The Key Changes of EUHT-5G specification

Nufront

Jan 2024

START

Clarification on concept of subchannel/channel (section 1.3)

NUFRONT

- One channel is one component carrier
  - The bandwidth of channel is CAP working bandwidth
- One channel can contain up to 10 sub-channels with the same sub-channel bandwidth
  - The bandwidth of sub-channel varies depending on different subcarrier spacings (SCS) and number of data sub-carriers (Nsd) in one OFDM symbol.
    - Example :Nd = 224, SCS = 78.125KHz, subchannel bandwidth is 20MHz
  - Each sub-channel in the EUHT-5G system includes a complete frame configuration with preamble, SICH, CCH, and TCH channels.

Frequency Division Multiplexing (OFDM) and Multiple Input Multiple Output (MIMO) technologies.

A component carrier is equivalent to a channel in EUHT-5G system. The EUHT-5G system supports single or multiple component carriers (channels), which means it supports carrier aggregation(CA).

The EUHT-5G system supports different bandwidth modes under various subcarrier spacings in one component carrier (channel), as defined in Table 3, section 1.7.3 and section 1.7.4.1. Within a single component carrier (channel) in the EUHT-5G system, multiple sub-channels can also be accommodated, to enhancing system flexibility.

The bandwidth of channel is defined as CAP working bandwidth (Refer to Table 3 and section 1.7.4.1). There are four different sets of CAP working bandwidth and each set contains up to eight different values of CAP working bandwidth, which are indexed as working bandwidth 1 ~ 8 (section 1.5.3.4.1). The index of CAP working bandwidth set is indicated in BCF, and the index of CAP working bandwidth inside the set is indicated in SICH (section 1.7.4.1).

EUHT-5G system uses working bandwidth 1 as the basic ~~channel bandwidth(sub-channel), and supports working bandwidth 2 and working bandwidth 3 in one component carrier, which is indicated in control channel (section 1.7.4.2).~~bandwidth (bandwidth of sub-channel). Each channel (component carrier) can contain up to 410 sub-channels~~. The~~ with the same basic bandwidth~~ of sub-channel is no more than the bandwidth of one channel. The bandwidth of each~~, indexed as sub-channel 0 ~ sub-channel 9 in order of ascending frequency. Therefore, the number of subchannels in one channel is equal to CAP working bandwidth ~~1 in the working~~/ basic bandwidth~~ set.~~.

~~EUHT-5G system supports carrier aggregation (CA). In CA mode, one component carrier (CC) is one channel, the channel bandwidth of each CC is stated in Broadcast Control Frame (BCF).~~

Bandwidth of channel and subchannel for single CC (section 1.5.3.4.1 and 1.7.4.1)

NUFRONT

- Indicated by Broadcast Control Frame (BCF) and System Information Channel (SICH)
- BCF indicates the CAP working bandwidth set, which contains up to 8 different bandwidth (indexed as bandwidth 1~8). Bandwidth 1 is the sub-channel bandwidth
- SICH indicates the index of bandwidth in the set, which gives the channel bandwidth.
- Example: to support CAP Working bandwidth = 100MHz
  - BCF: ”CAP Working bandwidth set ” is 011, 20/40/60/80/100 MHz, which means the sub-channel bandwidth = 20MHz
  - SICH: “CAP working bandwidth” is 100, which means the CAP working bandwidth is the bandwidth 5 in the set, that is 100MHz

