DESCRIPTION

TITLE OF INVENTION: COMMUNICATION APPARATUS AND COMMUNICATION METHOD FOR RESOURCE ALLOCATION FOR NDP FEEDBACK REPORT RESPONSE

TECHNICAL FIELD

[0001] The present disclosure relates generally to communication apparatuses and communication methods, and more particularly, communication apparatuses and communication methods for resource allocation for null data packet (NDP) feedback report response.

BACKGROUND

[0002] The Institute of Electrical and Electronics Engineers (IEEE) P802.11-REVme/D7.0 defines an NDP feedback report procedure that allows an access point (AP) to send an NDP feedback report poll (NFRP) Trigger frame, to solicit NDP feedback report responses from one or more stations (STAs). These NDP feedback report responses are trigger-based (TB) feedback NDPs. Each STA triggered by the NFRP Trigger frame may transmit a feedback status bit by modulating a set of subcarriers in the long training field (LTF) of the TB feedback NDP according to the assigned resource unit (RU) tone set index and feedback status.

[0003] However, in the current NDP feedback report procedure, an AP allocates a group of RU tone sets with contiguous indices to a group of STAs with association identifiers (AIDs) within a continuous range. This restricted resource allocation scheme may lead to issues including limited polling capability and inefficient utilisation of resources.

[0004] Accordingly, there exists a need to provide a novel communication apparatus and communication method for resource allocation for NDP feedback report response that can address the above issues.

[0005] Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0006] Non-limiting and exemplary embodiments facilitate providing communication apparatuses and communication methods for resource allocation for NDP feedback report response.

[0007] In a first aspect, the present disclosure provides a first communication apparatus comprising: circuitry, which in operation, generates a trigger frame for obtaining a response from one or more second communication apparatuses, the trigger frame comprising information for allocating respective resources to the one or more second communication apparatuses for transmitting the response; and a transmitter, which in operation, transmits the trigger frame to the one or more second communication apparatuses.

[0008] In a second aspect, the present disclosure provides a second communication apparatus comprising: a receiver, which in operation, receives a trigger frame from a first communication apparatus for obtaining a response from the second communication apparatus, the trigger frame comprising information for allocating a resource to the second communication apparatus for transmitting the response; and circuitry, which in operation, determines the resource for transmitting the response to the first communication apparatus based on the information.

[0009] In a third aspect, the present disclosure provides a communication method implemented by a first communication apparatus comprising: generating a trigger frame for obtaining a response from one or more second communication apparatuses, the trigger frame comprising information for allocating respective resources to the one or more second communication apparatuses for transmitting the response; and transmitting the trigger frame to the one or more second communication apparatuses.

[0010] In a fourth aspect, the present disclosure provides a communication method implemented by a second communication apparatus comprising: receiving a trigger frame from a first communication apparatus for obtaining a response from the second communication apparatus, the trigger frame comprising information for allocating a resource to the second communication apparatus for transmitting the response; and determining the resource for transmitting the response to the first communication apparatus based on the information.

[0011] It should be noted that general or specific embodiments may be implemented as a system, a method, an integrated circuit, a computer program, a storage medium, or any selective combination thereof. Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views and which together with the detailed description below are incorporated in and form part of the specification, serve to illustrate various embodiments and to explain various principles and advantages in accordance with present embodiments.

[0013] Figure 1 shows a schematic diagram illustrating an NDP feedback report procedure involving an AP and multiple STAs.

[0014] Figure 2 shows an exemplary format of an NFRP Trigger frame according to various embodiments of the present disclosure.

[0015] Figure 3 shows an exemplary format of a User Info field in an NFRP Trigger frame according to a first embodiment of the present disclosure.

[0016] Figure 4 shows another exemplary format of a User Info field in an NFRP Trigger frame according to the first embodiment of the present disclosure.

[0017] Figure 5 shows an example of two User Info fields in an NFRP Trigger frame according to the first embodiment of the present disclosure.

[0018] Figure 6 shows another example of two User Info fields in an NFRP Trigger frame according to the first embodiment of the present disclosure.

[0019] Figure 7 shows yet another example of two User Info fields in an NFRP Trigger frame according to the first embodiment of the present disclosure.

[0020] Figure 8 shows an exemplary format of a User Info field in an NFRP Trigger frame according to a first implementation of a second embodiment of the present disclosure.

[0021] Figure 9 shows an exemplary format of a User Info field in an NFRP Trigger frame according to a second implementation of the second embodiment of the present disclosure.

[0022] Figures 10 and 11 show an exemplary frequency resource allocation according to the second implementation of the second embodiment of the present disclosure.

[0023] Figure 12 shows an exemplary format of a User Info field in an NFRP Trigger frame according to a third implementation of the second embodiment of the present disclosure.

[0024] Figure 13 shows a flow chart illustrating a process for calculating offset according to the third implementation of the second embodiment of the present disclosure.

[0025] Figure 14 shows a schematic diagram illustrating allocation of different groups of RU tone sets to different groups of STAs according to the second embodiment of the present disclosure.

[0026] Figure 15 shows a schematic diagram illustrating allocation of RU tone sets within non-punctured subchannels to groups of STAs according to the second embodiment of the present disclosure.

[0027] Figure 16 shows a schematic diagram illustrating allocation of frequency resources and spatial resources to different groups of STAs according to variations of the second embodiment of the present disclosure.

[0028] Figures 17 to 19 show exemplary formats of a User Info field in an NFRP Trigger frame according to variations of the second embodiment of the present disclosure.

[0029] Figure 20 shows a flow chart illustrating a process implemented by an AP according to various embodiments of the present disclosure.

[0030] Figure 21 shows a flow chart illustrating a process implemented by a STA according to various embodiments of the present disclosure.

[0031] Figure 22 shows a flow chart illustrating a communication method according to various embodiments of the present disclosure.

[0032] Figure 23 shows a flow chart illustrating another communication method according to various embodiments of the present disclosure.

[0033] Figure 24 shows a schematic view of a communication apparatus according to various embodiments of the present disclosure.

[0034] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale.

DETAILED DESCRIPTION

[0035] The following detailed description is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any theory presented in the preceding background of the invention or the following detailed description.

[0036] Some embodiments of the present disclosure will be described, by way of example only, with reference to the drawings. Like reference numerals and characters in the drawings refer to like elements or equivalents.

[0037] In the following paragraphs, certain exemplifying embodiments are explained with reference to an access point (AP) and one or more stations (STA) for allocation of resources for NDP feedback report procedure.

