive, an UL ARS radio frame in the FDD system may have a R-RTI between AAI Access in the previous UL ARS frame and AAI Relay zone and a R-TTI between AAI Relay zone and AAI Access zone. The location of the R-RTI is the first OFDM symbol of the first AAI subframe of the AAI Relay zone, and the location of R-TTI is the last OFDM symbol of the last AAI subframe of the AAI Relay zone. The duration of R-RTI and R-TTI in UL for each ARS shall be calculated by Equation (347) and Equation (348).

$$\text{R-RTI} = \begin{cases} 0 & \text{if R\_IdleTime} - RTD/2 \geq ARSRTG \\ T_s & \text{if R\_IdleTime} - RTD/2 < ARSRTG \end{cases} \tag{347}$$

$$\text{R-TTI} = \begin{cases} 0 & \text{if } T_{adv} + RTD/2 \geq ARSTTG \\ T_s & \text{if } T_{adv} + RTD/2 < ARSTTG \end{cases} \tag{348}$$

where the RTD is the round-trip delay between the ARS and its superordinate station and T_s is defined in Table 6-153.

Figure 6-222 illustrates an example frame structure with ARS support for FDD mode, which is applicable to the nominal channel bandwidth of 5 MHz, 10 MHz, and 20 MHz with $G = 1/8$. All transition intervals R-TTI and R-RTI in the figure example are equal to the duration of one OFDMA symbol.

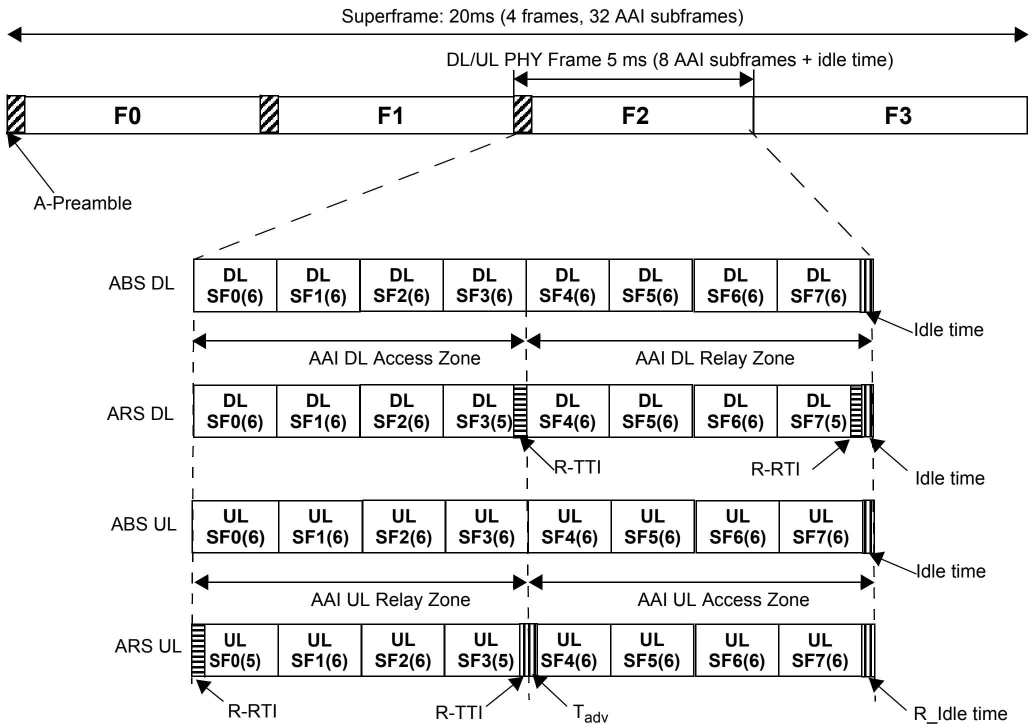

Figure 6-222—Example of ARS FDD frame structure with *G* = 1/8 in 5/10/20 MHz

6.6.3.2.2 TDD frame structure

The TDD frame shall be constructed on the basis of the basic frame structure defined in 6.3.3.

In the ARS radio frame, the ARS idle state time interval (R_IdleTime) shall be inserted before the switching point from DL to UL. The duration of the R_IdleTime for the ARS UL subframe is signaled by the ABS to the ARS through AAI-ARS-CONFIG-CMD during ARS network entry. The ARS UL frame may be advanced (T_{adv}) referring to the start of the ABS UL frame. The duration of T_{adv} is calculated according to Equation (349).

$$T_{adv} = TTG - \mathrm{R\_IdleTime} \tag{349}$$

The duration of R_IdleTime shall be less than or equal to the TTG. In each ARS radio frame, the RTG interval shall be inserted before the switching point from UL to DL.

An ARS radio frame in the TDD system shall have an R-TTI transition interval in DL between the AAI Access zone and the AAI Relay zones. The location of the R-TTI is the last OFDM symbol of the last AAI subframe of the AAI DL Access zone. The duration of the R-TTI in DL for each ARS shall be calculated by Equation (350).

$$\text{R-TTI} = \begin{cases} 0 & \text{if } RTD/2 \geq ARSTTG \\ T_s & \text{if } RTD/2 < ARSTTG \end{cases} \tag{350}$$

where RTD is the round-trip delay between the ARS and its superordinate station and T_s is defined in Table 6-153.

If the R-TTI is present (i.e., its duration is equal to T_s), then the ARS AAI DL Access zone AAI subframe with the R-TTI is formed by the Type 3 or Type 1 AAI subframe when the corresponding ABS AAI DL Access zone AAI subframe is the Type 1 or Type 2 AAI subframe, respectively. If there is no R-TTI (i.e., its duration is equal to zero), the AAI subframes in the DL Access zone at the ARS are the same as those at the ABS.

An ARS radio frame in the TDD system shall have an R-RTI transition interval in UL between AAI Access and AAI Relay zones. The location of the R-RTI is the first OFDM symbol of the first AAI subframe of the AAI UL Relay zone. The duration of the R-RTI in UL for each ARS shall be calculated by Equation (351).

$$\text{R-RTI} = \begin{cases} 0 \ \text{ if } \ T_{adv} - RTD/2 \geq ARSRTG \\ T_s \ \text{ if } T_{adv} - RTD/2 < ARSRTG \end{cases} \tag{351}$$

where RTD is the round-trip delay between the ARS and its superordinate station and T_s is defined in Table 6-153.

Figure 6-223 illustrates an example frame structure with ARS support for TDD mode D:U = 5:3, which is applicable to the nominal channel bandwidth of 5 MHz, 10 MHz, and 20 MHz with G = 1/8. The number of AAI subframes allocated to the Relay zone in DL direction is two and in UL direction is one. The duration of R-TTI and R-RTI is equal to the duration of one OFDMA symbol.

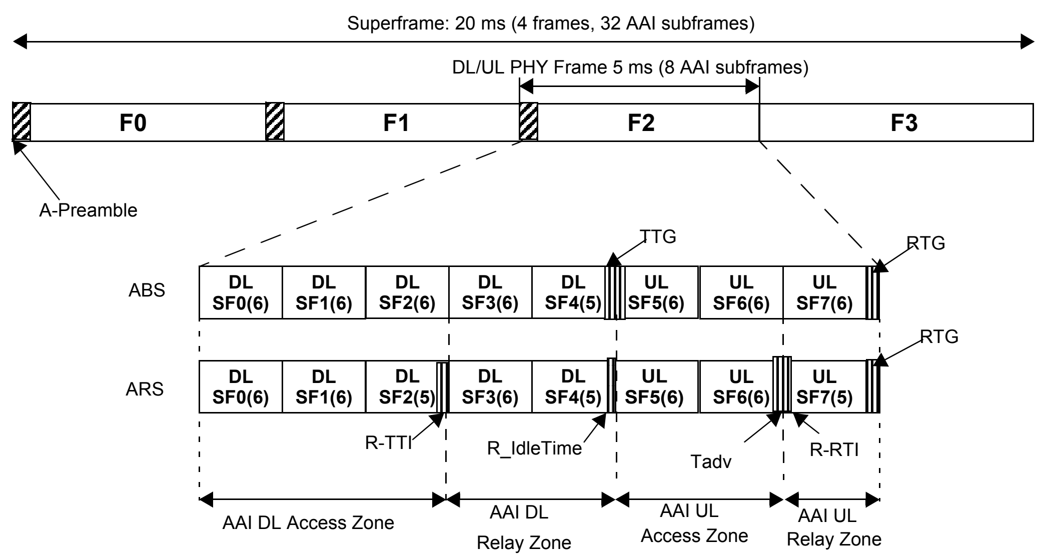

Figure 6-223—Example of ARS TDD frame structure with *G* = 1/8 in 5/10/20 MHz

6.6.3.2.3 Set of frame configurations for ARS operation

The ABS or ARS informs sets of the frame configurations and indexing for the AMS in S-SFH SP1 IE in Table 6-151, Table 6-152, and Table 6-153. Some sets of the frame configuration and indexing are not used when the ABS supports the ARS. If the basic frame structure in TDD or FDD is decided, the ratio of access zone and relay zone is also decided by Table 6-325.

Table 6-325—Frame configuration for ARS operation

Bandwidth (MHz)	CP	Frame configuration index	Duplex type	AAI DL Access zone : AAI DL relay zone ratio	AAI UL Access zone : AAI UL relay zone ratio	Notes
5/10/20	1/16	0	TDD	3:3	1:1	
5/10/20	1/16	1	TDD	3:2	2:1	
5/10/20	1/16	2	TDD	2:2	2:2	
5/10/20	1/16	3	TDD	2:1	3:2	
5/10/20	1/16	4	FDD	4:4	4:4	
5/10/20	1/8	0	TDD	3:3	1:1	
5/10/20	1/8	1	TDD	3:2	2:1	
5/10/20	1/8	2	TDD	2:2	2:2	R-TTI shall be equal to 0
5/10/20	1/8	4	FDD	4:4	4:4	
5/10/20	1/8	17	TDD	3:3	1:1	
5/10/20	1/8	18	TDD	2:3	1:2	R-TTI shall be equal to 0
5/10/20	1/4	3	FDD	3:4	3:4	
8.75	1/16	0	TDD	2:3	1:1	
8.75	1/16	1	TDD	2:2	2:1	
8.75	1/16	2	TDD	2:1	3:1	
8.75	1/16	3	FDD	3:4	3:4	
8.75	1/8	3	FDD	3:4	3:4	
8.75	1/4	3	FDD	3:3	3:3	
7	1/16	2	FDD	3:3	3:3	
7	1/8	2	FDD	2:3	2:3	
7	1/4	2	FDD	2:3	2:3	R-TTI shall be equal to 0

6.6.3.3 Relay downlink PHY structure

6.6.3.3.1 MIMO midamble

The ARS shall transmit the MIMO midamble signal in the AAI DL Access zone. This transmission shall be time aligned with the transmission of the MIMO midamble from the ABS to the AMS.

When the ABS has at least one attached subordinate ARS, the ABS may transmit an additional MIMO midamble in the AAI DL Relay zone of the first frame of each superframe. If the

AAI_Relay_zone_AMS_allocation_indicator field in the AAI-SCD message is set to 0, the additional MIMO midamble shall be transmitted.

The indication of MIMO midamble transmission in the AAI DL Relay zone shall be sent to the AMS by SFH SP2 and to the ARS by AAI-ARS-CONFIG-CMD.

In TDD mode, the MIMO midamble transmission in the AAI DL Relay zone shall occupy the last OFDMA symbol of the first non Type 3 AAI subframe of the AAI DL Relay zone counting from the end of the DL frame.

In FDD mode, the MIMO midamble transmission in the AAI DL Relay zone shall occupy the last OFDMA symbol of the second-to-last AAI subframe of the AAI DL Relay zone. If the second-to-last AAI subframe in the AAI DL Relay zone is the Type 3 subframe, then the MIMO midamble shall be transmitted in the last OFDMA symbol of the nearest preceding AAI DL Relay zone Type 1 or Type 2 AAI subframe.

The AAI subframe of the AAI DL Relay zone of both ABS and ARS frames where the MIMO midamble is located shall be transformed to the AAI subframe type where the number of symbols is reduced by one. For the Type 1 AAI subframe case, the remaining five consecutive symbols form a Type 3 subframe. For the Type 2 AAI subframe case, the remaining six consecutive symbols form a Type 1 subframe.

The physical structure of the MIMO midamble signal shall be the same as defined in 6.3.4.4.2.

6.6.3.3.2 Cell-specific resource mapping

In the AAI DL Relay zone of ABS and ARS frames, cell-specific resource mapping shall be performed in accordance with the procedure described in the 6.3.4.3.

If the AAI_Relay_zone_AMS_allocation_indicator field signaled in the AAI-SCD message and AAI-ARS-CONFIG-CMD message is equal to 1, which indicates that the ABS may allocate AMS transmissions in the AAI Relay zone, then the values of $DCAS_{SB,0}$, $DCAS_i$, $DCAS_{MB,0}$ used in the AAI DL Access zone shall be used for cell-specific resource mapping in the AAI DL Relay zones of ABS and ARS frames.

If the AAI_Relay_zone_AMS_allocation_indicator field signaled in the AAI-SCD message and AAI-ARS-CONFIG-CMD message is equal to 0, which indicates that the ABS does not allocate AMS transmissions in the AAI Relay zone, then the values of $DCAS_{SB,0}$, $DCAS_i$, $DCAS_{MB,0}$ used for cell-specific resource mapping in AAI DL Relay zones of ABS and ARS frames shall be set to the values $R\_DCAS_{SB,0}$, R_DCAS_i, $R\_DCAS_{MB,0}$ correspondingly. The values of cell-specific AAI Relay zone parameters $R\_DCAS_{SB,0}$, R_DCAS_i, $R\_DCAS_{MB,0}$ are explicitly signaled in the AAI-ARS-CONFIG-CMD message.

6.6.3.3.3 Downlink data subcarrier mapping

The downlink physical structure for both data and pilot subcarriers described in 6.3.4 is used for AAI DL Access and Relay zones at ABS and ARS frames.

In the FDD frame structure when R-RTI is equal to T_s in the AAI DL Relay zone of the ARS frame, the ARS shall decode all data and pilot subcarriers in the last AAI subframe of the AAI DL Relay zone assuming that the last symbol of this AAI subframe is punctured.

6.6.3.4 Downlink control structure

In the AAI DL Access zone of the ABS frame and ARS frame, all the DL control channels described in 6.3.5 are reused.

In the FDD frame structure when R-RTI is equal to T_s in the AAI DL Relay zone of the ARS frame, the ARS shall decode all control channel subcarriers in the last AAI subframe of the AAI DL Relay zone assuming that the last symbol of this AAI subframe is punctured.

6.6.3.4.1 Advanced preamble for relay

An ARS reuses PA-preamble and SA-preamble in 6.3.5.1.

6.6.3.5 Relay uplink physical structure

6.6.3.5.1 Cell-specific resource mapping

In the AAI UL Relay zone of ABS and ARS frames, cell-specific resource mapping shall be performed in accordance with the procedure described in the 6.3.4.3.

If the AAI_Relay_zone_AMS_allocation_indicator field signaled in the AAI-SCD message and AAI-ARS-CONFIG-CMD message is equal to 1, which indicates that the ABS may allocate AMS transmissions in the AAI Relay zone, then the values of $UCAS_{SB,0}$, $UCAS_i$, $UCAS_{MB,0}$ used in the AAI UL Access zone shall be used for cell-specific resource mapping in the AAI UL Relay zones of ABS and ARS frames.

If the AAI_Relay_zone_AMS_allocation_indicator field signaled in the AAI-SCD message and AAI-ARS-CONFIG-CMD message is equal to 0, which indicates that the ABS does not allocate AMS transmissions in the AAI Relay zone, then the values of $UCAS_{SB,0}$, $UCAS_i$, $UCAS_{MB,0}$ used for cell-specific resource mapping in AAI UL Relay zones of ABS and ARS frames shall be set to the values $R\_UCAS_{SB,0}$, R_UCAS_i, $R\_UCAS_{MB,0}$ correspondingly. The values of cell-specific AAI Relay zone parameters $R\_UCAS_{SB,0}$, R_UCAS_i, $R\_UCAS_{MB,0}$ are explicitly signaled in the AAI-ARS-CONFIG-CMD message.

6.6.3.5.2 Uplink data subcarrier mapping

The data subcarrier mapping rule in the UL Relay zone corresponds to the rule described in 6.3.9.2.3.

In the ARS TDD and FDD frames, to support an R-RTI insertion in the first OFDMA symbol of the first AAI subframe of the AAI UL Relay zone, the LRUs of the corresponding AAI subframe that are used for data transmissions shall be modified in the following way. For the six-symbol PRU case, the remaining five OFDMA symbols are formed to be a five-symbol PRU used for the data transmission. For the seven-symbol PRU case, the remaining six OFDMA symbols are formed to be a six-symbol PRU for the data transmission.

In the ARS FDD, to support an R-TTI insertion in the last OFDMA symbol of the last AAI subframe of the AAI UL Relay zone, the LRUs of the corresponding AAI subframe that are used for data transmissions shall be modified in the following way. For the six-symbol PRU case, the remaining five OFDMA symbols are formed to be a five-symbol PRU used for the data transmission. For the seven-symbol PRU case, the remaining six OFDMA symbols are formed to be a six-symbol PRU for the data transmission.

In the ARS FDD frames, when the AAI UL Relay zone occupies a single AAI subframe, to support a joint insertion of a R-RTI and a R-TTI in the first and the last OFDMA symbols, the LRUs of the corresponding AAI subframe that are used for the data transmission shall be modified in the following way. For the seven-symbol PRU case, the remaining five OFDMA symbols are formed to be a five-symbol PRU for the data transmission. The FDD frame structure configurations with the AAI UL Relay zone that comprise a single Type 1 AAI subframe shall not used if both a R-TTI and a R-RTI are present.

6.6.3.6 Uplink control structure

In both AAI UL Access zones of ABS and ARS frames, all UL control channels described in 6.3.8 are reused.

When R-RTI or R-TTI transition intervals in the AAI UL Relay zone are equal to T_S, the ARS shall puncture the fast feedback control channels described in 6.3.8 on subcarriers that belong to the OFDMA symbol where the R-RTI or R-TTI is placed. The ABS shall process the ARS UL control signals, assuming that the ARS has punctured the subcarriers and pilots that belong to the OFDMA symbol of the AAI subframe where the R-RTI or R-TTI is placed.

When R-RTI or R-TTI transition intervals in the AAI UL Relay zone are equal to T_S, the UL BR channel for the ARS shall be transmitted separately with the UL BR channel for the AMS connected to the ABS. The information of the UL BR channel allocation for the ARS is defined in the AAI-ARS-CONFIG-CMD message. The opportunity index starts next to the UL BR channels defined in SFH SP3 when the frame has both UL BR channels defined in AAI-ARS-CONFIG-CMD and defined in S-SFH SP3. The total number of UL BW REQ channels of Access zone and Relay zone in a frame is the maximum 4.

When the AAI_Relay_zone_AMS_allocation_indicator is 0b0, the "first UL AAI subframe" described in the "UL BW REQ channel information" field in S-SFH SP3 means the first UL AAI subframe in the UL Access zone for the UL BR channel for the AMS attached to the ABS and the ARS.

The UL HARQ and fast feedback channels transmitted by the ARS to the ABS are transmitted in the same region with those for the AMS connected to the ABS. In this case, the UL HARQ feedback channel from the ARS is transmitted by puncturing one HMT described in 6.3.8.2.2. In the case when the transition interval is inserted in the first OFDMA symbol of the control channel, HMT in the first and second symbols shall be punctured. In the case when the transition interval is inserted in the last OFDMA symbol of the control channel, HMT in the last two symbols shall be punctured.

If an R-RTI is equal to T_S, then the ARS shall not use a sounding channel in the first AAI subframe of the AAI UL Relay zone. In the ARS FDD frames, if an R-TTI is equal to T_S and the last AAI subframe of the AAI UL Relay zone is a Type 1 subframe, then the ABS shall not allocate a sounding channel in this AAI subframe.

The ranging operation for STR ARS shall be the same as for AMSs.

The TTR ARS shall use the same NS-RCH as applied for AMSs during initial access. The additional S-RCH may be allocated by the ABS to TTR ARS for periodic ranging (ARS-S-RCH). If an additional ARS-S-RCH is defined, the ABS shall allocate it to the AAI UL Relay zone and transmit operational parameters in the AAI-ARS-CONFIG-CMD message.

6.6.4 Physical layer for STR relay mode

In STR relay mode, both the ABS-ARS and ARS-AMS frame structures are the same as the ABS-AMS frame structure defined in 6.3.3. The basic physical layer design for communication between the ABS and the AMS defined in 6.3 shall be used for communication between the ABS and the ARS and for communication between the ARS and the AMS.

6.7 Support for self-organization

Self-organizing network (SON) functions are intended for ABSs (e.g., Macro, Micro, Femto, and Relay) to automate the configuration of ABS parameters and to optimize network performance, coverage, and capacity.

6.7.1 Self-organization

The scope of SON is the measurement and reporting of air interface performance metrics from the AMS/ABS, and the subsequent adjustments of ABS parameters. Self-organization consists of the following functions: self-configuration and self-optimization.

6.7.2 Self-configuration

Self-configuration is the process executed by the ABS at initialization, as well as during normal operation, whereby the ABS sets and modifies certain configurable parameters.

6.7.2.1 Femto ABS neighbor discovery

Femto ABS may discover its surrounding network topology by collecting information from the core network and AMS's scan reports (see 6.7.5).

Upon installing a Femto ABS, the Femto ABS may receive a neighbor list from the core network. The Femto ABS may scan the neighbor ABSs and update the initial neighbor list.

In Operational State, Femto ABS may schedule a scanning interval to scan neighbor ABSs. The Femto ABS broadcasts the AAI-SON-ADV message to inform such scanning intervals to AMSs. During the scanning interval, the Femto ABS listens to neighbor ABSs preambles. The Femto ABS may update the scanning neighbor list from its scanning result and the scanning reports from the AMSs.

6.7.2.2 Macro ABS neighbor list self-discovery

Macro ABS neighbor list self-discovery provides a mechanism to enable an ABS to automatically update its neighboring ABS list and their associated attributes, as neighboring ABSs are going online/offline dynamically. Since the deployment of macro ABS is planned, and their locations are known by operators, its neighbors can be automatically identified by cell site and sector bearing. Macro ABS neighbor list self-discovery is to support the following three scenarios:

a) An ABS is going online
b) An ABS is going offline
c) An ABS has attribute changes

ABS should report BSID, location of ABS (i.e., longitude, latitude, altitude, and sector bearing—indicating the direction where the sector is pointing), and ABS attributes (refer to AAI-NBR-ADV) to the SON server in order to initiate neighbor macro abs self-configuration function. In response, neighbor ABS attributes (as defined in AAI-NBR-ADV messages) in the ABS should be updated.

6.7.2.3 Femto ABS self-configuration

In the initialization, Femto ABS may operate in the AMS mode to scan its neighbors. After the scanning, the Femto ABS may report BSID and DL RSSI attributes to the SON server. The SON server may choose and download the MAC and PHY parameters that may enable the Femto ABS to work harmoniously with its neighbors.

6.7.3 Self-optimization

Self-optimization is the process of analyzing the reported SON measurement from the ABS/AMS and fine-tuning the ABS parameters in order to optimize the network performance that includes QoS, network efficiency, throughput, cell coverage, and cell capacity.

SON functions can automate the configuration of ABS parameters for optimizing network performance, coverage, and capacity. The air interface support for SON functions is to perform measurement/reporting of air interface performance metrics and the subsequent adjustments of ABS parameters.

6.7.3.1 Support of interference mitigation

When supporting Femto interference mitigation by blocking of radio resource, the allocation of the radio resource region among ABSs should be coordinated. An ABS can request to block a radio resource region identified by subframe index and sub-band CRU index for a T-ABS. The T-ABS may receive a response indicating if the T-ABS should block such radio resource region that is identified by subframe index and subband CRU index.

6.7.3.2 Support of multi-BS MIMO

Multi-BS MIMO operation may be supported by SON to coordinate the transmission among multiple ABSs. The ABS should report the feedback results defined in 6.3.6.2.5 received from AMSs for initiating the coordination to support multi-BS MIMO. The ABSs within the diversity set will be selected and a common zone will be assigned for those ABSs operating with DL or UL Multi-BS MIMO. The common zone used by the ABSs shall be aligned over the same time-frequency radio resource region. In case of Co-MIMO operation, this zone is the Co-MIMO zone.

6.7.4 Support of reconfigurations and restart

The SON server may trigger ABS(s) to reconfigure and/or restart. The ABS may announce the upcoming action of its reconfiguration and/or restart in advance using the AAI-SON_ADV message.

Before ABS changes its FA, it may send the AAI-SON-ADV message, which includes the current FA downtime, new FA, and its up time to the AMS. The AMS may perform network reentry into the same ABS, at the new FA uptime, and continue with its session.

6.7.5 AMS assisted Femto ABS neighbor list update

Femto ABS Neighbor Discovery, as described in 6.7.2.1, is to provide the neighbor list for a Femto ABS at the time of Femto ABS initialization. A Femto ABS can be powered on or off intermittently at its owner's wish, so its neighbor list has to be updated periodically. Since the neighbor list is intended to assist AMS handoff, the AMS is in the best position to discover the neighbor list. Figure 6-224 shows the control flow of the Femto ABS neighbor list update. At each Neighbor List Update Interval, as defined in Table 6-330, the ABS may send AAI-SCN-RSP periodically to ask an AMS to scan neighbors that are not limited to BSID provided in AAI-NBR-ADV. The AMS is not to scan its neighbors blindly, since Femto ABS can only operate in the licensed spectrum or the PHY modes predetermined by the operators. In each AMS scanning, the ABS should collect and report AMS measurements from AAI-SCN-REP, AMS location, and time of the scanning to the SON server.

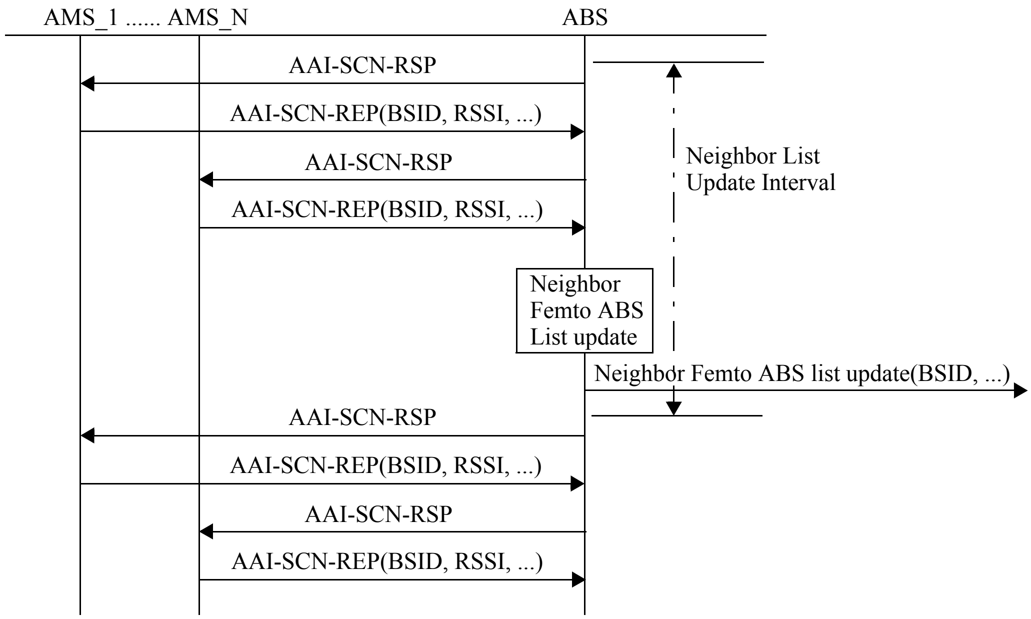

Figure 6-224—Femto ABS neighbor list update control flow

6.8 Support for location-based services (LBS)

The location determination feature includes support for over-the-air downlink and uplink measurements and reporting of AAI-based transmissions to help relevant entities on the AMS and/or in the network to determine the AMS's location. Location capabilities shall be supported in basic mode and may also be supported in enhanced mode as defined in the following paragraphs:

The Basic LBS support (6.8.2) capability involves support of similar functionality and framework as in Clause 6 to Clause 14 in IEEE Std 802.16 adapted to new frame and control channel structure in the AAI. This mode of operation reuses the generic PHY and does not require any location specific PHY layer transmission.

Enhanced LBS support capability (6.8.3) may also be supported, involving over-the-air transmissions and measurements schemes that are specifically designed to optimize measurements needed for more accurate location determination.

6.8.1 Location determination capability negotiation

The capability negotiation for LBS support and its mode are communicated through AAI-REG-REQ/RSP. (See 6.2.3.8 and 6.2.3.9.)

All AMSs shall support basic location measurement capabilities including RSSI, RD, and RTD measurements and report.

The capability negotiation also includes indications on whether the AMS supports special satellite-based positioning capability, e.g., GPS.

6.8.2 Basic LBS support

6.8.2.1 Basic functions supported using AAI-LBS-ADV message

AAI-LBS-ADV is a MAC control message broadcasted by the ABS to provide the AMS with geo-location of neighboring ABSs, which can be used by the AMS for triangularization or trilateration to enable location determination. This message may also contain time and frequency information to aid satellite-based solutions, e.g., GPS receivers, to improve their performance. The content of this message and its functionality is consistent with the LBS-ADV message in 6.3.2.3.59 in IEEE Std 802.16.

6.8.2.2 Measurements and reporting for location determination

The location measurement and report capabilities needed to support Basic LBS are the following:

— ABS's ability to provide the AMS with, and the AMS's ability to process, the AAI-LBS-ADV MAC control message identifying the neighboring ABS's, which need to be scanned by the AMS as well as their locations.
— ABS's capability to request the AMS to start scanning using an AAI MAC control message (e.g., AAI-SCN-RSP) and to report the results to the ABS using a MAC control messages (e.g., AAI-SCN-REP). This request shall include information about which parameter the AMS should measure and report (RSSI, RD, RTD, etc.)
— AMS's capability to request the ABS for scanning time for the LBS.
— AMS's capability for downlink scanning of SA-Preambles identified by a MAC control message to measure RSSI and RD.
— AMS's and the ABS's capability to enable measurement of relative delay or RTD based on ranging channel transmission by using the AAI-LBS-IND MAC control message.

— The AMS providing a scanning report to the ABS with measurement results based on LBS-specific instruction in a MAC control message.
— The MAC control message shall be used by the ABS to trigger measurements in support of location. These MAC control messages include an indication that the purpose of scanning and reporting is for location calculation.

6.8.2.3 Assistance for satellite-based location determination

The AAI support to assist satellite-based location involves the following two functions:

— The support of AAI-LBS-ADV that contains optional fields providing time and frequency information to aid satellite-based solutions, e.g., GPS, receivers to improve their performance. The content of this message and its functionality is consistent with the LBS-ADV message in IEEE Std 802.16.
— To further assist satellite-based location determination in connected mode, the AAI-L2-XFER messages may be used for the following Transfer-Types: GNSS assistance and LBS measurement. (See 6.2.3.30.)

6.8.2.4 LBS message formats

The AAI defines AAI-SCN-RSP/REP messages to assign the unavailable interval for the AMS to measure its location by receiving the DL reference signals from the candidate ABSs.

The location measurement procedure may be initiated by either the AMS or the network, which is requested by the application associated with the AMS or the client attached at the core network.

An ABS may trigger a location measurement by sending AAI-SCN-RSP to the AMS. The AMS shall respond to this with AAI-SCN-REP with the parameters that enable location determination. An ABS may trigger U-TDOA-based location including general and special U-TDOA methods by sending AAI-LBS-IND to the AMS. Operation descriptions on AAI-LBS-IND for general and special U-TDOA are shown in Figure 6-225 and Figure 6-226.

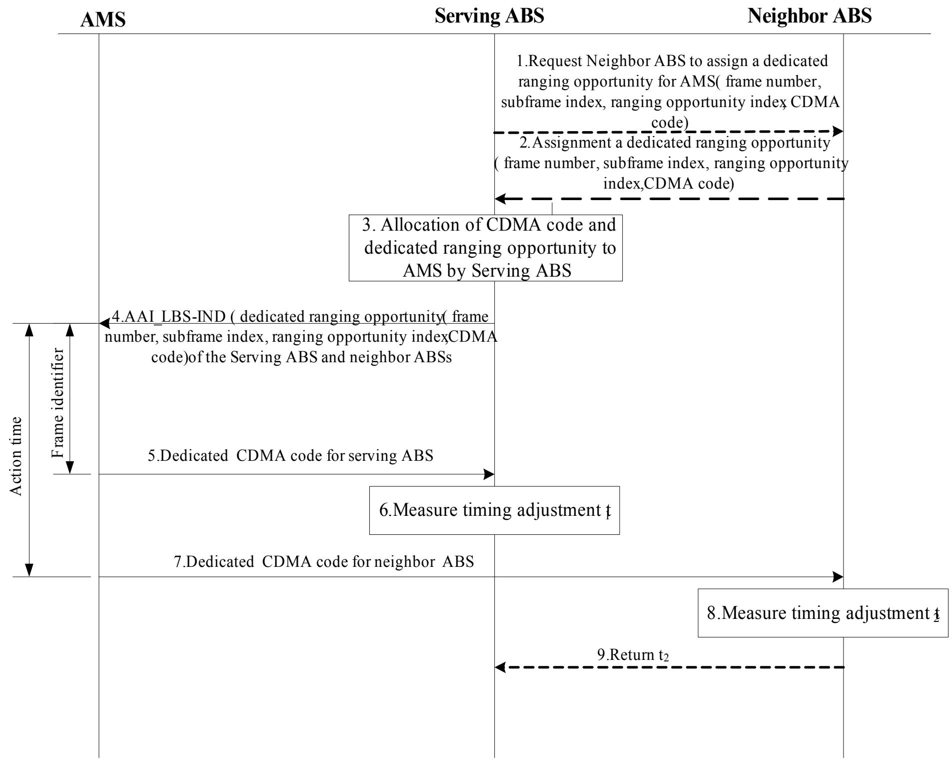

Figure 6-225—Operation description on AAI for general U-TDOA

a) Serving ABS requests neighbor ABS to assign the dedicated ranging opportunity for the AMS.

b) Neighbor ABS confirms the allocation of the dedicated ranging opportunity for the AMS and returns the related parameters used for dedicated ranging between the AMS and the neighbor ABS:

- Frame number
- Subframe index
- CDMA code
- Transmission opportunity index

c) Serving ABS allocates a CDMA code and dedicated ranging opportunity to the AMS.

d) AAI-LBS-IND message is sent to the AMS to request the AMS to initiate dedicated ranging signals for the serving ABS and neighbors. The following parameters are included in this message:

- Frame number
- Subframe index
- CDMA code
- Transmission opportunity index

e) AMS sends dedicated ranging signals to the serving ABS on the dedicated ranging opportunity.

f) Serving ABS measures timing adjustment t_1.

g) AMS sends dedicated ranging signal to the neighbor ABS on the dedicated ranging opportunity.

h) Neighbor ABS measures timing adjustment t_2.

i) Neighbor ABS returns t_2 to serving ABS.

