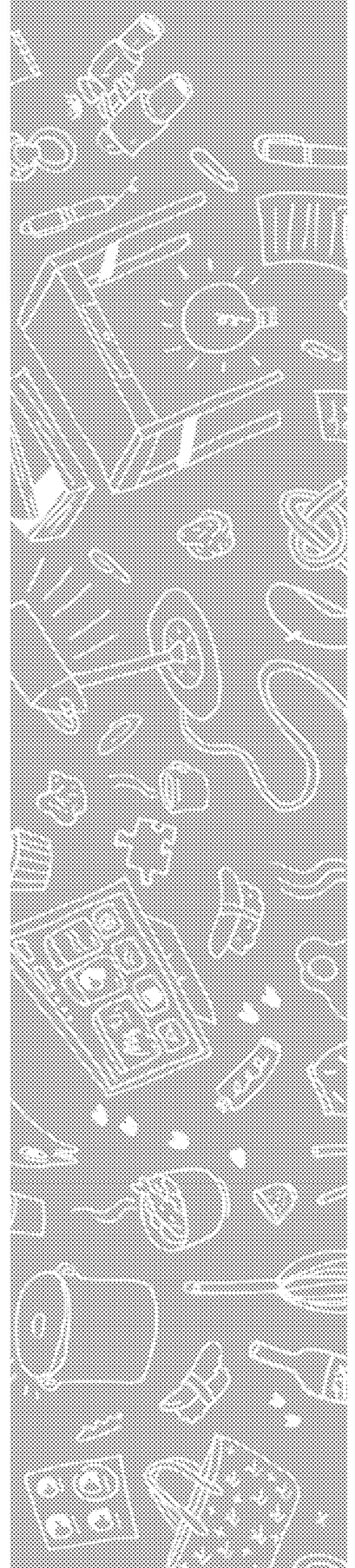
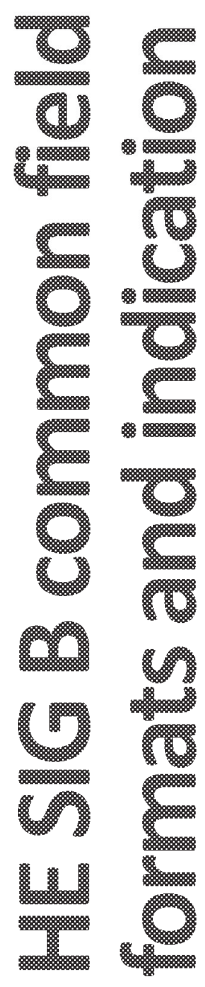


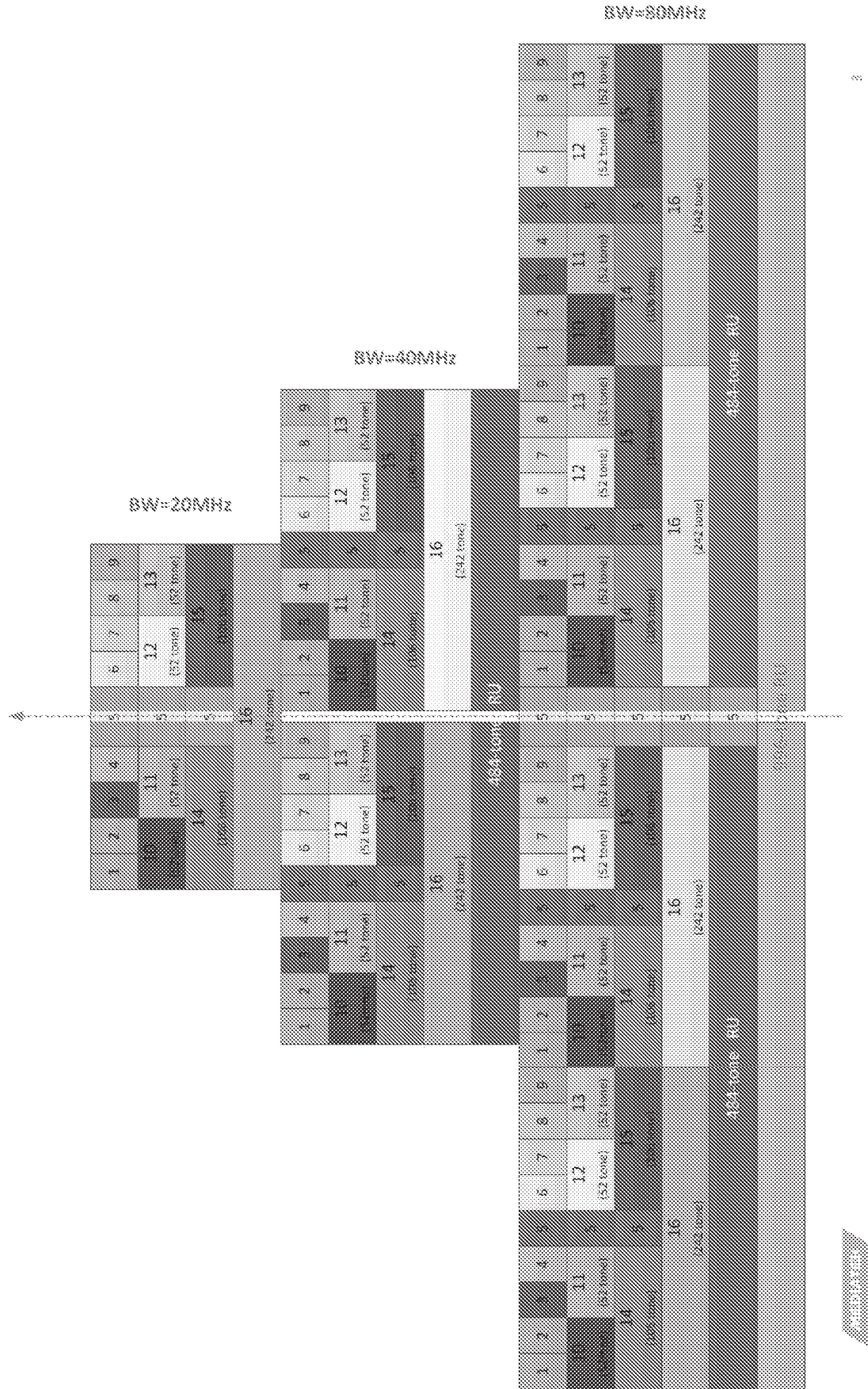


Background

- In 11ax, resource allocation(RA) needs to be indicated to support OFDMA and/or MU-MIMO
- In 11ax, the operation bandwidth are partitioned into resource units as defined in slide 3.
- The Resource allocation will be signaled in the common part of HE SIG B field. The structure of HE SIG B fields are designed as shown in slide 4.

