Enhanced Ultra High Throughput (EUHT) Technology Specification

Table of Contents

1 Scope

This specification specifies the media access control and physical layer for Enhanced Ultra High Throughput (EUHT) technology, including system reference model, structure, frame format and function of media access control layer, physical layer, etc.

2 Terms and definitions

The following terms and definitions apply to this specification.

2.1 medium access control protocol data unit

A data unit exchanged between two peer MAC entities using PHY layer services.

2.2 MAC management protocol data unit

A data unit exchanged between two peer MAC entities for implementing a MAC management protocol.

2.3 MAC service data unit

Information delivered as a unit between MAC service access points.

2.4 central access point

An entity to provide access service to the station for access.

2.5 station

A terminal device that has a MAC and PHY function interface and can communicate with the CAP.

2.6 modulation and coding scheme

A combination of specific modulation schemes and coding rates employed on the spatial stream.

2.7 beam forming

A technique for pre-processing transmitted data in accordance with known channel conditions.

2.8 spatial stream

A data stream that is spatially transmitted in parallel.

2.9 spatial time stream

A spatial-time encoded stream after space-time coding of the spatial stream.

2.10 group acknowledgement

The way to feedback acknowledgement information in batch.

2.11 short preamble sequence

Training sequence for automatic gain control and coarse synchronization.

2.12 long preamble sequence

Training sequence for fine synchronization and channel estimation. It also called common reference signal(CRS).

2.13 system information channel

A physical channel containing system information such as frame structure allocation.

2.14 control channel

A physical channel containing user’s uplink and downlink transmission scheduling information.

2.15 downlink sounding channel

A physical channel used to transmit downlink sounding signals and complete downlink channel measurements.

2.16 uplink sounding channel

A physical channel used to transmit uplink sounding signals and complete uplink channel measurements.

2.17 uplink scheduling request channel

A physical channel used to transmit uplink scheduling request signals.

2.18 uplink random access channel

The physical channel used to transmit uplink random access signals.

2.19 downlink traffic channel

A physical channel used to transmit user’s downlink service data and control information.

2.20 uplink traffic channel

A physical channel used to transmit user’s uplink service data and feedback information.

2.21 downlink guard interval

A guard interval in the physical layer frame structure for downlink to uplink conversion.

2.22 uplink guard interval

A guard interval in the physical layer frame structure for uplink to downlink conversion.

2.23 resource unit

A resource unit contains 16 data subcarriers, which is the minimum allocable unit for each STA in frequency domain.

3 Abbreviation

For the purposes of this document, the following abbreviations apply.

ACK: Acknowledgement

BCC: Binary Convolutional Code

BCF: Broadcasting Control Frame

BFM: Beam forming Matrix

BPSK: Binary Phase Shift Keying

BS: Buffer Size

BSTAID: Broadcasting STAID

CAP: Central Access Point

CCH: Control Channel

CP: Cyclic Prefix

CQI: Channel Quality Information

CRC: Cyclic Redundancy Check

CSI: Channel State Information

DL-SCH: Downlink Sounding Channel

DL-TCH: Downlink traffic channel

DSA: Dynamic Service Addition

DSC: Dynamic Service Change

DSD: Dynamic Service Delete

EQM: Equal Modulation

EUHT: Enhanced Ultra High Throughput

FCS: Frame Check Sequence

FFT: Fast Fourier Transform

FID: Flow ID

FPI: Feedback Pilot Interval

FSN: Fragment Sequence Number

G-MPDU: Group MPDU

Group Ack: Group Acknowledgement

IFFT: Inverse Fast Fourier Transform

IP: Internet Protocol

IACK: Instant Acknowledgement

LDPC: Low Density Parity Code

L-Preamble: Long Preamble

LSB: Least Significant Bit

MAC: Media Access Control

MCS: Modulation and Coding Scheme

MIMO: Multiple Input Multiple Output

MME: Mobility Management Entity

MMPDU: MAC Management Protocol Data Unit

MPDU: MAC Protocol Data Unit

MSB: Most Significant Bit

MSDU: MAC Service Data Unit

MU-MIMO: Multiple User MIMO

OFDM: Orthogonal Frequency Division Multiplexing

OFDMA: Orthogonal Frequency Division Multiplexing Access

PDU: Protocol Data Unit

PHY: Physical layer

PICS: Protocol implementation consistent assertion

PN: Pseudo Noise

QAM: Quadrature Amplitude Modulation

QoS: Quality of Service

QPSK: Quadrature Phase Shift Keying

RA: Random Access

REQ: Request

RMS: Root Mean Square

RSP: Response

RU: Resource Unit

SAP: Service Access Point

SBC: STA Basic Capability

SCG: Service Control Gateway

SDU: Service Data Unit

SICH: System Information Channel

SINR: Signal to Interference Noise Ratio

SN: Sequence Number

SNR: Signal to Noise Ratio

S-Preamble: Short Preamble

SSN: Starting Sequence Number

STA: Station (Termimal)

STAID: STA Identifier

STBC: Space Time Block Code

SU-MIMO: Single User MIMO

TDD: Time Division Duplexing

TRN: Training sequence

TSTAID: Temporary STAID

UEQM: Unequal Modulation

UGI: Uplink Guard Interval

UL-RACH: Uplink Random Access Channel

UL-SCH: Uplink Sounding Channel

UL-SRCH: Uplink Schedule Request Channel

UL-TCH: Uplink traffic channel

WAPI: WLAN Authentication and Privacy Infrastructure

4 System reference model

The system reference model is shown in Figure 1. The main functions of each layer are as follows:

a) The MAC layer includes the adaptation sublayer and MAC sublayer:

—— Adaptation sublayer: It mainly provides the function of mapping and conversion between external network data and MAC layer service data unit (MSDU) in this part;

—— MAC sublayer: In addition to acting as the Media Access Control, it also includes management and control functions of the system and supports specific functions of the PHY.

b) The PHY layer mainly provides a PHY transmission mechanism that maps the MAC Protocol Data Unit (MPDU) to the corresponding physical channel, using Orthogonal Frequency Division Multiplexing (OFDM) and Multiple Input Multiple Output (MIMO) technologies.

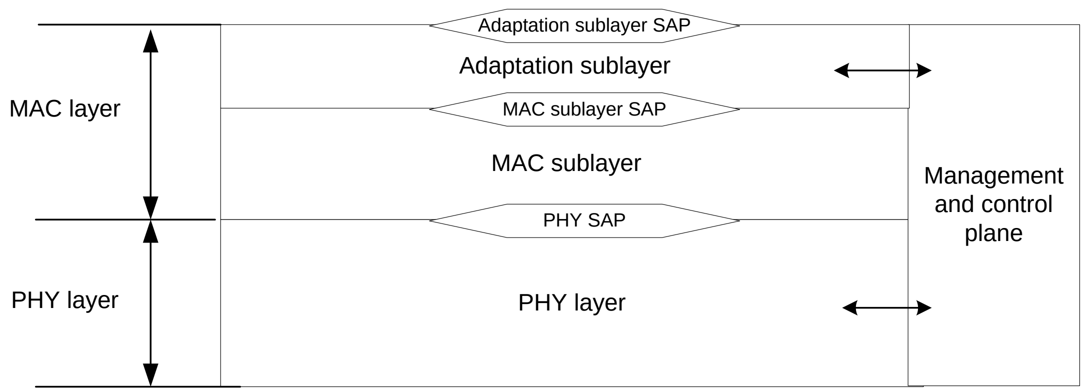


Figure 1 **System reference model**

5 Media Access Control layer

5.1 General

The MAC layer is used to manage and control the allocation and sharing of Physical Layer transmission resources among multiple users. The functional composition is shown in Figure 2. The MAC layer defined in this specification has the following characteristics:

-- The system uses centralized control architecture for multi-user scheduling;

-- The system MAC layer provides connection-oriented services for initial access process.

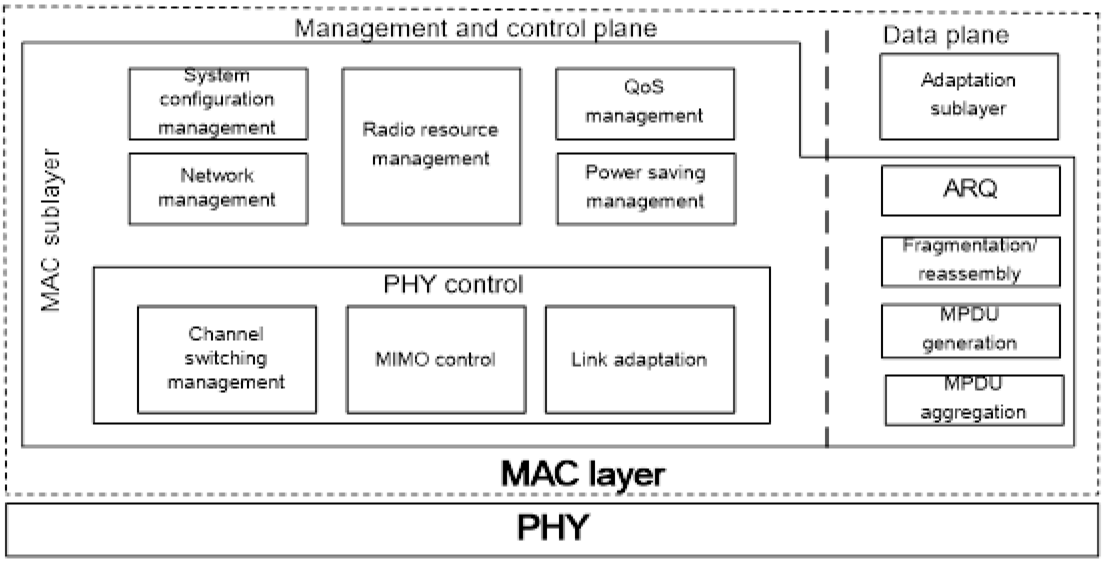


Figure 2 **Functions of MAC layer**

5.2 Adaptation sublayer

The MAC layer is divided into the adaptation sublayer and the MAC sublayer, and the former uses the services provided by the latter. The adaptation sublayer completes the functions as follows:

- receive Service Data Unit (SDU) from the upper layer;
- QoS classification of the received upper SDUs;
- For the service data unit whose QoS classification is completed, the header can be compressed as needed; when the service stream information is established, the header compression function can be switched on or off in the form of dynamic modification;
- Data encryption and decryption of the SDU;
- For services with low time delay and high reliability, in addition to improve reliability by the multi-connection service replication and arbitration mechanism at the application layer, service identification can also be carried out in the adaptation sublayer and the multi-connection transmission mode can be constructed therein. The multi-connection mode can be activated or deactivated by dynamic modification of the service flow information. If the multi-connection mode is enabled for the special type of service identified above, multiple copies of the message can be created by the message copy mode in the adaptation sublayer, and it is possible to schedule multiple copies of the same message in different physical resources in the frame to improve transmission reliability, and repeat message detection in the adaptation sublayer of the receiver to avoid duplicate message delivery.

- send the PDU of the adaptation sublayer generated by this layer to the MAC sublayer;

- receive the SDU of the adaptation sublayer in the peer entity.

5.3 MAC sublayer

The basic functions of the MAC sublayer are distinguished in the management control plane and the data plane.

The management control plane has the following functions:

a) System configuration: it manages system configuration and exchange system configuration information with the station.

b) Radio resource management: it mainly performs the service scheduling function to allocate resources based on service parameters and channel conditions, and has functions such as load balancing and access control.

c) Mobility management: Mobility management of the idle and connected state of the STA.

d) Network access and security management: responsible for initializing and accessing processes, generating the information required for the access process, including access code selection, capability negotiation, and so on. Assist the MME entity to realize two-way authentication between the mobile station and the network;

e) QoS management: it manages the QoS parameters of the service and maintains the establishment, modification and deletion of each service stream.

f) Power saving management: it manages STAs without service to enter the sleep state, and return from the sleep state to the active state.

g) PHY control, mainly including the following sub-functions:

1) Channel management: including channel switching, management spectrum measurement and message reporting;

2) Transmission mode management: channel sounding mechanism, and MIMO working mode selection;

3) Link adaptation:

- CQI measurement and feedback;
- MCS selection and feedback;
- Power control and management.

The data plane has the following functions:

- Instant frame acknowledgement (IACK)): The instant frame acknowledgement mechanism between the uplink and downlink scheduling periods of adjacent physical frames is an important measure to reduce the time delay, and complete acknowledgement and re-transmission operations for the MPDU of the MAC layer or for the fragmented/ aggregated MPDU, see section 7.9;
- Fragmentation / reassembly: according to the scheduling result, the upper layer service data unit is fragmented and sent to the next processing module, and multiple fragments are reassembled and restored at the receiving end;
- MPDU generation: it encapsulates the upper layer service units into the basic MAC frames, and then sends to the next processing module;
- MPDU aggregation: the sender aggregates the upper layer service data unit according to the scheduling result.

5.4 Status of STA

See Figure 3 for the basic state transition of the STA in this system. In the state transition diagram, the STA has four states, i.e. initial state, access state, connection state, and idle state, see below:

- Initial state: After the STA is powered on, search for the physical frame pilot to get system synchronization;
- Access state: The STA needs to get synchronization, and then access the process randomly or by capability negotiation. It includes three sub-states:

a) State of waiting for resource allocation requested by random access: after the STA sends the random access code, it transits to the state of waiting for resource allocation requested by random access, and waits for the CAP side to allocate the CCH for sending the subsequent random access request;

b) State of waiting for random access response: the STA uses the resources allocated by the CAP to send a random access request frame and transits to the state of waiting for random access response;

c) State of waiting for capability negotiation response: after the STA receives the random access response information and the allocated CCH, the STA sends the capability negotiation request frame and transits to the state of waiting for capability negotiation response.

- Connecting state: service running state, in which, reserved resources are allocated to users to apply for resources by taking uplink ACK resources in downlink services; response stream can be changed and request can be deleted; STA can transit to sleep state after receiving the sleep request; the user can quit the network after receiving the quit network frame and return to the initial state.
- Idle state: when the STA is not accessed to any connection, it enters the idle state; at this time, it can enter sleep mode, and it has the ability to be woke up immediately;

State transition conditions see Table 1.

Table 1 State transition conditions

No.	Transition	State before transition	State after transition	Transition condition description
1	Send random access code	Initial state	Waiting for resource allocation requested by random access	STA sends random access code
2	Send random access request	Waiting for resource allocation requested by random access	Waiting for random access response	STA receives the CCH allocated by the random access request resource, and sends random access request.
3	Random access succeeded	Waiting for random access response	Waiting for capability negotiation response	STA receives the random access response frame sent by the CAP.
4	Service stream is completed for construction	Waiting for capability negotiation response	Connecting state	CAP responses to the stream establishing request of the STA to establish a service stream for the user and allocate reserved resources for the user.
5	Quit the network	Connecting state	Initial state	The CAP receives the quit network request, responses the user, and deletes the user.
6	Service stream deletion	Connecting state	Idle state	After all the service connections of the STA are deleted, the STA transits to idle state.
7	Establishment of service stream	Idle state	Connecting state	If the STA in idle state establishes a service stream, it transits to the connecting state.
8	Stream modification, deletion	Connecting state	Connecting state	service stream management operation requested by the STA
9	Timeout I	Waiting for allocation requested by random access	Initial state	Timeout after sending random access request for resource allocation
10	Timeout II	Waiting for random access response	Initial state	Timeout of random access response

No.	Transition	State before transition	State after transition	Transition condition description
11	Timeout III	Waiting for capability negotiation response	Initial state	Timeout of capability negotiation response
12	Timeout IV	Connecting	Initial state	Timeout of stream establishment

The STA state transition is shown in Figure 3

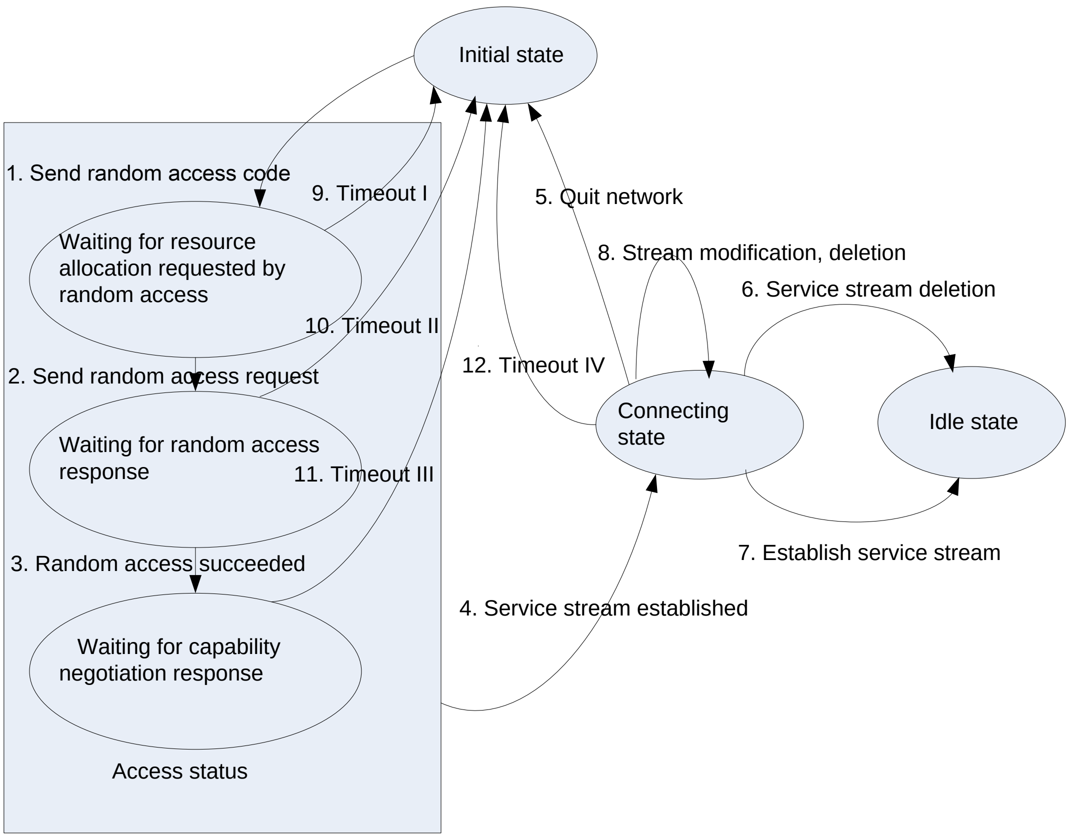


Figure 3 **STA state transition - media access control frame format**

6 MAC frame format

6.1 General MAC frame format

6.1.1 Overview of the general MAC frame format

The frame format of the MAC Protocol Data Unit (MPDU) is shown in Figure 4. Each MPDU can be divided into three parts: part one is a fixed-length general MAC header; part two is the payload carried by the MPDU; and part three is the frame check sequence (FCS) information.

Bits involved in all field of the MAC frame are numbered in a sequence from low to high and sent to the Physical Layer in this sequence. The bits in one byte are transmitted to the Physical Layer in the order from the least significant bit (LSB) to the most significant bit (MSB). The bits contained in the same byte correspond to decimal numbers in order from low to high, for example, b9~b11=000, corresponding to 0; b9~b11=001, corresponding to 4.

MAC header (6 bytes)						0 - 4095 bytes	4 bytes
Frame control	Fragment Sequence Number	Seq. Nr.	Reserved	Fragment indication	Length	Frame body	FCS
Bit : 16	4	12	3	1	12		

Figure 4 **General MAC frame format**

6.1.2 Frame control field

6.1.2.1 Frame control field overview

The frame control field contains the following: protocol version, frame type, subtype, Flow ID (FID), re-transmission indication and reservation. The specific format is shown in Figure 5. All MAC frames contain the frame control field.

Frame control (2 bytes)					
Protocol version	Frame type	Subtype	Flow ID	re-transmission indication	Reserved
Bit : 2	1	5	4	1	3

Figure 5 **Frame control field**

6.1.2.2 Protocol version field

The protocol version field is 2 bits long and always has the same length and position in all revisions of this specification. For this specification, the protocol version value is 0 and all other values are reserved.

6.1.2.3 Frame type and subtype fields

The frame type field has a length of 1 bit, and the subtype field has a length of 5 bits. Both fields collectively identify the function of the frame. There are two frame types: management control type and data type. Each frame type is subdivided into several subtypes. Table 2 defines various valid combinations of types and subtypes.

Table 2 **Combinations of valid types and subtypes**

Type b2	Type description	Subtype b7 b6 b5 b4 b3	Subtype description
0	Management/ control	00000	Broadcasting control frame (BCF)
		00001	Random access request frame (RA-REQ)
		00010	Random access response frame (RA-RSP)
		00011	STA basic capability request frame (SBC-REQ)
		00100	STA basic capability response frame (SBC-RSP)

		00101	Dynamic service addition request frame (DSA-REQ)
		00110	Dynamic service addition response frame (DSA- RSP)
		00111	Dynamic service change request frame (DSC-R EQ)
		01000	Dynamic service change response frame (DSC-RSP)
		01001	Dynamic service delete request frame (DSD-REQ)
		01010	Dynamic service delete response frame (DSD-RSP)
		01011	Independent resource request frame (RES-REQ)
		01100	Multiple input multiple output feedback frame based on channel state information (CSI-MIMO)
		01101	Channel quality information feedback frame (CQI-FB)
		01110	Reserved
		01111	Feedback frame based on beamforming matrix (BFM MIMO)
		10000	Acknowledgement frame (ACK)
		10001	Group acknowledgement request frame (Group AckReq)
		10010	Group acknowledgement frame (Group Ack)
		10011	Quit network frame (Quit)
		10100	Channel switching information frame (CSW - INF)
		10101	Sleep request frame (SLP-REQ)
		10110	Sleep response frame (SLP-RSP)
		10111	Downlink traffic indication frame (DTF-IND)
		11000～11111	Reserved
1	Data	00000	Data frame (DATA)
		00001	Data padding frame (PAD DATA)
		00010～11111	Reserved

6.1.2.4 Flow ID (FID) field

The length of the FID field is 4 bits. 0000 is used for management control stream, and 0001~1111 is for the data streams.

6.1.2.5 Re-transmission indication field

The re-transmission indication field is 1 bit in length. If the current frame is a re-transmission frame of the previous frame, the field is set to 1; otherwise, it is set to 0.

6.1.2.6 Reserved field

The reserved field is 3 bits, default of 0.

6.1.2.7 Fragment sequence number field

The fragment sequence number field is 4 bits long and used to indicate the number of each fragment of the MSDU/MMPDU. The value ranges from 0 to 15. When the MSDU/MMPDU has only one fragment, the FSN is 0; when the MSDU/MMPDU has multiple fragments, the first FSN is 0. The FSN of different fragments of the same MSDU/MMPDU is incremented by 1. In the instant acknowledgement mode, the fragment sequence number can be wrap-around, that is, after the FSN 15 is acknowledged, it counts from 0 subsequently.

6.1.2.8 Sequence number field

The sequence number field is 12 bits long and has a value range of 0 to 4095 to indicate the sequence number of the MSDU/MMPDU. All transmitted MSDU/MMPDUs in an FID stream are assigned a sequence number. The first MSDU/MMPDU sequence number is 0, and the sequence number of different MSDU/MIVIPDUs in the same FID is incremented by 1.

6.1.2.9 Reserved

The reserved field is 3 bits, default of 0.

6.1.3 Fragment indication field

The fragment indication field is 1 bit in length. In all data frames or management control frames with sequence numbers, if the current MSDU/MMPDU still has any fragment after the current frame, the field is set to 1; otherwise, the field is set to 0.

6.1.4 Length field

The length field is 12 bits, which indicates the total byte length of all fields between the MAC header field and FCS field.

6.1.5 Frame body field

The length of the frame body field is variable, the minimum frame body length is 0 byte, and the maximum frame body length is 4095 bytes.

6.1.6 Frame check sequence field

The FCS field is 32 bits, containing a 32-bit CRC. The FCS is calculated from the MAC header and the entire field of the frame body.

The FCS is calculated using the standard polynomial of degree 32. See Equation 1:

$$G(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x + 1 \qquad \text{(Equation 1)}$$

The initial state of the register is 0xFFFFFFFF, and the register state is inverted as the FCS field output after the end of the operation. The FCS field transmits in the order from high order to low.

6.2 Data frame

6.2.1 Data frame format

The format of the data frame is shown in Figure 6.

MAC header (6 bits)								0 - 4095 bytes	4 bytes
Frame control	Fragment Sequence Number	Seq. Nr	Reserved	Channel-associated request indication	Instant/ delayed acknowledgment	Fragment indication	Length	Frame body	FCS
Bit: 16	4	12	1	1	1	1	12		

Figure 6 **Data frame format**

6.2.2 Reserved field

The field is 1 bit long, and default of 0.

6.2.3 Channel-associated request indication field

The channel-associated request indication field is 1 bit in length. If the field is 1, it indicates that a channel-associated resource request field will be added at the forefront of the frame body; if the segment is 0, it indicates that there is no channel-associated resource request field.

6.2.4 Instant / delayed acknowledgement field

Instant /delayed acknowledgement field is 1 bit long. If the field is 1, it indicates that the sender notifies the receiver to immediately acknowledge all data frames that are not acknowledged when receiving the frame. If the field is 0, it indicates that the sender allows the receiver to delay the acknowledgement of the frame when receiving it.

6.2.5 Data padding frame

When the type is 1, and the subtype is 00001, it indicates that this is a data padding frame. At this time, the frame body is invalid data, and only used as a placeholder.

6.3 Management control frame

6.3.1 General

The management control frame is divided into the management control frames with and without the sequence number.

The management control frame without sequence number includes: random access request frame, random access response frame, STA basic capability request frame, STA basic capability response frame, dynamic service addition request frame, dynamic service addition response frame, dynamic service change request frame, dynamic service change response frame, dynamic service delete request frame, dynamic service delete response frame, independent resource request frame, ACK frame, Group AckReq frame, Group Ack frame, quit network frame, channel switching information frame, sleep request frame, sleep response frame, downlink traffic indication frame, CM-REQ, CM-RSP, HO-REQ, HO-CMD and extensible TLV frame.

The management control frame with sequence number includes the BCF frame, CSI-MIMO frame, BFM-MIMO frame, CQI-FB frame, and CM-REP frame.

6.3.2 General frame format of management control frame without sequence number

General frame format of management control frame without sequence number is shown in Figure 7.

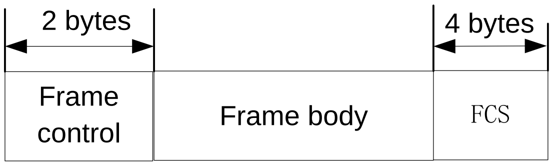


Figure 7 **General frame format of management control frame without sequence number**

6.3.3 General frame format of management control frame with sequence number

General frame format of management control frame with sequence number is shown in Figure 8 .

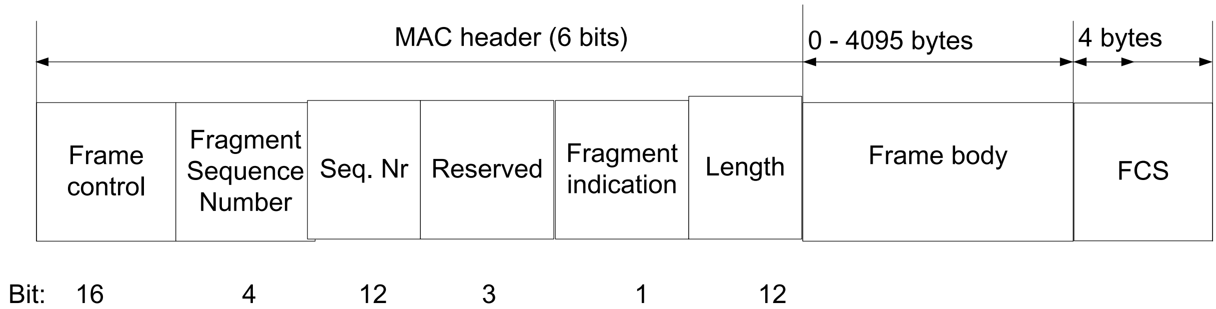


Figure 8 **General frame format of management control frame with sequence number**

6.3.4 Management control frame definition

6.3.4.1 Broadcast control frame

BCFs are used for CAP broadcast capabilities.

The frame body contains fixed and extensible parts. See Table 3 for information of the fixed part. The extensible part can be in a TLV structure.

Table 3 **Fixed part of BCF frame body**

Information	Length/ bit	Remarks
CAP-MAC address	48	Unique identifier of the CAP
Working channel number	8	The minimum channel number occupied by the CAP
work bandwidth	2	Working bandwidths for broadcasting CAP: 0: working bandwidth 1 in working bandwidth mode; 1: working bandwidth 2 in working bandwidth mode; 2: working bandwidth 4 in working bandwidth mode; 3: Reserved
CAP end antenna configuration	3	Indicates the antenna configuration at maximum on the CAP side, 0:1 antenna;

		1:2 antennas; 2:3 antennas; 3:4 antennas; 4:5 antennas; 5:6 antennas; 6:7 antennas; 7: 8 antennas;
Reserved	3	Default of 0.
Network identifier length	8	The valid length of the network identifier field. The value ranges from 1 to 31, in bytes.
Network identifier	248	A string started with a letter or number, with the maximum length of 31 bytes.
Time stamp	64	Provides a public clock within the CAP for system synchronization during STA initialization, unit: μs
BCF interval	16	Indicates the time cycle in which the BCF frame appears, unit: ms
The minimum backoff window for Random Access	4	Used for the control of the backoff window for Random Access, and the value of the minimum backoff window ranges within $0\sim2^n-1$
The minimum backoff window for scheduling request	4	Used to control the backoff window of the collision-based resource request, and the minimum window value ranges within $0\sim2^n-1$

Table 3 (Continued)

Information	Length/ bit	Remarks
The maximum backoff window for Random Access	8	Used for the control of the backoff window for Random Access, and the value of the maximum backoff window ranges within $0\sim2^n-1$
The maximum backoff window for scheduling request	8	Used to control the backoff window of the collision-based resource request, and the maximum window value ranges within $0\sim2^n-1$
CAP transmit power	8	Indicates the current transmit power of the CAP, The signed decimal number of the field is *n*, *n* = -128~127 (the negative part is represented in the complement form): the transmit power of CAP is *n* dBm
Reserved	5	Default of 0
Downlink sounding pilot pattern	3	Indicates the downlink sounding pilot pattern index (table F.1)
Position of the downlink sounding channel	8	Indicates the position of the downlink sounding channel in the DL-TCH. The field corresponds to a decimal number of *n* and *n*=0-255. The downlink sounding channel divides the DL-TCH into the front and rear parts, and the latter part has *n* OFDM symbols.
Demodulation reference signal time domain interval 0	7	Number of OFDM symbols for adjacent demodulation reference signal time domain intervals (configured with short interval)

Demodulation reference signal time domain interval 1	9	Number of OFDM symbols for adjacent demodulation reference signal time domain intervals (configured with long interval)
DGI	2	Downlink-uplink conversion time, 0: The guard interval is 2 OFDM symbol periods; 1: The guard interval is 4 OFDM symbol periods; 2~3: Reserved;
UGI	2	Uplink-downlink conversion time, 0: The guard interval is 2 OFDM symbol periods; 1: The guard interval is 4 OFDM symbol periods (delayed handling); 2~3: Reserved;
UL-RACH format	2	00: Random access format 1; 01: Random access format 2; 10: Random access format 3; 11: Random access format 1 with 8 repetition
LDPC support mode	1	0: support LDPC 448/1344/2688 code length 1: support LDPC 1344/2688/5376 code length
Reserved	9	Default of 0

In low-error mode, the fixed part of BCF frame body is as below:

Table 4 **Fixed part of BCF frame body In low-error mode**

Information	Length/ bit	Remarks
CAP-MAC address	48	Unique identifier of the CAP
Working channel number	8	The minimum channel number occupied by the CAP
work bandwidth	2	Working bandwidths for broadcasting CAP: 0: working bandwidth 1 in working bandwidth mode; 1: working bandwidth 2 in working bandwidth mode; 2: working bandwidth 4 in working bandwidth mode; 3: Reserved
CAP end antenna configuration	3	Indicates the antenna configuration at maximum on the CAP side, 0:1 antenna; 1:2 antennas; 2:3 antennas; 3:4 antennas; 4:5 antennas; 5:6 antennas; 6:7 antennas; 7: 8 antennas;
Reserved	3	Default of 0.
BCF interval	16	Indicates the time cycle in which the BCF frame appears, unit: ms

The minimum backoff window for Random Access	4	Used for the control of the backoff window for Random Access, and the value of the minimum backoff window ranges within $0 \sim 2^n-1$
The minimum backoff window for scheduling request	4	Used to control the backoff window of the collision-based resource request, and the minimum window value ranges within $0 \sim 2^n-1$

Table 4 (Continued)

Information	Length/ bit	Remarks
The maximum backoff window for Random Access	8	Used for the control of the backoff window for Random Access, and the value of the maximum backoff window ranges within $0\sim2^n-1$
The maximum backoff window for scheduling request	8	Used to control the backoff window of the collision-based resource request, and the maximum window value ranges within $0\sim2^n-1$
CAP transmit power	8	Indicates the current transmit power of the CAP, The signed decimal number of the field is *n*, *n* = -128~127 (the negative part is represented in the complement form): the transmit power of CAP is *n* dBm
Reserved	5	Default of 0
UL-RACH format	2	00: Random access format 1; 01: Random access format 2; 10: Random access format 3; 11: Reserved;
Reserved	9	Default of 0

6.3.4.2 Random access request frame

The random access request frame is shown in Figure 9, which is used by the STA to initiate the random access request to the CAP.

Bit:	16	48	48	8	8	32	32
	Frame control	STA-MAC	CAP-MAC	Power adjustment margin	STA transmit power	Reserved	FCS

Figure 9 **Random access request frame**

The contents of the random access request frame body are shown in Table 5.

Table 5 **Random access request frame body**

Name	Length/ bit	Value
STA-MAC address	48	MAC address of the STA
CAP-MAC address	48	MAC address of the CAP requested for access
Power adjustment margin	8	STA transmit power adjustment margin. The signed decimal number of the field is *n*, *n* = -128~127 (the negative part is represented in the complement form): the transmit power margin is *n* dBm
STA transmit power	8	The current transmit power of the STA. The signed decimal number of the field is *n*, *n* = -128~127 (the negative part is represented in the complement form): the STA transmit power is *n* dBm
Reserved	32	Default of 0

6.3.4.3 Random access response frame

The random access response frame is shown in Figure 10, which is used by the CAP to respond to the received random access request.

Bit:	16	8	2	6	48	12	36	32
	Frame control	Power	Access status	Reserved	STA-MAC	TSTAID	Reserved	FCS

Figure 10 **Random access response frame**

The contents of the random access response frame body are shown in Table 6.

Table 6 **Random access response frame body**

Name	Length/ bit	Value
Power adjustment	8	Transmit power adjustment value of the STA. The signed decimal number of the field is *n*, *n* = -128~127 (the negative part is expressed in complement form): the transmit power adjustment value is *n* dBm
Access status	2	0: reserved; 1: Give up 2: Success; 3: Re-access
Reserved	6	Default of 0
STA's MAC address	48	MAC address of the STA
TSTAID	12	Temporary identifier for identifying the user
Reserved	36	Default of 0

6.3.4.4 STA basic capability request frame

The STA basic capability request frame is used by the STA to notify the CAP of its basic capabilities. The information contained in the frame body is shown in Table 7.

Table 7 **STA basic capability request frame body**

Name	Length/ bit	Value
Number of STA antenna	3	0: an antenna; 1:2 antennas; 2:3 antennas; 3:4 antennas; 4:5 antennas; 5:6 antennas; 6:7 antennas; 7: 8 antennas;
STA's maximum working bandwidth	2	Support bandwidth in working bandwidth mode 0: bandwidth1 in working bandwidth mode(For example, if 20/40/80M working bandwidth mode, it is 20MHz); 1: bandwidth2 in working bandwidth mode(For example, if 20/40/80M

		working bandwidth mode, it is 40MHz); 2: bandwidth3 in working bandwidth mode(For example, if 20/40/80M working bandwidth mode, it is 80MHz); 3: Reserved
STA supporting spectrum aggregation	2	0: Not supported; 1: Support spectrum aggregation mode; 2~3: reserved
STA-supported scheduling mechanism	1	0: Only the round-robin scheduling is supported; 1: Reserved
STA working sub-channel mapping	4	0001: Sub-channel 0; 0010: Sub-channel 1; 0100: Sub-channel 2; 1000: Sub-channel 3; For Bitmap or computing, it can indicate working bandwidth 2 and working bandwidth 3 stations operating on multiple working bandwidth 1 subchannels
STA version number	4	Default of 0
Maximum number of STA transmit streams	3	0: the number of streams is 1; 1: the number of streams is 2; 2: The number of streams is 3; 3: The number of streams is 4; 4: The number of streams is 5; 5: The number of streams is 6; 6: The number of streams is 7; 7: The number of streams is 8
Maximum number of streams that STA receives	3	0: The number of streams is 1; 1: The number of streams is 2; 2: The number of streams is 3; 3: The number of streams is 4; 4: The number of streams is 5; 5: The number of streams is 6; 6: The number of streams is 7; 7: The number of streams is 8
Indication of MCS capability of the STA	1	0: 256-QAM is not supported; 1: Support 256-QAM
Indication of UEQM capability of the STA	1	0: UEQM is not supported; 1: Support UEQM
Indication of LDPC capability of the STA	1	0: LDPC code length 1 is not supported. 1: Support LDPC code length 1
Indication of Tx STBC capability of the STA	1	0: Not supported; 1: Support

Indication of Rx STBC Capability of the STA	1	0: Not supported; 1: Support
Indication of MU-MIMO capability of the STA	1	0: Not supported; 1: Support
Indication of precoding capability of the STA	1	0: not support precoding 1: support precoding
Feedback capability for subcarrier grouping Ns	3	Indicates the number of subcarriers in the group: 0: 1 subcarrier (not grouped) is included in the group (FPI = 1); 1: 2 subcarriers are included in the group (FPI = 2); 2: 4 subcarriers are included in the group (FPI = 4); 3: 8 subcarriers are included in the group (FPI = 8); 4: 16 subcarriers are included in the group (FPI = 16); 5 - 7: Reserved
Feedback mode of the supported MIMO	3	000: does not support feedback; 001: CSI-MIMO feedback; 010: BFM-MIMO feedback; 100: reserved; For Bitmap or computing, it can indicate the STA to support multiple feedbacks.
Uplink signaling/feedback channel format 2 indication	1	0: Not supported; 1: Support
STA DGI demand indication	2	0: 2 guard intervals between OFDM symbols are required; 1: 4 guard intervals between OFDM symbols are required; 2~3: reserved;
STA UGI demand indication	2	0: 2 guard intervals between OFDM symbols are required; 1: 4 guard intervals between OFDM symbols are required; 2~3: reserved;
Authentication access mode	2	0: Authentication is not supported; 1: Support authentication, local security context is available 2: Support authentication, no local security context 3: Reserved
STA support changing working bandwidth	4	Please refer to STA support working bandwidth mode. b2..b0 = 000: not support changing working bandwidth b0=1: support changing working bandwidth 3 b0=0: not support changing working bandwidth 3 b1=1: support changing working bandwidth 2 b1=0: not support changing working bandwidth 2 b2=1: support changing working bandwidth 1 b2=0: not support changing working bandwidth 1 b3: reserved
STA support working bandwidth	3	000: 5/10/20M working bandwidth mode 001: 10/20/40M working bandwidth mode

mode		010: 15/30/60M working bandwidth mode 011: 20/40/80M working bandwidth mode 100: 25/50/100M working bandwidth mode 101~111: reserved
STA support LDPC code length	4	b0： 0: not support LDPC 448 code length 1: support LDPC 448 code length b1： 0: not support LDPC 1344 code length 1: support LDPC 1344 code length b2： 0: not support LDPC 2688 code length 1: support LDPC 2688 code length b3： 0: not support LDPC 5376 code length 1: support LDPC 5376 code length
Reserved	51	Default of 0

6.3.4.5 STA basic capability response frame

The STA basic capability response frame is used by the CAP to notify the STA working parameters. The information contained in the frame body is shown in Table 8.

Table 8 **STA basic capability response frame body**

Name	Length/ bit	Value
STA ID	12	Used to identify users
Working subchannel mapping	4	0001: Sub-channel 0; 0010: Sub-channel 1; 0100: Sub-channel 2; 1000: Sub-channel 3; For Bitmap or computing, it can indicate working bandwidth 2 and working bandwidth 3 stations operating on multiple working bandwidth 1 subchannels
Spectrum aggregation mode	2	0: No aggregation; 1: Aggregation mode (discontinuous spectrum aggregation); 2~3: reserved
Scheduling mechanism	1	0: Only support the round-robin scheduling; 1: Reserved
MCS indication	1	Indicates whether the STA supports 256-QAM; 0: 256 QAM is not supported; 1: Support 256-QAM
UEQM indication	1	0: UEQM is not supported. 1: Support UEQM
LDPC indication	1	The encoding methods supported by STA: 0: LDPC code length 1 is not supported.

		1: Support LDPC code length 1
Tx STBC	1	0: Not supported; 1: Support
Rx STBC	1	0: Not supported; 1: Support
Maximum number of STA transmit streams	3	0: The number of streams is 1; 1: The number of streams is 2; 2: The number of streams is 3; 3: The number of streams is 4; 4: The number of streams is 5; 5: The number of streams is 6; 6: The number of streams is 7; 7: The number of streams is 8
Maximum number of streams that STA receives	3	0: The number of streams is 1; 1: The number of streams is 2; 2: The number of streams is 3; 3: The number of streams is 4; 4: The number of streams is 5; 5: The number of streams is 6; 6: The number of streams is 7; 7: The number of streams is 8
MU MIMO	1	0: Not supported; 1: Support
STA precoding	1	0: not support precoding 1: support precoding
Feedback capability for subcarrier grouping Ns	3	Indicates the number of subcarriers in the group: 0: 1 subcarrier is included in the group (not grouped) (FPI = 1); 1: 2 subcarriers are included in the group (FPI = 2); 2: 4 subcarriers are included in the group (FPI = 4); 3: 8 subcarriers are included in the group (FPI = 8); 4: 16 subcarriers are included in the group (FPI = 16); 5 - 7: Reserved
feedback mode of the supported MIMO	3	000: does not support feedback; 001: CSI-MIMO feedback; 010: BFM-MIMO feedback; 100: reserved; For Bitmap or computing, it is confirmed that the STA can be fed back in multiple combinations.
Uplink signaling/feedback channel format 2	1	0: Format 2 is not supported; 1: Format 2 is supported
Reserved	1	Default 0
STA DGI demand	2	0: 2 guard intervals between OFDM symbols are required; 1: 4 guard intervals between OFDM symbols are required; 2~3: reserved;

STA UGI demand	2	0: 2 guard intervals between OFDM symbols are required; 1: 4 guard intervals between OFDM symbols are required; 2~3: reserved;
Authentication instruction	2	0: Authentication is not supported; 1: Support authentication, security context is available. 2: Support authentication, no security context. 3: Reserved
STA wording bandwidth	2	0: bandwidth 1 in working bandwidth mode; 1: bandwidth 2 in working bandwidth mode; 2: bandwidth 3 in working bandwidth mode; 3: reserved
Indication of changed working bandwidth and sub-channel	4	b2…b0: 000: not change current sub-channel。 001: change to sub-channel 1 in working bandwidth 1 010: change to sub-channel 2 in working bandwidth 1 011: change to sub-channel 3 in working bandwidth 1 100: change to sub-channel 4 in working bandwidth 1 101: change to upper sideband in working bandwidth 2 110: change to lower sideband in working bandwidth 2 111: change to working bandwidth 3 b3: reserved
STA support LDPC code length mode	1	0: support LDPC448/1344/2688 code length 1: support LDPC 1344/2688/5376 code length
Reserved	59	Default 0

6.3.4.6 Service stream management

The dynamic service addition request frame is shown in Figure 11. It is used for the request for adding service streams between the CAP and the STA.

