Description

Title of Invention: A METHOD AND DEVICES FOR TRIGGER-BASED UPLINK BEAMFORMING

FIELD OF THE INVENTION

[0001] This invention relates to formatting and generating an uplink beamforming feedback report frame comprising parameters and precoder information.

BACKGROUND

[0002] A Sounding procedure is one of the key techniques in a Wireless Local Area Network (WLAN) that allows the transmitter to obtain channel information and compute a beamforming precoder that may optimise an upcoming user data transmission.

[0003] The main idea of uplink (UL) triggered beamforming (BF) is that an Access Point (AP) triggers one or more associated station devices (STAs) to transmit a Sounding null data PPDU (NDP) . The AP then uses the received Sounding NDP from each STA to estimate the status of each channel and consequently computes the precoder parameters. These parameters are then provided to each STA to be used for the next user uplink transmission of trigger based (TB) physical layer protocol data units (PPDU) . Following this UL Sounding procedure, the AP sends a trigger frame (TF) that might be accompanied with or might indicate the precoder parameters of each triggered STA, which triggers the STAs to transmit their data in a beamformed TB PPDU. Each of the triggered STAs transmits its data in a beamformed TB PPDU and is responded to with a Block Acknowledgement (BA) frame by the initiating AP. This procedure is illustrated in FIG. 1.

[0004] Previous approaches have introduced the format of a new TF that initiates the UL BF TB PPDU from one or more non-AP STAs. It can be seen in FIG. 2 that precoder information is included in an UL BF Feedback Report that is contained in the Trigger Dependent User Info. The UL BF Feedback Report includes some parameters that define the precoder structure. Also, the Grouping (Ng) subfield is not included.

[0005] In the previous 11ax version of the IEEE standard 802.11, sounding tone indices were defined for each resource unit (RU) size within each bandwidth (BW) . In the previous 11be version of the IEEE standard 802.11, a new tone plan and support for BW of 320MHz was added, and the minimal resolution of the sounding feedback was also reduced to 242-tone RUs.

[0006] However, for UL TB PPDU it is reasonable that a STA will be allocated a small RU or Multiple Resource Units (MRU) and then the precoder should be provided only for

the tones of the allocated RU or MRU. Previous proposals have included the use of indices for RUs smaller than a 242-tone RU for use with the new tone plan of 11be.

[0007] Therefore, this approach appears to work when the TF and the precoder data are within the limits of a single MAC protocol data unit (MPDU) size. However, if considering UL BF when addressing Multi-User –Multi-Input Multi-Output (MU-MIMO) scenarios with a large number of STAs, the actual size of the UL BF Feedback Report for each of the STAs may cross the boundaries of a single MPDU size and thus would no longer work with the proposed framework (i.e. can't be included within the Trigger frame that is common for all non-AP STAs) . Accordingly, it has been recognised that the design for the PPDU that includes the initiating TF for the beamformed TB PPDU doesn't fully cover all the BW and RU scenarios and is also missing some parameters that are required for the precoder transmission.

[0008] Specifically, there are three main issues that are not addressed in the previously proposed design.

[0009] Firstly, Precoder Report Segmentation –the current sounding procedure for the downlink that is defined in the IEEE 802.11 standard supports the BF Report segmentation in the case that the size of the BF Report exceeds the value of the maximum MPDU size. In such a case, the BF Report should be divided into several segments, where each segment is to be conveyed in an MPDU within A-MPDU. Each segment is then to be uniquely indicated in each MPDU within the MIMO Control Field that is also included in that MPDU. This is illustrated in FIG. 3, where bits 17 to 20 are designated for indicating the Remaining Feedback Segments and the First Feedback Segment.

[0010] The design of the TF as previously proposed is shown in FIG. 2. FIG. 2 shows that the report with the precoder values is transmitted within the same MPDU with the TF. This actually assumes that no segmentation can be considered. However, we need to consider the possibility of segmenting the uplink BF report scenario because, as mentioned above, in UL MU transmission the size of the UL precoder report may exceed the maximum MPDU size (especially when multiple precoder reports for multiple STAs are being transmitted) .

[0011] Secondly, Grouping indication (Ng) –grouping indication allows for changing the resolution of sounding and to transmit one item of feedback information for every Ng tones. This allows for feedback size reduction and thus reduces the overhead. This is also true for the precoder report transmission, however an Ng indication was not included in FIG. 2.

[0012] Thirdly, Tone indices for precoder report –the current IEEE 802.11 standard specifies tone indices for sounding report per BW, RU size and Ng value. Tone indices define the set of tones that the feedback is provided for. For example, if Ng equals 4, the

IEEE 802.11 standard defines a specific set of tones in a step of 4 sub-carriers for which feedback is provided. The receiver is supposed to use the feedback information for those tones that are defined in the tone indices set. The precoders for the remaining intervening tones may be computed by interpolating the values corresponding to the tones included in the provided feedback.