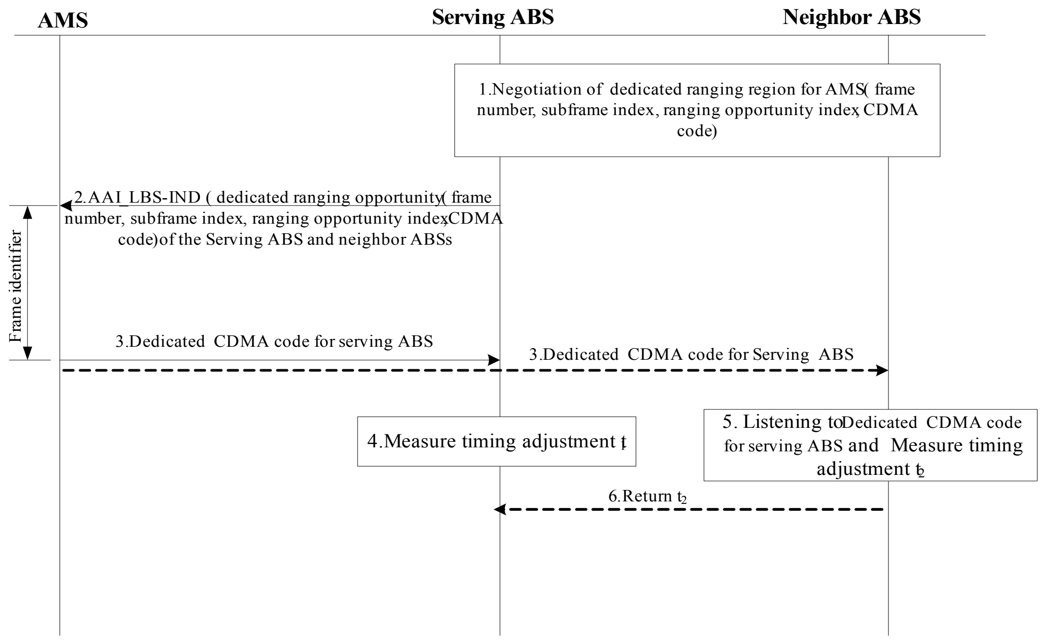

Figure 6-226—Operation description on AAI for special U-TDOA

1) Serving ABS and neighbor ABS negotiate the allocation of a dedicated ranging region for the AMS:
   - Frame number
   - Subframe index
   - CDMA code
   - Transmission opportunity index
2) AAI-LBS-IND message is sent to the AMS to request the AMS to initiate dedicated ranging signals for the serving ABS and neighbors. The following parameters are included in this message:
   - Frame number
   - Subframe index
   - CDMA code
   - Transmission opportunity index
3) AMS sends dedicated ranging signal to the serving ABS on the dedicated ranging opportunity. At the same time, the neighbor ABS shall make no allocations in that dedicated ranging region, and the neighbor ABS will listen to the dedicated ranging signal from the AMS.
4) Serving ABS measures Timing Adjustment t_1.
5) Neighbor ABS listens to the dedicated ranging signal from the AMS, and then measures Timing Adjustment t_2.
6) Neighbor ABS returns t_2 to serving ABS.

6.8.3 Enhanced LBS support

The Enhanced LBS (ELBS) is an optional LBS capability involving the following functions:

— ABS's ability to transmit special ELBS waveforms to be used for location-specific measurements to enable more accurate location determination.
— ABS's ability to signal to the AMS the operational parameters relevant to special ELBS waveforms.
— AMS's ability to detect, measure, and report relevant measurements to the ABS.
— LBS measurement may be performed on multiple carriers.

6.8.3.1 Enhanced LBS support in downlink

The enhanced LBS support in downlink involves coordinated transmission of special location beacons across multiple ABSs in a designated Downlink LBS zone to facilitate measurements of parameters related to location determination at the AMS side.

6.8.3.1.1 Basic description of downlink LBS zone

To enable enhanced location determination, a dedicated Downlink LBS zone (D-LBS zone) may be defined to transmit location beacons to be received by AMSs and facilitate their measurement of location-related parameters (RD, RTD, RSSI, etc.) with the higher accuracy.

Such a dedicated D-LBS zone, when supported, shall be spread over four consecutive superframes. The location beacon shall be transmitted on the first symbol of the first subframe of the last frame of each D-LBS zone superframe. For frame structures supporting the WirelessMAN-OFDMA R1 Reference System, the offset shall be applied as it is specified in 6.3.3.5.

The ABSs/ARSs configured to support the D-LBS zone shall coordinate and transmit location beacons in accordance with the predefined D-LBS transmission plan.

6.8.3.1.2 Allocation of D-LBS zone in frame structure

The one D-LBS zone shall span four consecutive superframes. When the D-LBS zone is activated, the first symbol of the first downlink AAI subframe of the last frame of the superframe that belongs to the D-LBS zone shall be used for location beacon transmission. For the Type 1 AAI subframe case, the remaining five consecutive symbols shall form a Type 3 AAI subframe. For the Type 2 AAI subframe case, when MIMO midamble and D-LBS zone location beacon are transmitted in one subframe, the five consecutive symbols between location beacon and MIMO midamble shall form a Type 3 AAI subframe. Figure 6-227 shows an example of the D-LBS zone allocation. In superframes where the D-LBS zone is allocated, the first frame symbols shall be represented by the following pattern of synchronization signals S-P-S-L, where S stands for SA-Preamble transmission in the first and the third frame of superframe, P stands for PA-Preamble transmission in the second frame of superframe, and L denotes location beacon transmission in the last frame of superframe.

The D-LBS zone transmission parameters are provided in S-SFH SP3. The field D-LBS zone configuration controls activation and periodicity of D-LBS zone transmission. The D-LBS zone when activated shall be transmitted periodically.

When the D-LBS zone is switched on or its periodicity is changed by S-SFH SP3, the initial start point of the D-LBS-zone should start from the superframe number (SFN) that satisfies Equation (352).

$$SFN_{Initialstartpoint} = mod(SFH_{S\text{-}SFH(SP3)} + D\text{-}LBS_{ZP} - (\mathrm{mod})(SFH_{S\text{-}SFH(SP3)}, D\text{-}LBS_{ZP}), 2^{12}) \quad (352)$$

where

$SFN_{Initialstartpoint}$ is the superframe number of the D-LBS zone initial start point.

$SFN_{S\text{-}SFH(SP3)}$ is the last superframe in the S-SFH change cycle containing the S-SFH SP3 with changed E-LBS zone configuration.

$D\text{-}LBS_{ZP}$ is the periodicity of the D-LBS zone.

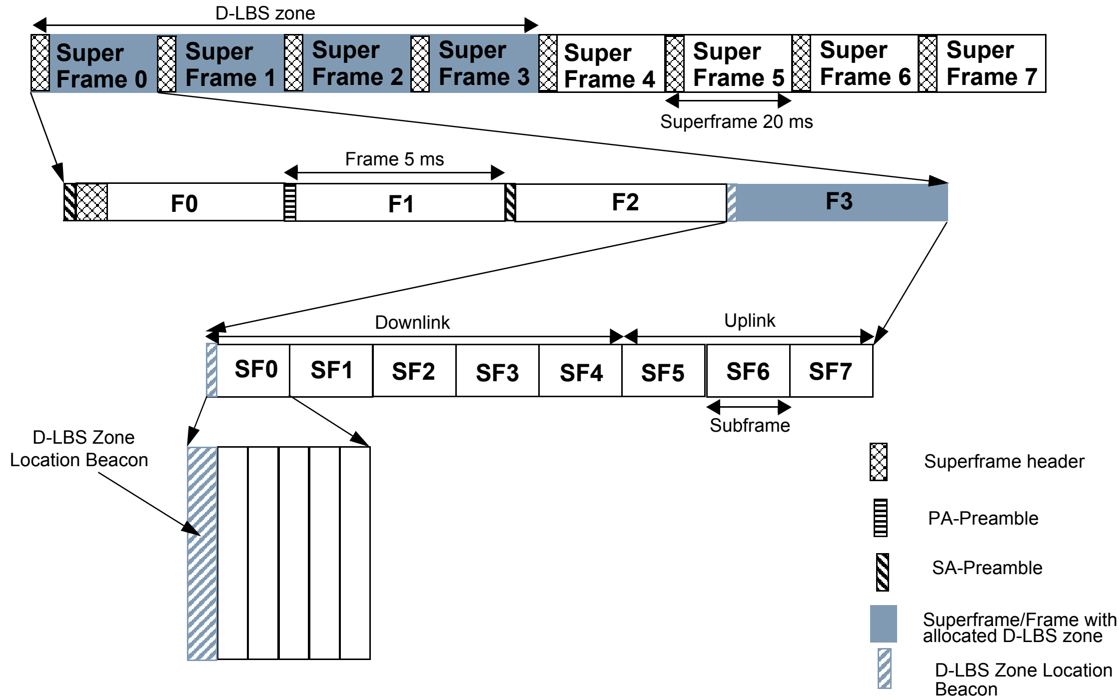

Figure 6-227—D-LBS zone allocation

6.8.3.2 D-LBS zone location beacon signals

The SA-Preamble shall be used as a reference location beacon signal for transmission inside of the D-LBS zone. The physical structure of the SA-Preamble signal transmitted by each ABS or ARS in the D-LBS zone shall be the same as defined in 6.3.5.1.2.

Each ABS/ARS shall transmit the corresponding SA-Preamble signal in the D-LBS zone in accordance with the predefined transmission plan that depends on the *IDcell* value assigned to the station. The location beacon transmission plan provides the time multiplexed transmission of these signals across neighboring ABSs/ARSs to simplify detection and measurements of the relevant signal location parameters from several ABSs/ARSs.

The D-LBS zone transmission plan spreads location beacon transmissions from different ABSs/ARSs over D-LBS zone OFDMA symbols and carrier sets.

6.8.3.3 Predefined D-LBS zone transmission plan

The predefined D-LBS zone transmission plan specifies on which orthogonal resource (OFDMA symbol and carrier set) of the D-LBS zone the location beacon shall be transmitted. To define the transmission plan, the existing set of SA-Preambles shall be partitioned into Q preamble location groups (PLGs). To determine PLG index, Equation (353) shall be used.

$$PLG = \mathrm{mod}(\mathrm{mod}(IDcell, 256), Q) \qquad (353)$$

The number of preamble location/LBS groups Q shall be set to 12, which is equal to the number of orthogonal resources available in one D-LBS zone. Table 6-326 determines the predefined D-LBS zone transmission plan that shall be used for transmission of location beacons.

Table 6-326—Predefined D-LBS zone transmission plan

Allocated carrier set	D-LBS zone symbol index $s = 0$ mod(*Superframe number*, 4) == 0	D-LBS zone symbol index $s = 1$ mod(*Superframe number*, 4) == 1	D-LBS zone symbol index $s = 2$ mod(*Superframe number*, 4) == 2	D-LBS zone symbol index $s = 3$ mod(*Superframe number*, 4) == 3
Carrier Set $n = 0$	PLG = 0	PLG = 1	PLG = 2	PLG = 3
Carrier Set $n = 1$	PLG = 4	PLG = 5	PLG = 6	PLG = 7
Carrier Set $n = 2$	PLG = 8	PLG = 9	PLG = 10	PLG = 11

In accordance with the predefined D-LBS zone transmission plan, each ABS and ARS shall determine the PLG index using Equation (353). The ABS and ARS shall transmit the location beacon signal on corresponding D-LBS zone symbol index s and carrier set n as it is defined in Table 6-326. The D-LBS symbol index and carrier set on which particular ABS and ARS transmit location beacons shall be determined from the PLG index using the following Equation (354).

$$\begin{aligned} s &= \mathrm{mod}(PLG, 4) \\ n &= \mathrm{floor}((PLG)/4) \end{aligned} \tag{354}$$

The D-LBS zone symbol index s shall be associated with the superframe number using the following equation $s = \mathrm{mod}(\text{Superframe number}, 4)$. When one station has multiple segments, all the segments shall transmit the same SA-Preamble sequence. The SA-Preamble sequence for the purpose of location beacon transmission shall be determined by new *IDcell* value ($IDcell_{PLG}$) equal to

$$IDcell_{PLG} = \mathrm{mod}(IDcell, 256) + \mathrm{floor}(PLG/4) \cdot 256$$

6.8.3.4 D-LBS zone measurement and report

An ABS may trigger a location measurement on the D-LBS zone by sending AAI-SCN-RSP including duration for measurements signal location parameters on the D-LBS zone, which may include multiple D-LBS zones. Duration for measurements signal location parameters on D-LBS zone indicates the whole duration in which the AMS should scan beacon signals of the D-LBS zone. The AMS may scan beacon signals of the D-LBS zone during the scan duration specified in the AAI-SCN-RSP message. The AMS may respond to this with AAI-SCN-REP with the parameters that enable location determination (see 6.2.3.14 and 6.2.3.15). An example of a scan for the D-LBS zone is shown in Figure 6-228.

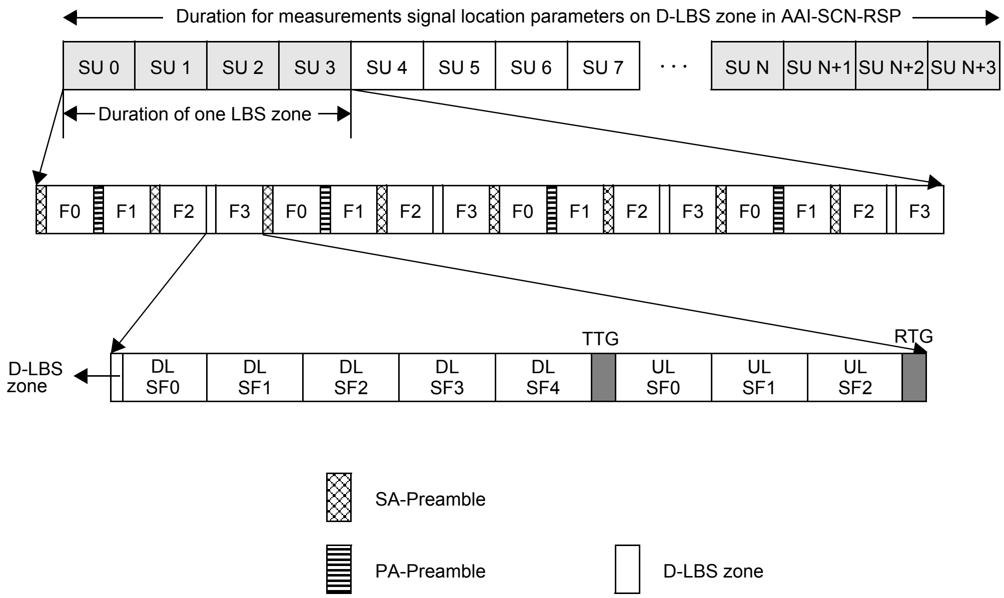

Figure 6-228—Example of scan for D-LBS zone

6.9 Support for enhanced multicast and broadcast service

Enhanced multicast and broadcast service (E-MBS) provides an efficient method for concurrent transport of DL data common to a group of users, using a common E-MBS ID and a FID. E-MBS service is offered in the downlink only and may be coordinated and synchronized among a group of ABS to allow macro-diversity.

QoS parameters for E-MBS flows are determined by network and do not need to be provisioned to each AMS.

Service flows to carry E-MBS data are instantiated on individual AMSs participating in the service while in Connected State. During such instantiation, the AMS learns the parameters that identify the service and associated service flows.

Each ABS capable of providing E-MBS belongs to a certain E-MBS zone and one ABS can belong to multiple E-MBS zones. An E-MBS zone defined as a set of ABSs where the same E-MBS ID and FID is used for transmitting the content of certain service flow(s). Each E-MBS zone is identified by a unique E-MBS_Zone_ID.

To ensure proper multicast operation on networks of ABS employing E-MBS, the E-MBS IDs and FIDs used for common E-MBS content and service shall be the same for all ABSs within the same E-MBS zone. This allows the AMS that has already registered with a service to be seamlessly synchronized with E-MBS transmissions within an E-MBS zone without communicating in the UL or re-registering with other ABS within that E-MBS zone.

6.9.1 E-MBS transmission modes

Continuous reception of E-MBS transmissions within an E-MBS zone relies on some coordination among ABSs in the E-MBS zone. Such coordination is applied to achieve frame level synchronization of the E-MBS in non-macro-diversity transmission mode or to achive symbol level synchronization with macro diversity transmission mode as described in the following subclauses.

An ABS may provide the AMS with E-MBS content locally within its coverage and independently of other ABSs. The single ABS provision of E-MBS is therefore a configuration where an E-MBS zone is configured to consist of a single ABS only. This configuration may be provided as one of the possible cases of E-MBS. In this case, the ABS may use any E-MBS ID and FID for providing the E-MBS service, independently of other ABSs, so the AMS receives the E-MBS data from its S-ABS, and the AMS should not expect the service flow for this E-MBS connection to continue when the AMS leave the S-ABS. However, if the AMS moves to an ABS that is transmitting the same E-MBS flows in another E-MBS zone and updates its Service Flow management encodings, the AMS may continue to receive the same E-MBS flows.

6.9.1.1 Non-macro-diversity mode

Non-macro-diversity mode is provided by frame level coordination only, in which the transmission of data across ABSs in an E-MBS zone is not synchronized at the symbol level. However, such transmissions are coordinated to be in the same frame. This MBS transmission mode is supported when macro-diversity is not feasible. For all ABSs that belong to the same E-MBS zone, the following coordination shall be assured:

— The set of MAC SDUs carrying E-MBS content shall be identical in the same frame in all ABSs in the same E-MBS zone.

— The mapping of MAC SDUs carrying E-MBS content onto MAC PDUs shall be identical in the same frame in all ABSs in the same E-MBS zone, meaning, in particular, identical SDU fragments and identical fragment sequence number and fragment size.

Coordination in the E-MBS zone assures that the AMS may continue to receive E-MBS transmissions from any ABS that is part of the E-MBS zone, regardless of the AMS operating mode-Active Mode, Sleep Mode and Idle Mode-without need for the AMS to register to the ABS from which it receives the transmission.

6.9.1.2 Macro-diversity mode

In addition to coordination, E-MBS transmissions may optionally be synchronized across all ABSs within an E-MBS zone. This option enables an AMS to extract macro-diversity gains in the multicast or broadcast transmission from multiple ABSs, thereby improve the reliability of reception. When macro-diversity is used, the mapping of SDUs into the E-MBS Bursts is identical, and the same E-MBS bursts are transmitted using the same time-frequency resource in all involved ABS; additional parameters may also be required to be identical across ABSs if macro-diversity is used.

In macro-diversity mode, within one E-MBS zone all ABSs participating in the same E-MBS service shall be time and frequency synchronized in the transmissions of common E-MBS data to allow macro-diversity gain at the AMS. When macro-diversity is enabled the E-MBS bursts positions and dimensions as well as PHY parameters shall be the same across all ABSs within the same E-MBS zone. In addition to the coordination parameters such as E-MBS zone ID, E-MBS ID and FID, MSI, and Packet Classification Rule parameter(s), macro-diversity synchronization requires that all ABSs within the same E-MBS zone shall use the same

- Transmission PHY parameters, MCS associated with each E-MBS Burst including FEC Type, Modulation Type
- Mapping of SDUs to PDU (order of the SDUs and fragments) including Extended Headers
- Mapping of PDUs to bursts
- Order of bursts in the zone/region
- E-MBS MAP construction

Mechanisms and procedures for multiple ABSs to accomplish the synchronized transmission (which implies performing functions like classification, fragmentation, scheduling at a centralized point like the E-MBS Server) are outside the scope of this standard.

6.9.2 E-MBS operation

Establishment of E-MBSs for a specific AMS with respect to certain service flow, when needed, shall be performed while the AMS is in connected state. E-MBS service flows are not dedicated to the specific AMS and are maintained even though the AMS is either in Active/Sleep mode or in the Idle mode. When an AMS is registered at an ABS for receiving E-MBS, multicast, and broadcast service flows shall be instantiated as multicast connections. Data of multicast and broadcast service flows may be transmitted from ABS and may be received at AMS also regardless of what mode the AMS is currently in. The ABS may establish a DL E-MBS by creating a multicast and broadcast service flows when the service commences. Mapping of multicast and broadcast service flows to corresponding E-MBS IDs and FIDs shall be known and be the same for all ABSs belonging to the same E-MBS zone. The method of making all ABS in the same E-MBS zone aware of E-MBS flows and associated E-MBS service flows-including E-MBS ID and FID assignment, QoS parameter set, and Classification Rule(s) is outside the scope of the standard. As the classification and transmission of E-MBS flows may be supported on an ABS in an E-MBS zone regardless of the presence or absence of any AMS in Active mode receiving the service, the ABS may retain E-MBS service flow management encodings to do classification and scheduling of E-MBS flows, even when no AMS in Active mode receiving the service is registered at the ABS.

In order to improve the efficiency of radio resource utilization, dynamic multicast service may be supported, in which the transmission of the multicast service data should be decided based on the number of the AMSs within the ABS. Dynamic multicast service may be supported regardless of the AMS operating state—Connected State and Idle State.

6.9.2.1 E-MBS connection establishment

The procedure of E-MBS Connection Establishment is showing in Figure 6-229. The procedure includes the following:

— Capability exchange using AAI-REG-REQ/RSP

— DSx procedure containing relevant E-MBS parameter to establish E-MBS connection

— Start/Update/End E-MBS service using AAI-E-MBS-REP for the carrier switching

To discover E-MBS service, the AMS will inform the ABS of support of E-MBS transmission by the AAI-REG-REQ message and the ABS will indicate if it supports any of the E-MBS modes for that AMS through the AAI-REG-RSP message. The basic E-MBS capability exchange in the AAI-REG-REQ/RSP message is described in 6.2.3.8 and 6.2.3.9.

When an AMS registers for receiving multicast and broadcast services, the S-ABS or the AMS may initiate the DSA procedure for multicast and broadcast connections. The AMS's discovery and registration of the E-MBS services with the ABS through upper layer signaling are outside the scope of this standard.

To prepare for subsequent E-MBS operation, the AMS obtains the E-MBS related configuration information receiving the AAI-SCD message and AAI-E-MBS-CFG message on the corresponding E-MBS carrier described in Table 6-59 and Table 6-106.

The AMS learns the E-MBS_Zone_ID(s) to which the serving and neighboring ABS belongs through the AAI-E-MBS-CFG message.

The ABS sends AAI-DSA, AAI-DSC and AAI-DSD messaging respectively to establish, change, and delete E-MBS service flows. The AMS initiated DSx may also be supported. In addition the E-MBS service flows may also be established optionally through upper layer signaling, which is outside the scope of this standard. When E-MBS services involve multiple flows, the compact form of DSx with group parameter should be used to reduce overhead and signaling delay associated with E-MBS flow management.

The ABS sends the AAI-DSA-REQ/RSP to the AMS containing the relevant E-MBS parameters. It also includes E-MBS IDs and FIDs, E-MBS zone IDs, E-MBS carrier information (physical carrier index). Selective decoding of content is at the granularity of FIDs.

If multicarrier feature is supported by the AMS and the ABS, the ABS should use AAI-DSA-REQ/RSP message to redirect the AMS to AAI E-MBS zone of other carriers, if such redirection is needed.

The AAI-E-MBS-REP message described in 6.2.3.59 shall be transmitted from an AMS to an ABS in order to request a start time, to update the receiving E-MBS stream(s), or to indicate that the AMS stops E-MBS carrier switching without releasing the E-MBS connection.

The AAI-E-MBS-RSP message shall be transmitted by the ABS in response to an AAI-EMBS-REP message sent by the AMS.

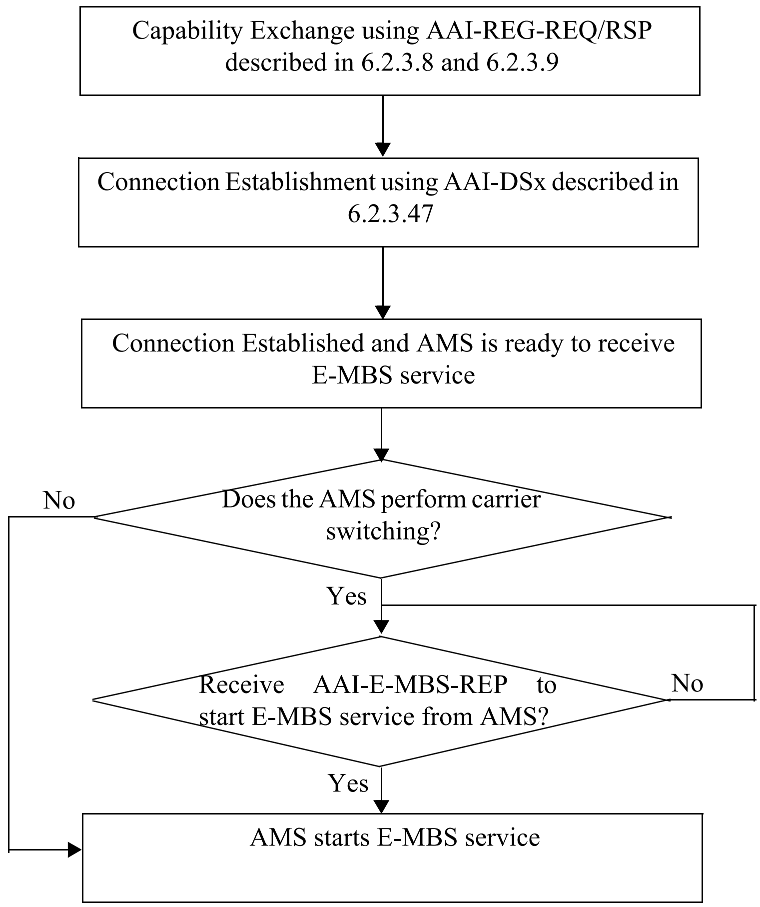

Figure 6-229—Procedure of E-MBS connection establishment to start E-MBS service

The AMS may continue to receive E-MBS transmissions from any ABS that is part of the E-MBS zone, regardless of the AMS operating mode—Active Mode, Sleep Mode, Idle Mode—without need for update to any service flow management encoding for the E-MBS flow.

To allow seamless transition from one E-MBS zone to another without any interruption of E-MBS data service and operation, the AMS should update E-MBS service flow management encodings including E-MBS IDs and FIDs, Packet Classification Rule parameter(s), E-MBS zone Identifier Assignment parameter. If the AMS has no E-MBS IDs and FIDs information regarding the new E-MBS zone, then the AMS is required to acquire E-MBS IDs and FIDs context through the other procedures, i.e., location-update if AMS is in the idle mode and handover if MS is in connected mode.

After successful configuration, the AMS shall reuse the same configuration when it moves to another ABS in the same E-MBS zone without re-configuration.

6.9.2.2 E-MBS operation in connected state

When an AMS moves across E-MBS zone boundaries in Active Mode or Sleep Mode, the AMS performs the handover procedure described in 6.2.6.3.

Once an AMS has received the E-MBS allocation information in the E-MBS-MAPs, it may not listen to the downlink channels till the next transmission of desired E-MBS flow or the next E-MBS-MAP.

The AMS does monitor downlink channels and follow the entire idle mode and connected mode procedures as required by other services. While receiving E-MBS data, the AMS may temporary interrupt the reception of E-MBS packets for any reason, e.g., if time critical scanning is needed, without notifying the ABS.

6.9.2.3 E-MBS operation in Idle state

When an AMS in Idle mode moves to an ABS that does not belong to the AMS's previous E-MBS zone, the AMS is expected to update the E-MBS service flow management encodings at that ABS to provide continuous reception of E-MBS content. The AMS may obtain the E-MBS information in the target E-MBS zone through broadcast messages in the E-MBS-Zone of the S-ABS. If the idle AMS has not received such information from the serving E-MBS zone, the AMS shall use location update procedure to acquire updated E-MBS service flow management encodings. In order to perform the MBS location update process, the AMS shall transmit AAI-RNG-REQ message with Ranging Purpose Indication = 0b0110. In response to the request for MBS location update, the ABS shall transmit AAI-RNG-RSP message, which may include the E-MBS zone identifier, E-MBS ID, FID, E-MBS zone Identifier Assignment parameter, and soon to provide update service flow management encodings for any affected E-MBS flow(s).

6.9.2.4 E-MBS Operation on the multicarrier deployment

On the multicarrier deployment, primary to secondary carrier switching is used for E-MBS only. With the carrier switching, the E-MBS data, including E-MBS configuration message, E-MBS MAP, and E-MBS contents, is transmitted on an active secondary carrier. When carrier switching is used, the E-MBS service flows are configured on the AMS's primary carrier, and the AMS is redirected to the carrier carrying E-MBS data through DSA as described in 6.9.2.1.

The AMS with multiple transceivers may be able to receive E-MBS data while communicating with ABS on primary carrier.

The AMS with only one transceiver may perform carrier switching when the E-MBS configuration message and the E-MBS data are transmitted on an alternative carrier to the AMSs' primary carrier. The detailed procedure is as follows:

— An AMS shall start the carrier switching operation when it is ready to receive E-MBS service.
— The AMS switches to the secondary carrier periodically to receive E-MBS data. After receiving the E-MBS data, the AMS returns to the primary carrier. The time period during which the E-MBS should remain in the primary carrier during active carrier switching is dictated by the unicast available interval bitmap.
— An AMS shall stop the carrier switching operation when it terminates the E-MBS service.
— After the AMS stops carrier switching operation, the AMS shall stay in the primary carrier until it starts carrier switching operation again.

A Carrier Switching Mode is included in AAI-DSA-REQ/RSP and AAI-DSC-REQ messages. If Carrier Switching Mode is 0b0, the AMS's availability in the primary carrier is indicated using Unicast Available Interval bitmap transmitted in the AAI-DSA-REQ, AAI-DSC-REQ messages to add and change the Unicast Available Interval.

When Carrier Switching Mode is 0b0, Unicast Available Interval Bitmap is included in the AAI-DSA-REQ/RSP message for carrier switching mode to indicate the duration in which the AMS is available in the primary carrier for unicast and the duration in which the AMS is in the secondary carrier to receive E-MBS. The unicast available interval bitmap is a string of N bits $b_0,b_1,b_2,...,b_N$, where b_i can take on a value of 0 or 1 and i indicates the position of the bit in the string. The value of N depends on the MBS scheduling interval(MSI). Each bit b_i corresponds to a time interval in the MSI. An MSI is split into N intervals with each interval represented by a bit. When the i-th bit b_i takes on value 0, then the AMS is unavailable to the primary carrier for unicast scheduling and is in the secondary carrier receiving E-MBS; if the i-th bit b_i takes on value 1, then the AMS is available to the primary carrier for unicast scheduling. Carrier switching from the secondary E-MBS carrier to the primary carrier occurs at the end of interval i when $b_i b_{i+1}$ == 01, i.e., when the bits in the string at the i-th and $i + 1$-th position are 0 and 1, respectively. Similarly, the AMS switches carrier from the primary carrier to the secondary E-MBS carrier occurs at the end of interval i when $b_i b_{i+1}$ == 10, i.e., when the bits in the string at the i-th and $i + 1$-th position are 1 and 0, respectively. Whenever the AMS adds E-MBS content, the AMS shall discontinue carrier switching, return to the primary carrier. The ABS shall re-allocate the Unicast Available Interval using the AAI-DSA transaction. The AAI-DSC transaction is also used to update the Unicast Available Interval Bitmap.

When Carrier Switching Mode is 0b1, an AMS transmits the AAI-E-MBS-REP message to the ABS to inform the ABS which E-MBS service(s) the AMS intends to receive. After receiving an AAI-E-MBS-REP message, the ABS uses the E-MBS connection bitmap to compute the interval during which the AMS is available at the primary carrier for unicast scheduling. The ABS schedules unicast services for the AMS on its primary carrier based on the available interval computed using the connection bitmap in the AAI-E-MBS-REP message. When the AMS changes the concurrent receiving E-MBS service(s), it sends the AAI-E-MBS-REP message with an updated E-MBS Connection Bitmap.

The AAI-E-MBS-REP message described in 6.2.3.59 shall be transmitted from AMS to ABS when one of the following conditions are satisfied:

— To request a start time from the ABS at which the AMS can switch to the E-MBS carrier after DSx transaction
— To update the indication regarding the E-MBS stream(s) the AMS is currently receiving
— To indicate that the AMS stops E-MBS carrier switching without releasing the E-MBS connection allocated via AAI-DSA-REQ/RSP

Upon receiving the AAI-E-MBS-REP message, the ABS shall transmit an AAI-E-MBS-RSP message to the AMS as described in 6.2.3.60.

When an AMS performs carrier switching from the primary carrier to the secondary carrier, the UL HARQ retransmission processes under way shall be terminated even if the corresponding UL HARQ bursts are not successfully decoded or transmitted up to maximum.

6.9.3 E-MBS protocol features and functions

6.9.3.1 E-MBS configuration indicators

The information regarding E-MBS configuration is transmitted periodically to the AMSs interested in E-MBS using a MAC control message called the AAI-E-MBS-CFG message. The E-MBS configuration indicators specify the resources reserved for E-MBS traffic in the downlink physical resources and additional information necessary for E-MBS operation. The details of E-MBS configuration indicators are described in 6.2.3.61.

6.9.3.2 E-MBS zone configuration

Different E-MBS IDs and FIDs may be used in different E-MBS zones for the same multicast and broadcast service flow. A multicast and broadcast zone identifier (E-MBS_ZONE_ID) is used to indicate a service area in which a E-MBS ID and FID for a broadcast and multicast service flow are valid. An ABS that supports E-MBS shall include the E-MBS zone identifier(s) to which it belongs in the AAI-E-MBS-CFG message. The E-MBS zone identifier shall not be ‘0’.

When the ABS sends the AAI-DSA message for establishment of connection for E-MBS_ZONE_ID, the E-MBS_ZONE_ID shall be encoded in the AAI-DSA message. One ABS may have multiple E-MBS_ZONE_IDs for different E-MBS services.

To support inter-MBS zone transition, AMSs need to get E-MBS_Zone_IDs to which the neighboring ABSs belong as well as any flow continuity across such neighboring zone.

6.9.3.3 E-MBS scheduling interval (MSI)

For each E-MBS zone, there is an E-MBS scheduling interval (MSI), which refers to a number of successive superframes for which the access network may schedule traffic for the streams associated with the MBS zone prior to the start of the interval. The MSI can span several superframes, and the length of this interval, denoted by N_{MSI}, depends on the particular use case of E-MBS. The MSI can be $N_{\mathrm{MSI}} = 4$, 8, 16, and 32 superframes long. The E-MBS_MAP message addresses the mapping of E-MBS data associated with an E-MBS zone for an entire MSI. The MBS MAP message is structured such that it may be used to efficiently define one transmission instance for a given stream within an MSI. The indication for the length of the MSI is transmitted in the AAI-SCD message. Using the superframe number, $N_{\mathrm{superframe}}$ from SFH, and N_{MSI} from the AAI-SCD message, the AMS computes the beginning of the MSI as follows:

The MSI begins at the superframe when its $N_{\mathrm{superframe}}$ meets the following condition:

$$N_{\mathrm{superframe}} \text{ modulo } \mathrm{N}_{\mathrm{MSI}} == 0$$

An AMS decodes only the E-MBS data bursts associated with user selected content. The AMS wakes up in each MSI in order to check whether there are E-MBS data bursts to be decoded.

6.10 Support for Advanced Air Interface in LZone

6.10.1 Support for network topology advertisement

6.10.1.1 DL frame prefix

Table 6-327 defines the structure of DL_Frame_Prefix to be transmitted in the LZone of an ABS supporting the WirelessMAN-OFDMA R1 Reference System.

Table 6-327—OFDMA DL Frame Prefix format

Syntax	Size (bit)	Notes
DL_Frame_Prefix_Format() {		
Used subchannel bitmap	6	Bit 0: Subchannel group 0 Bit 1: Subchannel group 1 Bit 2: Subchannel group 2 Bit 3: Subchannel group 3 Bit 4: Subchannel group 4 Bit 5: Subchannel group 5
R1/AAI coexistence indication	1	0b0: WirelessMAN-OFDMA R1 Reference System only 0b1: WirelessMAN-OFDMA R1 Reference System/WirelessMAN-Advanced Air Interface Co-existence System
Repetition_Coding_Indication		0b00: No repetition coding on DL-MAP 0b01: Repetition coding of 2 used on DL-MAP 0b10: Repetition coding of 4 used on DL-MAP 0b11: Repetition coding of 6 used on DL-MAP
Coding_Indication		0b000: CC encoding used on DL-MAP 0b001: BTC encoding used on DL-MAP 0b010: CTC encoding used on DL-MAP 0b011: ZT CC encoding used on DL-MAP 0b100: CC encoding with optional interleaver 0b101: LDPC encoding used on DL-MAP 0b110 to 0b111: *Reserved*
DL-Map_Length	8	—
Reserved	4	Shall be set to zero
}		

6.10.2 Support for zone switch operation

6.10.2.1 RNG-RSP management message encodings

The encodings in Table 6-328 are specific to the RNG-RSP message sent in the LZone of an ABS supporting the WirelessMAN-OFDMA R1 Reference System.