[0038] In the context of IEEE 802.11 (Wi-Fi) technologies, a station, which is interchangeably referred to as a STA, is a communication apparatus that has the capability to use the IEEE 802.11 protocol. Based on the IEEE 802.11-2020 definition, a STA can be any device that contains an IEEE 802.11-conformant media access control (MAC) and physical layer (PHY) interface to the wireless medium (WM).

[0039] For example, a STA may be a laptop, a desktop personal computer (PC), a personal digital assistant (PDA), either an access point or not (e.g., either an AP STA or a non-AP STA), or a Wi-Fi phone in a wireless local area network (WLAN) environment. The station may be

fixed or mobile. In the WLAN environment, the terms "STA", "non-AP STA", "client", "wireless client", "user", "user device", and "mobile terminal" are often used interchangeably.

[0040] Likewise, an AP, which may be interchangeably referred to as a wireless access point (WAP) in the context of IEEE 802.11 (Wi-Fi) technologies, is a communication apparatus that allows STAs in a WLAN to connect to a wired network. The AP usually connects to a router (via a wired network) as a standalone device, but it can also be integrated with or employed in the router. The AP may be a part of a basic service set (BSS), which consists of the AP and one or more STAs, facilitating communication between the STAs in the BSS.

[0041] As mentioned above, a STA in a WLAN may work as an AP at different occasions, and vice versa. This is because communication apparatuses in the context of IEEE 802.11 (Wi-Fi) technologies may include both STA hardware components and AP hardware components. In this manner, the communication apparatuses may switch between a STA mode and an AP mode, based on actual WLAN conditions and/or requirements.

[0042] In various embodiments below, each of the terms "channel" and "subchannel" may be used interchangeably with any one of "band", "subband" and "frequency segments". The term "circuitry" may be used interchangeably with "module".

[0043] Figure 1 shows a schematic diagram illustrating an NDP feedback report procedure 100 involving an AP and multiples STAs. The AP may transmit a trigger frame (e.g., NFRP Trigger frame 102) to multiple STAs for obtaining a response (e.g., NDP feedback report response 104, 106) from the STAs, where the trigger frame may comprise information for allocating respective resources (e.g., spatial resources and frequency resources) to the STAs for transmitting the response. Then, the STAs may transmit the response to the AP using the respective resources allocated.

[0044] Figure 2 shows an exemplary format of an NFRP Trigger frame 200 according to various embodiments of the present disclosure. The NFRP Trigger frame 200 in Figure 2 may be an example of the NFRP Trigger frame 102 in Figure 1. As shown in Figure 2, the NFRP Trigger frame 200 may comprise a Frame Control field, a Duration field, an RA field, a TA field, a Common Info field, one or more User Info fields 202, a Padding field, and an FCS field. The Common Info field may comprise a Trigger Type subfield 204 and a UL BW subfield 206, where the Trigger Type subfield 204 is set to indicate that the trigger frame is an NFRP Trigger frame.

[0045] In various embodiments, an AP may transmit a trigger frame (e.g., NFRP Trigger frame 200) comprising one or more information fields (e.g., User Info fields 202) to solicit a response (e.g., NDP feedback report response 104) from one or more groups of associated STAs, where each User Info field 202 addresses a group of STAs and contains resource allocation information. Then, a STA that receives the NFRP Trigger frame 200 may identify the resource for transmitting an NDP feedback report response 104, 106 based on the information provided in the User Info field 202.

[0046] Advantageously, this approach allows an AP to flexibly allocate resources for STAs to transmit NDP feedback report responses.

[0047] According to a first embodiment, the User Info field may comprise a subfield that indicates the spatial stream index allocated to the group of STAs for transmitting NDP feedback report responses, thereby allowing an AP to allocate spatial resources to STAs.

[0048] Figure 3 shows an exemplary format of a User Info field 300 in an NFRP Trigger frame according to a first embodiment of the present disclosure. The User Info field 300 in Figure 3 may be an example of the User Info field 202 in Figure 2. As shown in Figure 3, the User Info field 300 may comprise a Starting AID subfield, a Feedback Type subfield 302, a UL Target Receive Power subfield, a Spatial Stream Index subfield 304, in addition to Reserved subfields.

[0049] Table 1 shows an encoding of the Feedback Type subfield 302 in Figure 3.

Feedback Type subfield value	**User Info field format**	**Description**
0	Same as in IEEE 802.11	Resource request
1–15	New variant User Info field	Each value corresponds to a feedback type

Table 1

[0050] Table 2 shows an encoding of the Spatial Stream Index subfield 304 in Figure 3.

Spatial Stream Index subfield value	Description
0	The first spatial stream
1	The second spatial stream

Table 2

[0051] In this embodiment, bit B39 may be used for the Spatial Stream Index subfield 304 to indicate the spatial stream index, while in IEEE 802.11, B39 is used for the Number Of Spatially Multiplexed Users subfield.

[0052] Additionally, bits B21 to B24 may be used for the Feedback Type subfield 302, which may indicate the feedback type, as well as the User Info field format. Value '0' may indicate that the User Info field has the same format as defined in IEEE 802.11, i.e., B39 is the Number Of Spatially Multiplexed Users subfield, while values '1'–'15' may indicate the new variant User Info field 300, where each value corresponds to a feedback type. In one example, value '1' may indicate buffer status for low-latency (LL) traffic, value '2' may indicate ranging request, and value '3' may indicate Internet of Things (IoT) device status. In another example, one of the values from '1' to '15' may also indicate a resource request, similar to that indicated by value '0'.

[0053] Figure 4 shows another exemplary format of a User Info field 400 in an NFRP Trigger frame according to the first embodiment of the present disclosure. The User Info field 400 in Figure 4 may be an example of the User Info field 202 in Figure 2. As shown in Figure 4, the User Info field 400 may comprise a Starting AID subfield, a User Info Field Format subfield 402, a Feedback Type subfield 404, a UL Target Receive Power subfield, a Spatial Stream Index subfield 406 or a Number Of Spatially Multiplexed Users subfield 408, in addition to Reserved subfields.

[0054] In this implementation, 1 bit (e.g., B12) may be used to switch between the new variant User Info field 400 and the User Info field as defined in 802.11. For example, when B12 is set to '0', the User Info field may follow the same format as in IEEE 802.11, and B39 is interpreted as the Number of Spatially Multiplexed Users subfield 408. On the hand, when B12 is set to '1', the User Info field may be the new variant User Info field 400, and B39 may be interpreted as Spatial Stream Index subfield 406.

[0055] Bits B21–B24 may be used for Feedback Type subfield 404, which may indicate the feedback type.

[0056] To improve backwards compatibility, a further variation may set B12 to '0' when the Feedback Type is set to '0', such that the new variant User Info field is not allowed for Feedback Type '0'. One of the values from '1' to '15' may also indicate a resource request, similar to that indicated by value '0'.