[0013] The 802.11ax standard specifies sounding tone indices for every RU size, but doesn't support 320MHz BW. 802.11be standard supports 320MHz BW but does not specify sounding tone indices for RUs smaller than 242-tone RU. A simple combination of 11ax and 11be is not a valid solution as 802.11be changed tone plan for 80MHz BW and above.

[0014] Thus, there is a need to define a solution for precoder transmission to cover all the scenarios and thus support both 320MHz BW and tone indices for RUs of every size.

SUMMARY OF THE INVENTION

[0015] According to one aspect there is provided an access point for establishing an uplink trigger based data communication with one or more station devices across a plurality of tones in a radio band, the access point is configured to generate and transmit a physical layer protocol data unit to one or more station devices that contains a sounding feedback report frame for each of the station devices including a first field comprising precoder information for establishing a single uplink data connection between the access point and the station device and a second field comprising a set of parameters to instruct processing of the precoder information in the first field.

[0016] In an embodiment, the first field of the feedback report frame may be an uplink beamforming Precoder field and the second field of the feedback report frame may be an uplink, UL, beamforming, BF, multiple input multiple output, MIMO, Control field.

[0017] In an embodiment, the precoder information may be contained within the feedback report frame as a single MAC Protocol Data Unit, MPDU, and comprises one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data connection and the set of parameters in the second field correspond to processing only the segment of precoder information contained in the first field.

[0018] In an embodiment, the segment of precoder information and the set of parameters corresponding to that segment may be transmitted in the feedback report frame as a MAC Protocol Data Unit, MPDU, within an Aggregate MAC Protocol Data Unit, AMPDU.

[0019] In an embodiment, the AMPDU includes one or more of a plurality of precoder parameters for the station device.

[0020] In an embodiment, the second field of the feedback report frame may comprise the subfields: Grouping, Codebook Information, Remaining UL BF Feedback Segments, First UL BF Feedback Segment and Reserved.

[0021] In an embodiment, the Grouping subfield may indicate resolution of the precoder information in the frequency domain.

[0022] In an embodiment, the Codebook Information subfield may define the size in bits of each parameter corresponding to the precoder information.

[0023] In an embodiment, the Remaining UL BF Feedback Segments subfield may define the number of subsequent segments of precoder information for the station device from the current frame onwards.

[0024] In an embodiment, the First UL BF Feedback Segment subfield may indicate whether or not the feedback report frame includes a first segment of a plurality of segments of precoder information.

[0025] In an embodiment, the second field may comprise the subfields: Grouping, Codebook Information, and Reserved.

[0026] In an embodiment, the second field may comprise the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame.

[0027] In an embodiment, the second field may be a modified EHT MIMO Control Field where the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number are defined as reserved fields.

[0028] In an embodiment, the modified EHT MIMO Control Field the fields Nc Index and Nr Index may be defined as reserved.

[0029] In an embodiment, the second field and precoder information may be included within a Trigger Dependent User Info field of a trigger frame, TF.

[0030] In an embodiment, the access point may be configured to generate a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each station device to whom the sounding feedback report frame was transmitted.

[0031] In an embodiment, the access point may be configured to formulate the precoder information to comprise tone indices formatted based on the bandwidth and number of tones per resource unit, RU, to be used in the uplink trigger based data communication such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted with the tones of the RU as defined for data transmission and an additional tone from each adjacent RU as defined for data transmission outside of the bandwidth to be used.

[0032] In an embodiment, the adjacent tones outside of the bandwidth to be used may be Ng tones below the first tone of the tones as defined for data transmission within one

or more RUs to be used and Ng tones above the last tone of the tones as defined for data transmission within the one or more RUs to be used of the bandwidth to be used, where the last tone may be defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone.

[0033] In an embodiment, the tone indices format may be [lower adjacent tone by Ng: first tone: Ng: last tone in multiples of Ng: higher adjacent tone by Ng] .

[0034] In an embodiment, the access point may be configured to formulate the precoder information such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted to include one edge tone of the tones of the specified one or more RUs to be used as defined for data transmission.

[0035] In an embodiment, the tone indices format may be [first tone: Ng: last tone in multiples of Ng: edge tone] , where the last tone is defined as the last tone of the tones within the one or more RUs to be used as defined for data transmission which is a multiple of Ng tones above the first tone, and the edge tone is the last tone of the one or more RUs to be used.

[0036] In an embodiment, the physical layer protocol data unit may be a PPDU as defined in the Institute of Electrical and Electronics Engineers 802.11 standard.