TABLE 3

Fixed part of BCF frame body

Information	Length/ bit	Remarks
CAP-MAC address	48	Unique identifier of the CAP
~~Working channel number~~Center frequency	~~8~~19	~~The minimum channel number occupied by the CAP~~Indicates center frequency of current component carrier of CAP, Refer to Table E.3 for EUHT-ARFCN
~~work~~CAP Working bandwidth set	~~2~~3	~~Working bandwidths for broadcasting CAP:~~ ~~0: working bandwidth 1 in~~ For sub-6GHz band: 000: 5/10/15/20/25/30/40/50MHz working bandwidth mode~~;~~ (subcarrier spacing: 19.53125KHz & 39.0625KHz) ~~1:~~001: 10/20/30/40/50/60/80/100MHz working bandwidth ~~2 in~~mode (subcarrier spacing: 39.0625KHz) 010: 10/20/30/40/50MHz working bandwidth mode (subcarrier spacing: 78.125KHz) 011: 20/40/60/80/100MHz working bandwidth mode~~;~~ (subcarrier spacing: 78.125kHz) Others: reserved~~2:~~ For mmWave mode, working bandwidth ~~3~~is indicated in ~~working bandwidth mode;~~ ~~3:~~ SICH.~~Reserved~~
CAP antenna port configuration	3	Indicates the antenna port configuration on the CAP side, 0:1 antenna port;

TABLE 65

System Information field definition in Type-I SICH

Bit	Definition	Notes
$b_7b_6\ldots b_0$	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: 5/10/20MHz~~Working bandwidth of current CC (contain current SICH) of CAP: 0~7: working bandwidth 1~8 in working bandwidth mode; ~~001: 10/20/40MHz working bandwidth mode~~ ~~010: 15/30/60MHz working bandwidth mode~~ ~~011: 20/40/80MHz working bandwidth mode~~ ~~100: 25/50/100MHz working bandwidth mode~~ For mmWave mode, 000: 50MHz working bandwidth mode 001: 100MHz working bandwidth mode 010: 200MHz working bandwidth mode 011: 400MHz working bandwidth mode 100: 1GHz working bandwidth mode ~~Others: reserved~~

More flexible CA (Carrier Aggregation) (section 1.5.3.4.1)

- Each CC (Component Carrier) has complete frame structure including independent preamble, SICH, CCH and TCH.
- The information of each CC is indicated in the BCF, which includes CAP working bandwidth set, center frequency and subcarrier spacing
- The SICH is also independent for each CC, which indicates the CAP working bandwidth of current CC.
- Therefore, each CC can have different channel bandwidth, sub-channel bandwidth.

TABLE 6

Data field with TLV_type=0 of the extensible part of BCF

Name	Length/ bit	Value
~~starting~~Center frequency of component carrier #1	19	Indicates ~~starting~~center frequency of component carrier (CC) #1~~, i.e frequency when channel number=0~~. Refer to Table E.~~1~~-3 for EUHT-ARFCN
CAP Working Bandwidth set of component carrier #1	~~4~~3	~~0000 ~ 1101~~For sub-6GHz band: 000: 5/10/15/20/25/30/40/50MHz working bandwidth mode (subcarrier spacing: 19.53125KHz & 39.0625KHz) 001: 10/20/30/40/50/60/80/~~100/200/400/1000MHz~~100MHz working bandwidth mode (subcarrier spacing: 39.0625KHz) 010: 10/20/30/40/50MHz working bandwidth mode (subcarrier spacing: 78.125KHz) 011: 20/40/60/80/100MHz working bandwidth mode (subcarrier spacing: 78.125kHz) Others: reserved For mmWave mode, working bandwidth is indicated in SICH.
~~Reserved~~ Subcarrier spacing indication of component carrier #1	~~1~~2	For sub-6GHz band: 00: 19.53125KHz 01: 39.0625KHz 10: 78.125KHz 11: reserved For mmWave mode, 00: 390.625KHz 01: 976.5625KHz 10: reserved 11: reserved ~~Reserved~~

Each CC has complete frame structure including independent ~~CCH~~preamble, SICH, CCH and TCH, which means the relative processing (for example, resource allocation, MCS selection,

channel coding/decoding, etc.) is independent for each CC. The overhead of multiple CCs is similar as single CC, since each CC has similar overhead including ~~P~~preamble, SICH, CCH and TCH, etc. The frame structure and system parameters in each CC is defined in section 1.7.11, and SICH/CCH~~ and ~~/TCH in each component carrier can be different.

Network joining process (section 1.6.4)

NUFRONT

- Network joining is performed at sub-channel level
- STA can perform system synchronization by searching different carrier frequency to detect the preamble and get the system information in the sub-channel.
  - STA will try to use different subcarrier spacing and number of data sub-carriers to search preamble
- The random access and capability negotiation is also performed in the detected sub-channel.
- The process on single CC and multiple CCs are described in details.