[0057] Upon receiving the NFRP Trigger frame 200, the STA may identify the User Info field 300, 400 that addresses its AID. The STA may be addressed by the User Info field 300, 400 if its AID is greater than or equal to the Starting AID and less than the Starting AID + 18×2^{BW}, where BW is the value of the UL BW subfield 206 in the Common Info field.

[0058] Table 3 shows an encoding of the UL BW subfield 206 in Figure 2.

UL BW subfield value	Description
0	20 MHz
1	40 MHz
2	80 MHz
3	160 MHz

Table 3

[0059] After identifying the User Info field 300, 400 that addresses the STA's AID, the STA determines the RU tone set index and the spatial stream index for transmitting the NDP feedback report response. The RU tone set index may be determined using the equation: $\mathrm{RU_Tone_Set_Index} = 1 + (\mathrm{AID} - \mathrm{Starting\ AID})$, while the spatial stream index is indicated by the Spatial Stream Index subfield 304, 406.

[0060] The STA may further determine the set of subcarriers in the LTF to be modulated according to the RU tone set index, feedback status, and the UL BW indicated in the Common Info field.

[0061] Figure 5 shows an example of two User Info fields in an NFRP Trigger frame according to the first embodiment of the present disclosure. In this example, an AP may solicit NDP feedback report responses from two groups of STAs. The values of the Spatial Stream Index

subfield 506, 512 in the first and second User Info fields 502, 508 are set to '0' and '1', respectively, indicating the first and second spatial streams.

[0062] In the example shown in Figure 5, the first User Info field 502 may allocate the first spatial stream to a first group of STAs, with an AID range starting from the value indicated in the Starting AID subfield 504. The second User Info field 508 may allocate the second spatial stream to a second group of STAs, with an AID range starting from the value indicated in the Starting AID subfield 510. The number of STAs in both the first and second groups may be 18, 36, 72 or 144 when the UL BW is 20, 40, 80 or 160 MHz, respectively.

[0063] The AP may also solicit NDP feedback report responses from more than two groups of STAs. In such implementations, more than 1 bit may be allocated to indicate spatial stream index in each User Info field and more than two User Info fields may be included in the NFRP Trigger frame. Additionally, more than two LTF symbols may be used for the NDP feedback report.

[0064] Figure 6 shows another example of two User Info fields in an NFRP Trigger frame according to the first embodiment of the present disclosure. In this example, an AP may solicit NDP feedback report responses from two groups of STAs, where one group of STAs includes legacy STAs such as High Efficiency (HE) STAs or Extremely High Throughput (EHT) STAs. The first User Info field 602 may use the format as defined in IEEE 802.11 and the second User Info field 608 may use the format of the User Info field 300 as shown in Figure 3.

[0065] The first User Info field 602 may address the group of STAs that includes legacy STAs. The value of the Feedback Type subfield 604 may be set to '0', and bit B39 may be used for the Number Of Spatially Multiplexed Users subfield 606 and may be set to '0'. The legacy STAs may transmit NDP feedback report responses on the first spatial stream.

[0066] The second User Info field 608 may address the other group of STAs. The value of the Feedback Type subfield 610 may be set to a value from '1' to '15' depending on the feedback type, and bit B39 may be used for the Spatial Stream Index subfield 612 and may be set to '1'.

[0067] Figure 7 shows yet another example of two User Info fields in an NFRP Trigger frame according to the first embodiment of the present disclosure. In this example, an AP may solicit NDP feedback report responses from two groups of STAs, where one group of STAs includes legacy STAs (e.g., HE/EHT STAs). The first User Info field 702 and the second User Info field 708 may use the format of the User Info field 400 as shown in Figure 4.

[0068] The first User Info field 702 may address the group of STAs that includes legacy STAs. The value of the Feedback Type subfield 704 may be set to '0'. The legacy STAs may interpret bit B39 as the Number Of Spatially Multiplexed Users subfield, while the non-legacy STAs may interpret bit B39 as the Spatial Stream Index subfield 706 since the value of the User Info field format subfield is set to '1'. The legacy STAs may transmit NDP feedback report responses on the first spatial stream.

[0069] The second User Info field 708 may address the other group of STAs. The value of the Feedback Type subfield 710 may be set to a value from '0' to '15' depending on the feedback type. The value of the Spatial Stream Index subfield 712 may be set to '1'.

[0070] According to a second embodiment, the User Info field may comprise one or more subfields that indicate the frequency resources allocated to the group of STAs for transmitting NDP feedback report responses, thereby allowing an AP to flexibly allocate frequency resources to STAs.

[0071] Figure 8 shows an exemplary format of a User Info field 800 in an NFRP Trigger frame according to a first implementation of the second embodiment of the present disclosure. The User Info field 800 in Figure 8 may be an example of the User Info field 202 in Figure 2. As shown in Figure 8, the User Info field 800 may comprise a Starting AID subfield, an RU Tone Set Start Index subfield 802, a Feedback Type subfield 804, an RU Tone Set End Index subfield 806, a UL Target Receive Power subfield, in addition to a Reserved subfield.

[0072] Table 4 shows values of the RU Tone Set Start Index subfield 802 and RU Tone Set End Index subfield 806 in Figure 8 for different UL BW indicated in the Common Info field.

UL BW	**Range of Values for the RU Tone Set Start Index subfield and RU Tone Set End Index subfield**
20 MHz	0–17, 18–255 are reserved
40 MHz	0–35, 36–255 are reserved
80 MHz	0–71, 72–255 are reserved
160 MHz	0–143, 144–255 are reserved
Note: Value x indicates RU Tone Set Index $x + 1$.	

Table 4

[0073] In the first implementation, the frequency resources may be indicated by the start and end of RU tone set index. For example, the values of the RU Tone Set Start Index subfield 802 and RU Tone Set End Index subfield 806 may indicate the start and end of RU tone set index, and may be based on the UL BW 206 indicated in the Common Info field.

[0074] The number of RU tone sets allocated to the group of STAs is given by the following equation: $\mathrm{Number_Of_RU_Tone_Sets} = \mathrm{RU_Tone_Set_End_Index} - \mathrm{RU_Tone_Set_Start_Index} + 1$, where $\mathrm{RU_Tone_Set_Start_Index}$ is the value indicated by the RU Tone Set Start Index subfield 802, and $\mathrm{RU_Tone_Set_End_Index}$ is the value indicated by the RU Tone Set End Index subfield 806.

[0075] Advantageously, this implementation allows frequency resources to be allocated accurately to STAs.