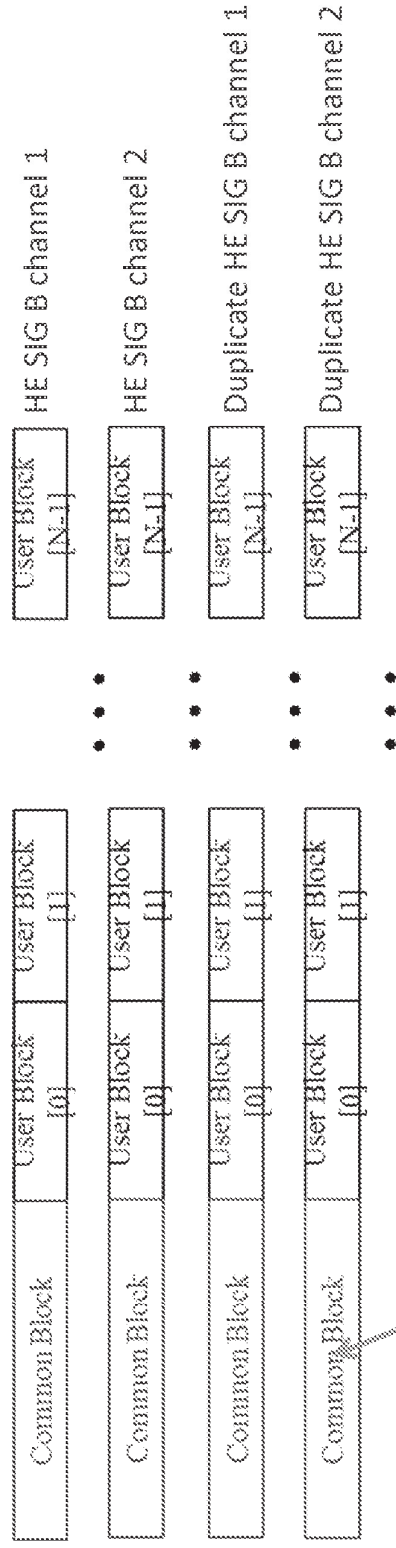


Resource units in 802.11ax

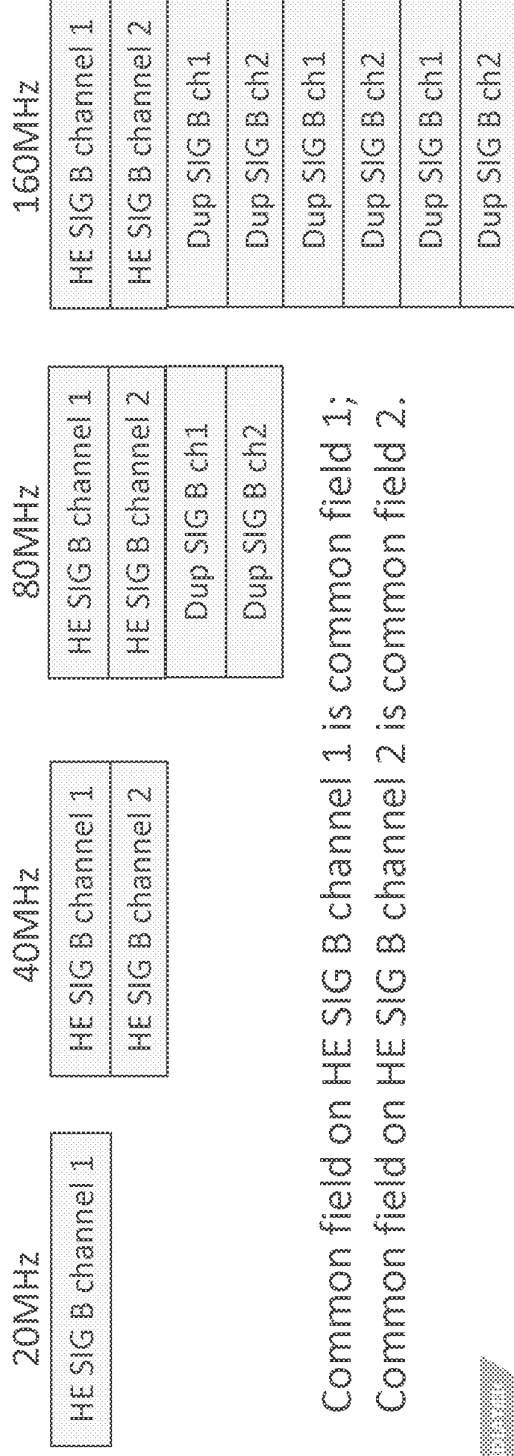


SIG B structure in 11ax

SIG B structure for 80MHz channel



The common field in HE SIG-B contains resource unit allocation.



Common field on HE SIG B channel 1 is common field 1;
Common field on HE SIG B channel 2 is common field 2.



Resource Allocation Signaling (1)

LUT 1:

- RU lookup table (LUT) Based →
5bits with 32 combinations

RU index labeling per 20MHz

1	2	3	4	5	6	7	8	9
10 (52 tone)	11 (52 tone)	12 (52 tone)	13 (52 tone)	14 (106 tone)	15 (106 tone)	16 (242 tone)	17 (106 tone)	18 (106 tone)
19 (106 tone)	20 (106 tone)	21 (106 tone)	22 (106 tone)	23 (106 tone)	24 (106 tone)	25 (106 tone)	26 (106 tone)	27 (106 tone)
28 (106 tone)	29 (106 tone)	30 (106 tone)	31 (106 tone)	32 (106 tone)	33 (106 tone)	34 (106 tone)	35 (106 tone)	36 (106 tone)



RU/LUT Index	RU Allocation Pattern	Description
0	[1 2 3 4 5 6 7 8 9]	all 26-tones
1	[10 11 12 13]	all 52-tones
2	[14 15]	all 106-tones
3	[10 3 4 5 6 7 8 9]	one 52-tones, seven 26-tones
4	[1 2 11 5 6 7 8 9]	one 52-tones, seven 26-tones
5	[1 2 3 4 5 12 8 9]	one 52-tones, seven 26-tones
6	[1 2 3 4 5 6 7 13]	one 52-tones, seven 26-tones
7	[10 11 5 6 7 8 9]	two 52-tone, five 26-tone
8	[10 3 4 5 12 8 9]	two 52-tone, five 26-tone
9	[10 3 4 5 6 7 13]	two 52-tone, five 26-tone
10	[1 2 11 5 12 8 9]	two 52-tone, five 26-tone
11	[1 2 11 5 6 7 13]	two 52-tone, five 26-tone
12	[1 2 3 4 5 12 13]	two 52-tone, five 26-tone
13	[10 11 5 12 8 9]	three 52-tone, three 26-tone
14	[10 11 5 6 7 13]	three 52-tone, three 26-tone
15	[10 3 4 5 12 13]	three 52-tone, three 26-tone
16	[1 2 11 5 12 13]	three 52-tone, three 26-tone
17	[14 5 6 7 8 9]	one 106-tone, all others
18	[14 5 12 8 9]	one 106-tone, all others
19	[14 5 6 7 13]	one 106-tone, all others
20	[14 5 12 13]	one 106-tone, all others
21	[1 2 3 4 5 15]	one 106-tone, all others
22	[10 3 4 5 15]	one 106-tone, all others
23	[1 2 11 5 15]	one 106-tone, all others
24	[10 11 5 15]	one 106-tone, all others
25	[16]	whole 20MHz (242-tone RU) for 1 STA
26	[16 16]	whole 40MHz (2x242 tone RU) for 1 STA
27	[16 16 16 16]	whole 80MHz (996 tone RU) for 1 STA
28	[14]* or [15]* or [14 15]*	106 tones allocation for MU
29	[16]*	whole 242 tones allocation for MU
30	[16 16]*	Whole 484 tones allocation for MU
31	[16 16 16 16]*	Whole 996 tones allocation for MU

- This is the basic RA signaling method for OFDMA.
- To support MU MIMO on OFDMA(index 28-31), number of STAs need to be provided for the MU-MIMO RUs.