The network join process for single CC is defined in the following ~~sections in non-CA mode. In,~~

To accelerate the ~~CA mode,~~scanning speed of STAs in EUHT-5G system, different frequency grids are defined for different frequency bands, as shown in Table E.4. CAP should select the center frequency of each sub-channel from the frequency values defined in Table E.4. The preamble transmitted by the CAP exists in each sub-channel of each component carrier (channel). The EUHT Sync_N is the frequency-search index calculated according to the formula given in the Table E. 4. For frequencies below 24250 MHz, the frequency grid is 2.5 MHz. For frequencies above 24250 MHz, the frequency grid is 25 MHz.

After the STA is turned on, it selects the corresponding global EUHT Sync_N frequency point according to the supported frequency band by this STA to search for the CAP. The cell search process ~~is similar~~ mainly includes the following steps: Detect the preamble defined in Section 1.7.3 to obtain synchronization with ~~the non-CA mode. The~~ CAP. Get the main information of the cell through the received BCF information (including MAC address, working bandwidth set, carrier aggregation related information, etc.). Refer to section 1.6.4.2 for details.

If STA successfully obtain system synchronization, it means that STA detect one subchannel on one CC. Then, STA can perform random access and capability negotiation on the detected subchannel of the detected CC, as indicated in section 1.6.4.3 and section 1.6.4.4. After joining the network, STA can switch to the center frequency and working bandwidth of detected CC based on the capability negotiation.

If there are more than one CC, the detail procedure ~~in CA mode~~ is defined below.

1) STA starts-up (turns on) and tries to get system synchronization ~~by receiving~~and receive the BCF

Higher modulation order (up to 4096 QAM)

NUFRONT

- Increase the highest modulation from 1024QAM to 4096QAM, refer to table 54 and table 60-2 in section 1.7.2.7, and update the corresponding MCS parameter in table A.6.
- Add the corresponding transmitter constellation error of 4096QAM in table 82 and minimum input sensitivity of 4096QAM in table 83 .

TABLE 54

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	$1/\sqrt{682}$
4096-QAM	$1/\sqrt{2730}$

Table 60-2

4096 - 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
000000	-63	000000	-63
000001	-61	000001	-61

TABLE ~~81~~82

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

4096-QAM	3/4	-38
4096-QAM	7/8	-38

TABLE ~~82~~83

Minimum input level sensitivity of receiver

4096-QAM	3/4	-52
4096-QAM	7/8	-52

Higher modulation order (up to 4096 QAM)

NUFRONT

- Add the corresponding MCS parameter of 4096QAM with different Nss(spatial streams) and R(code rate) in table A.6.
- The MCS index are renumbered in table A.6, table A.7 and tableA.8.

TABLE A. 6

MCS parameters in EQM mode

MCS index number	Modulation mode	N_{SS}	R	N_{BPSC}
76	4096-QAM	2	3/4	24
77	4096-QAM	2	7/8	24
78	4096-QAM	3	3/4	36
79	4096-QAM	3	7/8	36
80	4096-QAM	4	3/4	48
81	4096-QAM	4	7/8	48
100	BPSK	1	4/7	1
101	QPSK	1	4/7	2
102	QPSK	1	7/8	2
10~~2~~3	16QAM	1	4/7	4
10~~3~~4	1024-QAM	1	3/4	10
105	1024-QAM	1	5/6	10
1046	1024-QAM	1	7/8	10
107	4096-QAM	1	3/4	12
108	4096-QAM	1	7/8	12

TABLE A. 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		
11~~1~~5	256-QAM	64-QAM	-	-	3/4	14
11~~2~~6	1024-QAM	256-QAM	-	-	3/4	18
11~~3~~7	256-QAM	64-QAM	64-QAM	-	3/4	20

TABLE A. 8

MCS parameters in EQM mode with repetition

MCS index number	Modulation mode	N_{SS}	R	N_{BPSC}
12~~2~~4	QPSK	1	4/7 * 1/3	2
12~~3~~5	QPSK	1	4/7 * 1/4	2

Take MCS 12~~2~~4 as example, it is 4/7 coding rate and QPSK modulation. The QPSK OFDM symbols generated will be repeated 3 times in time domain according to repetition scheme in section 1.7.2.11.