Table 6-328—OFDMA-specific RNG-RSP message encodings

Name	Type (1 byte)	Length	Value
MZone A-Preamble index	41	2	
Time offset	42	1	Time offset between LZone and MZone.
Action Time	43	1	Action time of zone switch from LZone to MZone. The AMS performs a zone switch at Action Time. If Zone Switch Mode = 0, the ABS stops all resource allocation for the AMS at the LZone.
Zone Switch Mode	44	1	0x01: The AMS maintains its data communication with the ABS in the LZone while performing network reentry in the MZone; 0x00: The AMS breaks data communication in the LZone before performing network reentry in the MZone.
Temporary STID	46	1	Temporary STID to be used in the MZone.
MAPMask Seed	47	2	The 15 least significant bits of this field are the seed used at the BS in the MZone to initiate the PRBS generator used to scramble the 40-bit A-A-MAP IE when the value of the TSTID included in this message is used as the CRC Mask Masking Code. See 6.3.5.3.2.4.
Ranging initiation deadline	48	1	Valid time for Temporary STID. Shall be included if Temporary STID is included.
iotFP	49	1	IoT value of Frequency Partition used for AMS resource assignment, quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB, detail reference to the 6.2.3.32 AAI-ULPC-NI message. Shall be included if Temporary STID is included.
offsetControl	50	1	It represents the value among −15.5 dB to 16 dB with 0.5 dB step. Shall be included if Temporary STID is included.
TLV encoded information of ABS MZone's SFH	51	33	Data encoding of SFH SP1/SP2/SP3. It may be sent in case the AMS is not capable of SFH decoding in the MZone while operating in the LZone.

6.10.2.2 RNG-REQ management message encodings

The encodings in Table 329 are specific to the RNG-REQ message sent in the LZone of an AMS indicating its capability for Zone Switch Mode defined in 6.2.6.4.1.2.1.

Table 6-329—OFDMA-specific RNG-REQ message encodings

Name	Type (1 byte)	Length	Value
Zone Switch Capability	1	1	Informs the supported capability for Zone Switch. Bit 0: Indicates that the AMS is able to perform Zone Switch mode 0. Bit 1: Indicates that the AMS is able to perform Zone Switch mode 1. Bit 2–7: *Reserved.*

6.10.3 Migrating to AAI without impacting the deployed R1 network

The migration to the WirelessMAN-Advanced Air Interface may be done without impacting the deployed R1 network elements. The ABS should be able to connect to R1 access and core network elements.

6.11 Global values

Table 6-330—Parameters and constants

System	Name	Time reference	Minimum value	Default value	Maximum value
ABS	Neighbor List Update Interval	Time between Femto ABS neighbor list updates	10 min	60 min	1440 min
ABS	FFR Partition Update Interval	Time between FFR partition updates	1 min	60 min	143 200 min
AMS, ABS	T31	AMS : AAI-RNG-ACK reception timeout following the transmission of a ranging preamble code. ABS : AAI-RNG-ACK transmission timeout following the reception of a ranging preamble code	—	—	—
AMS	Contention Ranging Retries	Number of retries on contention Ranging Requests by ranging preamble code	16	—	—
AMS	Ranging Request Retries	Number of retries on ranging requests by AAI-RNG-REQ messages	3	—	16
AMS	Request Retries	Number of retries on bandwidth allocation requests	16	—	—
AMS	Registration Request Retries	Number of retries on registration requests	3	—	—
ABS, AMS	DSx Request Retries	Number of Timeout Retries on AAI-DSA/DSC/DSD Requests	—	3	—
ABS, AMS	DSx Response Retries	Number of Timeout Retries on AAI-DSA/DSC/DSD Responses	—	3	—
AMS	T2	Wait for broadcast ranging timeout	—	—	—

Table 6-330—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
AMS	T3	Ranging response reception timeout following the transmission of a ranging request, UL BW allocation timeout following the transmission of a fragment of ranging request, or UL BW allocation timeout following the success status notification to the HO ranging code	—	—	—
AMS	Tranging_code_ response	Ranging response reception timeout following the transmission of a ranging preamble code	—	—	-—
AMS	T4	Time interval between periodic ranging	—	—	35 s
AMS	T6	Wait for registration response	—	—	3 s
ABS, AMS	T7	Wait for AAI-DSA/DSC/ DSD Response timeout	10 ms	—	1 s
ABS, AMS	T8	Wait for AAI-DSA/DSC Acknowledge timeout	10 ms	—	300 ms
ABS	T9	The time allowed between the ABS sending a AAI-RNG-RSP (include temp STID) to an AMS, and receiving an AAI-SBC-REQ from that same AMS	300 ms	300 ms	—
ABS, AMS	T10	Wait for Transaction End timeout	600 ms	—	3 s
AMS	T14	Wait for AAI-DSX-RVD Timeout	—	—	100 ms

Table 6-330—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
ABS, AMS	T17	Time allowed for the AMS to complete the AMS Authorization and Key Exchange	—	1 min	—
AMS	T18	Wait for AAI-SBC-RSP timeout	—	100 ms	<<T9
ABS, AMS	T22	Wait for AAI-ARQ-Reset	—	—	0.5 s
AMS	SBC Request Retries	Number of retries on SBC Request	3	3	16
ABS	Ranging Correction Retries	Number of Ranging Correction Retries	—	16	2.5 ms
AMS	RNG-RSP Processing Time	Time allowed for an AMS following receipt of an AAI-RNG-RSP before it is expected to apply the corrections instructed by the ABS Minimum value	—	—	—
AMS, ABS	MIN_Sleep_ Cycle	Minimum size of Sleep Cycle	Listening Window	—	16 frames
AMS, ABS	MAX_Sleep_ Cycle	Maximum size of Sleep Cycle	MIN_Sleep _Cycle	—	1024 frames
AMS, ABS	Listening Window	The time duration during which the AMS, after waking up and synchronizing with the DL transmissions, can demodulate DL transmissions and decide whether to stay awake or go back to sleep	1 frame	-—	16 frames
ABS	AAI-NBR_ADV Interval	Nominal time between transmission of AAI-NBR-ADV messages	—	—	30 s

Table 6-330—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
AMS	Idle Mode Timer	AMS timed interval to conduct location update. Timer recycles on successful idle mode location update	128 s	4096 s	—
AMS	T43	Time the AMS waits for AAI-SLP-RSP, AAI-TRF_IND-RSP, or SCH	—	—	—
AMS	T44	Time the AMS waits for AAI-SCN-RSP	—	—	—
AMS	T45	Time the AMS waits for AAI-DREG-RSP	—	250 ms	500 ms
ABS	Management Resource Holding Timer	Time the ABS maintains connection information with the AMS after the ABS sends the AAI-DREG-RSP message to the AMS	—	500 ms	1 s
AMS	DREG Request Retry Count	Number of retries on DREG Request message	3	3	16
ABS	DREG CMD Retry Count	Number of retries on DREG Response message	3	3	16
ABS	T46	Time the ABS waits for AAI-DREG-REQ in case of unsolicited idle mode initiation from the ABS	50 ms	—	—
AMS	Max Dir Scan Time	Maximum scanning time of neighbor BSs by the AMS before reporting any results	—	—	—
ABS, AMS	Key agreement MSG#1 Timer	Time prior to resend of PKMv3 Key agreement MSG#1	0.5 s	1 s	2.0 s
ABS, AMS	Key agreement MSG#1 MAX Resends	Maximum number of transmissions of PKMv3 Key agreement MSG#1	1	3	3
ABS, AMS	Key agreement 3-way handshakeTimer	Time prior to resend of PKMv3 Key agreement MSG#2	0.1 s	0.3 s	1.0 s

Table 6-330—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
ABS, AMS	Key agreement MSG#2 MAX Resend	Maximum number of transmissions of PKMv3 Key agreement MSG#2	1	3	3
AMS, ABS	PMK pre-handshake lifetime	The lifetime assigned to PMK when created before successful key agreement 3-way handshake	5 s	10 s	15 min
ABS	PMK lifetime	If MSK lifetime is unspecified (i.e., by AAA server), PMK lifetime shall be set to this value	60 s	3600 s	86 400 s
AMS	Authentication Grace Time	Time prior to Authentication expiration AMS begins reauthentication	5 min (300 s)	10 min (600 s)	1 h (3600 s)
AMS	Rekey Wait Timer	PKMv3 TEK-Request retransmission interval from Rekey Wait state	1 s	1 s	10 s
AMS	Rekey Counter threshold	Maximum number of transmissions of PKMv3 TEK-Request	1	3	
AMS, ABS	PN Grace space	AMS's remaining PNs prior to PN exhaustion when PKMv3 TEK update procedure starts (PN Grace space of the ABS is set as larger than that of the AMS by 50)		400 000	
AMS, ABS	TEK Re-Auth Timer	Time prior to sending PKMv3 TEK-Request right after key agreement 3-way handshake	20 ms	40 ms	100 ms
AMS	Reauthentication request timer	Timer between resend of PKMv3 Reauth-Request message if reauthentication was not completed	10 s	10 s	60 s
ABS	AAI-LBS-ADV Interval	Nominal time between transmission of AAI-LBS-ADV messages	2 s	10 s	1800 s
AMS	Nms_max_neighbors	Maximum size of neighbor list	32	—	255

Table 6-330—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
ABS	AAI-SCD Interval	Nominal time between transmission of AAI-SCD messages	—	—	—
ABS	AAI-MC-ADV Interval	Nominal time between transmission of AAI-MC-ADV messages	—	—	—
AMS	T_AMS	This timer is for Listening Window Extension of the AMS	0 frame	—	31 frames
ABS	T_ABS	This timer is for Listening Window Extension of the ABS	≥ T_AMS	—	—
ABS	AAI-SII-ADV Interval	Nominal time between transmission of AAI-SII-ADV messages	—	—	—
ABS	T58	Minimum duration for the ABS to wait for the AAI-RNG-CFM message	—	—	—
ABS, AMS	BR ACK offset	BR ACK A-MAP IE reception time offset from the transmission of a BR preamble sequence. BR ACK offset shall be less than the BR timer	—	3 frames	—
AMS	BR timer	UL allocation waiting time for BR header after receiving a positive acknowledgment for a BR preamble sequence and a negative acknowledgment for a quick access message	—	—	—
AMS	Context Retention Timer	Time valid to retain DCR mode	—	—	—
AMS	$N_{Lost\text{-}SFH}$	Number of lost SFHs for DL sync loss detection	3	5	10

Table 6-330—Parameters and constants *(continued)*

System	Name	Time reference	Minimum value	Default value	Maximum value
ABS	$N_{CLD\_UL\_Grant}$	Number of Coverage Loss Detection UL Grants	2	3	10
ABS, AMS	BR grant timer	UL allocation waiting time for BR header during network entry	—	—	—
ABS, AMS	ACK timer	This timer is for AAI-MSG-ACK or MAEH. The ACK timer operation is described in 6.2.22	8 frames	—	—
ABS	active_ABS_tim er	Timer period for the ABS to check whether the AMS is active mode in connected state or not	—	—	—

Annex A

(informative)

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Annex B

(normative)

Definition of AAI MAC control messages

This annex defines MAC control messages using ASN.1 notation. The Packed Encoding Rules (PER) with a byte unaligned option shall be used to produce compact transfer syntax for the MAC control message to be transmitted over the air interface.

B.1 ASN.1 coding recommendations

a) The template of a MAC control message is shown below. It consists of one or more attributes. Each attribute should associate with a TYPE (e.g., INTEGER or OCTET STRING) that defines the type of the attribute.

```
AAI-XXX-XXX ::= SEQUENCE {
    attributes                TYPE
}
```

1) The underscore "_" should not be used, as it is not accepted by the ASN.1 compiler.
2) The attribute should use lowercase in the first letter. Lowercases and uppercases can be mixed to make the attribute easy to read (e.g., userBitmapSize).
3) The user-defined type should use uppercase in the first letter (e.g., ResourceBitmapList).
4) The ASN.1 coding should use `Courier` font and no Tab in spaces.
5) The length of attributes should be limited to 30 characters.
6) The length of TYPE should be limited to 20 characters.
7) The length of each line should be limited to 72 characters.
8) The attribute should avoid using keywords (e.g., *, +) in widely used languages (e.g., C and C++).
9) Each type should have a range, when applicable, e.g.,

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

10) Comments may be inserted to each attribute, e.g.,

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

b) Example of FOR loop implementation.

For (i = 1; $i \le 4$; i++) {		
Burst size	5	i-th burst size of the 4 burst sizes supported in the group
}		

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

c) Example of If statement implementation.

Deletion Flag	1	Flag to signal whether this message includes addition or deletion information. 0: Flow is added to a group 1: Flow is explicitly deleted from a group
If (Deletion Flag == 0) {		*i*-th burst size of the 4 burst sizes supported in the group
Group ID	5	ID of the group to which the flow is added
}		

```
graInfoForAddedFlow        GroupRsrcAllocInfo OPTIONAL
```

1) It is not necessary to define the Condition, since the ASN.1 compiler will automatically define a control bit for each OPTIONAL attribute.
2) If a MAC control message contains OPTIONAL attributes, it should include a table explaining the conditions of such attributes.

d) Each MAC control message should be free of compilation errors. A free online ASN.1 compiler is available from http://lionet.info/asn1c/asn1c.cgi.

e) Additional information on ASN.1 can be found in http://www.obj-sys.com/asn1tutorial/asn1only.html.