Resource Allocation Signaling (2)

- For better supporting of MU-MIMO on OFDMA
- Extend RU indexing:
 - with MU-MIMO → 6 bits with total 42 combinations
 - MU-MIMO + #-user → 8 bits with total 175 combinations
 - First 28 combinations are same as the table LUT1

LUT2:

	#1	#2	#3	#4	#5	#6	#7	#8	#9
28		106			26			106	
29			106		26			106	
30				106	26			106	
31					26	26	26	26	26
32					26	26	26	52	
33					26		52	26	26
34					26		52		52
35	26	26	26	26	26			106	
36	26	26		52	26			106	
37		52	26	26	26			106	
38		52		52	26			106	
39					242				
40					484				
41					996				
42					2*996				

- Does not disambiguate the # of users per MU-MIMO RU when STAID addressing is used.
- Needs additional signaling bits to indicate # of users



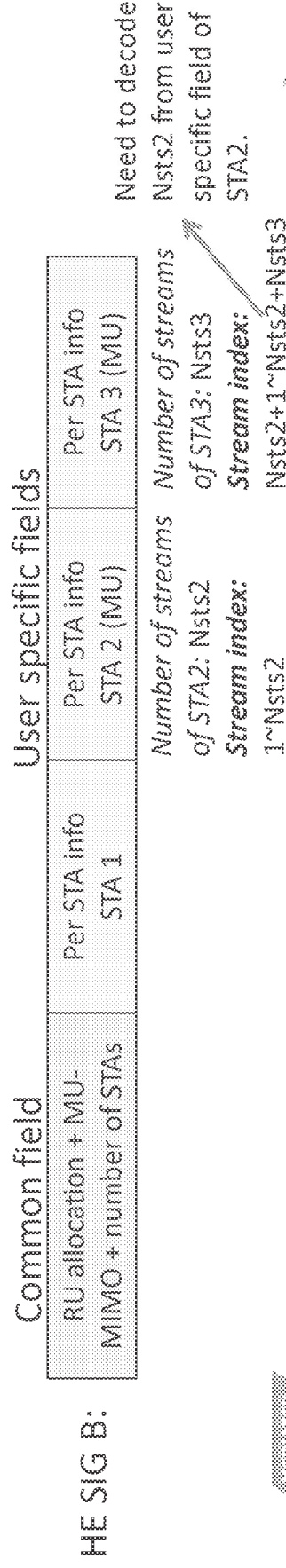
e.g. Index 3 – refers to SU transmissions in the RU
 Index 4 – refers to MU MIMO in the first 106 RU with 2 users and SU in the remaining RUs

LUT3:

	#1	#2	#3	#4	#5	#6	#7	#8	#9	Num User
1	26	26	26	26	26	26	26	26	26	1
2	52		52		26	52		52		1
3			106		26			106		64
56	52	26	26	26	26	26	26	26	26	1
67	26	26	52		26	26	26	26	26	1
68	26	26	26	26	26	52		26	26	1
69	26	26	26	26	26	26	26	52		1
70	52		52		26	26	26	26	26	1
71	52	26	26	26	26	52		26	26	1
72	52	26	26	26	26	26	26	52		1
73	26	26	52		26	52		26	26	1
74	26	26	52		26	26	26	52		1
75	26	26	26	26	26	52		52		1
76	52		52		26	52		26	26	1
77	52		52		26	26	26	52		1
78	52	26	26	26	26	52		52		1
79	26	26	52		26	52		52		1
87			106		26	26	26	26	26	8
95			106		26	26	26	52		8
103			106		26	52		26	26	8
111			106		26	52		52		8
119	26	26	26	26	26			106		8
127	26	26	52		26			106		8
135	52	26	26	26	26			106		8
143	52		52		26			106		8
151				242						8
159				484						8
167				996						8
175				2*996						8

Indication of stream allocation (1)

- Implicit stream allocation(SA) indication
 - Indicate the number of MU-MIMO STAs on each MU-MIMO RU in the common field
 - Each STA indicate the number of streams in its user specific field
 - No need to indicate the steam index or starting stream of an MU STA in its user specific field.
 - Drawback: An MU STA need to decode the number of streams of other MU STAs on the same RU to calculate its stream index.



Indication of stream allocation (2)

- Per user SA indication
 - To improve the reliability of HE-SIG B, avoid decoding of other STA's user specific information
 - Indicate the starting stream index and number of streams in the user specific field. The first MU STA of each MU RU can skip the starting stream index.

8

HE SIG B:	Common field		User specific fields			
	RU allocation + MU-MIMO + number of STAs	Per STA info STA 1	Per STA info STA 2 (MU)	Per STA info STA 3 (MU)	Per STA info STA 4 (MU)	
		Nsts1 (3bits)	Nsts2(3bits)	Nsts3 (3 bits)	Nsts4 (3 bits)	
				Starting stream index: Nsts2+1 (3 bits)	Starting stream index: Nsts2+Nsts3+1 (3 bits)	



Indication of stream allocation (3)

- SA indication in common field
 - Use a small SA LUT in the common field.
 - {1,2,3} and {2,1,3} can share the same index. Only need to assign indexes to sorted allocation patterns like {1,2},{1,2,2,3}, {1,2,3}
 - Only 58 stream allocation patterns for up to 8 streams
 - Per MU-MIMO RU, 6 bits in common part are enough for allocating streams to STAs and specifying the total number of streams

HE SIG B:

Common field		User specific fields	
RU allocation + MU-MIMO + number of STAs + SA LUT	Per STA info	Per STA info	Per STA info
	STA 1	STA 2 (MU)	STA 3 (MU)

For each RA LUT, add a SA LUT in the common field.

User specific fields for MU-MIMO STAs are same as non MU-MIMO STAs. No need to indicate the starting stream index. The index can be calculated from the stream allocation (SA) LUT.



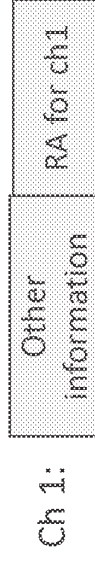
Remaining Problem

- The format and length of the HE SIG B common field need to be predetermined or indicated before HE SIG B.
 - We can design a fixed format common field in HE SIG B for each operation BW. Therefore the length and format of the common field is predetermined and need no indication in HE SIG A.
 - Simple but maybe less efficient.
 - We can also indicate the format of HE SIG B common field in the HE SIG A
 - to reduce the overhead and
 - enable flexible RA signaling in HE SIG B.



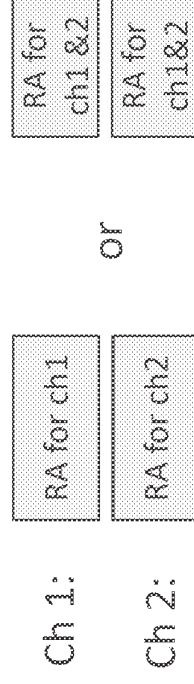
Fixed format Common field (1)

For 20MHz operation BW, there is one RA LUT on HE SIG B common field.



Other information in common field may include GI length for payload, LTF symbol length etc. These information bits have fixed length and format for all cases. Will skip in the following figures.

For 40MHz operation BW, there is one RA LUT on each HE SIG B common field.



To keep the fixed length and format of common field, RA LUT for 484 tone RU need to be duplicated on two common fields on HE SIG B channel 1&2

- RA for one channel means the RA LUT is signaling RU size ≤ 242 tone. Example: index < 158 in LUT 3.
- RA for 2 channels(example:ch1&2) means the RA LUT is signaling 484 tone RU. For example index 159-166 in LUT 3.
- RA for 4 channels(example: ch1-4) means the RA LUT is signaling 996 tone RU. For example index 167-174 in LUT 3.
- Format for user specific fields(USF): The RA LUT and the USFs for the STAs scheduled in the RA LUT are placed on the same HE SIG B channel. The USFs need to be placed in the order of their position in the RA LUT. The USF sets for STAs scheduled in different RA LUTs need to be placed in the same order of the RA LUTs.



Fixed format Common field (2)

For 80MHz operation BW, there are two RA LUTs on each HE SIG B common field.