Bit:	16	4	3	1	32	48	36	4	32
	Frame control	FID	Service type	Direction	Service guarantee rate	Target MAC address	Reserved	FID Max Buffer Size (MaxBufferSize)	FCS

Figure 11 **Dynamic service addition request frame**

The dynamic service addition response frame is shown in Figure 12, which is used to response on the dynamic service addition request initiated by the CAP to the STA.

Bit:	16	4	3	1	32	32	36	4	32
	Frame control	FID	Service type	Reserved	Service guarantee rate	Maximum service rate	Reserved	FID Max Buffer Size (MaxBufferSize)	FCS

Figure 12 **Dynamic service addition response frame**

The dynamic service change request frame is shown in Figure 13, which is used for the request to change the QoS parameters of the service stream initiated by the CAP and the STA.

Bit:	16	4	3	1	32	48	36	4	32
	Frame control	FID	Service type	Direction	Service guarantee rate	Target MAC address	Reserved	FID Max Buffer Size (MaxBufferSize)	FCS

Figure 13 **Dynamic service change request frame**

The dynamic service change response frame is shown in Figure 14, which is used to response on the request for the dynamic service change initiated by the CAP to the STA.

Bit:	16	4	3	1	32	32	36	4	32
	Frame control	FID	Service type	Reserved	Service guarantee rate	Maximum service rate	Reserved	FID Max Buffer Size (MaxBufferSize)	FCS

Figure 14 **Dynamic service change response frame**

The dynamic service delete request frame is shown in Figure 15, which is used to request to delete the service stream initiated by the CAP and STA.

Bit:	16	4	11	1	32
	Frame control	FID	Reserved	Direction	FCS

Figure 15 **Dynamic service delete request frame**

The dynamic service delete response frame is shown in Figure 16, which is used to response to the request initiated by the CAP to the STA for deleting the dynamic service stream.

Bit:	16	A	11	1	32
	Frame control	FID	Reserved	Direction	FCS

Figure 16 **Dynamic service delete response frame**

See Table 9 for the definition of contents of dynamic service addition request/ response frame, dynamic/ service change request/ response frame bodies.

Table 9 **Frame body field for service stream management**

Field	Length/ bit	Description
FID	4	Flow ID
Service type	3	Specific service type (see Table 31)
Direction	1	0: downlink, 1: uplink
Indication of reserved field extension function	2	00: No function extension; 01: Extension of the multi-connection function; 10: Extension of header compression; 11: Extension of header compression and multi-connection functions;
Reserved	34/1/11	Default of 0
Service guarantee rate	32	Unit: bit/s, value: within $0\sim2^{32}$
Maximum service rate	32	Unit: bit/s, value: within $0\sim2^{32}$
Target MAC address	48	48-bit MAC address

FID maximum buffer size (MaxBufferSize)	4	0: Buffer up to 8 MPDUs; 1: Buffer up to 16 MPDUs; 2: Buffer up to 32 MPDUs; 3: Buffer up to 64 MPDUs; 4: Buffer up to 128 MPDUs; 5: Buffer up to 256 MPDUs; 6 - 15: Reserved

6.3.4.7 Resource request frame

The resource request has two manners:

a) Independently send the resource request;

b) Carry the channel-associated resource request when sending data.

The independent resource request frame is used by the STA service stream to request bandwidth from CAP, as shown in Figure 17.

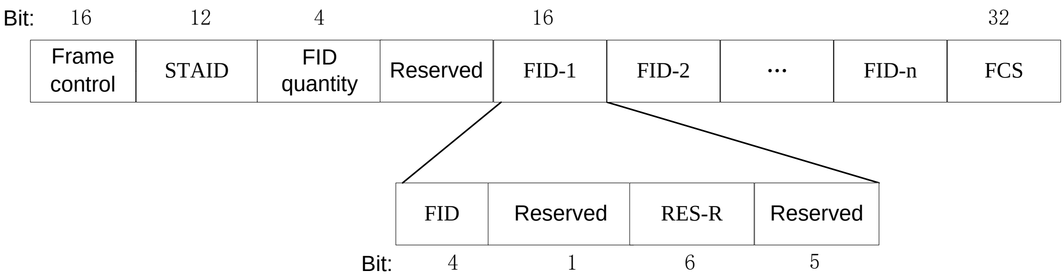


Figure 17 **Independent resource request frame**

The contents of the frame body of the independent resource request frame are shown in Table 10.

Table 10 **Independent resource request frame body**

Field	Length/ bit	Description
STAID	12	Uniquely identifies a STA
FID quant	4	Indicates the number of service streams of the resource request.
Reserved	16	Default of 0
FID	4	Indicates that the STA performs the resource request for the service stream FID.
Reserved	4	Default of 0
Resource index	7	Indicates the index of the requested resource size in the resource table
Reserved	1	Default of 0

The resource table is shown in Table 11.

Table 11 **Resource table**

Index	Resource size / byte	Index	Resource size / byte
0	BS=0	23	337<BS≤364
1	1<BS≤14	24	365<BS≤392

2	15<BS≤28	25	393<BS≤420
3	29<BS≤42	26	421<BS≤448
4	43< BS≤56	27	449<I3S<476
5	57<BS≤70	28	477<BS≤504
6	71<BS≤84	29	505<BS≤532
7	85<BS≤98	30	533<BS≤560
8	99<BS≤112	31	561<BS≤588
9	113<BS≤126	32	589<BS≤616
10	127<BS≤140	33	617<BS≤644
11	141<BS≤154	34	645<BS≤672
12	155<BS≤168	35	673<BS≤700
13	169<BS≤182	36	701<BS≤728
14	183<BS≤196	37	729<BS≤784
15	197<BS≤210	38	785<BS≤840
16	211<BS≤224	39	841<BS≤896
17	225<BS≤238	40	897<BS≤952
18	239<BS≤252	41	953<BS≤1008
19	253<BS≤266	42	1009<BS≤1064
20	267<BS≤280	43	1065<BS≤1120
21	281<BS≤308	44	1121<BS≤1176
22	309<BS≤336	45	1177<BS≤1232
46	1233<BS≤1288	80	5825<BS≤6272
47	1289< BS≤1344	81	6273 <BS≤6720
48	1345<BS≤1400	82	6721<BS≤7168
49	1401<BS≤1456	83	7169<BS≤7616
50	1457<BS≤1512	84	7617<BS≤8064
51	1513<BS≤1568	85	8065<BS≤8512
52	1569<BS≤1624	86	8513<BS≤8960
53	1625<BS≤1680	87	8961<BS≤9408
54	1681<BS≤1736	88	9409<BS≤9856
55	1737<BS≤1792	89	9857<BS≤10304
56	1793<BS≤1904	90	10305<BS≤10752
57	1905<BS≤2016	91	10753<BS≤11648
58	20I7<BS≤2128	92	11649<BS≤12544
59	2129<BS≤2240	93	12545<BS≤13440

60	2241<BS≤2352	94	13441<BS≤14336
61	2353<BS≤2464	95	14337<BS≤15232
62	2465<BS≤2576	96	15233<BS≤16128
63	2577<BS≤2688	97	16129<BS≤17920
64	2689<BS≤2800	98	17921<BS≤19712
65	2801<BS≤2912	99	19713<BS≤21504
66	2913<BS≤3024	100	21505<BS≤23296
67	3025<BS≤3136	101	23297<BS≤25088
68	3137<BS≤3360	102	25089<BS≤28672
69	3361<BS≤3584	103	28673<BS≤32256
70	3585<BS≤3808	104	32257<BS≤35840
71	3809<BS≤4032	105	35841<BS≤39424
72	4033<BS≤4256	106	39425<BS≤43008
73	4257<BS≤4480	107	43009<BS≤50176
74	4481<BS≤4704	108	50177<BS≤57344
75	4705<BS≤4928	109	57345<BS≤64512
76	4929<BS≤5152	110	64513<BS≤71680
77	5153<13S<5376	111	71681<BS≤86016
78	5377<BS≤5600	112	86017<BS≤100352
79	5601<BS≤5824	113	100353<BS≤114688
114	114689<BS≤129024	121	286721<BS≤344064
115	129025<BS≤143360	122	344065<BS≤458752
116	143361<BS≤172032	123	458753<BS≤573440
117	172033<BS≤200704	124	573441<BS≤802816
118	200705<BS≤229376	125	802817<BS≤1835008
119	229377<BS≤258048	126	1835009<BS≤3500000
120	258049<BS≤286720	127	BS>3500000

When the channel-associated request indicates that the field is 1, a channel-associated resource request field is added to the front of the frame body, as shown in Figure 18.

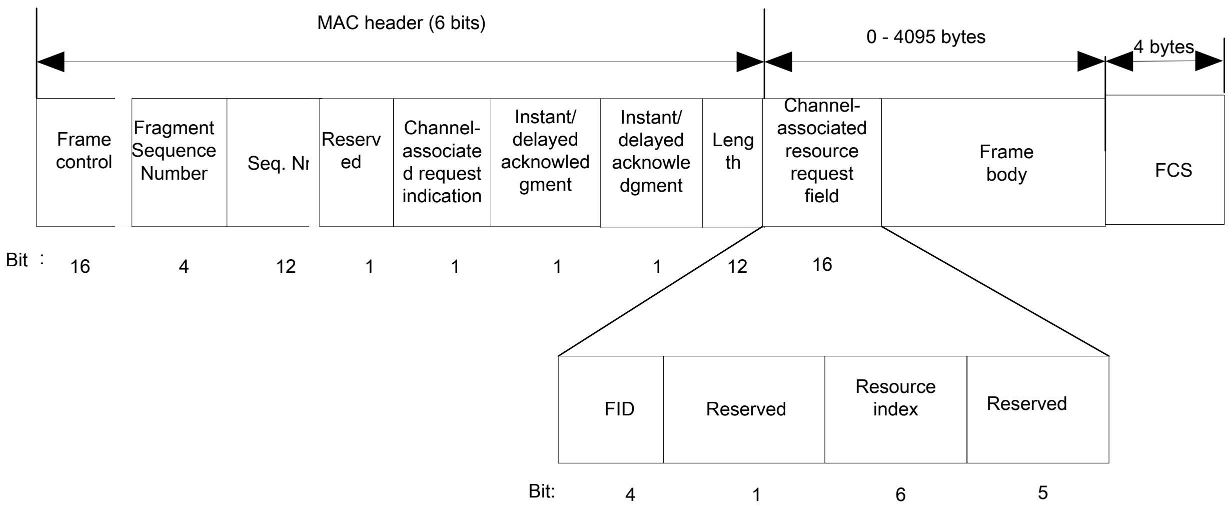


Figure 18 **Data frame with channel-associated resource request**

The FID and resource index definitions are shown in Table 10 and Table 11.

6.3.4.8 MIMO feedback frame

6.3.4.8.1 MIMO feedback type

The MIMO feedback type includes a channel state information matrix (CSI) and a beamforming matrix (BFM), as shown in Figure 19 and Figure 20.

When the bytes of the MAC frame body involved in this clause are not aligned, it is necessary to add 1~7 bits after the frame body to maintain byte alignment.

MIMO feedback control information	CSI matrix report

Figure 19 **CSI matrix feedback (CSI-MIMO) frame body**

MIMO feedback control information	Beamforming matrix report

Figure 20 **Beamforming matrix feedback (BFM-MIMO) frame body**

6.3.4.8.2 MIMO feedback control information

The MIMO feedback control information field is defined in Table 12.

Table 12 **MIMO feedback control information field**

Field	Length/ bit	Description
Subchannel mapping indication	4	Indicates the channel bandwidth fed back by the MIMO and specific subchannels
Quantitative mode	2	For CSI feedback, 00: Nb= 6; 01: Nb=8; 10,11: Reserved
Subcarrier grouping (Ns)	3	Indicates the number of subcarriers in the frame:

		0: 1 subcarrier is included in the group (not grouped) (FPI=1); 1: 2 subcarriers are included in the group (FPI = 2); 2: 4 subcarriers are included in the group (FPI = 4); 3: 8 subcarriers are included in the group (FPI = 8); 4: 16 subcarriers are included in the group (FPI = 16); 5 - 7: Reserved
Number of rows of CSI matrix	3	Number of rows of CSI matrix (Nr), 1~8 (000~111)
Number of columns of CSI matrix	3	Number of column of CSI matrix (Nc) , 1~8 (000~111)
Reserved	1	Default value: 0

6.3.4.8.3 Channel state information matrix report field

The CSI-MIMO feedback frame is shown in Table 13.

Among them, Nr is the number of rows of the CSI matrix of the feedback request (see Table 13).

The CQI information in Table 13 is represented by SINR, and the SINR is encoded as 8 bits. The decimal number of the 8-bit pair is *n,* valuing from 0 to 255*,* indicating that the linear average of the SNR of each subcarrier is (-10 + 0.25 *n*) dB.

The quantization of CSI matrix is shown in Annex F. The elements in CSI matrix are transmitted row by row. Each element contains real and imaginary part, in which the real part is transmitted first.

Table 13 **CSI report field in normal mode**

Field	Description
Receive CQI on antenna 1	Receive average Channel State Information on antenna 1
…….	
Receive CQI on antenna Nr	Receive average Channel State Information on antenna Nr
$M_H(k)$ value of subcarrier-(N_{FFT}/2-13)	See Annex F
……	
$M_H(k)$ value of subcarrier-1 -FPI*2	
$M_H(k)$ value of subcarrier-1 -FPI	
$M_H(k)$ value of subcarrier-1	
$M_H(k)$ value of subcarrier1	
$M_H(k)$ value of subcarrier 1+ FPI	
$M_H(k)$ value of subcarrier 1+ FPI*2	
……	
$M_H(k)$ value of subcarrier (N_{FFT}/2-13)	
CSI matrix of subcarrier-(N_{FFT}/2-13)	CSI matrix
……	

CSI matrix of subcarrier-1 -FPI*2	CSI matrix
CSI matrix of subcarrier-1 -FPI	CSI matrix
CSI matrix of subcarrier-1	CSI matrix
CSI matrix of subcarrier1	CSI matrix
CSI matrix of subcarrier 1+ FPI	CSI matrix
CSI matrix of subcarrier 1+ FPI*2	CSI matrix
……	
CSI matrix of subcarrier (N_{FFT}/2-13)	CSI matrix

Table 14 **CSI report field in OFDMA mode**

Field	Description
Receive CQI on antenna 1	Receive average Channel State Information on antenna 1
…….	
Receive CQI on antenna Nr	Receive average Channel State Information on antenna Nr
$M_H(k)$ value of 1st allocated RU	See Annex F
$M_H(k)$ value of 2nd allocated RU	
……	
$M_H(k)$ value of last allocated RU	
CSI matrix of 1st allocated RU	CSI matrix
CSI matrix of 2nd allocated RU	CSI matrix
……	
CSI matrix of last allocated RU	CSI matrix

6.3.4.9 Channel quality feedback frame

The channel quality feedback frame is shown in Figure 21. The CQI information part of the frame body includes subchannel mapping, MCS1 and MCS2, coding type and SINR. See Table 15 for the definition of the frame body in normal mode and See Table 16 for the definition of the frame body in OFDMA mode .

When the bytes of the MAC frame body involved in this clause are not aligned, it is necessary to add 1~7 bits after the frame body to maintain byte alignment.

	Subchannel mapping	MCS1	MCS2	Coding type	SINR
Bit:	4	7	7	2	…

Figure 21 **CQI information section**

Table 15 **CQI information section in normal mode**

Field	Length/ bit	Description
Subchannel mapping	4	0001: Feedback subchannel 0; 0010: Feedback subchannel 1; 0100: Feedback subchannel 2; 1000: Feedback subchannel 3
MCS1	7	Suggested MCS of codeword 1
MCS2	7	Suggested MCS of codeword 2
Coding type	2	Indicates the encoding method recommended by the STA. 0: BCC; 1: LDPC code length 1; 2: LDPC code length 2; 3: LDPC code length 3
Number of spatial stream (Ns)	3	1~8 (000 ~ 111)
SINR0	8	The average SINR on the first spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
SINR1	8	The average SINR on second spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
…	…	…
SINR Ns	8	The average SINR on Ns-h spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
Subcarrier SINR enable	1	0: no subcarrier SINR present 1: subcarrier SINR present
Number of subcarrier SINR streams (Nsts)	3	Indicates number of streams for subcarrier SINR feedback
Subcarrier grouping (Ns)	3	Indicates the number of subcarriers in the frame: 0: 1 subcarrier is included in the group (not grouped) (FPI=1); 1: 2 subcarriers are included in the group (FPI = 2); 2: 4 subcarriers are included in the group (FPI = 4); 3: 8 subcarriers are included in the group (FPI = 8); 4: 16 subcarriers are included in the group (FPI = 16); 5 - 7: Reserved
1st stream SINR of subcarrier-(N_{FFT}/2-13)	8	The average SINR on first spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
…	…	…

1st stream SINR of subcarrier-1 -FPI*2	8	Same as above
1st stream SINR of subcarrier-1 -FPI	8	
1st stream SINR of subcarrier-1	8	
1st stream SINR of subcarrier1	8	
1st stream SINR of subcarrier 1+ FPI	8	
1st stream SINR of subcarrier 1+ FPI*2	8	
……		
1st stream SINR of subcarrier (N_{FFT}/2-13)	8	
2nd stream SINR of subcarrier-(N_{FFT}/2-13)	8	The average SINR on first spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
…	…	…
2nd stream SINR of subcarrier-1 -FPI*2	8	Same as above
2nd stream SINR of subcarrier-1 -FPI	8	
2nd stream SINR of subcarrier-1	8	
2nd stream SINR of subcarrier1	8	
2nd stream SINR of subcarrier 1+ FPI	8	
2nd stream SINR of subcarrier 1+ FPI*2	8	
……		
2nd stream SINR of subcarrier (N_{FFT}/2-13)	8	
…	…	

Table 16 **CQI information section in OFDMA mode**

Field	Length/ bit	Description
Subchannel mapping	4	0001: Feedback subchannel 0; 0010: Feedback subchannel 1; 0100: Feedback subchannel 2; 1000: Feedback subchannel 3
MCS1	7	MCS of request channel codeword 1
MCS2	7	MCS of request channel codeword 2
Coding type	2	Indicates the encoding method recommended by the STA. 0: BCC; 1: LDPC code length 1; 2: LDPC code length 2; 3: LDPC code length 3
SINR0	8	The average SINR on the first spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
SINR1	8	The average SINR on second spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
…	…	…
SINR7	8	The average SINR on 7th spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
RU SINR enable	1	0: no RU SINR present 1: RU SINR present
1st stream SINR of 1st allocated RU	8	The average SINR on first spatial stream of the request channel. The corresponding decimal number of the field is *n*, and the value ranges from 0 to 255. The SINR is expressed as -10+ 0.25 *n* dB. The default value of n is 0.
1st stream SINR of 2nd allocated RU	8	Same as above
…	…	…
1st stream SINR of last allocated RU		
2nd stream SINR of 1st allocated RU		
2nd stream SINR		

of 2nd allocated RU		
…		
2nd stream SINR of last allocated RU		
…		

When the system is operating at working bandwidth 1, the CQI-FB frame body is as shown in Figure 22.

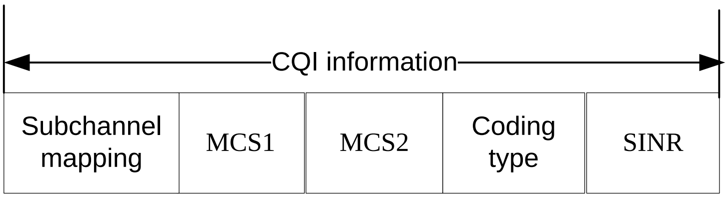


Figure 22 **CQI-FB frame body in working bandwidth 1**

When the system is operating in working bandwidth 2 aggregation mode, the CQI-FB frame body is as shown in Figure 23.

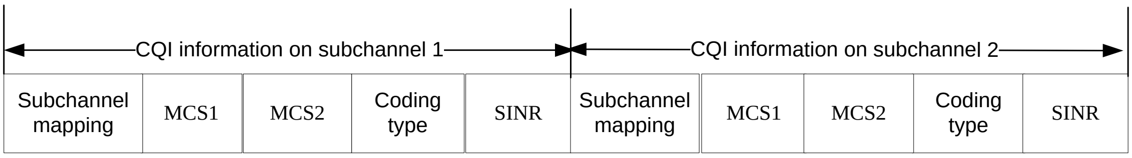


Figure 23 **CQI-FB frame body in working bandwidth 2 aggregation mode**

When the system is operating in working bandwidth 3 aggregation mode, the CQI-FB frame body is as shown in Figure 24.

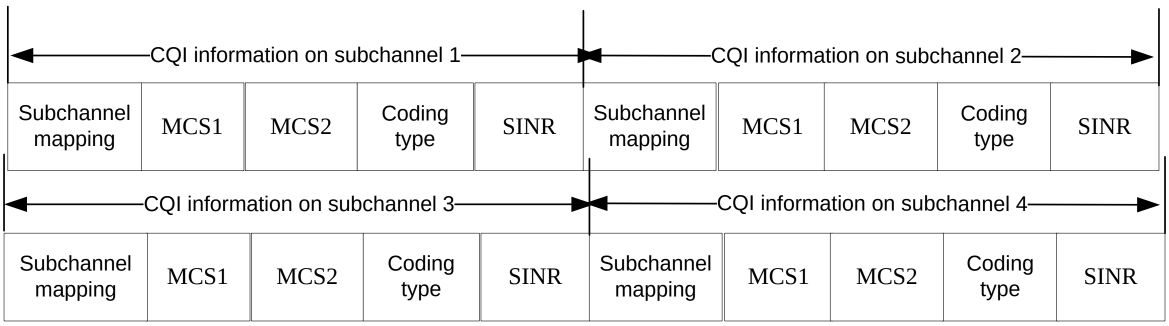


Figure 24 **CQI-FB frame body in working bandwidth 3 aggregation mode**

When the working bandwidth 3 system is operating at continuous working bandwidth 2, the CQI-FB frame body is as shown in Figure 25

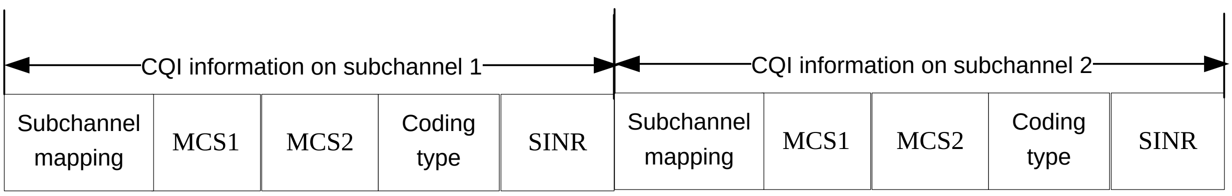


Figure 25 **CQI-FB frame body part when the working bandwidth 3 system operating at working bandwidth 2**

6.3.4.10 Acknowledgement frame

The acknowledgement frame field is defined as shown in Figure 26.

Bit:	16	4	4	4	12	32
	Frame control	Reserved	FID	FSN	SN	FCS

Figure 26 **ACK frame**

The contents of the frame body of the ACK frame are shown in Table 17.

Table 17 **ACK frame body**

Field	Length/ bit	Description
Reserved	4	Default of 0
FID	4	Flow ID
FSN	4	Indicates that the acknowledgement is acknowledgement for the frame with the Fragment Sequence Number of FSN. If no fragmentation is used, this field is set to 0.
SN	12	Indicates that the acknowledgement is acknowledgement for the MPDU with the Sequence Number of SN. If the frame needs to be acknowledged is a management control frame without sequence number, the SN is set to 0.

6.3.4.11 Group acknowledgement request frame

The group acknowledgement request frame field is defined as shown in Figure 27.

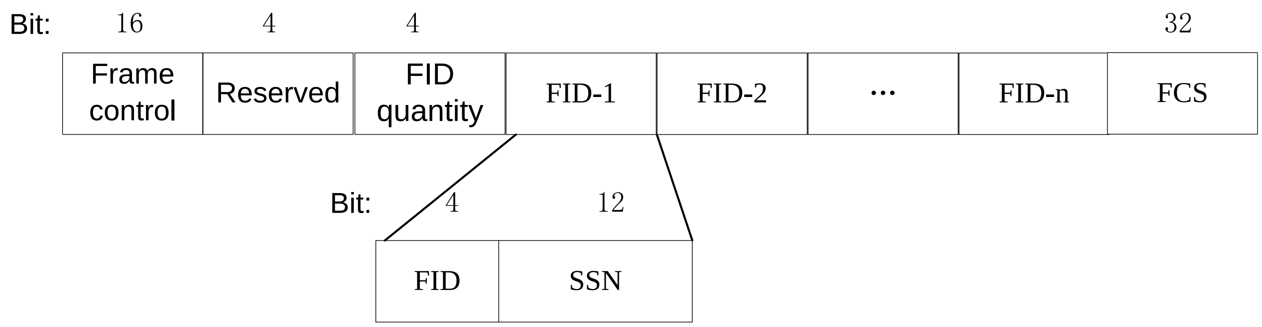


Figure 27 **Group acknowledgement request frame**

See Table 18 for the contents of the frame body.

Table 18 **Group acknowledgement request frame body**

Field	Length/ bit	Description
Reserved	4	Default of 0
FID number	4	Indicates the number of FID information blocks included between the field and the FCS. The format of each FID information block is the same
FID	4	Require the receiver to perform Group Ack on the FID service stream.
SSN	12	When the receiver is notified of the Group Ack, this value is used as the starting sequence number of the Bitmap.

6.3.4.12 Group acknowledgement frame

The group acknowledgement frame field is defined as shown in Figure 28.

Bit:	16	3	1	12					32
	Frame control	Reserved	Management control acknowledgement bit	Length	FID-1	FID-2	…	FID-n	FCS

Bit:	4	12	3	4	1	8/16/32/64/128/256
	FID	SSN	Reserved	Bitmap length	Fragment or not	Bitmap

Figure 28 **Group acknowledgement frame**

The contents of the frame body of the group acknowledgement frame are as shown in Table 19.

Table 19 **Group acknowledgement frame body**

Field	Length/ bit	Description
Reserved	3	Default of 0.
Management control frame acknowledgement bit	1	Indicates that acknowledgement is received for receiving a management control frame without sequence number.
Length	12	Indicates the total byte length of all fields between the length field and FCS field
FID	4	Notifies the sender that the FID information block is the Group Ack for a certain FID service stream
SSN	12	Notifies the sender of the Starting Sequence Number of the Bitmap for the FID information block
Bitmap Length	4	Indicates the length of the Bitmap for each FID information block. 0: 8 bits; 1: 16 bits; 2: 32 bits; 3: 64 bits; 4: 128 bits; 5: 256 bits; 6 - 15: Reserved
Reserved	3	Default of 0
Fragment or not	1	If the value is 1, it indicates the acknowledgement is for the fragmented data frame. At this point, each bit in the Bitmap is the acknowledgement for one fragment in the frame. If the value is 0, it indicates that the acknowledgement is for the unfragmented data frame. At this point, each bit in the Bitmap is the acknowledgement for a frame.
Bitmap	8/16/32/64/128/256	A bit in the Bitmap indicates whether a certain MPDU/fragment is successfully received. If received successfully, it is set to 1, otherwise it is set to 0. MPDU Sequence Number/Fragment Sequence Number is calculated based on the SSN and the

		offset.

6.3.4.13 Quit network frame

The quit network frame is shown in Figure 29, which is used by the STA to quit the network.

Bit	16	4	12	32
	Frame control	Reserved	STAID	FCS

Figure 29 **Quit network frame**

The frame body of the quit network frame is defined in Table 20.

Table 20 **Description of the frame body of the quit network frame**

Field	Length/ bit	Description
Reserved	4	Default of 0
STAID	12	Used to identify users

6.3.4.14 Channel switching information frame

The channel switch information frame is used by the CAP to notify the STA of channel switching, and the field is defined as shown in Figure 30.

Bit:	16	8	2	4	1	12	5	8	8	32
	Frame control	CAP/STA starting channel number	CAP/STA work bandwidth	Working subchannel mapping	Channel switching indication	STAID	Reserved	Channel switching mode	Channel switching counter	FCS

Figure 30 **Channel switching information frame**

The frame body content of the channel switching information frame is as shown in Table 21.

Table 21 **Channel switching information frame body**

Field	Length/ bit	Description
CAP/STA starting channel number	8	The lowest channel number corresponding to the starting frequency of the frequency band occupied by the CAP/STA, for example, channel number 3 of the 2.4G frequency band
CAP/STA working bandwidth	2	Indicates the working bandwidth of the CAP/STA 0: working bandwidth 1; 1: working bandwidth 2; 3: working bandwidth 3; 4: Reserved
Working subchannel mapping	4	0001: Sub-channel 0; 0010: Sub-channel 1; 0100: Sub-channel 2; 1000: Subchannel 3. For Bitmap or computing, it can indicate working bandwidth 2

		and working bandwidth 3 stations operating on multiple working bandwidth 1 subchannels
Channel switching indication	1	0：CAP channel switching 1：STA channel switching
STAID	12	STAID
Reserved	5	Default of 0
Channel switching mode	8	Indicates the limit on transmission during channel switching. 1: indicates that the CAP requires the STA to stop data transmission before channel switching; Other values indicate to be reserved
Channel switching counter	8	Indicates the elapsed time from sending the channel switching information frame to the STA switching to the new channel, in units of BCF intervals.

6.3.4.15 Sleep request frame

The sleep request frame is used for the switch request sent by the STA to the CAP for switching from the active mode to the sleep mode. The request field is defined as shown in Figure 31.

Bit:	16	4	4	16	16	16	32
	Frame control	Reserved	Subsequent sleep window changes	Sleep start time	Sleep start window	Window listener	FCS

Figure 31 **Sleep request frame**

The contents of the frame body of the sleep request frame are as shown in Table 22.

Table 22 **Sleep request frame body**

Field	Length/ bit	Description
Reserved	4	Default of 0
Subsequent sleep window changes	4	Indicates the change from the initial sleep window requested by the STA, 0: Unchanged; 1: Multiplication; Other values indicate to be reserved
Sleep start time	16	Indicates the start time of the first sleep window requested by the STA, which is expressed in frame number
Sleep start window	16	Indicates the size of the first sleep window requested by the STA, in time unit of a physical frame duration
Window listener	16	Indicates the size of the listening window requested by the STA, in time unit of a physical frame duration

6.3.4.16 Sleep response frame

The sleep response frame is used for the CAP to actively send the message to notice the STA for sleep, or for the response to the sleep request frame. The frame body field is defined as shown in Figure 32.

Bit:	16	4	4	16	16	16	32
	Frame control	Reserved	Subsequent sleep window changes	Sleep start time	Sleep start window	Window listener	FCS

Figure 32 **Sleep response frame**

The contents of the frame body of the sleep request frame are as shown in Table 23.

Table 23 **Description of the frame body of the sleep response frame**

Field	Length/ bit	Description
Reserved	4	Default of 0.
Subsequent changes in the sleep window	4	Indicates the change relative to the initial sleep window allowed by the CAP, 0: Unchanged; 1: Multiplication; Other values indicate to be reserved
Sleep start time	16	Indicates the start time of the first sleep window allowed by the CAP, which is expressed in frame number
Sleep start window	16	Indicates the size of the first sleep window allowed by the CAP, in time unit of a physical frame duration
Window listener	16	Indicates the size of the listening window allowed by the CAP, in time unit of a physical frame duration

6.3.4.17 Downlink traffic indication frame

The downlink traffic indication frame is used by the CAP to inform the sleeping STA of the downlink traffic information, and the frame body field is defined as shown in Figure 33.

Bit	16	12	4	32
	Frame control	Reserved	TI indication	FCS

Figure 33 **Downlink traffic indication frame**

The frame body content of the downlink traffic indication frame is as shown in Table 24.

Table 24 **Downlink traffic indication frame body field**

Field	Length/ bit	Description
Reserved	12	Default of 0
TI indication	4	Indicates whether there is downlink data of the STA on the CAP side. 0: indicates that there is no data of the STA; 1: indicates that there is data of the STA; Other values indicate to be reserved

6.3.4.18 Measuring request frame

The STA can actively send a CM-REQ message to the current CAP once the measured RSSI of the current cell is lower than the threshold, to request for measuring the time and the information list of neighbor cells. See Table 25 for the parameters carried by the CM-REQ.

Table 25 **Message Parameters of measuring request frame**

Field	Length (bit)	Description
Allocation of measuring time	8	Indicates the requested measuring time, in frames.
Average signal quality	8	Indicates the average RSSI strength of the current service CAP
Reserved	64	Default of 0

6.3.4.19 Measurement response frame

The CM-RSP can be used to response CM-REQ message, and can also be actively sent by the network to control the measurement of the STA. Parameters carried by CM-RSP can be found in Table 26.

Table 26 **Message parameters of measuring response frame**

Field	Length (bit)	Description
Allocation of measuring time	8	Indicates the allocated measuring time, in frames If set to 0, it indicates the measurement is rejected
Start time for measuring	8	Indicates the time duration from when the measuring response message is received by the STA to the start of the measurement, in frames.
Measurement result reporting mode	2	Indicates the measurement result reporting mode 0: Report triggered by event 1: Periodic report 2 - 3: Reserved
Measurement type	2	Indicates the type of measurement: 0: Indicates that only the SICH is detected; 1: Indicates that the BCF needs to be received; 2: Indicates that TA needs to be measured 3: Reserved
Reserved	4	Default of 0
Measurement interval	8	In frames
Number of measurements	8	Indicates the number of times the measurement result is reported
Measurement result reporting period	8	If the measurement result reporting mode is 1, this field indicates the measurement result reporting period, in units of frames.
Candidate CAP1 identifier	8	Indicates the lower 8 bits of the candidate CAP1's MAC address
Candidate CAP1 channel identifier	8	Indicates the channel number of the working channel of candidate CAP1
Candidate CAP2 identifier	8	Indicates the lower 8 bits of the candidate

		CAP2's MAC address
Candidate CAP2 channel identifier	8	Indicates the channel number of the working channel of candidate CAP2
Reserved	64	Default of 0

6.3.4.20 Measurement report frame

The STA reports the measurement results according to the indication information of the measurement report in the received CM-RSP message. See Table 27 for the parameters carried in the CM-REP message.

Table 27 **Message parameters of measurement report frame**

Field	Length (bit)	Description
Measurement result report mode	2	Indicates the reporting mode of the measurement result, 0: Report triggered by event 1: Periodic report 2 - 3: Reserved
Reserved	6	
Average RSSI of the current cell	8	Indicates the average RSSI received by the current cell.
Candidate CAP1 identifier	8	Indicates the lower 8 bits of the candidate CAP1's MAC address.
Candidate CAP1 channel number	8	Indicates the channel number of the candidate CAP1
Average RSSI of candidate CAP1	8	Indicates the average RSSI received by candidate CAP1
Candidate CAP2 identifier	8	Indicates the lower 8 bits of the MAC address of the candidate CAP2
Channel number of candidate CAP2	8	Indicates the channel number of the candidate CAP2
Average RSSI of candidate CAP2	8	Indicates the average RSSI received by candidate CAP2

6.3.4.21 Handover request frame

For STA-triggered handover, the STA can send a HO-REQ message to the currently serving CAP (CAP-S) to trigger the handover procedure. See Table 28 for the parameters carried by HO-REQ.

Table 28 **Message parameters of handover request frame**

Field	Length (bit)	Description
Candidate CAP1	8	Indicates the lower 8 bits of the candidate CAP1's MAC address
Candidate CAP1 channel identifier	8	Indicates the channel number of the working channel of candidate CAP1
Channel quality of candidate CAP1	8	Indicates the average RSSI strength of candidate CAP 1
Candidate CAP 2	8	Indicates the lower 8 bits of the candidate

		CAP2's MAC address
Candidate CAP2 channel identifier	8	Indicates the channel number of the working channel of candidate CAP2
Channel quality of candidate CAP 2	8	Indicates the average RSSI strength of the candidate CAP2
Reserved	64	

6.3.4.22 Handover command frame

The currently serving CAP sends an HO-CMD to trigger the handover, or to acknowledge the HO-REQ message sent by the STA. See Table 29 for the message parameters carried by HO-CMD.

Table 29 **Message parameters of handover command frame**

Field	Length (bit)	Description
Handover indication	2	Indicates whether to receive the handover initiated by the STA. 0: reject the handover; 1: accept the handover; 2~ 3: reserved
Handover type	2	Indicates the type of handover 0: Re-access type; 1: Competitive access type 2: Competition-free access type; 3: reserved
Reserved	4	Default of 0
Target CAP1	8	Indicates the lower 8 bits of the candidate CAP1's MAC address
Target CAP 1's channel identifier	8	Indicates the channel number of the working channel of candidate CAP1
TSTAID	12	If the handover type is 3, it indicates that the CAP-D pre-allocates for the STA for the temporary STAID during the handover time. If the handover type is in other values, this field is reserved
Effective time	4	Indicates the effective time of the TSTAID, in frames.
TA information	8	If the handover type is 3, this field indicates the TA information estimated by the CAP-D for the STA. If the handover type is in other values, this field is reserved
AK information	64	If the handover type is 3, this field indicates the authentication information in CAP-D If the handover type is in other values, this field is reserved
Reserved	64	

6.3.4.23 Custom frame (TLV structure)

Table 30 **TLV frame definition**

Field	TLV type	TLV length	Data
Bit	8	16	Customized

Custom frames can be used to extend management frames as well as to transmit other specific high-priority services.

6.4 Group MAC protocol data unit

The G-MPDU consists of a series of G-MPDU subframes, see Figure 34.

G-MPDU subframe 1	G-MPDU subframe 2	…	G-MPDU subframe n
Byte: changeable	Changeable		Changeable

Figure 34 **G-MPDU format**

The G-MPDU subframe includes a G-MPDU delimiter, an MPDU, and possible padding bytes. In addition to the last G-MPDU subframe, each G-MPDU subframe needs to be added with 0 to 1 padding bytes, so that the length of each G-MPDU subframe is an integer multiple of 2 bytes. The G-MPDU subframe format is as shown in Figure 35.

G - MPDU delimiter	MPDU	Padding
Bytes: 2	Changeable	0~1

Figure 35 **G-MPDU subframe format**

The delimiter of G-MPDU is 2 bytes long and is used to locate the MPDU of the G-MPDU. The format of the delimiter is as shown in Figure 36.

G-MPDU delimiter

Delimiter identifier	CRC
8bit	8bit

Figure 36 **G-MPDU delimiter**

The value of the delimiter identifier is fixed at 0x46. The CRC is obtained by removing the remaining length of the FCS from the MPDU. Using an 8-bit CRC, the CRC is generated using a standard polynomial, see Equation 2:

$$G(x) = x^8 + x^2 + x + 1 \quad \text{(Equation 2)}$$

The initial state of the register is 0xFF, and the register state is inverted as the CRC sequence output after the end of the operation. The CRC bits are transmitted in byte order from high order to low.

All MPDUs transmitted on the service transmission channel are transmitted by means of G-MPDU.

7 Media access control layer function

7.1 Adaptation sublayer

The function of the adaptation sublayer is to classify data of IP layer and to identify a service stream with an FID.

Within STA/CAP, the adaptation layer divides IP packets into multiple service streams, each of which belongs to an individual type of service and uses an FID identifier. The FID ranges from 1 to 15, and each FID service stream corresponds to a set of QoS parameters.

A maximum of 15 service streams can be established in each STA to occupy UL-TCH for data communication with CAP at the same time. Similarly, the CAP allows to establish 15 simultaneous service streams for each STA at the maximum to occupy DL-TCH for data communication with STA. Various management control frames occupy the data communication connections with the FID of 0 and it is default of being established successfully.

7.2 MAC sublayer

7.2.1 Addressing and connection

Both the STA and the CAP have a 48-bit globally unique MAC address as the identity. This address is used to acknowledge with each other and to forward intra-network packets during the network access phase. If the STA successfully accesses the network, the CAP assigns a 12-bit STA identifier (STAID) to the STA to uniquely identify it.

The MAC layer can provide connection-oriented services for applications. Up to 16 connections can be maintained between the CAP and each STA. Each connection is internally identified with a 4-bit FID.

7.2.2 Media access control address

Both the STA and the CAP use the globally unique 48-bit MAC address as the identifier.

7.2.3 Broadcast identification

The BSTAID is 12 bits long with the range of 0x000 ,0x001…0x007 to broadcast to all STAs in the CAP range. 0x001 can be used for the transmission of uplink unscheduled broadcast type.

7.2.4 STA identification

The STAID has a length of 12 bits with the range from 0x100 to 0xFFF.

After the STA completes the capability negotiation, the CAP allocates a unique identifier (STAID) within the scope of the CAP for each STA.

In the process of receiving and parsing CCH information, the STA needs to process the control information carried by the BSTAID in addition to the control information matching the STAID.

7.2.5 Temporary STA identification

The TSTAID is 12 bits in length and ranges from 0x002 to 0x0FF to temporarily identify an STA before assigning the STAID. The CAP assigns a TSTAID value to the STA through the random access response frame. The CAP assigns a TSTAID value to the STA through the random access response frame.

During the capability negotiation process between the STA and CAP, the STA uses the TSTAID to match the STAID carried in the CCH and parses out its own control information. Once the STA acquires the STAID, the original TSTAID is invalid.

7.2.6 Flow ID (FID)

The FID is 4 bits long and is used to identify an uplink or downlink service stream. The FID number is managed by the sender, and those of the uplink and downlink are independent of each other.

7.3 Central access point detects idle channel

The flow of the CAP to detect the idle channel is shown in Figure 37. The steps are as follows:

a) The CAP determines the list of channels to be detected.

b) Select an undetected channel number from the channel list one by one in sequence.

c) The CAP starts detecting the wireless signal energy on the selected channel and activates the detecting cycle timer.

-- During the detection period, if the detected signal energy is lower than the preset threshold, add the channel to the available channel list, and detect other undetected channels without interruption until all the channels in the channel list are detected.

-- During the detection period, if the detected signal energy exceeds the preset threshold, continue to scan other channels that have not been detected until all channels in the channel list are detected.

d) After all the channels in the channel list are detected, if the available channel list is not empty, the network creation process is started. Otherwise, restart the detection after a period of delay.