B.2 MAC control message definitions

```
WirelessMAN-Advanced-Air-Interface DEFINITIONS AUTOMATIC TAGS ::=
BEGIN

-- MAC Control Messages
MAC-Control-Message ::=     SEQUENCE {
   message                     MAC-Control-Msg-Type,
   ...
}

MAC-Control-Msg-Type ::=    CHOICE {
   -- System information
   aaiSCD                      AAI-SCD,
   aaiSIIAdv                   AAI-SII-ADV,
   aaiULPCNi                   AAI-ULPC-NI,
   -- Network entry / re-entry
   aaiRngReq                   AAI-RNG-REQ,
   aaiRngRsp                   AAI-RNG-RSP,
   aaiRngAck                   AAI-RNG-ACK,
   aaiRngCfm                   AAI-RNG-CFM,
   aaiSbcReq                   AAI-SBC-REQ,
   aaiSbcRsp                   AAI-SBC-RSP,
   aaiRegReq                   AAI-REG-REQ,
   aaiRegRsp                   AAI-REG-RSP,
   -- Network exit
   aaiDregReq                  AAI-DREG-REQ,
   aaiDregRsp                  AAI-DREG-RSP,
```



```
-- Connection management
aaiDsaReq                AAI-DSA-REQ,
aaiDsaRsp                AAI-DSA-RSP,
aaiDsaAck                AAI-DSA-ACK,
aaiDscReq                AAI-DSC-REQ,
aaiDscRsp                AAI-DSC-RSP,
aaiDscAck                AAI-DSC-ACK,
aaiDsdReq                AAI-DSD-REQ,
aaiDsdRsp                AAI-DSD-RSP,
aaiGrpCfg                AAI-GRP-CFG,
-- Security
aaiPkmReq                AAI-PKM-REQ,
aaiPkmRsp                AAI-PKM-RSP,
-- ARQ
aaiArqFbk                AAI-ARQ-FBK,
aaiArqDsc                AAI-ARQ-DSC,
aaiArqRst                AAI-ARQ-RST,
-- Sleep mode
aaiSlpReq                AAI-SLP-REQ,
aaiSlpRsp                AAI-SLP-RSP,
aaiTrfInd                AAI-TRF-IND,
aaiTrfIndReq             AAI-TRF-IND-REQ,
aaiTrfIndRsp             AAI-TRF-IND-RSP,
-- Handover
aaiHoInd                 AAI-HO-IND,
aaiHoReq                 AAI-HO-REQ,
aaiHoCmd                 AAI-HO-CMD,
aaiNbrAdv                AAI-NBR-ADV,
aaiScnReq                AAI-SCN-REQ,
aaiScnRsp                AAI-SCN-RSP,
aaiScnRep                AAI-SCN-REP,
-- Idle mode
aaiPagAdv                AAI-PAG-ADV,
aaiPgidInfo              AAI-PGID-INFO,
-- Multicarrier
aaiMcAdv                 AAI-MC-ADV,
aaiMcReq                 AAI-MC-REQ,
aaiMcRsp                 AAI-MC-RSP,
aaiCmCmd                 AAI-CM-CMD,
aaiCmInd                 AAI-CM-IND,
aaiGlobalConfig          AAI-GLOBAL-CFG,
-- Power Control
aaiUlPowerAdj            AAI-UL-POWER-ADJ,
aaiUlPsrConfig           AAI-UL-PSR-CFG,
-- Collocated Coexistence
aaiClcReq                AAI-CLC-REQ,
aaiClcRsp                AAI-CLC-RSP,
-- MIMO
aaiSbsMimoFbk            AAI-SBS-MIMO-FBK,
aaiMbsMimoFbk            AAI-MBS-MIMO-FBK,
aaiMbsMimoReq            AAI-MBS-MIMO-REQ,
aaiMbsMimoRsp            AAI-MBS-MIMO-RSP,
aaiMbsMimoSbp            AAI-MBS-MIMO-SBP,
aaiMbsSoundingCal        AAI-MBS-SOUNDING-CAL,
```

```
   aaiDlIm                    AAI-DL-IM,
   -- FFR
   aaiFfrCmd                  AAI-FFR-CMD,
   aaiFfrRep                  AAI-FFR-REP,
   -- SON
   aaiSonAdv                  AAI-SON-ADV,
   -- Relay
   aaiARSCfgCmd               AAI-ARS-CFG-CMD,
   -- EMBS
   aaiEmbsCfg                 AAI-EMBS-CFG,
   aaiEmbsRep                 AAI-EMBS-REP,
   aaiEmbsRsp                 AAI-EMBS-RSP,
   -- LBS
   aaiLbsAdv                  AAI-LBS-ADV,
   aaiLbsInd                  AAI-LBS-IND,
   -- Misc
   aaiL2Xfer                  AAI-L2-XFER,
   aaiMsgAck                  AAI-MSG-ACK,
   aaiResCmd                  AAI-RES-CMD,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Common type definitions
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
PhyCarrierIndex ::=        INTEGER (0..62)

PreambleIndex ::=          INTEGER (0..1023)

PreambleIndex2 ::=         INTEGER (0..63)

R1PreambleIndex ::=    INTEGER (0..127)

PCID ::=                   BIT STRING (SIZE (48))

PGID ::=                   BIT STRING (SIZE (16))

PgOffset ::=               INTEGER (0..4095)

FidChangeCount ::=         INTEGER (0..15)

AbsIndex ::=               INTEGER (0..255)

MBSZoneID ::=              INTEGER (0..127)

EMBSZoneID ::=             MBSZoneID

MacProtocolVersion ::=     INTEGER (0..255)

BSID ::=                   BIT STRING (SIZE (48))

STID ::=                   BIT STRING (SIZE (12))

CID ::=                    INTEGER (0..65535)
```



```
FID ::=                     INTEGER (0..15)

AKCount ::=                 INTEGER (0..65535)

NbrAdvChangeCount ::=       INTEGER (0..7)

FAIndex ::=                 INTEGER (0..255)

IDCell ::=                  INTEGER (0..1023)

-- IdCell partitioning in Table 6-168
PreamblePart ::=            BIT STRING (SIZE (4))

CPLength ::=                ENUMERATED {
                               one-eighth,
                               one-sixteenth,
                               one-fourth
                            }

DREGID ::=                  BIT STRING (SIZE (12))

PgCycle ::=                 INTEGER {
                               cycle4Superframes           (0),
                               cycle8Superframes           (1),
                               cycle16Superframes          (2),
                               cycle32Superframes          (3),
                               cycle64Superframes          (4),
                               cycle128Superframes         (5),
                               cycle256Superframes         (6),
                               cycle512Superframes         (7)
                            } (0..15)

CMACI ::=                   ENUMERATED {
                               cmacNotPresent,
                               cmacPresent
                            }

EMBSID ::=                  STID

MulticastGroupID ::=        BIT STRING (SIZE (12))

AMSMobilityLevel ::=        ENUMERATED {
                               slow,
                               medium,
                               fast
                            }

CenterFreq ::=              INTEGER (0..4294967295)     -- Unit = Hz

TriggerConditions ::=       SEQUENCE {
   hoTriggers                  SEQUENCE (SIZE (1..64)) OF SEQUENCE {
      hoConditionsList            SEQUENCE (SIZE (1..4)) OF SEQUENCE {
         absType                     INTEGER {
```

```
                                    any                        (0),
                                    macroABS                   (1),
                                    macroHotZoneABS            (2),
                                    femtoABS                   (3),
                                    r1BS                       (4)
                                 } (0..15),
         triggerType             INTEGER {
                                    cinr                       (0),
                                    rssi                       (1),
                                    rtd                        (2),
                                    numConsecutivePSFHsMissed  (3),
                                    rd                         (4)
                                 } (0..7),
         triggerFunction         INTEGER {
                                    nbrAbsGreaterThanAbsValue  (1),
                                    nbrAbsLessThanAbsValue     (2),
                                    nbrAbsGreaterThanSabsByRelVal (3),
                                    nbrAbsLessThanSabsByRelVal (4),
                                    sabsGreaterThanAbsValue    (5),
                                    sabsLessThanAbsValue       (6),
                                    nbrAbsCarriersGreaterThanThreshold (7)
                                 } (0..7),
         triggerAction           INTEGER {
                                    respondWithAAI-SCN-REP     (1),
                                    respondWithAAI-HO-REQ      (2),
                                    respondWithAAI-SCN-REQ     (3),
                                    declareABSUnreachable      (4),
                                    cancelHO                   (5)
                                 } (0..7),
         triggerValue            INTEGER (0..255),
         triggerAvgPara          INTEGER {
                                    one                        (0),
                                    oneOver2                   (1),
                                    oneOver4                   (2),
                                    oneOver8                   (3),
                                    oneOver16                  (4),
                                    oneOver32                  (5),
                                    oneOver64                  (6),
                                    oneOver128                 (7),
                                    oneOver256                 (8),
                                    oneOver512                 (9)
                                 } (0..255)
      }
   }
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Some boundary values
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
maxReceivedCodes            INTEGER ::= 32              -- N_Received_Codes(6 bits)

-- Equal to the size of RngAckBitmap
maxRngOpps                  INTEGER ::= 4
```



```
maxRngAckFrames             INTEGER ::= 8             -- N_Frame_Identifiers(3 bits)

maxPreassignedCarriers      INTEGER ::= 8             -- N_Preassigned_Carriers

maxPhyCarrierIndices        INTEGER ::= 64            -- N-PHY-Carrier-Indices

maxNeighborABSs             INTEGER ::= 64            -- N-NBR-ABSs

maxNeighborR1BSs            INTEGER ::= 64            -- N-NBR-R1BSs

maxCarriers                 INTEGER ::= 64            -- N-Carrier-Info

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- System Configuration Descriptor Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
Alpha ::=                   INTEGER {
                               one                        (0),
                               oneOver2                   (1),
                               oneOver4                   (2),
                               oneOver8                   (3),
                               oneOver16                  (4),
                               zero                       (5)
                            } (0..7)

-- The number of bits in the bit map = the maximum number of sub-bands
-- for a given FFT size (i.e., 2048 FFT, 1024 FFT, 512 FFT) - 1.
-- 2048 FFT: b0-b19
-- 1024 FFT: b0-b8
-- 512 FFT: b0-b2
-- bi = 1 if resource is changed between sub-band i and sub-band i+1.
-- bi = 0 if resource is not changed between sub-band i and sub-band i+1.
-- See 6.9.3.1.
ZoneAllocationBitmap ::=    CHOICE {
   fftSize2048                 BIT STRING (SIZE (20)),
   fftSize1024                 BIT STRING (SIZE (9)),
   fftSize512                  BIT STRING (SIZE (3))
}

-- Zone Flag bit. Indicates the use of the last zone.
-- 0b0: Unicast
-- 0b1: E-MBS
-- See 6.9.3.1.
ZoneFlag ::=                ENUMERATED {
                               unicast,
                               embs
                            }

-- The length of an MSI in units of the number of superframes
-- 0b00: 4 superframes, 80 ms (NMSI = 4)
-- 0b01: 8 superframes, 160 ms (NMSI = 8)
-- 0b10: 16 superframes, 320 ms (NMSI = 16)
-- 0b11: 32 superframes, 640 ms (NMSI = 32)
MsiLength ::=               INTEGER (4 | 8 | 16 | 32)
```

```
-- The location of the AAI frame where the E-MBS data burst ends
-- MSI length == 0b00: 4 bits
-- MSI length == 0b01: 5 bits
-- MSI length == 0b10: 6 bits
-- MSI length == 0b11: 7 bits
EmbsFrameOffset ::=         CHOICE {
   msiLength4FrameOffset       INTEGER (0..15),
   msiLength8FrameOffset       INTEGER (0..31),
   msiLength16FrameOffset      INTEGER (0..63),
   msiLength32FrameOffset      INTEGER (0..127)
}

DataSinrMax ::=             INTEGER (10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30
                                  | 32 | 34 | 36 | 38 | 40)

UlpcDataChannelSet ::=      SEQUENCE {
   -- gammaIotFp ( IoT) is the fairness and IoT control factor,
   -- broadcast by the ABS. It has 4 bits to represent the value among
   -- {0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2,
   -- 1.3, 1.4, 1.5}. It is different for each frequency partition
   -- (FP0, FP1, FP2, FP3)
   gammaIotArray               SEQUENCE (SIZE (4)) OF SEQUENCE {
      gammaIot                    INTEGER (0..15)             OPTIONAL
   },
   -- alpha is the factor according to the number of receive antennas
   -- at the ABS. It is 3 bits to express {1, 1/2, 1/4, 1/8, 1/16, 0,
   -- reserved, reserved}
   alpha                       Alpha,
   beta                        INTEGER (0..1),
   -- dataSinrMin is the SINR requirement for the minimum data rate
   -- expected by ABS. SINRmin_Data has 4 bits to represent the value
   -- in dB among {-INF, -3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5,
   -- 2, 2.5, 3, 3.5, 4}
   dataSinrMin                 INTEGER (0..15),
   -- dataSinrMax is the maximum SINR threshold defined by ABS.
   -- SINRmmax_Data has 4 bits to represent the value in dB among
   -- {10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40}
   dataSinrMax                 DataSinrMax
}

UlpcControlChannelSet ::=   SEQUENCE {
   -- It is the HARQ feedback channel target SINR value broadcasted
   -- by the ABS. It has 4 bits to represent the value among {-3.5, -3,
   -- -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4} dB
   targetHarqSinr              INTEGER (0..15),
   -- It is the synchronized channel target SINR value broadcasted
   -- by the ABS. It has 4 bits to represent the value among {-9, -8.5,
   -- -8, -7.5, -7, -6.5, -6, -5.5, -5, -4.5, -4, -3.5, -3, -2.5, -2,
   -- -1.5} dB
   targetSyncRangingSinr       INTEGER (0..15),
   -- It is the P-FBCH target SINR value broadcasted by the ABS.
   -- It has 4 bits to represent the value among {-4.5, -4, -3.5, -3,
   -- -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3} dB
   targetPfbchSinr             INTEGER (0..15),
```



```
   -- It is defined as 4 bits to represent {0, 0.5, 1, 1.5, 2, 2.5,
   -- 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5} dB.
   targetSfbchBaseSinr         INTEGER (0..15),
   -- It is defined as 3 bits to represent {0, 0.20, 0.21, 0.22, 0.23,
   -- 0.24, 0.25, 0.26}
   targetSfbchDeltaSinr        INTEGER (0..7),
   -- It is the bandwidth request channel target SINR value
   -- broadcasted by the ABS. It has 4 bits to represent the value
   -- among {-4.5, -4, -3.5, -3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5,
   -- 1, 1.5, 2, 2.5, 3} dB
   targetBwRequestSinr         INTEGER (0..15),
   -- It is 4 bits to represent the value among {0, 0.1, 0.2, 0.3, 0.4,
   -- 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5}.
   gammaIotSounding            INTEGER (0..15)             OPTIONAL,
   -- It is the minimum SINR requirement for sounding expected by ABS.
   -- It has 4 bits to represent the value in dB among { -4, -3.5, -3,
   -- -2.5, -2. -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5}
   soundingSinrMin             INTEGER (0..15)             OPTIONAL,
   -- It is the maximum SINR requirement for sounding expected by ABS.
   -- It has 4 bits to represent the value in dB among { 5, 6, 7, 8, 9,
   -- 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20}
   soundingSinrMax             INTEGER (5..20)             OPTIONAL
}

EMBSConfigParameters ::=    SEQUENCE {
   zoneAllocationBitmap        ZoneAllocationBitmap,
   zoneFlag                    ZoneFlag,
   msiLength                   MsiLength,
   embsFrameOffset             EmbsFrameOffset
}

PeriodOfPeriodicRngTimer ::= INTEGER (2 | 4 | 7 | 10 | 15 | 20 | 25 | 35) -- in sec

TReTxInterval ::=           CHOICE {
   dl-N-Max-ReTxEq4            INTEGER (1..8),
   dl-N-Max-ReTxEq8            INTEGER (1..4)
}

RangingSyncInfo ::=         SEQUENCE {
   -- the periodicity of ranging channel for synchronized AMSs
   -- allocation (Table 6-272)
   periodicityOfRngChSync      INTEGER (0..3),
   -- the parameter Ks controlling the start root index of ranging
   -- preamble codes for synchronized AMSs
   cntlStartCodeOfRngChSync    INTEGER (0..15),
   -- the number of codes for periodic ranging (Table 6-267)
   rangingPreambleCodeSync     INTEGER (0..3)
}

-- Sounding sequence
-- D is decimation value for frequency decimation multiplexing
-- P is number of codes for code division multiplexing
-- Present when Uplink AAI subframes for sounding in S-SFH SP1 is
-- not set to 0b000
```

```
MultiplexingType ::=        CHOICE {
   decimationValueD            INTEGER (4 | 6 | 8 | 9 | 12 | 16 | 18 | 36),
   maxCyclicShiftIndexP        INTEGER (4 | 6 | 8 | 9 | 12 | 16 | 18 | 36)
}

-- The number of HARQ feedback channel per HARQ feedback region.
-- Describes LHFB in 6.3.7.3.3.2.
HarqfdbkChannels ::=        CHOICE {
   fftSize512                  INTEGER (6 | 12 | 18 | 24),
   fftSize1024                 INTEGER (6 | 12 | 24 | 30),
   fftSize2048                 INTEGER (12 | 24 | 48 | 60)
}

-- quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB.
IotValue ::=                INTEGER (0..127)

NSPID ::=                   BIT STRING (SIZE (24))

VerboseName ::=             IA5String (SIZE (1..128))

VisitedNSPRealm ::=         IA5String (SIZE (1..128))

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- AAI-SCD message
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-SCD ::=                 SEQUENCE {
   configChangeCount           INTEGER (0..15),
   bsRestartCount              INTEGER (0..15),
   -- SA Preamble partition per ABS type
   -- 1: macro hot-zone,
   -- 2: Relay,
   -- 3: OSG femto,
   -- 4: CSG-open femto
   -- 5: CSG-closed femto ABSs
   -- Indicates the SA-Preamble partition information.
   -- Each 4 bits represent a partition range for each cell type,
   -- as defined in 6.3.5.1.2 and Table 6-170
   saPreamblePartitions        SEQUENCE (SIZE (5)) OF PreamblePart,
   triggers                    TriggerConditions,
   defaultTriggerAveParamForIntra ENUMERATED {
                                  one,
                                  half,
                                  quarter,
                                  one-8th,
                                  one-16th,
                                  one-32th,
                                  one-64th,
                                  one-128th,
                                  one-256th,
                                  one-512th
                               },
   defaultTriggerAveParamForInter ENUMERATED {
                                  one,
                                  half,
```



```
                              quarter,
                              one-8th,
                              one-16th,
                              one-32th,
                              one-64th,
                              one-128th,
                              one-256th,
                              one-512th
                           },
olMimoParameters           SEQUENCE {
   olRegionType0On            BOOLEAN,
   olRegionType1NLRUSize      INTEGER (0..15),
   olRegionType1SLRUSize      INTEGER (0..15),
   olRegionType2SLRUSize      INTEGER (0..15)
} OPTIONAL,
rangingSyncInfo            RangingSyncInfo             OPTIONAL,
periodOfPeriodicRngTimer   PeriodOfPeriodicRngTimer,
ulpcDataChannelIe          UlpcDataChannelSet,
ulpcControlChannelIe       UlpcControlChannelSet,
tReTxInterval              TReTxInterval,
-- BR Channel Configuration MIN Access Class for frame i, i+1, i+2,
-- and i+3 frame
brChCfgMINAccessClassForFrame SEQUENCE (SIZE (4)) OF SEQUENCE {
   accessClass                INTEGER (0..3)              OPTIONAL
},
-- Sounding sequence
-- D is decimation value for frequency decimation multiplexing
-- P is number of codes for code division multiplexing
-- Present when Uplink AAI subframes for sounding in S-SFH SP1 is
-- not set to 0b000
multiplexingType           MultiplexingType,
shiftValueUForSoundingSymbol INTEGER (0..255),
relayZoneAmsAlocIndc       INTEGER (0..1)              OPTIONAL,
embsConfigParameters       EMBSConfigParameters        OPTIONAL,
ulFeedbackInfoArray        SEQUENCE (SIZE (1..8)) OF SEQUENCE {
   primaryCarrierIndex        PhyCarrierIndex             OPTIONAL,
   -- The start DLRUs index for feedback channel
   startDLRUIndex             INTEGER (0..127),
   -- The number of DLRUs for feedback channel per UL AAI sub-frame
   -- (Refer to 6.3.8.3.3.2)
   numberOfDLRUs              INTEGER (0..15),
   -- The number of HARQ feedback channel per HARQ feedback region.
   -- Describes LHFB in 6.3.7.3.3.2. Channel numbers represented
   -- by the two bits (0, 1, 2, 3) are as follows.
   -- For 512 FFT size, 6, 12, 18, 24
   -- For 1024 FFT size, 6, 12, 24, 30
   -- For 2048 FFT size, 12, 24, 48, 60
   numberOfHARQChannels       HarqfdbkChannels
} OPTIONAL,
-- See Table 6-154 to Table 6-156.
-- Resource_Metric_FP2
-- Resource Metric of the first power deboosted frequency partition
-- which is defined in Table 6-144. This parameter does not affect
-- "Configuration Change Count"
```

```
   resourceMetricFP2           INTEGER (0..15)             OPTIONAL,
   -- See Table 6-151 to Table 6-153
   -- Resource_Metric_FP3
   -- Resource Metric of the second power deboosted frequency partition
   -- which is defined in Table 6-144. This parameter does not affect
   -- "Configuration Change Count"
   resourceMetricFP3           INTEGER (0..15)             OPTIONAL,
   -- Indicates whether ABS achives synchronization from backhaul
   -- network (0b01) or not (0b00)
   networkSynchronization      BOOLEAN                     OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Service Identity Information Advertisement
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-SII-ADV ::=             SEQUENCE {
   -- List of the verbose names of the NSPs. The value of Verbose
   -- NSP Name List is a list of verbose NSP names. The order of the
   -- Verbose NSP Names presented shall be in the same order as the
   -- NSP IDs presented in the NSP List.
   nspInfoList                 SEQUENCE (SIZE (1..16)) OF NSPID,
   -- Verbose NSP name string
   verboseNspNameList          SEQUENCE (SIZE (1..16)) OF VerboseName,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- AI_UL Noise and Interference Level Broadcast Message
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-ULPC-NI ::=             SEQUENCE {
   iotSounding                 IotValue                    OPTIONAL,
   -- IoT value of Frequency Partition #0, #1, #2, and #3,
   -- quantized in 0.5 dB steps as IoT level from 0 dB to 63.5 dB
   iotFreqPartitionList        SEQUENCE (SIZE (4)) OF SEQUENCE {
      iotValue                    IotValue                    OPTIONAL
   },
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Network entry / re-entry messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- single type definition for ranging messages
MACAddress ::=              BIT STRING (SIZE (48))

MACVersion ::=              INTEGER (0..255)

CRID ::=                    BIT STRING (SIZE (72))

DID ::=                     BIT STRING (SIZE (12))

CSGID ::=                   BIT STRING (SIZE (1..24))
```



```
SMS ::=                     OCTET STRING (SIZE (1..140))

SFID ::=                    BIT STRING (SIZE (32))

MapMaskSeed ::=             BIT STRING (SIZE (15))

IPv4Address ::=             OCTET STRING (SIZE (4))

IPPortNumber ::=            INTEGER (0..65535)

OperatorID ::=              BIT STRING (SIZE (24))

CapabilityIndex ::=         INTEGER (0..31)

DeviceClass ::=             INTEGER (0..31)

FeatureSupport ::=          ENUMERATED {
                               notSupported,
                               supported
                            }

IPv6HomeNetworkPrefix ::=   BIT STRING (SIZE (64))

-- complex type definition for ranging messages
FidInfo ::=                 SEQUENCE {
   flowIdentifier              FID,
   fidChangeCount              FidChangeCount,
   dlULIndicator               ENUMERATED {
                                  dl,
                                  ul
                               }
}

AddressOrDID ::=            CHOICE {
   -- be selected for R1 network mode
   macAddress                  MACAddress,
   -- be selected for non R1 network mode
   deregistrationID            DID
}

PagingControlInfo ::=       SEQUENCE {
   pagingControllerID          PCID,
   pagingGroupID               PGID,
   pagingCycle                 PgCycle,
   pagingOffset                PgOffset
}

CsgInfoItem ::=             SEQUENCE {
   operatorID                  OperatorID                  OPTIONAL,
   csgIdList                   SEQUENCE (SIZE (1..64, ...)) OF CSGID
}

LocationUpdateRsp ::=       INTEGER {
                               successOfLocationUpdate     (0),
```

```
                               failureOfLocationUpdate     (1),
                               successOfLocationUpdateAndDLTrafficPending (3),
                               allowAmsDcrInitReqOrExtensionReq (4),
                               rejectAmsDcrInitReqOrExtensionReq (5)
                               -- 0x6~0xF: Reserved
                            } (0..15)

BitmapPlusNewSfInfo ::=     SEQUENCE {
   serviceFlowUpdateBitmap     BIT STRING (SIZE (16)),
   -- for each 1 bit in the service flow update bitmap
   flowIDUpdate                SEQUENCE (SIZE (0..16)) OF SEQUENCE {
      newEMBSID                   EMBSID,
      newFID                      FID
   }
}

CurrentSfPlusNewSfInfo ::=  SEQUENCE {
   -- for loop of N_EMBS_IDs (maximum value is 7)
   flowInfoUpdate              SEQUENCE (SIZE (0..7)) OF SEQUENCE {
      currentEMBSID               EMBSID,
      currentFID                  FID,
      newEMBSID                   EMBSID,
      newFID                      FID
   }
}

BitmapAndSfInfo ::=         CHOICE {
   -- be selected when serviceFlowUpdateIndicator = 0b0
   bitmapPlusNewSfInfo         BitmapPlusNewSfInfo,
   -- be selected when serviceFlowUpdateIndicator = 0b1
   currentSfPlusNewSfInfo      CurrentSfPlusNewSfInfo
}

EMBSZoneInfoItem ::=        SEQUENCE {
   embsZoneID                  EMBSZoneID,
   newEMBSZoneID               EMBSZoneID                 OPTIONAL,
   physicalCarrierIndex        PhyCarrierIndex            OPTIONAL,
   bitmapAndServiceFlowInfo    BitmapAndSfInfo
}

SuccessOfLocationUpdate ::= SEQUENCE {
   paginggroupidupdate         BIT STRING (SIZE (32))      OPTIONAL,
   pagingoffsetupdate          BIT STRING (SIZE (24))      OPTIONAL,
   newPagingCycle              PgCycle                     OPTIONAL,
   newPagingGroupID            PGID                        OPTIONAL,
   newPagingOffset             PgOffset                    OPTIONAL,
   deregistrationID            DID                         OPTIONAL,
   newPagingControllerID       PCID                        OPTIONAL,
   embsZoneInfo                SEQUENCE (SIZE (1..8)) OF EMBSZoneInfoItem OPTIONAL,
   multicastInfo               SEQUENCE (SIZE (1..16)) OF SEQUENCE {
      currentMulticastGroupID     MulticastGroupID,
      currentFID                  FID,
      newMulticastGroupID         MulticastGroupID,
      newFID                      FID
```



```
   } OPTIONAL,
   smsMessage                  SMS                          OPTIONAL
}

RngRspForHoReentryInfo ::=  SEQUENCE {
   multicastInfo               SEQUENCE (SIZE (1..15)) OF SEQUENCE {
      currentMulticastGroupID     MulticastGroupID,
      currentFID                  FID,
      newMulticastGroupID         MulticastGroupID,
      newFID                      FID
   } OPTIONAL
}

LocationUpdateResponse ::=  SEQUENCE {
   locationUpdateRsp           LocationUpdateRsp            OPTIONAL,
   locationUpdateResult        CHOICE {
      -- locationUpdateResponse = 0x0
      successOfLocationUpdate     SuccessOfLocationUpdate,
      others                      NULL
   }
}

InitialNetworkEntry ::=     SEQUENCE {
   amsidOrMacAddress           CHOICE {
      -- be selected for advanced network mode and AMSID privacy is
      -- enabled
      amsidStarHashValue          MACAddress,
      -- be selected for other cases
      macAddress                  MACAddress
   },
   macVersion                  MACVersion,
   -- The bit size represents power level ranging from -15dB (0x00) to
   -- 26dB (0x1F)
   -- The value is determined by AMS after successful initial ranging
   -- process.
   initialOffsetUlpc           INTEGER (0..31),
   ...
}

HandoverReentry ::=         SEQUENCE {
   stidOrMacAddress            CHOICE {
      -- be selected if STID is not pre assigned
      stidInfo                    SEQUENCE {
         servingBsid                 BSID,
         previousSTID                STID
      },
      -- be selected if STID is pre assigned
      addressInfo                 CHOICE {
         -- be selected for R1 network mode
         macAddress                  MACAddress,
         -- be selected for non R1 network mode
         currentSTID                 STID
      }
   },
```

```
   akCount                   AKCount                     OPTIONAL,
   fidList                   SEQUENCE (SIZE (1..24)) OF FidInfo OPTIONAL,
   initialOffsetUlpc INTEGER (0..31)OPTIONAL,
   ...
}

NetworkReentryFromIdleMode ::= SEQUENCE {
   addressOrDID              AddressOrDID,
   pagingControlInfo         PagingControlInfo,
   akCount                   AKCount                     OPTIONAL,
   fidList                   SEQUENCE (SIZE (1..24)) OF FidInfo OPTIONAL,
   ...
}

LocationUpdate ::=        SEQUENCE {
   addressOrDID              AddressOrDID,
   pagingControlInfo         PagingControlInfo,
   pagingCycleChange         PgCycle                     OPTIONAL,
   pagingCarrierUpdate       INTEGER (0..63)             OPTIONAL,
   akCount                   AKCount                     OPTIONAL,
   amsMobility               AMSMobilityLevel            OPTIONAL,
   smsMessage                SMS                         OPTIONAL,
   ...
}

DCRModeExtension ::=      SEQUENCE {
   crid                      CRID,
   akCount                   AKCount                     OPTIONAL,
   ...
}

EmergencyCallSetup ::=    SEQUENCE {
   macAddress                MACAddress,
   macVersion                MACVersion,
   initialOffsetUlpc         INTEGER (0..31),
   ...
}

ReentryFromDCR ::=        SEQUENCE {
   crid                      CRID,
   stidInfo                  SEQUENCE {
      previousServingBsid       BSID,
      previousSTID              STID
   } OPTIONAL,
   akCount                   AKCount                     OPTIONAL,
   fidList                   SEQUENCE (SIZE (1..24)) OF FidInfo OPTIONAL,
   amsidOrMacAddress CHOICE {
      amsidStarHashValue MACAddress,
      macAddress MACAddress
   },
   macVersion MACVersion,
   initialOffsetUlpc INTEGER (0..31),
   ...
```



```
}

NetworkReentryFromR1 ::= SEQUENCE {
   -- be selected for advanced network mode and AMSID privacy is enabled
   amsidStarHashValue          MACAddress                  OPTIONAL,
   servingBsid                 BSID,
   macAddress                  MACAddress,
   akCount                     AKCount                     OPTIONAL,
   ...
}

ZoneSwitch ::=              SEQUENCE {
   -- be selected for advanced network mode and AMSID privacy is enabled
   zoneSwitchInfo              CHOICE {
      receiveTSTID                SEQUENCE {
         tstid                       STID,
         amsidStarHashValue          MACAddress                  OPTIONAL
      },
      receiveBsid                 SEQUENCE {
         servingBsid                 BSID,
         previousBasicCid            CID
      }
   },
   akCount                     AKCount                     OPTIONAL,
   ...
}

FemtoInterference ::=       SEQUENCE {
   akCount                     AKCount                     OPTIONAL,
   ...
}

NsEpCallSetup ::=           SEQUENCE {
   macAddress                  MACAddress,
   macVersion                  MACVersion,
   initialOffsetUlpc           INTEGER (0..31),
   ...
}
NetworkReentryFromIdleModeR1 ::= SEQUENCE {
   pagingControllerId PCID,
   macAddressMACAddressOPTIONAL,
   akCountAKCountOPTIONAL,
   ...
}

NetworkReentryFromIdleModeR1 ::= SEQUENCE {
   pagingControllerId PCID,
   ...
}

ReentryProOptimization ::=  BIT STRING {
                               omitSbcMessages             (0),
```

```
                            omitPkmAuthenticationPhase  (1),
                            omitRegMessages             (2),
                            omitIPRefresh               (3),
                            contextAvailability         (4)
                         } (SIZE (5))

ImCapabilities ::=       BIT STRING {                           -- 1: supported
                            dlPMICoordination           (0),
                            dlCollaborativeMBSMIMO      (1),
                            dlClosedLoopMbsMacroDiversity (2),
                            ulPmiCombination            (3),
                            multiBsSoundingCalibration  (4)
                         } (SIZE (5))

EmbsCapabilities ::=     BIT STRING {
                            servingAbsOnly              (0),
                            macroDiversityMultiAbs      (1),
                            nonMacroDiversityMultiAbs   (2)
                         } (SIZE (3))

R1R1Support ::=      BIT STRING {
                            fiveMHz                     (0),
                            tenMHz                      (1),
                            eightDotSevenFiveMHz        (2),
                            sevenMHz                    (3)
                         } (SIZE (4))

McCapabilities ::=       ENUMERATED {
                            noMcModes,
                            basicMcMode,
                            mcAggregation,
                            mcSwitching,
                            mcAggregationAndSwitching
                         }

SoundingAntennaSw ::=    ENUMERATED {
                            amongDLRx,
                            amongULTx
                         }

ReportMetric ::=         BIT STRING {
                            absCINRMean                 (0),
                            absRSSIMean                 (1),
                            relativeDelay               (2),
                            absRTD                      (3)
                         } (SIZE (4))

AmsCapabilities ::=      SEQUENCE {
   maxARQBufferSize         INTEGER (0..8388607)        OPTIONAL,
   maxNonARQBufferSize      INTEGER (0..8388607)        OPTIONAL,
   multicarrierCapabilities McCapabilities              OPTIONAL,
   zoneSwitchingMode        FeatureSupport              OPTIONAL,
   agpsMethod               FeatureSupport              OPTIONAL,
   imCapabilities           ImCapabilities              OPTIONAL,
```



```
   embsCapabilities            EmbsCapabilities            OPTIONAL,
   channelBwAndCyclicPrefix    BIT STRING {
                                  fiveMHz1Over16              (0),
                                  fiveMHz1Over8               (1),
                                  fiveMHz1Over4               (2),
                                  tenMHz1Over16               (3),
                                  tenMHz1Over8                (4),
                                  tenMHz1Over4                (5),
                                  twentyMHz1Over16            (6),
                                  twentyMHz1Over8             (7),
                                  twentyMHz1Over4             (8),
                                  eightDotSevenFiveMHz1Over16 (9),
                                  eightDotSevenFiveMHz1Over8  (10),
                                  eightDotSevenFive5MHz1Over4 (11),
                                  sevenMHz1Over16             (12),
                                  sevenMHz1Over8              (13),
                                  sevenMHz1Over4              (14)
                               } (SIZE (15))               OPTIONAL,
   frameConfigOfR1R1       R1R1Support             OPTIONAL,
   persistentAllocation        FeatureSupport              OPTIONAL,
   groupResourceAllocation     FeatureSupport              OPTIONAL,
   coLocatedCoexistence        BIT STRING {
                                  typeI                       (0),
                                  typeII-1                    (1),
                                  typeII-2                    (2),
                                  typeII-3                    (3),
                                  typeIII                     (4)
                               } (SIZE (5))                OPTIONAL,
   hoTriggerMetric             ReportMetric                OPTIONAL,
   ebbHandover                 FeatureSupport              OPTIONAL,
   -- shall be 0 when multicarrier capability = 0b010 or 0b100
   minHoRentryIntlvInterval    INTEGER (0..3)              OPTIONAL,
   soundingAntSwitching        FeatureSupport              OPTIONAL,
   antennaConfig               SoundingAntennaSw           OPTIONAL
}

CsCapabilities ::=          SEQUENCE {
   csSpecificationTypes        CsSpecificationTypes        OPTIONAL,
   maxNoOfClassificationRules  INTEGER (0..65535)          OPTIONAL,
   rohc                        FeatureSupport              OPTIONAL,
   phs                         INTEGER {
                                  packetPhs                   (1)
                               } (0..1)                    OPTIONAL,
   -- may only be present AAI_REG-RSP
   resourceRetainTime          INTEGER (0..65535)          OPTIONAL
}

ClcLimits ::=               SEQUENCE {
   type1Indicator              BOOLEAN,
   type2Indicator              BOOLEAN,
   -- 0: the maximum number of active CLC classes is 8
   -- otherwise: the maximum number = 1..7
   activeClassLimit            INTEGER (0..7),
   activeRatioLimit            INTEGER (0..63),
```

```
   activeIntervalLimit         INTEGER (0..31)
}

InterRatOpMode ::=          INTEGER {
                               singleRadioMode             (0),
                               multiRadioMode              (1)
                            } (0..3)

BroadcastRngAck ::=         SEQUENCE {
   aggregatedRngAckList        SEQUENCE (SIZE (1..maxRngAckFrames)) OF AggregatedRngAck
}

AggregatedRngAck ::=        SEQUENCE {
   frameIdentifier             FrameIdentifier,
   rngAckBitmap                RngAckBitmap,
   rngOppsStatusList           SEQUENCE (SIZE (1..maxRngOpps)) OF RangingOppStatus
        OPTIONAL
}

FrameIdentifier ::=         SEQUENCE {
   superFrameNumber            INTEGER (0..3),
   frameIndex                  INTEGER (0..3)
}

RngAckBitmap ::=            BIT STRING {
                               rngOpp1                     (0),
                               rngOpp2                     (1),
                               rngOpp3                     (2),
                               rngOpp4                     (3)
                            } (SIZE (4))

RangingOppStatus ::=        SEQUENCE {
   receivedCodesList           SEQUENCE (SIZE (1..maxReceivedCodes)) OF SEQUENCE {
      rngPreambleIndex            PreambleIndex2,
      rngStatus                   RangingStatus
   }
}

RangingStatus ::=           CHOICE {
   success                     AdjustmentParameters,
   abort                       RangingAbort,
   continue                    AdjustmentParameters
}

Sign ::=                    ENUMERATED {
                               positive,
                               negative
                            }

AdjustmentParameters ::=    SEQUENCE {
   timeingOffsetAdjustment     SEQUENCE {
      sign                        Sign,
      timingOffset                INTEGER (1..16384)
   } OPTIONAL, -- unit = 1/Fs
```



```
   powerLevelAdjustment        SEQUENCE {
      sign                        Sign,
      powerLevelOffset            INTEGER (1..8)
   } OPTIONAL, -- unit = dB
   frequencyOffsetAdjustment   SEQUENCE {
      -- unit = 2% of subcarrier spacing
      sign                        Sign,
      frequencyOffset             INTEGER (1..256)
   } OPTIONAL
}

RangingAbort ::=            CHOICE {
   noMoreRanging               NULL,
   rngAbortTimer               INTEGER (1..65535)
}

RedirectionInfo ::=         SEQUENCE {
   absidForNeighborABS         BSID,
   preambleForNeighborABS      PreambleIndex,
   centerFreqForNeighborABS    CenterFreq
}

ArqParameter ::= SEQUENCE {
   arqEnable ENUMERATED {
      arqNotRequested,
      arqRequested
   } OPTIONAL,
   arqWindowSize             INTEGER (1..65535) OPTIONAL, -- > 0 and • (ARQ_BSN_MODULUS/2)
   arqBlockLifeTime           INTEGER (0..65535) OPTIONAL,
   arqSyncLossTimeout         INTEGER (0..65535) OPTIONAL,
   arqPurgeTimeout            INTEGER (0..65535) OPTIONAL,
   arqSubBlockSize            INTEGER (0..7)    OPTIONAL,
   arqErrorDetectionTimeout    INTEGER (0..65535) OPTIONAL,
   arqFeedbackPollRetryTimeout INTEGER (0..65535) OPTIONAL
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Ranging Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-RNG-REQ ::=             SEQUENCE {
   -- Indicate whether this message is protected by CM
   cmacIndicator               CMACI,
   rangingPurposeDiffMessage   CHOICE {
      initialNetworkEntry         InitialNetworkEntry,
      handoverReentry             HandoverReentry,
      networkReentryFromIdleMode  NetworkReentryFromIdleMode,
      idleModeLocationUpdate      LocationUpdate,
      dcrModeExtension            DCRModeExtension,
      emergencyCallSetup          EmergencyCallSetup,         -- e.g., E911
      -- Location update for updating service flow management encoding
      -- of E-MBS flows
      locationUpdateEmbsFlows     LocationUpdate,
```

```
      -- Location update for transition to DCR mode from idle mode
      locationUpdateToDcrMode     LocationUpdate,
      -- Reentry from DCR mode, coverage loss or detection of
      -- different ABS restart count
      reentryFromDcr              ReentryFromDCR,
      -- Network reentry from a R1 BS
      networkReentryFromR1    NetworkReentryFromR1,
      -- Zone switch to MZONE from LZONE
      zoneSwitch                  ZoneSwitch,
      locationUpdatePowerDown     LocationUpdate,
      -- experiencing "femto interference"
      femtoInterference           FemtoInterference,
      -- NS/EP Call Setup
      nsEpCallSetup               NsEpCallSetup,
      networkReentryFromIdleModeR1  NetworkReentryFromIdleModeR1,
      ...
   },
   -- CSG information
   csgInformation              SEQUENCE (SIZE (1..15)) OF CsgInfoItem OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Ranging Response Message
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-RNG-RSP ::=             SEQUENCE {
   -- set to 1 when an ABS rejects the AMS
   rangingAbortFlag            BOOLEAN,
   timerOrSTID                 CHOICE {
      -- Timer defined by an ABS to prohibit the AMS from attempting
      -- network entry at this ABS, for a specific time duration
      -- Value 65535 (When the received CSGID(s) from the AMS
      -- does not match any of the CSGID(s) of the Femto ABS.
      -- This value indicates the Ranging Abort Timer is not
      -- to be used, and the AMS can range any time.)
      -- Value 0 (do not try ranging again at the ABS)
      -- Value 1-65534, in units of seconds
      rangingAbortTimer           INTEGER (0..65535),
      availableRangingRsp         RangingResponse
   },
   ...
}

RangingResponse ::=         SEQUENCE {
   tempStidOrSTID              CHOICE {
      temporarySTID               STID,
      stid                        STID
   } OPTIONAL,
   mapMaskSeed                 MapMaskSeed,
   amsidOrMacAddress           CHOICE {
      -- selected for advanced network mode and AMSID privacy is enabled
      amsidStarHashValue          MACAddress,
      -- selected for other cases
      macAddress                  MACAddress
```



```
},
crid                          CRID                        OPTIONAL,
-- response based on ranging purpose sent in AAI-RNG-REQ
rangingPurpose                CHOICE {
   emergencyCallSetup            SEQUENCE {
      emergencyServiceFID           FID (2..15)
   },
   nsEpCallSetup                 SEQUENCE {
      nsEPServiceFID                FID (2..15)
   },
   locationUpdatePowerDown       LocationUpdateResponse,
   locationUpdateEmbsFlows       LocationUpdateResponse,
   idleModeLocationUpdate        LocationUpdateResponse,
   locationUpdateToDcrMode       LocationUpdateResponse,
   dcrModeExtension              LocationUpdateResponse
} OPTIONAL,
-- bitmap for Reentry Process Optimization
reentryProcessOptimization  ReentryProOptimization      OPTIONAL,
activationDeadline            INTEGER (0..63)             OPTIONAL,
-- 1: perform neighbor station measurement report
nbrBsMeasurementRptIndicator BOOLEAN                      OPTIONAL,
resourceRetainTime            INTEGER (0..255)            OPTIONAL,
flowUpdating                  SEQUENCE (SIZE (1..24)) OF SEQUENCE {
   sfid                          SFID,
   updateOrDelete                ENUMERATED {
                                    update,
                                    delete
                                 },
   dlULIndicator                 ENUMERATED {
                                    dl,
                                    ul
                                 },
   updatedQoSInfo                QosParameter                OPTIONAL,
   rohc                          FeatureSupport              OPTIONAL,
   phs                           INTEGER {
                                    packetPhs                   (1)
                                 } (0..1)                    OPTIONAL
   arqParameter ArqParameter OPTIONAL
} OPTIONAL,
unsolicitedBsGrantIndicator BOOLEAN                       OPTIONAL,
clcResponse                   CLCResponse                 OPTIONAL,
csgIdList                     SEQUENCE (SIZE (1..64, ...)) OF CSGID OPTIONAL,
nbrAbsRedirectInfoList        SEQUENCE (SIZE (1..8)) OF RedirectionInfo OPTIONAL,
rangingRequestBit             BOOLEAN                     OPTIONAL,
invalidFIDList                SEQUENCE (SIZE (1..24)) OF SEQUENCE {
   fid                           FID,
   dlULIndicator                 ENUMERATED {
                                    dl,
                                    ul
                                 }
} OPTIONAL,
saidUpdateBitMap              BIT STRING (SIZE (16))      OPTIONAL,
rngRspForHandoverReentry      RngRspForHoReentryInfo      OPTIONAL,
mzoneSfidList                 SEQUENCE (SIZE (1..24)) OF SFID OPTIONAL,
```

```
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Ranging Acknowledge
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-RNG-ACK ::=             SEQUENCE {
   unicastIndication           CHOICE {
      broadcastRngAck             BroadcastRngAck,
      unicastRngAck               RangingStatus
   },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Ranging Confirmation
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-RNG-CFM ::=             SEQUENCE {
   amsStid                     STID,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Basic Capability Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-SBC-REQ ::=             SEQUENCE {
   amsNspRequest               CHOICE {
      serviceInfoQuery            BIT STRING {
                                     reqNspIdList                (0),
                                     reqVerboseNameList          (1)
                                  } (SIZE (2)),
      sbcRequest                  SEQUENCE {
         capabilityIndex             CapabilityIndex,
         deviceClass                 DeviceClass,
         clcRequest                  CLCRequest                 OPTIONAL,
         dlLongTTI                   FeatureSupport             OPTIONAL,
         ulSounding                  BIT STRING {
                                        fDM                        (0),
                                        cDM                        (1)
                                     } (SIZE (2))               OPTIONAL,
         oLRegion                    BIT STRING {
                                        type0                      (0),
                                        type1                      (1),
                                        type2                      (2)
                                     } (SIZE (3))               OPTIONAL,
         dlFfrResourceMetric         FeatureSupport             OPTIONAL,
         dlMaxNumOfSuMimoStreams     INTEGER (1..8)             OPTIONAL,
         dlMaxNumOfMuMimoStreams     INTEGER (1..2)             OPTIONAL,
         ulMaxNumOfSuMimoStreams     INTEGER (1..4)             OPTIONAL,
         ulMaxNumOfMuMimoStreams     INTEGER (1..4)             OPTIONAL,
         dlMIMOModes                 BIT STRING {
                                        -- 1: supported, 0: not supported
                                        mode0                      (0),
                                        mode1                      (1),
```



```
                              mode2                       (2),
                              mode3                       (3),
                              mode4                       (4),
                              mode5                       (5)
                           } (SIZE (6))                OPTIONAL,
    ulMIMOModes            BIT STRING {
                              -- 1: supported, 0: not supported
                              mode0                       (0),
                              mode1                       (1),
                              mode2                       (2),
                              mode3                       (3),
                              mode4                       (4)
                           } (SIZE (5))                OPTIONAL,
    dlFeedback             BIT STRING {                        -- 1: supported
                              differentialMode            (0),
                              mimoFeedbackMode0           (1),
                              mimoFeedbackMode1           (2),
                              mimoFeedbackMode2           (3),
                              mimoFeedbackMode3           (4),
                              mimoFeedbackMode4           (5),
                              mimoFeedbackMode5           (6),
                              mimoFeedbackMode6           (7),
                              mimoFeedbackMode7           (8),
                              longTermReporting           (9),
                              shortTermReporting          (10)
                           } (SIZE (11))               OPTIONAL,
    subBandAAMAP           FeatureSupport              OPTIONAL,
    dlPilotPatternMUmimo   BIT STRING {
                              dl4Stream                   (0),
                              dl8Stream                   (1)
                           } (SIZE (2))                OPTIONAL,
    ulPilotPatternMUmimo   BIT STRING {
                              ul2Stream                   (0),
                              ul4Stream                   (1),
                              ul8Stream                   (2)
                           } (SIZE (3))                OPTIONAL,
    numberOfTxAntennas     ENUMERATED {
                              oneAntenna,
                              twoAntenna,
                              fourAntenna
                           }                           OPTIONAL,
    modulationSchemes      BIT STRING {
                              dl64QAM                     (0),
                              ul64QAM                     (1)
                           } (SIZE (2))                OPTIONAL,
    ulHARQBufferingCap     INTEGER (1..128)            OPTIONAL,
    dlHARQBufferingCap     INTEGER (1..128)            OPTIONAL,
    amsDlProcessingCap     INTEGER (1..128)            OPTIONAL,
    amsUlProcessingCap     INTEGER (1..128)            OPTIONAL,
    fftSizes               BIT STRING {
                              fft2048                     (0),
                              fft1024                     (1),
                              fft512                      (2)
                           } (SIZE (3))                OPTIONAL,
```

```
        authorizationPolicy         ENUMERATED {
                                       noAuthorization,
                                       eapBasedAuthorization
                                    }                          OPTIONAL,
        interRatOperationMode       InterRatOpMode             OPTIONAL,
        interRatTypesSupport        BIT STRING {
                                       ieee802-11                  (0),
                                       geran                       (1),
                                       utran                       (2),
                                       e-utran                     (3),
                                       cdma2000                    (4)
                                    } (SIZE (5))               OPTIONAL,
        mihCapabilitySupported      FeatureSupport             OPTIONAL,
        maxTxPower                  SEQUENCE {
           maxTxPowerForQPSK           INTEGER (0..255),
           maxTxPowerFor16QAM          INTEGER (0..255),
           maxTxPowerFor64QAM          INTEGER (0..255)
        },
        aRSnetworkentry             SEQUENCE {
           relaymode                   BOOLEAN                    OPTIONAL,
           aRSTTG                      INTEGER (0..49)            OPTIONAL,
                --present if relaymode == 0
           aRSRTG                      INTEGER (0..49)            OPTIONAL
                --present if relaymode == 0
        } OPTIONAL,
        visitedNSPID                NSPID                      OPTIONAL,
        ...
     } --sbcRequest sequence
  }, -- amsNspRequest choice
  ...
}

NspInformation ::=          SEQUENCE {
  -- Shall present if AAI-SII-ADV Message Pointer is not included.
  -- Optional if AAI-SII-ADV Message Pointer is included.
  nspIdentifier               SEQUENCE (SIZE (1..16)) OF NSPID OPTIONAL,
  -- if SIQ bit 1 is set. The order of Verbose NSP Names presented shall be in
  -- the same order as the NSP IDs presented in the NSP List.
  verboseNspNameList          SEQUENCE (SIZE (1..16)) OF VerboseName OPTIONAL,
  aaiSiiAdvPointer            INTEGER (0..16383)          OPTIONAL
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Basic Capability Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-SBC-RSP ::=             SEQUENCE {
  sbcRspInfo                  CHOICE {
     nspInformation              NspInformation,
     noSiq                       SEQUENCE {
        capabilityIndex             CapabilityIndex,
        deviceClass                 DeviceClass,
        clcResponse                 CLCResponse                OPTIONAL,
        dlLongTTI                   FeatureSupport             OPTIONAL,
        ulSounding                  BIT STRING {
```



```
                            fDM                         (0),
                            cDM                         (1)
                         } (SIZE (2))                OPTIONAL,
oLRegion                 BIT STRING {
                            type0                       (0),
                            type1                       (1),
                            type2                       (2)
                         } (SIZE (3))                OPTIONAL,
dlFfrResourceMetric      FeatureSupport              OPTIONAL,
dlMaxNumOfSuMimoStreams  INTEGER (1..8)              OPTIONAL,
dlMaxNumOfMuMimoStreams  INTEGER (1..2)              OPTIONAL,
ulMaxNumOfSuMimoStreams  INTEGER (1..4)              OPTIONAL,
ulMaxNumOfMuMimoStreams  INTEGER (1..4)              OPTIONAL,
dlMIMOModes              BIT STRING {
                            -- 1: supported, 0: not supported
                            mode0                       (0),
                            mode1                       (1),
                            mode2                       (2),
                            mode3                       (3),
                            mode4                       (4),
                            mode5                       (5)
                         } (SIZE (6))                OPTIONAL,
ulMIMOModes              BIT STRING {
                            -- 1: supported, 0: not supported
                            mode0                       (0),
                            mode1                       (1),
                            mode2                       (2),
                            mode3                       (3),
                            mode4                       (4)
                         } (SIZE (5))                OPTIONAL,
dlFeedback               BIT STRING {                        -- 1: supported
                            differentialMode            (0),
                            mimoFeedbackMode0           (1),
                            mimoFeedbackMode1           (2),
                            mimoFeedbackMode2           (3),
                            mimoFeedbackMode3           (4),
                            mimoFeedbackMode4           (5),
                            mimoFeedbackMode5           (6),
                            mimoFeedbackMode6           (7),
                            mimoFeedbackMode7           (8),
                            longTermReporting           (9),
                            shortTermReporting          (10)
                         } (SIZE (11))               OPTIONAL,
subBandAAMAP             FeatureSupport              OPTIONAL,
dlPilotPatternMUmimo     BIT STRING {
                            dl4Stream                   (0),
                            dl8Stream                   (1)
                         } (SIZE (2))                OPTIONAL,
ulPilotPatternMUmimo     BIT STRING {
                            ul2Stream                   (0),
                            ul4Stream                   (1),
                            ul8Stream                   (2)
                         } (SIZE (3))                OPTIONAL,
numberOfTxAntennas       ENUMERATED {
```

```
                                 oneAntenna,
                                 twoAntenna,
                                 fourAntenna
                              }                          OPTIONAL,
        modulationSchemes     BIT STRING {
                                 dl64QAM                    (0),
                                 ul64QAM                    (1)
                              } (SIZE (2))               OPTIONAL,
        ulHARQBufferingCap    INTEGER (1..128)           OPTIONAL,
        dlHARQBufferingCap    INTEGER (1..128)           OPTIONAL,
        amsDlProcessingCap    INTEGER (1..128)           OPTIONAL,
        amsUlProcessingCap    INTEGER (1..128)           OPTIONAL,
        fftSizes              BIT STRING {
                                 fft2048                    (0),
                                 fft1024                    (1),
                                 fft512                     (2)
                              } (SIZE (3))               OPTIONAL,
        authorizationPolicy   ENUMERATED {
                                 noAuthorization,
                                 eapBasedAuthorization
                              }                          OPTIONAL,
        interRatOperationMode InterRatOpMode             OPTIONAL,
        interRatTypesSupport  BIT STRING {
                                 ieee802-11                 (0),
                                 geran                      (1),
                                 utran                      (2),
                                 e-utran                    (3),
                                 cdma2000                   (4)
                              } (SIZE (5))               OPTIONAL,
        mihCapabilitySupported FeatureSupport            OPTIONAL,
        visitedNspRealmName   VisitedNSPRealm            OPTIONAL
      }
   },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Registration Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
CsSpecificationTypes ::=    BIT STRING {
                               packetIpv4              (1),
                               packetIpv6              (2),
                               packetEthernet          (3),
                               packetIpv4OrIpv6        (14),
                               multiProtocol           (15)
                            } (SIZE (16))
MobilityFeaturesSupported ::= BIT STRING {
hoSupport (0),
sleepModeSupport (1),
dCRModeSupport (2)
reserved(3)
} (SIZE (4))
AAI-REG-REQ ::=             SEQUENCE {
```



```
   amsMacAddress               MACAddress,
   amsCapNegotiation           AmsCapabilities,
   csCapabilities              CsCapabilities,
   hostCfgCapIndicator         FeatureSupport,
   -- maximum requested host configuration size is 1023 octets
   requestedHostConfig         OCTET STRING (SIZE (0..1023)) OPTIONAL,
   globalCarrierConfigChangeCount INTEGER (0..7),
   amsInitAgpServiceAdaptation FeatureSupport              OPTIONAL,
   vendorID                    VendorID                    OPTIONAL,
   mobilityFeaturesSupported   MobilityFeaturesSupported   OPTIONAL.
...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Registration Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-REG-RSP ::=             SEQUENCE {
   stidAndMAPMaskSeed          SEQUENCE {
      stid                        STID,
      mapMaskSeed                 MapMaskSeed
   } OPTIONAL,
   crid                        CRID                        OPTIONAL,
   femtoAbsLdm                 SEQUENCE {
      startSuperframeOffset       INTEGER (0..511),
      availableIntervalLeng       INTEGER (0..15),
      unavailableIntervalLeng     INTEGER (0..255)
   } OPTIONAL,
   agpsMethod                  FeatureSupport              OPTIONAL,
   imCapabilities              ImCapabilities              OPTIONAL,
   antennaConfig               SoundingAntennaSw           OPTIONAL,
   embsCapabilities            EmbsCapabilities            OPTIONAL,
   persistentAllocation        FeatureSupport              OPTIONAL,
   groupResourceAllocation     FeatureSupport              OPTIONAL,
   hoTriggerMetric             ReportMetric                OPTIONAL,
   csCapabilities              CsCapabilities              OPTIONAL,
   ipv4HostAddress             IPv4Address                 OPTIONAL,
   ipv6HomeNetworkPrefix       IPv6HomeNetworkPrefix       OPTIONAL,
   -- maximum additional host configuration IE size is 1023 octets
   additionalHostConfigIe      OCTET STRING (SIZE (0..1023)) OPTIONAL,
   redirectionInfoArray        SEQUENCE (SIZE (1..8)) OF RedirectionInfo OPTIONAL,
   csgIdlength                 INTEGER (1..24)             OPTIONAL,
   globalCarrierCfgChangeCount INTEGER (0..7),
   multicarrierCapabilities    McCapabilities              OPTIONAL,
   csTypeOfDefaultServiceFlow  CsSpecification             OPTIONAL,
   clcLimits                   SEQUENCE (SIZE (1..2)) OF ClcLimits OPTIONAL,
   amsInitAgpServiceAdaptation FeatureSupport              OPTIONAL,
   vendorID                    VendorID                    OPTIONAL,
   mobilityFeaturesSupported   MobilityFeaturesSupported   OPTIONAL.
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Network exit Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