[0076] Figure 9 shows an exemplary format of a User Info field in an NFRP Trigger frame according to a second implementation of the second embodiment of the present disclosure. The User Info field 900 in Figure 9 may be an example of the User Info field 202 in Figure 2. As shown in Figure 9, the User Info field 900 may comprise a Starting AID subfield, an RU Tone Set Allocation subfield 902, a Feedback Type subfield 904, a UL Target Receive Power subfield, in addition to Reserved subfields.

[0077] Table 5 shows values of the RU Tone Set Allocation subfield 902 in Figure 9.

Value of the RU Tone Set Allocation subfield	UL BW	RU Tone Set Start Index	Number of RU tone sets
0	20 MHz, 40 MHz, 80 MHz, 160 MHz	1	18
1	40 MHz, 80 MHz, 160 MHz	19	
2	80 MHz, 160 MHz	37	
3	80 MHz, 160 MHz	55	
4	160 MHz	73	
5	160 MHz	91	
6	160 MHz	109	
7	160 MHz	127	

8	40 MHz, 80 MHz, 160 MHz	1	36
9	80 MHz, 160 MHz	37	
10	160 MHz	73	
11	160 MHz	109	
12	80 MHz, 160 MHz	1	72
13	160 MHz	73	
14	160 MHz	1	144

Table 5

[0078] In the second implementation, the frequency resources may be indicated by a value that corresponds to a group of RU tone sets. For example, the value of the RU Tone Set Allocation subfield 902 may indicate a group of RU tone sets. Table 5 above shows example values of the RU Tone Set Allocation subfield 902 and their corresponding groups of RU tone sets. The group of RU tone sets may be specified by the RU Tone Set Start Index and the number of RU tone sets. For example, the minimum number of RU tone sets indicated by the RU Tone Set Allocation subfield 902 may be '18'. In other examples, the minimum number of RU Tone Sets indicated by the RU Tone Set Allocation subfield 902 may be adjusted by modifying the number of bits allocated to the RU Tone Set Allocation subfield 902.

[0079] Figures 10 and 11 show an exemplary frequency resource allocation 1000, 1100 according to the second implementation of the second embodiment of the present disclosure. In particular, Figure 10 illustrates an example of the frequency resource allocation 1000 when the value of the RU Tone Set Allocation subfield 902 is from '0' to '7', while Figure 11 illustrates an example of the frequency resource allocation 1100 when the value of the RU Tone Set Allocation subfield 902 is from '8' to '14'.

[0080] Advantageously, this implementation allows Frequency resources to be allocated to STAs using fewer bits.

[0081] Figure 12 shows an exemplary format of a User information field 1200 in an NFRP Trigger frame according to a third implementation of the second embodiment of the present disclosure. The User Info field 1200 in Figure 12 may be an example of the User Info field 202 in Figure 2. As shown in Figure 12, the User Info field 1200 may comprise a Starting AID

subfield, an RU Tone Set Group Bitmap subfield 1202, a Feedback Type subfield 1204, a UL Target Receive Power subfield, in addition to Reserved subfields.

[0082] Table 6 shows an example of the RU Tone Set Group Bitmap subfield 1202 in Figure 12.

Bit number	RU Tone Set Index Range
0	1–18
1	19–36
2	37–54
3	55–72
4	73–90
5	91–108
6	109–126
7	127–144

Table 6

[0083] In the third implementation, the frequency resources may be indicated by a bitmap where each bit corresponds to a group of RU Tone Sets. For example, each bit of the RU Tone Set Group Bitmap subfield 1202 may correspond to a group of RU Tone Sets. Table 6 above shows an example of a RU Tone Set Group Bitmap subfield 1202, which may be an 8-bit bitmap where the lowest numbered bit (B0) corresponds to a group of RU tone sets with indices from '1' to '18'. If UL BW is 20 MHz, B1 to B7 may be reserved and set to '0'. If UL BW is 40 MHz, B2 to B7 may be reserved and set to '0'. If UL BW is 80 MHz, B4 to B7 may be reserved and set to '0'. If UL BW is 160 MHz, there may be no reserved bits in the RU Tone Set Group Bitmap subfield 1202.

[0084] For example, an unreserved bit in the bitmap ($\mathrm{B}i$) may be set to '1' to indicate that the corresponding RU tone sets are allocated to a group of STAs. The number of RU tone sets allocated to the group of STAs may be calculated using the following equation: $\mathrm{Number_Of_RU_Tone_Sets} = 18 \times \sum_{\mathrm{i}=0}^{7} \mathrm{B}i$, where i is the bit number.

[0085] Upon receiving the NFRP Trigger frame 200, the STA may identify the User Info field 800, 900, 1200 that addresses its AID. The STA may be addressed by the User Info field 800,

900, 1200 if its AID is greater than or equal to the Starting AID and less than the $\text{Starting AID} + 2 \times \text{Number_Of_RU_Tone_Sets}$.

- For the first implementation, $\text{Number_Of_RU_Tone_Sets} = \text{RU_Tone_Set_End_Index} - \text{RU_Tone_Set_Start_Index} + 1$
- For the second implementation, $\text{Number_Of_RU_Tone_Sets}$ is indicated by the RU Tone Set Allocation subfield 900.
- For the third implementation, $\text{Number_Of_RU_Tone_Sets} = 18 \times \sum_{i=0}^{7} \text{B}i$

[0086] After identifying the User Info field 800, 900, 1200 that addresses the STA's AID, the STA determines the RU tone set index and the spatial stream index for transmitting NDP feedback report response. The RU tone set index may be determined using the equation: $\text{RU_Tone_Set_Index} = \text{RU_Tone_Set_Start_Index} + ((\text{AID} - \text{Starting AID}) \bmod (\text{Number_Of_RU_Tone_Sets}))$

- For the first implementation, $\text{RU_Tone_Set_Start_Index}$ is the value of the RU Tone Set Start Index subfield 802.
- For the second implementation, $\text{RU_Tone_Set_Start_Index}$ is indicated by the RU Tone Set Allocation subfield 902.
- For the third implementation, $\text{RU_Tone_Set_Start_Index} = 1 + 18 \times \text{Offset}$, where the offset calculation may be performed according to the flow chart shown in Figure 13.

[0087] The spatial stream index may be calculated using the equation: $\text{Spatial_Stream_Index} = 1 + \lfloor (\text{AID} - \text{Starting AID}) \bmod (\text{Number_Of_RU_Tone_Sets}) \rfloor$

[0088] The STA may further determine the set of subcarriers in the LTF to be modulated according to the RU tone set index, feedback status, and the UL BW indicated in the Common Info field.