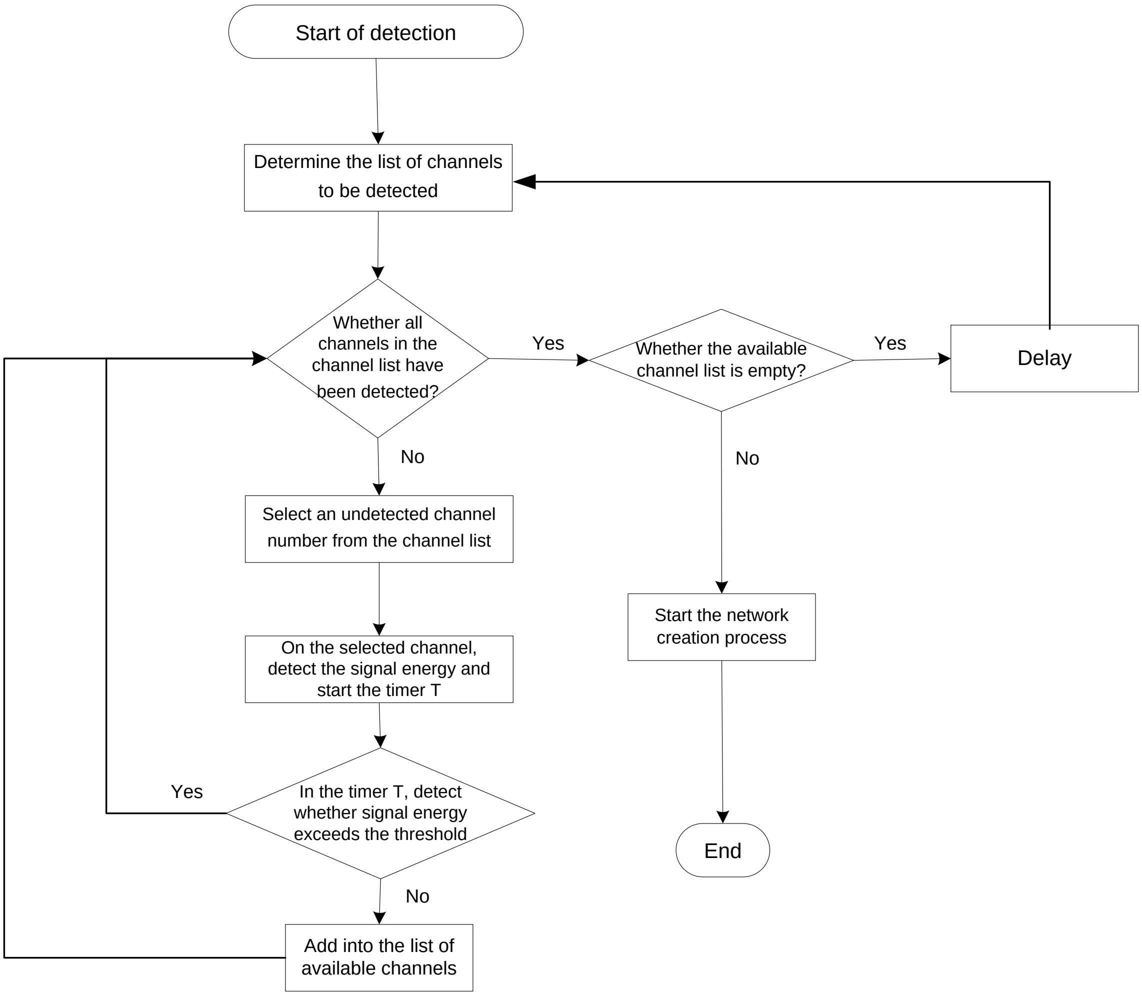


Figure 37 **Flow of detecting idle channels**

7.4 STA network access process

7.4.1 General

The network access process refers to the process in which the STA discovers the network and establishes a connection with the CAP. Network access includes the following steps:

a) Get system synchronization;

b) Random Access;

c) Capacity negotiation.

The network access process is as shown in Figure 38.

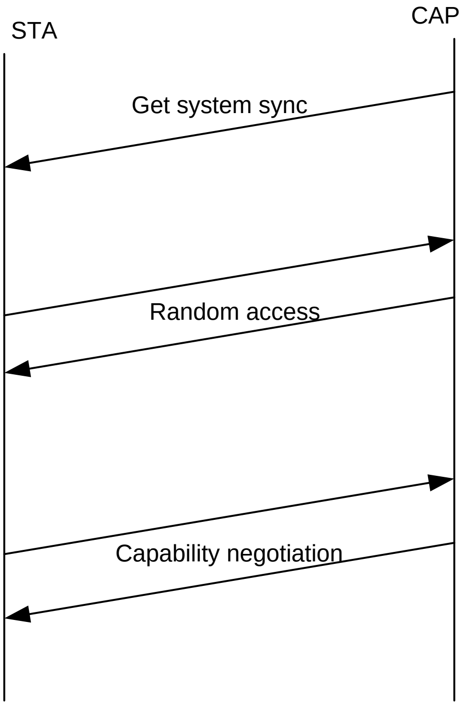


Figure 38 **Network access process**

7.4.2 System synchronization

The STA system synchronization process is as shown in Figure 39.

The main operation processes are as follows:

a) Scan physical signals on a channel;

b) If the STA can correctly detect the physical frame header, it considers that there is a physical frame on the channel. Otherwise, repeat the detection until time out, and then switch to the next channel and repeat the above operation;

c) If the STA can correctly parse the SICH and BCF information and successfully acquire the system information, the initial system synchronization is succeeded. Otherwise, after the waiting time is exceeded, switch to the next channel and repeat the above operation.

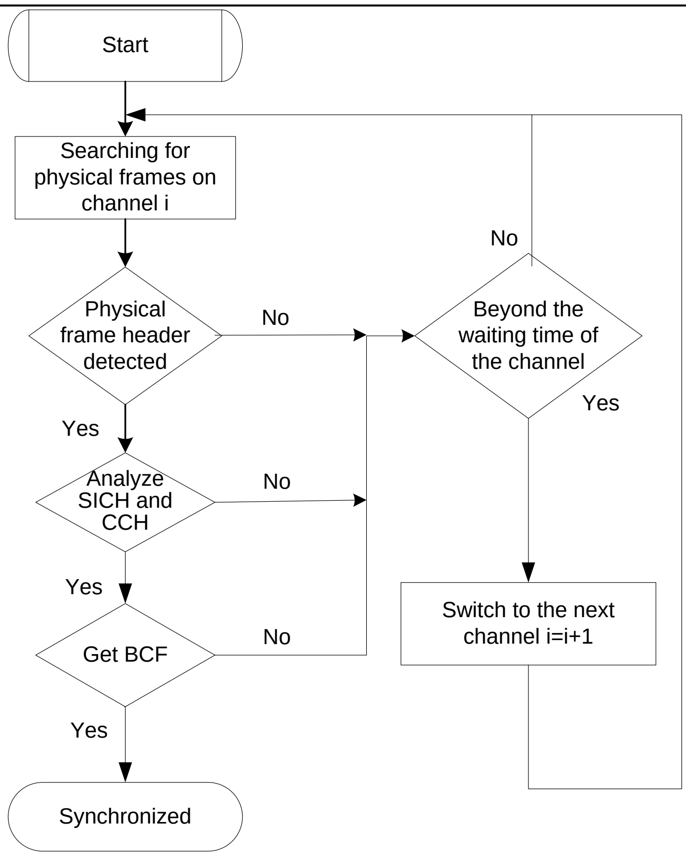


Figure 39 **STA system synchronization**

After the STA is initially synchronized, the synchronization is maintained thereafter.

If the SICH timer or the BCF timer expires, the STA needs to re-establish the initial synchronization, and proceeds to the flow of Figure 39. The process of maintaining synchronization is as shown in Figure 40.

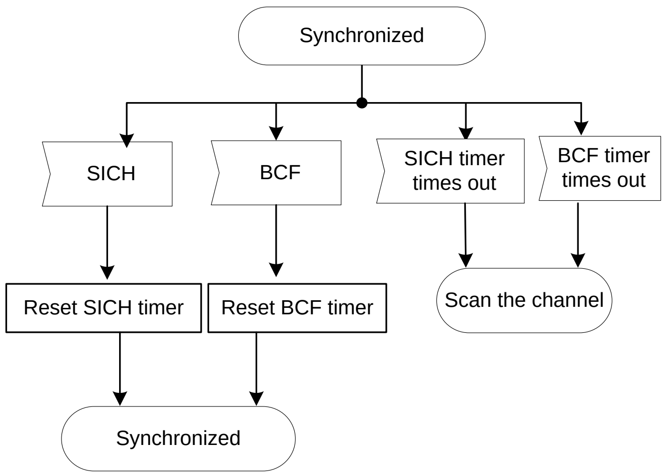


Figure 40 **Keep synchronized**

7.4.3 Random access

The random access process is as shown in Figure 41.

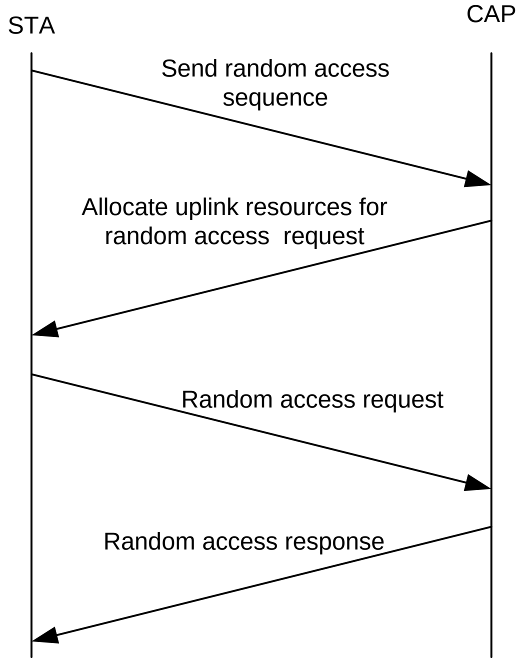


Figure 41 **Random access flow**

7.4.4 Capability negotiation

The capability negotiation process is as shown in Figure 42. The STA notifies the CAP of its basic capability by sending an STA Basic Capability Request frame (SBC-REQ). After the CAP receives the SBC-REQ, it compares the capability parameters. The capability parameters supported by both parties, as well as the resident channel and spectrum aggregation mode information allocated for the STA, are all included in the STA basic capability response frame (SBC-RSP) to notify the STA.

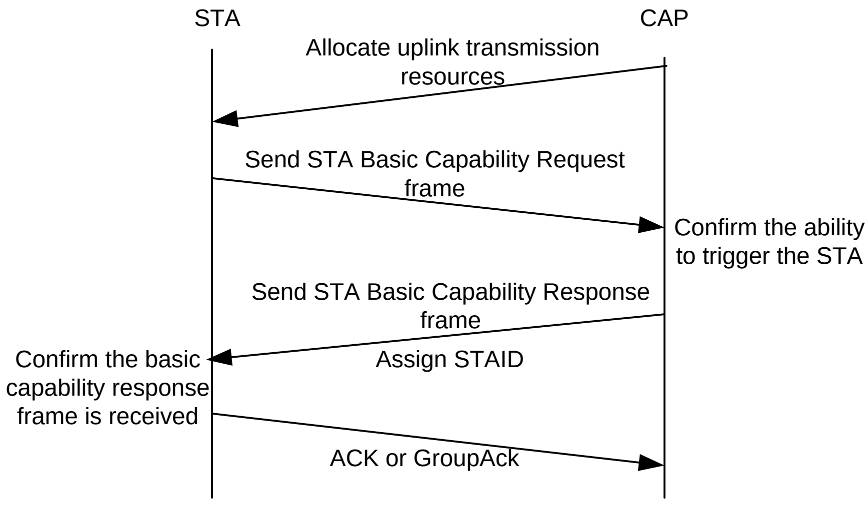


Figure 42 **Capability negotiation**

7.5 Managing service stream

7.5.1 Establishing service stream and data transmission

The establishment of uplink service stream and data transmission process are as shown in Figure 43.

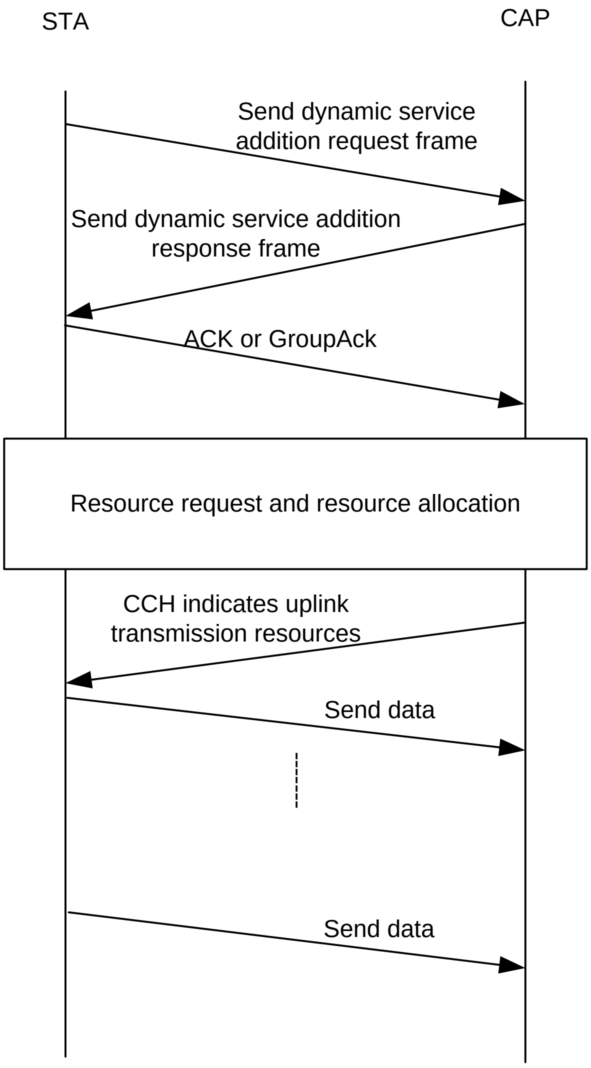


Figure 43 **Uplink service stream establishment and data transmission process**

The downlink service stream establishment and data transmission process is as shown in Figure 44.

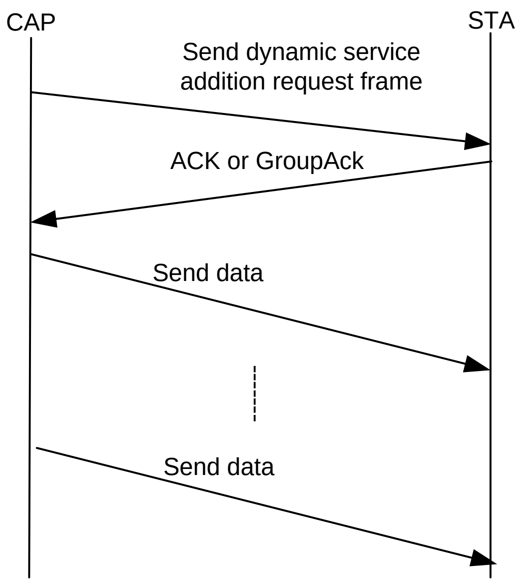


Figure 44 **Downlink service stream establishment and data transmission process**

7.5.2 Changing the service stream

The process of changing the uplink service stream and data transmission is as shown in Figure 45.

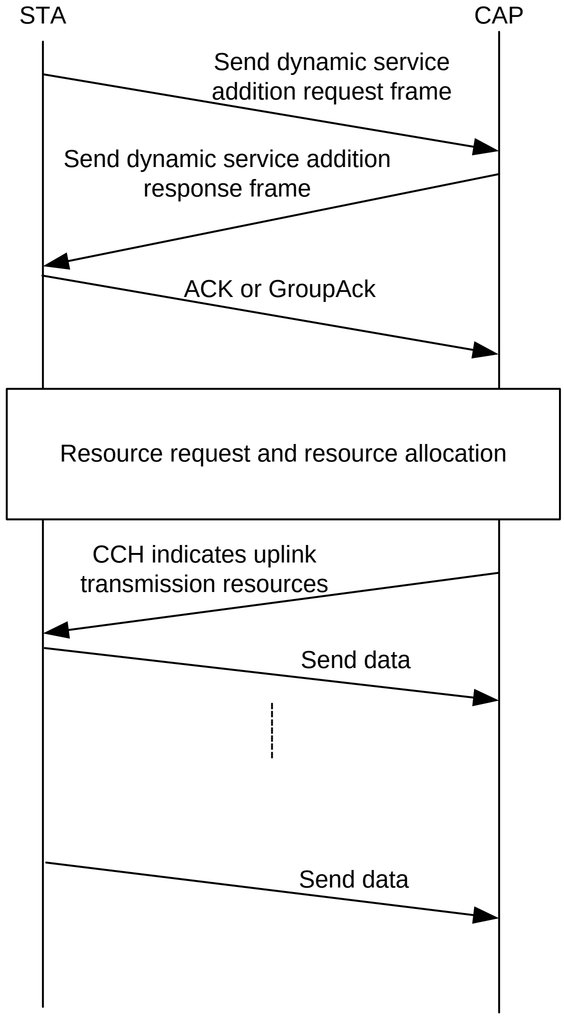


Figure 45 **Uplink service stream change and data transmission process**

The downlink service stream modification and data transmission process is as shown in Figure 46.

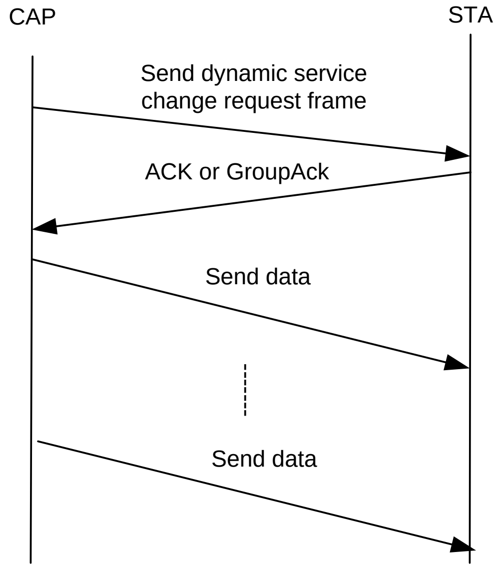


Figure 46 **Downlink service stream change and data transmission process**

7.5.3 Deleting the service stream

After the service transmission ends, the STA initiates the Dynamic Service Delete process, as shown in Figure 47.

After the service transmission ends, the CAP initiates the Dynamic Service Delete process, as shown in Figure 48. Wherein, The CAP can delete the uplink service stream by setting the direction field of the Dynamic Service Delete Request frame.

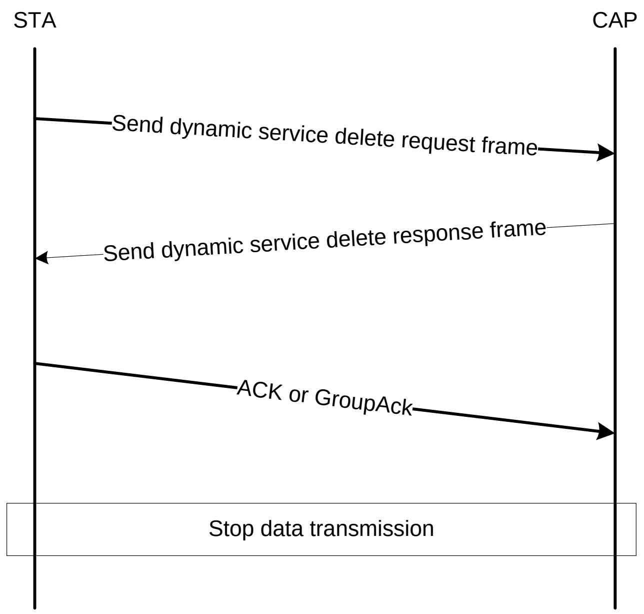


Figure 47 **Uplink service stream deletion process**

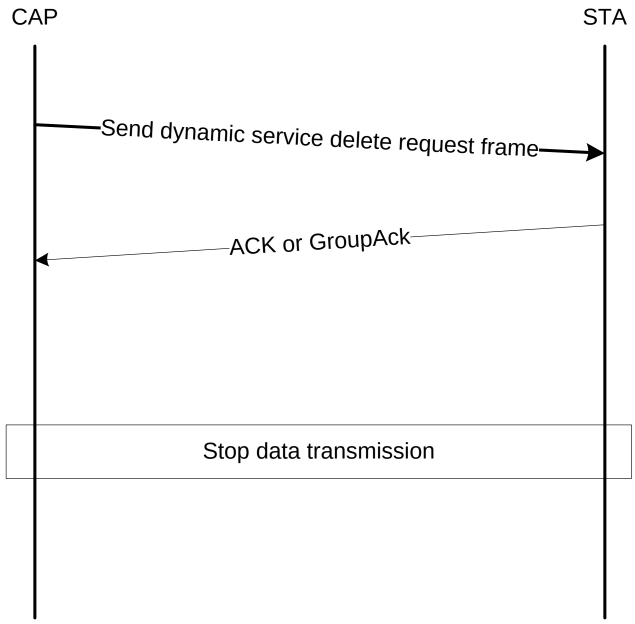


Figure 48 **Downlink/Uplink service stream delete process**

7.6 Resource request and resource allocation

7.6.1 Resource request

7.6.1.1 Resource request overview

The resource request manners supported by this standard system are as follows:

a) Collision-based resource request: The STA transmits the scheduling request sequence on the scheduling request channel;

b) Polling: The STA issues a resource request frame within the uplink bandwidth allocated by the CAP in polling manner;

c) Channel-associated resource request: The STA sends the resource request through the channel-associated field when it has the uplink resource.

7.6.1.2 Collision-based resources request

When the STA needs uplink transmission resources, the STA transmits the scheduling request sequence on the uplink scheduling request channel to request resources. The resource request process is as shown in Figure 49.

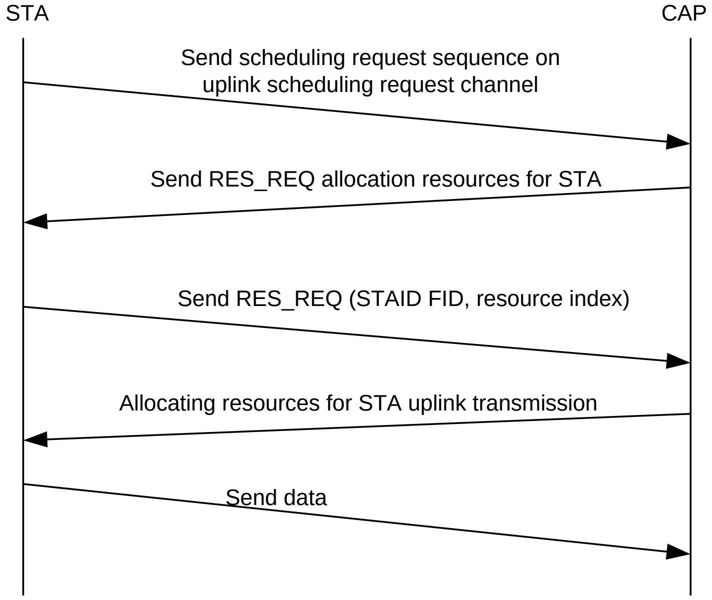


Figure 49 **Collision-based resources request**

7.6.1.3 Polling

If the CAP has sufficient bandwidth resources, it can perform unicast polling on the STA. The CAP maintains a timer for each STA. When the timer expires, the CAP allocates resources to the STA for uplink service transmission and resets the timer.

The polling process is as shown in Figure 50.

The flowchart of polling is described as following:

a) Check if the CAP has enough bandwidth for polling.

b) If no, the process ends.

c) If yes, check if the STA's polling timer expires.

d) If yes, allocate resources for data transmission to the STA and reset the polling timer.

e) If no, the process ends.

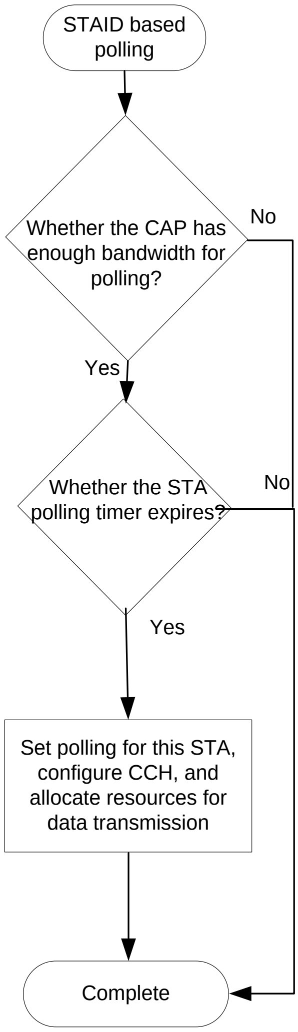


Figure 50 **Polling flow chart**

7.6.1.4 Uplink unscheduled transmission

In some emergent scenarios where the time delay is tightened, the CAP supports the uplink unscheduled transmission. It can be achieved by the resources reserved in the uplink UL-TCH and using the BSTAID to allocate broadcast resources to the uplink, to provide the STA with a schedule-free information reporting channel. In this case, the uplink broadcast CCH can be formed by using the BSTAID to scramble the unicast signaling of the UL defined in section 8.4.2. The uplink of the same physical frame can be configured with multiple uplink broadcast CCH broadcast resources. The users compete for broadcast resources by the pre-negotiated mechanism.

7.6.2 Resource allocation

The STA requests for resources according to the FID service stream, and the CAP allocates the resources to the STA through the CCH. The resource allocation between all FID streams of the STA is completed by the STA internal scheduling. The resource request and the distribution process are as shown in Figure 51.

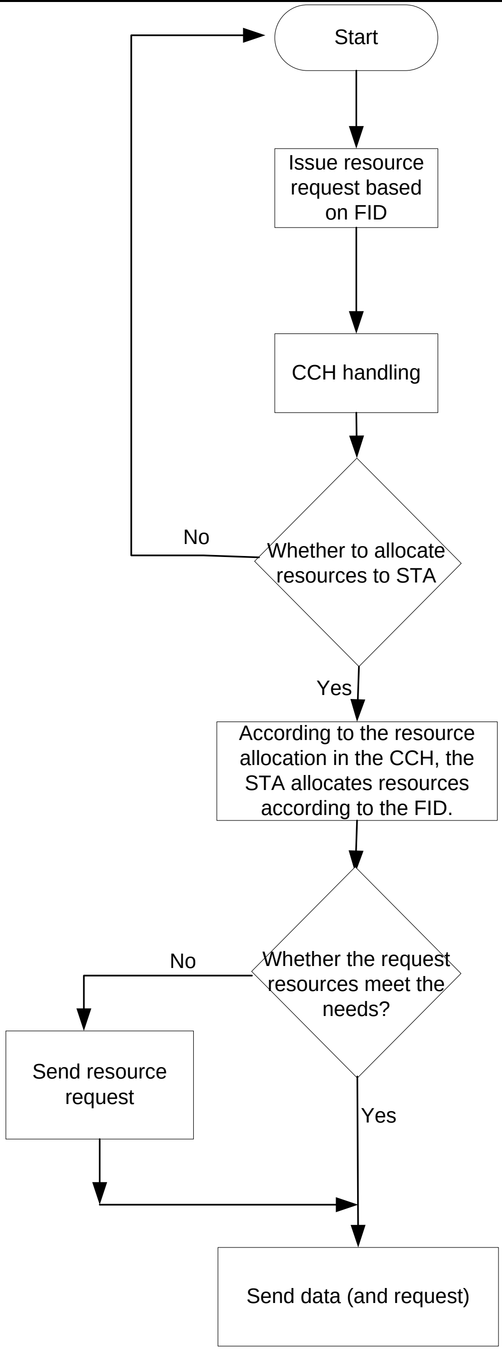


Figure 51 **Resource request/ assignment process**

7.7 Service type and QoS

7.7.1 QoS

The QoS parameters of the service stream are as follows:

- Service type: This parameter identifies the unique type of the service.
- Service priority: This parameter specifies the priority assigned to a service stream.
- Service guarantee rate: This parameter defines the basic rate that guarantees the service, in bits per second, which matches the SDU rate entered by the IP Adaptation Layer. This parameter does not cover the rate occupied by the MAC.
- Maximum service rate: This parameter describes the maximum service rate that the system provides to the service for rate shaping. Additional data beyond this rate will be discarded. The unit is bit per

second. And it matches the SDU rate entered by the IP Adaptation Layer. This parameter does not cover the rate occupied by the MAC.

7.7.2 Service type

According to the QoS parameters of the service, eight types of services are defined at the MAC layer, and are classified into reserved resources and non-reserved resources. The service type 0 to 4 belong to the reserved resource class, and the system reserves the transmission bit rate for the corresponding services; the service type 5 to 7 belong to the unreserved resource class, and the system does not guarantee the transmission bit rate for the corresponding services.

The service type and parameter requirements are as shown in Table 31.

Table 31 **Application categories and main QoS parameters of eight services**

Service type	Resource Type	Priority	Delay budget	Packet loss rate budget	Service example
0	Reserved resources	1	50 ms	10^{-3}	Emergency safety service
1		2	100 ms	10^{-2}	Voice session
2		4	150 ms	10^{-3}	Video session (real time streaming service)
3		3	50 ms	10^{-3}	Real-time game
4		5	300 ms	10^{-6}	Non-session video (cache stream service)
5	No resources reserved	6	100 ms	10^{-3}	Interactive game
6		7	300 ms	10^{-6}	Video (cache streaming service), TCP-based services (for example, WWW, FTP, P2P file sharing, etc.)
7		8	1000 ms	10^{-6}	Background E-mail reception, file download and file printing with low transmission time requirements

7.8 Fragmentation and reassembly

The process of dividing an MSDU/ MMPDU into a smaller set of MAC frames is called fragmentation, as shown in Figure 52. Fragmentation is done by the sender. The process of multiple fragments be reassembled together at the receiving end is reassembly.

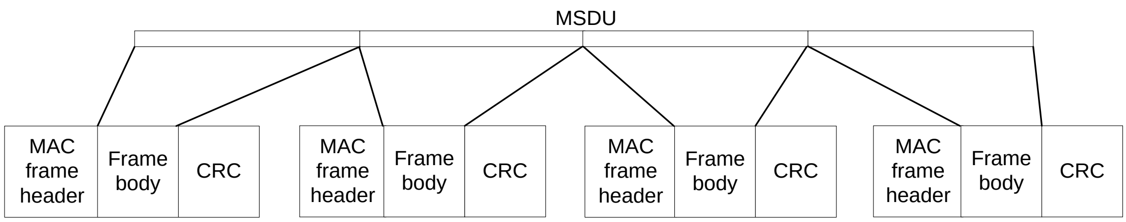


Figure 52 **MAC frame fragmentation**

In the instant acknowledgement mode, when the remaining resources of the physical frame are insufficient to send an entire data packet, a part of the data may be transmitted first by the fragment according to the remaining resource size, thereby occupying the entire channel so as to improve the utilization of the channel resource. The fragment transmission condition can be judged by the instant acknowledgement. When the fragment transmission succeeds, the next physical frame continues to transmit the remaining portion, and the remaining portion can be fragmented again according to the channel resource condition. When fragment transmission fails, it can be re-fragmented according to the channel resources. The fragment size is not required to be the same as the last fragment length, but it needs to meet the requirement that each physical frame can only transmit the same fragment in the data package with the same sequence number. In multi-connection mode, multiple copies of one package with one sequence number in one physical frame must be consistent. The receiver reassembles according to the sequence number of the package, fragment sequence number and fragmentation instructions. When receiving multiple pieces of data with the same sequence number and fragment sequence number, the last received data shall prevail.

7.9 Instant acknowledgement (IACK) and re-transmission mechanism

All non-broadcast management control frames in this specification, except random access request response frame and independent resource request frame, need to send acknowledgement frame or implied acknowledgement. The implicit acknowledgement means that the response frame for the unicast management control frame can be regarded as the acknowledgement frame. The non-broadcast management control frame does not need to be immediately acknowledged, and the response frame is allowed to respond within the maximum permitted number of physical frames. If the response frame sent by the CAP does not receive the acknowledgement frame of the STA, the response frame can be re-transmitted until the “maximum number of re-transmissions of the MPDU” is reached. When it exceeds the maximum number of re-transmissions of the MPDU, the sender will discard the frame.

This specification adopts the frame structure of the self-contained frame, which can be reasonably scheduled and complete group acknowledgement on the data of the last time period in the next time period quickly and efficiently. The time period mentioned here is one of the downlink period or the uplink period of the physical frame. The sender determines the data frame to be acknowledged immediately or in a delayed manner. By default, the instant acknowledgement is used to reduce the system delay. The group acknowledgement frame (Group ACK) of the instant acknowledgement type transmits in the short signaling channel of the next time period in a highly reliable manner, enabling an efficient group acknowledgement. The receiver determines whether the acknowledgement is needed immediately according to the immediate/delayed acknowledgement field of the MAC header. If the acknowledgement frame is not received in the next time period, the data frame can be re-transmitted before the maximum number of MPDU re-transmissions is reached. After it exceeds the maximum number of MPDU re-transmissions, the sender will discard the frame. The next time period mentioned here may be from an uplink physical frame period to a downlink physical frame period, or vice versa. When the MPDU is re-transmitted, the Sequence Number and Fragment Sequence Number remain unchanged.

For the service message with low time delay and high reliability, multiple copies are created in the adaptation sublayer by means of message copying. The above-mentioned messages are detected in the adaptation sublayer on the receiving end to avoid duplicate message delivery. If the physical frame receives a copy of any message, it instantly acknowledges and there is no need to re-transmit. Otherwise, it can be fast re-transmitted in the next time period. The re-transmission also uses the message copying manner to improve reliability.

7.10 Frame acknowledgement

In this specification, ACK frame or Group Ack frame are used for acknowledgement.

For the management control frame, the unicast management control frame without corresponding response frame needs to use ACK or Group Ack for acknowledgement. Otherwise, the corresponding response frame is used directly for acknowledgement, and the corresponding response frame list is as shown in Table 32.

Table 32 **Corresponding response frame list**

Request frame	Corresponding response frame

Random access request frame (RA-REQ)	Random access response frame (RA-RSP)
STA basic capability request (SBC-REQ)	STA basic capability response (SBC-RSP)
Uplink dynamic service addition request (DSA-REQ)	Dynamic service addition response (DSA-RSP)
Uplink dynamic service change request (DSC-REQ)	Dynamic service change response (DSC-RSP)
Uplink dynamic service delete request (DSD-REQ)	Dynamic service delete response (DSD-RSP)
Group acknowledgement request frame (Group AckReq)	Group acknowledgement frame (Group Ack)
Sleep request frame (SLP-REQ)	Sleep response frame (SLP-RSP)

The ACK frame and the Group Ack frame no longer require other frames for the acknowledgement.

According to the fragment acknowledgement indication field in the DSS-REQ/DSA-RSP or DSS-REQ/DSC-RSP messages, if the field is 0, it indicates that the fragment /assembly acknowledgement mechanism is adopted. The sender sends multiple fragments in sequence, and the receiver does not acknowledge for the individual fragment. After the receiver correctly receives all the data fragments, the entire data frame is acknowledged. After the sender sends all the fragments, if the acknowledgement is not received, the entire data frame needs to be re-transmitted instead of re-transmitting the fragments of the data frame.

For fragmented and unfragmented data frames, either ACK or Group Ack mode can be used for acknowledgement.

The waiting interval of the instant frame acknowledgement is a time period. While the waiting interval of the delayed frame acknowledgement is determined by the sender.

The receiver will send the MSDU to the next MAC processing flow in ascending order of SN. Any MSDU sent to the next MAC processing flow will be removed from the cache.

7.11 Link adaptation

7.11.1 Downlink adaptation

7.11.1.1 Downlink adaptation overview

The CAP end adaptively selects different physical layer transmission modes for the STA according to the channel quality information (CQI), service type, packet loss rate fed back by the STA, including the MIMO working mode, coding type, and MCS etc.

7.11.1.2 Request-response based feedback mechanism

The request-response based feedback mechanism means that the CAP actively sends CQI feedback request, as shown in Figure 53.

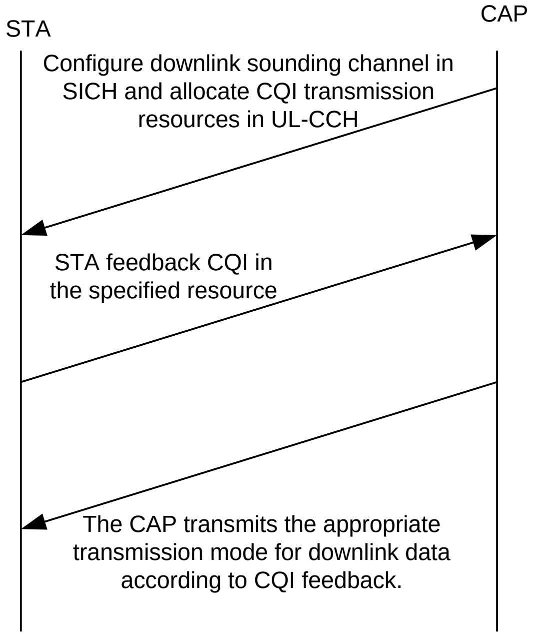


Figure 53 **Request-response based downlink adaptation**

7.11.1.3 Active feedback

The STA can actively send a CQI to the CAP. The feedback of the required resources can be acquired by the following means:

a) CQI feedback is directly aggregated with the data and transmitted using the allocated uplink data resources;

b) The STA carries the resource request reported by the corresponding CQI in the uplink data frame, and then the CAP allocates resources;

c) The STA sends the resource request by sending a scheduling request sequence, and feeds the request resource allocation back to the CQI.

In the case of active feedback, the CQI information is encapsulated into CQI-FB frame.

7.11.2 Uplink adaptation

The CAP can adaptively adjust the Physical Layer transmission mode for the STA according to information such as the uplink quality, service type, uplink power and packet loss rate of the STA.

7.11.3 Closed-loop MIMO mode

Closed-loop MIMO operating modes include SU-MIMO and MU-MIMO. Among them, SU-MIMO can be used as a special case of MU-MIMO to be processed by a unified MAC layer processing flow, as shown in Figure 54.

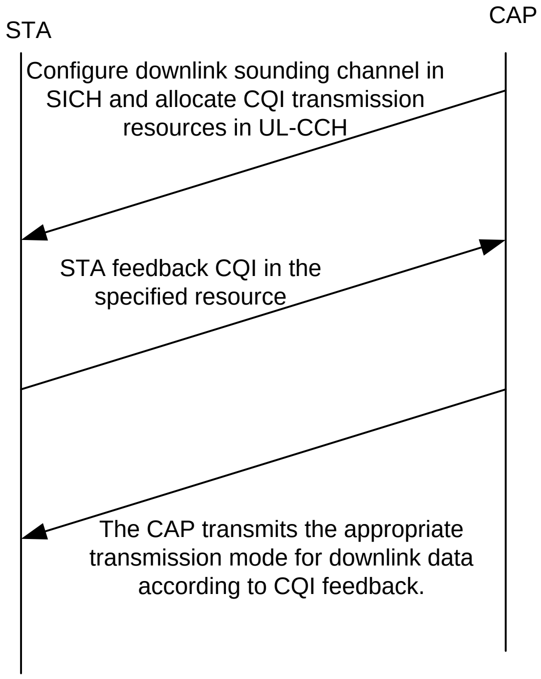


Figure 54 **Downlink closed-loop MIMO working mode flow**

7.12 Quit network process

When the STA wants to quit the network, it actively sends a quit network frame to the CAP, and after receiving the ACK feedback from the CAP, it can exit the network. The downlink CAP may send a quit network frame to the STA, requesting the STA to exit the network, as shown in Figure 55 and Figure 56.

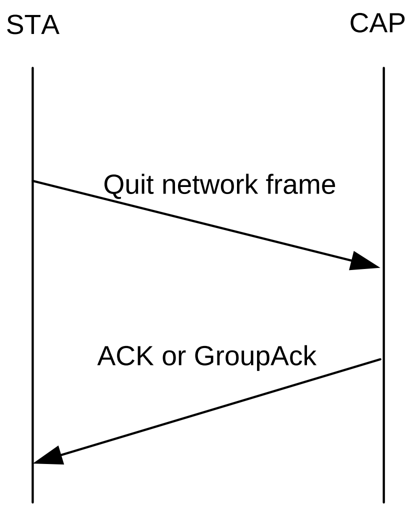


Figure 55 **Uplink quit network process**

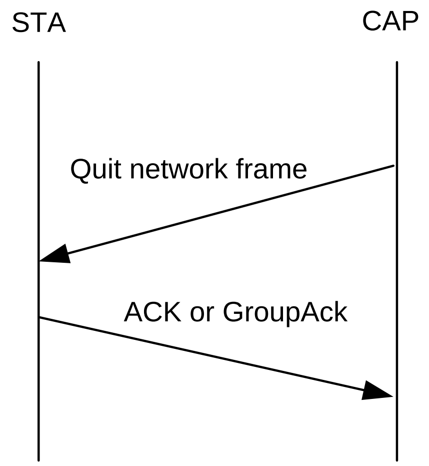


Figure 56 **Downlink quit network process**

7.13 Random backoff

A binary exponential backoff algorithm is used to handle collisions. The sizes of the minimum and maximum back-off windows of the binary exponential backoff algorithm are controlled by the CAP and broadcast in BCF frames (see Table 3).

The random backoff steps are as follows:

a) Step 1: When the STA sends the random access sequence or the scheduling request sequence, first set its internal backoff window equal to the minimum backoff window CW_{min} in the BCF frame;

b) Step 2: The STA sends a random access sequence on the random access channel or a scheduling request sequence on the scheduling request channel.

c) Step 3: The STA waits for resource allocation information for the random access request or the resource request in the subsequent CCH;

d) Step 4: If the STA receives the resource allocation information, the processing ends;

e) Step 5: If the resource allocation information for the random access request or the resource request is not detected in the CCH within the "Random Access Maximum Waiting Frame Interval" or the "Scheduling Request Maximum Waiting Frame Interval", the STA regards this as conflict;

f) Step 6: The STA will randomly select the backoff value within [0 $2^{m-1} \cdot CW_{min}$] (the backoff window is not greater than the maximum backoff window), and the backoff unit is one frame, where m represents the number of re-transmissions;

g) Step 7: After the backoff counter counts to 0, the STA sends the random access sequence or scheduling request sequence again. Then, repeat steps 4, 5, 6, and 7 until the "maximum number of attempts for random access" is reached.

7.14 Exception handling

7.14.1 Exception handling overview

Exception handling is divided into two types, i.e. exception caused by conflicts and exception caused by unexpected situations.

7.14.2 Exception handling caused by conflicts

7.14.2.1 Random access sequence conflict

After the STA sends the random access sequence, if the resource allocation information of the CAP is not obtained after the “Random Access Maximum Waiting Frame Interval” is expired, it is regarded as the random access fails and the random access process needs to be restarted.

After the STA sends the random access request frame, if the random access response frame is not received after the “Random Access Maximum Waiting Frame Interval” is expired, it is regarded as the random access fails and the random access process needs to be restarted.

7.14.2.2 Scheduling request sequence conflict

After the STA sends the scheduling request sequence, if the resource allocation information of the CAP is not obtained after the “Scheduling Request Maximum Waiting Frame Interval” is expired, it is regarded as the resource request fails and needs to be request again.

After the STA sends the independent resource request frame, if the resource allocation information of the CAP is not obtained after the “Resource Request Maximum Waiting Frame Interval” is expired, it is regarded as the resource request fails and needs to be request again.

7.14.3 Exception handling caused by unexpected conditions

7.14.3.1 STA out of sync

If the STA does not receive the BCF frame until the BCF timer expires, it is considered that the STA has lost synchronization with the CAP and needs to re-access the network.

7.14.3.2 Successive transmission failures of central access point

After the CAP sends an MPDU/G-MPDU to the STA, if it does not receive the correct acknowledgement from any MPDU, it is considered that the transmission fails and starts the counter to count the number of transmission failures. If it fails to transmit the subsequent of MPDU/G-MPDU to the STA successively, the number of transmission failures is accumulated. If the correct acknowledgement of any MPDU is received, the accumulated counter will be reset. If the accumulated value exceeds the “maximum number of consecutive transmission failures allowed by the CAP to the STA”, the CAP considers that the STA is abnormal and deletes it from the active STA list.