More MCSs in low error mode

NUFRONT

- More MCSs (QPSK,16QAM,64QAM) are supported in low error mode with different repetition times in time and frequency domain.

TABLE 69

Control field definition in low-error mode

$b_{12}b_{11}b_{10}$	~~DL~~ Modulation, Code rate (R) and Repetition ~~number in time domain(M)~~Shemes for DL	~~00: 1~~ ~~01: 2~~ ~~10: 3~~ ~~11:~~ 4000: QPSK, R=4/7 , repeat 3 times in time domain and repeat 4 times in frequency domain 001: QPSK R=4/7, repeat 2 times in time domain and repeat 4 times in frequency domain 010: QPSK R=4/7 , no repetition in time domain and repeat 4 times in frequency domain 011: QPSK R=4/7 , repeat 3 times in time domain and no repetition in frequency domain 100: QPSK R=4/7 , repeat 2 times in time domain, no repetition in frequency domain 101: QPSK R=4/7 no repetition 110: 16QAM R=4/7 no repetition 111: 64QAM R= 4/7 no repetition
~~b_{21}~~$b_{22}b_{21}b_{20}$	~~UL~~ Modulation, Code rate (R) and Repetition ~~number in frequency domain(N)~~ Shemes for UL	~~0: 2~~ ~~1:~~ 4000: QPSK, R=4/7, repeat 3 times in time domain and repeat 4 times in frequency domain 001: QPSK, R=4/7, repeat 2 times in time domain and repeat 4 times in frequency domain 010: QPSK, R=4/7, no repetition in time domain and repeat 4 times in frequency domain 011: QPSK, R=4/7, repeat 3 times in time domain and no repetition in frequency domain 100: QPSK, R=4/7, repeat 2 times in time domain, no repetition in frequency domain 101: QPSK, R=4/7, no repetition 110: 16QAM, R=4/7, no repetition 111: 64QAM, R= 4/7, no repetition

Support up to 32 antennas at CAP

- Increase the maximum number of CAP antenna ports from 16 to 32, and update the corresponding fields in fixed part of BCF.

TABLE 3

Fixed part of BCF frame body

CAP antenna port configuration	3	Indicates the antenna port configuration on the CAP side, 0:1 antenna port; 1:2 ~~antennas~~antenna ports; 2:4 ~~antennas~~antenna ports ; 3:6 ~~antennas~~antenna ports ; 4:8 ~~antennas~~antenna ports; 5:16 ~~antennas~~antenna ports; 6~~-~~:32 antenna ports; 7: reserved

TABLE 4

Fixed part of BCF frame body in low-error mode

CAP antenna port configuration	3	Indicates the antenna port configuration on the CAP side, 0:1 antenna port; 1:2 ~~antennas~~antenna ports; 2:4 ~~antennas~~antenna ports ; 3:6 ~~antennas~~antenna ports ; 4:8 ~~antennas~~antenna ports; 5:16 ~~antennas~~antenna ports; 6~~-~~:32 antenna ports; 7: reserved

More Robust Control Channel (CCH)

NUFRONT

- Define more transmission types for CCH
  - Transmission Type-I for CCH: QPSK , 4/7 coderate.
  - Transmission Type-II for CCH: QPSK, 3/14 coderate.
  - Transmission Type-III for CCH is the two times repetition of Transmission Type-II for CCH in time domain.
- CAP can decide which transmission type is used for unicast /broadcast CCH

1.7.4.2 Control channel field

~~The control channel consists of multiple unicast and broadcast scheduling signaling.~~ There are three transmission types ~~of~~for CCH in normal mode: Transmission Type-I ~~CCH,~~, Transmission Type-II ~~CCH~~ and Transmission Type-III ~~CCH. CAP can decide~~. Different transmission types for CCH use different MCS, coding type and number of repetitions which ~~types~~ are scheduled by CAP. The payload of Transmission Type-I for CCH is 85bits, using MCS101 with LDPC coding. The payload of Transmission Type-II for CCH is 96bits, using QPSK with LDPC 3/14 coding rate. Transmission Type-III for CCH ~~are used.~~ is the two times repetition of Transmission Type-II for CCH in time domain.