[0037] According to another aspect there is provided a method for providing precoder information for establishing an uplink trigger-based data communication across a plurality of tones of a radio band between an access point and one or more station devices, the method comprising: generating at the access point, in response to triggering a sounding null data physical layer protocol data unit from the one or more station devices, a physical layer protocol data unit for transmitting to the one or more station devices, the physical layer protocol data unit containing a sounding feedback report frame for each of the station devices including a first field comprising precoder information for establishing a single uplink data connection between the access point and one of the one or more the station devices and a second field comprising a set of parameters to instruct processing of the precoder information in the first field; and transmitting the physical layer protocol data unit containing the sounding feedback report frame to the one or more station devices.

[0038] In an embodiment, the method may comprise generating the first field of the feedback report frame as an uplink beamforming Precoder field and the second field of the feedback report frame as an uplink, UL, beamforming, BF, multiple input multiple output, MIMO, Control field.

[0039] In an embodiment, the method may comprise including the precoder information in the first field within the feedback report frame as a single MAC Protocol Data Unit, MPDU, where the precoder information comprises one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data

connection and the set of parameters in the second field correspond to processing only the segment of precoder information contained in the first field.

[0040] In an embodiment, the segment of precoder information and the set of parameters corresponding to that segment may be transmitted in the feedback report frame as a MAC Protocol Data Unit, MPDU, within an Aggregate MAC Protocol Data Unit, AMPDU.

[0041] In an embodiment, the AMPDU includes one or more of a plurality of precoder parameters for the station device.

[0042] In an embodiment, the method may comprise generating the second field of the sounding feedback report frame to comprise the subfields: Grouping, Codebook Information, Remaining UL BF Feedback Segments, First UL BF Feedback Segment and Reserved.

[0043] In an embodiment, the Grouping subfield may indicate resolution of the precoder information in the frequency domain.

[0044] In an embodiment, the Codebook Information subfield may define the size in bits of each parameter corresponding to the precoder information.

[0045] In an embodiment, the Remaining UL BF Feedback Segments subfield may define the number of subsequent segments of precoder information for the station device from the current frame onwards.

[0046] In an embodiment, the First UL BF Feedback Segment subfield may indicate whether or not the current feedback report frame includes a first segment of a plurality of segments of precoder information.

[0047] In an embodiment, the second field may comprise the subfields: Grouping, Codebook Information, and Reserved.

[0048] In an embodiment, the second field may comprise the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame.

[0049] In an embodiment, the second field may be a modified EHT MIMO Control Field where the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number are defined as reserved subfields.

[0050] In an embodiment, the modified EHT MIMO Control Field the subfields Nc Index and Nr Index may be defined as reserved.

[0051] In an embodiment, the second field and precoder information may be included within a Trigger Dependent User Info field of trigger frame, TF.

[0052] In an embodiment, the method may comprise generating, by the access point, a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each station device to whom the sounding feedback

report frame was transmitted; and transmitting the sounding feedback report frame with the trigger frame contained within the physical layer protocol data unit.

[0053] In an embodiment, the precoder information may comprise tone indices formatted based on the bandwidth and number of tones per resource unit, RU, to be used in the uplink trigger based data communication such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted with an additional tone from each adjacent RU outside of the bandwidth to be used.

[0054] In an embodiment, the adjacent tones outside of the bandwidth to be used may be Ng tones below the first tone of the one or more RUs to be used and Ng tones above the last tone of the one or more RUs to be used of the bandwidth to be used, where the last tone may be defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone.

[0055] In an embodiment, the tone indices format may have the following parameterisation [lower adjacent tone by Ng: first tone: Ng: last tone in multiples of Ng: higher adjacent tone by Ng] .

[0056] In an embodiment, the access point may be configured to formulate the precoder information such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted to include one edge tone of the specified one or more RUs to be used.

[0057] In an embodiment, the tone indices format may have the following parameterisation [first tone: Ng: last tone in multiples of Ng: edge tone] , where the last tone is defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone, and the edge tone is the last tone of the one or more RUs to be used.

[0058] In an embodiment, the physical layer protocol data unit may be a PPDU as defined in the Institute of Electrical and Electronics Engineers 802.11 standard.

[0059] According to another aspect there is provided a non-access point station device for establishing an uplink trigger based data communication with an access point across a plurality of tones in a radio band, the station device configured to: receive from the access point a sounding feedback report frame; and process the report frame including a first field comprising precoder information for establishing a single uplink data connection between the access point and the station device and a second field comprising a set of parameters to instruct processing of the precoder information in the first field and maintain the precoder parameters when triggered and indicated by the access point to transmit a trigger-based physical layer protocol data unit containing beam-formed uplink data frames.

[0060] In an embodiment, the first field of the sounding feedback report frame may be an uplink beamforming Precoder field and the second field of the feedback report frame is an uplink, UL, beamforming, BF, multiple input multiple output, MIMO, Control field.