[0089] Figure 13 shows a flow chart illustrating a process 1300 for calculating offset according to the third implementation of the second embodiment of the present disclosure.

[0090] In step 1302, an AP may first calculate a value of d, where $d = (\text{AID} - \text{Starting AID}) \bmod (\text{Number_Of_RU_Tone_Sets})$. Then, in step 1304, the AP may initialise the values of i, k, and Offset, setting them to '0'. Next, the AP may check whether the value of a bit ($\text{B}i$) in the bitmap is '1' in step 1306. If $\text{B}i = 1$, the process proceeds to step 1308, where

the AP increases the value of k by 1 (i.e., $k = k + 1$). Otherwise, the AP may increase the value of both Offset and i by 1 (i.e., $\mathrm{Offset} = \mathrm{Offset} + 1$ and $i = i + 1$) in steps 1310 and 1312, respectively, and then repeats step 1306. In step 1314, the AP may then check whether the value of d is less than $18 \times k$. If $d < 18 \times k$, the process ends. Otherwise, the AP proceeds to step 1312 and further increases the value of i by 1 before repeating step 1306.

[0091] In an example according to the second embodiment, an AP may solicit NDP feedback report responses from its associated STAs using one or more User Info fields 800, 900, 1200, where each User Info field 800, 900, 1200 may allocate a group of RU Tone Sets to a group of STAs. The values of the Feedback Type subfield 804, 904, 1204 in each User Info field may depend on the specific type of feedback that the AP wants to collect from each group of STAs.

[0092] Figure 14 shows a schematic diagram illustrating allocation of different groups of RU tone sets to different groups of STAs 1402, 1404, 1406 according to the second embodiment of the present disclosure.

[0093] Table 7 shows an example of frequency resource allocation when UL BW is 80 MHz.

STA Group	Option 1		Option 2	Option 3
	RU Tone Set Start Index	RU Tone Set End Index	RU Tone Set Allocation	RU Tone Set Group Bitmap
1	1	36	8	11000000
2	37	54	2	00100000
3	55	72	3	00010000

Table 7

[0094] In another example according to the second embodiment, if one of the 20 MHz or 40 MHz subchannels is punctured, an AP may allocate the RU tone sets within the non-punctured subchannels to the STAs.

[0095] Figure 15 shows a schematic diagram illustrating allocation of RU tone sets within non-punctured subchannels to groups of STAs according to the second embodiment of the present disclosure.

[0096] For example, given a 1×11 puncturing pattern in an 80 MHz BSS, where the second lowest 20 MHz subchannel is punctured, and the AP wants to solicit NDP feedback report responses from STAs with AIDs from 1 to 108:

- For the first and second implementations, two User Info fields may be needed. The first User Info field may allocate RU tone sets 1 to 18 (1502) to STAs with AIDs 1 to 36, and the second User Info field may allocate RU Tone Sets 37 to 72 (1504) to STAs with AIDs 37 to 108.
- For the third implementation, one User Info field may be needed. The RU Tone Set Group Bitmap may be set to '10110000'. The STAs with AIDs 1 to 18 and 55 to 72 may be allocated to RU Tone Sets 1 to 18 (1502), and the STAs with AIDs 19 to 54 and 73 to 108 may be allocated to RU Tone Sets 37 to 72 (1504).

[0097] In various implementations of the second embodiment, the User Info field may further comprise a Spatial Stream Index subfield.

[0098] Figure 16 shows a schematic diagram illustrating allocation of frequency resources (e.g., RU tone sets) and spatial resources (e.g., spatial streams) to different groups of STAs 1602, 1604, 1606 according to variations of the second embodiment of the present disclosure.

[0099] Figures 17 to 19 show exemplary formats of a User Info field 1700, 1800, 1900 in an NFRP Trigger frame according to variations of the second embodiment of the present disclosure. The User Info field 1700, 1800, 1900 in Figures 17 to 19 may be examples of the User Info field 202 in Figure 2 and may be variations of the User Info field 800, 900, 1200 according to the first, second, and third implementations, respectively, with additional Spatial Stream Index subfield 1702, 1802, 1902.

- For the variation of the first implementation, bit B20 may be used for the Spatial Stream Index subfield 1702.
- For the variations of the second and third implementations, bit B39 may be used for the Spatial Stream Index subfield 1802, 1902. Alternatively, other reserved bits may also be used for the Spatial Stream Index subfield 1802, 1902.

[0100] Advantageously, such variations allow an AP to allocate both frequency resources and spatial resources to STAs.

[0101] In various implementations of the first and second embodiments, instead of the Starting AID subfield, the User Info field may comprise a Group ID subfield that identifies a group of STAs. For example, an AP may negotiate with a group of STAs and assign them a Group ID. As shown in Table 8 below, each STA included in the group of STAs identified by the same Group ID may know its position within the group of STAs. The User Info field may similarly comprise resource allocation information for the STAs identified by the same Group ID. In such implementations, the STA may determine the allocated resource based on its position within the group of STAs.

[0102] Table 8 shows an example of the respective positions of each STA included in a group of STAs identified by the same Group ID.

STAs identified by a Group ID	**STA 1**	**STA 2**	···	**STA N**
Position	1	2	···	N

Table 8

[0103] Figure 20 shows a flow chart illustrating a process 2000 implemented by an AP according to various embodiments of the present disclosure. In step 2002, the AP may select one or more feedback types, and then select the STAs to be polled for each feedback type in step 2004, followed by allocating resources for the STAs in step 2006. After constructing an NFRP Trigger frame (e.g., NFRP Trigger frame 102, 200) in step 2008, the AP may then send the NFRP Trigger frame to one or more STAs in step 2010.

[0104] Figure 21 shows a flow chart illustrating a process 2100 implemented by a STA according to various embodiments of the present disclosure. In response to receiving an NFRP Trigger frame (e.g., NFRP Trigger frame 102, 200) from an AP in step 2102, the STA may carry out step 2104 to check the User Info field (e.g., User Info field 300, 400, 502, 508, 602, 608, 702, 708, 800, 900, 1200, 1700, 1800, 1900) of the NFRP Trigger frame. The STA determines whether it is addressed by the User Info field in step 2106. If the STA is addressed by the User Info field, the process moves to step 2108, where the STA then determines the resource to send an NDP feedback report response (e.g., NDP feedback report response 104, 106). Finally, in step 2110, the STA may construct and send the NDP feedback report response to the AP.