```
IdleModeRetain ::=          BIT STRING {
                               sbcMessages                 (0),
                               -- Retain info associated with SBC messages
                               pkmMessages                 (1),
                               -- Retain info associated with PKM messages
                               regMessages                 (2),
                               -- Retain info associated with REG messages
                               networkAddr                 (3),
                               -- Retain info associated with network addresses
                               msState                     (4)
                               -- Retain MS state information
                            } (SIZE (5))

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DeRegistration Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-DREG-REQ ::=            SEQUENCE {
   deRegReqCode                CHOICE {
      deregFromABSAndNetwork      NULL,                       -- 0x00
      deregAndInitIdleMode        DeregAndInitIdleMode,       -- 0x01
      unsolicitedDeregRspWithAct05 NULL,                      -- 0x02
      rejectUnsolicitedDeregRsp   NULL,                       -- 0x03
      deregToEnterDcrMode         DeregToEnterDcrMode,        -- 0x04
      unsolicitedDeregRspWithAct00-01-02-03 NULL,             -- 0x05
      ...
   },
   ...
}

DeregAndInitIdleMode ::=    SEQUENCE {
   pgCycleReq                  PgCycle,
   idleModeRetainInfo          IdleModeRetain,
   -- if a system supports Mobility information
   -- Slow (0-10km/h), Medium (10-120km/h), Fast (above 120km/h)
   mobilityInfo                AMSMobilityLevel            OPTIONAL
}

DeregToEnterDcrMode ::=     SEQUENCE {
   idleModeRetainInfo          IdleModeRetain
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DeRegistration Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-DREG-RSP ::=            SEQUENCE {
   actionCode                  CHOICE {
      attempyNewNtwkEntry         NULL,                       -- 0x00
      listenAndNoTx               NULL,                       -- 0x01
      listenAndTxOnControlConnection NULL,                    -- 0x02
      returnAndTxOnActiveConnection NULL,                     -- 0x03
      amsTerminateNormalOperation NULL,                       -- 0x04
      initiateIdleMode            InitiateIdleMode,           -- 0x05
      rejectIdleModeInitiationRequest RejectIdleModeInitiationRequest, -- 0x06
      allowIdleModeInitiationRequest AllowIdleModeInitiationRequest, --0x07
```

```
      allowConnectionInfoRetention NULL,                        -- 0x08
      rejectConnectionInfoRetention NULL,                       -- 0x09
      ...
   },
   ...
}

InitiateIdleMode ::=        SEQUENCE {
   pagingCycle                 PgCycle,
   pagingOffset                PgOffset,
   pagingControllerId          PCID,
   pagingGroupId               PGID,
   -- if Network Configuration indicates ABS is attached to the advanced network
   deRegId                     DREGID                      OPTIONAL,
   idleModeRetainInfo          IdleModeRetain,
   reqDuration                 INTEGER (0..255)            OPTIONAL
}

RejectIdleModeInitiationRequest ::= SEQUENCE {
   reqDuration                 INTEGER (0..255)            OPTIONAL
}

AllowIdleModeInitiationRequest ::= SEQUENCE {
   pagingCycle                 PgCycle,
   pagingOffset                PgOffset,
   pagingControllerId          PCID,
   pagingGroupId               PGID,
   -- if Network Configuration indicates ABS is attached to the advanced network
   deRegId                     DREGID                      OPTIONAL,
   idleModeRetainInfo          IdleModeRetain
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Connection management Messages *
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
ServiceClassName ::=        IA5String (SIZE (2..128))

DataRate ::=                INTEGER (0..4294967295)

Interval ::=                INTEGER (0..65535)

GlobalServiceClassName ::=  SEQUENCE {
   directionIndicator          DirIndicator                OPTIONAL,
   maxSustainedRate            INTEGER (0..63)             OPTIONAL,
   maxTrafficBurst             INTEGER (0..63)             OPTIONAL,
   minReservedTrafficRate      INTEGER (0..63)             OPTIONAL,
   maxLatency                  INTEGER (0..63)             OPTIONAL,
   pagingPreference            PagingPreference            OPTIONAL,
   reqTransmissionPolicy       ReqTransmissionPolicy       OPTIONAL,
   ulGrantScheduling           UlGrantScheduling           OPTIONAL,
   toleratedJitter             INTEGER (0..63)             OPTIONAL,
   trafficPriority             INTEGER (0..7)              OPTIONAL,
   unsolicitedGrantInterval    INTEGER (0..63)             OPTIONAL,
   unsolicitedPollingInterval  INTEGER (0..63)             OPTIONAL
```

```
}

VendorID ::=                BIT STRING (SIZE (24))

QosParameterSetType ::=     BIT STRING {
                               provisionedSet              (0),
                               admittedSet                 (1),
                               activeSet                   (2)
                            } (SIZE (3))

DirIndicator ::=            ENUMERATED {
                               uplink,
                               downlink
                            }

ConfirmationCode ::=        ENUMERATED {
                               successful,
                               failure
                            }

-- The mapping of predefined BR index used in quick access message to
-- BR size and BR actions
PredefinedBrIndex ::=       SEQUENCE {
   brIndex                     INTEGER (0..15)             OPTIONAL,
   brAction                    INTEGER {
                                  ertPS                       (0),
                                  aGP                         (1),
                                  br                          (2)
                               } (0..3)                    OPTIONAL,
   brSize                      INTEGER (0..2047)           OPTIONAL
} -- bytes

UplinkQosInfo ::=           SEQUENCE {
   ulGrantScheduling           UlGrantScheduling           OPTIONAL,
   ulSchedulingType            CHOICE {
      ertPs                       SEQUENCE {
         unsolicitedGrantInterval    Interval
      }, -- ms
      ugs                         SEQUENCE {
         unsolicitedGrantInterval    Interval
      }, -- ms
      rtPs                        SEQUENCE {
         unsolicitedPollingInterval  Interval
      }, -- ms
      agPs                        SEQUENCE {
         priGrantPollingInterval     Interval,                          -- ms
         secGrantPollingInterval     Interval                 OPTIONAL, -- ms
         priGrantSize                GrantSize,                         -- bytes
         secGrantSize                GrantSize                OPTIONAL, -- bytes
         adaptationMethod            ENUMERATED {
                                        absInitiated,
                                        amsInitiated
                                     }
      }
```



```
   },
   accessClass                 INTEGER (0..3)              OPTIONAL,
   differentiatedBrTimer       INTEGER (1..64)             OPTIONAL, -- frames
   predefinedBrIndexList       SEQUENCE (SIZE (0..15)) OF PredefinedBrIndex OPTIONAL,
   initialBackoffWindowSize    INTEGER (0..15)             OPTIONAL,
   maxBackoffWindowSize        INTEGER (0..15)             OPTIONAL,
   backoffScalingFactor        INTEGER (0..15)             OPTIONAL
}

QosParameter ::=            SEQUENCE {
   trafficPriority             INTEGER (0..7)              OPTIONAL,
   maxSustainedRate            DataRate                    OPTIONAL, -- bps
   maxTrafficBurst             DataRate                    OPTIONAL, -- bytes
   minReservedTrafficRate      DataRate                    OPTIONAL, -- bps
   maxLaytency                 DataRate                    OPTIONAL, -- ms
   pagingPreference            PagingPreference            OPTIONAL,
   reqTransmissionPolicy       ReqTransmissionPolicy       OPTIONAL,
   toleratedJitter             DataRate                    OPTIONAL, -- ms
   directionalQosInfo          CHOICE {
      downlinkInfo                NULL,
      uplinkInfo                  UplinkQosInfo
   },
   macInOrderDelivery          ENUMERATED {
                                  notPreserved,
                                  preserved
                               }                           OPTIONAL,
   orderPreservation           CHOICE {
      notPreservation             NULL,
      preservation                SEQUENCE {
         nonArqReorderTimeout        INTEGER (1..32)
      }
   }, -- 5ms
   vendorId                    VendorID                    OPTIONAL
}

GrantSize ::=               INTEGER (0..65535)

UlGrantScheduling ::=       ENUMERATED {
                               undefined,
                               bestEffort,
                               nrtPs,
                               rtPs,
                               ertPs,
                               ugs
                            }

ReqTransmissionPolicy ::=   BIT STRING {
                               broadcastBr                 (0),
                               multicastBr                 (1),
                               piggyback                   (2),
                               noFragmentation             (3),
                               noPhs                       (4),
                               noPcking                    (5),
                               noRohc                      (6)
```

```
                            } (SIZE (7))

PagingPreference ::=        ENUMERATED {
                               noPagingGeneration,
                               pagingGeneration
                            }

DataDeliveryServices ::=    INTEGER {
                               ugs                            (0),
                               rtVrs                          (1),
                               nrtVrs                         (2),
                               be                             (3),
                               ertVrs                         (4),
                               aGPs                           (5)
                            } (0..255)

CsSpecification ::=         INTEGER {
                               packetIpv4                     (1),
                               packetIpv6                     (2),
                               packetEthernet                 (3),
                               packetIpv4OrIpv6               (14),
                               multiProtocol                  (15)
                            } (0..255)

PacketErrorRate ::=         SEQUENCE {
   perMeasurement              ENUMERATED {
                                  postArqHarq,
                                  beforeArqHarq
                               },
   perValue                    CHOICE {
      percentage                  INTEGER (0..63),            -- 0 to 63%
      negExponentialOf10          INTEGER (0..63)
   } -- PER = 10EXP -N/10
}

ArqAttribute ::=            SEQUENCE {
   arqEnable                   ENUMERATED {
                                  arqNotRequested,
                                  arqRequested
                               }                             OPTIONAL,
   arqWindowSize               INTEGER (1..65535)            OPTIONAL, --
   arqBlockLifeTime            INTEGER (0..65535)            OPTIONAL, -- 100us
   arqSyncLossTimeout          INTEGER (0..65535)            OPTIONAL, -- 100us
   arqPurgeTimeout             INTEGER (0..65535)            OPTIONAL, -- 100us
   -- sub-block size = 2^(P+3), 0<=P<=7
   arqSubBlockSize             INTEGER (0..7)                OPTIONAL, -- Bytes
   arqErrorDetectionTimeout    INTEGER (0..65535)            OPTIONAL, -- 100s
   arqFeedbackPollRetryTimeout INTEGER (0..65535)            OPTIONAL  -- 100s
}

IpAddrAndMask ::=           CHOICE {
   ipV4                        SEQUENCE {
      ipAddr                      BIT STRING (SIZE (32)),
      ipMask                      BIT STRING (SIZE (32))
```



```
   },
   ipV6                        SEQUENCE {
      ipAddr                      BIT STRING (SIZE (128)),
      ipMask                      BIT STRING (SIZE (128))
   }
}

ProtocolPortRange ::=       SEQUENCE {
   lowPortNumber               IPPortNumber,
   highPortNumber              IPPortNumber
}

ClassificationRule ::=      SEQUENCE {
   priority                    INTEGER (0..255)            OPTIONAL,
   protocolField               INTEGER (0..255)            OPTIONAL,
   ipMaskAndSrcAddr            IpAddrAndMask               OPTIONAL,
   ipMaskAndDestAddr           IpAddrAndMask               OPTIONAL,
   protocolSrcPortRange        ProtocolPortRange           OPTIONAL,
   protocolDestPortRange       ProtocolPortRange           OPTIONAL,
   associatedPhsiIndex         INTEGER (0..255)            OPTIONAL,
   classificationRuleIndex     INTEGER (0..65535)          OPTIONAL,
   vendorID                    VendorID                    OPTIONAL,
   ipV6FlowLabel               BIT STRING (SIZE (24))      OPTIONAL,
   classificationAction        ENUMERATED {
                                  none,
                                  discard
                               }                           OPTIONAL,
   dscpValue                   INTEGER (0..63)             OPTIONAL,
   phsDscAction                PHSDSCAction                OPTIONAL,
   phsRuleAdded                PhsRuleActions              OPTIONAL,
   ethernetAttributes          EthernetAttributes          OPTIONAL,
   innerIpProtocolInfo         InnerIpProtocolInfo         OPTIONAL
}

InnerIpProtocolInfo ::=     SEQUENCE {
   innerSrcIpAddr              BIT STRING (SIZE (32))      OPTIONAL,
   innerDestIpAddr             BIT STRING (SIZE (32))      OPTIONAL,
   innerProtocolField          BIT STRING (SIZE (8))       OPTIONAL,
   innerTos                    BIT STRING (SIZE (8))       OPTIONAL,
   innerIpv6FlowLable          BIT STRING (SIZE (8))       OPTIONAL
}

PHSDSCAction ::=            ENUMERATED {
                               addPHSRule,
                               setPHSRule,
                               deletePHSRule,
                               deleteAllPHSRules
                            }

PhsRuleActions ::=          CHOICE {
   addPhsRule                  PhsRule,
   setPhsRule                  PhsRule,
   deletePhsRule               INTEGER (0..255),
   deleteAllPhsRules           NULL
```

```
}

PhsRule ::=                 SEQUENCE {
   phsiField                   INTEGER (0..255)            OPTIONAL,
   phsfField                   OCTET STRING (SIZE (0..255)) OPTIONAL,
   -- phsmField[x] = 0 don't surpress x's byte,
   -- phsmField[x] = 1 subpress x's byte
   phsmField                   BIT STRING (SIZE (0..255))  OPTIONAL,
   phssField OCTET STRING (SIZE (0..255)) OPTIONAL,
   phsvField                   ENUMERATED {
                                  verify,
                                  doNotVerify
                               }                           OPTIONAL,
   vendorSpecificPHSParameters OCTET STRING (SIZE (0..999)) OPTIONAL
}

EthMacAddrAndMask ::=       SEQUENCE {
   ethMacAddress               MACAddress,
   ethMaskAddress              MACAddress
}

EtherType ::=               ENUMERATED {
                               noLayer3Matching,
                               dixSnap,
                               dsap
                            }

EtherType16Bits ::=         SEQUENCE {
   eprot1                      BIT STRING (SIZE (16)),
   eprot2                      BIT STRING (SIZE (16))
}

EtherType8Bits ::=          SEQUENCE {
   eprot1                      BIT STRING (SIZE (8)),
   eprot2                      BIT STRING (SIZE (8))
}

Ieee802Dot2Sap ::=          SEQUENCE {
   ethType                     EtherType,
   layer3ProtocolId            CHOICE {
      noL3Matching                NULL,
      dixSnapEncp                 EtherType16Bits,
      dsapEncp                    EtherType8Bits
   }
}

UserPriority ::=            SEQUENCE {
   priorityLow                 INTEGER (0..7),
   priorityHigh                INTEGER (0..7)
}

EthernetAttributes ::=      SEQUENCE {
   ethMaskAndDestMacAddr       EthMacAddrAndMask           OPTIONAL,
   ethMaskAndSrcMacAddr        EthMacAddrAndMask           OPTIONAL,
```



```
   ieee802Dot2Sap              Ieee802Dot2Sap              OPTIONAL,
   userPriority                UserPriority                OPTIONAL,
   vlanId                      BIT STRING (SIZE (12))      OPTIONAL
}

RohcAttributes ::=          SEQUENCE {
   maxContextId                INTEGER (0..65535)          OPTIONAL,
   largeContextId              INTEGER {
                                  smallCid                    (0),
                                  largeCid                    (1)
                               } (0..255)                  OPTIONAL,
   -- 0: no segmentation,
   -- 1..65535 Maximum reconstructed reception unit in Byte
          rohcMrru                    INTEGER (0..65535)          OPTIONAL,
   rohcProfile OCTET STRING (SIZE (0..255)) OPTIONAL,
   -- 0: no associated ROHC feedback,
   -- 1.. 8388607 SFID for ROHC feedback.
   rohcFeedbackChannel    INTEGER (0..8388607)    OPTIONAL
}

EMBSService ::=             BIT STRING {
                               embsInServingABSOnly        (0),
                               embsInZoneWithMacroDiversity (1),
                               embsInZoneWithoutMacroDiversity (2)
                            } (SIZE (3))

ClassifierDSCAction ::=     ENUMERATED {
                               dscAddClassifier,
                               dscReplaceClassifier,
                               dscDeleteClassifier
                            }

GroupID ::=                 INTEGER (0..4095)

GroupResourceAllocInfo ::=  SEQUENCE {
   groupID                     GroupID,
   longTTIIndicator            ENUMERATED {
                                  oneAAISubframe,
                                  fourOrAllAAISubframes
                               },
   periodicity                 ENUMERATED {
                                  oneFrame,
                                  twoFrames,
                                  fourFrames,
                                  eightFrames
                               },
   mimoModeSet                 ENUMERATED {
                                  mode0,
                                  mode1And2,
                                  mode2,
                                  mode2And4
                               },
   userBitmapSize              ENUMERATED {
```

```
                                size4,
                                size8,
                                size16,
                                size32
                             },
   userBitmapIndex           INTEGER (0..31),
   initialACID               INTEGER (0..15),
   numberOfACIDs             INTEGER (0..7),
   resourceSizeInclusionBitmap BIT STRING (SIZE (16))
}

SleepRspCode ::=            ENUMERATED {
                               unsolicitedRequest,
                               slpReqApproved,
                               slpReqRejected
                            }

FastFbkChannelOp ::=        ENUMERATED {
                               fastFbkChKept,
                               fastFbkChDeallocAtFrame,
                               autoFastFbkChDealloc
                            }

SleepCycleSetting ::=       CHOICE {
   request                     SleepReqAction,
   response                    SleepRspAction
}

SleepReqAction ::=          SEQUENCE {
   operation                   CHOICE {
      switchSleepCycle            SEQUENCE {
         sleepCycleID                SCID,
         startFrameNumber            INTEGER (0..63)
      },
      changeSleepCycle            SEQUENCE {
         sleepCycleID                SCID,
         startFrameNumber            INTEGER (0..63),
         trafficIndicationFlag       TrafficIndicationFlag,
         listeningWindowExtFlag      ListeningWindowExtFlag,
         nextSleepCycleIndicator     NextSleepCycleIndicator,
         initialSleepCycle           INTEGER (0..15),
         finalSleepCycle             INTEGER (0..1023),
         listeningWindow             INTEGER (0..63),
         newInitialSleepCycle        INTEGER (0..31)            OPTIONAL,
         tAMS                        INTEGER (0..31)            OPTIONAL
      }
   }
}

SleepRspAction ::=          SEQUENCE {
   responseCode                SleepRspCode,
   operation                   CHOICE {
      switchSleepCycle            SEQUENCE {
         sleepCycleID                SCID                       OPTIONAL,
```



```
         startFrameNumber            INTEGER (0..63)             OPTIONAL,
         ffbchOperation              FastFbkChannelOp            OPTIONAL
      },
      changeSleepCycle            SEQUENCE {
         sleepCycleID                SCID                        OPTIONAL,
         startFrameNumber            INTEGER (0..63)             OPTIONAL,
         ffbchOperation              FastFbkChannelOp            OPTIONAL,
         trafficIndicationFlag       TrafficIndicationFlag       OPTIONAL,
         listeningWindowExtFlag      ListeningWindowExtFlag      OPTIONAL,
         nextSleepCycleIndicator     NextSleepCycleIndicator     OPTIONAL,
         initialSleepCycle           INTEGER (0..15)             OPTIONAL,
         finalSleepCycle             INTEGER (0..1023)           OPTIONAL,
         listeningWindow             INTEGER (0..63)             OPTIONAL,
         slpId                       SLPID                       OPTIONAL,
         newInitialSleepCycle        INTEGER (0..31)             OPTIONAL,
         tAMS                        INTEGER (0..31)             OPTIONAL
      }
   } OPTIONAL,
   reqDuration                 INTEGER (0..255)            OPTIONAL
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DSA Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AbsInitDsaInfo ::=          SEQUENCE {
   sfid                        SFID,
   fid                         FID
}

UnicastAvailIntervalBitmap ::= CHOICE {
   nmsi4                       BIT STRING (SIZE (4)),
   nmsi8                       BIT STRING (SIZE (8)),
   nmsi16                      BIT STRING (SIZE (16)),
   nmsi32                      BIT STRING (SIZE (32))
}

AdditionalSfInfo ::=        SEQUENCE {
   qosParameterSet             QosParameterSetType         OPTIONAL,
   serviceClassName            ServiceClassName            OPTIONAL,
   globalServiceClass          GlobalServiceClassName      OPTIONAL,
   csSpecificationType         CsSpecification             OPTIONAL,
   dataDeliveryServices        DataDeliveryServices        OPTIONAL,
   arqAttributes               ArqAttribute                OPTIONAL,
   classificationRules         ClassificationRule          OPTIONAL,
   rohcAttributes              RohcAttributes              OPTIONAL,
   sduInterArrival             Interval                    OPTIONAL, -- 0.5ms
   timeBase                    Interval                    OPTIONAL, -- ms
   sduSize                     INTEGER (0..255)            DEFAULT 49,
   targetSaid                  INTEGER (0..255)            OPTIONAL,
   packetErrorRate             PacketErrorRate             OPTIONAL,
   macHeaderType               ENUMERATED {
                                  agmh,
                                  spmh
                               }                           OPTIONAL
```

```
}

GroupParaCreateChange ::=   SEQUENCE {
   commonQosParameters         SEQUENCE {
      qosParameter                QosParameter                OPTIONAL,
      additionalSfInfo            AdditionalSfInfo            OPTIONAL
   },
   qtySfid                     INTEGER (1..32)             OPTIONAL,
   groupFidList                SEQUENCE (SIZE (1..32)) OF SEQUENCE {
      fid                         FID
   },
   groupFidParameterArray      SEQUENCE (SIZE (1..32)) OF SEQUENCE {
      fid                         FID,
      nonCommonQosParameters      SEQUENCE {
         qosParameter                QosParameter                OPTIONAL,
         additionalSfInfo            AdditionalSfInfo            OPTIONAL
      }
   } OPTIONAL
}

CoupledGroupCreateChange ::= SEQUENCE {
   commonQosParameters         SEQUENCE {
      qosParameter                QosParameter                OPTIONAL,
      additionalSfInfo            AdditionalSfInfo            OPTIONAL
   },
   qtyCoupledSfid              INTEGER (0..32)             OPTIONAL,
   coupledFidArray             SEQUENCE (SIZE (1..16)) OF SEQUENCE {
      fid                         FID
   },
   coupledNonCommonFidArray    SEQUENCE (SIZE (1..16)) OF SEQUENCE {
      fid                         FID,
      nonCommonQosParameters      SEQUENCE {
         qosParameter                QosParameter                OPTIONAL,
         additionalSfInfo            AdditionalSfInfo            OPTIONAL
      }
   } OPTIONAL
}

AAI-DSA-REQ ::=             SEQUENCE {
   fidChangeCount              FidChangeCount,
   absInitDsaInfo              AbsInitDsaInfo              OPTIONAL,
   directionIndicator          DirIndicator,
   qoSParameters               QosParameter                OPTIONAL,
   additionalSfInfo            AdditionalSfInfo            OPTIONAL,
   emergencyIndication         BOOLEAN                     OPTIONAL,
   embsService                 EMBSService                 OPTIONAL,
   fullEMBSIDArray             SEQUENCE (SIZE (1..8)) OF SEQUENCE {
      embsZoneID                  EMBSZoneID,
      carrierIndex                PhyCarrierIndex,
      embsidFIDMappingList        SEQUENCE (SIZE (1..15)) OF SEQUENCE {
         embsid                      EMBSID,
         fid                         FID
      }
   } OPTIONAL,
```



```
   unicastAvailIntervalBitmap  UnicastAvailIntervalBitmap  OPTIONAL,
   groupParameterCreateChange  GroupParaCreateChange       OPTIONAL,
   coupledGroupCreateChange    CoupledGroupCreateChange    OPTIONAL,
   multicastGroup              SEQUENCE (SIZE (1..16)) OF SEQUENCE {
      multicastGroupId            MulticastGroupID,
      fid                         FID
   } OPTIONAL,
   sleepCycleSetting           SleepCycleSetting           OPTIONAL,
   harqChannelsList            SEQUENCE (SIZE (1..16)) OF INTEGER (0..15) OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DSA Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-DSA-RSP ::=             SEQUENCE {
   fidChangeCount              FidChangeCount,
   confirmationCode            ConfirmationCode,
   fid                         FID                         OPTIONAL,
   groupParameterCreateChange  SEQUENCE {
      fidArray                    SEQUENCE (SIZE (1..16)) OF SEQUENCE {
         fid                         FID                         OPTIONAL
      }
   } OPTIONAL,
   embsService                 EMBSService                 OPTIONAL,
   fullEMBSIDArray             SEQUENCE (SIZE (1..8)) OF SEQUENCE {
      embsZoneID                  EMBSZoneID,
      carrierIndex                PhyCarrierIndex             OPTIONAL,
      embsidFIDMappingArray       SEQUENCE (SIZE (1..15)) OF SEQUENCE {
         embsid                      EMBSID,
         fid                         FID
      }
   } OPTIONAL,
   carrierSwitching            CHOICE {
      unicastAvailIntervalBitmap  UnicastAvailIntervalBitmap,
      aaiEmbsRepMsg               NULL
   } OPTIONAL,
   multicastGroup              SEQUENCE (SIZE (1..16)) OF SEQUENCE {
      multicastGroupId            MulticastGroupID
   } OPTIONAL,
   sleepCycleSetting           SleepCycleSetting           OPTIONAL,
   macHeaderType ENUMERATED {
      agmh,
      spmh
   } OPTIONAL,
   predefinedBrIndexList SEQUENCE (SIZE (0..15)) OF PredefinedBrIndex OPTIONAL,
   arqAttributes ArqAttribute OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DSA Acknlowledge
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

```
AAI-DSA-ACK ::=             SEQUENCE {
   fidChangeCount              FidChangeCount,
   confirmationCode            ConfirmationCode,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DSC Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AbsInitDscInfo ::=          SEQUENCE {
   sfid                        SFID
}

AAI-DSC-REQ ::=             SEQUENCE {
   fidChangeCount              FidChangeCount,
   absInitDscInfo              AbsInitDscInfo              OPTIONAL,
   directionIndicator          DirIndicator,
   serviceClassName            ServiceClassName            OPTIONAL,
   globalServiceClass          GlobalServiceClassName      OPTIONAL,
   qosParameterSet             QosParameterSetType         OPTIONAL,
   qoSParameters               QosParameter                OPTIONAL,
   sduInterArrival             Interval                    OPTIONAL, -- 0.5ms
   timeBase                    Interval                    OPTIONAL, -- ms
   classifierDSCAction         ClassifierDSCAction         OPTIONAL,
   classificationRules         ClassificationRule          OPTIONAL,
   arqAttributes  ArqAttribute OPTIONAL,
   rohcAttributes              RohcAttributes              OPTIONAL,
   packetErrorRate             PacketErrorRate             OPTIONAL,
   emergencyIndication         BOOLEAN                     OPTIONAL,
   embsService                 EMBSService                 OPTIONAL,
   fullEMBSIDArray             SEQUENCE (SIZE (1..8)) OF SEQUENCE {
      embsZoneID                  EMBSZoneID,
      newEmbsZoneID               EMBSZoneID,
      carrierIndex                PhyCarrierIndex             OPTIONAL,
      serviceFlowUpdateType       CHOICE {
         bitmapAndNew                SEQUENCE {
            serviceFlowUpdateBitmap     BIT STRING (SIZE (16)),
            embsidFIDMappingArray       SEQUENCE (SIZE (1..16)) OF SEQUENCE {
               newEMBSID                   EMBSID,
               newFID                      FID
            }
         },
         currentAndNew               SEQUENCE (SIZE (1..16)) OF SEQUENCE {
            currentEMBSID               EMBSID,
            currentFID                  FID,
            newEMBSID                   EMBSID,
            newFID                      FID
         }
      }
   } OPTIONAL,
   unicastAvailIntervalBitmap  UnicastAvailIntervalBitmap  OPTIONAL,
   groupParameterCreateChange  GroupParaCreateChange       OPTIONAL,
   coupledGroupCreateChange    CoupledGroupCreateChange    OPTIONAL,
   multicastGroupAddition      SEQUENCE (SIZE (1..16)) OF SEQUENCE {
```



```
      multicastGroupAddedId       MulticastGroupID
   } OPTIONAL, -- multicast group id to be added
   multicastGroupDeletion      SEQUENCE (SIZE (1..16)) OF SEQUENCE {
      multicastGroupDeletedId     MulticastGroupID
   } OPTIONAL, -- multicast group id to be deleted
   sleepCycleSetting           SleepCycleSetting           OPTIONAL,
   initialBackoffWindowSize    INTEGER (0..15)             OPTIONAL,
   maxBackoffWindowSize        INTEGER (0..15)             OPTIONAL,
   backoffScalingFactor        INTEGER (0..15)             OPTIONAL,
   harqChannelsList            SEQUENCE (SIZE (1..16)) OF INTEGER (0..15) OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DSC Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-DSC-RSP ::=             SEQUENCE {
   fidChangeCount              FidChangeCount,
   sfid                        SFID                        OPTIONAL,
   confirmationCode            ConfirmationCode,
   groupParameterCreateChange  SEQUENCE {
      fidArray                    SEQUENCE (SIZE (1..16)) OF SEQUENCE {
         fid                         FID                         OPTIONAL
      }
   } OPTIONAL,
   sleepCycleSetting           SleepCycleSetting           OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DSC Acknlowledge
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-DSC-ACK ::=             SEQUENCE {
   fidChangeCount              FidChangeCount,
   confirmationCode            ConfirmationCode,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DSD Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
DsdEmbsInfo ::=             SEQUENCE {
   embsZoneID                  EMBSZoneID,
   embsidFIDMappingArray       SEQUENCE (SIZE (1..15)) OF SEQUENCE {
      embsid                      EMBSID,
      fid                         FID
   }
}

AAI-DSD-REQ ::=             SEQUENCE {
   fidChangeCount              FidChangeCount,
   fid                         FID                         OPTIONAL,
   dsdEmbsInfo                 DsdEmbsInfo                 OPTIONAL,
   sleepCycleSetting           SleepCycleSetting           OPTIONAL,
```

```
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- DSD Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-DSD-RSP ::=             SEQUENCE {
   fidChangeCount              FidChangeCount,
   fid                         FID                          OPTIONAL,
   confirmationCode            ConfirmationCode,
   sleepCycleSetting           SleepCycleSetting            OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Group Configuration
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Group Configuration
AAI-GRP-CFG ::=             SEQUENCE {
   deletionFlag                ENUMERATED {
                                  flowAdded,
                                  flowDeleted
                               },
   dlULIndicator               ENUMERATED {
                                  dlAllocation,
                                  ulAllocation
                               },
   flowID                      FID,
   burstSize                   INTEGER (0..31)              OPTIONAL,
   graInfo                     CHOICE {
      graInfoForDeletededFlow     NULL,
      graInfoForAddedFlow         GroupResourceAllocInfo
   },
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Security Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
PKMID ::=                   INTEGER (0..255)

AKID ::=                    BIT STRING (SIZE (64))

SAID ::=                    INTEGER (0..255)

KeyLifetime ::=             INTEGER (0..4294967295)

CounterTEK ::=              INTEGER (0..65535)

EKS ::=                     INTEGER (0..3)

Nonce ::=                   BIT STRING (SIZE (64))

PKM-ReauthRequest ::=       SEQUENCE {
```



```
   cmacIndicator               CMACI,
   ...
}

PKM-EAPTransfer ::=         SEQUENCE {
   eapPayload                  OCTET STRING (SIZE (1..1400)),
   ...
}

PKM-KeyAgreementMsg1 ::=    SEQUENCE {
   nonceABS                    Nonce,
   akID                        AKID,
   keyLifetime                 KeyLifetime,
   cmacIndicator               CMACI,
   ...
}

PKM-KeyAgreementMsg2 ::=    SEQUENCE {
   nonceABS                    Nonce,
   nonceAMS                    Nonce,
   akID                        AKID,
   securityNegoParameters      SecurityNegotiationPara     OPTIONAL,
   cmacIndicator               CMACI,
   ...
}

PKM-KeyAgreementMsg3 ::=    SEQUENCE {
   nonceABS                    Nonce,
   nonceAMS                    Nonce,
   supportingSAs               SupportingSAs               OPTIONAL,
   securityNegoParameters      SecurityNegotiationPara     OPTIONAL,
   cmacIndicator               CMACI,
   ...
}

PKM-TEKRequest ::=          SEQUENCE {
   said                        SAID,
   tekRefreshFlag              ENUMERATED {
                                  secondTEKUpdate,
                                  firstTEKUpdate
                               }                           OPTIONAL,
   cmacIndicator               CMACI,
   ...
}

PKM-TEKReply ::=            SEQUENCE {
   said                        SAID,
   counterTEK                  CounterTEK,
   eks                         EKS,
   cmacIndicator               CMACI,
   ...
}

PKM-TEKInvalid ::=          SEQUENCE {
```

```
   said                        SAID,
   cmacIndicator               CMACI,
   ...
}

SecurityNegotiationPara ::= SEQUENCE {
   sizeOfICV                   ENUMERATED {
                                  thirtyTwoBits,
                                  sixtyFourBits
                               },
   windowSize                  INTEGER (0..65535)
}

SupportingSAs ::=           BIT STRING {
                               nullSASupported             (0),
                               said1Supported              (1),
                               said2Supported              (2)
                            } (SIZE (3))

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Privacy Key Management Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-PKM-REQ ::=             SEQUENCE {
   pkmid                       PKMID,
   pkmMessage                  CHOICE {
      reauthRequest               PKM-ReauthRequest,
      eapTransfer                 PKM-EAPTransfer,
      keyAgreementMsg2            PKM-KeyAgreementMsg2,
      tekRequest                  PKM-TEKRequest,
      tekInvalid                  PKM-TEKInvalid,
      ...
   },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Privacy Key Management Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-PKM-RSP ::=             SEQUENCE {
   pkmid                       PKMID,
   pkmMessage                  CHOICE {
      eapTransfer                 PKM-EAPTransfer,
      keyAgreementMsg1            PKM-KeyAgreementMsg1,
      keyAgreementMsg3            PKM-KeyAgreementMsg3,
      tekReply                    PKM-TEKReply,
      tekInvalid                  PKM-TEKInvalid,
      ...
   },
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- ARQ Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```



```
ArqBlockSn ::=              INTEGER (0..1023)

-- Maximum size of ARQFeedbackIe is the maximum number of transport
-- flow IDs
ARQFeedbackIe ::=           SEQUENCE (SIZE (0..11)) OF SEQUENCE {
   fid                         FID,
   arqFeedbackIeType           CHOICE {
      cumulativeAck               SEQUENCE {
         -- indicates ARQ blocks up to and including the sequence number
         -- in the SN field have been received successfully.
         sequenceNumber              ArqBlockSn
      },
      selectiveAck                SEQUENCE {
         -- indicates ARQ blocks less than the sequence number in the SN
         -- field have been received successfully.
         sequenceNumber              ArqBlockSn,
         nackSuspendedIndicator      ENUMERATED {
                                        zeroIndicatesNACK,
                                        zeroIndicatesNACKSuspended
                                     },
         -- Each bit in the map represents ACK or NACK or NACK Suspended
         -- of corresponding ARQ block.
         -- 0: NACK or NACK suspended,
         -- 1: ACK
         -- Maximum number of selectiveAckMap is the ARQ_Window_size
         -- (512)
         selectiveAckMap             BIT STRING (SIZE (1..512)),
         arqSubBlockInfo             SEQUENCE {
            -- The numbers of bits in subblock-Existence Map is equal to
            -- the number of bits that indicates the NACKed ARQ blocks in
            -- the Selective ACK MAPs.
            -- 1: Partially NACKed ARQ block,
            -- 0: Completely NACKed ARQ blocks
            subBlockExistenceMap        BIT STRING (SIZE (1..512)),
            -- The size of ssnSeriesList equals to the number of bits = 1
            -- in subBlockExistenceMap
            ssnSeriesList               SEQUENCE (SIZE (1..512)) OF
                 CorrectlyRcvdArqSubBlockList
         } OPTIONAL
      }
   },
   ...
}