[0061] In an embodiment, the precoder information may be contained within the feedback report frame as a single MAC Protocol Data Unit, MPDU, and comprises one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data connection and the station device is configured to process only the segment of precoder information contained in the first field according to the set of parameters in the second field.

[0062] In an embodiment, the segment of precoder information and the set of parameters corresponding to that segment may be received in the feedback report frame as a MAC Protocol Data Unit, MPDU, within an Aggregate MAC Protocol Data Unit, AMPDU.

[0063] In an embodiment, the AMPDU may include one or more of a plurality of precoder parameters for the station device and the station device is configured to receive said one or more of a plurality of precoder parameters.

[0064] In an embodiment, the second field may comprise the subfields: Grouping, Codebook Information, Remaining UL BF Feedback Segments, First UL BF Feedback Segment and Reserved.

[0065] In an embodiment, the Grouping subfield may indicate resolution of the precoder information in the frequency domain.

[0066] In an embodiment, the Codebook Information subfield may define the size in bits of each parameter corresponding to the precoder information.

[0067] In an embodiment, the Remaining UL BF Feedback Segments subfield may define the number of subsequent segments of precoder information for the station device from the current frame onwards.

[0068] In an embodiment, the First UL BF Feedback Segment subfield may indicate whether or not the feedback report frame includes a first segment of a plurality of segments of precoder information.

[0069] In an embodiment, the second field may comprise the subfields: Grouping, Codebook Information, and Reserved.

[0070] In an embodiment, the second field may comprise the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame.

[0071] In an embodiment, the second field may be a modified EHT MIMO Control Field where the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number are defined as reserved subfields.

[0072] In an embodiment, the modified EHT MIMO Control Field the subfields Nc Index and Nr Index may be defined as reserved.

[0073] In an embodiment, the second field and precoder information may be included within a Trigger Dependent User Info field of a trigger frame.

[0074] In an embodiment, the station device may be configured to receive a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each non-access point station device to whom the sounding feedback report frame was transmitted.

[0075] In an embodiment, the station device may be configured to process the precoder information comprising tone indices formatted based on the bandwidth and number of tones per resource unit, RU, to be used in the uplink trigger based data communication such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted with an additional tone from each adjacent RU outside of the bandwidth to be used.

[0076] In an embodiment, the adjacent tones outside of the bandwidth to be used may be Ng tones below the first tone of the one or more RUs to be used and Ng tones above the last tone of the one or more RUs to be used of the bandwidth to be used, where the last tone is defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone.

[0077] In an embodiment, the tone indices format may have the following parameterisation [lower adjacent tone by Ng: first tone: Ng:last tone in multiples of Ng: higher adjacent tone by Ng] .

[0078] In an embodiment, the station device may be configured to process the precoder information where tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted to include one edge tone of the specified one or more RUs to be used.

[0079] In an embodiment, the tone indices format may have the following parameterisation [first tone: Ng: last tone in multiples of Ng:edge tone] , where the last tone is defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone, and the edge tone is the last tone of the one or more RUs to be used.

[0080] In an embodiment, the physical layer protocol data unit may be a PPDU as defined in the Institute of Electrical and Electronics Engineers 802.11 standard.

[0081] BRIEF DESCRIPTION OF THE FIGURES

[0082] The present invention will now be described by way of example with reference to the accompanying drawings. In the drawings:

[0083] FIG. 1 shows a process for UL sounding and trigger based BF uplink data transmission.

[0084] FIG. 2 shows a trigger frame of modified format with precoder information included in an UL BF Feedback Report that is contained in a Trigger Dependent User Info subfield.

[0085] FIG. 3 shows the current format of the EHT Sounding MIMO Control field.

[0086] FIG. 4 shows a feedback report frame consisting of two main fields.

[0087] FIG. 5 shows the proposed structure for the process where each data unit for a specific station device is divided up into a trigger frame and one or more precoder segments.

[0088] FIG. 6 shows an example format of the proposed second field.

[0089] FIG. 7 shows an example format of the proposed second field.

[0090] FIG. 8 shows an example format of the proposed second field.

[0091] FIG. 9 shows an example format of the proposed second field as an adapted format of an EHT MIMO Control Field.

[0092] FIG. 10 shows a trigger frame with modified user specific information.

[0093] FIG. 11 shows an example structure which provides all combinations of BW and RU size with tone indices plan definitions.

DETAILED DESCRIPTION OF THE INVENTION

[0094] The presently proposed approach provides a design comprising new fields for UL Feedback report transmission with precoder parameters.

[0095] As mentioned above, the procedure in FIG. 1 is proposed for future standard versions. The design of the TF that forms part of this procedure and includes the precoder information was also introduced as in FIG. 2.