[0105] Figure 22 shows a flow chart illustrating a communication method 2200 according to various embodiments of the present disclosure. The communication method 2200 may be

implemented by a first communication apparatus (e.g., an AP). At step 2202, the first communication apparatus may generate a trigger frame for obtaining a response from one or more second communication apparatuses, the trigger frame comprising information for allocating respective resources to the one or more second communication apparatuses for transmitting the response. At step 2204, the first communication apparatus may transmit the trigger frame to the one or more second communication apparatuses.

[0106] Figure 23 shows a flow chart illustrating another communication method 2300 according to various embodiments of the present disclosure. The communication method 2300 may be implemented by a second communication apparatus (e.g., a STA). At step 2302, the second communication apparatus may receive a trigger frame from a first communication apparatus for obtaining a response from the second communication apparatus, the trigger frame comprising information for allocating a resource to the second communication apparatus for transmitting the response. At step 2304, the second communication apparatus may determine the resource for transmitting the response to the first communication apparatus based on the information.

[0107] Figure 24 shows a schematic view of a communication apparatus 2400 according to various embodiments of the present disclosure. The communication apparatus 2400 may be implemented as an AP or a STA.

[0108] Various functions and operations of the communication apparatus 2400 are arranged into layers in accordance with a hierarchical model. In the model, lower layers report to higher layers and receive instructions therefrom in accordance with IEEE specifications. For the sake of simplicity, details of the hierarchical model are not discussed in the present disclosure.

[0109] As shown in Figure 24, the communication apparatus 2400 may include circuitry 2414, at least one radio transmitter 2402, at least one radio receiver 2404, and at least one antenna 2412 (for the sake of simplicity, only one antenna is depicted in Figure 24 for illustration purposes). The circuitry 2414 may include at least one controller 2406 for use in software and/or hardware aided execution of tasks that the at least one controller 2406 is designed to perform, including control of communications with one or more other devices in a wireless network. The circuitry 2414 may further include at least one transmission signal generator 2408 and at least one receive signal processor 2410. The at least one controller 2406 may control the at least one transmission signal generator 2408 for generating frames (e.g., NFRP Trigger frames, NDP feedback report response frame) to be sent through the at least one radio transmitter 2402 to one or more other communication apparatuses (e.g., STAs or APs).

The at least one controller 2406 may control the at least one receive signal processor 2410 for processing frames received through the at least one radio receiver 2404 from the one or more other communication apparatuses. The at least one transmission signal generator 2408 and the at least one receive signal processor 2410 may be stand-alone modules of the communication apparatus 2400 that communicate with the at least one controller 2406 for the above-mentioned functions. Alternatively, the at least one transmission signal generator 2408 and the at least one receive signal processor 2410 may be included in the at least one controller 2406. It is appreciable to those skilled in the art that the arrangement of these functional modules is flexible and may vary depending on the practical needs and/or requirements. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets.

[0110] In various embodiments, when in operation, the at least one radio transmitter 2402, at least one radio receiver 2404, and at least one antenna 2412 may be controlled by the at least one controller 2406. Furthermore, while only one radio transmitter 2402 is shown, it will be appreciated that there can be more than one of such transmitters.

[0111] In various embodiments, when in operation, the at least one radio receiver 2404, together with the at least one receive signal processor 2410, forms a receiver of the communication apparatus 2400. The receiver of the communication apparatus 2400, when in operation, provides functions required for processing an information container. While only one radio receiver 2404 is shown, it will be appreciated that there can be more than one of such receivers.

[0112] The communication apparatus 2400, when in operation, provides functions required for resource allocation for NDP feedback report response. In one example, the communication apparatus 2400 may be a first communication apparatus (e.g., an AP), and the circuitry 2414 may, in operation, generate a trigger frame for obtaining a response from one or more second communication apparatuses (e.g., one or more STAs), the trigger frame comprising information for allocating respective resources to the one or more second communication apparatuses for transmitting the response. The transmitter 2402 may, in operation, transmit the trigger frame to the one or more second communication apparatuses.

[0113] Additionally or alternatively, the one or more second communication apparatuses may be grouped into one or more groups, the trigger frame for obtaining a response from the one or more groups, and the trigger frame comprising information for allocating respective resources to each of the one or more groups for transmitting the response. The trigger frame

may comprise one or more information fields, each information field corresponding to a respective group of the one or more groups and comprising information for allocating a respective resource to the respective group for transmitting the response. The information in each information field may indicate a type of response to be obtained from the respective group.

[0114] Additionally or alternatively, the circuitry 2414 may determine the type of response to be obtained from the respective group prior to generating the trigger frame. The information in each information field may indicate an information field format. The information in each information field may indicate a spatial stream allocated to the respective group for transmitting the response. The information in each information field may indicate a frequency resource allocated to the respective group for transmitting the response.

[0115] Additionally or alternatively, the information in each information field may comprise a start index and an end index, the start index and the end index being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response. The information in each information field may comprise a value, the value being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response. The information in each information field may comprise a plurality of bits, the plurality of bits being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response.

[0116] Additionally or alternatively, the information in each information field may comprise a starting association identifier. The information in each information field may comprise a group identifier corresponding to the respective group.

[0117] Additionally or alternatively, the receiver 2404 may, in operation, receive the response from the one or more second communication apparatuses.

[0118] In another example, the communication apparatus 2400 may be a second communication apparatus (e.g., a STA). The receiver 2404 may, in operation, receive a trigger frame from a first communication apparatus (e.g., an AP) for obtaining a response from the second communication apparatus, the trigger frame comprising information for allocating a resource to the second communication apparatus for transmitting the response. The circuitry 2414 may, in operation, determine the resource for transmitting the response to the first communication apparatus based on the information.

[0119] Additionally or alternatively, the second communication apparatus may be in a group of second communication apparatuses, the trigger frame for obtaining a response from the group of second communication apparatuses, and the trigger frame comprising information for allocating the resource to the group of second communication apparatuses for transmitting the response. The trigger frame may comprise an information field corresponding to the group of second communication apparatuses, and the trigger frame comprising the information for allocating the resource to the group of second communication apparatuses for transmitting the response.

[0120] Additionally or alternatively, the information may comprise a starting association identifier, and wherein the circuitry determines the information field corresponding to the group of second communication apparatuses based on an association identifier of the second communication apparatus and the starting association identifier. The information may comprise a group identifier corresponding to the group of second communication apparatuses, and wherein the circuitry determines the information field corresponding to the group of second communication apparatuses based on the group identifier.

[0121] Additionally or alternatively, the transmitter 2402 may, in operation, transmit the response to the first communication apparatuses using the resource allocated to the second communication apparatus.

[0122] Additionally or alternatively, the information may indicate a type of response to be obtained from the group of second communication apparatuses. The information may indicate an information field format. The information may indicate a spatial stream allocated to the group of second communication apparatuses for transmitting the response.