CorrectlyRcvdArqSubBlockList ::= SEQUENCE (SIZE (1..1024)) OF SEQUENCE {
   -- Start of ARQ subblock SN which was received correctly.
   startSsnRecvCorrectly       INTEGER (0..2047),
   -- Number of consecutive ARQ subblocks which were received
   -- correctly from START_SSN onwards
   numOfSsnRecvCorrectly       INTEGER (0..2047)
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Standalone ARQ Feedback
```



```
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-ARQ-FBK ::=             SEQUENCE {
   arqFeedback                 ARQFeedbackIe,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- ARQ Discard
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-ARQ-DSC ::=             SEQUENCE {
   fid                         FID,
   sequenceNumber              ArqBlockSn,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- ARQ Reset
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-ARQ-RST ::=             SEQUENCE {
   directionIndicator          ENUMERATED {
                                  dl,
                                  ul
                               },
   fid                         FID,
   type                        ENUMERATED {
                                  originalMessageFromInitiator,
                                  acknowledgementFromResponder,
                                  confirmationFromInitiator
                               },
   -- ARQ transmitter sets this field to
   -- (ARQ_TX_WINDOW_START_SN + ARQ_WINDOW_SIZE) mod
   -- (ARQ_SN_MODULUS).See 6.2.13.5.4 for details
   sequenceNumber              ArqBlockSn                 OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Sleep Mode Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
SCID ::=                    INTEGER (0..15)

TrafficIndicationFlag ::=   ENUMERATED {
                               doNotSend,
                               send
                            }

ListeningWindowExtFlag ::=  ENUMERATED {
                               fixed,
                               extensible
                            }

NextSleepCycleIndicator ::= INTEGER {
                               resetToInitialSleepCycle    (0),
                               doubleOrFinal               (1),
```



```
                            resetToAnotherValue         (2)
                         } (0..3)

EnterOrChangeSleepMode ::=  SEQUENCE {
   sleepCycleID                SCID,
   startFrameNumber            INTEGER (0..63),
   trafficIndicationFlag       TrafficIndicationFlag,
   listeningWindowExtFlag      ListeningWindowExtFlag,
   nextSleepCycleIndicator     NextSleepCycleIndicator,
   initialSleepCycle           INTEGER (0..15),
   finalSleepCycle             INTEGER (0..1023),
   listeningWindow             INTEGER (0..63),
   listeningSubframeBitmap     BIT STRING (SIZE (8)),
   newInitialSleepCycle        INTEGER (0..31)             OPTIONAL,
   tAMS                        INTEGER (0..31)             OPTIONAL
}

SleepOperation ::=          ENUMERATED {
                               exitSleepMode,
                               enterSleepMode,
                               changeSleepCycleSetting,
                               switchSleepCycleSetting
                            }

SLPID ::=                   INTEGER (0..1023)

FfbchOperation ::=          ENUMERATED {
                               ffbchKept,
                               ffbchDeallocatedAtFrame,
                               ffbchDeallocatedAtBeginningOfSleepWindow,
                               ...
                            }

SleepResponseInfo ::=       SEQUENCE {
   trafficIndicationFlag       TrafficIndicationFlag,
   listeningWindowExtFlag      ListeningWindowExtFlag,
   nextSleepCycleIndicator     NextSleepCycleIndicator,
   initialSleepCycle           INTEGER (0..15),
   finalSleepCycle             INTEGER (0..1023),
   listeningWindow             INTEGER (0..63),
   listeningSubframeBitmap     BIT STRING (SIZE (8))
}

ReqUnsolicitedOrApproved ::= SEQUENCE {
   operation                   SleepOperation              OPTIONAL,
   sleepRspOperation           CHOICE {
      enterSleepMode              SEQUENCE {
         sleepCycleID                SCID,
         ffbchOperation              FfbchOperation,
         startFrameNumber            INTEGER (0..63),
         sleepResponseInfo           SleepResponseInfo
      },
      changeSleepCycle            SEQUENCE {
         sleepCycleID                SCID,
```



```
         ffbchOperation              FfbchOperation,
         startFrameNumber            INTEGER (0..63),
         sleepResponseInfo           SleepResponseInfo,
         slpid                       SLPID                        OPTIONAL,
         newInitialSleepCycle        INTEGER (0..31)              OPTIONAL,
         tAMS                        INTEGER (0..31)              OPTIONAL
      },
      switchSleepCycle            SEQUENCE {
         sleepCycleID                SCID,
         ffbchOperation              FfbchOperation
      }
   }
}

SlpidBitmapBasedTrfIndInfo ::= SEQUENCE {
   --the bitmap has one bit for each SLPID group
   slpidGroupIndicationBitmap  BIT STRING (SIZE (32)),
   -- the array has one bitmap for each SLPID group whose bit in
   -- slpidGroupIndicationBitmap is set to 1
   -- each bitmap has one bit for each SLPID in the group
   trafficIndicationBitmapArray SEQUENCE (SIZE (0..32)) OF BIT STRING (SIZE (32))
        OPTIONAL
}

SlpidBasedTrfIndInfo ::=    SEQUENCE {
   slpidArray                  SEQUENCE (SIZE (0..63)) OF SLPID
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Sleep Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-SLP-REQ ::=             SEQUENCE {
   operation                   SleepOperation,
   sleepReqOperationInfo       CHOICE {
      enterSleepMode              EnterOrChangeSleepMode,     -- Op = 1
      changeSleepMode             EnterOrChangeSleepMode,     -- Op = 2
      switchSleeCycle             SEQUENCE {                              -- Op = 3
         sleepCycleID                SCID,
         ffbchOperation              FfbchOperation,
         startFrameNumber            INTEGER (0..63)
      }
   },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Sleep Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-SLP-RSP ::=             SEQUENCE {
   responseCode                ENUMERATED {
                                  unsolicitedReqByAbs,
                                  requestApproval,
                                  requestRejection
                               },
```



```
   sleepResponseInfo           CHOICE {
      unsolicitRequest            ReqUnsolicitedOrApproved,
      sleepReqApproval            ReqUnsolicitedOrApproved,
      sleepReqreject              SEQUENCE {
         requestDuration             INTEGER (0..255)            OPTIONAL
      },
      ...
   },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Traffic Indication
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-TRF-IND ::=             SEQUENCE {
   frmt                        ENUMERATED {
                                  slpidBitmapBased,
                                  slpidBased
                               },
   emergencyAlert              BOOLEAN,
   trafficIndication           CHOICE {
      slpidBitmapBased            SlpidBitmapBasedTrfIndInfo,
      slpidBased                  SlpidBasedTrfIndInfo
   },
   slpidUpdateArray            SEQUENCE (SIZE (1..1024)) OF SEQUENCE {
      oldSlpid                    SLPID,
      newSlpid                    SLPID
   } OPTIONAL,
   trafficLocationIndicator    BIT STRING (SIZE (1..63))   OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Traffic Indication Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-TRF-IND-REQ ::=         SEQUENCE {
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Traffic Indication Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-TRF-IND-RSP ::=         SEQUENCE {
   emergencyAlert              BOOLEAN,
   frameNumber                 INTEGER (0..1023),
   sleepCycleLength            INTEGER (0..1023),
   newSlpid                    SLPID                       OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Handover Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

```
-- Handover Indication
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-HO-IND ::=              SEQUENCE {
   hoEventCode                 CHOICE {
      targetABSSelection          TargetABSSelection,         -- 0b00
      targetABSUnreachable        TargetABSSelection,         -- 0b01
      servingABSUnreachable       TargetABSSelection,         -- 0b10
      handoverCancel              HandoverCancel              -- 0b11
   },
   ...
}

TargetABSSelection ::=      SEQUENCE {
   targetABSID                 BSID,
   targetPhyCarrierID          PhyCarrierIndex             OPTIONAL,
   servingPhyCarrierID         PhyCarrierIndex             OPTIONAL
}

HandoverCancel ::=          SEQUENCE {
   sfhMismatch                 BOOLEAN,
   akCount                     AKCount
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Handover Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
maxNewABSIndices            INTEGER ::= 256

maxNewABSFull               INTEGER ::= 256
maxNewR1BSIndices INTEGER ::= 256

AAI-HO-REQ ::=              SEQUENCE {
   nbrAdvChangeCount NbrAdvChangeCount,
   carrierPreassignmentIndicator BOOLEAN                   OPTIONAL,
   newABSIndexList             NewABSIndexList             OPTIONAL,
   newABSFullList              NewABSFullList              OPTIONAL,
   newR1BSIndexList   NewR1BSIndexList   OPTIONAL,
   ...
}

NewABSFullList ::=          SEQUENCE (SIZE (1..maxNewABSFull)) OF NewABSFullInfo
NewR1BSIndexList ::= SEQUENCE (SIZE (1..maxNewR1BSIndices)) OF NewR1BSIndexInfo

NewABSIndexInfo ::=         SEQUENCE {
   nbrABSIndex                 INTEGER (0..255),
   cinrMean                    CINRMean                    OPTIONAL,
   rssiMean                    RSSIMean                    OPTIONAL,
   physicalCarrierIndex  PhyCarrierIndex  OPTIONAL
}

NewABSFullInfo ::=          SEQUENCE {
   nbrABSID                    BSID,
   cinrMean                    CINRMean                    OPTIONAL,
```



```
   rssiMean                     RSSIMean                    OPTIONAL,
   physicalCarrierIndex  PhyCarrierIndex  OPTIONAL
}
NewR1BSIndexInfo ::=          SEQUENCE {
   nbrAdvChangeCount   NbrAdvChangeCount,
   nbrR1BSIndex   INTEGER (0..255),
   cinrMeanCINRMean OPTIONAL,
   rssiMean RSSIMean OPTIONAL
}

CINRMean ::=                INTEGER (0..255)

RSSIMean ::=                INTEGER (0..255)

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Handover Command
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-HO-CMD ::=              SEQUENCE {
   mode                        CHOICE {
      hoCmd                       HandoverCommand,            -- 0b00
      zsCmd                       ZoneSwitchCommand,          -- 0b01
      hoReject                    NULL,                       -- 0b10
      reserved                    NULL                        -- 0b11
   },
   ...
}

HandoverCommand ::=         SEQUENCE {
   hoReentryMode               CHOICE {
      bbeHO                       NULL,
      ebbHO                       EBBHOInfo
   },
   disconnectTimeOffset        INTEGER (0..255),
   resourceRetainTime          INTEGER (0..255)            OPTIONAL,
   targetBSList                SEQUENCE (SIZE (0..maxNewABSIndices)) OF TargetBSInfo
}

EBBHOInfo ::=               SEQUENCE {
   -- "interleavingMode" is used to avoid using
   -- OPTIONAL to those hoReentryXXXX parameters
   interleavingMode            CHOICE {
      -- hoReentryInterleavingInterval > 0
      withInterleaving            HoReentryInterleavingInfo,
      -- hoReentryInterleavingInterval = 0(multicarrier EBB)
      noInterleaving              NULL
   },
   servingPhyCarrierID         PhyCarrierIndex             OPTIONAL
}

HoReentryInterleavingInfo ::= SEQUENCE {
   hoReentryInterleavingInterval INTEGER (1..256),
   hoReentryInterval           INTEGER (1..256),
   hoReentryIteration          INTEGER (1..8)
```

```
}

TargetBSInfo ::=            SEQUENCE {
   targetBSID                  BSID,
   preambleIndex               CHOICE {
      saPreambleIndex             PreambleIndex,
      r1PreambleIndex         R1PreambleIndex
   },
   centerFrequency             CenterFreq                  OPTIONAL,
   -- Only included for the target R1 BS
   actionTime                  INTEGER (0..255),
   seamlessHO                  BOOLEAN,
   cdmaRngFlag                 CHOICE {
      offsetInfo                  OffsetInfo,
      -- CDMA_RNG_FLAG=0: skip CDMA ranging
      dedicatedRngInfo            DedicatedRngInfo
      -- CDMA_RNG_FLAG=1: perform CDMA ranging
   },
   reentryProcessOptimization  BIT STRING (SIZE (5)),
   rngInitDeadline             INTEGER (0..255),
   preassignedSTID             STID                        OPTIONAL,
   preassignedMAPMaskKey       BIT STRING (SIZE (15))      OPTIONAL,
   serviceLevelPrediction      ServiceLevelPrediction,
   targetPhyCarrierID          PhyCarrierIndex             OPTIONAL,
   channelBandwidth            INTEGER (0..255)            OPTIONAL,
   cpLength                    CPLength                    OPTIONAL,
   preassignedCarrierList      SEQUENCE (SIZE (0..maxPreassignedCarriers)) OF
        PreassignedCarrierInfo OPTIONAL,
   preallocatedBasicCID        CID                         OPTIONAL,
   sfhDeltaInfo                SEQUENCE {
      s-SFHChangeCount            INTEGER (0..15),
      s-SFHApplicationIndication  ENUMERATED {
                                     sfhNotApp,
                                     -- 0: SFH delta information is not applied
                                     -- at the action time
                                     sfhApp
                                     -- 1: SFH delta information is applied
                                     -- at the action time
                                  }                           OPTIONAL,
      sfhDeltaInfo                SEQUENCE {
         sfhSubpacket1               OptSFHSubpacket1            OPTIONAL,
         sfhSubpacket2               OptSFHSubpacket2            OPTIONAL,
         sfhSubpacket3               OptSFHSubpacket3            OPTIONAL
      } OPTIONAL,
   dcdConfigurationChangeCount DcdConfigurationChangeCount OPTIONAL,
   ucdConfigurationChangeCount UcdConfigurationChangeCount OPTIONAL,
   -- dcdInfo includes the TLV encoded DCD information of R1 BS
   dcdInfo DcdInfo OPTIONAL,
   -- ucdInfo includes the TLV encoded DCD information of R1 BS
   ucdInfo UcdInfo OPTIONAL
   }
}
```



```
OffsetInfo ::=              SEQUENCE {
   offsetData                  INTEGER (0..127)            OPTIONAL,
   offsetControl               INTEGER (0..127)            OPTIONAL
}

DedicatedRngInfo ::=        SEQUENCE {
   dedicatedCDMARngCode        INTEGER (0..31),
   iotFP                       INTEGER (0..3),
   offsetControl               INTEGER (0..127),
   rngOptIndex                 INTEGER (0..1)              OPTIONAL,
   rngOptSubframeIndex         INTEGER (0..7)              OPTIONAL
}

ServiceLevelPrediction ::=  ENUMERATED {
                               noServiceAvailable,
                               partiallyServiceAvailable,
                               allServiceAvailable,
                               noServiceLevelPrediction
                            }

PreassignedCarrierInfo ::=  SEQUENCE {
   carrierStatusIndication     BOOLEAN,
   physicalCarrierIndex        PhyCarrierIndex
}

DcdConfigurationChangeCount ::= INTEGER (0..255)
UcdConfigurationChangeCount ::= INTEGER (0..255)
DcdInfo ::= OCTET STRING (SIZE (0..1023))
UcdInfo ::= OCTET STRING (SIZE (0..1023))

ZoneSwitchCommand ::=       SEQUENCE {
   hoReentryMode               BOOLEAN,
   resourceRetainTime          INTEGER (0..255)            OPTIONAL,
   faIndex                     FAIndex                     OPTIONAL,
   actionTime                  INTEGER (0..255),
   preambleIndexLZone          BIT STRING (SIZE (8)),
   preallocatedBasicCID        CID                         OPTIONAL
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Neighbor Advertisement
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-NBR-ADV ::=             SEQUENCE {
   changeCount                 INTEGER (0..7),
   totalNumberOfCellTypes      INTEGER (1..8),
   cellType                    ENUMERATED {
                                  macro,
                                  micro,
                                  macro-hotzone,
                                  femto,
                                  ttrRelay,
                                  r1-lzone,
                                  spare2,
```

```
                                spare1
                            },
   totalNumberOfSegments        INTEGER (1..16),
   segmentIndex                 INTEGER (0..15),
   startingABSIndex             INTEGER (0..255),
   nbrABSInfoList               SEQUENCE (SIZE (1..maxNeighborABSs)) OF NeighborABSInfo,
   nbrR1BSInfoList              SEQUENCE (SIZE (1..maxNeighborR1BSs)) OF NeighborR1BSInfo
        OPTIONAL,
   -- For ABS type whose system info are not included in AAI_NBR-ADV
   cellTypeInfo                 CellTypeInfo                OPTIONAL,
   -- Optional LDM parameters included when they are to be changed
   ...
}

CellTypeInfo ::=            SEQUENCE {
   rangeIDCell                  SEQUENCE (SIZE (1..maxPhyCarrierIndices)) OF
                                   RangeIDCell OPTIONAL
}

RangeIDCell ::=             SEQUENCE {
   phyCarrierIndex              PhyCarrierIndex,
   idCellStartEnd               SEQUENCE {
      startIDCell                  IDCell,
      endIDCell                    IDCell
   }
}

NeighborABSInfo ::=         SEQUENCE {
   bsID                         BSID,
   macVersion                   MacProtocolVersion,
   cpLength                     CPLength,
   carrierInfoList              SEQUENCE (SIZE (1..maxCarriers)) OF CarrierInfo,
   nbrSpecificTrigger           Triggers                    OPTIONAL
}

CarrierInfo ::=             SEQUENCE {
   idCell                       IDCell,
   phyCarrierIndex              PhyCarrierIndex,
   pgid                         PGID,
   sfhChangeCount               INTEGER (0..15),
   sfhEncFmt                    CHOICE {
      -- All parameters of SFHSubpacket shall be included
      fullSubpkt                   SFHSubpacket,
      -- Parameters of SFHSubpacket are partially included
      deltaInfoCurrentCxr          OptSFHSubpacket,
      -- Parameters of SFHSubpacket are partially included
      deltaInfoPrecedingCxr        OptSFHSubpacket,
      noSFHIncluded                NULL
   }
}

NeighborR1BSInfo ::=        SEQUENCE {
   bsID                         BSID,
   r1PreambleIndex              BIT STRING (SIZE (8)),
```



```
   phyModeID                    INTEGER (0..65535),
   channelBW                    ENUMERATED {
                                   five-mhz,
                                   seven-mhz,
                                   eightPoint75-mhz,
                                   ten-mhz
                                },
   r1BSCenterFreq               CenterFreq,
   dcdConfigurationChangeCount DcdConfigurationChangeCount OPTIONAL,
   ucdConfigurationChangeCount UcdConfigurationChangeCount OPTIONAL,
   -- dcdInfo includes the TLV encoded DCD information of R1 BS
   dcdInfo DcdInfo OPTIONAL,
   -- ucdInfo includes the TLV encoded DCD information of R1 BS
   ucdInfo UcdInfo OPTIONAL
}

--
-- Parameters of SFH IEs
-- All variables in SFH-SP1, SFH-SP2 and SFH-SP3 will be OPTIONAL
-- so that the SFHSbpacket structure can be reused by CarrierInfo
-- for different sfhEncFormat
--
SFHSubpacket ::=            SEQUENCE {
   sfh-sp1                     SFHSubpacket1               OPTIONAL,
   sfh-sp2                     SFHSubpacket2               OPTIONAL,
   sfh-sp3                     SFHSubpacket3               OPTIONAL
}

OptSFHSubpacket ::=         SEQUENCE {
   sfh-sp1                     OptSFHSubpacket1,
   sfh-sp2                     OptSFHSubpacket2,
   sfh-sp3                     OptSFHSubpacket3
}

FreqPartitionReuse ::=      ENUMERATED {
                               reusePartition1,
                               reusePowerBoostedPartition3
                            }

MaxRetransmissions ::=      ENUMERATED {
                               four,
                               eight
                            }

IotCorrectionValue ::=      ENUMERATED {
                               plus1dB,
                               plus0Dot5dB,
                               zerodB,
                               minus0Dot5dB
                            }

DlHarqfdbkA-Maps ::=        CHOICE {
   fftSize512                  INTEGER (4 | 8 | 12 | 16),
```

```
   fftSize1024                INTEGER (8 | 16 | 24 | 32),
   fftSize2048                INTEGER (16 | 32 | 48 | 64)
}

PwrControlRscSize ::=       ENUMERATED {
                               noUseOfPcAMap,
                               seven,
                               fourteen,
                               twentyFour
                            }

A-MapMcsSelection ::=       ENUMERATED {
                               reuse1-qpsk-1half-1forth-reuse3-qpsk-1half,
                               reuse1-qpsk-1half-1eighth-reuse3-qpsk-1forth
                            }

CellBar ::=                 ENUMERATED {
                               cellNotBarred,
                               cellBarred
                            }

RxProcessingTime ::=        ENUMERATED {
                               threeSubframes,
                               fourSubframes
                            }

CellSpecRngConfig ::=       ENUMERATED {
                               femtoAbs,
                               nonFemtoAbs
                            }

UcasDcas-Sb0-Mb0 ::=        CHOICE {
   fftSize2048                 BIT STRING (SIZE (5)),
   fftSize1024                 BIT STRING (SIZE (4)),
   fftSize512                  BIT STRING (SIZE (3))
}

UcasDcas-i ::=              CHOICE {
   fftSize2048                 BIT STRING (SIZE (3)),
   fftSize1024                 BIT STRING (SIZE (2)),
   fftSize512                  BIT STRING (SIZE (1))
}

UlSubframesSounding ::=     INTEGER {
                               noSoundingSymbol            (0),
                               oneAaiSubframe              (1),
                               twoAaiSubframe              (2),
                               threeAaiSubframe            (3),
                               fourAaiSubframe             (4)
                            } (0..7)

SFHSubpacket1 ::=           SEQUENCE {
   superframe                  INTEGER (0..255),
   absMacIdLsb                 BIT STRING (SIZE (12)),
```



```
   ulHarqFbkChannels           HarqfdbkChannels,
   dlHarqFbkAMaps              DlHarqfdbkA-Maps,
   powerControlRscSize         PwrControlRscSize,
   dlFreqPartLocation          FreqPartitionReuse,
   ulFreqPartLocation          FreqPartitionReuse,
   aMapMcsSelection            A-MapMcsSelection,
   dcasSb0                     UcasDcas-Sb0-Mb0,
   dcasMb0                     UcasDcas-Sb0-Mb0,
   dcasI                       UcasDcas-i,
   frameConfigurationIndex     INTEGER (0..63),
   ulSubframesSounding         UlSubframesSounding,
   absEirp                     INTEGER (1..64),
   cellBar                     CellBar,
   ulMaxReTx                   MaxRetransmissions,
   dlMaxReTx                   MaxRetransmissions,
   rxProcessingTime            RxProcessingTime,
   cellSpecificRangingConfig   CellSpecRngConfig,
   wirelessManOdfma            FeatureSupport,
   choice                      CHOICE {
      fdmBasedUlPuscZone          SEQUENCE {
         rchAllocPeriodicity         INTEGER (0..3),
         rchSubframeOffset           INTEGER (0..3),
         startRPCode                 INTEGER (0..15),
         rpCodePartition             INTEGER (0..15),
         ulPermBase                  INTEGER (0..127)
      },
      femtocell                   SEQUENCE {
         rchAllocPeriodicity         INTEGER (0..3),
         rchSubframeOffset           INTEGER (0..3),
         startRPCode                 INTEGER (0..15),
         rpCodePartition             INTEGER (0..15),
         rchTxTiming                 INTEGER (0..7),
         ucasSb0                     UcasDcas-Sb0-Mb0,
         ucasMb0                     UcasDcas-Sb0-Mb0,
         ucasI                       UcasDcas-i
      },
      other                       SEQUENCE {
         rchAllocPeriodicity         INTEGER (0..3),
         rchSubframeOffset           INTEGER (0..3),
         startRPCode                 INTEGER (0..15),
         rpCodePartition             INTEGER (0..15),
         cyclicShiftedRPCodes        INTEGER (0..3),
         nsRchFormat                 INTEGER (0..1),
         ucasSb0                     UcasDcas-Sb0-Mb0,
         ucasMb0                     UcasDcas-Sb0-Mb0,
         ucasI                       UcasDcas-i
      }
   },
   ...
}

NetworkConfig ::=           ENUMERATED {
                               aaiNetworkConfig,
                               wirelessManOfdmaConfig
```

```
                            }

DsacUsac ::=                CHOICE {
   fftSize2048                 BIT STRING (SIZE (5)),
   fftSize1024                 BIT STRING (SIZE (4)),
   fftSize512                  BIT STRING (SIZE (3))
}

DfpscUfpsc ::=              CHOICE {
   fftSize2048                 BIT STRING (SIZE (3)),
   fftSize1024                 BIT STRING (SIZE (2)),
   fftSize512                  BIT STRING (SIZE (1))
}

MimoMidamble ::=            ENUMERATED {
                               notTransmittedInRelayZone,
                               transmittedInRelayZone
                            }

SFHSubpacket2 ::=           SEQUENCE {
   macVersion                  INTEGER (0..15),
   ulCarrierFrequency          INTEGER (0..65536),
   absMacIdMsb                 BIT STRING (SIZE (36)),
   networkConfig               NetworkConfig,
   olRegion                    INTEGER (0..1),
   dsac                        DsacUsac,
   dfpc                        DfpscUfpsc,
   dfpsc                       DfpscUfpsc,
   usac                        DsacUsac,
   ufpc                        DfpscUfpsc,
   ufpsc                       DfpscUfpsc,
   amsTxPowerLimitation        INTEGER (0..31),
   eiRxP                       INTEGER (0..31),
   mimoMidamble                MimoMidamble,
   ...
}

SsfhChangeCycle ::=         INTEGER {
                               sixteen                      (0),
                               thirtyTwo                    (1),
                               sixtyFour                    (2)
                            } (0..15)

NumTxAntennas ::=           INTEGER {
                               twoAntenna                   (0),
                               fourAntenna                  (1),
                               eightAntenna                 (2)
                            } (0..4)

UlBwReqChannelInfo ::=      INTEGER {
                               firstAaiSubframein1stFrame  (0),
                               firstAaiSubframein1stAnd2ndFrame (1),
                               firstAaiSubframeinEveryFrame (2),
                               first2AaiSubframeinEveryFrame (3),
```

```
                            first4AaiSubframeinEveryFrame (4)
                         } (0..7)

D-LbsZoneConfig ::=         ENUMERATED {
                            noLbsZoneTransmission,
                            zonePeriodicity4,
                            zonePeriodicity16,
                            zonePeriodicity32
                         }

SFHSubpacket3 ::=           SEQUENCE {
   ssfhChangeCycle             SsfhChangeCycle,
   preambleSeqSoftPartitioning INTEGER (0..15),
   ulIotCorrectionValues       SEQUENCE {
      iotCorrValueSounding        IotCorrectionValue,
      iotCorrValueFP0             IotCorrectionValue,
      iotCorrValueFP1             IotCorrectionValue,
      iotCorrValueFP2             IotCorrectionValue,
      iotCorrValueFP3             IotCorrectionValue
   },
   ulFeedbackSize              INTEGER (0..15),
   numTxAntennas               NumTxAntennas,
   spSchedulingPeriodicity     INTEGER (0..15),
   hoRangingBackoffStart       INTEGER (0..15),
   hoRangingBackoffEnd         INTEGER (0..15),
   initialRangingBackoffStart  INTEGER (0..15),
   initialRangingBackoffEnd    INTEGER (0..15),
   ulBwReqChannelInfo          INTEGER (0..7),
   bandwidthRequestBackoffStart INTEGER (0..15),
   bandwidthRequestBackoffEnd  INTEGER (0..15),
   fpPowerConfig               INTEGER (0..7),
   dLbsZoneConfig              D-LbsZoneConfig,
   nspChangeCount              INTEGER (0..15),
   scdCount                    INTEGER (0..15),
   ...
}

OptSFHSubpacket1 ::=        SEQUENCE {
   superframe                  INTEGER (0..255)            OPTIONAL,
   absMacIdLsb                 BIT STRING (SIZE (12))      OPTIONAL,
   ulHarqFbkChannels           HarqfdbkChannels            OPTIONAL,
   dlHarqFbkAMaps              DlHarqfdbkA-Maps            OPTIONAL,
   powerControlRscSize         PwrControlRscSize           OPTIONAL,
   dlFreqPartLocation          FreqPartitionReuse          OPTIONAL,
   ulFreqPartLocation          FreqPartitionReuse          OPTIONAL,
   aMapMcsSelection            A-MapMcsSelection           OPTIONAL,
   dcasSb0                     UcasDcas-Sb0-Mb0            OPTIONAL,
   dcasMb0                     UcasDcas-Sb0-Mb0            OPTIONAL,
   dcasI                       UcasDcas-i                  OPTIONAL,
   frameConfigurationIndex     INTEGER (0..63)             OPTIONAL,
   ulSubframesSounding         UlSubframesSounding         OPTIONAL,
   absEirp                     INTEGER (1..64)             OPTIONAL,
   cellBar                     CellBar                     OPTIONAL,
   ulMaxReTx                   MaxRetransmissions          OPTIONAL,
```

```
   dlMaxReTx                   MaxRetransmissions          OPTIONAL,
   rxProcessingTime            RxProcessingTime            OPTIONAL,
   cellSpecificRangingConfig   CellSpecRngConfig           OPTIONAL,
   wirelessManOdfma            FeatureSupport              OPTIONAL,
   choice                      CHOICE {
      fdmBasedUlPuscZone          SEQUENCE {
         rchAllocPeriodicity         INTEGER (0..3)              OPTIONAL,
         rchSubframeOffset           INTEGER (0..3)              OPTIONAL,
         startRPCode                 INTEGER (0..15)             OPTIONAL,
         rpCodePartition             INTEGER (0..15)             OPTIONAL,
         ulPermBase                  INTEGER (0..127)            OPTIONAL
      },
      femtocell                   SEQUENCE {
         rchAllocPeriodicity         INTEGER (0..3)              OPTIONAL,
         rchSubframeOffset           INTEGER (0..3)              OPTIONAL,
         startRPCode                 INTEGER (0..15),
         rpCodePartition             INTEGER (0..15)             OPTIONAL,
         rchTxTiming                 INTEGER (0..7)              OPTIONAL,
         ucasSb0                     UcasDcas-Sb0-Mb0            OPTIONAL,
         ucasMb0                     UcasDcas-Sb0-Mb0            OPTIONAL,
         ucasI                       UcasDcas-i                  OPTIONAL
      },
      other                       SEQUENCE {
         rchAllocPeriodicity         INTEGER (0..3)              OPTIONAL,
         rchSubframeOffset           INTEGER (0..3)              OPTIONAL,
         startRPCode                 INTEGER (0..15)             OPTIONAL,
         rpCodePartition             INTEGER (0..15)             OPTIONAL,
         cyclicShiftedRPCodes        INTEGER (0..3)              OPTIONAL,
         nsRchFormat                 INTEGER (0..1)              OPTIONAL,
         ucasSb0                     UcasDcas-Sb0-Mb0            OPTIONAL,
         ucasMb0                     UcasDcas-Sb0-Mb0            OPTIONAL,
         ucasI                       UcasDcas-i                  OPTIONAL
      }
   },
   ...
}

OptSFHSubpacket2 ::=        SEQUENCE {
   macVersion                  INTEGER (0..15)             OPTIONAL,
   ulCarrierFrequency          INTEGER (0..65535)          OPTIONAL,
   absMacIdMsb                 BIT STRING (SIZE (36))      OPTIONAL,
   networkConfig               NetworkConfig               OPTIONAL,
   olRegion                    INTEGER (0..1)              OPTIONAL,
   dsac                        DsacUsac                    OPTIONAL,
   dfpc                        DfpscUfpsc                  OPTIONAL,
   dfpsc                       DfpscUfpsc                  OPTIONAL,
   usac                        DsacUsac                    OPTIONAL,
   ufpc                        DfpscUfpsc                  OPTIONAL,
   ufpsc                       DfpscUfpsc                  OPTIONAL,
   amsTxPowerLimitation        INTEGER (0..31)             OPTIONAL,
   eiRxP                       INTEGER (0..31)             OPTIONAL,
   mimoMidamble                MimoMidamble                OPTIONAL,
   ...
}
```



```
OptSFHSubpacket3 ::=        SEQUENCE {
   ssfhChangeCycle             SsfhChangeCycle             OPTIONAL,
   preambleSeqSoftPartitioning INTEGER (0..15)             OPTIONAL,
   ulIotCorrectionValues       SEQUENCE {
      iotCorrValueSounding        IotCorrectionValue          OPTIONAL,
      iotCorrValueFP0             IotCorrectionValue          OPTIONAL,
      iotCorrValueFP1             IotCorrectionValue          OPTIONAL,
      iotCorrValueFP2             IotCorrectionValue          OPTIONAL,
      iotCorrValueFP3             IotCorrectionValue          OPTIONAL
   } OPTIONAL,
   ulFeedbackSize              INTEGER (0..15)             OPTIONAL,
   numTxAntennas               NumTxAntennas,
   spSchedulingPeriodicity     INTEGER (0..15)             OPTIONAL,
   hoRangingBackoffStart       INTEGER (0..15)             OPTIONAL,
   hoRangingBackoffEnd         INTEGER (0..15)             OPTIONAL,
   initialRangingBackoffStart  INTEGER (0..15)             OPTIONAL,
   initialRangingBackoffEnd    INTEGER (0..15)             OPTIONAL,
   ulBwReqChannelInfo          UlBwReqChannelInfo          OPTIONAL,
   bandwidthRequestBackoffStart INTEGER (0..15)            OPTIONAL,
   bandwidthRequestBackoffEnd  INTEGER (0..15)             OPTIONAL,
   fpPowerConfig               INTEGER (0..7)              OPTIONAL,
   dLbsZoneConfig              D-LbsZoneConfig             OPTIONAL,
   nspChangeCount              INTEGER (0..15)             OPTIONAL,
   scdCount                    INTEGER (0..15)             OPTIONAL,
   ...
}

--
-- Triggers
-- Designed based on Table 6-120
--
maxNumberOfTriggers         INTEGER ::= 64

maxNumberOfConditions       INTEGER ::= 4

Triggers ::=                SEQUENCE {
   triggerList                 SEQUENCE (SIZE (1..maxNumberOfTriggers)) OF TriggerInfo
}

TriggerInfo ::=             SEQUENCE {
   absType                     ENUMERATED {
                                  any,
                                  macro,
                                  macro-hotzone,
                                  femto,
                                  r1,
                                  spare11,
                                  spare10,
                                  spare9,
                                  spare8,
                                  spare7,
                                  spare6,
                                  spare5,
```

```
                            spare4,
                            spare3,
                            spare2,
                            spare1
                         },
   triggerAveParamForIntra   ENUMERATED {
                            one,
                            half,
                            quarter,
                            one-8th,
                            one-16th,
                            one-32th,
                            one-64th,
                            one-128th,
                            one-256th,
                            one-512th
                         }                            OPTIONAL,
   triggerAveParamForInter   ENUMERATED {
                            one,
                            half,
                            quarter,
                            one-8th,
                            one-16th,
                            one-32th,
                            one-64th,
                            one-128th,
                            one-256th,
                            one-512th
                         }                            OPTIONAL,
   conditionList             SEQUENCE (SIZE (1..maxNumberOfConditions)) OF
        ConditionInfo
}

ConditionInfo ::=         SEQUENCE {
   typeFuncAction            TypeFuncAction,
   triggerValue              INTEGER (0..255)
}

-- Table 6-121
TypeFuncAction ::=        SEQUENCE {
   triggerType               ENUMERATED {
                            cinr,
                            rssi,
                            rtd,
                            nMissedP-SFHs,
                            rd,
                            spare3,
                            spare2,
                            spare1
                         },
   triggerFunc               ENUMERATED {
                            dummy,
                            nbr-greater-than-absolute-value,
                            nbr-less-than-absolute-value,
```



```
                              nbr-greater-than-sabs-by-relative-value,
                              nbr-less-than-sabs-by-relative-value,
                              sabs-greater-than-absolute-value,
                              sabs-less-than-absolute-value,
                              nbr-carriers-greater-than-threshold
                           },
   triggerAction           ENUMERATED {
                              dummy,
                              response-aai-scn-rep,
                              response-aai-ho-req,
                              response-aai-scn-req,
                              declare-abs-unreachable,
                              cancel-ho,
                              spare2,
                              spare1
                           }
}

--
-- CA Specific Triggers
-- Designed based on Table 6-122 and Table 6-123--
CAConditionInfo ::=        SEQUENCE {
   triggerType             ENUMERATED {
                              cinr,
                              rssi
                           },
   triggerFunction         ENUMERATED {
                              inactive2ndCrxGreaterThanAbsValue,
                              spare1
                           },
   triggerAction           ENUMERATED {
                              responstAAI-SCN-REP,
                              spare1
                           },
   triggerValue            INTEGER (0..255),
   triggerAveParam         ENUMERATED {
                              one,
                              half,
                              quarter,
                              one-8th,
                              one-16th,
                              one-32th,
                              one-64th,
                              one-128th,
                              one-256th,
                              one-512th,
                              spare6,
                              spare5,
                              spare4,
                              spare3,
                              spare2,
                              spare1
                           }
}
```

```
CASpecificTriggers ::=      SEQUENCE {
   conditionList               SEQUENCE (SIZE (1..maxNumberOfConditions)) OF
        CAConditionInfo
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Scanning Interval Allocation Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
SuperframeNumberLSB ::=     INTEGER (0..63)

RecommandCarrierIndexList ::= SEQUENCE (SIZE (0..63)) OF PhyCarrierIndex

NbrBitmapInfo ::=           SEQUENCE {
   nbrBitmap                   BIT STRING (SIZE (1..256)),
   nbrInfoList                 SEQUENCE (SIZE (1..64)) OF RecommandCarrierIndexList
}

NbrIndexInfo ::=            SEQUENCE {
   nbrABSIndex                 INTEGER (0..255),
   recommandCarrierIndexList   RecommandCarrierIndexList
}

NbrFullInfo ::=             SEQUENCE {
   nbrABSID                    BSID,
   recommandCarrierIndexList   RecommandCarrierIndexList
}

SaFaOfPreamble ::=          SEQUENCE {
   centerFrequency             CenterFreq,
   saPreambleIndexList         SEQUENCE (SIZE (0..15)) OF PreambleIndex
}

NbrR1FullInfo ::=       SEQUENCE {
   nbrBSID                     BSID
}

AAI-SCN-REQ ::=             SEQUENCE {
   scanDuration                INTEGER (0..255),
   interleaving                INTEGER (0..255),
   scanIteration               INTEGER (0..63),
   recommendStartSuperFrame    SuperframeNumberLSB         OPTIONAL,
   recommendedStartFrame       INTEGER (0..3)              OPTIONAL,
   nRecommendedABS             CHOICE {
      zeroRecommendABS            NULL,
      nonzeroRecommendABS         SEQUENCE {
         configChangeCount           INTEGER (0..7),
         nbrIndication               CHOICE {
            nbrBitmapInfo               NbrBitmapInfo,
            nbrIndexInfoList            SEQUENCE (SIZE (1..64)) OF NbrIndexInfo,
            fullAbsIdList               SEQUENCE (SIZE (1..64)) OF NbrFullInfo
         }
      }
   },
```



```
   nbrR1FullInfoList       SEQUENCE (SIZE (0..63)) OF NbrR1FullInfo,
   saFaOfPreambleList          SEQUENCE (SIZE (0..15)) OF SaFaOfPreamble,
   sabsCarrierIndexList        SEQUENCE (SIZE (0..63)) OF PhyCarrierIndex,
   csgIDInfoList               SEQUENCE (SIZE (0..15)) OF SEQUENCE {
      csgFemtoCellOperatorID      OperatorID,
      csgIDList                   SEQUENCE (SIZE (1..64)) OF CSGID
   },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Scanning Interval Allocation Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
RecommandCarrierInfo ::=    SEQUENCE {
   carrierIndex                PhyCarrierIndex,
   saPreambleIndex             PreambleIndex
}

ReqBitmapInfo ::=           SEQUENCE {
   bitmapIndex                 BIT STRING (SIZE (1..64)),
   absInfoList                 SEQUENCE (SIZE (1..64)) OF RecommandCarrierInfo
}

ABSFullInfo ::=             SEQUENCE {
   absID                       BSID,
   absInfo                     RecommandCarrierInfo
}

RecommendABSIndexInfo ::=   SEQUENCE {
   nbrAbsIndex                 INTEGER (0..255),
   absInfo                     RecommandCarrierInfo
}

AbsFullNotInNbrAdvList ::=  SEQUENCE {
   absID                       BSID,
   recommendedCarrierList      SEQUENCE (SIZE (1..64)) OF SEQUENCE {
      recommandCarrierIndex       RecommandCarrierInfo,
      bandwidth                   INTEGER {
                                     tenMHz                     (0),
                                     twentyMHz                  (1),
                                     fiveMHz                    (3),
                                     sevenMHz                   (4),
                                     eightDotSevenFiveMHz       (5)
                                  } (0..7)
   }
}

ScanInfo ::=                SEQUENCE {
   scanDuration                INTEGER (1..255),
   startSuperFrame             SuperframeNumberLSB,
   startFrame                  INTEGER (0..3),
   interleavingInterval        INTEGER (0..255),
   scanIteration               INTEGER (0..63),
   nbrAdvChangeCount           INTEGER (0..7),
```

```
   nbrIndication                CHOICE {
      nbrBitmapInfo                ReqBitmapInfo,
      nbrIndexInfoList             SEQUENCE (SIZE (1..64)) OF RecommendABSIndexInfo,
      fullAbsIdList                SEQUENCE (SIZE (1..64)) OF ABSFullInfo
   },
   absFullNotInNbrAdvList       SEQUENCE (SIZE (0..63)) OF
                                   AbsFullNotInNbrAdvList OPTIONAL,
   nbrR1FullInfoList        SEQUENCE (SIZE (0..63)) OF NbrR1FullInfo,
   saFaOfPreambleList           SEQUENCE (SIZE (0..15)) OF SaFaOfPreamble,
   recommendSABSCarriers        SEQUENCE (SIZE (0..63)) OF PhyCarrierIndex,
   scanningCarrierIndex         PhyCarrierIndex             OPTIONAL
}

AAI-SCN-RSP ::=              SEQUENCE {
   scanDuration                 CHOICE {
      zeroScanDuration             NULL,
      nonzeroScanDuration          ScanInfo
   },
   reportMode                   ENUMERATED {
                                   noReport,
                                   periodicReport,
                                   eventTriggerReport,
                                   oneTimeReport
                                },
   reportMetric                 BIT STRING {
                                   cinrMean                    (0),
                                   rssiMean                    (1),
                                   relativeDelay               (2),
                                   absRTD                      (3)
                                } (SIZE (4)),
   reportPeriod                 INTEGER (0..255),
   d-LBS-measDuration           INTEGER (0..15)             OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Scanning Result Report
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
ScanReport ::=               SEQUENCE {
   carrierIndex                 PhyCarrierIndex,
   cinrMean                     INTEGER (0..255)            OPTIONAL,
   rssiMean                     INTEGER (0..255)            OPTIONAL
}

CarrierReportList ::=        SEQUENCE {
   scanReportList               SEQUENCE (SIZE (0..63)) OF ScanReport,
   rtd                          INTEGER (0..255)            OPTIONAL
}

NbrBitmapReport ::=          SEQUENCE {
   repBitmap                    BIT STRING (SIZE (1..64)),
   nbrReportList                CarrierReportList
}
```



```
NbrIndexReport ::=          SEQUENCE {
   nbrABSIndex                 INTEGER (0..255),
   nbrReport                   CarrierReportList
}

ABSReport ::=               SEQUENCE {
   reportedABSID               BSID,
   carrierReportList           CarrierReportList
}

NbrR1FullReport ::=     SEQUENCE {
   reportBSID                  BSID,
   cinrMean                    INTEGER (0..255)            OPTIONAL,
   rssiMean                    INTEGER (0..255)            OPTIONAL
}

SAPreambleReport ::=        SEQUENCE {
   centerFrequency             CenterFreq,
   saPreambleIndex             SEQUENCE (SIZE (0..15)) OF SAPreambleReportIndex
}

SAPreambleReportIndex ::=   SEQUENCE {
   saPreambleIndex             PreambleIndex,
   cinrMean                    INTEGER (0..255)            OPTIONAL,
   rssiMean                    INTEGER (0..255)            OPTIONAL
}

AAI-SCN-REP ::=             SEQUENCE {
   reportMode                  ENUMERATED {
                                  eventTriggerReport,
                                  periodicReport,
                                  oneTimeReport
                               },
   sabsCarrierReportList       CarrierReportList,
   nbrAdvChangeCount           INTEGER (0..7),
   absReportIndication         CHOICE {
      nbrBitmapReport             NbrBitmapReport,
      nbrABSReportList            SEQUENCE (SIZE (1..63)) OF NbrIndexReport,
      absFullReportList           SEQUENCE (SIZE (1..63)) OF ABSReport
   },
   nbrR1FullReportList     SEQUENCE (SIZE (0..63)) OF NbrR1FullReport,
   saPreambleReportList        SEQUENCE (SIZE (0..15)) OF SAPreambleReport,
   neighborRequest             SEQUENCE {
      requestBSType               BIT STRING {
                                     csgClosedFemto              (0),
                                     csgOpenFemto                (1),
                                     osgFemto                    (2)
                                  } (SIZE (3))                OPTIONAL,
      csgIDList                   SEQUENCE (SIZE (0..63)) OF CSGID
   } OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
```

```
-- Idle Mode Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
MACAddressHash ::=          BIT STRING (SIZE (24))

PagedMSInfo ::=             SEQUENCE {
   -- if Network Configuration indicates ABS is attached to the advanced network
   deRegId                     DREGID                      OPTIONAL,
   -- if Network Configuration indicates ABS is attached to the R1 network
   macAddressHash              MACAddressHash              OPTIONAL,
   -- if Network Configuration indicates ABS is attached to the advanced network
   pagingCycle                 PgCycle                     OPTIONAL,
   actionCode                  ENUMERATED {
                                  networkReentry,
                                  locationUpdate
                               }
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Paging Advertisement
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-PAG-ADV ::=             SEQUENCE {
   pagingGroupIDBitmap         BIT STRING (SIZE (1..4)),
   pagingGroupInfoArray        SEQUENCE (SIZE (0..4)) OF SEQUENCE {
      pagedMSInfoArray            SEQUENCE (SIZE (1..32)) OF PagedMSInfo
   },
   extensionFlag               ENUMERATED {
                                  lastFragmentOfPagAdv,
                                  moreFragmentOfPagAdv
                               },
   emergencyAlert              BOOLEAN                     OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Paging Group Information
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-PGID-INFO ::=           SEQUENCE {
   pagingGroupInfoArray        SEQUENCE (SIZE (1..4)) OF SEQUENCE {
      pagingGroupID               PGID,
      m                           INTEGER (1..4)
   },
   multiCarrierPgidInfo        CHOICE {
      samePagingCarrierIndicationBitmap BIT STRING (SIZE (1..64)),
      pagingCarrierIndicationBitmapArray SEQUENCE (SIZE (1..4)) OF SEQUENCE {
         pagingCarrierIndicationBitmap BIT STRING (SIZE (1..64))
      }
   } OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Multicarrier Messages
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```