7.14.3.3 Random access phase anomaly

After the STA sends the random access sequence and waits until the "Random Access Maximum Waiting Frame Interval" expires, if it does not receive the resource indication of the random access request frame sent by the CAP, the random access sequence shall be resent. After receiving the STA random access sequence and waiting until the "Random Access Maximum Waiting Frame Interval" expires, if the CAP does not receive the random access request frame from the STA, it deletes all the information of the corresponding STA. After the STA sends the random access request frame and waits until the "Random Access Response Maximum Waiting Frame Interval" expires, if it does not receive the random access response frame from the CAP, it re-sends the random access sequence. The STA detects the MAC address of the STA in the received random access response frame. If the address does not match the STA's own address, the random access sequence will be resent.

7.14.3.4 Capability negotiation phase anomaly

After the STA receives the random access response frame of the CAP and waits until the “STA Basic Capability Request Frame's Maximum Waiting Frame Interval” expires, if it does not receive the resource indication of the STA basic capability request frame, it is considered that the capability negotiation fails and the random access process is restarted.

After the STA sends the STA basic capability request frame and waits until the “STA Basic Capability Response Frame's Maximum Waiting Frame Interval” expires, if it does not receive the STA basic capability response frame, it is considered that the capability negotiation fails and the random access process is restarted.

After the CAP sends the STA basic capability response frame and waits until the “STA Basic Capability Response Frame Acknowledgment's Maximum Waiting Frame Interval” expires, if it does not receive the acknowledgement of the STA basic capability response frame from the STA, it is considered that the capability negotiation fails. Before the maximum waiting frame interval for the STA basic capability negotiation response frame acknowledgement expires, the CAP can re-transmit the STA basic capability response frame.

7.14.3.5 Dynamic service stream management phase anomaly

In the uplink service stream management process, the STA sends the service stream management request. If the “maximum waiting frame interval of the service stream response frame” expires, it is considered that the service stream management process fails. After the CAP sends the the service stream response frame, if the "maximum waiting frame interval of the acknowledgement of the service stream response frame” expires, it is considered that the service stream management process fails.

After the CAP sends the service stream management request frame, if the "maximum waiting frame interval of the acknowledgement of the downlink service stream request frame” expires, it is considered that the service stream management process fails.

After the re-transmission times of the CAP sending service stream management request response frame exceed the limit, the CAP actively initiates the process of deleting the service stream. During the downlink service stream management process, after the re-transmission times of the CAP sending service stream management request exceed the limit, the CAP actively initiates the process of deleting the service stream. In the above two processes, after the accumulated re-transmission times of the CAP exceed the “maximum times of consecutive CAP re-transmission”, the CAP considers that the STA is abnormal and actively removes it from the active STA list.

7.15 Channel switching management

7.15.1 General

The system supports CAP and STA networking with different bandwidth capabilities and communicates with each other. The EUHT system uses working bandwidth 1 as the basic channel bandwidth, and supports working bandwidth 2 and working bandwidth 3 continuous or discontinuous bandwidths by spectrum aggregation. The multichannel working mode supported by the EUHT includes the aggregation mode according to whether the intermediate protection subcarrier is used for data transmission, and the specific aggregation modes can be seen at section 8.11.

In the EUHT system, the MAC layer uniformly manages and controls multiple subchannels, i.e. the CAP determines the bandwidth mode to be adopted by the STA for each transmission at the PHY layer according to the currently available bandwidth, the bandwidth capability of the STA, and the scheduling result. The multichannel working mode supported by the EUHT system is shown in Figure 57. The CAP can support switching between STAs on different channels and working bandwidths.

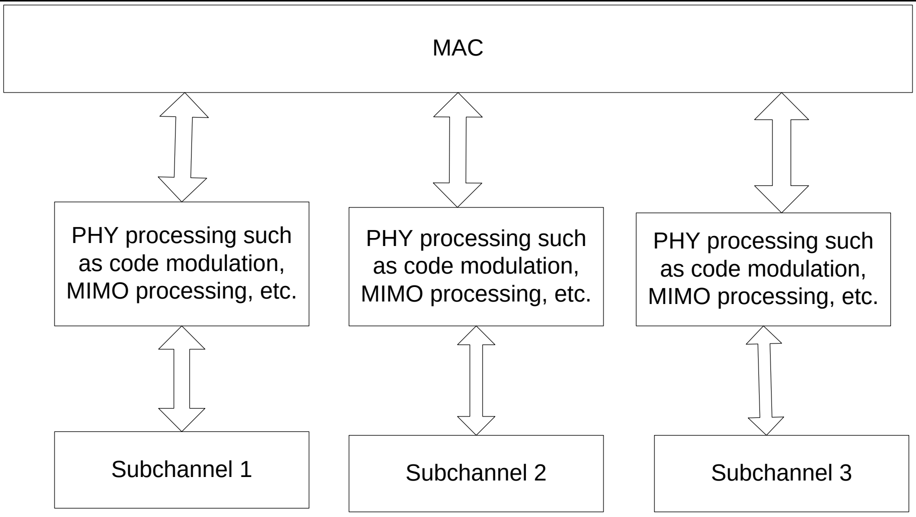


Figure 57 **Multi-carrier and multichannel working mode of EUHT system**

7.15.2 Channel switching management

The CAP or the STA may trigger the switching of the working bandwidth or the channel, or trigger the switching of the working bandwidth together with the channel according to the channel measurement result. The channel switching is to switch from one channel to another, and the working bandwidth switching refers to the switching of the working bandwidth between working bandwidth 1, working bandwidth 2 and working bandwidth 3.

The CAP can change the CAP working channel and the CAP working bandwidth domain through the channel switch information frame.

If the STA needs to perform channel switching, the CAP needs to send a channel switch information frame to the STA to notify the STA of the channel switching related operation parameters. For details, see 6.3.4.14.

Note: The channel switching management here only applies to the CAP operating in consecutive subchannels.

7.16 Power saving management

7.16.1 General

The STA has two power states:

- Active state: that is, the STA is in a normal communication mode with full power;

- Sleep state: the STA is in a low power state mode and cannot send and receive data.

The transition between these two states is determined by the power management modes of the STA. The management modes are as follows:

- Active mode (AM) means that the STA is active and can receive frames at any time.
- Sleep Mode (SM) means that the STA is in a lowest power state within a certain period, thereby saving power and air interface resources.

In sleep mode, the sleep cycle includes a sleep window and a listening window. In the sleep window, the STA cannot communicate with the CAP. At this time, one or more hardware devices can be turned off in one or more physical frames to save power. There will be a listening window at the end of each sleep window. Within the listening window, the CAP indicates the STA whether there is data arriving through the DTF-IND frame. After the listening window ends, if the STA receives the data arrival indication, it exits the sleep mode and is ready to receive data. Otherwise, it maintains the sleep mode and returns to the sleep window.

7.16.2 Power saving mechanism

7.16.2.1 Overview of power saving mechanism

The sleep mode applies to both STA and CAP. The sleep mode of STA can be triggered by the STA or each CAP. The sleep parameter can be negotiated between the STA and the CAP through MAC layer signaling. The sleep mode of CAP is triggered by CAP.

7.16.2.2 Sleep triggered by STA

When the STA does not transmit uplink data for a certain period of time, it can trigger the corresponding sleep operation, and negotiate the parameters such as the sleep period and the sleep start time with the CAP through the corresponding management control frame interaction (SLP-REQ/SLP-RSP). For details, see 7.3.4.15 and 7.3.4.16.

The CAP caches the downlink data for the STA in the sleep mode. When the cached data reaches a certain threshold, the CAP sends a DTF-IND frame in the listening window to activate the sleeping STA. The specific process is shown in Figure 58.

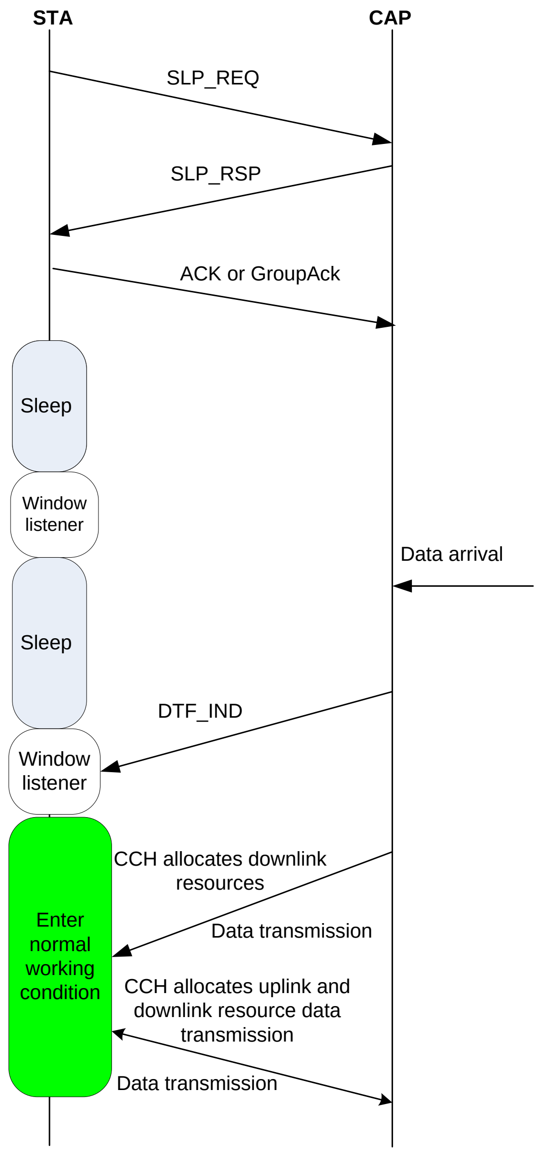


Figure 58 **Example -- sleep triggered by STA, waked up by CAP**

7.16.2.3 Sleep triggered by CAP

The CAP notifies the STA to enter the sleep state through the SLP-RSP frame according to the working state of the STA, and carries the sleep parameters of the STA in the SLP-RSP frame.

During the STA sleep period, the CAP caches the downlink data of the STA. When the cached data reaches a certain threshold, the CAP sends a DTF-IND frame in the listening window to activate the sleeping STA. The specific process is shown in Figure 59.

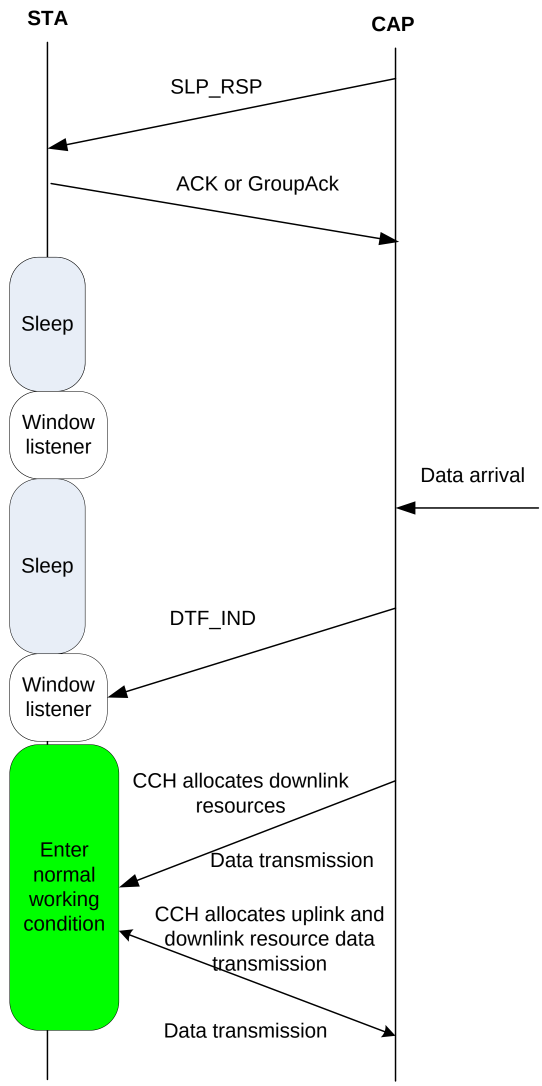


Figure 59 **Process -- sleep triggered by CAP and waked up by CAP**

7.16.2.4 Wake-up by STA

If the sleeping STA has uplink data to be transmitted, the STA can actively terminate the sleep and enter the active state. The specific process is shown in Figure 60.

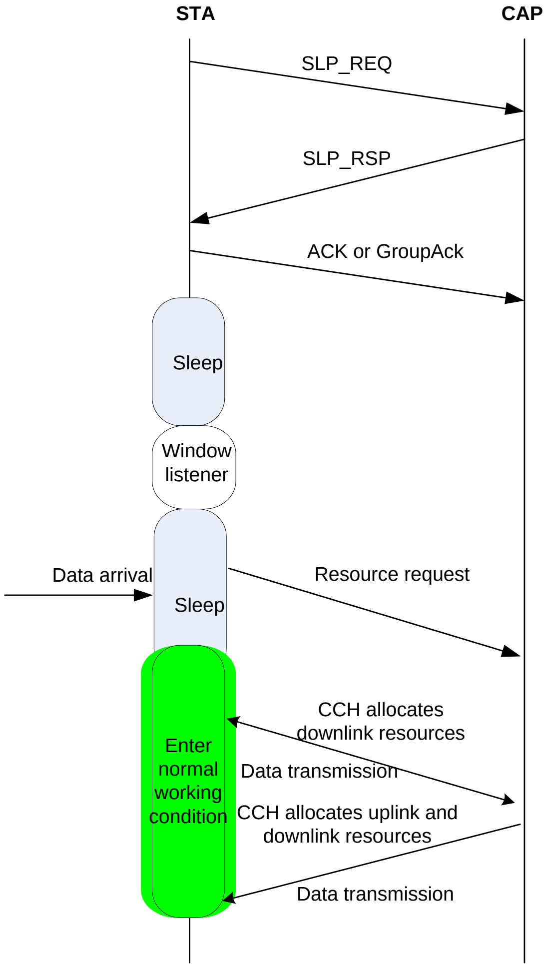


Figure 60 **Process of wake-up by STA/CAP**

7.16.2.5 Wake-up by CAP

CAP caches downlink data of STA in STA sleep period. When cached data reach a certain threshold, CAP sends DTF-IND frame in monitoring window to active sleep STA. In this case, the sleeping STA terminates sleep mode when the TI indication field in DTF MAC frame is 1. The specific process is also shown in Figure 60.

7.16.2.6 Power Saving for CAP

In the wireless transmission, the BCF frame must be transmitted periodically. The BCF frame is used in the STA to detect the CAP and obtain the basic information on the CAP. The BCF interval and the physical frame length can be configured through the network. The BCF interval range is up to 65535ms. The physical frame length in BCF frame is one of the sets of {0.5, 1, 1.6, 2, 2.5, 4, other} ms. The higher value of BCF interval will increase the energy efficiency of CAP. If there is no data to transfer in the network, CAP may enter hibernation mode after sending one physical frame which contains BCF to allow terminal to join the network or request to access network. Following by one physical frame to allow terminal to join the network or request to access network. Also, the hibernating CAP is ready to receive RA PN in every RA channel. The period of physical frames containing RA channel can be configured. In practice, the typical BCF interval is 100ms to reduce the access latency. Therefore, the hibernation rate can be about 99.5%.

7.17 System configuration parameters

System configuration parameters are shown in Table 33.

Table 33 **System configuration parameter settings table**

Parameter name	Defaults	Description
Random access maximum waiting frame interval	4	The maximum number of waiting frames that can be allowed after the STA sending the random access sequence.
Random access response maximum waiting frame interval	4	The maximum number of waiting frames that can be allowed after the STA sending the random access request frame.
STA Basic Capability Request Maximum Waiting Frame Interval	4	The maximum number of frames that the STA waits for the CAP to allocate resources to it after receiving the random access request response frame.
Maximum frame interval of STA basic capability response frames	4	The maximum number of waiting frames that can be allowed after the STA sending the STA basic capability request frame.
STA Basic Capability Response Frame Acknowledgment's Maximum Waiting Frame Interval	4	The maximum number of waiting frames that can be allowed after the CAP sending the STA basic capability request frame
Maximum waiting frame interval of traffic stream response frame	4	The maximum number of waiting frames that can be allowed after the STA sending the service stream request frame.
Maximum waiting frame interval of the acknowledgement frame of the downlink service stream request	4	The maximum number of waiting frames that can be allowed after the CAP sending the service stream request frame
Maximum waiting frame interval of the acknowledgement of the service stream response frame	4	The maximum number of waiting frames that can be allowed after the CAP sending the service stream response frame
Scheduling Request Maximum Waiting Frame Interval	4	The maximum number of waiting frames that can be allowed after the STA sending the scheduling request sequence
Resource Request Maximum Waiting Frame Interval	4	The maximum number of waiting frames that can be allowed after the STA sending the independent resource request frame.
Maximum number of consecutive failed transmissions allowed by the CAP to the STA	20	The number of consecutive transmission failures that the CAP can tolerate for a certain STA
MPDU maximum re-transmission times	5	The maximum number of attempts to re-transmit an MPDU
Maximum number of attempts for random access	10	The maximum number of times the STA can try the Random Access
Max Buffer Size of the connection in which FID is 0	16	The connection with FID of 0 can buffer 16 MPDU at maximum

7.18 Identification and confidentiality

The identification and confidential mechanism of EUHT is completed by the cooperation between the STA on the mobile station side and the network side. The security mechanism of the “identification and authentication generated by negotiation with keys” is adopted to achieve the two-way identification and authentication between the network and the mobile station so as to ensure authorized access of the legitimate users. And the encryption and decryption keys for secure data transmission are generated during the identification and authentication process to ensure the security of data transmission.

In order to enhance security, the root key is not transmitted in the air interface and network path, but only local to the STA and network side.

The two-way authentication between the mobile station and the network is possible, that is, the network can identify the mobile station and the mobile station can also identify the network. Isolation of encryption and decryption keys on data plane is possible: each STA encrypts and decrypts with a different and individual key on each CAP. The encrypted and decrypted data plane messages can be securely transmitted. The security of control signaling is critical to the security of radio communication systems. The system can enter the secure transmission mode after being authenticated. It encrypts and decrypts the control signaling through the encryption and decryption algorithm to ensure the secure transmission of key signaling in the control layer. At the same time, the system has a CRC checking mechanism in the MAC layer to ensure that the integrity of the control signaling is not falsified.
The AES encryption and decryption algorithm can be used to encrypt and decrypt data packets, ensuring the secure transmission.

7.18.1 Authentication flow

The MME (Mobility Management Entity) network element is introduced into the system to implement the authentication function of the Authentication Server. A peer-to-peer control protocol flow is added between the STA and the MME to realize the function. A peer-to-peer control protocol flow is added between the CAP and the MME to support the implementation of the function. The specific authentication process supported by this system is as Figure 61:

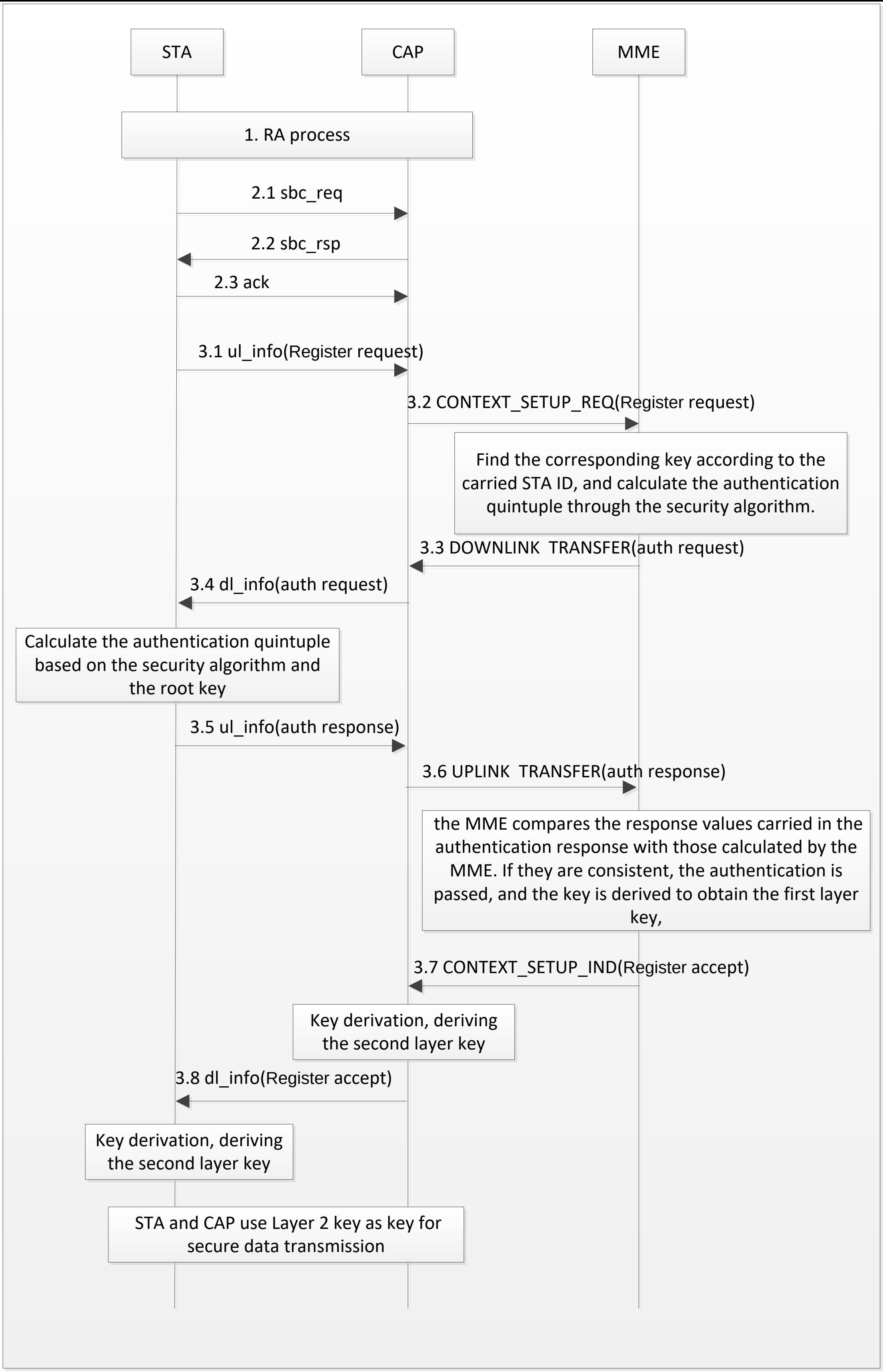


Figure 61 **Authentication flow**

1. RA process
2. In the SBC process, the STA carries the initial network access in the SBC_REQ signaling, and the

CAP informs the STA in the SBC_RSP signaling that the upper layer authentication process needs to be initiated.

3. Specific authentication process is described as follows:

3.1 The STA sends an uplink message ul_info (which carries the up layer signaling "Register Request, which carries the STA ID information").

3.2 After receiving the message, the CAP sends a context establishment request (in which the up layer signaling "Register Request" is carried).

3.3 After receiving the message, the MME finds the corresponding root key according to the carried STA ID, and calculates a set of authentication vectors by using a security algorithm, where the response value is used for subsequent authentication of the STA. And a downlink message, which carries the up layer signaling "authentication request, carrying specific authentication vectors such as RAND, AUTN etc.", is sent, expecting the STA to use the authentication vectors to calculate an response value to report to the network.

3.4 After receiving the message, the CAP sends a downlink message dl_info (which carries the up layer signaling "authentication request, carrying specific authentication vectors such as RAND, AUTN, etc.").

3.5 After receiving the message, the STA calculates a set of authentication vectors according to the root key by the security algorithm, and puts the calculated response value into the up layer signaling "Authentication Response" and sends it to the CAP.

3.6 The CAP sends the received message to the MME through an uplink message ("Authentication Response, carrying the specific response value calculated by the STA").

3.7 After receiving the authentication response message, the MME compares the response values carried in the authentication response with those calculated by the MME. If they are consistent, the authentication is passed, and the key is derived to obtain the first layer key, which is sent to the CAP. At the same time, a downlink message is sent, which carries the up layer signaling "registration success".

3.8 After receiving the message, the CAP derives the second layer key for subsequent encryption and decryption. Simultaneously, a downlink message, which carries the up layer signaling "registration success", is sent. After receiving the message, the STA learns that the network authentication has been passed, and uses the root key to derive the second layer key. The STA and the CAP use the second layer key as the key for encrypting and decrypting the data message.

(Note: If the Response value calculated by the MME is not consistent with the MME's own calculation, the MME considers it to be an illegal user and will reject the registration process. The STA will not be allowed to perform service transmission in the following).

7.19 Mobility management

Mobility management is mainly divided into two categories based on the state of the STA, i.e. mobility management in idle state and in connection state. The mobility management in the idle state is mainly performed through the cell reselection process, and that in the connection state through the handover process.

7.19.1 Cell re-select process

In idle mode, cell reselection is triggered during monitoring the channel quality measurements of the serving cell and neighboring cells. The serving cell may indicate and configure the STA to search and measure information of neighboring cells by measuring the response message. The criteria for cell reselection relate to measurements of serving cells and neighboring cells. The STA determines whether to initiate the cell reselection process according to the reselection decision criterion based on the current channel quality measurement result and the configured threshold value at the Network network side. Once it is determined to reselect the target cell, the STA initiates a network access procedure with the target cell. After the target cell completes the network access procedure, the STA may stay in the local cell and send a location update message to the core network. The process is as shown in Figure 62.

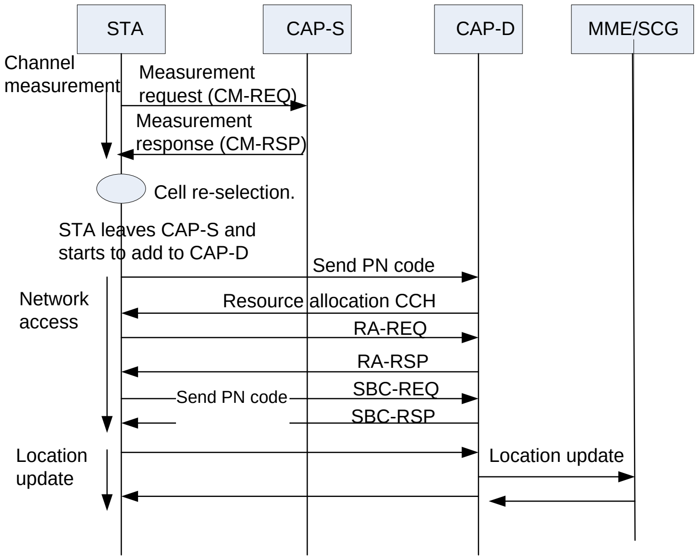


Figure 62 Cell re-select process

7.19.2 Handover management

7.19.2.1 Basic handover procedure

When the STA is in the service connection state, its mobility management can be performed through the handover process. The handover procedure covers the channel measurement handover triggering, the handover decision and preparation, and the handover execution. The basic handover procedure is shown in Figure 63.

- Channel measurement:

To assist the handover decision, the CAP may allocate a corresponding time interval for the STA to perform channel scan measurement, and report channel measurement results of the serving cell and the neighboring cells, in preparation for subsequent channel switching and cell handover.

The measurement steps are as follows:

Step 1: the STA measures the average Received Signal Strength Indication (RSSI) of the working channel of the current cell.

Step 2: the average RSSI measurement value of the working channel of the current cell is compared with the set threshold value RSSI_DL_DROP. When the measured value is less than the threshold value RSSI_DL_DROP, the timer starts counting.

Step 3: If the measured value of the average RSSI of the current cell in the set lag time T_1 is less than the threshold RSSI_DL_DROP, send a measurement request message to the CAP-S.

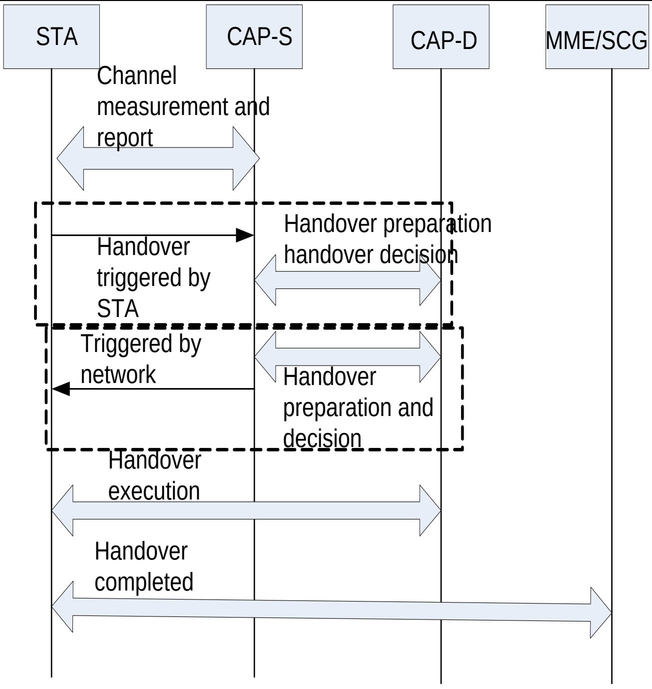


Figure 63 **Basic process of handover**

Step 4: According to the measurement response message returned by the CAP-S, which carries the allocated measurement time and candidate cell list information, measurement of the candidate cell starts, and the RSSI of the working channel of the candidate cell is measured.

Step 5: If the candidate cell meets the handover condition, a handover request containing the average RSSI measurement value of the working channel of the candidate cell is sent to the CAP-S.

The CAP-S makes a handover decision according to the handover request sent by the STA and executes the subsequent handover procedure.

- Handover triggering

The handover may be triggered by the STA according to the channel change; for the STA-triggered handover, the STA sends a HO-REQ message to the CAP-S to trigger the handover procedure, and then starts the signaling interaction prepared by the handover between the CAP and the CAP.

The network side can also initiate handover according to the purpose of load balancing. For the handover triggered by the network side, the network side sends a HO-CMD message to the STA to trigger the handover by the CAP-S, and the handover preparation interaction procedure between the CAP-S and the CAP-D is completed before the handover triggering, as shown in Figure 63.

- Handover decision and preparation

For the STA-triggered handover, the CAP-S may send a handover preparation message to one or more candidate CAPs according to the recommended one or more candidate CAP information carried by the HO-REQ message, and query parameters such as available resources to determine the target CAP-D for the STA. The STA is notified by the HO-CMD message.

For the handover triggered by the network side, the network side selects the target CAP for the STA according to the previous handover preparation interaction, and carries the target CAP-D information through the HO-CMD message. Once the CAP-D is determined, the CAP-S can send STA capability information, service context and other information to the CAP-D through the backbone network before handover to optimize the handover performance.

In this phase, the CAP-D can pre-allocate the temporary STAID parameters, send them to the STA through the CAP-S and by the HO-CMD message. After receiving the HO-CMD command, the STA shall update the information according to the parameters carried by the HO-CMD, including the TSTAID that shall be assigned to the CAP-D by the STAID. And the authentication message shall be the authentication and other messages used by the CAP-D. If the CAP-D has assigned TSTAID to the STA during the handover process, then the FID used by the STA does not need to be updated during the handover process.

- Handover execution

Upon receiving the HO-CMD message, the STA begins executing the CAP-D network access procedure within the specified handover time. If the HO-CMD message carries the TSTAID parameter assigned by the CAP-D, during the validity period of the temporary STAID parameter, the STA shall use the TSTAID parameter to complete the access procedure that is not conflict with the CAP-D. That is, the STA waits for the resource indication allocated by the TSTAID to proceed with the competition-free access, wherein the station can implement seamless frame handover between the same frequency or different frequency points with the lowest delay in the handover execution, and achieve fast synchronization and seamless acquisition of main control signaling. If the temporary STAID expires, the STA shall randomly select the PN code to compete for the random access in the RACH channel. After receiving the ranging code, the CAP-D will send the ranging CCH and allocate the uplink bandwidth of the RA-REQ. After the STA receives the RA-RSP, the STA successfully accesses the CAP-D, that is, the STA can communicate normally.

- Handover completed

After the STA and the CAP-D can communicate normally, the CAP-D sends an update routing message to the MME/SCG to update the background routing.

7.19.2.2 Handover process

Since the handover process is a complex process that spans multiple network entities across multiple layers of protocols, the following describes the most basic handover process of the air interface in this system.

The handover process triggered by the STA as an example is shown in Figure 64. The dotted line portion is an optional step, and the handover process is determined according to the indication type of the handover command.

The handover steps are as follows:

a) When the signal quality (average RSSI) of the current cell has been lower than the measurement threshold for a certain period of time, the STA sends a measurement request message to the current serving cell (CAP-S).

b) The CAP-S returns the measurement response message, and allocates channel measurement time to the STA and carries candidate list information.

c) The STA judges the handover condition based on the channel measurement result. If the received signal quality (average RSSI) exceeds the handover threshold for a period of time, the handover request is sent to the CAP-S to trigger the handover.

d) The CAP-S performs a handover decision according to the recommended candidate CAP carried in the handover request, and determines the target CAP-D.

e) The CAP-S sends a handover preparation message to the target CAP-D1 to reserve the handover resource.

f) The CAP-S sends a handover command message to the STA. The handover command message carries a handover type indication.

g) After receiving the handover command, the STA initiates a handover process to the CAP-D according to the relevant parameters carried in the handover command. According to the handover type carried in the handover command message, the STA enters different handover processes. If the handover type is Re-Access Type, the STA will initiate an access process on the CAP-D, which is the same as the network access process. If the handover type is competitive access, it is accessed following steps 8) to 11), and the capability negotiation process is omitted. If the switch type is competition-free access, it is handed over following step 12)

h) The STA transmits the PN code on the RACH channel of the CAP-D, and adopts the competitive access mode in the same manner as the new STA.

i) After receiving the PN code, the CAP-D sends the uplink resource allocation CCH that transmits the

RA-REQ and carries power and uplink TA information.

j) The STA sends an RA-REQ on the allocated resource, and carries the STA MAC address.

k) After receiving the RA-REQ, the CAP-D sends the RA-RSP and assigns a unique STAID.

l) In the competition-free access mode, the CAP-D needs to assign the STAID to the user in advance, and informs the STA in the handover command of the temporary STAID and other information allocated by the CAP-D; the STA completes the synchronization and obtains the control signaling of the new base station with the minimum delay so as to achieve seamless frame handover.

m) The CAP-D sends a route update message to the core network device MME/SCG to recover the downlink service transmission.

n) So far, the STA completes the uplink and downlink service handover through the CAP-D, and notifies the CAP-S to release the resources.

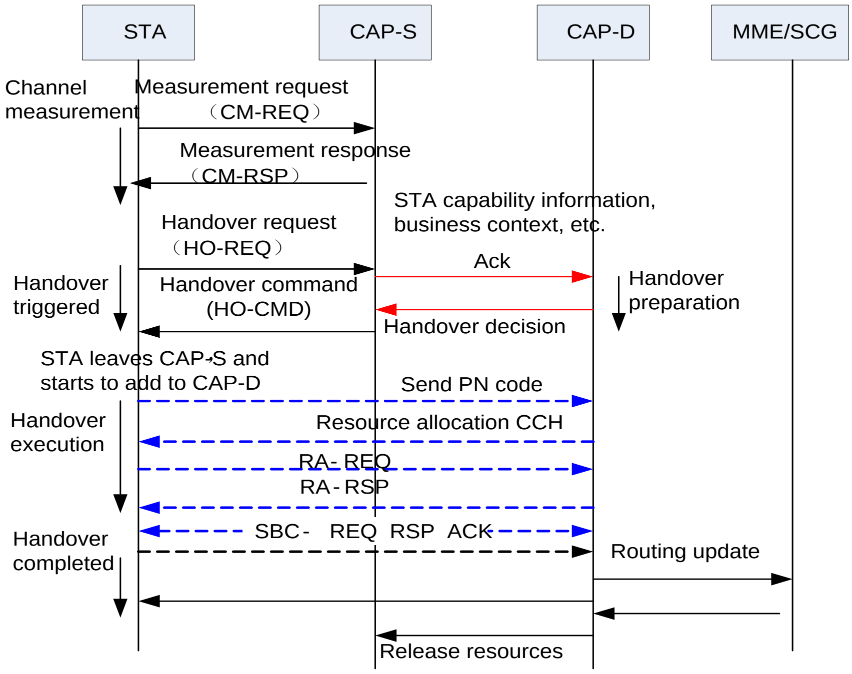


Figure 64 **Example of air interface handover process triggered by STA**

7.19.2.3 Lossless Handover

EUHT system supports mobility by using the network control and STA-assisted handover mechanism.

The network provides measurement configuration information to STA. According to the network configuration information, when the STA detects that the threshold of start-up measurement is satisfied, the STA initiates measurements of neighboring cells; when the STA detects that the threshold of measurement report is satisfied, the STA reports the measurement results to the network.

In the handover process, the source CAP decides whether to initiate the handover procedure based on the measured results reported by the STA. The source CAP initiates a handover procedure and sends a "CAP Handover Request" message to the target CAP when the source CAP judges that the handover condition is satisfied. The message carries service flow info, security info, etc. The info helps the target CAP establish Radio Bearer and restore Air Interface data transmission.

The target CAP provides some information to help the STA have access to the target CAP. The target CAP sends the information to the source CAP through the "CAP Handover Response" message. Then the source CAP sends the information that can be used in the target CAP to the STA by sending the "Handover Command" message through the air interface so as to help the STA access the target CAP when it hands over.

For some data flow services that are required to support lossless handover, in the handover process, the source CAP will forward the buffer memory of the target CAP the data packets that have been sent to the STA through the air interface and have not received ACK from the STA. Meanwhile, the source

CAP also forwards the buffer memory of the target CAP the data packets newly received from the network side in the handover process.

The STA synchronizes and accesses the target CAP according to the information received from the source CAP in the "Handover Command" message.

The target CAP sends a “Path Update" message to the CN (Core Network)to notify the path of the change. The source CAP receives a “Path Release” message from the network and releases the STA information.

Through the above control plane and user plane procedure, the STA completes the handover procedure and establishes a new radio connection with the target CAP for data transmission.

Figure 65 **Lossless handover flow**

mobility interruption time:

There are some properties support 0ms interrupt time in EUHT, such as:

The mode of multiple access is OFDMA in EUHT, thus can realize the carrier aggregation (CA) function, and STA could connect with source CAP and target CAP.

RACH – less is used in EUHT, the target CAP can pre-allocate resources for STA to reduce handover latency.

7.19.3 Interworking with other systems

EUHT system can support interwork with other wireless communication systems by using dual-mode terminal. Take the interworking with LTE system for example. The STA of EUHT system can integrate LTE function. According to the wireless coverage of EUHT and LTE system, and combined with the traffic load of the two systems, the appropriate wireless system can be selected for communication. Mobility management between two systems can be supported. The main processes are as follows:

STA receives the "Inter system selection rules" issued by the source system base station, and starts the measurement at the appropriate time according to the specified rules.

According to the Inter system selection rules of the base station of the source system, when STA meets the criteria of measurement reporting, it will report the results of "Inter system measurement" to the base station of the source system.

The base station of the source system chooses to send "Handover to Inter system command" to STA if it needs to handover to other system according to the result of STA reporting.

STA executes synchronized target system base station and accesses target system network.

8 Physical Layer

8.1 Frame structure and basic parameters

8.1.1 Frame structure

The general physical layer frame structure is shown in Figure 66. The frame length can be dynamically adjusted within the allowable range. For the adaptation of the specific frame length, see Section 8.13. The system frame structure adopts a self-contained frame format, in which the system information channel broadcasts the frame structure. The channels can be controlled according to actual service conditions. Resources can be dynamically and adaptively allocated to uplink and downlink service channels and short signalling resources in one frame (see 8.5.6). The granularity of resource allocation is one OFDM symbol.

Combined with the adaptation sublayer's multi-connection function, service layer's service replication and arbitration functions, and spectrum aggregation function (see 8.11), system-level multi-connection and multichannel processing transmission can be flexibly implemented to further improve service reliability.

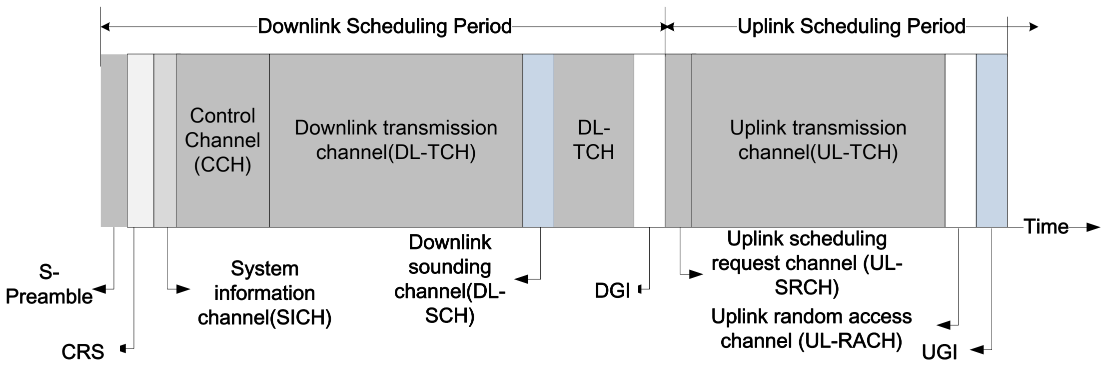


Figure 66 **General Frame Structure of physical layer**

See Table 34 for the definition of each subchannel in the frame structure. The generation procedure of each subchannel is described in 8.2 and can be classified into three working mode: normal mode, low-error mode and mmWave mode. Both normal mode and low-error mode are used for sub 6GHz band, in which the low-error mode is used to achieve high reliability. mmWave mode is used in millimeter wave band (above 24GHz, etc.). The normal mode and low-error mode can be distinguished by preamble sequence detection.

The length of UGI can be adjusted in unit of samples to align the frame with timing source (GPS, etc.) and achieve time synchronization between multiple CAPs.

Table 34 Subchannel definition in frame structure

Name	Function
Short preamble sequence (S-Preamble)	System coarse synchronization
Long preamble sequence (L-Preamble)	System fine synchronization and channel estimation
System information channel (SICH)	Broadcast frame structure configuration
Transmission control channel (CCH)	Uplink traffic channel resource scheduling Downlink traffic channel resource scheduling
Downlink sounding channel (DL-SCH)	Downlink channel measurement
Uplink sounding channel (UL-SCH)	Uplink channel measurement
Uplink scheduling request channel (UL-SRCH)	Uplink scheduling request
Uplink random access channel (UL-RACH)	STA initial access
Downlink traffic channel (DL-TCH)	Downlink data transmission Downlink signaling transmission
Uplink traffic channel (UL-TCH)	Uplink data transmission Uplink feedback transmission
Downlink guard interval (DGI)	Downlink to uplink transceiving guard interval
Uplink guard interval (UGI)	Uplink to downlink transceiving guard interval

8.1.2 Basic parameters of orthogonal frequency division multiplexing

There are three types of subcarrier spacing parameter, 19.53KHz, 39.0625KHz and 78.125KHz, in which 19.53KHz, 39.0625KHz is optional for product implementation.

With each type of subcarrier spacing parameter, different bandwidths are supported This clause describes the parameters of OFDM with different subcarrier spacing and bandwidth settings.

The basic parameters of OFDM are shown in Table 35,Table 36,Table 37. It should be noted that the N_{FFT} values in those tables are the number of subcarriers which occupy the whole bandwidth. It is implementation related to choose different number of points of FFT operation.

Two cyclic prefix (CP) lengths are supported: normal CP and short CP. Only normal CP is supported in low error mode.