[0123] Additionally or alternatively, the information may indicate a frequency resource allocated to the group of second communication apparatuses for transmitting the response. The information may comprise a start index and an end index, the start index and the end index being indicative of a group of resource unit tone sets allocated to the group of second communication apparatuses for transmitting the response. The information may comprise a value, the value being indicative of a group of resource unit tone sets allocated to the group of second communication apparatuses for transmitting the response. The information may comprise a plurality of bits, the plurality of bits being indicative of a group of resource unit tone sets allocated to the group of second communication apparatuses for transmitting the response.

[0124] The present disclosure can be realised by software, hardware, or software in cooperation with hardware. Each functional block used in the description of each embodiment described above can be partly or entirely realised by an LSI such as an integrated circuit, and each process described in each embodiment may be controlled partly or entirely by the same LSI or a combination of LSIs. The LSI may be individually formed as chips, or one chip may be formed so as to include a part or all of the functional blocks. The LSI may include a data input and output coupled thereto. The LSI here may be referred to as an IC, a system on a chip (SoC), a system LSI, a super LSI, or an ultra LSI depending on a difference in the degree of integration. However, the technique of implementing an integrated circuit is not limited to the LSI and may be realised by using a dedicated circuit, a general-purpose processor, or a special-purpose processor. In addition, an FPGA (Field Programmable Gate Array) that can be programmed after the manufacture of the LSI or a reconfigurable processor in which the connections and the settings of circuit cells disposed inside the LSI can be reconfigured may be used. The present disclosure can be realised as digital processing or analogue processing. If future integrated circuit technology replaces LSIs as a result of the advancement of semiconductor technology or other derivative technology, the functional blocks could be integrated using the future integrated circuit technology. Biotechnology can also be applied.

[0125] The present disclosure can be realised by any kind of apparatus, device or system having a function of communication, which is referred to as a communication apparatus.

[0126] Some non-limiting examples of such a communication apparatus include a phone (e.g., cellular (cell) phone, smart phone), a tablet, a personal computer (PC) (e.g., laptop, desktop, netbook), a camera (e.g., digital still/video camera), a digital player (digital audio/video player), a wearable device (e.g., wearable camera, smart watch, tracking device), a game console, a digital book reader, a telehealth/telemedicine (remote health and medicine) device, and a vehicle providing communication functionality (e.g., automotive, airplane, ship), and various combinations thereof.

[0127] The communication apparatus is not limited to be portable or movable, and may also include any kind of apparatus, device or system being non-portable or stationary, such as a smart home device (e.g., an appliance, lighting, smart meter, control panel), a vending machine, and any other "things" in a network of an "Internet of Things (IoT)".

[0128] The communication may include exchanging data through, for example, a cellular system, a wireless LAN system, a satellite system, etc., and various combinations thereof.

[0129] The communication apparatus may comprise a device such as a controller or a sensor which is coupled to a communication device performing a function of communication described in the present disclosure. For example, the communication apparatus may comprise a controller or a sensor that generates control signals or data signals which are used by a communication device performing a communication function of the communication apparatus.

[0130] The communication apparatus also may include an infrastructure facility, such as a base station, an access point, and any other apparatus, device or system that communicates with or controls apparatuses such as those in the above non-limiting examples.

[0131] It will be understood that while some properties of the various embodiments have been described with reference to a device, corresponding properties also apply to the methods of various embodiments, and vice versa.

[0132] In the following paragraphs, certain exemplifying embodiments are explained with reference to terms related to wireless communication and the present disclosure regarding communication apparatuses and communication methods for resource allocation for NDP feedback report response, namely:

Example 1. A first communication apparatus comprising:

circuitry, which in operation, generates a trigger frame for obtaining a response from one or more second communication apparatuses, the trigger frame comprising information for allocating respective resources to the one or more second communication apparatuses for transmitting the response; and

a transmitter, which in operation, transmits the trigger frame to the one or more second communication apparatuses.

Example 2. The first communication apparatus of example 1, wherein the one or more second communication apparatuses are grouped into one or more groups, the trigger frame for obtaining a response from the one or more groups, and the trigger frame comprising information for allocating respective resources to each of the one or more groups for transmitting the response.

Example 3. The first communication apparatus of example 2, wherein the trigger frame comprises one or more information fields, each information field corresponding to a respective

group of the one or more groups and comprising information for allocating a respective resource to the respective group for transmitting the response.

Example 4. The first communication apparatus of example 3, wherein the information in each information field indicates a type of response to be obtained from the respective group.

Example 5. The first communication apparatus of example 4, wherein the circuitry determines the type of response to be obtained from the respective group prior to generating the trigger frame.

Example 6. The first communication apparatus of any one of examples 3 to 5, wherein the information in each information field indicates an information field format.

Example 7. The first communication apparatus of any one of examples 3 to 6, wherein the information in each information field indicates a spatial stream allocated to the respective group for transmitting the response.

Example 8. The first communication apparatus of any one of examples 3 to 7, wherein the information in each information field indicates a frequency resource allocated to the respective group for transmitting the response.

Example 9. The first communication apparatus of example 8, wherein the information in each information field comprises a start index and an end index, the start index and the end index being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response.

Example 10. The first communication apparatus of example 8, wherein the information in each information field comprises a value, the value being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response.

Example 11. The first communication apparatus of example 8, wherein the information in each information field comprises a plurality of bits, the plurality of bits being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response.

Example 12. The first communication apparatus of any one of examples 3 to 11, wherein the information in each information field comprises a starting association identifier.

Example 13. The first communication apparatus of any one of examples 3 to 11, wherein the information in each information field comprises a group identifier corresponding to the respective group.

Example 14. The first communication apparatus of any one of examples 1 to 13, further comprising:

a receiver, which in operation, receives the response from the one or more second communication apparatuses.

Example 15. A second communication apparatus comprising:

a receiver, which in operation, receives a trigger frame from a first communication apparatus for obtaining a response from the second communication apparatus, the trigger frame comprising information for allocating a resource to the second communication apparatus for transmitting the response; and

circuitry, which in operation, determines the resource for transmitting the response to the first communication apparatus based on the information.

Example 16. The second communication apparatus of example 15, wherein the second communication apparatus is in a group of second communication apparatuses, the trigger frame for obtaining a response from the group of second communication apparatuses, and the trigger frame comprising information for allocating the resource to the group of second communication apparatuses for transmitting the response.

Example 17. The second communication apparatus of example 16, wherein the trigger frame comprises an information field corresponding to the group of second communication apparatuses, and the trigger frame comprising the information for allocating the resource to the group of second communication apparatuses for transmitting the response.