[0096] In FIG. 2 it can be seen that the precoder information and some parameters corresponding to the precoder are included in the Trigger Dependent User Info as part of the TF.

[0097] The current sounding procedure defined for downlink transmissions defines the BF report transmission as an independent management frame which includes two main fields: MIMO Control Field and Compressed BF Report Field. The MIMO Control Field is shown in FIG. 3 and includes the set of values that are required to generate the complete downlink transmission parameters based on the feedback information that is provided in the Compressed BF Report Field.

[0098] The proposed approach herein defines a design for precoder information transmission which supports all possible scenarios and provides all the required parameters to allow the STAs to successfully decode the precoder data in an uplink transmission procedure. Specifically, there is a desire to support precoder report transmission with segmentation. Thus, there is defined an UL BF Feedback Report Frame with an adapted format.

[0099] FIG. 4 shows a frame 400 consisting of two main fields.

[0100] The first field, UL BF Precoder Field 404 contains the precoder parameters included in current UL BF Feedback Report Frame or a segment thereof.

[0101] The second field, UL BF MIMO Control Field 402, is a field that contains the set of parameters corresponding to the precoder information and any precoder information segmentation. The precoder information is contained in a UL BF Precoder Field.

[0102] Thus, there is provided herein a method for providing precoder information for establishing an uplink beamformed trigger-based data communication across a plurality of tones of a radio band between an access point and one or more station devices. The method comprises generating at the access point, in response to triggering a sounding null data physical layer protocol data unit from the one or more station devices, a physical layer protocol data unit for transmitting to the one or more station devices. The physical layer protocol data unit contains one or more sounding feedback report frames where each frame includes a first field and a second the field that correspond to parameters of a specific precoder to be used by the station devices. The first field comprises precoder information for establishing a single uplink data connection between the access point and one of the one or more the station devices. The second field comprises a set of parameters to instruct processing of the precoder information in the first field. The method further comprises transmitting the physical layer protocol data unit containing the sounding feedback report frame to the one or more station devices.

[0103] The proposed method may additionally comprise generating the first field of the feedback report frame as an uplink (UL) beamforming (BF) Precoder field and the second field of the feedback report frame as an uplink (UL) beamforming (BF) multiple input multiple output (MIMO) Control field.

[0104] The proposed method may comprise including the precoder information in the first field within the feedback report frame as a single MAC Protocol Data Unit, MPDU, where the precoder information comprises one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data connection. The set of parameters in the second field may thus correspond to processing only the segment of precoder information contained in the first field. The segment of precoder information and the set of parameters corresponding to that segment may thus be transmitted in the feedback report frame as a MAC Protocol Data Unit, MPDU, within an Aggregate MAC Protocol Data Unit, AMPDU.

[0105] There is therefore also provided herein an access point and non-access point station device configured to implement the described method. Accordingly, there is provided an access point for establishing an uplink trigger based data communication with one or more station devices across a plurality of tones in a radio band. The access point is

configured to generate and transmit a physical layer protocol data unit to one or more station devices that contains one or more sounding feedback report frames for each of the station devices including a first field and a second field. Specifically, the first field comprises precoder information for establishing a single uplink data connection between the access point and the station device and the second field comprises a set of parameters to instruct processing of the precoder information in the first field.

[0106] The access point may therefore be configured to generate the data unit where the first field of the feedback report frame is an uplink beamforming Precoder field and the second field of the feedback report frame is an uplink (UL) beamforming (BF) multiple input multiple output (MIMO) Control field.

[0107] Additionally, the access point may be configured to generate the data unit such that the precoder information is contained within the feedback report frame as a single MAC Protocol Data Unit (MPDU) and comprise one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data connection. The set of parameters in the second field may therefore correspond to processing only the segment of precoder information contained in the first field. The segment of precoder information and the set of parameters corresponding to that segment may be transmitted in the feedback report frame as a MAC Protocol Data Unit, MPDU, within an Aggregate MAC Protocol Data Unit, AMPDU.

[0108] Accordingly, there is provided a non-access point station device for establishing an uplink beamformed trigger based data communication with an access point across a plurality of tones in a radio band. The station device is configured to receive from the access point a sounding feedback report frame and process the report frame including a first field comprising precoder information for establishing a single uplink data connection between the access point and the station device and a second field comprising a set of parameters to instruct processing of the precoder information in the first field. The non-access point station device is also configured to maintain the precoder parameters when triggered and indicated by the access point to transmit a trigger-based physical layer protocol data unit containing beam-formed uplink data frames. The first field of the sounding feedback report frame may be an uplink beamforming Precoder field and the second field of the feedback report frame may be an uplink, UL, beamforming, BF, multiple input multiple output, MIMO, Control field.