Ch 1:

RA for ch1	RA for ch3
------------	------------

RA for ch1	RA for ch3&4
------------	--------------

Ch 2:

RA for ch2	RA for ch4
------------	------------

RA for ch2	RA for ch3&4
------------	--------------

Ch 3:

RA for ch1	RA for ch3
------------	------------

RA for ch1	RA for ch3&4
------------	--------------

Ch 4:

RA for ch2	RA for ch4
------------	------------

RA for ch2	RA for ch3&4
------------	--------------

Or

Or

RA for ch1&2	RA for ch3
--------------	------------

RA for ch1-4	RA for ch1-4
--------------	--------------

RA for ch1&2	RA for ch4
--------------	------------

RA for ch1-4	RA for ch1-4
--------------	--------------

RA for ch1&2	RA for ch3
--------------	------------

RA for ch1-4	RA for ch1-4
--------------	--------------

RA for ch1&2	RA for ch4
--------------	------------

RA for ch1-4	RA for ch1-4
--------------	--------------

This is MU-MIMO only case. For this case, an alternative signaling method is using 1 bit in HE SIG A to indicate and save all the RA LUTs in the HE SIG B common field. ¹²

To define the common field format, RA LUT need to be placed following some rules.

- 1). For STAs scheduled on RU size ≤ 242 tone, the RA LUT shall be found on the 20MHz channel that contains the scheduled RU for data.
- 2). For STAs scheduled on 484 tone RU, the RA LUT shall be duplicated on common fields.
- 3). For STAs scheduled on 996 tone RU, the RA LUT shall be duplicated twice on all common fields
- 4). On each common field, RA LUTs need to be placed in order. For example in the order of channel index signaled in the RA LUT, from lower channel to upper channel.

Fixed format Common field (3)

For 160MHz operation BW, there are four RA LUTs on each HE SIG B common field.

Ch 1:

RA for ch1	RA for ch3	RA for ch5	RA for ch7
---------------	---------------	---------------	---------------

Ch 2:

RA for ch2	RA for ch4	RA for ch6	RA for ch8
---------------	---------------	---------------	---------------

Ch 3:

RA for ch1	RA for ch3	RA for ch5	RA for ch7
---------------	---------------	---------------	---------------

Ch 4:

RA for ch2	RA for ch4	RA for ch6	RA for ch8
---------------	---------------	---------------	---------------

Ch 5:

RA for ch1	RA for ch3	RA for ch5	RA for ch7
---------------	---------------	---------------	---------------

Ch 6:

RA for ch2	RA for ch4	RA for ch6	RA for ch8
---------------	---------------	---------------	---------------

Ch 7:

RA for ch1	RA for ch3	RA for ch5	RA for ch7
---------------	---------------	---------------	---------------

Ch 8:

RA for ch2	RA for ch4	RA for ch6	RA for ch8
---------------	---------------	---------------	---------------

Or

RA for ch1-4	RA for ch1-4	RA for ch5&6	RA for ch7
-----------------	-----------------	-----------------	---------------

RA for ch1-4	RA for ch1-4	RA for ch5&6	RA for ch8
-----------------	-----------------	-----------------	---------------

: Duplicate on other channels similarly

Or

RA for ch1-4	RA for ch1-4	RA for ch5-8	RA for ch5-8
-----------------	-----------------	-----------------	-----------------

RA for ch1-4	RA for ch1-4	RA for ch5-8	RA for ch5-8
-----------------	-----------------	-----------------	-----------------

:

Or

RA for ch1-8	RA for ch1-8	RA for ch1-8	RA for ch1-8
-----------------	-----------------	-----------------	-----------------

RA for ch1-8	RA for ch1-8	RA for ch1-8	RA for ch1-8
-----------------	-----------------	-----------------	-----------------

:

Following the rules described in last slide, we can generate the HE SIG B common field for 160MHz operation BW similarly. For STAs scheduled on 2 x 996 tone RU, the RA LUT shall be duplicated 4 times on all common fields. This MU-MIMO only case can also be replaced by 1 bit indication in HE SIG A.



Common field format indication (1)

- To save some overhead in HE SIG B common field, we can use a few bits in HE SIG A to indicate the format of common field
 - Different format(or mode) of common field means different length and definition of common field.
 - The number of RA LUTs can be reduced with format indication.
 - For 80 MHz operation BW, without RA LUT duplication, 2 common fields (on HE SIG B channel 1 and channel 2) each may contain 1 or 2 RA LUTs. Need 2 bits to indicate all the combinations.
 - For 160MHz operation BW, without RA LUT duplication, 2 common fields each may contain 1, 2, 3 or 4 RA LUTs. Need 4 bits to indicate all the combinations.
 - To reduce the indication bits in HE SIG A, a smaller number of bits can be used to indicate a subset of the combinations.
 - All these bits in HE SIG A are reserved when BW is 20 or 40MHz.
 - With some additional indication in HE SIG A, the flexible signaling of resource allocation can also be supported.



Common field format indication (2)

- Using 2 bits format indication for 80MHz operation BW
 - The 2 bits format indication can be defined as:
 - 00: 2 RA LUTs on HE SIG B channel 1 and 2 RA LUTs on HE SIG B channel 2 (2, 2)
 - 01: 2 RA LUTs on HE SIG B channel 1 and 1 RA LUT on HE SIG B channel 2 (2, 1)
 - 10: 1 RA LUT on HE SIG B channel 1 and 2 RA LUTs on HE SIG B channel 2 (1, 2)
 - 11: 1 RA LUT on HE SIG B channel 1 and 1 RA LUT on HE SIG B channel 2 (1, 1)

Mode of HE SIG-B common field. Indicated in HE SIG A

00	RA for ch1	RA for ch3	User specific fields
	RA for ch2	RA for ch4	User specific fields
01	RA for ch1	RA for ch3&4	User specific fields
	RA for ch2	User specific fields	User specific fields
10	RA for ch3	User specific fields	User specific fields
	RA for ch1&2	RA for ch4	User specific fields
11	RA for ch1&2	User specific fields	User specific fields
	RA for ch3&4	User specific fields	User specific fields

HE SIG B Ch 1

HE SIG B Ch 2

RA LUT for 484 tone RU will not be duplicated on 2 HE SIG B channels. It can be flexibly placed on either channel.

With 2 RA LUTs for 484 tone RU, an order need to be defined. For example RA LUT signaling lower 484 tone RU shall be placed on HE SIG B channel 1.



Common field format indication (3)

■ Using 2 bits format indication for 160MHz operation BW

— The 2 bits format indication can be defined as:

- 00: (4, 4); 01: (3, 3); 10: (2, 2); 11: (1, 1)

User specific fields skipped in the figure.

New rules for RA LUT position need to be defined to avoid ambiguity.

7 RA LUTs case: There is 1 RA LUT for 484 tone RU. Duplicate the LUT for 484 tone RU to fit the (4, 4) structure.

8 LUTs	00	RA for ch1	RA for ch3	RA for ch5	RA for ch7
	00	RA for ch2	RA for ch4	RA for ch6	RA for ch8
7 LUTs	00	RA for ch1	RA for ch3	RA for ch5	RA for ch7&8
	00	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8

6 LUTs	01	RA for ch1	RA for ch3&4	RA for ch5	
	01	RA for ch2	RA for ch6	RA for ch7&8	

5 LUTs	01	RA for ch1&2	RA for ch3	RA for ch7&8	
	01	RA for ch4	RA for ch5&6	RA for ch7&8	

5 LUTs	01	RA for ch1-4	RA for ch5	RA for ch7	
	01	RA for ch1-4	RA for ch6	RA for ch8	

6 RA LUTs case: There are 2 RA LUTs for 484 tone RU. The LUT for lower 484 RU shall be placed on common field 1.

No duplication needed to fit the (3, 3) structure.