Table 35 **OFDM parameters with 19.53125 kHz subcarrier spacing**

System bandwidth	BW(n) = 5/10/15/20/25/30/40/50 MHz, n=1:8
Subcarrier spacing	19.53125kHz
FFT sample points	N_{FFT}= 256/512/768/1024/1280/1536/2048/2560, n=1:8
CP sample points	N_{FFT}/8 (Short CP), N_{FFT} /4 (Normal CP)
Number of data	224/448/672/896/1120/1344/1792/2240

subcarriers	
Number of phase tracking pilot subcarriers	6/12/18/24/30/36/48/60 For OFDMA mode, 16/32/48/64/80/96/128/160
Phase tracking pilot index	For each bandwidth mode index n, the phase tracking pilot set is given below: Define basic phase tracking pilot index set: Pb = [-99, -66, -33, 33, 66, 99] For OFDMA mode, Pb = [-120, -103, -86, -69, -52, -35, -18, -1, 1, 18, 35, 52, 69, 86, 103, 120] If BW(n)/5 is odd: k = [0, …, (BW(n)/5-1)/2], { Pb-k*256, Pb-(k-1)*256, ..., Pb, ..., Pb+(k-1)*256, Pb+k*256 } if BW(n)/5 is even: k = [0, …, BW(n)/10-1], { Pb-128-k*256, Pb-128-(k-1)*256, ..., Pb-128, Pb+128, ..., Pb+128+(k-1)*256, Pb+128+(k-1)*256 }
Number of virtual subcarriers	26/52/78/104/130/156/208/260 For OFDMA mode, 16/32/48/64/80/96/128/160
Virtual subcarrier index	For each bandwidth mode index n, the virtual subcarrier set is given below: Define basic virtual sbucarrier index set: Vb = [-128, ..., -116, 0, 116, ... ,127] For OFDMA mode, Vb = [-128, ..., -121, 0, 121, ..., 127] If BW(n)/5 is odd: k = [0, …, (BW(n)/5-1)/2], { Vb-k*256, Vb-(k-1)*256, ..., Vb, ..., Vb+(k-1)*256, Vb+k*256} If BW(n)/5 is even: k = [0, …, BW(n)/10-1], { Vb-128-k*256, Vb-128-(k-1)*256, ..., Vb-128, Vb+128, ..., Vb+128+(k-1)*256, Vb+128+(k-1)*256 }
FFT time window	51.2 μs
Cyclic Prefix	6.4μs (Short CP) , 12.8μs (Normal CP)
OFDM symbol period	57.6μs (Short CP) , 64μs (Normal CP)

Table 36 **OFDM parameters with 39.0625 kHz subcarrier spacing**

System bandwidth	BW(n) = 5/10/15/20/25/30/40/50/60/80/100 MHz, n=1:11
Subcarrier spacing	39.0625kHz
FFT sample points	N_{FFT} = 128/256/384/512/640/768/1024/1280/1536/2048/2560, n=1:11
CP sample points	N_{FFT}/8 (Short CP), N_{FFT}/4 (Normal CP)
Number of data subcarriers	112/224/336/448/560/672/896/1120/1344/1792/2240
Number of phase tracking pilot subcarriers	4/6/12/12/20/18/24/30/36/48/60 For OFDMA mode, 8/16/24/32/40/48/64/80/96/128/160
Phase tracking	For each bandwidth mode index n, the phase tracking pilot index set is given below:

pilot index	1) n=1,3,5: Pb = [-44, -22, 22, 44] ; for OFDMA mode, Pb = [-60, -43, -26, -9, 9, 26, 43, 60]
	n=1, { Pb }
	n=3, { Pb-128, Pb, Pb+128 }
	n=5, { Pb-256, Pb-128, Pb, Pb+128, Pb+256 }
	
	2) n=2,4,6,7,8,9,10,11: Pb = [-99, -66, -33, 33, 66, 99] ; for OFDMA mode, Pb = [-120, -103, -86, -69, -52, -35, -18, -1, 1, 18, 35, 52, 69, 86, 103, 120]
	if BW(n)/10 is odd: k = [0, …, (BW(n)/10-1)/2]:
	{ Pb-k*256, Pb-(k-1)*256, ..., Pb, ..., Pb+(k-1)*256, Pb+k*256 }
	if BW(n)/10 is even: k = [0, …, BW(n)/20-1]:
	{ Pb-128-k*256, Pb-128-(k-1)*256, ..., Pb-128, Pb+128, ..., Pb+128+(k-1)*256, Pb+128+(k-1)*256 }

Virtual subcarrier index	For each bandwidth mode index n, the virtual subcarrier index set set is given below:
	1) n=1,3,5: Vb = [-64, …, -59, 0, 59, …, 63] ; for OFDMA mode, Vb = [-64, ..., -61, 0, 61, 63]
	n=1, { Vb }
	n=3, { Vb-128, Vb, Vb+128 }
	n=5, { Vb-256, Vb-128, Vb, Vb+128, Vb+256 }
	
	2) n=2,4,6,7,8,9,10,11: Vb = [-128, …, -116, 0, 116, …, 127]; for OFDMA mode, Vb = [-128, …, -121, 0, 121, …, 127]
	if BW(n)/10 is odd: k = [0, …, (BW(n)/10-1)/2]:
	{ Vb-k*256, Vb-(k-1)*256, ..., Vb, ..., Vb+(k-1)*256, Vb+k*256 }
	if BW(n)/10 is even: k = [0, …, BW(n)/20-1]:
	{ Vb-128-k*256, Vb-128-(k-1)*256, ..., Vb-128, Vb+128, ..., Vb+128+(k-1)*256, Vb+128+(k-1)*256 }

FFT time window	25.6 μs
Cyclic Prefix	3.2μs (Short CP), 6.4μs (Normal CP)
OFDM symbol period	28.8μs (Short CP), 32μs (Normal CP)

Table 37 **OFDM parameters with 78.125 kHz subcarrier spacing**

System bandwidth	BW(n) = 5/10/15/20/25/30/40/50/60/80/100 MHz, n=1:11
Subcarrier spacing	78.125 kHz
FFT sample points	N_{FFT}= 64/128/196/256/320/384/512/640/768/1024/1280, n=1:11
CP sample points	N_{FFT}/8(Short CP), N_{FFT}/4 (Normal CP)
Number of data subcarriers	56/112/168/224/280/336/448/560/672/896/1120 For OFDMA mode, 48/112/144/224/240/336/448/560/672/896/1120
Number of phase tracking pilot subcarriers	2/4/6/6/10/12/12/20/18/24/30 For OFDMA mode, 4/8/12/16/20/24/32/40/48/64/80
Phase tracking pilot index	For each bandwidth mode index n, the different phase tracking pilot set is given below:

	1) n=1,3,5: Pb = [-22, 22] ; for OFDMA mode, Pb = [-26, -9, 9, 26]
	n=1, { Pb }
	n=3, { Pb-64, Pb, Pb+64}
	n=5, { Pb-128, Pb-64, Pb, Pb+64, Pb+128}
	
	2) n=2,6,8: Pb = [-44, -22, 22, 44] ; for OFDMA mode, Pb = [-60, -43, -26, -9, 9, 26, 43, 60]
	n=2, { Pb }
	n=6, { Pb-128, Pb, Pb+128 }
	n=8, { Pb-256, Pb-128, Pb, Pb+128, Pb+256 }
	
	3) n=4,7,9,10,11: Pb = [-99, -66, -33, 33, 66, 99] ; for OFDMA mode, Pb = [-120, -103, -86, -69, -52, -35, -18, -1, 1, 18, 35, 52, 69, 86, 103, 120]
	if BW(n)/20 is odd: k = [0, …, (BW(n)/20-1)/2]:
	{ Pb-k*256, Pb-(k-1)*256, ..., Pb, ..., Pb+(k-1)*256, Pb+k*256 }
	if BW(n)/20 is even: k = [0, …, BW(n)/40-1]:
	{ Pb-128-k*256, Pb-128-(k-1)*256, ..., Pb-128, Pb+128, ..., Pb+128+(k-1)*256, Pb+128+(k-1)*256 }

Virtual subcarrier index	For each bandwidth mode index n, the virtual subcarrier set is given below:
	1) n=1,3,5: Vb = [-32, -31, -30, 0, 30, 31] ; for OFDMA mode, Vb = [-32, ..., -27, 0, 27, ..., 31]
	n=1, { Vb }
	n=3, { Vb-64, Vb, Vb+64}
	n=5, { Vb-128, Vb-64, Vb, Vb+64, Vb+128}
	
	2) n=2,6,8: Vb = [-64, …, -59, 0, 59, …, 63] ; for OFDMA mode, Vb = [-64, ..., -61, 0, 61, 63]
	n=2, { Vb }
	n=6, { Vb-128, Vb, Vb+128 }
	n=8, { Vb-256, Vb-128, Vb, Vb+128, Vb+256 }
	
	3) n=4,7,9,10,11: Vb = [-128, …, -116, 0, 116, …, 127]; for OFDMA mode, Vb = [-128, …, -121, 0, 121, …, 127]
	if BW(n)/20 is odd: k = [0, …, (BW(n)/20-1)/2]:
	{ Vb-k*256, Vb-(k-1)*256, ..., Vb, ..., Vb+(k-1)*256, Vb+k*256 }
	if BW(n)/20 is even: k = [0, …, BW(n)/40-1]:
	{ Vb-128-k*256, Vb-128-(k-1)*256, ..., Vb-128, Vb+128, ..., Vb+128+(k-1)*256, Vb+128+(k-1)*256 }

FFT time window	12.8 μs
Cyclic Prefix	1.6μs (Short CP), 3.2μs (Normal CP)
OFDM symbol period	14.4μs (Short CP), 16μs (Normal CP)

In mmWave mode, 50MHz, 100MHz, 200 MHz and 400MHz bandwidths are supported. The basic parameters of OFDM are shown in Table 38,Table 39,Table 40 and Table 41, respectively. Two cyclic prefix (CP) lengths are supported: normal CP and short CP.

Table 38 **OFDM basic parameters with 50 MHz Bandwidth in mmWave mode**

System bandwidth	50 MHz
Subcarrier spacing in frequency domain	390.625 kHz
FFT sample points	128
CP sample points	16(Short CP)/32(Normal CP)
Number of data subcarriers	112
Data subcarrier index	[-58 ...-50][-48...-33][-31...-1] [+58 ...+50][+48...+33][+31...+1]
Number of phase tracking pilot subcarriers	4
Phase tracking pilot index	[-49 -32 32 49]
Number of virtual subcarriers	12
FFT time window	2.56μs
Cyclic Prefix	0.32us(Short CP)/0.64us(Normal CP)
OFDM symbol period	2.88us(Short CP)/3.20us(Normal CP)

Table 39 **OFDM basic parameters with 100 MHz Bandwidth in mmWave mode**

System bandwidth	100 MHz
Subcarrier spacing in frequency domain	390.625 kHz
FFT sample points	256
CP sample points	32(Short CP)/64(Normal CP)
Number of data subcarriers	224
Data subcarrier index	[-115…-100][-98…-67][-65…-34][-32…-1] [+115…+ 100][+98…+ 67][+ 65…+ 34][+ 32…+1]
Number of phase tracking pilot subcarriers	6
Phase tracking pilot index	[-99 -66 -33 +33 +66 +99]
Number of virtual subcarriers	26
FFT time window	2.56μs
Cyclic Prefix	0.32us(Short CP)/0.64us(Normal CP)
OFDM symbol period	2.88us(Short CP)/3.20us(Normal CP)

Table 40 **OFDM basic parameters with 200 MHz Bandwidth in mmWave mode**

System bandwidth	200 MHz
Subcarrier spacing in frequency domain	390.625 kHz
FFT sample points	512

CP sample points	64(Short CP)/128(Normal CP)
Number of data subcarriers	448
Data subcarrier index	[-243…-228][-226…-195][-193…-162][-160…-129] [-127...-96][-94...-63][-61...-30][-28...-13] [+243…+228][+226…+195][+193…+162][+160…+129] [+127...+96][+94...+63][+61...+30][+28...+13]
Number of phase tracking pilot subcarriers	12
Phase tracking pilot index	[-227 -194 -161 -95 -62 -29 29 62 95 161 194 227]
Number of virtual subcarriers	52
FFT time window	2.56μs
Cyclic Prefix	0.32us(Short CP)/0.64us(Normal CP)
OFDM symbol period	2.88us(Short CP)/3.20us(Normal CP)

Table 41 **OFDM basic parameters with 400 MHz Bandwidth in mmWave mode**

System bandwidth	400 MHz
Subcarrier spacing in frequency domain	390.625 kHz
Baseband sampling clock	400MHz
FFT sample points	1024
CP sample points	128(Short CP)/256(Normal CP)
Number of data subcarriers	896
Data subcarrier index	[-499...-484][-482...-451][-449...-418][-416...-385] [-383...-352][-350...-319][-317...-286][-284...-269] [-243…-228][-226…-195][-193…-162][-160…-129] [-127...-96][-94...-63][-61...-30][-28...-13] [+499...+484][+482...+451][+449...+418][+416...+385] [+383...+352][+350...+319][+317...+286][+284...+269] [+243…+228][+226…+195][+193…+162][+160…+129] [+127...+96][+94...+63][+61...+30][+28...+13]
Number of phase tracking pilot subcarriers	24
Phase tracking pilot index	[-483 -450 -417 -351 -318 -285 -227 -194 -161 -95 -62 -29 29 62 95 161 194 227 285 318 351 417 450 483]
Number of virtual subcarriers	104
FFT time window	2.56μs

Cyclic Prefix	0.32us(Short CP)/0.64us(Normal CP)
OFDM symbol period	2.88us(Short CP)/3.20us(Normal CP)

The EUHT system uses working bandwidth sets to facilitate implementation. Please refer to section 6.3.4.4, 6.3.4.5 and 8.4.1 for the working bandwidth sets details.

8.1.3 Physical layer symbol

The definition of the Physical layer symbols associated with this specification is shown in Table 42.

Table 42 **Physical layer symbol definition**

Symbol	Definition
N_{ID}^{CAP}	CAP MAC: the lowest 7 bits of the address
N_{ID}^{STA}	STA MAC: the lowest 12 bits of the address
N_{Frame}	Frame Number
N_{FFT}	Number of FFT sample points
N_{cp}	Number of CP sample points
N_{sr}	The Highest useful subcarrier index
Δ_f	Subcarrier spacing
N_{sympss}	Number of OFDM symbols per spatial stream
N_{scpsym}	Number of data subcarriers per OFDM symbol
N_{cbpsym}	Number of encoded bits carried per OFDM symbol
N_{cbpsc}	Number of encoded bits carried per subcarrier
N_{ss}	Number of paralleled spatial streams
N_{Tx}	Number of transmitting antennas
DPI_F	Demodulation reference signal frequency domain internal (subcarrier spacing)
DPI_T	Demodulation reference signal time domain internal (OFDM symbol interval)
DPI_{num}	Number of OFDM symbols occupied by demodulation reference signal
SPI_F	Sounding pilot frequency domain internal (subcarrier spacing)
SPI_{num}	Number of OFDM symbols occupied by the sounding pilot
SC_{dp}^{sti}	The stith space-time stream demodulation reference signal subcarrier set index
SC_{sp}^{ti}	The Ith transmit antenna detection pilot subcarrier aggregation index
si	Spatial stream index
sti	Space time stream index
ti	Transmitting antenna index

In OFDMA mode, N_{scpsym} and N_{cbpsym} of a STA is number of subcarriers and coded bits of the total resource units allocated to the STA in one OFDM symbol.

8.2 Transmitter block diagram and signal processing flow

8.2.1 Transmitter block diagram

The transmitter block diagram at the CAP side is shown in Figure 67.

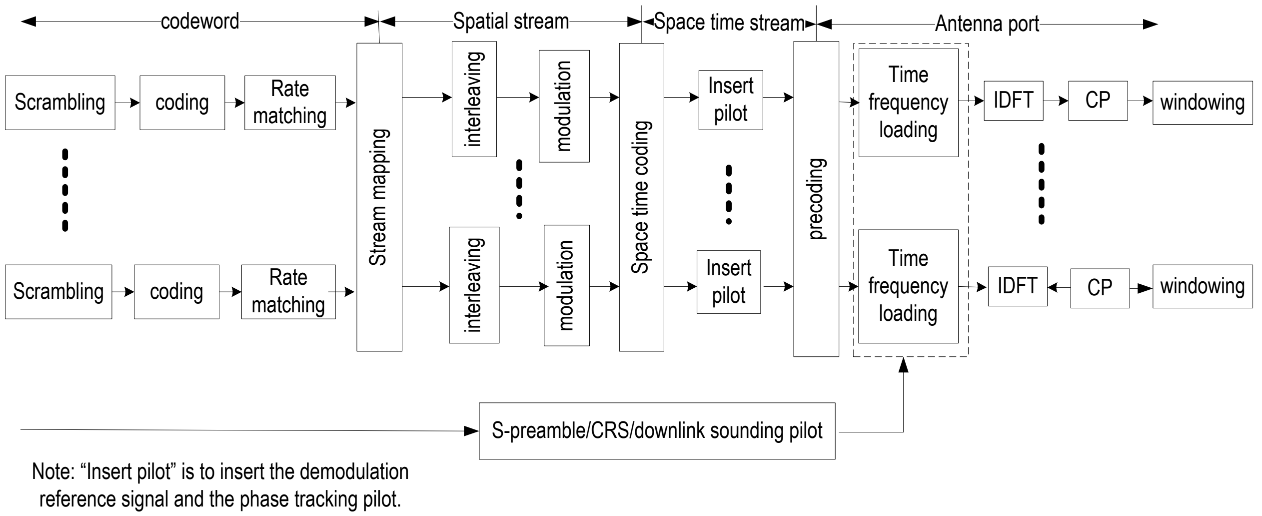


Figure 67 **Transmitter block diagram at CAP side**

The transmitter block diagram at the STA side is shown in Figure 68.

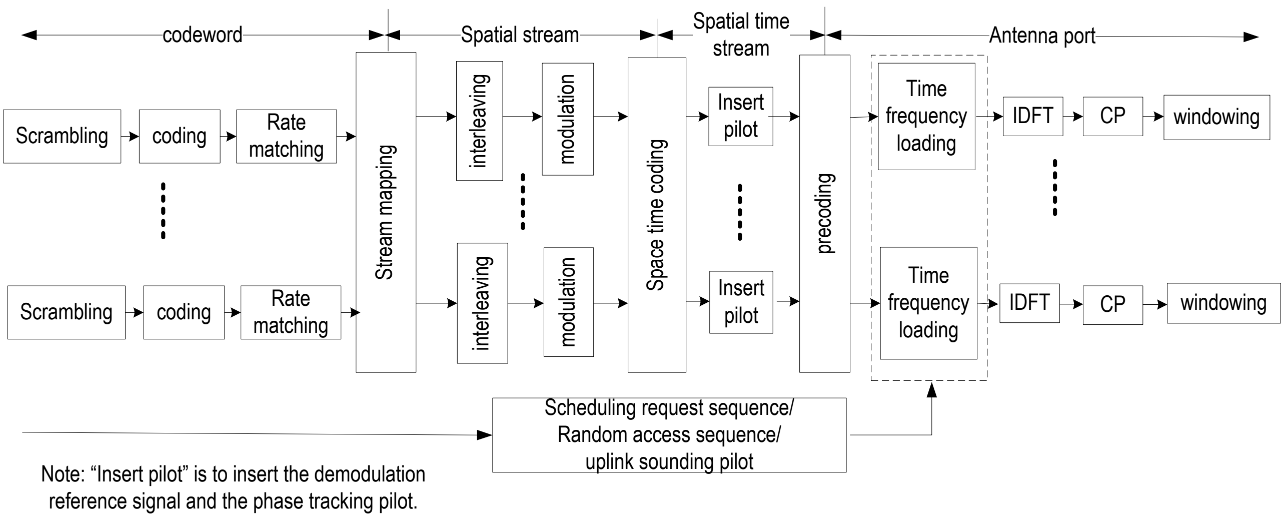


Figure 68 **transmitter block diagram at STA**

One codeword supports up to 4 streams. Up to two codewords is supported.

8.2.2 Scrambling

The output binary sequence $[s_0 s_1 \cdots s_{\text{len-bit-1}}]$ of the maximum-length linear feedback shift register with a polynomial of $1+X^{11}+X^{15}$ is generated as the scrambling code sequence to scramble the data bit sequence $[b_0 b_1 \cdots b_{\text{len-bit-1}}]$. Each code block in the system is scrambled and reset once. The block diagram of the generation of scrambling code sequence is shown in Figure 69.

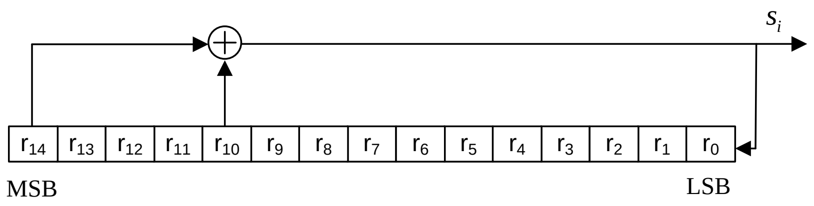


Figure 69 **Block diagram of the generation of scrambling code sequence**

For the Downlink system information channel, the initial value of the register $r_{init} = [101010001110110]_b$, MSB on the left, and LSB on the right; for other uplink and downlink control channels and traffic channels, the initial value of the register $r_{init} = [0\ 0\ 1\ 0\ 1\ 0\ 1\ 1\ N_{ID}^{CAP}]$, where N_{ID}^{CAP} are the lowest 7 bits of the CAP MAC address, and indicated in the system information channel.

The data bit sequence and the scrambling code sequence are XORed bit by bit according to Equation 3, and the bit sequence $[\tilde{b}_0\tilde{b}_1 \cdots \tilde{b}_{Len_bit-1}]$of the scrambled output can be obtained

$$\tilde{b}_i = (b_i + s_i)\, mod\, 2\, , i = 0,1,\ldots Len\_bit - 1 \qquad \text{(Equation 3)}$$

8.2.3 Channel coding

8.2.3.1 General

The channel coding module performs FEC protection on the data bit sequence $[\tilde{b}_0\ \tilde{b}_1\ \cdots\ \tilde{b}_{Len_bit-1}]$of the scrambled output. This specification supports two forward error correction codes, i.e. convolutional code and LDPC code.

8.2.3.2 Convolutional coding

The convolutional code structure in this specification is [133 171], see Figure 70. The convolutional code output is $[c_0c_1\cdots c_{len\_cw-1}]$

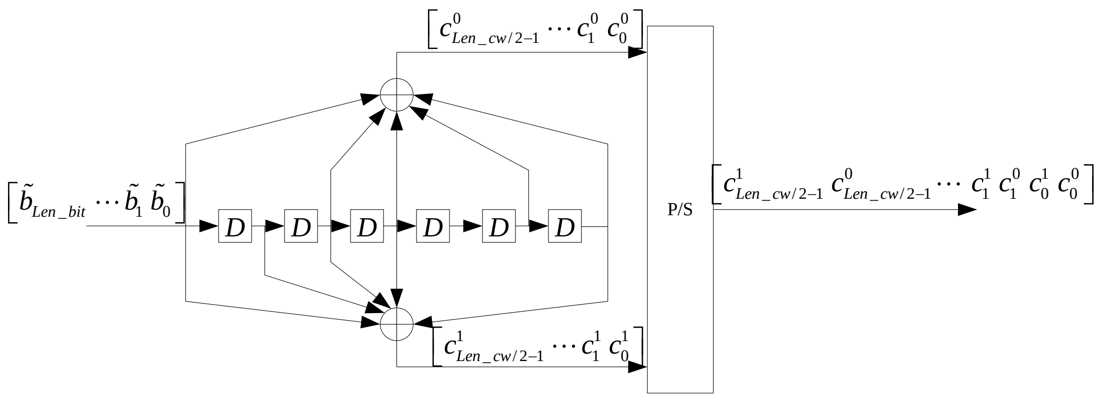


Figure 70 **Convolutional encoder structure**

In the figure, $c_{2l} = c_l^0, c_{2l+1} = c_l^1, l = 0,1,\cdots Len\_cw/2$.

Zero tailed convolutional code and tail-biting convolutional code (TBCC) are used in this specification.

When a zero tailed convolutional code is used, the initial state of the six registers of the encoder is all zeros, and six zero bits need to be padded after the bit sequence$[\tilde{b}_0\ \tilde{b}_1\ \cdots\ \tilde{b}_{Len_bit-1}]$. The encoded bit length is:

$$Len\_cw = (2 \times Len\_bit + 6) \qquad \text{(Equation 4)}$$

When a tail-biting convolutional code (TBCC) is used, the initial state of the six registers of the encoder is the last 6 bits of the data bit sequence, that is $[\tilde{b}_{Len\_bit-1}\ \tilde{b}_{Len\_bit-2}\ \tilde{b}_{Len\_bit-3}\ \tilde{b}_{Len\_bit-4}\ \tilde{b}_{Len\_bit-5}\ \tilde{b}_{Len\_bit-6}]$, and zero bits are not required to be padded after the data bit sequence. The encoded bit length is:

$$Len\_cw = 2 \times Len\_bit \quad \text{(Equation 5)}$$

8.2.3.3 Low density parity check coding

8.2.3.3.1 Low-density parity check matrix and generator matrix

The check matrix *H* of LDPC can be expressed as follows, see Equation 6:

$$\boldsymbol{H} = \begin{bmatrix} \boldsymbol{A}_{0,0} & \boldsymbol{A}_{0,1} & \cdots & \boldsymbol{A}_{0,c-1} \\ \boldsymbol{A}_{1,0} & \boldsymbol{A}_{1,1} & \cdots & \boldsymbol{A}_{1,c-1} \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{A}_{\rho-1,0} & \boldsymbol{A}_{\rho-1,1} & \cdots & \boldsymbol{A}_{\rho-1,c-1} \end{bmatrix} \quad \text{(Equation 6)}$$

Where, $A_{i,j}$ is a t×t cyclic matrix with a row weight of 0 or 1. Each row of the matrix is rotated one bit to the right by one line, where the first row is the right shift of the last row. The codeword represented by the matrix *H* is called (N, K) LDPC code, where N is the code length, K represents the length of the information bits, and its code rate is R=K/N. The first line of $A_i=[A_{i,0}, A_{i,1} \cdots, A_{i,c-1}]$, i = 0, 1, ..., ρ-1 is called the (i + 1)th row generator of *H* , then *H* has a total of ρ row generators.

The check matrix *H* can be converted into the form of the system check matrix H_{sys} by row-based modulo 2 operation and permutation operation. H_{sys} can be expressed as:

$$\mathbf{Hsys} = \left[\mathbf{P}^T \mid \mathbf{I}_{N-K}\right] \quad \text{(Equation 7)}$$

Where I_{N-K} is the identity matrix of (N-K) x (N-K) and $\mathbf{P}^T$ is the matrix of (N-K) x K.

The generator matrix G corresponding to the system check matrix H_{sys} can be expressed as:

$$\boldsymbol{G} = [\boldsymbol{I}_K|\boldsymbol{P}] \quad \text{(Equation 8)}$$

Where I_K is the unit matrix of K x K, *P* is the transposed matrix of P^T, and *P* can be expressed as:

$$\boldsymbol{P} = \begin{bmatrix} \boldsymbol{P}_{0,0} & \boldsymbol{P}_{0,1} & \cdots & \boldsymbol{P}_{0,\rho-1} \\ \boldsymbol{P}_{1,0} & \boldsymbol{P}_{1,1} & \cdots & \boldsymbol{P}_{1,\rho-1} \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{P}_{c-\rho-1,0} & \boldsymbol{P}_{c-\rho-1,1} & \cdots & \boldsymbol{P}_{c-\rho-1,\rho-1} \end{bmatrix} \quad \text{(Equation 9)}$$

Where $P_{i,j}$ is a t×t cyclic matrix, and each column of the matrix is obtained by shifting one column of the previous column downwards, wherein the first column is the cyclic shift of the last column. The first column of $P_j=[P_{0,j},P_{1,j},\cdots P_{c-\rho-1,j}]^T$, j=0,1,⋯ ρ-1 is call the (j+1)th column generator of the matrix G, then *G* has a total of ρ column generators.

8.2.3.3.2 Low density parity encoding

The information bit length K is obtained based on the selected LDPC code length and code rate. The data bit sequence $[\tilde{b}_0\ \tilde{b}_1\ \cdots\ \tilde{b}_{Len\_bit-1}]$ is sequentially divided into N_{SB} sub-block. The first R_{SB} sub-blocks, each sub-block carries $\lfloor Len\_bit/N_{SB} \rfloor + 1$ data bits; the follow in $N_{SB} - R_{SB}$ sub-blocks, each sub-block carries $\lfloor Len\_bit/N_{SB} \rfloor$ data bits. Among them:

$$N_{SB} = \lceil \text{Len\_bit} / K \rceil \quad \text{(Equation 10)}$$

$$R_{SB} = mod(Len\_bit, N_{SB}) \quad \text{(Equation 11)}$$

When the number of bits carried by the sub-block is less than *K*, the data bit sequence in the sub-block is used for cyclic padding to ensure that the number of bits of the sub-block after padding is equal to *K*.

The LDPC code encoding process of each sub-block can be expressed as Equation 12:

$$x = u \cdot G \qquad \text{(Equation 12)}$$

Where u = (u_0, u_1, ..., u_{K-1}) indicates K coded information bits, x = (u_0, u_1, ⋯u_{k-1}, v_0, v_1, ⋯v_{N-K-1}) stands for the codeword with a length of N, v=(v_1, . . . , v_{n-K-1}) is *N* - *K* check bits, and the coded code words satisfy the check equation $H \cdot x^T = 0$.

The LDPC code length, code rate, information bit length, and size of the cyclic submatrix are as shown in Table 43. See Annex E for the LDPC check matrix.

Table 43 **LDPC coding parameters**

N	K	R	t
448	224	1/2	28
448	256	4/7	32
1344	672	1/2	56
1344	840	5/8	56
1344	1008	3/4	56
1344	1176	7/8	42
2688	1344	1/2	112
2688	1680	5/8	112
2688	2016	3/4	112
2688	2352	7/8	84
5376	2688	1/2	112
5376	3360	5/8	112
5376	4032	3/4	112
5376	4704	7/8	112

After the LDPC encoding, the N_{SB} LDPC codewords are generated, and the bits of these LDPC codewords are sequentially combined into a bit sequence $[c_0 c_1 c_2 \ldots c_{Len\_cw-1}]$, where $Len\_cw = N_{SB} \times N$.

8.2.4 Rate matching

If the channel is coded in the manner of convolutional code, the encoder output code rate is 1/2. Other code rates (4/7, 5/8, 2/3, 3/4, 5/6 and 7/8) are obtained by puncture. The puncture pattern is shown in Figure 71 to Figure 76

a) 4/7 code rate

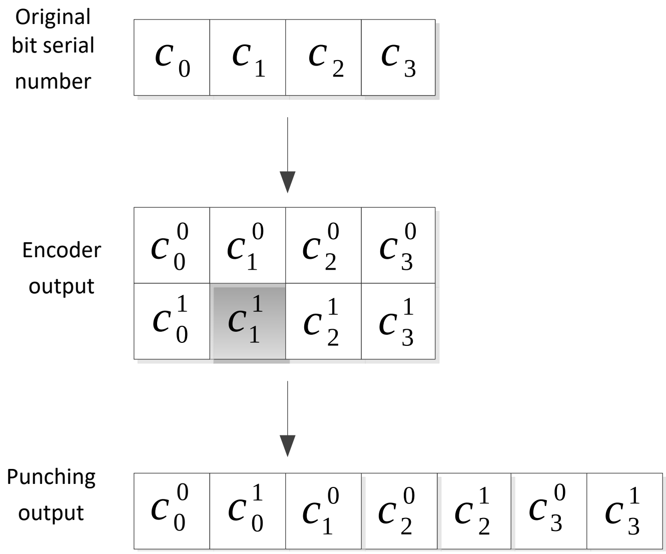


Figure 71 **4/7 Puncture Pattern**

b) 5/8 code rate

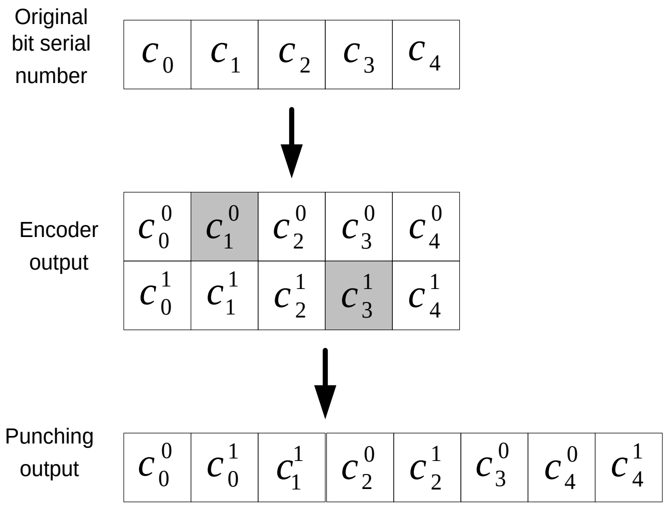


Figure 72 **5/8 Puncture Pattern**

c) 2/3 code rate

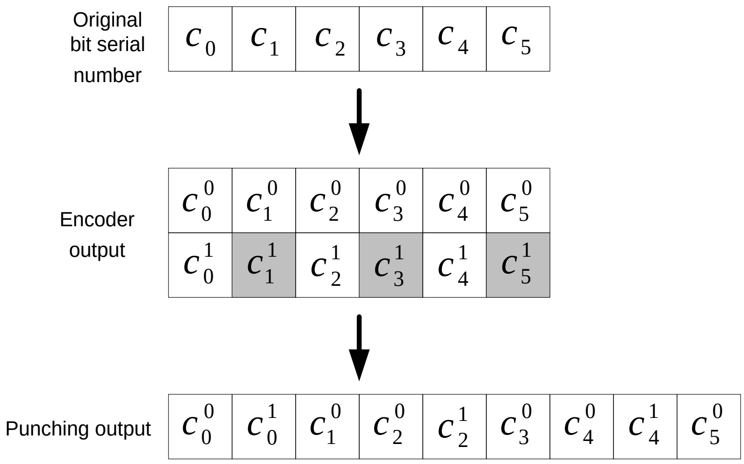


Figure 73 **2/3 Puncture Pattern**

d) 3/4 code rate

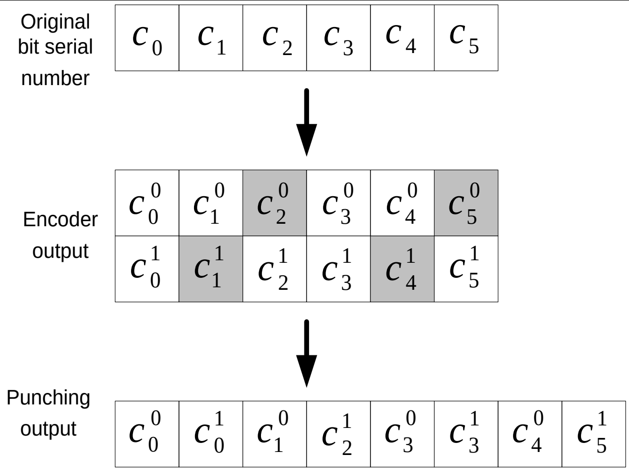


Figure 74 **3/4 Puncture Pattern**

e) 5/6 code rate

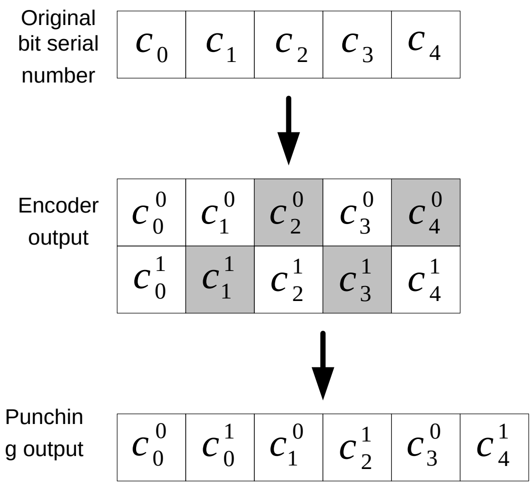


Figure 75 **5/6 Puncture Pattern**

f) 7/8 code rate

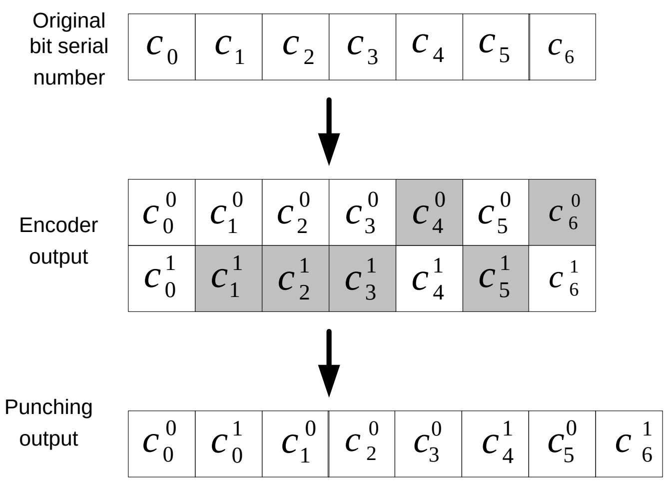


Figure 76 **7/8 Puncture Pattern**

The puncture output bits are $[\tilde{c}_0\ \tilde{c}_1\ \cdots\ \tilde{c}_{Len\_punc\_ini-1}][\tilde{c}_0\ \tilde{c}_1\ \cdots\ \tilde{c}_{\mathrm{Len\_punc\_ini\text{-}1}}]$.

If the channel is coded in the manner of LDPC, the above puncturing process is not required, $\tilde{c}_i = c_i, (i = 0,1 \ldots Len_{cw})$, where $Len_{cw} = Len\_punc\_ini$.

After convolutional coding or LDPC coding, padding bits will be added to make sure there are integer number of OFDM symbols. In low-error mode, padding bits will used to keep integer number of OFDM symbols after frequency repetition. The value of padding bits is implementation related.

8.2.5 Stream mapping

The coded bits are mapped to multiple streams as follows.

The coded bits are split into groups. The number of bits in each group (N_{cbpsc_total}) is the total number of bits in one subcarrier summing over all spatial streams. Coded bits in a group are round-robin mapped to spatial streams. If si[th] spatial stream is already allocated with $N_{cbpsc}(si)$ bits, si[th] spatial stream will be skipped, as illustrated in Figure 77. The mapping operation above is repeated group by group until all the coded bits are mapped.

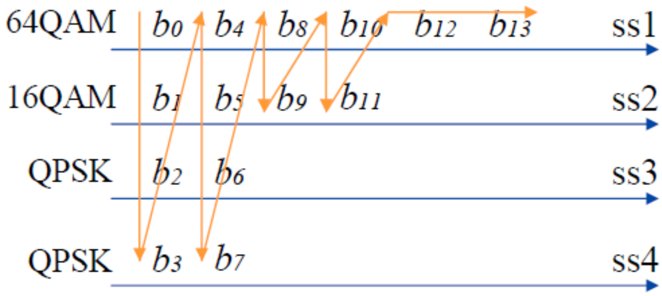


Figure 77 Example of stream mapping

When the spatial streams are transmitted in parallel, it is indicated in the control channel how each codeword is mapped to the spatial stream (see Table 56).

Code bits q_i^{si} mapped to each spatial stream perform the following cyclic shift within each OFDM symbol, see Equation 13,

$$r = \left[l + si \cdot N_{cbpsc}(si) \cdot 37\right] mod\left[N_{scpsym} \cdot N_{cbpsc}(si)\right]$$
$$l = 0,1,2,\cdots,N_{scpsym} \cdot N_{cbpsc}(si) - 1 \qquad \text{(Equation 13)}$$

After the cyclic shift, each spatial stream outputs a bit sequence $q_{r(l)}^{si}$ $l = 0,1,\cdots,N_{scpsym} \cdot N_{cbpsc}(si) - 1$ to the bit interleaver.

8.2.6 Bit interleaving

If the channel is coded in the manner of LDPC, bit interleaving processing is optional; if in the manner of convolutional code, the following bit interleaving process is employed. The interleaving depth of each spatial stream is shown in Equation 14

$$N_{cbpsym}(si) = N_{cbpsc}(si) \cdot N_{scpsym} \qquad \text{(Equation 14)}$$

The following two permutation processes were employed.

For the first permutation, see Equation 15:

$$i = \left(N_{cbpsym}(si)/16\right) \cdot mod(k,16) + \lfloor k/16 \rfloor \qquad i,k = 0,1,\cdots N_{cbpsym} - 1 \qquad \text{(Equation 15)}$$

For the second permutation, see Equation 16:

$$j = \tilde{Q}(si) \times \lfloor i/\tilde{Q}(si) \rfloor + mod\{[i + N_{cbpsym}(si) - \lfloor 16 \times i/N_{cbpsym}(si) \rfloor], \tilde{Q}(si)\}$$ (Equation 16)

In which,

$$\tilde{Q}(si) = max\left(\frac{N_{cbpsc}(si)}{2}, 1\right)$$

After the above interleaving process, each stream outputs a bit sequence as $[\tilde{q}_0^{si}\ \tilde{q}_1^{si}\ \cdots\ \tilde{q}_{Len\_cw(si)-1}^{si}]$.

The deinterleaving process is as follows. For the first permutation, see Equation 17 :

$$i = \tilde{Q}(si) \times \lfloor j/\tilde{Q}(si) \rfloor + mod\{[j + \lfloor 16 \times j/N_{cbpsym}(si) \rfloor], \tilde{Q}(si)\}$$ (Equation 17)

where $j = 0,1, \cdots N_{cbpsym} - 1$

For the second permutation, see Equation 18,

$$k = 16 \cdot i - (N_{cbpsym}(si) - 1) \times \lfloor 16 \times i/N_{cbpsym}(si) \rfloor$$ (Equation 18)

8.2.7 Constellation mapping

Each subcarrier can support BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM and 1024-QAM modulation. Each subcarrier modulation outputs symbol as shown in Equation 19.

$$d = (I + jQ) \times K_{MOD}$$ (Equation 19)

K_{MOD} is the normalized parameter for different modulation modes. See Table 44.

Table 44 **Normalized parameters of different modulation modes**

Modulation	K_{MOD}
BPSK	1
QPSK	$1/\sqrt{2}$
16-QAM	$1/\sqrt{10}$
64-QAM	$1/\sqrt{42}$
256-QAM	$1/\sqrt{170}$
1024-QAM	$1/\sqrt{682}$

The bit mapping relationship of different modulation modes is shown in the following tables.