[0109] The station device may be configured to receive and process the report frame where the precoder information is contained within the feedback report frame as a single MAC Protocol Data Unit, MPDU, and comprises one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data connection and the station device is configured to process only the segment of precoder information contained in the first field according to the set of parameters

in the second field. The station device may additionally be configured to receive and process the report frame where wherein the segment of precoder information and the set of parameters corresponding to that segment are received in the feedback report frame as a MAC Protocol Data Unit, MPDU, within an Aggregate MAC Protocol Data Unit, AMPDU.

[0110] The proposed design described herein enables the previously proposed process to divide the precoder information into several segments and transmit each segment as an MPDU within an A-MPDU. This is illustrated in FIG. 5.

[0111] FIG. 5 shows the proposed structure for the process. Each A-MPDU 502 (ato c) for a specific STA (for example station number two) is divided up into a TF 504 (ato c) and one or more UL BF precoder segments 506. The TF and each of the precoder segments are contained within a respective single A-MDPU 508. Each A-MPDU is destined for an individual associated non-AP STA.

[0112] The implementation of this process may be one of multiple different options and is evidenced by the design of the UL BF MIMO Control Field 402 and which specific parameters related to precoder information are included therein.

[0113] Analysis of the current EHT MIMO Control Field design as shown in FIG. 3 has been carried out to understand which parameters should be included in UL BF MIMO Control Field. It is assumed that the precoder information may be carried within the same A-MPDU in which the MPDU that contains the TF is included. Therefore, if some information corresponding to the precoder is already included in the TF, it is possible with the new structure to exclude one or more fields from the UL BF MIMO Control Field.

[0114] Nc field and Nr field indicate the number of spatial streams and the number of transmit antennas respectively. This is also indicated in the TF and in the preceding NDPR –thus there is no need to repeat them in the content of the second field.

[0115] Similarly, BW is indicated in the TF. Therefore, BW does not need to be indicated in the second field of the presently proposed structure.

[0116] Partial BW Info is actually also already defined by the RU allocation field in the TF. Therefore, Partial BW information is also not required in the second field.

[0117] Dialog Token Number is irrelevant in this context as STA is mandated to apply the specified precoder in current TB PPDU. Therefore, this information is also redundant.

[0118] Grouping, Codebook Info, First Feedback Segment and Remaining Feedback Segments are all important as they define the precoder format of the proposed procedure and define the number of MPDUs. Therefore, this information should be included within the newly designed second field.

[0119] Thus, the main concept described herein, where the UL BF MIMO Control field is part of UL BF Feedback Report frame, allows for precoder report segmentation

and indication of all the parameters required to successfully process each segment independently.

[0120] In a first example embodiment there is proposed a UL BF MIMO Control Field 600 of the format shown in FIG. 6.

[0121] A first subfield 602 of the second field may be a Grouping (Ng) subfield. The Grouping subfield indicates the resolution of the precoder information in frequency. A second subfield 604 of the second field may be a Codebook Information subfield. The Codebook Information subfield may define the number of bits for precoder parameters. A third subfield 606 of the second field 600 may be a Remaining UL BF Feedback Segments subfield. The Remaining UL BF Feedback Segments subfield may define the number of subsequent UL BF Feedback segments to be carried in that A-MPDU from this point onwards. A fourth subfield 608 of the second field 600 may be a First UL BF Feedback Segment subfield. The First UL BF Feedback Segment subfield may be used to indicate that this segment is a first segment. A fifth subfield 610 of the second field 600 may be a Reserved subfield. The Reserved subfield 610 may be retained for additional parameters to be defined in procedures or processes to be incorporated into future IEEE standards.

[0122] The number of bits of each subfield is shown below each subfield. The number of bits per subfield as shown in FIG. 6 is an example only, other distributions and numbers of bits per subfield may also be used to provide the proposed subfields.

[0123] Therefore, there is provided a method comprising generating the second field of the sounding feedback report frame to comprise the subfields Grouping, Codebook Information, Remaining UL BF Feedback Segments, First UL BF Feedback Segment and Reserved. The Grouping subfield indicates resolution of the precoder information in frequency domain. The Codebook Information subfield defines the size in bits of each parameter corresponding to the precoder information. The Remaining UL BF Feedback Segments subfield defines the number of subsequent segments of precoder information for the station device from the current frame onwards. The First UL BF Feedback Segment subfield indicates whether or not the current feedback report frame includes a first segment of a plurality of segments of precoder information.

[0124] Therefore, there is provided an access point configured to generate the second field of the feedback report frame comprising the subfields Grouping, Codebook Information, Remaining UL BF Feedback Segments, First UL BF Feedback Segment and Reserved. There is also provided a station device configured to receive a feedback report frame where the second field comprises the subfields Grouping, Codebook Information, Remaining UL BF Feedback Segments, First UL BF Feedback Segment and Reserved.