5 LUTs case: There will be 1) 3 LUTs for 484 tone RU or 2) 1 LUT for 996 tone RU.

For 1), The LUT for lowest 484 RU shall be placed on common field 1, LUT for middle 484 tone RU shall be placed on common field 2, LUT for upper most 484 tone RU shall be duplicated.

For 2), duplicate the LUT for 996 tone RU to fit the (3, 3) structure.



Common field format indication (4)

4 LUTs	10	RA for ch1&2	RA for ch5&6
	10	RA for ch3&4	RA for ch7&8
4 LUTs	10	RA for ch1	RA for ch3&4
	10	RA for ch2	RA for ch5-8
3 LUTs	10	RA for ch1-4	RA for ch5&6
	10	RA for ch1-4	RA for ch7&8
2 LUTs	11	RA for ch1-4	
	11	RA for ch5-8	
1 LUT	11	RA for ch1-8	
	11	RA for ch1-8	

4 LUTs case: There will be: 1) 4 LUTs for 484 tone RU or 2) 1 LUT for 996 tone RU and 1 LUT for 484 tone RU.
For 1), The LUTs shall be placed in order on common field 1 and 2. From lower RU to upper RU placed on common field 1-> 2->1->2. For 2), the LUT for 996 tone RU and LUT for 484 tone RU shall be placed on different common field.

3 LUTs case: There are 2 LUTs for 484 tone RU and 1 LUT for 996 tone RU. The LUT for 996 tone RU shall be duplicate on 2 common fields. The LUTs for 484 tone RU shall be placed on 2 common fields in order. For example lower 484 tone RU on common field 1. **2 LUTs case:** There are 2 LUTs for 996 tone RU. The LUTs shall be placed on 2 common fields in order.

1 LUT case: There are 1 LUT for 2x996 tone RU. The LUT shall be duplicated on 2 common fields. This is MU-MIMO only case.

Summary of rules for RA LUT position:

1. For STAs scheduled on RU size ≤ 242 tone, their RA LUTs shall be found on the same 20MHz channel as data.
2. RA LUTs for same number of 20MHz channels shall be placed on common field 1 and 2 in some special order. For example place LUTs signaling lower channels to upper channels on common field 1->2->1->2....
3. On each common field, all RA LUTs shall be placed in some given order. For example order the RA LUTs from LUT signaling lower channel to LUT signaling upper channel.
4. If LUT duplication is needed, duplicate the LUT for largest number of channels. If there are multiple such LUTs, duplicate the LUT for upper most channel.



Common field format indication (5)

- Using 1 bit format indication for 80MHz operation BW
 - Example of 1 bit format indication:
 - 0: Each common field include 2 RA LUTs (2, 2)
 - 1: Each common field include 1 RA LUT (1, 1)
 - For (2,1) or (1,2) case, duplicate the RA LUT for 484 tone RU. And the order of RA LUTs follow same rule as described in slide 17.

0	RA for ch1	RA for ch3	User specific fields	HE SIG B Ch 1
0	RA for ch2	RA for ch4	User specific fields	HE SIG B Ch 2
0	RA for ch1	RA for ch3&4	User specific fields	
0	RA for ch2	RA for ch3&4	User specific fields	
0	RA for ch1&2	RA for ch3	User specific fields	
0	RA for ch1&2	RA for ch4	User specific fields	
1	RA for ch1&2	User specific fields		
1	RA for ch3&4	User specific fields		



Common field format indication (6)

- Using 1 bit format indication for 160MHz operation BW
 - Example of 1 bit format indication:
 - Example 1: 0 indicate Each common field include 4 RA LUTs (4, 4); 1 indicate (1, 1). For all other combinations, signal the RA LUT follow the rules on slide 12.

6 LUTs

0	RA for ch1	RA for ch3&4	RA for ch5	RA for ch7&8
0	RA for ch2	RA for ch3&4	RA for ch6	RA for ch7&8

2 LUTs

1	RA for ch1-4
1	RA for ch5-8

- Example 2: 0 indicate (4, 4); 1 indicate (2, 2). For the cases with 5-8 RA LUTs, signal the LUTs follow the rules on slide 12. For the cases with 3-4 LUTs, follow the rules on slide 17. For 2 LUT case and 1 LUT case, duplicate to fit the (2, 2) structure.

2 LUTs

1	RA for ch1-4	RA for ch5-8
1	RA for ch1-4	RA for ch5-8

1 LUT

1	RA for ch1-8	RA for ch1-8
1	RA for ch1-8	RA for ch1-8



Common field format indication (7)

- Using 3 bit format indication
 - For 80MHz BW, reserve 1 bit and use 2 bits indication same as slide 15.
 - For 160MHz BW, 3 bits can indicate 8 RA LUT combinations on 2 common fields. Example of 3 bit format indication
 - 000~111 indicates LUT combination (4, 4), (4, 3), (3, 4), (2, 2), (2, 1), (1, 2), (1, 1), (0, 0). (0, 0) means pure MU-MIMO case and no RA LUTs in the common fields.
- Using 4 bit format indication
 - For 80MHz BW, reserve 2 bits and use 2 bits indication same as slide 15.
 - For 160MHz BW, 4 bits can indicate all RA LUT combinations on 2 common fields.



Flexible resource allocation signaling (1)

- The number of STAs scheduled by one RA LUT varies a lot.
 - Range from 1 to 17 if no limitation on number of STA per 20Mhz. Range from 1 to 9 if number of STA for each 20Mhz limited to 9.
 - The number of user specific field on 2 common fields can be quite different. But the length of HE SIG B is the same for all channels.

LUT 1 schedule		LUT 3 schedule		A lot of padding bits needed for unbalanced HE SIG B channels.	
1 STA for ch 1		1 STA for ch 3			
00	RA for ch1	RA for ch3	STA 1	STA 2	HE SIG B Ch 1
00	RA for ch2	RA for ch4	STA 3	STA 4	HE SIG B Ch 2
			...	STA 12	

- User specific fields
- With flexible resource allocation(FRA) signaling, the load of 2 HE SIG B channels can be balanced.



Flexible resource allocation signaling (2)

- One method for FRA is adding a few bits for each RA LUT indicating which channel the corresponding LUT is scheduling for.

Channel index:

Indicate the channel that the following LUT is signaling for

User specific fields

00	Ch 1	RA LUT 1	Ch 2	RA LUT 2	STA 1	STA 3	...	STA 7
00	Ch 3	RA LUT 3	Ch 4	RA LUT 4	STA 2	STA 8	...	STA 12

- The format of HE SIG B common field is different when FRA is enabled.

- Additional NxM bits are needed in common fields to support FRA
 - N is the number of RA LUTs in the common field and M is the number of bits for signaling the channel index.
- In some scenarios, FRA is not needed and common field can save the additional bits.

- We propose to add 1 bit in HE SIG A to enable/disable the FRA feature.