If there are different transmission types ~~of~~for CCH in the ~~CCH sub-~~control channel field, the OFDM symbols which contain the same transmission type ~~of CCHs~~for CCH should be put together. The order in time domain should be [Transmission Type-I for CCH (if exists), Transmission Type-II for CCH (if exists), Transmission Type III for CCH (if exists)]. The index of starting OFDM symbol of CCH with Transmission Type-II ~~CCH~~ and CCH with Transmission Type-III ~~CCH~~ is indicated in SICH.

~~Type-I CCH uses MCS101with LDPC coding.~~ Both unicast and broadcast CCH can be transmitted in Transmission Type-I/II/III if the payload of the CCH is not larger than payload of the transmission type, as indicated in field definition tables of CCH.

TABLE 74

Signaling/feedback transmission channel assignment signaling field definition

$b_{84}b_{83} \ldots b_{69}$	16-bit CRC is scrambled by BSTAID if using Transmission Type-I.
$b_{79}\ b_{78} \ldots b_{69}$	Reserved bits if using Transmission Type-II/III.
$b_{95}\ b_{94} \ldots b_{80}$	CRC protection based on BSTAID if using Transmission Type-II/III.

TABLE 75

Efficient Signaling/feedback transmission channel assignment signaling field definition

$b_{84}b_{83} \ldots b_{69}$	16-bit CRC is scrambled by STAID if using Transmission Type-I
$b_{79}\ b_{78} \ldots b_{69}$	Reserved bits if using Transmission Type-II/III.
$b_{95}\ b_{94} \ldots b_{80}$	CRC protection based on STAID if using Transmission Type-II/III.

More robust preamble in low error mode (section 1.7.3)

- There are 8 candidate sequences for CAP to select in Low-error mode.

  - ✓ For Short Preamble:

    In Low-error mode, short preamble(S-Preamble) is 5 identical ~~PN~~ sequences and each ~~PN~~ sequence has 255 points~~. The~~ (denoted as SP255). For the 255-point ~~PN~~sequence, there are 8 candidate sequences for CAP to select, as defined below. The selected index of sequence is denoted as SEQ_ID. The STA shall search the S-Preamble with all the eight possible sequences. . :

  - ✓ For Long Preamble:

    ~~Based on the above PN sequences, different~~ For the 511 point sequence, there are 8 candidate sequences for CAP to select, as defined below. The selected index of sequence shall be equal to SEQ_ID. Therefore, the STA will have the information of which long preamble sequences is transmited from CAP after the STA succesfully detectes the S-Preamble.

More flexible phase tracking pilots (section 1.7.2.9)

NUFRONT

- There are two modes for inserting the phase tracking pilots, as indicated by SICH.

TABLE 65

System Information field definition in Type-I SICH

b_{66}	~~Reserved~~ Mode for inserting the phase tracking pilot	~~Reserved~~ For sub-6GHz band: 0: mode 0; 1: mode 1; For mmWave mode: only mode 0 is supported;

- ✓ For mode 0, the index of the phase tracking pilots are fixed.
- ✓ For mode 1, the index of the phase tracking pilots are changed with the OFDM symbols.

Phase tracking pilots and DRS shall be inserted before precoding.

There are two modes for inserting the phase tracking pilots, as indicated by SICH. CAP can decide which mode is used for current physical layer frame. For mode 0, the index of the phase tracking pilots are fixed,as indicated in 1.7.1.2 . For mode 1, the index of the phase tracking pilots change with the OFDM symbols. In this mode, phase tracking pilots can be used for better channel tracking.

NUFRONT

Thank You

END