[0125] In a second example embodiment there is proposed an alternative UL BF MIMO Control Field and is a reduced version compared to the Control Field described above and shown in FIG. 6. The reduced Control Field of FIG. 7 is an example design which may be used in cases where there is a restriction such that segmentation is not used.

[0126] FIG. 7 shows the format of a second example embodiment of the proposed UL BF MIMO Control Field 700. A first subfield 702 of the second field may be a Grouping (Ng) subfield. The Grouping subfield indicates the resolution of the precoder information in frequency. A second subfield 704 of the second field may be a Codebook Information subfield. The Codebook Information subfield may define the number of bits for precoder parameters. A third subfield 706 of the second field 700 may be a Reserved subfield. The Reserved subfield 706 may be retained for additional parameters to be defined in procedures or processes to be incorporated into future IEEE standards.

[0127] Thus, there may be provided a method wherein the second field comprises the subfields Grouping, Codebook Information, and Reserved. These subfields are as defined above. The proposed access point and station device may be configured to generate and receive feedback report frames with this structure respectively.

[0128] In a third example embodiment there is provided an alternative UL BF MIMO Control Field which is an extended version compared to the Control Field described above and shown in FIG. 6. The extended UL BF MIMO Control Field of FIG. 8 is provided for the case where Nc and Nr parameters may differ from the number of spatial streams indicated by the TF and the number of transmit antennas indicated by the NDPR. Thus, the example Control Field of FIG. 8 is the same as that of FIG. 6 except with the addition of the subfields Nc 802 and Nr 804 which explicitly state the values of these parameters.

[0129] Accordingly, there may be provided the method described above but wherein the second field comprises the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame. Therefore, there may also be provided an access point configured to generate the second field comprising the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame. Additionally, there may be provided a station device configured to receive the data unit wherein the second field comprises the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame.

[0130] In a further embodiment there is proposed an approach which reuses the format of the EHT MIMO Control Field. The prosed adapted format of the EHT MIMO Control Field 900 is shown in FIG. 9. The adapted format 900 redefines the irrelevant fields

902 as Reserved fields. The Nc field 904 and Nr field 906 may be defined as reserved fields or may be used if required, as described above is reference to FIG. 8.

[0131] Accordingly, there is proposed a method as described above but where the second field is a modified EHT MIMO Control Field in which the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number are defined as reserved subfields. Additionally, the modified EHT MIMO Control Field may also comprise the subfields Nc Index and Nr Index re-defined as reserved subfields.

[0132] Thus, there is proposed herein an access point configured to generate a data unit where the second field is a modified EHT MIMO Control Field with the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number defined as reserved fields. Additionally, the modified EHT MIMO Control Field may comprise the fields Nc Index and Nr Index also re-defined as reserved. Correspondingly, a station device is proposed configured to receive a data unit where the second field may be a modified EHT MIMO Control Field with the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number defined as reserved subfields. Further, the modified EHT MIMO Control Field may have the subfields Nc Index and Nr Index re-defined as reserved subfields.

[0133] FIG. 10 shows another embodiment of the proposed format. In this embodiment there is proposed an alternative TF design with a UL BF MIMO Control Field. So long as all of the precoder reports for all the STAs and the TF do not exceed the size of a single MPDU it is possible to include the precoder data within a Trigger Dependent User Info field of the TF. Thus, there is proposed an updated design of the TF where it includes an UL BF MIMO Control Field within the Trigger Dependent User info field as depicted in FIG. 10.

[0134] FIG. 10 shows an existing TF design 1000 with modified user specific information 1002. The Trigger Dependent User Info subfield 1004 of the Per User Info 1002 field of the TF is modified to contain the second field UL BF MIMO Control Field 402 as described above. That is, the required parameters for processing the precoder information (matrix) V 402 which is either in one or multiple segments depending on the size (e.g. the number of stations to be accounted for) . Hence, the same TF design may be used for a single precoder data segment as well as for multiple segments.

[0135] Thus, the proposed method may comprise the second field and precoder information included within a Trigger Dependent User Info field of trigger frame (TF) . Accordingly, there is proposed an access point configured to generate the second field and precoder information included within a Trigger Dependent User Info field of a trigger frame. Similarly, there may be provided a station device configured to receive

and process the second field and precoder information of the data unit included within a Trigger Dependent User Info field of a trigger frame.

[0136] As mentioned above, there is a need to define tone indices for precoder transmission for each BW and all RU sizes. Thus, there is a need to indicate indices for the RUs of BWs of at least 20, 40, 80, 160, and 320MHz and RUs of sizes 26, 52, 106, 242, 484, 996, 2x996, and 4x996-tones which may include one or more MRU. For each MRU the tone indices will be a combination of RUs that comprises the MRU. Note that RUs of size smaller than 242-tones are called small RUs and RUs of size larger or equal to 242-tones are called large RUs.