1	00	Ch 1	RA LUT 1	Ch 2	RA LUT 2
1	00	Ch 3	RA LUT 3	Ch 4	RA LUT 4

FRA indication bit

FRA enabled

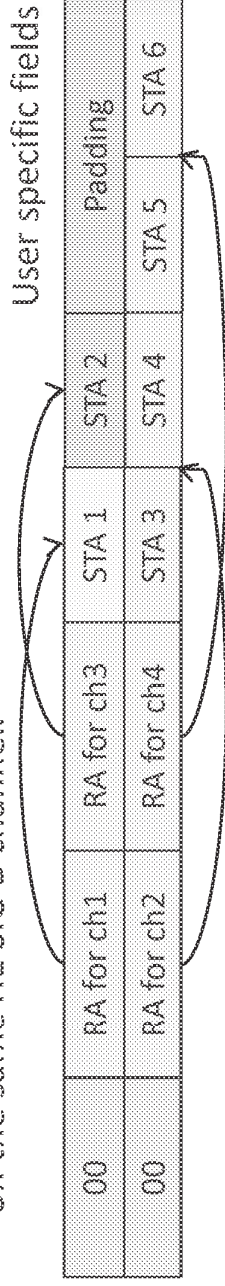
0	00	RA LUT 1	RA LUT 3
0	00	RA LUT 2	RA LUT 4

FRA disabled

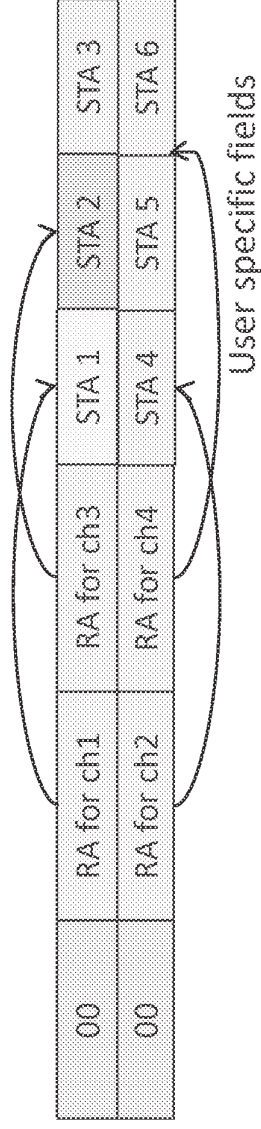


Flexible resource allocation signaling (3)

- All the previous signaling method has an assumption:
 - The RA LUT and the user specific fields for the STAs scheduled in the RA LUT are placed on the same HE SIG B channel.



- An alternative method to enable FRA signaling is to allow placing the user specific field of a STA on different channel from the RA LUT signaling it.
 - Need to define some rules for placing the user specific field to balance the load.
 - STAs scheduled by one RA LUT need to be placed in order. Sets of STAs scheduled by ordered RA LUTs also need to be placed in same order as LUTs.



Flexible resource allocation signaling (4)

- User specific field placing rules to achieve load balancing on 2 HE SIG B channels.
 - Assume N1 RA LUTs on HE SIG B channel 1 scheduling M1 STAs and N2 RA LUTs on HE SIG B channel 2 scheduling M2 STAs.
 - Order the M=M1+M2 STAs together. For example order M2 STAs scheduled by LUTs on HE SIG B channel 2 after M1 STAs scheduled by LUTs on HE SIG B channel 1.
 - Place the user specific fields for first S STAs on HE SIG B channel 1 and the user specific fields for the rest of the STAs on HE SIG B channel 2 so that the length difference of 2 HE SIG B channels is minimized.

$$S = \text{argmin}_{\{S\}} \left(\frac{\text{Bits_total}}{2 - \text{Bits_comm1} - \text{Bits}_S} \right)$$

where Bits_total is the total number of bits in HE SIG B for 2 channels. Can be calculated based the information from common fields.

$$\text{Bits_total} = \text{Bits_comm1} + \text{Bits_comm2} + \text{Bits}_M$$

Bits_comm1 is the number of bits for common field on HE SIG B channel 1, including information bits and CRC/Tail bits.

Bits_S is the total number of bits for user specific fields from STA 1 to STA S, including information bits and CRC/Tail bits for each BCC block of user specific fields.



Flexible resource allocation signaling (5)

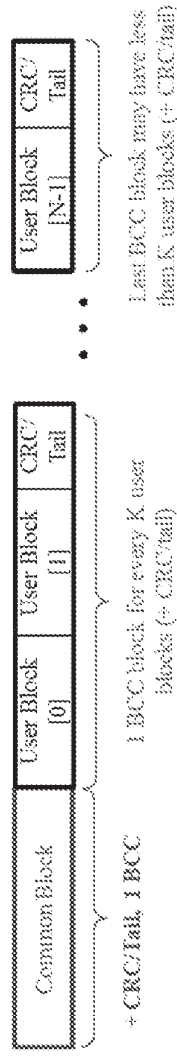
- If the following coding structure is applied for HE SIG B
 - Assume M STAs scheduled by all the RA LUTs in the HE SIG B can be grouped into C BCC blocks.
 - Place the user specific fields for first S BCC blocks of STAs on HE SIG B channel 1 and the user specific fields for the rest of the STAs on HE SIG B channel 2 so that the length difference of 2 HE SIG B channels is minimized.

$$S = \text{argmin}_{\{S\}}(|\text{Bits_total}/2 - \text{Bits_comm1} - \text{Bits_S}|)$$

where Bits_total is the total number of bits in HE SIG B for 2 channels.

Bits_comm1 is the number of bits for common field on HE SIG B channel 1.

Bits_S is the total number of bits for user specific fields from BCC block 1 to BCC block S, including information bits and CRC/Tail bits for each BCC block.



Indication of FRA signaling in HE SIG A

- We proposed 1 bit FRA indication in HE SIG A to enable/disable the flexible resource allocation signaling feature.

STA 1 to STA M1 scheduled in RA LUTs on HE SIG B channel 1

0	00	RA for ch1	RA for ch3	STA 1	...	STA M1	Padding	HE SIG B Ch 1
0	00	RA for ch2	RA for ch4	STA M1+1	...	...	STA M1+M2	HE SIG B Ch 2

✓ FRA disabled

STA M1+1 to STA M1+M2 scheduled in RA LUTs on HE SIG B channel 2

1	00	RA for ch1	RA for ch3	STA 1	...	STA S	HE SIG B Ch 1
1	00	RA for ch2	RA for ch4	STA S+1	...	STA S+M2	HE SIG B Ch 2

- ✓ FRA enabled
- Common field format but their user specific fields are placed on HE SIG B channel 1 to indication bits balance the load of the 2 HE SIG B channels.
- With FRA enable bit and common field format indication bits, the length of HE SIG B can be calculated after HE SIG B common field is decoded.

- Length of HE SIG B field bits in HE SIG A may not needed. Therefore indication FRA and common field format in HE SIG A may not bring any additional overhead.



Indication of middle 26 tone RU for 80Mhz BW and 160Mhz BW (1)

- The middle 26 tone RU for 80MHz BW can not be signaled in the existing RA LUTs shown in slide 5 and 6.
- One indication method is 1 bit indication in the common field
 - If operation BW is 80MHz, define 1 bit in the common field to indicate whether the middle 26 tone RU is used. This bit duplicates on common field 1 and 2.
 - If operation BW is 160MHz, define 1 bit in the common field to indicate whether the middle 26 tone RU is used.
 - The bit in common field 1 indicates the middle 26 tone RU for the lower 80MHz.
 - The bit in common field 2 indicates the middle 26 tone RU for the upper 80MHz.
 - The user specific field for the STA assigned to the middle RU shall be placed in a predefined position.
 - For 80MHz, it can be placed at end of HE SIG B channel 1 or 2 or both. It can also be placed at the end of the shorter HE SIG B channel to help balance the load.
 - For 160MHz, STA assigned to middle RU of lower 80MHz can be placed at the end of HE SIG B channel 1 and STA assigned to middle RA of upper 80MHz can be placed at the end of HE SIG B channel 2.



Indication of middle 26 tone RU for 80Mhz BW and 160Mhz BW (2)

- Method 2: Always define one user specific field for the middle 26 tone RU when operation BW is 80MHz and define two user specific fields for middle RU of lower and upper 80MHz when operation BW is 160MHz.
 - If no STA assigned on the middle RU, define the user specific field for a virtual STA (use a special AID or unallocated AID).
 - No need for the 1 bit indication in the common field. Since most of the cases AP shall not waste the middle 26 tone RU, the 1 bit indication is saved in the common field.
 - The method to place the user specific field for the STA(s) assigned to the middle RU(s) is the same as described in last slide(27).