Table 45 **BPSK constellation mapping**

Input bit (b_0)	Output of channel *I*	Output of channel *Q*
0	-1	0
1	1	0

Table 46 **QPSK constellation mapping**

Input bit (b_0)	Output of channel *I*	Input bit (b_1)	Output of channel *Q*
0	-1	0	-1
1	1	1	1

Table 47 **16 - QAM constellation mapping**

Input bit (b_0b_1)	Output of channel *I*	Input bit (b_2b_3)	Output of channel *Q*
00	-3	00	-3
01	-1	01	-1
11	1	11	1
10	3	10	3

Table 48 **64 - QAM constellation mapping**

Input bit ($b_0b_1b_2$)	Output of channel *I*	Input bit (b_3 b_4b_5)	Output of channel *Q*
000	-7	000	-7
001	-5	001	-5
011	-3	011	-3
010	-1	010	-1
110	1	110	1
111	3	111	3
101	5	101	5
100	7	100	7

Table 49 **256 - QAM constellation mapping**

Input bit ($b_0b_1b_2b_3$)	Output of channel *I*	Input bit ($b_4b_5b_6b_7$)	Output of channel *Q*
0000	-15	0000	-15
0001	-13	0001	-13
0011	-11	0011	-11
0010	-9	0010	-9
0110	-7	0110	-7
0111	-5	0111	-5
0101	-3	0101	-3
0100	-1	0100	-1
1100	1	1100	1
1101	3	1101	3
1111	5	1111	5
1110	7	1110	7
1010	9	1010	9
1011	11	1011	11
1001	13	1001	13
1000	15	1000	15

Table 50 **1024 - QAM constellation mapping**

Input bit ($b_0b_1b_2b_3b_4$)	Output of channel *I*	Input bit ($b_5b_6b_7b_8b_9$)	Output of channel Q
00000	-31	00000	-31
00001	-29	00001	-29
00011	-27	00011	-27
00010	-25	00010	-25
00110	-23	00110	-23
00111	-21	00111	-21
00101	-19	00101	-19
00100	-17	00100	-17
01100	-15	01100	-15
01101	-13	01101	-13
01111	-11	01111	-11
01110	-9	01110	-9
01010	-7	01010	-7
01011	-5	01011	-5
01001	-3	01001	-3
01000	-1	01000	-1
11000	1	11000	1
11001	3	11001	3
11011	5	11011	5
11010	7	11010	7
11110	9	11110	9
11111	11	11111	11
11101	13	11101	13
11100	15	11100	15
10100	17	10100	17
10101	19	10101	19
10111	21	10111	21
10110	23	10110	23
10010	25	10010	25
10011	27	10011	27
10001	29	10001	29
10000	31	10000	31

After the above modulation mapping, each spatial stream outputs a modulation symbol stream as $\left[d_0^{si}\ d_1^{si}\ \cdots\ d_{Len\_mod(si)-1}^{si}\right]$, see Equation 20 .

$$Len\_mod(si) = N_{sympss} \cdot N_{scpsym} \quad \text{(Equation 20)}$$

8.2.8 Space time coding

The system defined in this specification supports the space-time coding for one, two, three and four parallel modulation symbol streams, expanding the spatial streams to two, four, six and eight space time streams, so that the system obtains the transmit diversity gain. If the space-time coding is used in the transmission, b_{55} in Table 56 is set to 1, otherwise it is set to 0.

Modulation output symbol is $d_{k,i,n}; k = 0 \dots N_{scpsym} - 1; i = 0 \dots N_{ss} - 1; n = 0 \dots N_{sympss} - 1$, after encoded by STBC, outputs as $\tilde{d}_{k,i,n}; k = 0 \dots N_{scpsym} - 1; i = 0 \dots N_{sts} - 1; n = 0 \dots N_{sympss} - 1$. The mapping relationship between STBC output symbols and input symbols is shown in Table 51.

Table 51 **Space time coding**

N_{sts}	N_{ss}	i_{STS}	$\tilde{d}_{k,i,2m}$	$\tilde{d}_{k,i,2m+1}$
2	1	1	$d_{k,1,2m}$	$d_{k,1,2m+1}$
		2	$-d^*_{k,1,2m+1}$	$d^*_{k,1,2m}$
4	2	1	$d_{k,1,2m}$	$d_{k,1,2m+1}$
		2	$-d^*_{k,1,2m+1}$	$d^*_{k,1,2m}$
		3	$d_{k,2,2m}$	$d_{k,2,2m+1}$
		4	$-d^*_{k,2,2m+1}$	$d^*_{k,2,2m}$
6	3	1	$d_{k,1,2m}$	$d_{k,1,2m+1}$
		2	$-d^*_{k,1,2m+1}$	$d^*_{k,1,2m}$
		3	$d_{k,2,2m}$	$d_{k,2,2m+1}$
		4	$-d^*_{k,2,2m+1}$	$d^*_{k,2,2m}$
		5	$d_{k,3,2m}$	$d_{k,3,2m+1}$
		6	$-d^*_{k,3,2m+1}$	$d^*_{k,3,2m}$
8	4	1	$d_{k,1,2m}$	$d_{k,1,2m+1}$
		2	$-d^*_{k,1,2m+1}$	$d^*_{k,1,2m}$
		3	$d_{k,2,2m}$	$d_{k,2,2m+1}$
		4	$-d^*_{k,2,2m+1}$	$d^*_{k,2,2m}$
		5	$d_{k,3,2m}$	$d_{k,3,2m+1}$
		6	$-d^*_{k,3,2m+1}$	$d^*_{k,3,2m}$
		7	$d_{k,4,2m}$	$d_{k,4,2m+1}$
		8	$-d^*_{k,4,2m+1}$	$d^*_{k,4,2m}$

8.2.9 Insert pilot

The transmission symbols of the phase tracking pilots are repeated sequence of [1 0] with the sequence length equals to the number of phase tracking pilots. Then the repeated sequence are loaded into the phase tracking pilot subcarrier after BPSK modulation. Please refer to section 8.1.2 for detailed information about the number and subcarrier index of phase tracking pilot.

The demodulation reference signal (DRS) are inserted before precoding. The generation and pattern of DRS is described in sector 8.5.3.

8.2.10 Precoding

The optional precoding can be performed before time-frequency loading as descried in section 8.5.4.

8.2.11 Time-frequency loading

For the ti[th] antenna port, the transmitted symbol stream is $\left[\tilde{x}_0^{ti}\ \tilde{x}_1^{ti}\ \cdots\ \tilde{x}_{Len\_precode-1}^{ti}\right]$, see Equation 21.

$$Len\_precode = N_{sympss} + Len\_dp \quad \text{(Equation 21)}$$

Where: *Len-dp* is the number of the demodulation reference signal symbols. According to the demodulation reference signal pattern indicated by the scheduling signaling (see 8.5.3), the number of OFDM symbols occupied by the demodulation reference signal can be calculated.

The time-frequency loading sequence is shown in Figure 78. The frequency domain is loaded first and then the time domain.

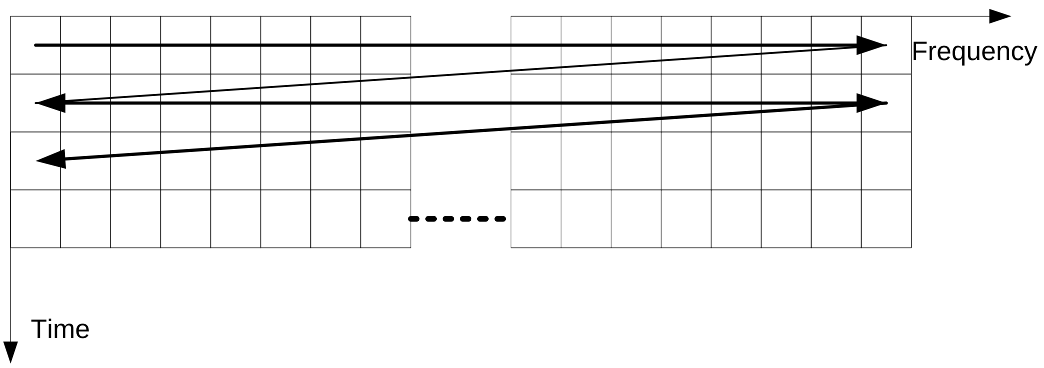


Figure 78 **Time-frequency loading sequence for precoding output symbols stream**

In low-error mode and mmWave mode, the repetition in frequency domain and time domain is used to increase reliability. The N times repetition in frequency domain divides valid subcarriers into N groups, and each group transmits the same modulation symbols, the number of modulation symbols transmitted in one group is P=Nsd/N, please refer to section 8.1 for definition of Nsd. Assume that input modulation symbols is $S_0S_1 \ldots S_T$, then the first group is $S_0S_1 \ldots S_{P-1}$, the second group is $S_PS_{P+1} \ldots S_{2P-1}$, and so on. The phase tracking pilots are not repeated in frequency domain repetition. The repetition in time domain repeats baseband OFDM symbols M times. Please refer to control channel in section 8.4.2 for repeat number N and M.

8.3 Preamble sequence

In normal mode, the Physical layer preamble sequence consists of short preamble sequence and long preamble sequence (also known as common reference signal, CRS), and each occupies one OFDM symbol, as shown in Figure 79.

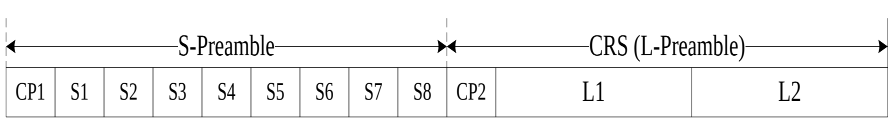


Figure 79 **Physical layer preamble sequence**

The preamble, system information channel and Transmission control channel use the same Subcarrier spacing. Traffic channel can use different Subcarrier spacing.

There are 3 different basic types for both short preamble and long preambles: P1, P2 and P3, which will occupy one basic bandwidth. The basic preambles can be duplicated with rotation factors in frequency domain to support higher bandwidth as shown in Table 52.

Table 52 **Preamble duplication in different Subcarrier spacing** and **bandwidth modes**

Subcarrier spacing (kHz)	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz	100 MHz
	Nsd	Nsd	Nsd	Nsd	Nsd	Nsd	Nsd	Nsd	Nsd	Nsd	Nsd
19.53125	224	448	672	896	1120	1344	1792	2240	N/A	N/A	N/A
Duplication number (Basic Preamble type)	1 (P1)	2 (P1)	3 (P1)	4 (P1)	5 (P1)	6 (P1)	8 (P1)	10 (P1)	N/A	N/A	N/A
39.0625	112	224	336	448	560	672	896	1120	1344	1792	2240
N (Basic Preamble Mode)	1 (P2)	1 (P1)	3 (P2)	2 (P1)	5 (P2)	3 (P1)	4 (P1)	5 (P1)	6 (P1)	8 (P1)	10 (P1)
78.125	56	112	168	224	280	336	448	560	672	896	1120
N (Basic Preamble Mode)	1 (P3)	2 (P2)	3 (P3)	1 (P1)	5 (P3)	3 (P2)	2 (P1)	5 (P2)	3 (P1)	4 (P1)	5 (P1)

The generation procedure of basic preamble is given below.

The basic short preamble sequence is generated by modulating elements of a length-N of Zadoff-Chu sequence.

The ZC sequences are generated according to the Equation 22,

$$Z(n) = e^{j\pi\frac{rn^2}{N}},\ \ n = 0,1,\dots N-1; \qquad \text{(Equation 22)}$$

Three different Zadoff-Chu sequences with different sequence root index values can be used for different short preamble ID.

Table 53 Parameters of Different Short Preamble Types

Parameters	Short Preamble type P1	Short Preamble type P2	Short Preamble type P3
Sequence length: N	28	14	6
ZC Root index r for different S-Preamble ID {1,2,3}	{27, 1, 26}	{13, 1, 12}	{5, 1, 4}
N_e	-112	-56	-24

The short preamble sequence is mapped to N frequency domain subcarriers by the following method.

The set of subcarriers to be filled is: $\{k_n | k_n = Ne + 8 \cdot m,\ m = 0,1,2 \cdots N\text{，}k_n \neq 0\ \}$

The CRS sequence(L-Preamble) occupies N subcarriers in the frequency domain. A pseudo-random sequence $\{C_n, \cdot n = 0, 1, ..., N-1\}$ with a length of N is BPSK-modulated and then according to the configuration of the current cell. The different value of N for 3 long preamble types is shown the table below.

Table 54 Parameters of Different Long Preamble Types

Parameters	Long Preamble type P1	Long Preamble type P2	Long Preamble type P3
Sequence length: N	114	58	28
N_e	-114	-58	-28

The BPSK-modulated sequence is mapped onto subcarriers by one of the following methods.

The set of subcarriers to be filled is: $\{\mathrm{Kn}\ |\mathrm{kn} = \mathrm{Ne} + 2 \bullet \mathrm{m}, \mathrm{m} = 0,1,2 \ldots\ \mathrm{N}, \mathrm{Kn} \neq 0\ \}$ or $\{\mathrm{Kn}\ |\mathrm{kn} = \mathrm{Ne} + 2 \bullet \mathrm{m} + 1, \mathrm{m} = 0,1,2 \ldots\ \mathrm{N} - 1, \mathrm{Kn} \neq 0\ \}$

. For the long preamble type P1, the BPSK-modulated sequence (LP) is {-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,-1,1,-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,-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,-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,-1,1,1,1,-1,-1,-1,1,-1,1,-1}

For the long preamble type P2, the BPSK-modulated sequence (LP) is {-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,-1,1,-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,-1,1,-1,1,1,-1}

For the long preamble type P3, the BPSK-modulated sequence (LP) is {-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,-1,1,-1}.

After the mapping to subcarriers, the long preamble transmitted from different CAP should add phase shift $\varphi_{i,k}$Equation 23,

$$\varphi_{i,k} = e^{-j\frac{2\pi k \delta^{i}}{N_{FFT}}} \qquad \text{(Equation 23)}$$

in which i is the index of different CAP, $\delta^{i} = \{0, \frac{N_{FFT}}{4}, \frac{N_{FFT}}{2}, N_{FFT} \times \frac{3}{4}\}$.

In Low-error mode, short preamble(S-Preamble) is 7 identical PN sequences and each PN sequence has 255 points. The 255-point PN sequence is:

S255={ 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,-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,-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,-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,-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,-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,-1,1,1,1,1,-1,1,1,1,-1,1,-1,-1,-1,1,-1,1,-1,-1,-1,-1,1,1,-1,-1,1,-1,-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,-1,1,-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,-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};

In Low-error mode, long preamble is 511-point PN sequence, and each 64 zeros before and after it. The 511-point PN sequence is:

S511={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,-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,-1,1,-1,1,1,1,-1,-1,1,-1,-1,1,1,-1,-1,-1,-1,-1,1,1,-1,-1,-1,-1,1,1,1,-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,-1,-1,1,1,-1,-1,-1,1,-1,1,1,1,-1,-1,-1,-1,-1,1,-1,-1,-1,-1,1,1,1,1,1,-1,-1,-1,1,-1,-1,-1,-1,-1,-1,1,1,1,1,-1,-1,-1,-1,1,-1,-1,-1,1,1,1,1,-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,-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,-1,-1,-1,-1,1,1,-1,1,1,-1,1,-1,-1,-1,1,1,1,-1,-1,-1,1,1,1,1,1,1,1,-1,-1,-1,1,-1,-1,-1,1,-1,1,1,-1,-1,-1,-1,1,-1,1,-1,1,1,-1,1,-1,1,1,1,1,1,1,-1,1,-1,1,-1,1,1,-1,1,-1,-1,-1,-1,-1,1,-1,1,-1,-1,1,-1,1,1,1,1,1,-1,-1,1,-1,-1,-1,1,-1,-1,1,-1,-1,1,-1,1,-1,-1,1,1,1,1,1,-1,1,-1,1,-1,-1,1,-1,-1,-1,-1,-1,1,1,1,1,-1,-1,-1,-1,1,1,1,-1,-1,1,-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,-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,-1,1,1,1,-1,-1,1,1,1,1,1,1,1,1,-1,-1,1,1,1,-1,-1,1,1,1,-1,1,1,-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,-1,1,1,-1,-1,1,-1,-1,-1,-1,-1,-1,1,1,-1,1,-1,-1,1,1,-1,1,-1,1,1,1,1,-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,-1,1,1,1,1,-1,-1,1,-1,1,-1,1,-1,1,1,1,-1,-1,-1,1,1,-1,1,1,1,1,-1,-1,1,1,1,-1,1,1,1,1,-1}

In Low-error mode, the short preamble and long preamble should be filtered to meet the requirements of frequency mask.

In mmWave mode, the Physical layer preamble sequence consists of short preamble sequence and CRS sequence and occupies two OFDM symbols.

For 50MHz and 100MHz bandwidth, the preamble generation procedure is given as follows. For 200MHz/400MHz bandwidth, the short preamble and CRS shall be duplicated with rotation factors in frequency domain in the unit of 100MHz.

For 50MHz bandwidth, the short preamble sequence occupies 14 subcarriers in the frequency domain. These sub carriers are modulated by elements consisting of the sequence Z(n),

$$Z(n) = e^{j\pi\frac{rn^2}{N}}, n = 0,1,\ldots 13; r = 13; N = 14 \quad \text{(Equation 24)}$$

The set of sub carriers to be filled is:$\{k_n | k_n = -56 + 8 * m, m = 0,1,2\ldots 14, m \neq 7\}$

For 100MHz bandwidth, the short preamble sequence occupies 28 sub carriers in the frequency domain. These sub carriers are modulated by elements consisting of the sequence Z(n), see Equation 24,.

The set of subcarriers to be filled is:$\{k_n | k_n = -112 + 8 * m, m = 0,1,2\ldots 28, m \neq 14\}$

For 50MHz bandwidth, the long preamble sequence occupies 58 sub carriers in the frequency domain. A pseudo-random sequence {C_n,·n = 0, 1, ..., 57} with a length of 58 is BPSK-modulated and mapped onto subcarriers by the following method.

The set of subcarriers to be filled is: $\{k_n | k_n = -58 + 2 * m, m = 0,1,2\ldots 58, m \neq 29\}$

After mapping by the above method, the symbols loaded by subcarriers -115~+115 are:

$L_{-58,58}$={0, -1, 0, -1, 0, 1, 0.1, 0, 1, 0, -1, 0.1, 0, 1,0, -1,0, -1,0, 1, 0, -1, 0, 1, 0,1, 0, -1,0,-1-0,-1, 0,1,0,1,0,-1, 0, 1,0,-1, 0,-1,-0,-1, 0,-1,0,-1, 0, 1,0,-1, 0, 1, 0,-1, 0, 0, 0,1, 0,-1,0,1, 0, -1, 0, 1, 0, 1, 0, -1, 0, -1, 0, -1, 0, 1, 0, -1, 0, 1, 0,1, 0,1, 0, -1,0, 1, 0,1, 0, -1, 0, 1, 0, 1, 0, 1, 0,-1, 0,-1, 0, 1.0,-1, 0, 1, 0, 1, 0,1,0, -1,0}

For 100MHz bandwidth, the long preamble sequence occupies 114 sub carriers in the frequency domain. A pseudo-random sequence {C_n,·n = 0, 1, ..., 113} with a length of 114 is BPSK-modulated and mapped onto subcarriers by the following method.

The set of subcarriers to be filled is:$\{k_n | k_n = -114 + 2 * m, m = 0,1,2\ldots 114, m \neq 57\}$

After mapping by the above method, the symbols loaded by subcarriers -115~+115 are:

$L_{-115,115}$={0, -1, 0, -1, 0, 1, 0.1, 0, 1, 0, -1, 0.1, 0, 1,0, -1,0, -1,0, 1, 0, -1, 0, 1, 0,1, 0, -1,0,-1-0,-1, 0,1,0,1,0,-1, 0, 1,0,-1, 0,-1-0,-1, 0,-1,0,-1, 0, 1,0,-1, 0, 1, 0,-1, 0, 1, 0,-1,0,1, 0, -1, 0, 1, 0, 1, 0, -1, 0, -1, 0, -1, 0, 1, 0, -1, 0, 1, 0,1, 0,1, 0, -1,0, 1, 0,1, 0, -1, 0, 1, 0, 1, 0, 1, 0,-1, 0,-1, 0, 1.0,-1, 0, 1, 0, 1, 0,0,0,-1, 0, 1, 0, 1, 0, 1, 0,-1, 0,-1, 0,-1, 0, 1, 0,-1, 0,-1, 0, 1, 0,-1, 0, 1, 0, 1, 0,-1, 0, 1, 0,-1.0,-1, 0,-1, 0, 1, 0,-1, 0,-1, 0, 1, 0,-1, 0, 1, 0, 1.0, 1, 0, 1, 0, 1, 0,-1, 0, 1, 0, 1, 0, -1, 0, -1, 0, 1, 0, 1, 0, -1, 0, 1, 0, 1, 0,-1, 0, 1, 0,-1, 0, 1, 0,-1, 0,-1, 0,-1, 0,-,0, 1, 0, 1, 0, 1, 0,-1, 0,-1, 0,-1, 0, 1, 0,-1, 0,1, 0,-1,0}

8.4 System information channel and control channel

8.4.1 System information channel field definition

In normal mode and mmWave mode, the system information channel transmits using MCS0 with normal CP. Convolutional coding is applied for system information channel. The SICH is repeated with frequency repetition number is 2 and time repetition number is 4 in mmWave mode. The system information field is defined in Table 55.

Table 55 **System Information field definition**

Bit	Definition	Notes
$b_7 b_6 \cdots b_0$	The lowest 8 bits of this CAP MAC address	CAP identifier and scrambling code seed

$b_{10}b_9b_8$	CAP Working bandwidth set	For sub-6GHz band: 000: 5/10/20M working bandwidth mode 001: 10/20/40M working bandwidth mode 010: 15/30/60M working bandwidth mode 011: 20/40/80M working bandwidth mode 100: 25/50/100M working bandwidth mode For mmWave mode, 000: 50M working bandwidth mode 001: 100M working bandwidth mode 010: 200M working bandwidth mode 011: 400M working bandwidth mode Others: reserved
$b_{12}b_{11}$	Subcarrier spacing indication for TCH in normal mode	00: 19.53125KHz 01: 39.0625KHz 10: 78.125KHz 11: reserved
$b_{19}\cdots b_{13}$	Reserved	Reserved
b_{20}	Cyclic Prefix Type for CCH and TCH	0: Normal CP; 1: Short CP
$b_{23}b_{22}\cdots b_{21}$	CAP antenna configuration	000:1 antenna; 001:2 antennas; … 111: 8 antennas;
$b_{29}b_{28}\cdots b_{24}$	Control channel length indication	Control channel length, ≤63 OFDM symbols.
b_{30}	DRS Mode in MU-MIMO	0, DRS for different STAs are allocated to different OFDM symbols 1, DRS for different STAs are allocated to the same OFDM symbols
b_{31}	Interleaving with LDPC	0: No bit interleaving if LDPC is used 1: Bit interleaving if LDPC is used
$b_{42}b_{39}\cdots b_{32}$	Downlink traffic channel length indication	Number of OFDM symbols in downlink traffic channel For normal mode, $b_{40}b_{39}\cdots b_{32}$ is used For mmWave mode, $b_{42}b_{39}\cdots b_{32}$ is used.
$b_{45}b_{44}b_{43}$	Reserved	Reserved
$b_{56}b_{55}\cdots b_{46}$	Uplink traffic channel length indication	Number of OFDM symbols in uplink traffic channel For normal mode, $b_{53}b_{39}\cdots b_{46}$ is used For mmWave mode, $b_{56}b_{39}\cdots b_{46}$ is used.

$b_{63}b_{62}\cdots b_{57}$	Indication of DGI and UGI configuration in long distance ranging	b_{63}=1, ranging mode b_{63}=0, non-ranging mode $b_{62}\ldots b_{57}$: OFDM symbol number of UGI in non-ranging mode(b63=0), and DGI in both ranging mode and non-ranging mode.
b_{64}	Downlink sounding channel configuration	0: No downlink sounding channel
		1: With downlink sounding channel, the parameters of sounding signal is shown in Annex C.
$b_{66}b_{65}$	Reserved	Reserved
b_{67}	Uplink sounding channel configuration	0: No uplink sounding channel; 1: With downlink sounding channel, the parameters of sounding signal is shown in Annex C.
b_{68}	Reserved	Reserved
$b_{70}b_{69}$	Uplink scheduling request channel	00: No scheduling request channel
		01: Scheduling request channel is configured with 1 OFDM symbol;
		10: Scheduling request channel is configured with 2 OFDM symbols;
		11: Scheduling request channel is configured with 4 OFDM symbols;
b_{71}	Uplink random access channel configuration	0: No uplink random access channel;
		1: With uplink random access channel
b_{72}	Indication of RACH and ranging	b72=0，RACH b72=1，ranging
$b_{75}b_{74}b_{73}$	Reserved	Reserved
$b_{87}b_{86}\cdots b_{76}$	Frame number	0~4095, frame number counter
$b_{103}b_{102}\cdots b_{88}$	16-bit CRC	CRC protection
$b_{111}b_{110}\cdots b_{104}$	Convolutional encoder zero bit	Return the end state of the convolutional code to zero
Note: The system information channel adopts the 16-bit CRC, and the CRC generator polynomial is $g(D)=D^{16}+D^{12}+D^{5}+1$. The initial state of the register is 0xFF, and the register state is inverted as the CRC sequence output after the end of the operation. The high-order register output corresponds to the high bit (b_{103}) and the low-order register output corresponds to the low bit (b_{88}).		

In low-error mode, the function of system information channel is integrated into the control channel to reduce the overhead.

.

8.4.2 Control channel field

In normal mode, the control channel transmits in MCS101. LDPC coding is applied for control channel. The control channel consists of multiple unicast and broadcast scheduling signaling. The uplink and downlink unicast scheduling signaling field is shown in Table 56.

Table 56 **Definition of control channel field**

<table>
<tr><th rowspan="2">Bit</th><th colspan="2">Definition</th></tr>
<tr><th>DL</th><th>UL</th></tr>
<tr><td>b_0</td><td colspan="2">b_0=1, downlink scheduling;
b_0=0, uplink scheduling</td></tr>
<tr><td>b_1</td><td colspan="2">b_1=0, SU-MIMO transmission;
b_1=1, MU-MIMO transmission</td></tr>
<tr><td>b_5 b_4... b_2</td><td colspan="2">[$b_5b_4...b_2$], Bit Map indicates the effective subchannel position of the scheduling signaling (refer to section 8.11.2.4), the bandwidth of each subchannel is working bandwidth 1 in the working bandwidth set.</td></tr>
<tr><td>b_6</td><td colspan="2">Indicates the current transmission mode:
0: Open loop transmission;
1: Closed loop transmission (dedicated demodulation reference signal mode);</td></tr>
<tr><td>b_7</td><td colspan="2">Bit Map indicates the index of resource unit (RU) in OFDMA mode with $b_{68}\ b_{67} \cdots b_{56}$ together. Each bit indicates the corresponding index RU is occupied. ($b_{68}\ b_{67} \cdots b_{56} b_7$)</td></tr>
<tr><td>b_{16} b_{15}... b_8</td><td colspan="2">User resource group starting OFDM symbol index, field value: 0~510</td></tr>
<tr><td>b_{23} b_{22}... b_{17}</td><td colspan="2">MCS of codeword I indication (see Annex B)</td></tr>
<tr><td>b_{32} b_{31}... b_{24}</td><td colspan="2">Number of consecutive OFDM symbols in the user resource group, field value: 1 to 511</td></tr>
<tr><td>b_{39} b_{38}... b_{33}</td><td>MCS of codeword II and number of parallel spatial streams indication: 1111111, this transmission uses only one codeword
1111110, this transmission is a 2-stream MU-MIMO;
1111101, this transmission is a 3-stream MU-MIMO;
1111100, this transmission is 4-stream MU-MIMO;
1111011, this transmission is 5-stream MU-MIMO;
1111010, this transmission is 6-stream MU-MIMO;
1111001, this transmission is 7-stream MU-MIMO;
1111000, this transmission is 8-stream MU-MIMO;
0000000~1100011, MCS of SU-MIMO codeword II and number of streams (see Annex B)</td><td>When$b_{42}b_{41} \neq 11$,
b_{36}... b_{33}, Bitmap indicates CQI or CSI,
feedback subchannel
$b_{39}\ b_{38}b_{37}$When$b_{42}b_{41} = 11$, indicates
the MCS of codeword II
1111111, this transmission uses only one codeword
0000000~1100011, MCS and number of streams for SU-MIMO codeword II (see Annex B).</td></tr>
<tr><td>b_{42} $b_{41}b_{40}$</td><td>SU-MIMO: 000;
MU-MIMO: spatial stream starting position index, field value 0~7</td><td>b_{40}=1, request CQI feedback
$b_{42}b_{41}$=01, request CSI feedback;
$b_{42}b_{41}$=11, MCS of codeword II is indicated by b_{39} b_{38}... b_{33}</td></tr>
<tr><td>$b_{44}b_{43}$</td><td colspan="2">00: BCC code;</td></tr>
</table>

<table>
<tr><td></td><td colspan="2">01: LDPC code length is 1 (determined by capability response frame);
10: LDPC code length is 2 (determined by capability response frame);
11: LDPC code length is 3 (determined by capability response frame)</td></tr>
<tr><td>b_{45}</td><td colspan="2">0: Time domain demodulation reference signal interval 0 (short demodulation reference signal interval, see Table 3);
1: Time domain demodulation reference signal interval 1 (long demodulation reference signal interval, see Table 3)</td></tr>
<tr><td>$b_{47}b_{46}$</td><td colspan="2">00: frequency domain demodulation reference signal interval pattern 1 (DPI = 1);
01: frequency domain demodulation reference signal interval pattern 2 (DPI = 2);
10: frequency domain demodulation reference signal interval pattern 3 (DPI = 4);
11: Reserved</td></tr>
<tr><td rowspan="2">b_{54} b_{53}... b_{48}</td><td colspan="2">$b_1 = 0$, SU-MIMO transmission,
b_{48}=0, $b_{54} \cdots b_{49}$indicates the resources used for signaling and feedback transmission in the user resource group, the field value is 0~63;
b_{48}=1, $b_{54} \cdots b_{49}$reserved</td></tr>
<tr><td>$b_1 = 1$, downlink MU-MIMO transmission, b54…b48, reserved</td><td>$b_1 = 1$, total number of uplink MU-MIMO streams and spatial stream starting position index
b54..b52,
001, this transmission includes a 2-stream MU-MIMO;
010, this transmission includes a 3-stream MU-MIMO;
011, this transmission includes a 4-stream MU-MIMO;
100, this transmission includes a 5-stream MU-MIMO;
101, this transmission includes a 6-stream MU-MIMO;
110, this transmission includes a 7-stream MU-MIMO;
111, this transmission includes a 8-stream MU-MIMO;
b51..b49,
Spatial stream starting position index, field value 0~7.</td></tr>
<tr><td>b_{55}</td><td colspan="2">Format 0 (capability negotiation decision, STBC mode):
0, STBC transmission not adopted;
1, STBC transmission adopted.
Format 1 (capability negotiation decision, Precoding mode):
0, precoding group size = 8(SU-MIMO), 1(MU-MIMO)
1, precoding group size = 16(SU-MIMO), 4(MU-MIMO)</td></tr>
<tr><td>b_{68} b_{67}... b_{56}</td><td colspan="2">Bit Map indicates the index of resource unit (RU) in OFDMA mode with b_7 together. Each bit indicates the corresponding index RU is occupied.
(b_{68} $b_{67} \cdots b_{56} b_7$)</td></tr>
<tr><td>b_{84} b_{83}... b_{69}</td><td colspan="2">CRC protection and STA ID identification</td></tr>
</table>

Note 1: b_{84} b_{83}... b_{69} is the CRC of the unicast scheduling signaling field and the unique 12-bit ID of the cell allocated by the CAP. $[b_{84}\ b_{83}\ldots b_{69}]$ =XOR($[0000d_{11}d_{10}\ldots d_0]_{STAID}$, $[c_{15}c_{14}\ldots c_0]_{CRC}$)   Note 2: The control channel is checked by a 16-bit CRC. The CRC generator polynomial is g(D) = D^{16} + D^{12}+ D^5+1. Definition is the same as that in Table 55.   Note 3: The signaling and feedback transmission formats indicated by b_{54}...b_{49} are given in 8.5.6.

In low-error mode, the control channel field is defined in the table below. The CCH transmission uses MCS1. Convolutional coding is applied for control channel with frequency repetition number is 4 and time repetition number is 3.

Table 57 **Control field definition in low-error mode**

Bit	Definition	Notes
$b_3b_2\cdots b_0$	The lowest 4 bits of this CAP MAC address	$[0\ 0\ 0\ b_3b_2\cdots b_0]$ is used for CAP identifier and scrambling code seed
b_5 b_4	Frame length	00: 0.5ms 01: 1ms 10: 2ms 11: 4ms
$b_8b_7b_6$	DL ratio ： UL ratio	000: 1:1 001: 2:1 010: 4:1 011: 8:1 100: 1:2 101: 1:4 110: 1:8 111: reserved
b_9	DL MCS	0: QPSK, 1/2 coding rate 1: QPSK, 4/7 coding rate
b_{10}	UL MCS	0: QPSK, 1/2 coding rate 1: QPSK, 4/7 coding rate
b_{11}	DL Coding type	0: TBCC code; 1: LDPC with codeword size is 448
b_{12}	UL Coding type	0: TBCC code; 1: LDPC with codeword size is 448
$b_{14}b_{13}$	DL Repetition number in frequency domain(N)	b_5=0 (non-OFDMA mode, support frequency domain repetition), 00: 1 01: 2 10: 4 11: 8 b_5=1 (OFDMA mode, frequency domain repetition is fixed to be 1), $[b_{18}b_{17}b_{14}b_{13}]$, Bit Map indicate the index of resource unit (RU) in OFDMA mode

		0000 ~ 1101: RU #1 ~ RU #14 1110: reserved 1111: the whole bandwidth is occupied
$b_{16}b_{15}$	DL Repetition number in time domain(M)	00: 1 01: 2 10: 3 11: 4
$b_{18}b_{17}$	UL Repetition number in frequency domain(N)	b_5=0 (non-OFDMA mode, support frequency domain repetition), 00: 1 01: 2 10: 4 11: 8 b_5=1 (OFDMA mode, frequency domain repetition is fixed to be 1), [$b_{18}b_{17}b_{14}b_{13}$], Bit Map indicate the index of resource unit (RU) in OFDMA mode 0000 ~ 1101: RU #1 ~ RU #14 1110: reserved 1111: the whole bandwidth is occupied
$b_{20}b_{19}$	UL Repetition number in time domain(M)	00: 1 01: 2 10: 3 11: 4
$b_{26}b_{22}\cdots b_{21}$	Frame number	0~63, frame number counter
$b_{28}b_{27}$	Uplink scheduling request channel	00: No uplink scheduling request channel;
		01: Scheduling request channel is configured with 1 OFDM symbol;
		10: Scheduling request channel is configured with 2 OFDM symbols;
		11: Scheduling request channel is configured with 4 OFDM symbols;
b_{29}	Uplink random access channel configuration	0: No uplink random access channel;
		1: With downlink sounding channel, the parameters of sounding signal is shown in Annex C.
b_{30}	Indication of RACH and ranging	0，RACH 1，ranging
b_{31}	Indication of OFDMA mode	0: non-OFDMA mode 1: OFDMA mode
$b_{55}b_{54}\cdots b_{32}$	24-bit CRC	CRC protection

Note 1: $b_{55}b_{54}..b_{32}$ is the CRC of the unicast scheduling signaling field and the unique 12-bit ID of the cell allocated by the CAP.

$$[b_{55}\ b_{54}\ \cdots\ b_{32}] = [0\ 0\ 0\ 0\ d_{11}\ d_{10}\ \cdots\ d_0]_{STAID} \oplus [c_{23}\ c_{22}\ \cdots\ c_0]_{CRC}$$

Note 2: The control channel is checked by a 24-bit CRC. The CRC generator polynomial is $g(D) = D^{24} + D^{23} + D^{18} + D^{17} + D^{14} + D^{11} + D^{10} + D^{7} + D^{6} + D^{5} + D^{4} + D^{3} + D + 1$. Definition is the same as that in Table 55. Note 3: The DL/UL symbol number with different DL/UL ratio is calculated as follows: DLTCH_symbol_number = floor(N*DL_Ratio/(DL_Ratio+UL_Ratio)) ULTCH_symbol_number = N - DLTCH_symbol_number For non-OFDMA mode: 0.5/1/2/4ms frame, N=12/43/106/231; For OFDMA mode: 0.5/1/2/4ms frame, N=8/39/102/227;

In mmWave mode, the control channel transmits in MCS101. LDPC coding is applied for control channel with frequency repetition number is 4 and time repetition number is 4. The field of CCH is shown in Table 58.

Table 58 Definition of control channel field in mmWave mode

Bit	Definition	
	DL	UL
b_0	b_0=1, downlink scheduling; b_0=0, uplink scheduling	
b_1	b_1=0, SU-MIMO transmission; b_1=1, MU-MIMO transmission	
b_5 b_4... b_2	[$b_5 b_4 ... b_2$], Bit Map indicates the effective subchannel position of the scheduling signaling (refer to section 8.11.2.4), the bandwidth of each subchannel is working bandwidth 1 in the working bandwidth set.	
b_6	Indicates the current transmission mode: 0: Open loop transmission; 1: Closed loop transmission (dedicated demodulation reference signal mode);	
b_7	Bit Map indicates the index of resource unit (RU) in OFDMA mode with $b_{68}\ b_{67} \cdots b_{56}$together. Each bit indicates the corresponding index RU is occupied. $(b_{68}\ b_{67} \cdots b_{56} b_7)$	
b_{18} ... b_8	User resource group starting OFDM symbol index, field value: 0~2046	
b_{20}... b_{19}	Repetition number in time domain 00: 1 01: 2 10: 3 11: 4	
b_{22}... b_{21}	Repetition number frequency domain 00: 1 01: 2 10: 4 11: 8	
b_{25}... b_{23}	reserved	
b_{32} ... b_{26}	MCS of codeword I indication (see Annex B)	
b_{39} b_{38}... b_{33}	MCS of codeword II and number of parallel spatial streams indication: 1111111, this	When$b_{42} b_{41} \neq 11$,

<table>
<tr><td></td><td>transmission uses only one codeword
1111110, this transmission is a 2-stream MU-MIMO;
1111101, this transmission is a 3-stream MU-MIMO;
1111100, this transmission is 4-stream MU-MIMO;
1111011, this transmission is 5-stream MU-MIMO;
1111010, this transmission is 6-stream MU-MIMO;
1111001, this transmission is 7-stream MU-MIMO;
1111000, this transmission is 8-stream MU-MIMO;
0000000~1100011, MCS of SU-MIMO codeword II and number of streams (see Annex C)</td><td>b_{36}... b_{33}, Bitmap indicates CQI or CSI, feedback subchannel
$b_{39}\ b_{38}b_{37}$ When $b_{42}b_{41} = 11$, indicates the MCS of codeword II
1111111, this transmission uses only one codeword
0000000~1100011, MCS and number of streams for SU-MIMO codeword II (see Annex C).</td></tr>
<tr><td>$b_{42}\ b_{41}b_{40}$</td><td>SU-MIMO: 000;
MU-MIMO: spatial stream starting position index, field value 0~7</td><td>b_{40}=1, request CQI feedback
$b_{42}b_{41}$=01, request CSI feedback;
$b_{42}b_{41}$=11, MCS of codeword II is indicated by $b_{39}\ b_{38}$... b_{33}</td></tr>
<tr><td>$b_{44}b_{43}$</td><td colspan="2">00: BCC code;
01: LDPC code length is 1 (determined by capability response frame);
10: LDPC code length is 2 (determined by capability response frame);
11: LDPC code length is 3 (determined by capability response frame)</td></tr>
<tr><td>b_{45}</td><td colspan="2">0: Time domain demodulation reference signal interval 0 (short demodulation reference signal interval, see Table 3);
1: Time domain demodulation reference signal interval 1 (long demodulation reference signal interval, see Table 3)</td></tr>
<tr><td>$b_{47}b_{46}$</td><td colspan="2">00: frequency domain demodulation reference signal interval pattern 1 (DPI = 1);
01: frequency domain demodulation reference signal interval pattern 2 (DPI = 2);
10: frequency domain demodulation reference signal interval pattern 3 (DPI = 4);
11: Reserved</td></tr>
<tr><td rowspan="2">$b_{54}\ b_{53}$... b_{48}</td><td colspan="2">$b_1 = 0$, SU-MIMO transmission,
b_{48}=0, $b_{54} \cdots b_{49}$ indicates the resources used for signaling and feedback transmission in the user resource group, the field value is 0~63;
b_{48}=1, $b_{54} \cdots b_{49}$ reserved</td></tr>
<tr><td>$b_1 = 1$, downlink MU-MIMO transmission,
b_{54}…b_{48}, reserved</td><td>$b_1 = 1$, total number of uplink MU-MIMO streams and spatial stream starting position index
b54..b52,
001, this transmission includes a 2-stream MU-MIMO;
010, this transmission includes a 3-stream MU-MIMO;
011, this transmission includes a 4-stream MU-MIMO;
100, this transmission includes a 5-stream</td></tr>
</table>

		MU-MIMO; 101, this transmission includes a 6-stream MU-MIMO; 110, this transmission includes a 7-stream MU-MIMO; 111, this transmission includes a 8-stream MU-MIMO; b51..b49, Spatial stream starting position index, field value 0~7.
b_{55}	Format 0 (capability negotiation decision, STBC mode): 0, STBC transmission not adopted; 1, STBC transmission adopted. Format 1 (capability negotiation decision, Precoding mode): 0, precoding group size = 8(SU-MIMO), 1(MU-MIMO) 1, precoding group size = 16(SU-MIMO), 4(MU-MIMO)	
b_{68} b_{67}... b_{56}	Bit Map indicates the index of resource unit (RU) in OFDMA mode with b_7 together. Each bit indicates the corresponding index RU is occupied. ($b_{68}\ b_{67}\cdots b_{56}b_7$)	
B_{72} $b_{71}b_{70}$ b_{69} B_{76} $b_{75}b_{74}$ b_{73} B_{80} $b_{79}b_{78}$ b_{77} B_{84} $b_{83}b_{82}$ b_{81} B_{88} $b_{87}b_{86}$ b_{85} B_{92} $b_{91}b_{90}$ b_{89} B_{96} $b_{95}b_{94}$ b_{93} B_{100} $b_{99}b_{98}$ b_{97}	For each tx antenna, there are N TRN units and each TRN unit contains M TRN sequences. The M TRN sequences in one TRN unit are transmitted with the same direction. The different TRN units can be transmitted with different direction. 0000: M=1, N=4 0001: M=1, N=16 0010: M=1, N=32 0011: M=1, N=64 0100: M=4, N=1 0101: M=4, N=4 0110: M=4, N=8 0111: M=4, N=16 1000: M=16, N=1 1001: M=16, N=2 1010: M=16, N=4 1011: M=32, N=1 1100: M=32, N=2 1101: M=64, N=1 B_{72} $b_{71}b_{70}$ b_{69} is set for tx antenna1 B_{76} $b_{75}b_{74}$ b_{73} is set for tx antenna2 B_{80} $b_{79}b_{78}$ b_{77} is set for tx antenna3 B_{84} $b_{83}b_{82}$ b_{81} is set for tx antenna4 B_{88} $b_{87}b_{86}$ b_{85} is set for tx antenna5 B_{92} $b_{91}b_{90}$ b_{89} is set for tx antenna6 B_{96} $b_{95}b_{94}$ b_{93} is set for tx antenna7 B_{100} $b_{99}b_{98}$ b_{97} is set for tx antenn8	
b_{111}... b_{101}	Number of consecutive OFDM symbols in the user resource group, field value: 1 to	

	2047
$b_{127}\ldots b_{112}$	CRC protection and STA ID identification

Note 1: $b_{116}\, b_{115}\ldots b_{101}$ is the CRC of the unicast scheduling signaling field and the unique 12-bit ID of the cell allocated by the CAP.

$$[b_{116}\, b_{115}\ldots b_{101}] = XOR([0000 d_{11} d_{10}\ldots d_0]_{STAID}, \quad [c_{15} c_{14}\ldots c_0]_{CRC})$$

Note 2: The control channel is checked by a 16-bit CRC. The CRC generator polynomial is $g(D) = D^{16} + D^{12} + D^5 + 1$. Definition is the same as that in Table 55.

Note 3: The signaling and feedback transmission formats indicated by $b_{54}\ldots b_{49}$ are given in 8.5.6.