Example 18. The second communication apparatus of example 16 or 17, wherein the information comprises a starting association identifier, and wherein the circuitry determines the information field corresponding to the group of second communication apparatuses based on an association identifier of the second communication apparatus and the starting association identifier.

Example 19. The second communication apparatus of example 16 or 17, wherein the information comprises a group identifier corresponding to the group of second communication

apparatuses, and wherein the circuitry determines the information field corresponding to the group of second communication apparatuses based on the group identifier.

Example 20. The second communication apparatus of any one of examples 15 to 19, further comprising:

a transmitter, which in operation, transmits the response to the first communication apparatuses using the resource allocated to the second communication apparatus.

Example 21. The second communication apparatus of any one of examples 16 to 20, wherein the information indicates a type of response to be obtained from the group of second communication apparatuses.

Example 22. The second communication apparatus of any one of examples 16 to 21, wherein the information indicates an information field format.

Example 23. The second communication apparatus of any one of examples 16 to 22, wherein the information indicates a spatial stream allocated to the group of second communication apparatuses for transmitting the response.

Example 24. The second communication apparatus of any one of examples 16 to 23, wherein the information indicates a frequency resource allocated to the group of second communication apparatuses for transmitting the response.

Example 25. The second communication apparatus of example 24, wherein the information comprises a start index and an end index, the start index and the end index being indicative of a group of resource unit tone sets allocated to the group of second communication apparatuses for transmitting the response.

Example 26. The second communication apparatus of example 24, wherein the information comprises a value, the value being indicative of a group of resource unit tone sets allocated to the group of second communication apparatuses for transmitting the response.

Example 27. The second communication apparatus of example 24, wherein the information comprises a plurality of bits, the plurality of bits being indicative of a group of resource unit tone sets allocated to the group of second communication apparatuses for transmitting the response.

Example 28. A communication method implemented by a first communication apparatus comprising:

generating a trigger frame for obtaining a response from one or more second communication apparatuses, the trigger frame comprising information for allocating respective resources to the one or more second communication apparatuses for transmitting the response; and

transmitting the trigger frame to the one or more second communication apparatuses.

Example 29. A communication method implemented by a second communication apparatus comprising:

receiving a trigger frame from a first communication apparatus for obtaining a response from the second communication apparatus, the trigger frame comprising information for allocating a resource to the second communication apparatus for transmitting the response; and

determining the resource for transmitting the response to the first communication apparatus based on the information.

[0133] While exemplary embodiments have been presented in the foregoing detailed description of the present embodiments, it should be appreciated that a vast number of variations exist. It should further be appreciated that the exemplary embodiments are examples, and are not intended to limit the scope, applicability, operation, or configuration of this disclosure in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing exemplary embodiments, it being understood that various changes may be made in the function and arrangement of steps and method of operation described in the exemplary embodiments and modules and structures of devices described in the exemplary embodiments without departing from the scope of the subject matter as set forth in the appended claims.

CLAIMS

1. A first communication apparatus comprising:

circuitry, which in operation, generates a trigger frame for obtaining a response from one or more second communication apparatuses, the trigger frame comprising information for allocating respective resources to the one or more second communication apparatuses for transmitting the response; and

a transmitter, which in operation, transmits the trigger frame to the one or more second communication apparatuses.

2. The first communication apparatus of claim 1, wherein the one or more second communication apparatuses are grouped into one or more groups, the trigger frame for obtaining a response from the one or more groups, and the trigger frame comprising information for allocating respective resources to each of the one or more groups for transmitting the response.

3. The first communication apparatus of claim 2, wherein the trigger frame comprises one or more information fields, each information field corresponding to a respective group of the one or more groups and comprising information for allocating a respective resource to the respective group for transmitting the response.

4. The first communication apparatus of claim 3, wherein the information in each information field indicates a type of response to be obtained from the respective group.

5. The first communication apparatus of claim 4, wherein the circuitry determines the type of response to be obtained from the respective group prior to generating the trigger frame.

6. The first communication apparatus of claim 3, wherein the information in each information field indicates an information field format.

7. The first communication apparatus of claim 3, wherein the information in each information field indicates a spatial stream allocated to the respective group for transmitting the response.

8. The first communication apparatus of claim 3, wherein the information in each information field indicates a frequency resource allocated to the respective group for transmitting the response.

9. The first communication apparatus of claim 8, wherein the information in each information field comprises a start index and an end index, the start index and the end index being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response.

10. The first communication apparatus of claim 8, wherein the information in each information field comprises a value, the value being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response.

11. The first communication apparatus of claim 8, wherein the information in each information field comprises a plurality of bits, the plurality of bits being indicative of a group of resource unit tone sets allocated to the respective group for transmitting the response.

12. The first communication apparatus of claim 3, wherein the information in each information field comprises a starting association identifier.

13. The first communication apparatus of claim 3, wherein the information in each information field comprises a group identifier corresponding to the respective group.

14. The first communication apparatus of claim 1, further comprising:

a receiver, which in operation, receives the response from the one or more second communication apparatuses.

15. A second communication apparatus comprising:

a receiver, which in operation, receives a trigger frame from a first communication apparatus for obtaining a response from the second communication apparatus, the trigger frame comprising information for allocating a resource to the second communication apparatus for transmitting the response; and

circuitry, which in operation, determines the resource for transmitting the response to the first communication apparatus based on the information.

16. The second communication apparatus of claim 15, wherein the second communication apparatus is in a group of second communication apparatuses, the trigger frame for obtaining a response from the group of second communication apparatuses, and the trigger frame comprising information for allocating the resource to the group of second communication apparatuses for transmitting the response.

17. The second communication apparatus of claim 16, wherein the trigger frame comprises an information field corresponding to the group of second communication apparatuses, and the trigger frame comprising the information for allocating the resource to the group of second communication apparatuses for transmitting the response.

18. The second communication apparatus of claim 16, wherein the information comprises a starting association identifier, and wherein the circuitry determines the information field corresponding to the group of second communication apparatuses based on an association identifier of the second communication apparatus and the starting association identifier.

19. A communication method implemented by a first communication apparatus comprising:

generating a trigger frame for obtaining a response from one or more second communication apparatuses, the trigger frame comprising information for allocating respective resources to the one or more second communication apparatuses for transmitting the response; and

transmitting the trigger frame to the one or more second communication apparatuses.

20. A communication method implemented by a second communication apparatus comprising:

receiving a trigger frame from a first communication apparatus for obtaining a response from the second communication apparatus, the trigger frame comprising information for allocating a resource to the second communication apparatus for transmitting the response; and

determining the resource for transmitting the response to the first communication apparatus based on the information.