User specific field for STA assigned on middle 26 tone RU

BW = 80Mhz

0	00	RA LUT 1	RA LUT 3	STA 1	...	STA M1	Mid RU	HE SIG B Ch 1
0	00	RA LUT 2	RA LUT 4	STA M1+1	...	...	STA M1+M2 P	HE SIG B Ch 2

User specific field for STA assigned on middle 26 tone RU of lower 80Mhz

BW = 80Mhz

0	00	RA LUT 1	RA LUT 3	STA 1	...	STA M1	Lower 80	Padding
0	00	RA LUT 2	RA LUT 4	STA M1+1	...	...	STA M1+M2 Upper 80	

User specific field for STA assigned on middle 26 tone RU of upper 80Mhz



Indication of middle 26 tone RU for 80Mhz BW and 160Mhz BW (3)

- Method 3: Use 2 unused indices in the RA LUT to indicate whether the middle 26 tone RU for 80Mhz is assigned or not.
 - Need an additional RA LUT in common field when operation BW is 80Mhz or 160Mhz.

LUT for middle 26 tone RU of lower 80Mhz indicates this RU is assigned to some STA. User specific field for STA assigned on middle 26 tone RU of lower 80Mhz

BW = 160Mhz

0	00	RA LUT 1	RA LUT 3	Lower 80	STA 1	...	STA M1	Lower 80
0	00	RA LUT 2	RA LUT 4	Upper 80	STA M1+1	...	STA M1+M2	P

LUT for middle 26 tone RU of upper 80Mhz indicates this RU is not assigned to any STA.

No user specific field for middle 26 tone RU of upper 80Mhz



Backup slides: Some other thoughts on Common field format indication



Common field format indication

- With indication in HE SIG-A, overhead can be saved for common fields.
- The common field format indication are related to the following:
 - Common field has SA indication?
 - Common field duplicate on all 20Mhz?
 - If common field not duplicate on all 20Mhz, but only duplicate on odd or even 20Mhz channels, is flexible resource allocation signaling supported?
 - Flexible resource allocation signaling means allowing signaling the resource allocation of any 20Mhz channel on any common field. (Common field on odd or even channels.)
 - If no flexible RA signaling, RA signaling odd channels shall be placed on common field on odd channels and RA signaling even channels placed on even channels.

20MHz

Ch 1:	RA for ch1	RA for ch3	Per STA info part	Data on ch1	Ch 1:	RA for ch1	RA for ch2	RA for ch3	Per STA info part	Data on ch1
Ch 2:	RA for ch2	RA for ch4	Per STA info part	Data on ch2	Ch 2:	RA for ch4	Per STA info part			Data on ch2
Ch 3:	RA for ch1	RA for ch3	Per STA info part	Data on ch3	Ch 3:	RA for ch1	RA for ch2	RA for ch3	Per STA info part	Data on ch3
Ch 4:	RA for ch2	RA for ch4	Per STA info part	Data on ch4	Ch 4:	RA for ch4	Per STA info part			Data on ch4



Flexible RA signaling

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Common field format indication for case 1 (1)

- No SA in common field; No flexible RA signaling; common field 1 and 2 are not duplicated

- Need to indicate mode of HE SIG B common field on odd and even channels. For 160MHz BW, each common field may have 1~4 RA LUTs hence need 2 bits indication. For 2 common fields, we need 4 bits in HE SIG A to indicate the modes.

Mode of HE SIG B common field:

Mode 1 is mode of common field on odd 20MHz channels. It can be number of RA LUTs;

Mode 2 is mode of common field on even 20MHz channels. It can be number of RA LUTs.

Ch 1:	Mode 1, mode 2	Other contents	RA for ch1	RA for ch3&4	Per STA info STA 1	Per STA info STA 6 (MU)	Per STA info STA 7 (MU)	padding
Ch 2:	Mode 1, mode 2	Other contents	RA for ch2	Per STA info STA 2	Per STA info STA 3	Per STA info STA 4 (MU)	Per STA info STA 5 (MU)	
Ch 3:	Mode 1, mode 2	Other contents	RA for ch1	RA for ch3&4	Per STA info STA 1	Per STA info STA 6 (MU)	Per STA info STA 7 (MU)	
Ch 4:	Mode 1, mode 2	Other contents	RA for ch2	Per STA info STA 2	Per STA info STA 3	Per STA info STA 4 (MU)	Per STA info STA 5 (MU)	

HE SIG A Common field 1 Common field 2

Common field format indication for case 1 (2)

Save 3 RA LUTs

LUT for 996 tone RU

Ch 1:	<table><tr><td>1, 1</td><td>RA for ch1-4</td></tr></table>	1, 1	RA for ch1-4	<table><tr><td>1, 2</td><td>RA for ch1-4</td></tr></table>	1, 2	RA for ch1-4	<table><tr><td>3, 4</td><td>RA for ch1</td><td>RA for ch3</td><td>RA for ch5</td></tr></table>	3, 4	RA for ch1	RA for ch3	RA for ch5		
1, 1	RA for ch1-4												
1, 2	RA for ch1-4												
3, 4	RA for ch1	RA for ch3	RA for ch5										
Ch 2:	<table><tr><td>1, 1</td><td>RA for ch5-8</td></tr></table>	1, 1	RA for ch5-8	<table><tr><td>1, 2</td><td>RA for ch5&6</td><td>RA for ch7&8</td></tr></table>	1, 2	RA for ch5&6	RA for ch7&8	<table><tr><td>3, 4</td><td>RA for ch2</td><td>RA for ch4</td><td>RA for ch6</td><td>RA for ch7&8</td></tr></table>	3, 4	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8
1, 1	RA for ch5-8												
1, 2	RA for ch5&6	RA for ch7&8											
3, 4	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8									
Ch 3:	<table><tr><td>1, 1</td><td>RA for ch1-4</td></tr></table>	1, 1	RA for ch1-4	<table><tr><td>1, 2</td><td>RA for ch1-4</td></tr></table>	1, 2	RA for ch1-4	<table><tr><td>3, 4</td><td>RA for ch1</td><td>RA for ch3</td><td>RA for ch5</td></tr></table>	3, 4	RA for ch1	RA for ch3	RA for ch5		
1, 1	RA for ch1-4												
1, 2	RA for ch1-4												
3, 4	RA for ch1	RA for ch3	RA for ch5										
Ch 4:	<table><tr><td>1, 1</td><td>RA for ch5-8</td></tr></table>	1, 1	RA for ch5-8	<table><tr><td>1, 2</td><td>RA for ch5&6</td><td>RA for ch7&8</td></tr></table>	1, 2	RA for ch5&6	RA for ch7&8	<table><tr><td>3, 4</td><td>RA for ch2</td><td>RA for ch4</td><td>RA for ch6</td><td>RA for ch7&8</td></tr></table>	3, 4	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8
1, 1	RA for ch5-8												
1, 2	RA for ch5&6	RA for ch7&8											
3, 4	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8									
Ch 5:	<table><tr><td>1, 1</td><td>RA for ch1-4</td></tr></table>	1, 1	RA for ch1-4	<table><tr><td>1, 2</td><td>RA for ch1-4</td></tr></table>	1, 2	RA for ch1-4	<table><tr><td>3, 4</td><td>RA for ch1</td><td>RA for ch3</td><td>RA for ch5</td></tr></table>	3, 4	RA for ch1	RA for ch3	RA for ch5		
1, 1	RA for ch1-4												
1, 2	RA for ch1-4												
3, 4	RA for ch1	RA for ch3	RA for ch5										
Ch 6:	<table><tr><td>1, 1</td><td>RA for ch5-8</td></tr></table>	1, 1	RA for ch5-8	<table><tr><td>1, 2</td><td>RA for ch5&6</td><td>RA for ch7&8</td></tr></table>	1, 2	RA for ch5&6	RA for ch7&8	<table><tr><td>3, 4</td><td>RA for ch2</td><td>RA for ch4</td><td>RA for ch6</td><td>RA for ch7&8</td></tr></table>	3, 4	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8
1, 1	RA for ch5-8												
1, 2	RA for ch5&6	RA for ch7&8											
3, 4	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8									
Ch 7:	<table><tr><td>1, 1</td><td>RA for ch1-4</td></tr></table>	1, 1	RA for ch1-4	<table><tr><td>1, 2</td><td>RA for ch1-4</td></tr></table>	1, 2	RA for ch1-4	<table><tr><td>3, 4</td><td>RA for ch1</td><td>RA for ch3</td><td>RA for ch5</td></tr></table>	3, 4	RA for ch1	RA for ch3	RA for ch5		
1, 1	RA for ch1-4												
1, 2	RA for ch1-4												
3, 4	RA for ch1	RA for ch3	RA for ch5										
Ch 8:	<table><tr><td>1, 1</td><td>RA for ch5-8</td></tr></table>	1, 1	RA for ch5-8	<table><tr><td>1, 2</td><td>RA for ch5&6</td><td>RA for ch7&8</td></tr></table>	1, 2	RA for ch5&6	RA for ch7&8	<table><tr><td>3, 4</td><td>RA for ch2</td><td>RA for ch4</td><td>RA for ch6</td><td>RA for ch7&8</td></tr></table>	3, 4	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8
1, 1	RA for ch5-8												
1, 2	RA for ch5&6	RA for ch7&8											
3, 4	RA for ch2	RA for ch4	RA for ch6	RA for ch7&8									