8.5 Downlink/Uplink traffic channel

8.5.1 Resource allocation type of Downlink/Uplink traffic channel

8.5.1.1 General

In the downlink/uplink traffic channel, this specification supports TDMA and OFDMA resource multiplexing scheduling. The time-frequency resources allocated to each STA in the uplink or downlink traffic channel are called resource groups.

8.5.1.2 Time division multiplexing resource allocation

In the case of time division multiplexing, the OFDM symbol index in the STA resource group is from 0 to $D(b_{32}b_{31}\ldots b_{24})$-1,where $D(b_{32}b_{31}\ldots b_{24})$ represents the decimal number corresponding to the bits $b_{32}b_{31}\ldots b_{24}$.

8.5.1.3 OFDMA resource allocation

In OFDMA mode, the unit of resource allocation is one resource unit (RU). One RU is composed by 16 subcarriers. The RUs in OFDM symbols is consecutive and non-overlapped.

8.5.2 Resource indication of Downlink/Uplink traffic channel

8.5.2.1 Indication of time division multiplexing resource allocation

In STA scheduling signaling (see Table 56), use [$b_{16}, b_{15}\ldots b_8$] to indicate the STA resource group starting OFDM symbol index, possible value is 0~510; use [$b_{32}b_{31}\ldots b_{24}$] to indicate the number of the continuous OFDM symbols occupied by the STA resource group.

The resource group allocated for the STA includes the resources occupied by the demodulation reference signal.

8.5.2.2 Indication of OFDMA resource allocation

The indication of OFDMA resource allocation is indicated in control channel (see Table 56).

8.5.3 Traffic channel demodulation reference signal

8.5.3.1 General

This specification can dynamically adjust the demodulation reference signal (DRS) pattern in normal and mmWave mode. Different time domain interval of DRS can be configured through the Control Channel field b_{45}; different frequency domain interval of DRS can be configured through the Control Channel field $b_{47}b_{46}$.

If b_6 in Control Channel field is 1, the demodulation reference signal can be precoded (i.e. dedicated demodulation reference signal); if b_6 in Control Channel field is 0, demodulation reference signal cannot be precoded (i.e. common demodulation reference signal).

In low-error mode without OFDMA (see Table 57), there is no downlink DRS and CRS is used for both CCH and DL-TCH channel estimation. The uplink DRS shall be used for channel estimation in uplink TCH. The uplink DRS shall be generated in the same way as the CRS.

In low-error mode with OFDMA (see Table 57), there are both downlink DRS and uplink DRS. The frequency domain interval DPI_F of both downlink and uplink DRS is fixed to be 1. The frequency domain repetition number of both downlink and uplink DRS is fixed to be 1. The time domain repetition number of both downlink and uplink DRS is the one-fourth of the time domain repetition number of uplink and downlink TCH, respectively.

8.5.3.2 Demodulation reference signal pattern

See Annex A for the demodulation reference signal pattern.

8.5.3.3 Demodulation reference signal interval

Different time domain intervals of DRS can be configured by control channel scheduling signaling b_{45} (see Table 56) to adapt to different radio propagation environments. Time domain pilot interval configuration, DPI_T, is to insert a set of demodulation reference signal in every DPI_T OFDM symbols. If b_{45}=0, it is a short DPI_T, and if b_{45}=1, it is a long DPI_T. The values of long and short DPI_T are indicated in the MAC layer BCF frame.

8.5.3.4 Demodulation reference signal sequence

The generator polynomial of the pilot sequence is $1+X^{11}+X^{15}$. The structure of the linear feedback shift register with the maximum length is as shown in Figure 69. The generated sequence is BPSK-modulated to obtain the pilot symbol sequence {Si} i = 0, 1, ..., 32767. Initial state of the register is: $[0\ 0\ 1\ 0\ 1\ 0\ 1\ 1\ a_6\ a_5\ a_4\ a_3\ a_2\ a_1\ a_0]$ .MSB is on the left, and LSB on the right. $[a_6\ a_5\ a_4\ a_3\ a_2\ a_1\ a_0]$ are the lowest 7 bits of the CAP's MAC address. In low-error mode, $[a_3\ a_2\ a_1\ a_0]$ are the lowest 4 bits of the CAP's MAC address and $[a_6\ a_5\ a_4]$ are fixed to be 0.

In normal mode, there are 3 different basic DRS signal (D1, D2 and D3), which can be duplicated with rotation factor in frequency domain to support various bandwidths and subcarrier spacings, as shown in Table 59. The generation method of D1, D2 and D3 is as follows, where the value of Nsr is 115, 58 and 29 for D1, D2 and D3, respectively. In OFDMA mode, the value of Nsr is 120, 60, 26 for D1, D2 and D3, respectively.

In normal mode, the bits of {Si} is BPSK-modulated to generate {Mi, i = 0, 1, ..., 32767}. Then {Mi} is mapped to the time-frequency resource start from i=0, based on the following rules, to generate $p_{k,l}^{sti}$

$$i = 0 \qquad \text{(Equation 25)}$$

$$for\ l = 0{:}1{:}DP_{num} - 1$$

$$
\begin{aligned}
& for\ k = -N_{sr}:1:+N_{sr} \\
& \quad if\ k \in SC_{dp}^{sti} \\
& \quad\quad p_{k,l}^{sti} = M_i \\
& \quad else \\
& \quad\quad p_{k,l}^{sti} = 0 \\
& \quad end \\
& \quad i = i + 1 \\
& \quad end \\
& end
\end{aligned}
$$

SC_{dp}^{sti} is the set of subcarriers defined as,

$$SC_{dp}^{sti} = [\pm(1 + sti - (l-1)\cdot DPI_F), \pm(1 + DPI_F + sti - (l-1)\cdot DPI_F), \cdots, \pm(N + sti - (l-1)\cdot DPI_F)]_{l=\lfloor \frac{sti}{DPI_F} \rfloor + 1}$$

$$
\begin{aligned}
& N = 1 + DPI_F \cdot \lfloor (N_{sr} - sti + (l-1)\cdot DPI_F - 1)/DPI_F \rfloor \\
& DPI_F = 1,2,4 \\
& sti = 0 \sim 7
\end{aligned}
\qquad \text{(Equation 26)}
$$

D1, D2 and D3 is generated by adding zeros to $p_{k,l}^{sti}$ at positions of virtual subcarriers given by Table 35, Table 36 and Table 37.

Table 59 DRS duplication modes in different Subcarrier spacing and bandwidth

Subcarrier spacing (kHz)	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz	100 MHz
	N_{FFT}	N_{FFT}	N_{FFT}	N_{FFT}	N_{FFT}	N_{FFT}	N_{FFT}	N_{FFT}	N_{FFT}	N_{FFT}	N_{FFT}
19.53125	256	512	768	1024	1280	1536	2048	2560	N/A	N/A	N/A
Duplication number (Basic DRS Signal)	1 (D1)	2 (D1)	3 (D1)	4 (D1)	5 (D1)	6 (D1)	8 (D1)	10 (D1)	N/A	N/A	N/A
39.0625	128	256	384	512	640	768	1024	1280	1536	2048	2560
Duplication number (Basic DRS Signal)	1 (D2)	1 (D1)	3 (D2)	2 (D1)	5 (D2)	3 (D1)	4 (D1)	5 (D1)	6 (D1)	8 (D1)	10 (D1)
78.125	64	128	192	256	320	384	512	640	768	1024	1280
Duplication number (Basic DRS Signal)	1 (D3)	2 (D2)	3 (D3)	1 (D1)	5 (D3)	3 (D2)	2 (D1)	5 (D2)	3 (D1)	4 (D1)	5 (D1)

For cells in which the DPI is configured with 2 or 4，1~3 subcarrier offsets can be add to the SC_{dp}^{sti}，through which demodulation pilots of different cells can be mapped onto different subcarriers.

DRS transmitted from different CAP should add phase shift $\varphi_{i,k}$ as follows,

$$\varphi_{i,k} = e^{-j\frac{2\pi k\delta^i}{N_{FFT}}} \qquad \text{(Equation 27)}$$

in which i is the index of different CAP, $\delta^i = \{0，\frac{N_{FFT}}{4}，\frac{N_{FFT}}{2}，N_{FFT}\times\frac{3}{4}\}$.

For uplink In OFDMA mode, the same DRS generation procedure is applied first for the whole bandwidth, then the values of subcarriers which do not belong to current user are set to 0 before IFFT operation.

In mmWave mode, the Demodulation reference signal shall be generated as follows:

For 50MHz bandwidth, the demodulation reference signal is mapped to the time-frequency resource according to the rules of Equation 28.

$$i = 117 * l + (k + 58) \qquad \text{(Equation 28)}$$

Where $k = -58, \ldots +58$; $l = 0,1$

$$
\begin{aligned}
& \qquad i = 0 \\
& for \quad l = 0:1 \\
& \qquad for \quad k = -58:1:+58 \\
& \qquad\quad if \quad k \in \{SC_{dp}^{sti}\} \\
& \qquad\qquad P_{k,l}^{sti} = M_i \\
& \qquad\quad else \\
& \qquad\qquad P_{k,l}^{sti} = 0 \\
& \qquad\quad end \\
& \qquad\quad i = i + 1 \\
& \qquad end \\
& end
\end{aligned}
$$

For 100MHz bandwidth, the demodulation reference signal is mapped to the time-frequency resource according to the rules of Equation 29.

$$i = 231 * l + (k + 115) \qquad \text{(Equation 29)}$$

Where$k = -115, \ldots +115$; $l = 0,1$

$$
\begin{aligned}
& i = 0 \\
& for \quad l = 0:1 \\
& \qquad for \quad k = -115:1:+115 \\
& \qquad\quad if \quad k \in \{SC_{dp}^{sti}\} \\
& \qquad\qquad P_{k,l}^{sti} = M_i \\
& \qquad\quad else \\
& \qquad\qquad P_{k,l}^{sti} = 0 \\
& \qquad\quad end \\
& \qquad\quad i = i + 1 \\
& \qquad end \\
& end
\end{aligned}
$$

For 200MHz/400MHz bandwidth, the demodulation reference signal shall be duplicated in frequency domain in the unit of 100MHz.

In mmWave mode, training sequence signals (also known as TRN) are used for channel tracking and beam tracking, this field is added ahead of the first Demodulation reference signal. The structure of the training sequence signals is shown in the figure below.

PN-CP1	PN_{511}	PN-CP2

The training sequence signals are transmitted using the sequence PN_{511}. The CP length for the training sequence signals is 127 sequence length and should be added ahead and behind the reference signals.

See Annex D for the values of PN sequence.

8.5.4 Multi-antenna schemes for downlink traffic channel

8.5.4.1 General

In the multi-antenna transmission mode, the time domain baseband signal of the ti[th] antenna port is obtained by the Equation 30

$$r_{Field}^{(ti)}(t) = \frac{1}{\sqrt{N_{Field}^{Tone} \cdot N_{sts}}} w_T(t) \sum_{\substack{k=-N_{FFT}/2 \\ k \notin SC_V}}^{N_{FFT}/2-1} \sum_{si=1}^{N_{sts}} [Q_k]_{ti,si} \tilde{x}_k^{(si)} \exp(j2\pi k \Delta f t) \qquad \text{(Equation 30)}$$

In which,

$w_T(t)$ - time domain window function, which is implementation related;

$\tilde{x}_k^{(si)}$- the loading symbol of the k[th] subcarrier on the si[th] spatial stream;

SC_V – the set of virtual subcarriers;

Δf – Subcarrier spacing

$[Q_k]_{ti,si}$- Elements of the ti[th] row and the si[th] column of the precoding matrix Q_k, $Q_k \in C^{N_{TX} \times N_{ss}}$.

The downlink multi-antenna transmission includes:

Mode 1: Open loop SU-MIMO;

Mode 2: Closed loop SU-MIMO;

Mode 3: Closed loop MU-MIMO.

8.5.4.2 Mode 1: open loop SU-MIMO

Open loop SU-MIMO can support up to 8 streams. In open loop SU-MIMO, the STA can receive up to two codewords in parallel. Matrix $Q_k \in C^{N_{TX} \times N_{sts}}$ in open loop mode is a column orthogonal matrix. The value of Q_k is implementation related. The same Q_k should be applied to both DRS and data OFDM symbols for one user.

8.5.4.3 Mode 2: closed loop SU-MIMO

Closed loop SU-MIMO can support up to 8 streams. The same precoding is performed in each subcarrier group, which is defined as precoding group. The number of precoding groups is N_g. The number of subcarriers in the g[th] precoding group is Ω_g.

The number of subcarriers Ω_g in the precoding group in SU-MIMO mode is determined by Equation 31, which is indicated by bit 55 of control channel field.

$$\Omega_g = 8,16 \qquad \text{(Equation 31)}$$

The group begins from center useful subcarrier to the edge subcarriers for both positive and negative frequency until there are less than Ω_g subcarriers left at the edge. Those subcarriers left form a new precoding group.

In OFDMA mode, the precoding group contains a resource unit and the adjacent pilot subcarrier towards the center direction. The precoding groups at left and right edge contain two adjacent pilot subcarriers.

8.5.4.4 Mode 3: closed loop MU-MIMO

In closed loop MU-MIMO, each STA can only support one codeword. The same precoding is performed in each subcarrier group, which is defined precoding group. The number of precoding groups is N_g. The number of subcarriers in the g^{th} precoding group is Ω_g.

The number of subcarriers Ω_g in the precoding group in MU-MIMO mode is determined by Equation 32, which is indicated by bit 55 of control channel field.

$$\Omega_g = 1,4 \qquad \text{(Equation 32)}$$

The group begins from center useful subcarrier to the edge subcarriers for both positive and negative frequency until there are less than Ω_g subcarriers left in the edge. Those subcarriers left form a new precoding group.

In OFDMA mode, the precoding group contains a resource unit and the adjacent pilot subcarrier towards the center direction. The precoding groups at left and right edge contain two adjacent pilot subcarriers.

8.5.5 Multi-antenna solution for uplink traffic channel

The uplink multi-antenna transmission supports:

Mode 1: Open loop SU-MIMO;

Mode 2: Closed-loop SU-MIMO.

Mode 3: Uplink MU-MIMO.

8.5.5.1 Mode 1: open loop SU-MIMO

Same as 8.5.4.2.

8.5.5.2 Mode 2: closed loop SU-MIMO

Same as 8.5.4.3.

8.5.5.3 Mode 3: Uplink MU-MIMO

For STA side, the uplink MU-MIMO transmission is same as SU-MIMO. CAP may schedule multiple STAs to form the MU-MIMO group, in which STAs can transmit simultaneously. Each STA can only support one codeword. The MIMO detection processing at CAP side is used to obtain the spatial streams from different STAs. The detailed MIMO detection and scheduling algorithms are implementation related.

8.5.6 Signaling/feedback transmission channel

8.5.6.1 General

The signaling/feedback information can be transmitted in traffic channel (grouped with other MAC frames) or signaling/feedback channel. There are two types of signaling/feedback channel. The first one is the dedicated signaling/feedback channel, which is located at the beginning of STA's resource group. The second one is the common signaling/feedback channel, which is located at the beginning of the whole DL/UL TCH.

The transmission format of both common signaling/feedback channel and dedicated signaling/feedback channel is shown in Table 60.

Table 60 **Signaling/ feedback transmission format**

Coding	Convolutional code, 1/2 code rate

Number of streams	Single stream
Modulation	QPSK
Space time coding	Disable
Demodulation Reference Signal	$DPI_F = 1$
Transmission mode	Open loop MIMO

Define D ($b_{54}b_{53}...b_{49}$) as the decimal number corresponding to $b_{54}b_{53}...b_{49}$, where b_{54} is the most significant bit, and b_{49} is the least significant bit. Within the STA resource group, OFDM symbol 0 to D ($b_{54}b_{53}...b_{49}$)-1 are used for dedicated signaling or feedback transmission, and the transmission format is independent of the indication in Table 56.

The indication of the common signaling/feedback channel is shown in the following chapters.

8.5.6.2 Downlink Signaling/ feedback transmission channel

The downlink signaling/ feedback transmission channel is at the beginning of the DL-TCH, as shown in Figure 80. All downlink signaling/ feedback transmission channels share a demodulation reference signal.

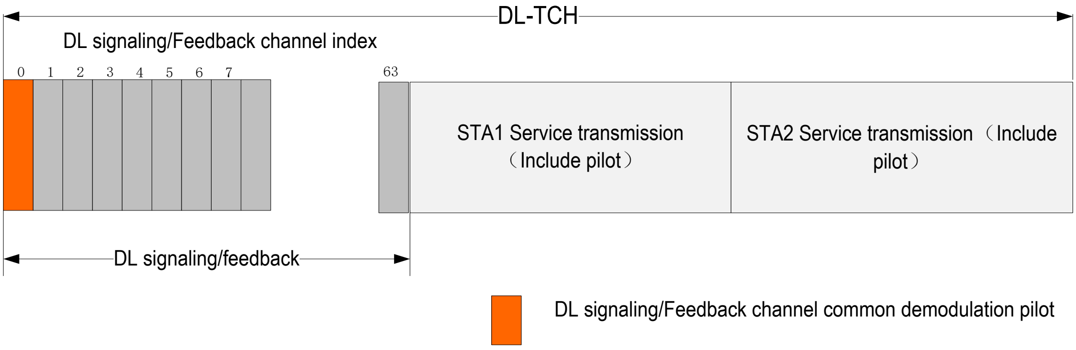


Figure 80 **Downlink signaling/feedback transmission channel**

8.5.6.3 Uplink Signaling/ feedback transmission channel

Uplink signaling/ feedback transmission channel multiplexes the UL-TCH resources as shown in Figure 81, each STA has its own DRS.

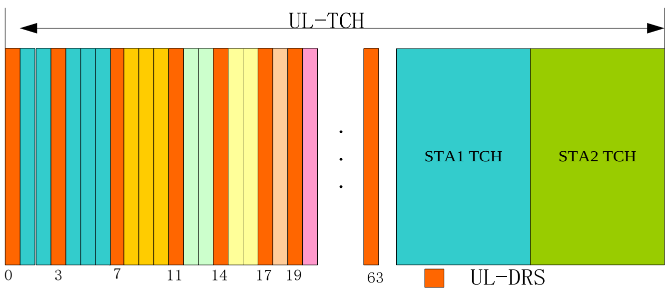


Figure 81 **Uplink signaling/feedback channel**

8.5.6.4 Resource indication of Signaling/ feedback transmission channel

The information of signaling/ feedback channel is indicated by broadcasting CCH with CRC scrambled with BSTAID. See Table 61 for the specific fields.

Table 61 **Field definition of resource indication signaling of the signaling/ feedback transmission channel**

<table>
<tr><th rowspan="2">Bit</th><th colspan="2">Definition</th></tr>
<tr><th>DL</th><th>UL</th></tr>
<tr><td>$b_3\ b_2\ b_1\ b_0$</td><td colspan="2">Broadcast type:
$b_3\ b_2\ b_1\ b_0$=0001 indicates the downlink signaling/feedback channel resource;
$b_3\ b_2\ b_1\ b_0$=0000 indicates the uplink signaling/feedback channel resource</td></tr>
<tr><td>$b_7\ b_6\ b_5\ b_4$</td><td colspan="2">working bandwidth 1 subchannel Bitmap, multiple subchannels can be set to the same signaling/feedback channel</td></tr>
<tr><td>$b_{16}\ b_{15}\ \ldots\ b_8$</td><td colspan="2">Signaling/ feedback channel resource group starting OFDM symbol index, field value: 0~510</td></tr>
<tr><td>$b_{22}\ b_{21}\ \ldots\ b_{17}$</td><td colspan="2">Reserved</td></tr>
<tr><td>$b_{28}\ b_{27}\ \ldots\ b_{23}$</td><td colspan="2">Number of symbols occupied by the signaling/feedback channel, field values 1 to 63</td></tr>
<tr><td>$b_{30}b_{39}$</td><td>Reserved</td><td>00: Format 1;
01: Format 2;
10～11: Reserved</td></tr>
<tr><td>b_{31}</td><td>0: The downlink broadcast channel allocation is valid; 1: The downlink broadcast channel allocation is invalid</td><td rowspan="3">Reserved</td></tr>
<tr><td>$b_{36}b_{35}\ \ldots\ b_{32}$</td><td>Signaling/feedback channel starting index occupied by the downlink broadcast channel, field value 1 to 31</td></tr>
<tr><td>$b_{39}\ b_{38}\ b_{37}$</td><td>Number of OFDM symbols occupied by the downlink broadcast channel, field value: 1~7</td></tr>
<tr><td>$B_{68}\ b_{54}\ldots\ b_{40}$</td><td colspan="2">Reserved</td></tr>
<tr><td>$B_{84}\ b_{70}\ \ldots\ b_{69}$</td><td colspan="2">16-bit CRC is scrambled by BSTAID</td></tr>
<tr><td colspan="3">Note 1: The number of OFDM symbols occupied by the downlink signaling feedback channel is D ($b_{28}\ b_{27}\ \ldots\ b_{23}$), and the OFDM symbol with index 0 is the common demodulation reference signal occupying resources.
Note 2: The CRC is defined the same as in Table 55.</td></tr>
</table>

8.5.6.5 Signaling/feedback transmission channel assignment

The CAP may assign the resources in the signaling/feedback channel to the STA through broadcasting CCH with CRC scrambled with BSTAID, as shown in Table 62.

Table 62 **Signaling/ feedback transmission channel assignment signaling field definition**

Bit	Definition

	DL	UL
$b_3 b_2 b_1 b_0$	Broadcast type: $b_3 b_2 b_1 b_0$=0011, downlink signaling/feedback channel allocation; $b_3 b_2 b_1 b_0$=0010, uplink signaling/feedback channel allocation	
$b_7 b_6 b_5 b_4$	Subband bitmap	
$b_{19} b_{18} \ldots b_8$	STA ID	
$b_{24}b_{23}\ldots b_{19}$	index of starting OFDM symbol in the signaling/feedback channel. The field value ranges from 0 to 63	
$b_{30}b_{29}\ldots b_{25}$	the number of OFDM symbols occupied, field values 1 to 63; a field value of 0 indicates that the channel indication is invalid.	
$b_{44}b_{43}\ldots b_{31}$	Resource Unit bit map, “1” in each bit indicates the corresponding RU is occupied	
b_{45}	0: information is duplicated in subbands; 1: information is different in subbands	
$b_{68}b_{67} \ldots b_{46}$	reserved	
$b_{84}b_{83} \ldots b_{69}$	16-bit CRC is scrambled by BSTAID	

.

8.5.7 Directional broadcast channel

In mmWave mode, Directional broadcast channel(D-BCH) is transmitted periodically to allow STAs to received network information and perform initial access. The structure of frames following D-BCH is defined in 8.1.1.

Directional broadcast channel(D-BCH) are composed of Directional System information(D-SICH) and Directional STA initial access(D-RACH). Each D-BCH occupy 1ms.The period of D-BCH can be detected by STA based on the preamble of D-BCH.

The directional system information Bits shall be converted into complex constellation points by using QPSK modulation. The constellation points shall then be spread using the sequence PN_{127}. The directional system information field is defined in the table below.

The directional System information channel with different beam pattern can be used for completing the base station TX antenna beam training.

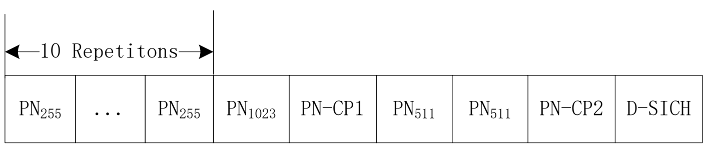
The directional System information channel are composed of Synchronous signals, demodulation reference signals and directional System information field.

Synchronous signals are transited using the sequence PN_{255} and PN_{1023}, the sequence PN_{255} are transited with the time domain repetition number 10.

10 repetitions of PN_{255} is used for coarse synchronization and frequency offset estimation, PN_{1023} is used for fine synchronization and frequency offset estimation.

The demodulation reference signals are transited using the sequence PN_{511} with the time domain repetition number 2. The CP length for the demodulation reference signals is 127 sequence length and should be added ahead and behind the reference signals.

The structure of the directional System information channel is shown in the figure below.



See Annex D for the values of PN sequence.

Table 63 **Directional System Information field**

Bit	Definition	Notes
$b_7b_6\cdots b_0$	The lowest 8 bits of this CAP MAC address	CAP identifier and scrambling code seed
$b_{19}b_{18}\ldots b_8$	System Frame Number	0~4095，
$b_{25}b_{24}\ldots b_{20}$	Beam Num	≤ 64 Beam
$b_{31}b_{30}\ldots b_{26}$	Beam ID	≤ Beam Num, used to indicate the beam index where the current SICH is located, can be used to calculate time synchronization
$b_{33}b_{32}$	bandwidth	00: 50M 01: 100M 10: 200M 11: 400M
$b_{35}b_{34}$	RACH num	RACH number for a single Beam: 00： 1 01： 2 10： 4 11： 8
$b_{37}b_{36}$	RACH Root set	Indicates ZC sequence root set index ： 00: 1 01: 2 10: 3 11: 4
$b_{41}b_{40}b_{39}b_{38}$	Cap txpower	Indicates that CAP's current transmit power in dBm: 0000: 40 0001: 29 0010: 22.4 0011: 34
b_{42}	BeamLoad	Indicates the current beam load: 0:Light load 1:Heavy load
$B_{45}\ldots b_{43}$	Reserved	
$b_{61}\ b_{60}\ldots\ b_{46}$	CRC	CRC protection

Directional STA initial access(D-RACH)：

- The initial channel access of D-RACH is based on a fully competitive mode, including the corresponding RACH channel resources and the preamble. The available random-access resources and preamble sets can be obtained by receiving the D-SICH.
- The initial random access process includes scanning different beams to obtain relevant D-SICH information, selecting the RACH channel corresponding to the most appropriate beam, randomly selecting a preamble in the alternative set to initiate the access and waiting to receive a random access response (DL-CCH) message which carries the initial TA, allocated uplink transmission resources, etc., and then the STA uses the allocated resources to send the first uplink message (connection

establishment request) while opening a window to wait for the connection establishment response message. If the access fails, the STA can continuously try to initiate an access for several times.

The preamble is Zadoff-Chu sequence with Length = 1023，and the sequences are generated according to the equation following:

$$Z(n) = e^{j\pi\frac{\mu n^2}{N}},\ n = 0,1,\ldots N\text{-}1; N = 1023;\ \mu\text{: root index} \qquad \text{(Equation 33)}$$

8.6 Downlink/ Uplink sounding channel

8.6.1 Downlink sounding channel

When b_{64}=1 in the system information field SICH, it indicates that the frame is configured with downlink sounding channel. The specific location of the downlink traffic channel and the downlink sounding channel is indicated by the MAC layer BCF frame.

The downlink sounding channel can support up to 8 antenna ports. The pilot pattern is shown in Annex C. The generation of downlink sounding pilot is same as DRS, as shown in 8.5.3.4. It should be noted that the DPI_F is fixed to be 4 and the number of spatial streams is equal to the number of antenna ports.

8.6.2 Uplink sounding channel

When b_{67}=1 in the system information field SICH, it indicates that the frame is configured with uplink sounding channel. The uplink sounding channel is included in uplink TCH of each STA. The OFDM symbol number calculation of the uplink payload should subtract the OFDM symbol number of uplink sounding channel first if b_{67}=1.

The uplink sounding channel can support up to 8 antenna ports. The pilot pattern is shown in Annex C. The generation of uplink sounding pilot is same as DRS, as shown in 8.5.3.4. It should be noted that the DPI_F is fixed to be 4 in normal mode and 1 in OFDMA mode. The number of spatial streams should be equal to the number of antenna ports.

8.7 Uplink scheduling request channel

8.7.1 General

The position of the uplink scheduling request channel (UL SRCH) in the uplink frame is in Figure 66. Each STA can randomly select a subband to transmit it's SRCH. The request signal for each subband is generated in accordance with the method shown in Figure 82

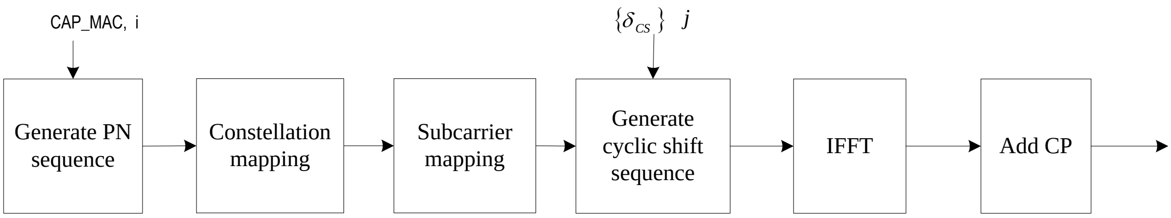


Figure 82**Scheduling request signal generation method**

In the figure, CAP_MAC means that the lowest 7 bits of the CAP's MAC address. *i* is the PN sequence index（$0 \le i < 4$），$\{\delta_{CS}\}$ is the cyclic shift parameter set, and j is the cyclic shift parameter index (0≤j < 8). Each STA shall randomly select the value of i and j with equal probability.

8.7.2 Generation of PN sequences

The PN sequence adopts the linear feedback shift register sequence with the maximum length with a generator polynomial of $1+X^{11}+X^{15}$. Its block diagram is shown in Figure 83.

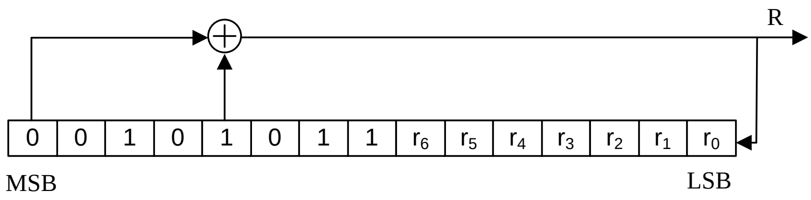


Figure 83 **PN sequence generator**

The initial value of the register is $r_{init} = [00101011r_6r_5r_4r_3r_2r_1r_0]_b$, MSB is on the left and the LSB on the right; where $[r_6r_5r_4r_3r_2r_1r_0]_b = \text{CAP\_MAC}$, are the lowest 7 bits of the CAP's MAC address.

The generated PN sequence {X} is divided into 4 different PN sequence {Si, i = 0,1,2,3}, where Si = X[i*4096 i*4096+1 … (i+1)*4096].

8.7.3 Modulation mapping

Sequence S_i is BPSK-modulated (Table 45) to obtain sequence C_i.

8.7.4 Subcarrier mapping

The sequence C_i is mapped to useful subcarriers to obtain sequence M_i.

8.7.5 Frequency domain cyclic shift

The subcarrier mapped sequence M_i is cyclically shifted according to Equation 34 to obtain sequence T_i.

$$T_{i,k}^{j} = M_{i,k} e^{-j\frac{2\pi k \delta_{CS}^{j}}{N_{FFT}}} \quad \text{(Equation 34)}$$

Where, N_{FFT} is the number of FFT points, $k \in [-\frac{N_{FFT}}{2}, \frac{N_{FFT}}{2} - 1]$ is a cyclic shift parameter, and the unit is the number of sampling points. $\{\delta_{CS}\} = \left\{0, \frac{N_{FFT}}{8}, \frac{2\times N_{FFT}}{8}, \dots, \frac{7\times N_{FFT}}{8}\right\}$.

8.7.6 Resource allocation for independent resource request frame

The CAP allocates the UL-TCH resources occupied by the independent resource request frame to the STA through the signaling shown in Table 64.

Table 64 **Source allocation for independent resource request frame**

Bit	Definition
b_3 b_2 b_1 b_0	Broadcast type: b_3 b_2 b_1 b_0=0110, independent resource request frame (allocation of resources for independent resource Request frame)
b_7 b_6 b_5 b_4	b_5b_4=00, the resource allocation of this independent resource request frame is for 3 allocations b_5b_4=01, the resource allocation of this independent resource request frame is for 2 allocations.

		b_5b_4=10, the resource allocation of this independent resource request frame is for 1 allocation b_7b_6: reserved
b_{23} b_{22} … b_8 Allocation 1		b_9b_8=00, corresponding to the scheduling request to the first OFDM symbol of UL-SRCH; b_9b_8=01, corresponding to the scheduling request to the second OFDM symbol of UL-SRCH; b_9b_8=10, corresponding to the scheduling request to the third OFDM symbol of UL-SRCH; b_9b_8=11, corresponding to the scheduling request to the fourth OFDM symbol of UL-SRCH;
		b_{11} b_{10}, PN sequence index, field value 0~3
		b_{14} b_{13} b_{12}, PN sequence frequency domain circular shift index,
		b_{17} b_{16} b_{15}, indication of the lowest 3 bits of the system frame number generated by random access
		b_{23} b_{22}… b_{18}, the starting position index of the resources allocated to the scheduling request on the signaling/feedback channel, with the field value ranging from 1 to 63, and value 0 is invalid.
b_{39} b_{38} … b_{24} Allocation 2, if b_5b_4 = 00 or 01		$b_{25}b_{24}$, defined the same as b_9b_8
		b_{27} b_{26}, PN sequence index, field value 0~3
		b_{30} b_{29} b_{28}, PN sequence frequency domain circular shift index,
		b_{33} b_{32} b_{31}, indication of the lowest 3 bits of the system frame number generated by random access
		b_{39} b_{38}… b_{34}, the starting position index of the resources allocated to the scheduling request on the signaling/feedback channel, with the field value ranging from 1 to 63, and value 0 is invalid.
b_{55} b_{54} … b_{40}	b_5b_4=00, allocation 3	$b_{41}b_{40}$, defined the same as b_9b_8
		b_{43} b_{42}, PN sequence index, field value 0~3
		$b_{46}b_{45}b_{44}$, PN sequence frequency domain circular shift index.
		b_{49} b_{48} b_{47}, indication of the lowest 3 bits of the system frame number generated by random access
		$b_{55}b_{54}$…b_{50}, the starting position index of the resources allocated to the scheduling request on the signaling/feedback channel, with the field value ranging from 1 to 63, and value 0 is invalid.
b_{55} b_{54} … b_{40}	b_5b_4 = 01	b_{40}=0: allocation 1, subband copy b_{40}=1: allocation 1, sideband transmission b_{41}=0: allocation 2, subband copy b41=1: allocation 2, sideband transmission b_{45}…b_{42}: allocation 1 is sent on this subband (b_{40}=1 is valid) b_{49}…b_{46}: allocation 2 is sent on this subband (b_{41}=1 is valid) b_{63}...b_{50}: Reserved
b_{55} b_{41} … b_{24}	b_5b_4 = 10 for allocation 1	b_{24}=0: allocation 1, subband copy b_{24}=1: allocation 1, subband transmission b_{28}…b_{25}: subband bitmap, set to "1" if allocation 1 is sent on this subband (if b_{24}=1) b_{42}…b_{29}: OFDMA resource unit bitmap b_{48}…b_{43}: the number of OFDM symbols b_{55}…b_{49}: Reserved
b_{68} … b_{56}		reserved

$b_{84}\, b_{83} \ldots b_{69}$	16-bit CRC is scrambled by BSTAID

8.8 Uplink random access channel

8.8.1 Generation of random access signal

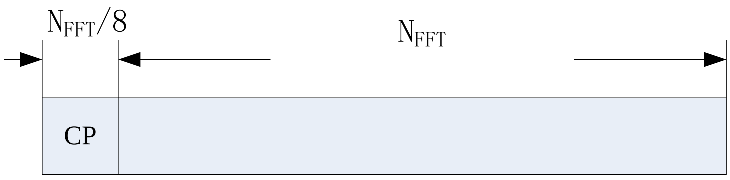
The position of the uplink random access channel (UL RACH) is at the end of the uplink frame as shown in Figure 66. Each STA can randomly select a subband to transmit it's RACH. The frequency domain RACH signal for each subband is generated in the same way as UL SRCH, as specified in 8.7.1~8.7.5, where Each STA shall randomly select the value of i and j with equal probability. It should be noted that different frequency domain cyclic shift values are used, as shown in the following sections.

The frequency domain RACH signal generated is transformed to time domain signal with the sampling points of N_{FFT}. CP and GP (Guard Period) are then added to generate the RACH channel, where there is no signal transmitting during GP.

8.8.2 Random access channel format

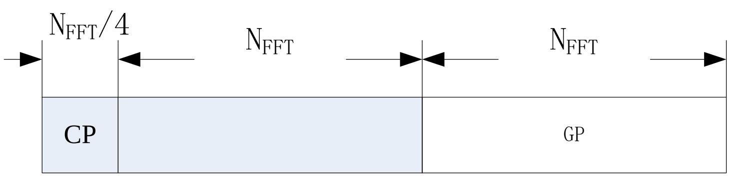
There are 3 RACH formats with different configurations of CP and GP. The RACH format is indicated by BCF. The format 1 RACH can be repeated transmitted to increase the reliability as specified in BCF.

8.8.2.1 Format 1



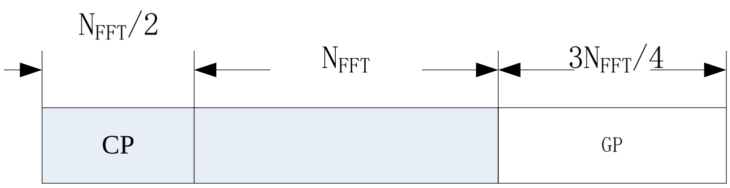
$$\{\delta_{CS}\} = \left\{0, \frac{N_{FFT}}{8}, \frac{2\times N_{FFT}}{8}, \ldots, \frac{7\times N_{FFT}}{8}\right\}.$$

8.8.2.2 Format 2



$$\{\delta_{CS}\} = \left\{0, \frac{N_{FFT}}{4}, \frac{2\times N_{FFT}}{4}, \frac{3\times N_{FFT}}{4}\right\}$$

8.8.2.3 Format 3



$$\{\delta_{CS}\} = \left\{0, \quad \frac{N_{FFT}}{2}\right\}$$

8.8.3 Resource allocation for random access request frame

After receiving the RACH from STA, the CAP allocates the UL signaling/feedback channel resources occupied by the random access request frame to the STA through broadcasting CCH shown in Table 65.

Table 65 **Resource allocation for random access request frame**

<table>
<tr><th colspan="2">Bit</th><th>Definition</th></tr>
<tr><td colspan="2">b_3 b_2 b_1 b_0</td><td>Broadcast type
b_3 b_2 b_1 b_0=0100, random access request (allocate resources for random access request frame)</td></tr>
<tr><td colspan="2">b_7 b_6 b_5 b_4</td><td>b_4=0, the resource allocation indication is for 2 STAs.
b_4=1, the resource allocation indication is for 1 STA.
b_7...b_5, reserved</td></tr>
<tr><td colspan="2" rowspan="5">b_{31} b_{30}… b_8
Allocation 1</td><td>b_9 b_8, PN sequence index, field value 0 - 3</td></tr>
<tr><td>b_{12} b_{11} b_{10}, PN sequence frequency domain circular shift index,</td></tr>
<tr><td>b_{15} b_{14} b_{13}, the lowest 3 bits of the system frame number generated by Random Access</td></tr>
<tr><td>b_{25} b_{24}... b_{16}, emission timing advance</td></tr>
<tr><td>b_{31} b_{30}... b_{26}, the starting position index of the resources allocated to Random Access Request on the signaling/feedback channel, with the field value ranging from 1 to 63, and value 0 is invalid.</td></tr>
<tr><td rowspan="6">b_{55} b_{54}…
b_{32}</td><td rowspan="5">b_4=0,
allocation
2</td><td>b_{33} b_{32}, PN sequence index, field value 0 - 3</td></tr>
<tr><td>b_{36} b_{35}... b_{34}, PN sequence frequency domain circular shift index,</td></tr>
<tr><td>b_{39} b_{38} b_{37}, the lowest 3 bits of the system frame number generated by Random Access</td></tr>
<tr><td>b_{49} b_{48}... b_{40}, emission timing advance</td></tr>
<tr><td>$b_{55}b_{54}$... b_{50}, the starting position index of the resources allocated to Random Access Request on the signaling/feedback channel, with the field value ranging from 1 to 63, and value 0 is invalid.</td></tr>
<tr><td>b_4=1</td><td>b_{38}…b_{32}, the high bits of the emission timing advance
b_{55}...b_{39}, reserved</td></tr>
<tr><td colspan="2">b_{68} … b_{56}</td><td>reserved</td></tr>
<tr><td colspan="2">b_{84} b_{83} … b_{69}</td><td>16-bit CRC is scrambled by BSTAID</td></tr>
</table>

8.8.4 Resource allocation for random access response frame

The CAP indicates the DL signaling/feedback channel resources occupied by the random access response frame to the STA through the signaling shown in Table 66.

Table 66 **Resource allocation for random access response frame**

Bit	Definition
b_3 b_2 b_1 b_0	Broadcast type b_3 b_2 b_1 b_0=0101, Random Access Response Frame (allocate resources for Random

	Access Response frame)
b_7 b_6 b_5 b_4	b_4=0: allocation 1, subband copy b_4=1: allocation 1 is transmitted on corresponding subband, and no copy is performed. b_5=0: allocation 2, subband copy b_5=1: allocation 2 is transmitted on corresponding subband, and no copy is performed. b_6=0: allocation 3, subband copy b_6=1: allocation 3 is transmitted on corresponding subband, and no copy is performed. b_7 reserved
b_{23} b_{22} … b_8 Allocation 1	b_9 b_8, PN sequence index, field value 0 - 3
	b_{12} b_{11} b_{10}, PN sequence frequency domain circular shift index. The circular shift of 000 is 0, of 001 is32, and of 111 is 224
	b_{15} b_{14} b_{13}, the lowest 3 bits of the system frame number generated by Random Access
	b_{21} b_{20}... b_{16}, the starting position index of the resources allocated to Random Access Request on the signaling/feedback channel, with the field value ranging from 1 to 63, and value 0 is invalid.
	b_{23} b_{22}, reserved
b_{39} b_{38} … b_{24} Allocation 2	b_{25} b_{24}, PN sequence index, field value 0 - 3
	b_{28} b_{27}... b_{26}, PN sequence frequency domain circular shift index, The circular shift of 000 is 0, of 001 is32, and of 111 is 224
	b_{31} b_{30} b_{29}, the lowest 3 bits of the system frame number generated by Random Access
	b_{37} b_{36}... b_{32}, the starting position index of the resources allocated to Random Access Response on the signaling/feedback channel, with the field value ranging from 1 to 63, and value 0 is invalid.
	b_{39} b_{38}, allocation 2 is sent in this sub-band.
b_{55} b_{54} … b_{40} Allocation 3	b_{41} b_{40}, PN sequence index, field value 0~3
	b_{44} b_{43} b_{42}, PN sequence frequency domain circular shift index, The circular shift of 000 is 0, of 001 is 32, and of 111 is 224
	b_{47} b_{46} b_{45}, the lowest 3 bits of the system frame number generated by Random Access
	b_{53} b_{52}… b_{48}, the starting position index of the resources allocated to Random Access Response on the signaling/feedback channel, with the field value ranging from 1 to 63, and value 0 is invalid.
	b_{55} b_{54}, allocation 3 is sent in this sub-band.
b_{71} b_{70}... b_{56}	16-bit CRC is scrambled by BSTAID

8.9 Uplink power and timing advance control

8.9.1 Open loop power control

Considering the channel reciprocity of the uplink and downlink of the TDD system, open loop power control can be used, see 36.

$$P_{STA} = min\{P_{STA\_MAX}, \quad P_0 + \alpha \times PL_{OL}\}(dBm) \qquad \text{(Equation 35)}$$

In which,

P_0, α - configurable parameters

PL_{OL} - transmission path loss estimate. It can be estimated according to the STA received signal power and the CAP transmit power. The CAP transmit power is indicated in the MAC layer BCF frame. In mmWave mode, the CAP transmit power is given in D-SICH.