```
-- AAI-MC-ADV message
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
CarrierActivationInfo ::=   SEQUENCE {
   activationDeadline          INTEGER (0..63),
   carrierInfoArray            SEQUENCE (SIZE (1..8)) OF SEQUENCE {
      targetCarrier               PhyCarrierIndex,
      dlULActivated               ENUMERATED {
                                     bothActivated,
                                     dlOnlyActivated
                                  },
      rangingIndicator            RangingIndicator
   }
}

CarrierDeactivationInfo ::= SEQUENCE {
   carrierInfoArray            SEQUENCE (SIZE (1..8)) OF SEQUENCE {
      targetCarrier               PhyCarrierIndex,
      dlULDeactivated             ENUMERATED {
                                     bothDeactivated,
                                     ulOnlyDeactivated
                                  }
   }
}

RangingIndicator ::=        ENUMERATED {
                               noRangingRequired,
                               periodicRangingRequired
                            }

OptUlpcDataChSet ::=        SEQUENCE {
   gammaIotArray               SEQUENCE (SIZE (4)) OF SEQUENCE {
      gammaIot                    INTEGER (0..15)            OPTIONAL
   },
   alpha                       Alpha                      OPTIONAL,
   beta                        INTEGER (0..1)             OPTIONAL,
   dataSinrMin                 INTEGER (0..15)            OPTIONAL,
   dataSinrMax                 DataSinrMax                OPTIONAL
}

OptUlpcControlChSet ::=     SEQUENCE {
   targetHarqSinr              INTEGER (0..15)            OPTIONAL,
   targetSyncRangingSinr       INTEGER (0..15)            OPTIONAL,
   targetPfbchSinr             INTEGER (0..15)            OPTIONAL,
   targetSfbchBaseSinr         INTEGER (0..15)            OPTIONAL,
   targetSfbchDeltaSinr        INTEGER (0..7)             OPTIONAL,
   targetBwRequestSinr         INTEGER (0..15)            OPTIONAL,
   gammaIotSounding            INTEGER (0..15)            OPTIONAL,
   soundingSinrMin             INTEGER (0..15)            OPTIONAL,
   soundingSinrMax             INTEGER (5..20)            OPTIONAL
}

SfhScdDeltaInfo ::=         SEQUENCE {
   sfhSubpacket1               OptSFHSubpacket1           OPTIONAL,
   sfhSubpacket2               OptSFHSubpacket2           OPTIONAL,
```



```
   sfhSubpacket3               OptSFHSubpacket3            OPTIONAL,
   bsRestartCount              INTEGER (0..15)             OPTIONAL,
   saPreamblePartitions        SEQUENCE (SIZE (5)) OF PreamblePart OPTIONAL,
   triggers                    Triggers                    OPTIONAL,
   periodicityOfRngChSync      INTEGER (0..3)              OPTIONAL,
   periodOfPeriodicRngTimer    PeriodOfPeriodicRngTimer,
   olMimoParameters            SEQUENCE {
      olRegionType0On             BOOLEAN                     OPTIONAL,
      olRegionType1NLRUSize       INTEGER (0..15)             OPTIONAL,
      olRegionType1SLRUSize       INTEGER (0..15)             OPTIONAL,
      olRegionType2SLRUSize       INTEGER (0..15)             OPTIONAL
   } OPTIONAL,
   cntlStartCodeOfRngChSync    INTEGER (0..15)             OPTIONAL,
   rangingPreambleCodeSync     INTEGER (0..3)              OPTIONAL,
   ulpcDataChannelIe           OptUlpcDataChSet            OPTIONAL,
   ulpcControlChannelIe        OptUlpcControlChSet         OPTIONAL,
   tReTxInterval               TReTxInterval               OPTIONAL,
   brChCfgMINAccessClassForFrame SEQUENCE (SIZE (4)) OF SEQUENCE {
      accessClass                 INTEGER (0..3)              OPTIONAL
   } OPTIONAL,
   multiplexingType            MultiplexingType            OPTIONAL,
   shiftValueUForSoundingSymbol INTEGER (0..255)           OPTIONAL,
   relayZoneAmsAlocIndc        INTEGER (0..1)              OPTIONAL,
   resourceMetricFP2           INTEGER (0..15)             OPTIONAL,
   resourceMetricFP3           INTEGER (0..15)             OPTIONAL,
   embsConfigParameters        EMBSConfigParameters        OPTIONAL,
   networkSynchronization      BOOLEAN                     OPTIONAL
}

ServingABSCarrierInfo ::=   SEQUENCE {
   pagingGroupID               PGID,
   carrierIndex                PhyCarrierIndex,
   saPreambleIndex             PreambleIndex,
   pagingCarrierIndicator      ENUMERATED {
                                  noPagingCarrier,
                                  pagingCarrier
                               }                           OPTIONAL,
   referenceCarrier            PhyCarrierIndex             OPTIONAL,
   caSpecificTrigger           CASpecificTriggers          OPTIONAL,
   pccSpecificTrigger          Triggers                    OPTIONAL,
   sSFHChangeCount             INTEGER (0..15),
   scdChangeCount              INTEGER (0..15),
   sfhScdInfo                  CHOICE {
      sfhSubpack                  SEQUENCE {
         sfhSubpacket1               SFHSubpacket1,
         sfhSubpacket2               SFHSubpacket2,
         sfhSubpacket3               SFHSubpacket3,
         aaiSCDInfo                  AAI-SCD
      },
      deltaRefToCurCarrier        SfhScdDeltaInfo,
      deltaRefToPrevCarrier       SfhScdDeltaInfo
   }
}
```



```
AAI-MC-ADV ::=               SEQUENCE {
   mcChangeCount                INTEGER (0..15),
   macProtocolVersion           MacProtocolVersion,
   nNbrCrxForMCTrigger          ENUMERATED {
                                   twoCarriers,
                                   threeCarriers
                                }                          OPTIONAL,
   crxSpecificPHYCtrlMode       BOOLEAN                    OPTIONAL,
   servingABSCarrierInfoArray  SEQUENCE (SIZE (1..7)) OF ServingABSCarrierInfo,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Multicarrier Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
maxCarrierCombinations       INTEGER ::= 4

maxAssignedCarriers          INTEGER ::= 8

DLULIndicator ::=            ENUMERATED {
                                dl-ul,
                                dl-only
                             }

AAI-MC-REQ ::=               SEQUENCE {
   globalSupport                CHOICE {
      partialSupport               CarrierCombinaitonList,
      fullSupport                  NULL
   },
   guardSubcarrierSupport       BOOLEAN,
   powerSharingGroupsDescription SEQUENCE (SIZE (1..16)) OF SEQUENCE {
      maxTxPower                   SEQUENCE {
         maxTxPowerForQPSK            INTEGER (0..255),
         maxTxPowerFor16QAM           INTEGER (0..255),
         maxTxPowerFor64QAM           INTEGER (0..255)
      },
      carrersInGroup               SEQUENCE (SIZE (1..16)) OF PhyCarrierIndex
   },
   ...
}

CarrierCombinaitonList ::=  SEQUENCE (SIZE (0..maxCarrierCombinations)) OF
     CarrierCombinaiton

CarrierCombinaiton ::=       SEQUENCE {
   phyCarrierList               SEQUENCE (SIZE (1..maxAssignedCarriers)) OF
        PhyCarrierIndex,
   dlulIndicator                DLULIndicator
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Multicarrier Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-MC-RSP ::=               SEQUENCE {
```

```
   globalAssign                CHOICE {
      partialAssignment           CarrierAssignment,
      fullAssignment              NULL
   },
   ...
}

CarrierAssignment ::=       SEQUENCE (SIZE (1..maxAssignedCarriers)) OF
     AssignedCarrierInfo

AssignedCarrierInfo ::=     SEQUENCE {
   phyCarrierIndex             PhyCarrierIndex,
   dlulIndicator               DLULIndicator,
   guardSubcarrierSupport      FeatureSupport
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Carrier Management Command
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-CM-CMD ::=              SEQUENCE {
   carrierManagement           CHOICE {
      secondaryCarrier            SEQUENCE {
         activation                  CarrierActivationInfo       OPTIONAL,
         deactivation                CarrierDeactivationInfo     OPTIONAL
      },
      primaryCarrier              SEQUENCE {
         carrierIndex                PhyCarrierIndex,
         actionTime                  INTEGER (0..7),
         nextStateOfServCarrier      ENUMERATED {
                                        deactivate,
                                        keepActive
                                     },
         activationDeadline          INTEGER (0..63)             OPTIONAL,
         rangingIndicator            RangingIndicator
      }
   },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Carrier Management Indication
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-CM-IND ::=              SEQUENCE {
   actionCode                  ENUMERATED {
                                  secondaryCarrierManagement,
                                  primaryCarrierChange
                               },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Global Carrier Configuration
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
CarrierTypeForFDD ::=       ENUMERATED {
```



```
                            fullyConfigured,
                            partiallyConfigured
                         }

AAI-GLOBAL-CFG ::=          SEQUENCE {
   changeCount                 INTEGER (0..7),
   carrierGroupInfoArray       SEQUENCE (SIZE (1..16)) OF SEQUENCE {
      duplexingMode               ENUMERATED {
                                     tdd,
                                     fdd
                                  },
      mcConfigurationIndex        INTEGER (0..63),
      numberOfcarriers            CHOICE {
         oneCarrier                  SEQUENCE {
            centerFrequency             CenterFreq,
            carrierIndex                PhyCarrierIndex,
            carrierTypeForFdd           CarrierTypeForFDD           OPTIONAL
         },
         multipleCarriers            SEQUENCE {
            startFrequency              CenterFreq,
            carrierInfoArray            SEQUENCE (SIZE (1..16)) OF SEQUENCE {
               carrierIndex                PhyCarrierIndex,
               carrierTypeForFDD           CarrierTypeForFDD           OPTIONAL
            }
         }
      }
   },
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Power Control Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
FeedbackControlInfo ::=     SEQUENCE {
   channelIndex                INTEGER (0..255),
   shortTermFeedbackPeriod     INTEGER (0..7),
   longTermFeedbackPeriod      INTEGER (0..3),
   frameOffsetNumber           INTEGER (0..3),
   subframeIndex               INTEGER (0..7),
   allocationDuration          INTEGER (0..7)
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Uplink Transmit Power Adjustment
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-UL-POWER-ADJ ::=        SEQUENCE {
   offsetData                  INTEGER (0..63),
   -- -15.5+0.5*offsetData
   offsetControl               INTEGER (0..63)  OPTIONAL,
   -- -15.5+0.5*offsetControl
   carrierIndex                PhyCarrierIndex           OPTIONAL,
   feedbackControlInfo         FeedbackControlInfo       OPTIONAL,
   ...
}
```

```
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Uplink Power Status Reporting Configuration
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-UL-PSR-CFG ::=          SEQUENCE {
   powerStatusReportConfig     SEQUENCE {
      txPowerRptThreshold         INTEGER (0..15),
      -- If 0b1111, infinite. Otherwise, 0.5*txPowerRptThreshold
      txPowerRptMinInterval       INTEGER (0..15),
      -- If 0b1111, infinite. Otherwise, (2^txPowerRptMinInterval) frames
      txPowerRptPeriodicInterval  INTEGER (0..15)
      -- If 0b1111, infinite. Otherwise, (2^txPowerRptPeriodicInterval) frames
   } OPTIONAL,
   carrierIndex                PhyCarrierIndex            OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Co-Located Coexistence Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Co-Located Coexistence Request Message (AAI-CLC-REQ)
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
CLCID ::=                   INTEGER (0..7)

CLCType1Configuration ::=   SEQUENCE {
   startSubFrameIndex          INTEGER (0..7),
   type1clcActiveInterval      INTEGER (0..255),
   -- number of subframes
   type1clcActiveCycle         INTEGER (0..2097151)
   --number of micorseconds
}

CLCType2Subtype1Configuration ::= SEQUENCE {
   type2ST1clcActiveBitmap     BIT STRING (SIZE (8))
}

CLCType2Subtype2Configuration ::= SEQUENCE {
   startSubFrameIndex          INTEGER (0..7),
   type2ST2clcActiveInterval   INTEGER (0..255),
   -- number of subframes
   type2ST2clcActiveCycle      INTEGER (0..255)                      --number of frames
}

CLCType2Subtype3Configuration ::= SEQUENCE {
   type2ST3clcActiveCycle      INTEGER (0..2),
   -- this number plus 2 is the length of extended bitmap
   type2ST3ExtendedActiveBitmap BIT STRING (SIZE (1..32))
}

CLCType3Configuration ::=   SEQUENCE {
   type3clcActiveInterval      INTEGER (0..255)
   -- number of superframes
}
```



```
CLCconfiguration ::=        SEQUENCE {
   clcID                       CLCID,
   startSuperFrameNumber       INTEGER (0..7),
   startFrameIndex             INTEGER (0..3),
   schedulingImpact            ENUMERATED {
                                  dlANDul,
                                  dlOnly,
                                  ulOnly
                               },
   flag                        ENUMERATED {
                                  clcType1,
                                  clcType2subtype1,
                                  clcType2subtype2,
                                  clcType2subtype3,
                                  clcType3
                               },
   clcType                     CHOICE {
      clcType1Config              CLCType1Configuration,
      clcType2Subtype1Config      CLCType2Subtype1Configuration,
      clcType2Subtype2Config      CLCType2Subtype2Configuration,
      clcType2Subtype3Config      CLCType2Subtype3Configuration,
      clcType3Config              CLCType3Configuration
   }
}

CLCReport ::=               SEQUENCE {
   clcReportType               ENUMERATED {
                                  collocatedInterferenceLevel,
                                  nonCollocatedInterferenceLevel,
                                  interenceLevelUnown
                               },
   interferenceLevel           INTEGER (-127..127)
}

CLCRequest ::=              SEQUENCE {
   requestActionBitmap         BIT STRING (SIZE (8)),
   numberOfCLCclasses          INTEGER (1..16),
   clcConfigurations           SEQUENCE (SIZE (1..16)) OF CLCconfiguration
}

AAI-CLC-REQ ::=             SEQUENCE {
   clcRequestReportIndicator   CHOICE {
      -- The 2-bit "CLC request/report indicator" field will be automatically
      -- added when the "CHOICE" statement is coded by the ASN.1 encoder
      clcRequest                  CLCRequest,
      clcReport                   CLCReport,
      clcRequestAndReport         SEQUENCE {
         clcRep                      CLCReport,
         clcReq                      CLCRequest
      }
   },
   ...
}
```

```
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Co-Located Coexistence Response Message (AAI-CLC-RSP)
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
CLCResponse ::=            SEQUENCE {
   clcID                      CLCID,
   startSFnumber              INTEGER (0..7),
   startFrameIndex            INTEGER (0..3)
}

AAI-CLC-RSP ::=            SEQUENCE {
   confirmedActionBitmap      BIT STRING (SIZE (8)),
   clcResponseList            SEQUENCE (SIZE (1..8)) OF CLCResponse OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- MIMO Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
RowOf2X2Matrix ::=         CHOICE {
   firstRow                   SEQUENCE {
      diagonalEntry              Diagonal,
      offDiagonalEntry           OffDiagonal
   },
   secondRow                  SEQUENCE {
      empty                      NULL,
      diagonalEntry              Diagonal
   }
}

RowOf4X4Matrix ::=         CHOICE {
   firstRow                   SEQUENCE {
      diagonalEntry              Diagonal,
      c2offDiagonalEntry         OffDiagonal,
      c3offDiagonalEntry         OffDiagonal,
      c4offDiagonalEntry         OffDiagonal
   },
   secondRow                  SEQUENCE {
      empty1                     NULL,
      diagonalEntry              Diagonal,
      c3offDiagonalEntry         OffDiagonal,
      c4offDiagonalEntry         OffDiagonal
   },
   thirdRow                   SEQUENCE {
      empty1                     NULL,
      empty2                     NULL,
      diagonalEntry              Diagonal,
      c4offDiagonalEntry         OffDiagonal
   },
   fourthRow                  SEQUENCE {
      empty1                     NULL,
      empty2                     NULL,
      empty3                     NULL,
      diagonalEntry              Diagonal
```

```
   }
}

RowOf8X8Matrix ::=           CHOICE {
   firstRow                     SEQUENCE {
      diagonalEntry                Diagonal,
      c2offDiagonalEntry           OffDiagonal,
      c3offDiagonalEntry           OffDiagonal,
      c4offDiagonalEntry           OffDiagonal,
      c5offDiagonalEntry           OffDiagonal,
      c6offDiagonalEntry           OffDiagonal,
      c7offDiagonalEntry           OffDiagonal,
      c8offDiagonalEntry           OffDiagonal
   },
   secondRow                    SEQUENCE {
      empty1                       NULL,
      diagonalEntry                Diagonal,
      c3offDiagonalEntry           OffDiagonal,
      c4offDiagonalEntry           OffDiagonal,
      c5offDiagonalEntry           OffDiagonal,
      c6offDiagonalEntry           OffDiagonal,
      c7offDiagonalEntry           OffDiagonal,
      c8offDiagonalEntry           OffDiagonal
   },
   thirdRow                     SEQUENCE {
      empty1                       NULL,
      empty2                       NULL,
      diagonalEntry                Diagonal,
      c4offDiagonalEntry           OffDiagonal,
      c5offDiagonalEntry           OffDiagonal,
      c6offDiagonalEntry           OffDiagonal,
      c7offDiagonalEntry           OffDiagonal,
      c8offDiagonalEntry           OffDiagonal
   },
   fourthRow                    SEQUENCE {
      empty1                       NULL,
      empty2                       NULL,
      empty3                       NULL,
      diagonalEntry                Diagonal,
      c5offDiagonalEntry           OffDiagonal,
      c6offDiagonalEntry           OffDiagonal,
      c7offDiagonalEntry           OffDiagonal,
      c8offDiagonalEntry           OffDiagonal
   },
   fifthRow                     SEQUENCE {
      empty1                       NULL,
      empty2                       NULL,
      empty3                       NULL,
      empty4                       NULL,
      diagonalEntry                Diagonal,
      c6offDiagonalEntry           OffDiagonal,
      c7offDiagonalEntry           OffDiagonal,
      c8offDiagonalEntry           OffDiagonal
   },
```

```
   sixthRow                    SEQUENCE {
      empty1                      NULL,
      empty2                      NULL,
      empty3                      NULL,
      empty4                      NULL,
      empty5                      NULL,
      diagonalEntry               Diagonal,
      c7offDiagonalEntry          OffDiagonal,
      c8offDiagonalEntry          OffDiagonal
   },
   seventhRow                  SEQUENCE {
      empty1                      NULL,
      empty2                      NULL,
      empty3                      NULL,
      empty4                      NULL,
      empty5                      NULL,
      empty6                      NULL,
      diagonalEntry               Diagonal,
      c8offDiagonalEntry          OffDiagonal
   },
   eighthRow                   SEQUENCE {
      empty1                      NULL,
      empty2                      NULL,
      empty3                      NULL,
      empty4                      NULL,
      empty5                      NULL,
      empty6                      NULL,
      empty7                      NULL,
      diagonalEntry               Diagonal
   }
}

-- Diagonal entry of correlation matrix as defined
-- in 6.3.6.2.5.5
Diagonal ::=                INTEGER (0..1)

-- Off Diagonal entry of correlation matrix as defined
-- in 6.3.6.2.5.5
OffDiagonal ::=             INTEGER (0..15)

MfmBitmap ::=               BIT STRING {
                               mfm0                        (0),
                               mfm1                        (1),
                               mfm2                        (2),
                               mfm3                        (3),
                               mfm4                        (4),
                               mfm5                        (5),
                               mfm6                        (6),
                               mfm7                        (7)
                            } (SIZE (8))

Mfm0InfoSet ::=             SEQUENCE {
   wbstcRate                   StcRateSet                  OPTIONAL,
   widebandCqi                 WidebandCqi
```



```
}

Mfm1InfoSet ::=             SEQUENCE {
   widebanCqi                  WidebandCqi
}

Mfm2InfoSet ::=             SEQUENCE {
   bestSubbandIndex            BestSubbands                OPTIONAL,
   stcRate                     StcRateSet                  OPTIONAL,
   subbandCqi                  SubbandCqiSetChoice
}

Mfm3InfoSet ::=             SEQUENCE {
   bestSubbandIndex            BestSubbands                OPTIONAL,
   stcRate                     StcRateSet                  OPTIONAL,
   subbandCqi                  SubbandCqiSetChoice,
   subbandPmi                  SubbandPmiSetChoice
}

Mfm4InfoSet ::=             SEQUENCE {
   wbstcRate                   StcRateSet                  OPTIONAL,
   widebandCqi                 WidebandCqi,
   widebandPmi                 WidebandPmiSet              OPTIONAL
}

Mfm5InfoSet ::=             SEQUENCE {
   bestSubbandIndex            BestSubbands                OPTIONAL,
   subbandCqi                  SubbandCqiSetChoice,
   subbandStream               SubbandStreamSetChoice
}

Mfm6InfoSet ::=             SEQUENCE {
   bestSubbandIndex            BestSubbands                OPTIONAL,
   subbandCqi                  SubbandCqiSetChoice,
   subbandPmi                  SubbandPmiSetChoice
}

Mfm7InfoSet ::=             SEQUENCE {
   widebandCqi                 WidebandCqi,
   widebandPmi                 WidebandPmiSet              OPTIONAL
}

WidebandPmiSet ::=          CHOICE {
   nt2                         BIT STRING (SIZE (3)),
   nt4CodeBook0                BIT STRING (SIZE (6)),
   nt4CodeBook1                BIT STRING (SIZE (4)),
   nt8                         BIT STRING (SIZE (4))
}

WidebandCqi ::=             INTEGER (0..15)

BestSubbands ::=            CHOICE {
   fiveM                       BestSubbandForFiveM,
   tenM                        BestSubbandForTenM,
```

```
   twentyM                     BestSubbandForTwentyM
}

BestSubbandForFiveM ::=     CHOICE {
   best1                       INTEGER (0..3)
}

BestSubbandForTenM ::=      CHOICE {
   best1                       INTEGER (0..9),
   best6                       INTEGER (0..209)
}

BestSubbandForTwentyM ::=   CHOICE {
   best1                       INTEGER (0..20),
   best6                       INTEGER (0..54263),
   best12                      INTEGER (0..293929)
}

StcRateSet ::=              CHOICE {
   maxMt2                      BIT STRING (SIZE (1)),
   maxMt3Or4                   BIT STRING (SIZE (2)),
   maxMtMoreThan4              BIT STRING (SIZE (3))
}

SubbandCqiSetChoice ::=     CHOICE {
   best1SubbandCqi             Cqi,
   -- For best 6 or full feedback for 512 FFT belongs here
   best6SubbandCqiSet          SEQUENCE (SIZE (1..6)) OF Cqi,
   -- For best 12 or full feedback for 1024 FFT belongs here
   best12SubbandCqiSet         SEQUENCE (SIZE (1..12)) OF Cqi,
   -- full feedback for 2048 FFT belongs here
   best21SubbandCqiSet         SEQUENCE (SIZE (1..21)) OF Cqi
}

SubbandPmiSetChoice ::=     CHOICE {
   best1SubbandPmi             PmiSet,
   -- For best 6 or full feedback for 512 FFT belongs here
   best6SubbandPmiSet          SEQUENCE (SIZE (1..6)) OF PmiSet,
   -- For best 12 or full feedback for 1024 FFT belongs here
   best12SubbandPmiSet         SEQUENCE (SIZE (1..12)) OF PmiSet,
   -- full feedback for 2048 FFT belongs here
   best21SubbandPmiSet         SEQUENCE (SIZE (1..21)) OF PmiSet
}

SubbandStreamSetChoice ::=  CHOICE {
   best1SubbandStream          StreamSet,
   -- For best 6 or full feedback for 512 FFT belongs here
   best6SubbandStreamSet       SEQUENCE (SIZE (1..6)) OF StreamSet,
   -- For best 12 or full feedback for 1024 FFT belongs here
   best12SubbandStreamSet      SEQUENCE (SIZE (1..12)) OF StreamSet,
   -- full feedback for 2048 FFT belongs here
   best21SubbandStreamSet      SEQUENCE (SIZE (1..21)) OF StreamSet
}
```

```
StreamSet ::=               CHOICE {
   mmi0MaxMt2                  BIT STRING (SIZE (1)),
   mmi0MaxMt3Or4               BIT STRING (SIZE (2)),
   mmi1                        BIT STRING (SIZE (1))
}

PmiSet ::=                  CHOICE {
   nt2                         BIT STRING (SIZE (3)),
   nt4CodeBook0                BIT STRING (SIZE (6)),
   nt4CodeBook1                BIT STRING (SIZE (4)),
   nt8                         BIT STRING (SIZE (4))
}

Cqi ::=                     INTEGER (0..15)