Modes:

1 LUT for common field 1

1 LUT for common field 2

Example of some modes for HE SIG-B common fields



Common field format indication for case 1 (3)

- To avoid ambiguity, need to define some rules for RA positioning in the common field.
 - In each common field, the RA LUT shall be placed in the order of channel index they are signaling.
 - RA for 484 tone RU can be placed in common fields of either odd channels or even channels.
 - Position of RA for 996 tone RU(index 167-174 in LUT3) of lower and upper 80MHz need to be defined. Example:
 - RA for 996 tone RU of lower 80 MHz (ch 1-4 in last slide) shall be placed on common field of odd channels.
 - RA for 996 tone RU of upper 80 MHz (ch 1-4 in last slide) shall be placed on common field of even channels.
 - If not specified, there will be ambiguity. Middle fig in last slide can have different interpretation.



Common field format indication for case 2

- No SA in common field and common field duplicate on all 20MHz channels (No flexible RA signaling)
 - If for each 20MHz, resource allocation (RA, including RU allocation, MU-MIMO and number of STAs on each MU RU) can be indicated by a fixed number of bits(using LUT3), HE SIG A need to indicate the mode of HE SIG B common field. The mode can be defined as length of HE SIG B common field or number of LUTs in the HE SIG B common field.
 - Example: One LUT may indicate RA for 20MHz, 40MHz or 80MHz. Therefore for 80MHz bandwidth(BW) OFDMA system, there might be 2, 3 or 4 LUTs in the common field. For 160MHz BW, there might be 2, 3, 4, 5, 6, 7 or 8 LUTs in the common field. Need 3 bits indication in HE SIG A.

20MHz

Ch 1:	Include # of LUTs	Other contents	RA for ch1	RA for ch2	RA for ch3&4	Per STA info STA 1	Per STA info STA 2	Per STA info STA 3
Ch 2:	Include # of LUTs	Other contents	RA for ch1	RA for ch2	RA for ch3&4	Per STA info STA 4 (MU)	Per STA info STA 5 (MU)	Per STA info STA 6 (MU)
Ch 3:	Include # of LUTs	Other contents	RA for ch1	RA for ch2	RA for ch3&4	Per STA info STA 1	Per STA info STA 2	Per STA info STA 3
Ch 4:	Include # of LUTs	Other contents	RA for ch1	RA for ch2	RA for ch3&4	Per STA info STA 4 (MU)	Per STA info STA 5 (MU)	Per STA info STA 6 (MU)

HE SIG A

Duplicate common fields



Common field format indication for case 3

- No SA in common field; flexible RA signaling; common field duplicate on odd or even 20MHz channels.
 - For each common field, the number of RAs is not fixed. When operation bandwidth(BW) is 160MHz, the number of RAs on one common field can be 1-7. Need to indicate the number of RAs (# RA LUT) for both common field on odd channels and even channels. Need 3 bits for one common field and total 6 bits in HE SIG-A for common field format indication.
 - Totally we have 28 combination of # RAs. So we can use 5 bits indication in HE SIG A.
 - (1,1);(1,2);(1,3);(1,4);(1,5);(1,6);(1,7);
 - (2,1);(2,2);(2,3);(2,4);(2,5);(2,6);
 - ...
 - (7,1)



Common field format indication for case 4

- Include SA in common field; no flexible RA signaling; common field duplicate on odd or even 20MHz channels.
 - For each common field, need to indicate the number of RA LUTs and number of SA LUTs.
 - For 160MHz BW, each common field may include 1-4 RA LUT and 0-8 SA LUTs hence need 2+4 bits indication in HE SIG A. Total 12 bits needed for common field format indication



Common field format indication for case 5

- Include SA in common field; no flexible RA signaling; common field duplicate on all 20MHz channels
 - Need to indicate the number of RA LUTs and number of SA LUTs for the common field.
 - For 160MHz BW, common field may include 2-8 RA LUT and 0-16 SA LUTs hence need totally $3+5=8$ bits indication in HE SIG A.

Common field format indication for case 6

- Include SA in common field; flexible RA signaling; common field duplicate on odd or even 20MHz channels.
 - Need to indicate the number of RA LUTs and number of SA LUTs for two common fields on odd and even channels.
 - For 160MHz BW, each common field may include 1-7 RA LUT and 0-14 SA LUTs hence need $3+4=7$ bits indication. Total 14 bits indication in HE SIG A.

Our major claims

- Indication of HE SIG B common field format in HE SIG A
- Indication of flexible resource allocation signaling in HE SIG A
- Methods to indicate the middle 26 tone RU for 80MHz and 160MHz operation BW in HE SIG B.
- For fixed format HE SIG B common field, design the rules to define the HE SIG B common field format
- With common field format indication, design the rules to define the HE SIG B common field format
- The algorithm for flexible resource allocation



Claim

1. A method, comprising,
transmitting by a first wireless device a packet;
wherein the packet comprises a HE SIG A field and a HE SIG B field, and the HE SIG A field includes an indication of a HE SIG B common field format.
2. A wireless device, comprising,
a signal processing circuit for generating a packet, wherein the packet comprises a HE SIG A field and a HE SIG B field, and the HE SIG A field includes an indication of a HE SIG B common field format; and
a transmitting circuit for transmitting the packet.
3. A method, comprising,
transmitting by a first wireless device a packet;
wherein the packet comprises a HE SIG A field, and the HE SIG A field includes an indication of flexible resource allocation signaling .
4. A wireless device, comprising,
a signal processing circuit for generating a packet, wherein the packet comprises a HE SIG A field, and the HE SIG A field includes an indication of flexible resource allocation signaling ; and
a transmitting circuit for transmitting the packet.





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page 1 of 3