Other open power control schemes can be used to achieve better performance.

8.9.2 Closed loop power and timing advance control

The closed loop power control is transmitted by broadcasting CCH, shown in Table 67.

Table 67 **Closed loop control signaling**

Bit	Definition
b_3 b_2 b_1 b_0	Broadcast type b_3 b_2 b_1 b_0=1001, closed loop link control
b_7 b_6 b_5 b_4	b_4=0, the closed-loop control signaling is for 100ns resolution of TA. b_4=1, the closed-loop control signaling is for 50ns resolution of TA. b_7...b_5, reserved
b_{55} $b_{54...}$ b_8 Indication	$b_{19}b_{18...}$ b_8, STAID
	b_{29} $b_{28...}$ b_{20}, timing advance
	$b_{31}b_{30}$, reserved
	$b_{39}b_{38...}$ b_{32}, the transmit power is increased or decreased by n*0.25 dB, where n is the signed decimal number represented by $b_{39}b_{38...}$ b_{32}. If the value of n is positive, the transmit power is increased. If the value of n is negative, the transmit power is decreased.
	b_4=0: b_{55}...b_{46} reserved (b_{29}...b_{20} is timing advance, with resolution of 100ns) b_4=1: b_{46}..b_{40}, the high bits of the timing advance ([b_{46}..b_{40} b_{29}..b_{20}] is the timing advance, with resolution of 50ns) b_{55}...b_{47}, reserved
	reserved
b_{68} … b_{56}	16-bit CRC is scrambled by BSTAID

8.10 Uplink distance measurement-based scheduling

The CAP can assign PN sequence index and circular shift index for STA to measure the distance. The assignment is indicated in broadcast CCH, as shown in Table 68.

Table 68 **Indication of uplink distance measurement based scheduling**

Bit	Definition
$b_3b_2b_1b_0$	Broadcast type $b_3b_2b_1b_0$=1011, measurement indication
$b_7b_6b_5b_4$	Reserved
$b_{31}b_{30}\cdots b_8$ Indication	$b_{19}b_{18}\cdots b_8$, STAID
	$b_{21}b_{20}$, PN sequence index
	$b_{23}b_{22}$, reserved
	$b_{26}b_{25}b_{24}$, circular shift index
	$b_{31}b_{30}\cdots b_{27}$, reserved
$b_{55}b_{54}\cdots b_{32}$ Indication	$b_{43}b_{42}\cdots b_{32}$, STAID
	$b_{45}b_{44}$, PN sequence index
	$b_{47}b_{46}$, reserved
	$b_{50}b_{49}b_{48}$, circular shift index
	$b_{55}b_{54}\cdots b_{51}$, reserved
$b_{71}\ b_{70}\cdots b_{56}$	16-bit CRC is scrambled by BSTAID

8.11 Spectrum aggregation mode

The EUHT system uses component carrier as the basic channel bandwidth, and support higher bandwidths by spectrum aggregation as shown in Figure 84. The number of component carriers is up to 16. The frame structure, system parameters of each component carrier is the same. The SICH is duplicated and transmitted in all component carriers. CCH and TCH in each component carrier can be different.

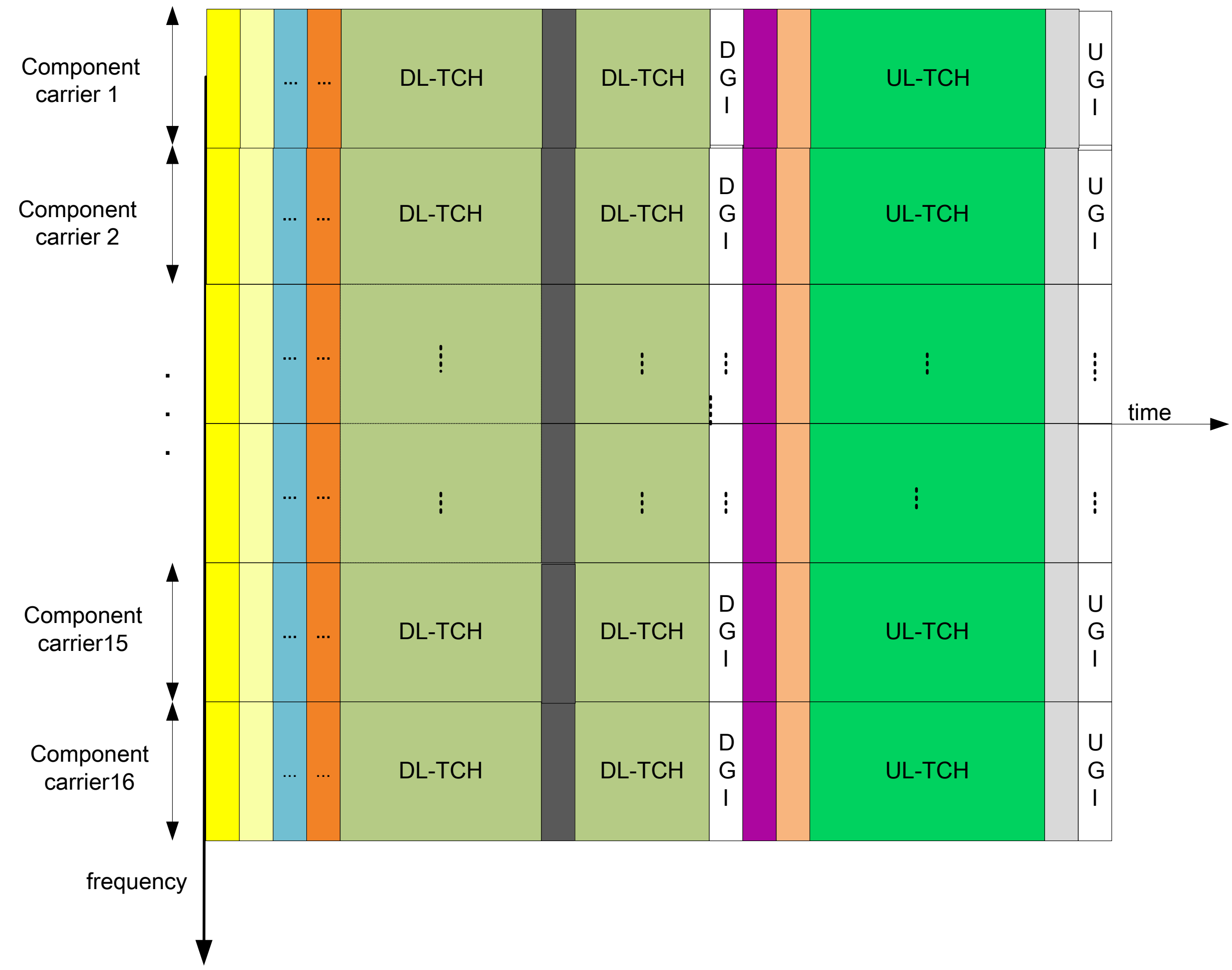


Figure 84 Spectrum aggregation mode

8.12 Transmitter and receiver specifications

8.12.1 Working frequency band and channel

The system defined in this specification can operate in the sub-6G band and millimeter wave band, or other bands that may be planned in the future.

8.12.2 Emission spectrum template

The spectrum emission template for bandwidth (BW) is shown in Figure 85, where $F_1 = \frac{BW}{2} - d_F, F_2 = \frac{BW}{2} + d_F,\ d_F = \left(\frac{N_{FFT}}{2} - N_{sr} - 1\right) \times \Delta_f$

It should be noted that the spectrum emission templates are also subject to the regional regulatory requirements.

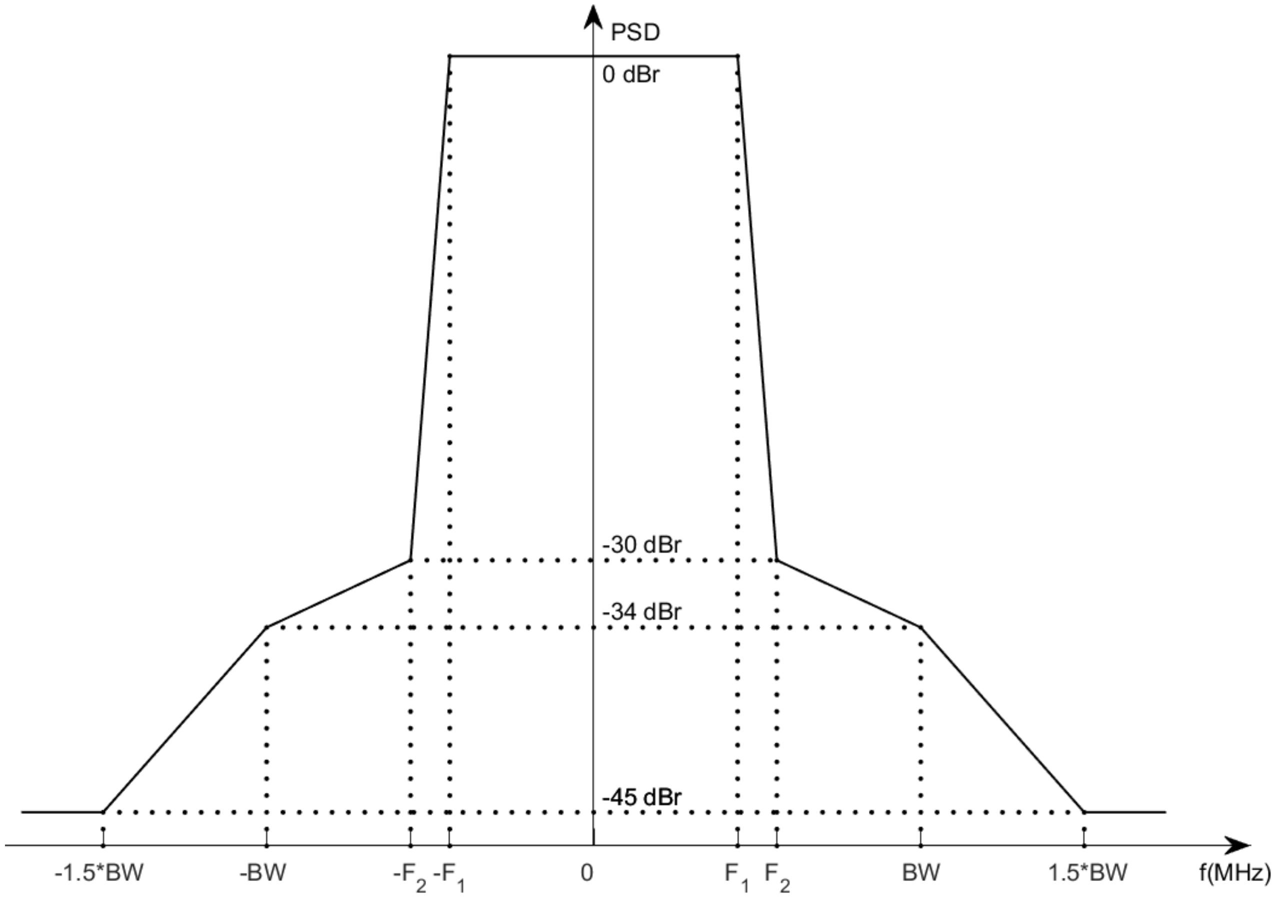


Figure 85 **Spectrum emission template**

8.12.3 Transmit power

The maximum output power of CAP and STA is limited by regional regulatory requirements.

8.12.4 Transmission frequency and Symbol clock frequency tolerance

The transmission frequency and Symbol clock frequency tolerance is subject to the requirements specified in the relevant documents of the Radio Management Department. Different transmission link center frequencies (LO) and each transmit link symbol clock frequency shall be generated by the same reference oscillator.

8.12.5 Transmitter constellation error

The averaging RMS error of the transmitted constellation frame shall not exceed the value defined in Table 69.

Table 69 **Relation between the allowable relative constellation error, constellation size and coding rate**

Modulation	Coding rate	Relative constellation error / dB
BPSK	1/2	-6
BPSK	4/7	-7
QPSK	1/2	-10

QPSK	4/7	-11
QPSK	3/4	-13
16-QAM	1/2	-16
16-QAM	4/7	-17
16-QAM	5/8	-18
16-QAM	3/4	-20
16-QAM	7/8	-21
64-QAM	2/3	-24
64-QAM	3/4	-25
64-QAM	5/6	-26
64-QAM	7/8	-27
256-QAM	3/4	-30
256-QAM	5/6	-32
256-QAM	7/8	-33
1024-QAM	3/4	-35
1024-QAM	7/8	-38

8.12.6 Minimum input sensitivity of receiver

For a packet with a length of 1000 bytes payload, when the packet error rate is less than 10%, the minimum sensitivity of the receiver input level is shown in Table 70. The sensitivity requirements apply for both convolutional coding and LDPC. It should be noted that the table below only shows the requirement for 20MHz. The requirements for bandwidth of W MHz can be obtained by adding the values at 20MHz to 10*log10(W/20).

Table 70 **Minimum input level sensitivity of receiver**

Modulation	Coding rate R	Minimum sensitivity / dBm (20MHz bandwidth)
BPSK	1/2	-82
BPSK	4/7	-81
QPSK	1/2	-79
QPSK	4/7	-78
QPSK	3/4	-77
16-QAM	1/2	-74
16-QAM	4/7	-73
16-QAM	5/8	-72
16-QAM	3/4	-70
16-QAM	7/8	-69

64-QAM	2/3	-66
64-QAM	3/4	-65
64-QAM	5/6	-64
64-QAM	7/8	-63
256-QAM	3/4	-60
256-QAM	5/6	-58
256-QAM	7/8	-57
1024-QAM	3/4	-54
1024-QAM	7/8	-51

Annex A
(Normative)
Demodulation reference signal Pattern

The demodulation reference signal pattern is shown in Table A. 1.

Table A. 1**Demodulation reference signal pattern**

Index	N_{sts}	DPI_F	DP_{num}
1	1	1	1
2	1	2	1
3	2	1	2
4	2	2	1
5	3	1	3
6	3	2	2
7	3	4	1
8	4	1	4
9	4	2	2
10	4	4	1
11	5	1	5
12	5	2	3
13	5	4	2
14	6	1	6
15	6	2	3
16	6	4	2
17	7	1	7
18	7	2	4
19	7	4	2
20	8	1	8
21	8	2	4
22	8	4	2

Note:

- Pilot period DPI_F refers to the subcarrier period of the pilot symbol in one space time stream. For example, $DPI_F = 2$ indicates a demodulation reference signal for every 2 adjacent useful subcarriers.
- Number of DRS symbols, DP_{num}, refers to the number of consecutive OFDM symbols occupied by the demodulation reference signal in the time domain.

Annex B
(Normative)
MCS Parameters

Table B. 1 defines the symbols used for the MCS parameter table, and the symbols in the symbol-dependent rate table.

Table B. 1 **Symbols used for the MCS parameter table**

Symbol	Definition
R	Code rate
N_{BPSC}	The sum of the number of encoded bits of each spatial stream per subcarrier

Table B. 2 defines the MCS set for each spatial stream in equal-order modulation.

Table B. 2 **MCS parameters in EQM mode**

MCS index number	Modulation mode	N_{SS}	R	N_{BPSC}
0	BPSK	1	1/2	1
1	QPSK	1	1/2	2
2	QPSK	1	3/4	2
3	16-QAM	1	1/2	4
4	16-QAM	1	5/8	4
5	16-QAM	1	3/4	4
6	16-QAM	1	7/8	4
7	64-QAM	1	2/3	6
8	64-QAM	1	3/4	6
9	64-QAM	1	5/6	6
10	64-QAM	1	7/8	6
11	256-QAM	1	3/4	8
12	256-QAM	1	5/6	8
13	256-QAM	1	7/8	8
14	BPSK	2	1/2	2
15	QPSK	2	1/2	4
16	QPSK	2	3/4	4
17	16-QAM	2	1/2	8
18	16-QAM	2	5/8	8
19	16-QAM	2	3/4	8
20	16-QAM	2	7/8	8
21	64-QAM	2	2/3	12

Table B.2 (continued)

MCS index number	Modulation mode	N_{ss}	R	N_{BPSC}
22	64-QAM	2	3/4	12
23	64-QAM	2	5/6	12
24	64-QAM	2	7/8	12
25	256-QAM	2	3/4	16
26	256-QAM	2	5/6	16
27	256-QAM	2	7/8	16
28	BPSK	3	1/2	3
29	QPSK	3	1/2	6
30	QPSK	3	3/4	6
31	16-QAM	3	1/2	12
32	16-QAM	3	5/8	12
33	16-QAM	3	3/4	12
34	16-QAM	3	7/8	12
35	64-QAM	3	2/3	18
36	64-QAM	3	3/4	18
37	64-QAM	3	5/6	18
38	64-QAM	3	7/8	18
39	256 QAM	3	3/4	24
40	256 QAM	3	5/6	24
41	256-QAM	3	7/8	24
42	BPSK	4	1/2	4
43	QPSK	4	1/2	8
44	QPSK	4	3/4	8
45	16-QAM	4	1/2	16
46	16-QAM	4	5/8	16
47	16-QAM	4	3/4	16
48	16-QAM	4	7/8	16
49	64-QAM	4	2/3	24
50	64-QAM	4	3/4	24
51	64-QAM	4	5/6	24
52	64-QAM	4	7/8	24
53	256-QAM	4	3/4	32
54	256-QAM	4	5/6	32

55	256-QAM	4	7/8	32

Table B. 3 defines the MCS set for 2 spatial streams in unequal modulations.

Table B. 3 **MCS parameters of UEQM with N_{ss} = 2**

MCS index number	Modulation mode		R	N_{BPSC}
	Stream 1	Stream 2		
56	16-QAM	QPSK	1/2	6
57	64-QAM	QPSK	1/2	8
58	64-QAM	16-QAM	1/2	10
59	16-QAM	QPSK	3/4	6
60	64-QAM	QPSK	3/4	8
61	64-QAM	16-QAM	3/4	10

Table B. 4 defines the MCS set for 3 spatial streams in unequal modulations.

Table B. 4 **MCS parameters of UEQM with N_{ss} = 3**

MCS index number	Modulation mode			R	N_{BPSC}
	Stream 1	Stream 2	Stream 3		
62	16-QAM	QPSK	QPSK	1/2	8
63	16-QAM	16-QAM	QPSK	1/2	10
64	64-QAM	QPSK	QPSK	1/2	10
65	64-QAM	16-QAM	QPSK	1/2	12
66	64-QAM	16-QAM	16-QAM	1/2	14
67	64-QAM	64-QAM	QPSK	1/2	14
68	64-QAM	64-QAM	16-QAM	1/2	16
69	16-QAM	QPSK	QPSK	3/4	8
70	16-QAM	16-QAM	QPSK	3/4	10
71	64-QAM	QPSK	QPSK	3/4	10
72	64-QAM	16-QAM	QPSK	3/4	12
73	64-QAM	16-QAM	16-QAM	3/4	14
74	64-QAM	64-QAM	QPSK	3/4	14
75	64-QAM	64-QAM	16-QAM	3/4	16

Table B. 5 defines the MCS set for 4 spatial streams in unequal modulations.

Table B. 5 **MCS parameters of UEQM with N $_{ss}$ = 4**

MCS index number	Modulation mode				R	N_{BPSC}
	Stream 1	Stream 2	Stream 3	Stream 4		
76	16-QAM	QPSK	QPSK	QPSK	1/2	10
77	16-QAM	16-QAM	QPSK	QPSK	1/2	12
78	16-QAM	16-QAM	16-QAM	QPSK	1/2	14
79	64-QAM	QPSK	QPSK	QPSK	1/2	12
80	64-QAM	16-QAM	QPSK	QPSK	1/2	14
81	64-QAM	16-QAM	16-QAM	QPSK	1/2	16
82	64-QAM	16-QAM	16-QAM	16-QAM	1/2	18
83	64-QAM	64-QAM	QPSK	QPSK	1/2	16
84	64-QAM	64-QAM	16-QAM	QPSK	1/2	18
85	64-QAM	64-QAM	16-QAM	16-QAM	1/2	20
86	64-QAM	64-QAM	64-QAM	QPSK	1/2	20
87	64-QAM	64-QAM	64-QAM	16-QAM	1/2	22
88	16-QAM	QPSK	QPSK	QPSK	3/4	10
89	16-QAM	16-QAM	QPSK	QPSK	3/4	12
90	16-QAM	16-QAM	16-QAM	QPSK	3/4	14
91	64-QAM	QPSK	QPSK	QPSK	3/4	12
92	64-QAM	16-QAM	QPSK	QPSK	3/4	14
93	64-QAM	16-QAM	16-QAM	QPSK	3/4	16
94	64-QAM	16-QAM	16-QAM	16-QAM	3/4	18
95	64-QAM	64-QAM	QPSK	QPSK	3/4	16
96	64-QAM	64-QAM	16-QAM	QPSK	3/4	18
97	64-QAM	64-QAM	16-QAM	16-QAM	3/4	20
98	64-QAM	64-QAM	64-QAM	QPSK	3/4	20
99	64-QAM	64-QAM	64-QAM	16-QAM	3/4	22

Table B. 6 **MCS parameters in EQM mode**

MCS index number	Modulation mode	Nss	R	N_{BPSC}
100	BPSK	1	4/7	1
101	QPSK	1	4/7	2
102	16QAM	1	4/7	4
103	1024-QAM	1	3/4	10

104	1024-QAM	1	7/8	10
105	1024-QAM	2	3/4	20
106	1024-QAM	2	7/8	20
107	1024-QAM	3	3/4	30
108	1024-QAM	3	7/8	30
109	1024-QAM	4	3/4	40
110	1024-QAM	4	7/8	40

Table B. 7 **MCS parameters of UEQM with higher order modulation**

MCS index number	Modulation mode				R	N_{BPSC}
	Stream 1	Stream 2	Stream 3	Stream 4		
111	256-QAM	64-QAM	-	-	3/4	14
112	1024-QAM	256-QAM	-	-	3/4	18
113	256-QAM	64-QAM	64-QAM	-	3/4	20
114	1024-QAM	256-QAM	64-QAM	-	3/4	24
115	256-QAM	64-QAM	64-QAM	16-QAM	1/2	24
116	256-QAM	64-QAM	64-QAM	16-QAM	3/4	24
117	1024-QAM	256-QAM	64-QAM	16-QAM	1/2	28
118	1024-QAM	256-QAM	64-QAM	16-QAM	3/4	28
119	1024-QAM	256-QAM	64-QAM	16-QAM	7/8	28

Annex C
(Normative)
Sounding Pilot Pattern

Table C. 1 defines the sounding pilot pattern in this specification.

Table C. 1 **Sounding pilot pattern**

Index	N_{tx}	SPI_F	SP_{num}
1	1	4	1
2	2	4	1
3	3	4	1
4	4	4	1
5	5	4	2
6	6	4	2
7	7	4	2
8	8	4	2

Table D.2 defines the subcarrier positions corresponding to the pilot symbols in the demodulation reference signal pattern for 20/40/80MHz bandwidth.

Table C. 2 **Sounding pilot location**

Carrier aggregation mode	Bandwidth	Sounding pilot subcarrier set
1	20 MHz	$SC_{sp}^{ti} = [\pm(1+ti-(l-1)\cdot SPI), \pm(1+SPI+ti-(l-1)\cdot SPI), \cdots, \pm(N+ti-(l-1)\cdot SPI)]_{l=\lfloor \frac{ti}{SPI} \rfloor +1}$ $N = 1+SPI\cdot\lfloor (N_{sr}-ti+(l-1)\cdot SPI-1)/SPI \rfloor$ $SPI = 4$ $ti = 0 \sim 7$ $N_{sr} = 115$
	40 MHz	$SC_{sp}^{ti} = \begin{cases} 128+[\pm(1+ti-(l-1)\cdot SPI)), \pm(1+SPI+ti-(l-1)\cdot SPI)), \cdots, \pm(N+ti-(l-1) \\ -128+[\pm(1+ti-(l-1)\cdot SPI)), \pm(1+SPI+ti-(l-1)\cdot SPI)), \cdots, \pm(N+ti-(l-1 \end{cases}$ $N = 1+SPI\cdot\lfloor (N_{sr}-ti+(l-1)\cdot SPI-1)/SPI \rfloor$ $SPI = 4$ $ti = 0 \sim 7$ $N_{sr} = 115$
	80 MHz	$SC_{sp}^{ti} = \begin{cases} 384+[\pm(1+ti-(l-1)\cdot SPI)), \pm(1+SPI+ti-(l-1)\cdot SPI)), \cdots, \pm(N+ti-(l-1) \\ 128+[\pm(1+ti-(l-1)\cdot SPI)), \pm(1+SPI+ti-(l-1)\cdot SPI)), \cdots, \pm(N+ti-(l-1) \\ -128+[\pm(1+ti-(l-1)\cdot SPI)), \pm(1+SPI+ti-(l-1)\cdot SPI)), \cdots, \pm(N+ti-(l-1 \\ -384+[\pm(1+ti-(l-1)\cdot SPI)), \pm(1+SPI+ti-(l-1)\cdot SPI)), \cdots, \pm(N+ti-(l-1 \end{cases}$ $N = 1+SPI\cdot\lfloor (N_{sr}-ti+(l-1)\cdot SPI-1)/SPI \rfloor$ $SPI = 4$ $ti = 0 \sim 7$ $N_{sr} = 115$

Note: SC_{sp}^{sti} is sounding pilot subcarrier index set for the ti sounding pilot port ; l = 1,..., SP $_{num}$ indicates the OFDM symbol occupied by the sounding pilot

Annex D
(Normative)
PN Sequence

Table D. 1 Values of PN Sequences

PN_{127}	{ 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, -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, -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, 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, 1, -1, -1, -1, -1, 1, 1, 1, -1, 1, -1, 1, 1, 1, 1, -1, -1, 1, 1, 1, 1, 1, -1};
PN_{255}	{ 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, -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, -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, -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, -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, 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, 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, -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, 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, 1, 1, 1, -1, -1, -1, 1, -1, 1, 1, -1, 1, 1, 1, -1, -1, -1, 1, 1, 1, -1}
PN_{511}	{ 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, -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, 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, -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, 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, -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, -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, -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, 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, -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, 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, 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, -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, -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, 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, -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, -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, 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, 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, 1, -1, 1, 1, 1, 1, -1, -1, 1, 1, 1, -1, 1, 1, 1, 1, -1}
PN_{1023}	{ 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, 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, -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, -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, 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, -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, -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, 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, 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, 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, -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, -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, 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, -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, 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, -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, -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, -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, 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, -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, 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, 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, -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, -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, -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, -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, 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, 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, -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, 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, -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, -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, -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, -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, -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, -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, -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, -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, 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, 1, -1, 1, 1, 1, 1, 1, 1, -1}
PN-CP1	{ 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, -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, 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, 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, 1, 1, -1, -1, -1, 1, 1, -1, 1, 1, 1, 1, -1, -1, 1, 1, 1, -1, 1, 1, 1, 1, -1}
PN-CP2	{ 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, -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, 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, -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, 1, 1, -1, -1, -1, 1, -1, 1, 1, 1, -1, -1, -1, -1, -1, 1, -1, -1, -1, -1, 1, 1, 1}

Annex E
(Normative)
LDPC Matrix

The check matrix H of the (N, K) LDPC code is generated by cyclically shifting its row generator, and each row generator is represented by the index of columns (range: 0 to N-1) in which the element 1 is located.

Table E. 1 shows the row generator of the (448, 224) LDPC check matrix, where the $(i + 1)^{th}$ row corresponds to the $(i + 1)^{th}$ row generator ($0 \le i < 8$).

Table E. 1 **8 row generators for the (448, 224) LDPC check matrix**

62 139 216 302 371 405
90 167 168 330 357 433
19 149 195 272 358 427
47 122 223 224 386 413
53 87 174 251 328 441
10 81 202 279 280 395
38 109 131 230 308 384
2 66 159 258 289 336

Table E. 2 shows the row generator of the (448, 256) LDPC check matrix, where the $(i + 1)^{th}$ row corresponds to the $(i + 1)^{th}$ row generator ($0 \le i < 6$).

Table E. 2 **6 row generators for the (448, 256) LDPC check matrix**

4	46	77	133	181	239	299	391
33	79	98	166	228	256	331	424
9	66	110	131	199	261	301	364
42	106	143	164	302	326	397	421
6	75	138	197	236	333	359	430
15	39	99	212	269	366	392	420

Table E. 3 shows the row generator of the (1344, 672) LDPC check matrix, where the $(i + 1)^{th}$ row corresponds to the $(i + 1)^{th}$ row generator ($0 \le i < 12$).

Table E. 3 **12 row generators for the (1344, 672) LDPC check matrix**

177 411 505 975 1030 1190
234 468 562 844 1075 1247
291 358 619 901 1132 1304
82 348 636 728 1085 1289
139 405 513 786 1142 1187
8 462 570 696 1024 1244
10 295 523 751 903 1178
65 195 586 800 972 1256
122 224 643 684 857 1313
68 179 339 741 976 1069
125 236 396 806 867 1126
26 293 453 697 896 1028

Table E. 4shows the row generator of the (1344, 840) LDPC check matrix, where the $(i + 1)^{th}$ row corresponds to the $(i + 1)^{th}$ row generator ($0 \le i < 9$).

Table E. 4 **9 row generators for the (1344, 840) LDPC check matrix**

188 234 410 639 752 848 1071 1197 1251
119 301 346 566 696 809 1020 1128 1308
20 236 403 462 676 866 902 1144 1311
77 284 354 523 733 810 959 1201 1242

61 118 394 451 568 853 967 1024 1252
13 186 341 508 626 790 897 1076 1299
25 172 299 468 565 746 896 1009 1198
82 127 240 522 622 694 953 1066 1130
8 139 342 520 751 860 908 1123 1247

Table E. 5shows the row generator of the (1344, 1008) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 6).

Table E. 5 **6 row generators for the (1344, 1008) LDPC check matrix**

10 80 245 344 415 475 585 694 795 844 902 957 1081 1146 1196
67 137 281 401 470 504 642 751 852 901 1014 1078 1138 1253 1312
25 124 194 338 468 527 561 627 699 808 909 958 1016 1071 1195
82 181 251 290 395 525 584 618 684 728 865 966 1015 1128 1252
139 238 300 347 448 582 675 741 785 922 970 1072 1185 1249 1292
5 168 288 357 404 505 639 732 798 842 1027 1129 1187 1242 1295

Table E. 6shows the row generator of the (1344, 1176) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 4).

Table E. 6 **4 row generators for the (1344, 1176) LDPC check matrix**

18 62 86 137 196 245 278 324 365 379 434 501 523 573 601 638 678 747 763 808 856 913 948 969 1029 1059 1130 1174 1213 1275 1325
19 58 105 129 180 239 288 321 367 408 422 477 544 566 616 644 681 721 790 806 851 899 956 991 1012 1072 1102 1173 1217 1242 1337
20 48 101 148 172 223 282 331 364 410 451 465 520 587 609 659 687 724 764 833 849 894 942 999 1034 1055 1115 1145 1216 1254 1285
44 87 130 173 216 259 302 345 388 431 474 517 560 603 646 689 732 775 818 861 904 947 990 1033 1076 1119 1162 1205 1218 1261 1343

Table E. 7shows the row generator of the (2688, 1344) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 12).

Table E. 7 **12 row generators for the (2688, 1344) LDPC check matrix**

314 766 992 1670 2009 2348
418 802 1094 1757 2020 2381
531 915 1207 1870 2133 2494
644 1028 1320 1983 2246 2607
56 757 1141 1433 2096 2359
169 870 1254 1546 2209 2472
18 282 983 1659 2322 2585
131 395 1096 1413 1772 2435
244 508 1209 1526 1885 2548
357 621 1322 1639 1998 2661
64 470 734 1435 1752 2111
177 583 847 1548 1865 2224

Table E. 8shows the row generator of the (2688, 1680) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 9).

Table E. 8 **9 row generators for the (2688, 1680) LDPC check matrix**

88 427 992 1105 1670 2009 2235 2461
152 506 1094 1223 1388 1757 2255 2554
265 619 1207 1336 1501 1870 2368 2667

67 378 732 1320 1614 1983 2023 2481
180 491 757 845 1433 1727 2136 2594
293 604 870 958 1546 1840 2016 2249
137 654 717 1222 1659 1788 2129 2585
250 395 830 1335 1413 1901 2242 2435
81 508 943 1018 1526 2014 2018 2548

Table E. 9 shows the row generator of the (2688, 2016) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 6).

Table E. 9 **6 row generators for the (2688, 2016) LDPC check matrix**

201	314	540	653	766	879	992	1105	1444	1670	1896	2009	2122	2348	2574
89	227	418	657	802	929	1094	1223	1388	1527	1757	1991	2137	2381	2599
110	202	340	531	915	1042	1207	1336	1452	1501	1640	1870	2104	2250	2494
223	315	453	644	732	1028	1155	1320	1565	1614	1753	1983	2217	2363	2607
56	224	428	566	757	845	1141	1268	1433	1678	1727	1866	2096	2330	2476
24	169	337	541	679	870	958	1254	1546	1791	1840	1979	2209	2443	2589

Table E. 10 shows the row generator of the (2688, 2352) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 4).

Table E. 10 **4 row generators for the (2688, 2352) LDPC check matrix**

104 204 277 341 443 515 628 672 795 847 925 1035 1111 1214 1294 1368 1430 1526 1602 1697 1786 1852 1945 2046 2137 2212 2300 2383 2439 2536 2645
41 168 253 362 447 532 617 702 787 872 957 1042 1127 1212 1297 1382 1467 1552 1598 1683 1768 1853 1938 2023 2108 2193 2278 2363 2448 2533 2618
15 105 289 363 426 528 600 713 757 880 932 1010 1120 1196 1299 1379 1453 1515 1622 1687 1782 1871 1937 2030 2131 2222 2297 2385 2468 2524 2621
4 106 184 371 448 511 613 685 756 842 965 1017 1095 1205 1281 1384 1464 1538 1634 1707 1772 1867 1956 2022 2115 2216 2307 2382 2470 2553 2609

Table E. 11 shows the row generator of the (5376, 2688) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 24).

Table E. 11 **24 row generators for the (5376, 2688) LDPC check matrix**

147 281 1109 1381 2089 4658 5232
98 607 826 1108 1813 2024 4398
1220 1333 1605 2406 3031 4661 4998
248 526 1445 1906 2238 2248 4854
880 968 1092 1162 1557 2149 3494
322 718 827 992 1080 1274 4317
434 1316 1668 3048 3214 3305 5109
377 765 815 1216 2354 3417 3743
1163 1610 1686 1892 2005 2466 3591
658 1039 1166 1275 2117 2808 3967
1101 1151 2501 2682 2985 4079 4571
796 1019 1213 2341 2613 3083 3865
502 706 908 1325 1776 2802 4795
37 818 991 1020 1487 2933 5213
614 930 1300 1835 3682 4764 5325
357 558 946 1244 2394 2676 4953
751 886 1356 1773 1823 2059 2949
100 764 1468 2336 3321 4168 4537
213 876 975 1378 1580 2730 3433
688 835 988 1692 2159 2560 2772

783 1199 1334 2760 3750 4081 4472
912 1311 1504 1916 2884 3952 4193
699 1024 1171 1999 2196 5097 5345
184 771 3221 3474 3816 4315 4840

Table E. 12 shows the row generator of the (5376, 3360) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 18).

Table E. 12 **18 row generators for the (5376, 3360) LDPC check matrix**

60 773 981 1045 1226 1234 1576 1846 2969 4437
22 566 772 1093 2048 2289 3329 3984 4318 5344
315 408 532 678 1977 2070 2505 2792 3494 4742
432 520 714 790 996 1570 2936 3214 3305 3367
826 1221 1429 1493 1674 2024 2201 3016 4654 5222
382 491 744 868 938 1786 2313 4137 4189 4997
119 367 603 1126 1445 1470 2238 2747 3395 4301
479 715 968 1444 1557 1765 2350 3234 3830 4413
347 1080 1204 1877 1941 2130 2472 2832 4653 4816
459 653 703 830 939 1462 3662 3703 4585 4765
302 571 942 1216 1428 1918 3056 3195 3815 5040
431 628 877 1054 1163 1328 1686 2458 3307 5290
210 370 543 572 740 1039 1166 2389 2570 4973
153 386 655 907 1101 2682 2821 3998 4907 5085
498 796 1213 1263 1664 2613 3531 3625 4110 4527
438 879 908 1076 1864 2453 2661 3045 4222 5257
550 608 818 1020 1188 1243 2773 2837 3368 3526
8 527 662 720 834 930 1103 3130 3616 3745

Table E. 13 shows the row generator of the (5376, 4032) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 12).

Table E. 13 **12 row generators for the (5376, 4032) LDPC check matrix**

0	181	342	661	686	869	933	1963	2919	3105	3183	3270	4398	4518	5076
64	308	378	660	773	1365	2177	2450	2568	2723	2878	3532	4144	4770	5344
296	490	566	772	885	1477	1678	1688	2562	2680	3721	4077	4256	4661	5240
320	532	602	884	997	1022	1450	1458	1589	1790	1800	3193	4011	4205	4854
267	432	644	714	790	1134	1317	1381	1562	1902	2089	3367	3868	4506	4966
379	544	632	826	902	1246	1674	1682	2014	2294	2729	2898	3016	3048	4846
382	491	656	744	868	1014	2126	2136	2313	2406	2496	3438	3942	4361	4730
60	157	317	367	494	768	856	1050	1126	1906	2608	3641	3889	4054	4990
235	429	479	606	715	1162	1238	1444	1557	1582	1765	3352	3507	3662	5102
292	347	541	827	1080	1204	1274	2742	2832	3464	3774	3927	4316	5214	5294
236	459	703	939	1806	2053	2234	2242	3083	3185	3576	3608	3886	4428	4697
319	348	516	571	765	815	1893	1918	2354	2686	2966	3297	3720	4089	4225

Table E. 14 shows the row generator of the (5376, 4704) LDPC check matrix, where the (i + 1)th row corresponds to the (i + 1)th row generator (0 ≤ i < 6).

Table E. 14 **6 row generators for the (5376, 4704) LDPC check matrix**

70 154 230 436 549 574 757 821 1002 1010 1141 1342 1352 1953 2226 2499 2745 2807 2993 3071 3308 3563 3869 4398 4549 4770 4891 5232
196 266 342 548 661 686 869 1122 1253 1464 1824 1963 2065 2338 2456 2611 2766 2857 3105 3183 3675 3801 3981 4096 4430 4510 4661 5003
184 308 378 454 660 773 798 981 1226 1753 1846 1936 2075 2450 2568 2878 2969 3217 3295 3382 3532 3609 3787 4093 4208 4542 4773 4882
208 296 420 490 566 772 885 910 1093 1157 1346 1477 1678 1688 1865 2187 2680

2990 3081 3494 4077 4320 4368 4654 4734 4994 5110 5352
30 155 320 408 532 602 678 884 1022 1269 1450 1458 1589 2160 2299 2792 3193 3255 3441 3756 3833 4011 4189 4317 4618 4885 4966 5106
62 158 267 432 520 644 714 790 996 1109 1317 1381 1570 1701 2089 2272 2411 2513 2617 3367 3631 3868 3945 4249 4301 5078 5218 5334

Annex F
(Normative)
Quantization of Channel Information Matrix

The process of performing quantization coding on the channel state information matrix $H_{eff}(k)$ is defined as follows.

Calculate the maximum value of the real and imaginary parts of each element in the subcarrier matrix $m_H(k)$：

$$m_H(k) = max\left\{max\left\{\left|Re\left(H_{eff(m,l)}(k)\right)\right|_{m=1,l=1}^{m=N_r,l=N_c}\right\}, max\left\{\left|Im\left(H_{eff(m,l)}(k)\right)\right|_{m=1,l=1}^{m=N_r,l=N_c}\right\}\right\} \quad \text{(Equation 36)}$$

Where $H_{eff(m,l)}(k)$ represents the element in $H_{eff}(k)$, $Re\left(H_{eff(m,l)}(k)\right)$ represents the real part of $H_{eff(m,l)}(k)$, $Im\left(H_{eff(m,l)}(k)\right)$ represents the imaginary part of $H_{eff(m,l)}(k)$; m is the row position parameter, l is the column position parameter, Nr is the maximum number of rows, Nc is the maximum number of columns, $1 \le m \le Nr$，$1 \le l \le Nc$，$Nr \ge 1$，$Nc \ge 1$，m、l、Nr and Nc are positive integer; k is a positional parameter of a subcarrier, and can be a numbered form;

Calculate the scaling according to and perform Mbits quantization to get MH(k), and calculate the linear part $M_H^{lin}(k)$:

$$M_H(k) = min\{2^M - 1, \lceil max(0, a \cdot log_b(m_H(k)))\rceil\} \quad \text{(Equation 37)}$$

Where M represents the number of quantization bits, and the value is M=3

$\lceil x \rceil$ represents the largest integer not less than x.

a represents the optimization factor, with a value $a = 4.11, b = 2$.

Linear part $M_H^{lin}(k)$ calculation formula:

$$M_H^{lin}(k) = b^{M_H(k)/a}$$

Nb-bit quantization is performed for each element of the real and imaginary parts of the $H_{eff}^q(k)$ matrix:

$$H_{eff(m,l)}^{q(R)} = sign(H_{eff(m,l)}(k)) * min\left(2^{N_b-1} - 1, round\left(\frac{\left|Re\left(H_{eff(m,l)}(k)\right)\right|}{M_H^{lin}(k)}(2^{N_b-1} - 1)\right)\right)$$

$$H_{eff(m,l)}^{q(I)} = sign(H_{eff(m,l)}(k)) * min\left(2^{N_b-1} - 1, round\left(\frac{\left|Im\left(H_{eff(m,l)}(k)\right)\right|}{M_H^{lin}(k)}(2^{N_b-1} - 1)\right)\right) \quad \text{(Equation 38)}$$

Where $H_{eff(m,l)}(k)$ represents the element in $H_{eff}(k)$, $H_{eff(m,l)}^{q(R)}$represents the real part after $H_{eff(m,l)}(k)$ quantization, $H_{eff(m,l)}^{q(I)}(k)$ represents the imagery part after $H_{eff(m,l)}(k)$ quantization, m is the row position parameter, l is the column position parameter, $sign(H_{eff(m,l)}(k))$ means taking the symbol polarity of $H_{eff(m,l)}(k)$, "｜ ｜" means taking absolute value.

The receiver restores the CSI matrix as follows:

The amplitude value $r(k)$ is restored according to $M_H(k)$:

Specifically, reverse processing is performed according to the method of $M_H(k)$ quantization to recover $r(k)$.

$$r(k) = b^{M_H(k)/a} \quad \text{(Equation 39)}$$

Then, the real part $H_{eff(m,l)}^{q(R)}$ and the imaginary part $H_{eff(m,l)}^{q(I)}(k)$ of each element $H_{eff(m,l)}^{q}(k)$ in $H_{eff}^{q}(k)$ are scaled according to $r(k)$ to recover the channel matrix $\widetilde{H}_{eff}(k)$ of the subcarrier.

Specifically, the following formula can be used:

$$Re\left(\widetilde{H}_{eff(m,l)}(k)\right) = \frac{r(k)H_{eff(m,l)}^{q(R)}(k)}{(2^{N_b-1} - 1)}$$

$$Im\left(\widetilde{H}_{eff(m,l)}(k)\right) = \frac{r(k)H_{eff(m,l)}^{q(I)}(k)}{(2^{N_b-1} - 1)} \qquad \text{(Equation 40)}$$