-- Number of reports are same as N_multiBS_reports transmitted in
-- Feedback_Polling_A-MAP IE
MultiBsRpt ::=              SEQUENCE {
   pmi                         CHOICE {
      nt2                         BIT STRING (SIZE (3)),
      nt4                         BIT STRING (SIZE (4)),
      nt8                         BIT STRING (SIZE (4))
   },
   ictRelatedReport            CHOICE {
      ict00or01                   Ict00or01Set,
      ict10                       SEQUENCE {
         pmi                         INTEGER (0..7)
      },
      ict11                       SEQUENCE {
         pmi                         INTEGER (0..7),
         relativeAmp                 INTEGER (0..15)
         -- (-1*relativeAmp)dB
      }
   }
}

Ict00or01Set ::=            SEQUENCE {
   tempBsid                    INTEGER (0..15),
   measurementMetric           MeasurementMetric,
   pmiSubsetSize               PmiSubsetSize,
   pmiCoordinationSubset       PMICoordinationSubset       OPTIONAL
}

PMICoordinationSubset ::=   ENUMERATED {
                               levelN1,
                               levelN2
                            }

MeasurementMetric ::=       ENUMERATED {
                               dot25dB,
                               dot50dB,
                               onedB,
                               greaterThan1dot5dB
                            }
```

```
PmiSubsetSize ::=            ENUMERATED {
                                pmi,
                                multiplePmi
                             }

MultiBSMIMORequestInfo ::=  CHOICE {
   singleBSPrecoding           SEQUENCE {
      nipValueForSingleBS         NipvalueforsingleBS,
      tempBSID                    SEQUENCE (SIZE (1..8)) OF INTEGER (0..15)
   },
   multiBSJointMIMOProcessing  SEQUENCE {
      bitmapForRequestedAdjABSs   BIT STRING (SIZE (8)),
      nipValueForJoint            Nipvalueforjoint
   }
}

NipvalueforsingleBS ::=      ENUMERATED {
                                nipth1,
                                nipth1plusdot5dB,
                                nipth1plusonedB,
                                nipth1plusgreaterThan1dot5dB
                             }

Nipvalueforjoint ::=         ENUMERATED {
                                nipth2,
                                nipth2plusdot5dB,
                                nipth2plusonedB,
                                nipth2plusgreaterThan1dot5dB
                             }

PmiCombinationRatio ::=      ENUMERATED {
                                dot125,
                                dot375,
                                dot625,
                                dot875
                             }

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Single-BS MIMO Feedback
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-SBS-MIMO-FBK ::=         SEQUENCE {
   matrix                       CHOICE {
      matrix2X2                    SEQUENCE (SIZE (2)) OF RowOf2X2Matrix,
      matrix4X4                    SEQUENCE (SIZE (4)) OF RowOf4X4Matrix,
      matrix8X8                    SEQUENCE (SIZE (8)) OF RowOf8X8Matrix
   } OPTIONAL,
   mfmBitmap                    MfmBitmap,
   mfm0Info                     Mfm0InfoSet                 OPTIONAL,
   mfm1Info                     Mfm1InfoSet                 OPTIONAL,
   mfm2Info                     Mfm2InfoSet                 OPTIONAL,
   mfm3Info                     Mfm3InfoSet                 OPTIONAL,
   mfm4Info                     Mfm4InfoSet                 OPTIONAL,
   mfm5Info                     Mfm5InfoSet                 OPTIONAL,
```



```
   mfm6Info                    Mfm6InfoSet                 OPTIONAL,
   mfm7Info                    Mfm7InfoSet                 OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Multiple-BS MIMO Feedback
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-MBS-MIMO-FBK ::=        SEQUENCE {
   ictInfo                     CHOICE {
      ict0b10                     SEQUENCE {
         cqi                         Cqi
      },
      ict0b11                     SEQUENCE {
         maxAmpBs                    BOOLEAN                     OPTIONAL,
         -- Present if S-ABS does not have the maximum channel amplitude
         -- among collaborative ABS
         maxAmpBsIndex               INTEGER (0..7)              OPTIONAL,
         -- Present if S-ABS does not have the maximum channel amplitude
         -- (relativeServingBs+1)dB
         relativeServingBs           INTEGER (0..7)              OPTIONAL
      }
   },
   multiBsReport               SEQUENCE (SIZE (1..8)) OF MultiBsRpt,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Multi-BS MIMO Request
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-MBS-MIMO-REQ ::=        SEQUENCE {
   multiBSMIMORequest          MultiBSMIMORequestInfo,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Multi-BS MIMO Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-MBS-MIMO-RSP ::=        SEQUENCE {
   adjABSBitmapMultiBSMIMO     BIT STRING (SIZE (8)),
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Multi-BS MIMO SBP Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-MBS-MIMO-SBP ::=        SEQUENCE {
   nbrInfoArray                SEQUENCE (SIZE (1..8)) OF SEQUENCE {
      pmiMin                      CHOICE {
         nt2                         BIT STRING (SIZE (4)),
         nt4                         BIT STRING (SIZE (6))
      },
      isl                         ENUMERATED {
                                     one,
```

```
                                    two,
                                    three,
                                    four
                                 }
   },
   pcr                           PmiCombinationRatio,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Multi-BS Sounding Calibration
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-MBS-SOUNDING-CAL ::=    SEQUENCE {
   calibrationMode             INTEGER (0..1),
   superframeNumber            ENUMERATED {
                                  two,
                                  four,
                                  six,
                                  eight
                               },
   frameNumber                 INTEGER (0..3),
   soundingAAISubframe         INTEGER (0..7),
   soundingSubbandBitmap       BIT STRING (SIZE (6..24)),
   decimationOffset            INTEGER (0..63),
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Downlink Interference Mitigation
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-DL-IM ::=               SEQUENCE {
   fp2Power                    INTEGER (0..31)             OPTIONAL,
   -- if 0b00000, -Inf. Otherwise -10+(fp2Power-1)*0.5
   fp3Power                    INTEGER (0..31)             OPTIONAL,
   -- if 0b00000, -Inf. Otherwise -10+(fp3Power-1)*0.5
   multiBSMIMOInfo             SEQUENCE {
      bcsiInfo                    CHOICE {
         twoTxBCSI                   BIT STRING (SIZE (8)),
         fourOrEightTxBCSI           BIT STRING (SIZE (16))
      },
      nipTh1                      INTEGER (0..15),
      -- -7.5+nipTh1*0.5 dB
      nipTh2                      INTEGER (0..15),
      -- -7.5+nipTh2*0.5 dB
      cinrTh                      INTEGER (0..15),
      -- -4.0+cinrTh*0.5 dB
      diversitySets               SEQUENCE {
         changeCount                 INTEGER (0..255),
         tempBSIDSetArray            SEQUENCE (SIZE (1..16)) OF AbsIndex
      } OPTIONAL
   } OPTIONAL,
   ...
}
```



```
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- FFR Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
InterferenceMean ::=        INTEGER (0..255)

InterferenceVariance ::=    INTEGER (0..15)

SINRMean ::=                INTEGER (0..255)

SINRVariance ::=            INTEGER (0..15)

FFR-FeedbackIE ::=          SEQUENCE {
   interferenceMean            InterferenceMean            OPTIONAL,
   -- If 0x00~0x68, (-134+InterferenceMean) dBm. Otherwise, reserved
   interferenceVariance        InterferenceVariance        OPTIONAL,
   sinrMean                    SINRMean                    OPTIONAL,
   -- If 0x00~0x8A, (-16+0.5*SINRMean) dB. Otherwise, reserved
   sinrVariance                SINRVariance                OPTIONAL
}

IntfStatistics ::=          ENUMERATED {
                               doNotSendReport,
                               sendReport
                            }

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- FFR Measurement Report Command
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-FFR-CMD ::=             SEQUENCE {
   frequencyPartitionBitmap    SEQUENCE (SIZE (4)) OF IntfStatistics,
   reportType                  BIT STRING {
                                  interferenceMean            (0),
                                  interferenceVariance        (1),
                                  sinrMean                    (2),
                                  sinrVariance                (3)
                               } (SIZE (4)),
   frameOffset                 INTEGER (0..255),
   physicalCarrierIndex        PhyCarrierIndex             OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- FFR Measurement Report
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-FFR-REP ::=             SEQUENCE {
   -- One report for each frequency partition.
   -- A report is sent if the corresponding element of
   -- frequencyPartitionBitmap in AAI-FFR-CMD is set to sendReport
   frequencyPartitionBitmap    SEQUENCE (SIZE (4)) OF IntfStatistics,
   reportType                  BIT STRING {
                                  interferenceMean            (0),
                                  interferenceVariance        (1),
                                  sinrMean                    (2),
                                  sinrVariance                (3)
```

```
                            } (SIZE (4)),
   ffrReports               SEQUENCE (SIZE (4)) OF SEQUENCE {
      report                   FFR-FeedbackIE             OPTIONAL
   },
   physicalCarrierIndex     PhyCarrierIndex             OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- SON Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
UnavailableTime ::=         SEQUENCE {
   -- Start of unavailable time in unit of frame
   unavailableStartTime        INTEGER (0..255),
   -- Interval of unavailable time in unit of superframe
   unavailableTimeInterval     INTEGER (0..255)
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- SON Advertisement
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-SON-ADV ::=             SEQUENCE {
   sonAction                   CHOICE {
      aBSReconfiguration          SEQUENCE {
         newIDCell                   IDCell,
         unavailableTimes            UnavailableTime
      },
      aBSRestart                  SEQUENCE {
         unavailableTimes            UnavailableTime
      },
      aBSScanning                 SEQUENCE {
         unavailableTimes            UnavailableTime
      },
      aBSReliability              SEQUENCE {
         unavailableTimes            UnavailableTime             OPTIONAL,
         reason                      CHOICE {
            powerDown                   SEQUENCE {
               -- Expected time when the Femto ABS will be
               --powered down in units of frame
               timeOfPowerDown             INTEGER (0..255),
               -- Expected uptime of BS in units of superframe
               expectedUptimeOfBs          INTEGER (0..255)            OPTIONAL
            },
            powerReduction              SEQUENCE {
               -- dB value of Tx power reduction
               txPowerReduction            INTEGER (0..1023),
               -- Expected resource adjustment time in units of frame
               expectedTimeOfPowerReduction INTEGER (0..255)
            },
            fAChange                    SEQUENCE {
               -- FA index
               fAIndex                     FAIndex,
               -- Expected current FA downtime in units of frame
               expectedDowntimeOfCurrentFa INTEGER (0..255),
```



```
               -- Expected uptime of new FA in units of superframe
               expectedUptimeOfNewFa       INTEGER (0..255)            OPTIONAL
            },
            -- The status of DL subframes
            -- Bit 0: the status of the first DL subframe
            -- Bit 1: the status of the 2nd DL subframe
            -- Bit 2: the status of the 3rd DL subframe
            -- Bit 3: the status of the 4th DL subframe
            -- Bit 4: the status of the 5th DL subframe
            -- Bit 5: the status of the 6th DL subframe
            -- (0 means disabled or no such subframe; 1 means enabled)
            disabledSubframesIndex      BIT STRING (SIZE (6))
         }
      },
      ldmParameterChange          SEQUENCE {
         -- The new AI for LDM
         lDmParameterAi              INTEGER (0..16),
         -- The new UAI for LDM
         lDmParameterUai             INTEGER (0..255),
         -- The new SFO for LDM
         lDmParameterSfo             INTEGER (0..511)
      }
   },
   recommendedBSIDList         SEQUENCE (SIZE (0..255)) OF BSID OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Relay Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
RelayZoneAllocation ::=     SEQUENCE {
   rUCASSB0                    BIT STRING (SIZE (3..5)),
   rUCASMB0                    BIT STRING (SIZE (3..5)),
   uUCASi                      BIT STRING (SIZE (1..3))
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- ARS Configuration Command
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-ARS-CFG-CMD ::=         SEQUENCE {
   dlRelayZoneDuration         INTEGER (1..8),
   ulRelayZoneDuration         INTEGER (1..8),
   relayZoneAMSallocInd        BOOLEAN,
   mimoMidambleTxInRelayZones  BOOLEAN,
   amsAllocation               CHOICE {
      amsAllocatedInRelayZones    NULL,
      allocation                  SEQUENCE {
         dlRelayZone                 RelayZoneAllocation,
         ulRelayZone                 RelayZoneAllocation
      }
   },
   ...
}
```

```
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- EMBS Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- E-MBS Configuration
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-EMBS-CFG ::=            SEQUENCE {
   lifetime                    INTEGER (0..15),
   embsZoneIDInfoArray         SEQUENCE (SIZE (1..8)) OF SEQUENCE {
      embsZoneID                  EMBSZoneID,
      mapResourceIndex            INTEGER (0..2047),
      mapSizeOffset               INTEGER (0..31),
      aaiNbrAdvChangeCount        INTEGER (0..7),
      nbrEmbsZoneInfoArray        SEQUENCE (SIZE (1..8)) OF SEQUENCE {
         nbrEMBSZoneID               EMBSZoneID,
         carrierIndex                PhyCarrierIndex             OPTIONAL,
         nbrABSInfoArray             SEQUENCE (SIZE (1..256)) OF SEQUENCE {
            nbrAbsIndex                 INTEGER (0..255)
         },
         embsFIDMappingArray         SEQUENCE (SIZE (0..15)) OF SEQUENCE {
            currentEmbsId               EMBSID,
            currentFid                  FID,
            newEmbsId                   EMBSID,
            newFid                      FID
         }
      } OPTIONAL
   },
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- E-MBS Report
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-EMBS-REP ::=            SEQUENCE {
   embsZoneId                  EMBSZoneID,
   reportMode                  CHOICE {
      carrierSwStartTime          NULL,                      -- report mode == 0b00
      -- Each bit of the bitmap represents an E-MBS connection
      -- E-MBS services are mapped in ascending order of E-MBS+FID
      -- from LSB to MSB of the bitmap
      -- 0: The AMS does not intend to receive the E-MBS service
      -- 1: The AMS currently receives E-MBS or
      -- the AMS may switch to this service
      embsConnectionBitmap        BIT STRING (SIZE (16)),     -- report mode == 0b01
      endCarrierSwitching         NULL
   }, -- report mode == 0b10
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- E-MBS Response
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-EMBS-RSP ::=            SEQUENCE {
   carrierSwitchingStartTime   INTEGER (0..15)             OPTIONAL,
```



```
   -- Each bit indicates which service is available during each superframe
   -- 0: the AMS is available for E-MBS data in secondary carrier
   -- 1: the AMS is available for unicast data in primary carrer
   unicastAvailIntervalBitmap  UnicastAvailIntervalBitmap  OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- LBS Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Message specific types
RelativePosition ::=        SEQUENCE {
   longitude                   INTEGER (0..65535),
   latitude                    INTEGER (0..65535),
   altitude                    INTEGER (0..65535)          OPTIONAL
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- LBS Advertizement
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-LBS-ADV ::=             SEQUENCE {
   absLocation                 CHOICE {
      absoluteLongFormat          SEQUENCE {
         longitude                   SEQUENCE {
            resolution                  INTEGER (0..63),
            integer                     INTEGER (0..511),
            fraction                    INTEGER (0..33554431)
         },
         latitude                    SEQUENCE {
            resolution                  INTEGER (0..63),
            integer                     INTEGER (0..511),
            fraction                    INTEGER (0..33554431)
         },
         altitude                    SEQUENCE {
            unit                        ENUMERATED {
                                           meter,
                                           floor,
                                           ...
                                        },
            resolution                  INTEGER (0..63),
            integer                     INTEGER (0..4194303),
            fraction                    INTEGER (0..255)
         }
      },
      absoluteShortFormat         SEQUENCE {
         longitude                   INTEGER (0..16777215),
         latitude                    INTEGER (0..16777215),
         altitude                    INTEGER (0..65535)          OPTIONAL
      }
   },
   gpsTime                     SEQUENCE {
      time                        INTEGER (0..4194303),
      frameTransmissionTimeOffset INTEGER (0..1023),
      accuracy                    INTEGER (0..31)
```

```
   },
   frequencyAccuracy           INTEGER (0..255),
   bsInfoArray                 SEQUENCE (SIZE (1..255)) OF SEQUENCE {
      bsid                        BSID,
      relativePosition            RelativePosition
   } OPTIONAL,
   aaiNbrAdvConfigChangeCount  INTEGER (0..7)              OPTIONAL,
   bsIndexInfoArray            SEQUENCE (SIZE (1..256)) OF SEQUENCE {
      nbrBSIndex                  INTEGER (0..255),
      relativePosition            RelativePosition
   } OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- LBS Indication
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-LBS-IND ::=             SEQUENCE {
   frameIdentifier             INTEGER (0..15),
   dedicatedRangingCode        INTEGER (0..31),
   rangingOppIndex             INTEGER (0..7),
   subframeIndex               INTEGER (0..3),
   nbrAbsInfoList              SEQUENCE (SIZE (0..255)) OF SEQUENCE {
      nbrAbsIndex                 INTEGER (0..255),
      actionTime                  INTEGER (0..255),
      nbrDedicatedRangingCode     INTEGER (0..31),
      nbrRangingOppIndex          INTEGER (0..7),
      nbrSubframeIndex            INTEGER (0..3)
   } OPTIONAL,
   ...
}

-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- Misc Messages
-- *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Layer 2 Transfer
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-L2-XFER ::=             SEQUENCE {
   transferType                INTEGER {
                                  gnssAssistance              (1),
                                  lbsMeasurement              (2),
                                  deviceBootstrap             (3),
                                  wirelessMAN                 (4),
                                  oratMsg                     (5),
                                  sms                         (6),
                                  mihFrame                    (7),
                                  relaySupport                (8),
                                  emergencyAlert              (9)
                                  --values 10 to 127 are reserved
                                  --values 128 to 255 are for vendor-specific types
                               } (0..255),
   transferSubtype             CHOICE {
      oratMsg                     INTEGER {
```



```
                                geran                        (1),
                                utran                        (2),
                                e-utran                      (3),
                                td-scdma                     (4),
                                cdma2000                     (5)
                             } (0..15),
      sms                    INTEGER {
                                smsData                      (1),
                                smsConfirmation              (2)
                             } (0..15),
      mihFrame               INTEGER {
                                serviceManagement            (1),
                                eventService                 (2),
                                commandService               (3),
                                informationService           (4)
                             } (0..15)
   } OPTIONAL,
   payload                OCTET STRING (SIZE (1..9999)) OPTIONAL,
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- MAC Message Acknowledgement
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-MSG-ACK ::=          SEQUENCE {
   ackSN                    INTEGER (0..255),
   cccid                    INTEGER (0..1),
   ...
}

-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
-- Reset Command
-- +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
AAI-RES-CMD ::=          SEQUENCE {
   ...
}

END
```

Annex C

(informative)

Test vectors

C.1 Cryptographic method test vectors

Note that all values are shown in hexadecimal notation.

C.1.1 AES-CCM

C.1.1.1 Short payload and short ICV

- Plaintext PDU:
  - Advanced Generic MAC header = D0 06
  - Payload = 9c 05 3f 24
  - STID = 234, FID = D
- Ciphertext PDU where TEK = D50E18A844AC5BF38E4CD72D9B0942E5, EKS = 1 (2 bits), PN = 0x17F6BC (22 bits), and ICV length is 4 bytes:
  - Initial CCM block B0 (128 bits): 09 D0 0D 23 4D 00 00 00 00 00 00 57 F6 BC 00 04
  - Encrypted MAC PDU consisting of unencrypted AGMH (2 bytes), unencrypted EKS + PN (3 bytes), encrypted payload (4 bytes), and encrypted ICV (4 bytes):

    D0 0D 57 F6 BC 10 71 D1 B0 FF 70 71 B1

C.1.1.2 Long payload and long ICV

- Plaintext PDU:
  - Advanced Generic MAC header = A0 CA
  - Payload (200 bytes):

    00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
    10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
    20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
    30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
    40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
    50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
    60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
    70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
    80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F
    90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
    A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
    B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
    C0 C1 C2 C3 C4 C5 C6 C7
  - STID = 234, FID = A
- Ciphertext PDU where TEK = B74EB0E4F81AD63D121B7E9AECCD268F, EKS = 3 (2 bits), PN = 0x3B5F11 (22 bits), and ICV length is 8 bytes:

— Intial CCM block B_0 (128 bits): 19 A0 D5 23 4A 00 00 00 00 00 00 FB 5F 11 00 C8

— Encrypted MAC PDU consisting of unencrypted AGMH (2 bytes), unencrypted EKS + PN (3 bytes), encrypted payload (200 bytes), and encrypted ICV (8 bytes):

A0 D5 FB 5F 11
EA 53 E1 74 89 B2 0B F3 F0 9B 0C 1B 84 9A A7 78
B8 D2 67 35 4F F6 95 D1 8B 60 79 F6 67 DB FF 3D
8C 76 AC C1 0C B5 A6 BB 6C 54 1B 61 FB 13 45 DA
4E A9 0A F4 B9 AC B5 AF 28 21 20 95 41 02 7B 4B
13 A8 BA 16 3B 9F 88 42 56 3E B4 0B 8C 4C EA 68
C0 74 F3 C1 CC BF D0 84 C2 7F D1 AC 48 44 E6 7D
63 63 1A F3 D9 39 F2 8F 6D F5 64 31 06 4B AA DE
2C AB C2 C9 8C BC 87 41 78 B7 85 27 C4 DD 33 D0
02 50 32 81 14 B2 32 8C 28 C7 11 72 75 CE FF 57
F2 E5 80 83 B2 08 24 4E 7A C4 18 63 3F CB 38 85
7C 7B DC AC E9 D1 1B 6B 8B EF E3 54 16 AE 3D 26
5A 10 7C FA 39 D6 51 17 67 16 46 3B 26 EE EF 85
EE 74 67 A7 13 DC 03 EF
2F 6B 08 CF 49 2A E1 04

C.1.2 AES-CTR

C.1.2.1 Short payload

— Plaintext PDU:

— Advanced Generic MAC header = 20 06

— Payload = 9c 05 3f 24

— STID = 234, FID = D

— Ciphertext PDU where TEK = D50E18A844AC5BF38E4CD72D9B0942E5, EKS = 1 (2 bits), and PN = 17F6BC (22 bits):

— Encrypted MAC PDU consisting of unencrypted AGMH (2 bytes), unencrypted EKS + PN (3 bytes), and encrypted payload (4 bytes): D0 09 57 F6 BC 86 FB 65 B7

C.1.2.2 Long payload

— Plaintext PDU:

— Advanced Generic MAC header = A0 CA

— Payload (200 bytes):

00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F
20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F
30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F
40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F
50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F
60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F
70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F
80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E 8F

90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E 9F
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE AF
B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE BF
C0 C1 C2 C3 C4 C5 C6 C7

— STID = 234, FID = A

— Ciphertext PDU where TEK = B74EB0E4F81AD63D121B7E9AECCD268F, EKS = 3 (2 bits), and PN = 3B5F11 (22 bits):

— Encrypted MAC PDU consisting of unencrypted AGMH (2 bytes), unencrypted EKS+PN (3 bytes), and encrypted payload (200 bytes):

A0 CD FB 5F 11
EC 86 6C FF 73 C8 CF A6 25 A6 2D E5 8E 68 0E 35
CD 0E AC 0F 0B A6 EE 50 6C CC 13 81 67 6C 85 6E
83 99 58 DF B8 BB 89 74 10 37 3A C3 37 0B 7D C6
BF 52 34 9C 85 25 92 27 79 85 D3 5C 62 F1 A9 67
DA 21 2B 87 04 D6 70 6C CC FD 2E B6 AD 27 64 CD
F9 DA AD 86 5B 20 5F 8D 20 37 BA 36 13 CD E8 E0
51 43 D4 C8 D5 CF 0B FA 92 8D 49 0F 91 2B 70 9A
6C 7C A0 9F FB 48 14 EB 08 03 DA 9E 13 A0 1C A3
E5 01 86 12 22 BD 1C 8A B5 E3 4E 17 A5 00 FC C7
91 DA F2 98 C5 A2 49 EC FC 92 39 ED 6B 4C F4 6A
2E 0D D2 58 55 0F DB 7F 97 A6 3B 3B 67 E3 BF 29
43 F6 7A 31 E2 6F 1B EB 51 12 D4 1C 07 F6 48 B0
A6 BF AB C6 77 2E 6E 27

C.1.3 AES-CMAC

This CMAC calculation is performed according to the formula indicated in the 6.2.5.2.3.2.

C.1.3.1 Short MAC control message

— Plaintext PDU:

—ASN.1 encoded MAC control message = 9c 05 3f 24

—STID = 234, FID = D

— Signature where:

CMAC_KEY = D50E18A844AC5BF38E4CD72D9B0942E5,

AKID = A67B1FE254CD290A (64 bits), and

CMAC_PN=0x57F6BC (24 bits):

— Message header (AK ID | CMAC_PN |STID|FID|24-bit zero padding | ASN.1 encoded MAC_Control_Message) = A6 7B 1F E2 54 CD 29 0A 57 F6 BC 23 4D 00 00 00

— CMAC value (8 bytes)= 78 1C 63 71 6F 48 6A 6F

C.1.3.2 Long MAC control message

— Plaintext PDU:

— ASN.1 encoded MAC control message (100 bytes):

00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F

20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F

30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F

40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F

50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F

60 61 62 63

— STID = ABC, FID = A

— Signature where CMAC_KEY = B74EB0E4F81AD63D121B7E9AECCD268F,

AKID = D5F725AE30F45B3C (64 bits), and CMAC_PN = 3B5F11 (24 bits):

— Message header (AK ID | CMAC_PN |STID|FID|24-bit zero padding | ASN.1 encoded MAC_Control_Message) = D5 F7 25 AE 30 F4 5B 3C 3B 5F 11 AB CA 00 00 00

— CMAC value (8 bytes) = DA 0A 50 5D 04 2A 08 38

Annex D

(informative)

Supported frequency bands

This standard supports deployment of the WirelessMAN-Advanced Air Interface in all bands identified for IMT in ITU-R Radio Regulations. In addition, this standard supports deployment of the WirelessMAN-Advanced Air Interface non-IMT bands below 6 GHz allocated to the Fixed Service and/or Mobile Service. See Table D-1 for more information on some, but not all, of the bands in which the standard can be deployed.

Table D-1—Some of the supported frequency bands

UL AMS Transmit frequency (MHz)	DL AMS Receive frequency (MHz)	Duplex mode
2300–2400	2300–2400	TDD
2305–2320, 2345–2360	2305–2320, 2345–2360	TDD
2345–2360	2305–2320	FDD
2496–2690	2496–2690	TDD
2496–2572	2614–2690	FDD
3300–3400	3300–3400	TDD
3400–3600	3400–3600	TDD
3400–3500	3500–3600	FDD
3600–3800	3600–3800	TDD
1710–1770	2110–2170	FDD
1920–1980	2110–2170	FDD
1710–1755	2110–2155	FDD
1710–1785	1805–1880	FDD
1850–1910	1930–1990	FDD
1710–1785, 1920–1980	1805–1880, 2110–2170	FDD
1850–1910, 1710–1770	1930–1990, 2110–2170	FDD
698–862	698–862	TDD

Table D-1—Some of the supported frequency bands *(continued)*

UL AMS Transmit frequency (MHz)	DL AMS Receive frequency (MHz)	Duplex mode
776–787	746–757	FDD
788–793, 793–798	758–763, 763–768	FDD
788–798	758–768	FDD
698–862	698–862	TDD/FDD
824–849	869–894	FDD
880–915	925–960	FDD
698–716, 776–793	728–746, 746–763	FDD
1785–1805, 1880–1920, 1910–193, 2010–2025, 1900–1920	1785–1805, 1880–1920, 1910–193, 2010–2025, 1900–1920	TDD
450–470	450–470	TDD
450.0–457.5	462.5–470.0	FDD

Annex E

(normative)

Radio specifications for WirelessMAN-Advanced Air Interface

WirelessMAN system transmitters shall conform with unwanted emission specifications.

Local and regional regulations should be consulted for unwanted emission specifications for the appropriate frequency band for each WirelessMAN-Advanced band class. In the absence of any local/regional regulation, the following specifications shall apply.

This annex uses the following definitions:

- ChBW — Nominal channel bandwidth
- f_c — Channel center frequency
- Δf — Absolute value of frequency offset from f_c
- Integration bandwidth — Frequency range over which the emission power is integrated
- F_{ue} — Upper edge of the band (either uplink or downlink whichever larger)

E.1 AMS specifications

E.1.1 AMS spectral masks

Table E-1, Table E-2, and Table E-3 specify the out-of-band emission requirements for AMSs.

Table E-1—AMS channel mask for 5 MHz bandwidth

No	f (MHz)	Integration bandwidth (kHz)	Maximum allowed emission level (dBm/integration bandwidth) as measured at the antenna port
1	$2.5 \le \Delta f < 3.5$	50	–13
2	$3.5 \le \Delta f \le 12.5$	1000	–13

NOTE 1—The first measurement position with a 50 kHz filter is at Δf equal to 2.525 MHz; the last is at Δf equal to 3.475 MHz. The first measurement position with a 1 MHz filter is at Δf equal to 4.0 MHz; the last is at Δf equal to 12.0 MHz.

Table E-2—AMS channel mask for 10 MHz bandwidth

No	f (MHz)	Integration bandwidth (kHz)	Maximum allowed emission level (dBm/integration bandwidth) as measured at the antenna port
1	$5 \leq \Delta f < 6$	100	–13
2	$6 \leq \Delta f \leq 25$	1000	–13

NOTE 2—The first measurement position with a 100 kHz filter is at Δf equal to 5.050 MHz; the last is at Δf equal to 5.950 MHz. The first measurement position with a 1 MHz filter is at Δf equal to 6.5 MHz; the last is at Δf equal to 24.5 MHz.

Table E-3—AMS channel mask for 20 MHz bandwidth

No	f (MHz)	Integration bandwidth (kHz)	Maximum allowed emission level (dBm/integration bandwidth) as measured at the antenna port
1	$10 \leq \Delta f < 11$	200	–13
2	$11 \leq \Delta f \leq 50$	1000	–13

NOTE 3—The first measurement position with a 200 kHz filter is at Δf equal to 10.1 MHz; the last is at Δf equal to 10.9 MHz. The first measurement position with a 1 MHz filter is at Δf equal to 11.5 MHz; the last is at Δf equal to 49.5 MHz.

E.1.2 AMS spurious emissions requirements

Table E-4 specifies the spurious emission requirements for AMSs.

Table E-4—AMS spurious emissions requirements

No	Spurious emission frequency, f	Measurement bandwidth	Maximum allowed emission level (dBm)
1	9 kHz $\leq f <$ 150 kHz	1 kHz	–36
2	150 kHz $\leq f <$ 30 MHz	10 kHz	–36
3	30 MHz $\leq f <$ 1000 MHz	100 kHz	–36
4	1 GHz $\leq f < 5F_{ue}$	30 kHz, if 2.5ChBW $\leq f <$ 10ChBW 300 kHz, if 10ChBW $\leq f <$ 12ChBW 1 MHz, if 12ChBW $\leq f$	–30

E.1.3 AMS power classes

Table E-5provides the list of AMS power classes.

Table E-5—AMS power classes

Class Identifier	P_{nom} (dBm)
Power Class 1	20
Power Class 2	23
Power Class 3	26

In Table E-5, P_{nom} is the declared maximum conducted transmit power.

In the power classes of Table E-5, tolerances are not included. In general, tolerances associated with P_{nom} depend on various parameters including MCS level, spectrum band span (associated with band edge), and so on. Generic and band-specific tolerances associated with these parameters may be added, if applicable.

E.2 ABS specifications

E.2.1 ABS spectral masks

Table E-6, Table E-7, and Table E-8 specify the out-of-band emission requirements for ABSs.

Table E-6—ABS channel mask for 5 MHz bandwidth

No	f (MHz)	Integration bandwidth (kHz)	Maximum allowed emission level (dBm/integration bandwidth) as measured at the antenna port
1	$2.5 \le \Delta f < 7.5$	100	$-7 - 7(\Delta f - 2.55)/5$
2	$7.5 \le \Delta f \le 12.5$	100	–14

NOTE 1—The first measurement position with a 100 kHz filter is at Δf equal to 2.550 MHz; the last is at Δf equal to 12.450 MHz.

Table E-7—ABS channel mask for 10 MHz bandwidth

No	f (MHz)	Integration bandwidth (kHz)	Maximum allowed emission level (dBm/integration bandwidth) as measured at the antenna port
1	$5 \le \Delta f < 10$	100	$-7 - 7(\Delta f - 5.05)/5$
2	$10 \le \Delta f < 15$	100	–14
3	$15 \le \Delta f \le 25$	1000	–13

NOTE 2—The first measurement position with a 100 kHz filter is at Δf equal to 5.05 MHz; the last is at Δf equal to 14.95 MHz. The first measurement position with a 1 MHz filter is at Δf equal to 15.5 MHz; the last is at Δf equal to 24.5 MHz.

Table E-8—ABS channel mask for 20 MHz bandwidth

No	f (MHz)	Integration bandwidth (kHz)	Maximum allowed emission level (dBm/integration bandwidth) as measured at the antenna port
1	$10 \le \Delta f < 15$	100	$-7 - 7(\Delta f - 10.05)/5$
2	$15 \le \Delta f < 20$	100	–14
3	$20 \le \Delta f \le 50$	1000	–13

NOTE 3—The first measurement position with a 100 kHz filter is at Δf equal to 10.05 MHz; the last is at Δf equal to 19.95 MHz. The first measurement position with a 1 MHz filter is at Δf equal to 20.5 MHz; the last is at Δf equal to 49.5 MHz.

E.2.2 ABS spurious emissions requirements

Table E-9 specifies the spurious emission requirements for ABSs.

Table E-9—ABS spurious emissions requirements

No	Spurious emission frequency, f	Measurement bandwidth	Maximum allowed emission level (dBm)
1	9 kHz $\le f <$ 150 kHz	1 kHz	–36
2	150 kHz $\le f <$ 30MHz	10 kHz	–36
3	30 MHz $\le f <$ 1000 MHz	100 kHz	–36
4	1 GHz $\le f < 5F_{ue}$	30 kHz, if 2.5ChBW $\le f <$ 10ChBW 300 kHz, if 10ChBW $\le f <$ 12ChBW 1 MHz, if 12ChBW $\le f$	–30

Annex F

(normative)

Default capability class and parameters

Table F-1—Default capability class and parameters for the AAI PHY

Feature	Feature Subset1	Feature Subset2	Description	Subclause
8.4.9.4.2 Channel Coding	Data Channel	Modulation	DL QPSK	8.4.9.4.2 in IEEE Std 802.16
			DL 16QAM	8.4.9.4.2 in IEEE Std 802.16
			UL QPSK	8.4.9.4.2 in IEEE Std 802.16
			UL 16QAM	8.4.9.4.2 in IEEE Std 802.16

Table F-2—Default capability class and parameters for AAI MAC

Feature	Feature Subset1	Feature Subset2	Description	Subclause
5.2 CS Options and functions	Support of IPCS		Support of IPCS	5.2.5
6.2.3.47 Service Flow Management	a. Service flow addition		Support of service flow addition (BS initiated)	6.2.3.47
	b. Service flow change		Support of service flow change (BS initiated)	
	c. Service flow release		Support of service flow release (BS initiated)	
6.2.6 HO	a. scanning	i) Scanning initiation	AMS initiated Scanning (SCN-REQ)	6.2.6.1.2
			ABS initiated Scanning (SCN-RSP)	6.2.6.1.2
			Event Triggered Scan request	6.2.6.1.2

Table F-2—Default capability class and parameters for AAI MAC *(continued)*

Feature	Feature Subset1	Feature Subset2	Description	Subclause
		ii) Scan Reporting Type Support	Periodic scan report	6.2.6.2
			Event triggered scan report	6.2.6.2
	b. HO Trigger	i) Trigger Metrics	BS CINR mean	6.2.6.2
			BS RSSI mean	6.2.6.2
6.2.11 Bandwidth Request (BR) and Allocation	Standalone BR		Support of Standalone BR Header	6.2.11.1.2
6.2.12 Quality of Service	Support of R1 scheduling services		Support of R1 scheduling services	6.2.12.2
6.2.22 Reliability of MAC control message	Support of message ACK	Support of AAI-MSG-ACK as message ACK	Support of message ACK using AAI-MSG-ACK	6.2.22