[0137] Therefore, there is proposed a format for defining tone indices in a further embodiment of the proposed method.

[0138] The tone indices for large RUs was updated and defined in IEEE standard 802.11be. The tone indices for small RUs within 20 and 40MHz BW was defined in IEEE standard 802.11ax and is still relevant in 11be. Other methods have been proposed for defining tone indices for small RUs within BW larger than 40MHz.

[0139] One option is to combine these three approaches for defining tone indices so that all combinations of BW and RU size are covered. This arrangement is depicted in FIG. 11.

[0140] The proposed method described herein may therefore comprise precoder information comprising tone indices formatted based on the bandwidth and number of tones per resource unit, RU, to be used in the uplink trigger based data communication. For example, tone indices for RUs with fewer than 242 tones in bandwidths 20MHz and 40MHz may be formatted with the parameterisation according to the plan defined in IEEE standard 802.11ax. Tone indices for RUs with 242 tones or more in all bandwidths may be formatted with the parameterisation according to the plan defined in IEEE standard 802.11be. Tone indices for RUs with fewer than 242 tones in bandwidths 80MHz, 160MHz, and 320MHz may be formatted with the parameterisation according to other existing methods. As explained above, the use of all of these tone indices indication methods to cover the proposed extended range and sized of RUs and bandwidths within the same feedback report frame has not previously been proposed. By the phrase ‘all bandwidths’ it is intended to refer to the bandwidths as defined in the IEEE standard for WiFi communications. For example, the communication bandwidths supported and defined as in the standards 802.11ax or 802.11be.

[0141] The proposed access point and station device may be configured to generate and receive feedback report frames with precoder information comprising tone indices formatted based on the bandwidth and number of tones per resource unit, RU, to be used in the uplink trigger based data communication as described above.

[0142] Alternatively, one or more of these previously presented approaches may be utilised in part of the BW for some of the RU sizes and a new tone indices format may be proposed for the remaining BWs and RU sizes. The general format may be described as having the following parameterisation [first tone: Ng: last tone] .

[0143] For example, the definition for tone indices as provided in IEEE standard 802.11ax for BW of 20 and 40MHz and the definition for tone indices as provided in IEEE standard 802.11be for large RUs. However, the remaining tone indices for small RUs in BW larger than 80MHz may be defined as follows. Each RU is defined by every Ng tones from tones of this RU as defined in the tone plan of IEEE standard 802.11be in combination with one additional tone from the adjacent RU. For example, the tone indices for the 26-tone RU #21 in 80MHz are defined as [39-64] , the tone indices for RU #20 are [13-38] , and for RU #22 are [67: 92] . Thus, if the adapted format is [tone indices from previous tone: first tone indices of current RU: Ng tones: last tone in increments of Ng in current RU: first tone in following RU in increments of Ng] then the tone indices for precoder information for RU #21 would be [35, 39: 4: 63, 67] . Where 39 is the first tone if RU #21, Ng is 4, 4 tones before 39 is 35, 63 is the last tone in RU #21 in increments of 4 from 39, and 67 is 4 tones after 63.

[0144] Therefore, there is proposed the method described above wherein the precoder information is formulated such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted with an additional tone from each adjacent RU outside of the bandwidth to be used. The bandwidths above 80MHz which are formulated accordingly are those defined according to the IEEE standard 802.11be for the proposed communications.

[0145] The proposed method may comprise the adjacent tones outside of the bandwidth to be used are Ng tones below the first tone of the one or more RUs to be used and Ng tones above the last tone of the one or more RUs to be used of the bandwidth to be used. Accordingly, the last tone is defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone. Ng tones is the defined granularity of the of the provided feedback data. The value of Ng may be defined by the standard or set as another value in a preceding process or part thereof.

[0146] Therefore, the tone indices format may have the following parameterisation [lower adjacent tone by Ng: first tone: Ng: last tone in multiples of Ng: higher adjacent tone by Ng] .

[0147] There may thus be provided an access point configured to formulate the tone indices according to the above parameterisation. The access point may be configured to formulate the precoder information such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted with the tones of the RU as defined for data transmission and an additional tone from each adjacent RU as defined

for data transmission outside of the bandwidth to be used. Wherein the adjacent tones outside of the bandwidth to be used are each Ng tones below the first tone of the tones as defined for data transmission within one or more RUs to be used and Ng tones above the last tone of the tones as defined for data transmission within the one or more RUs to be used of the bandwidth to be used respectively. Where the last tone is defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone. Thus, the tone indices format may have the parameterisation [lower adjacent tone by Ng: first tone: Ng: last tone in multiples of Ng: higher adjacent tone by Ng] .

[0148] Similarly, there may be provided a station device configured to process the precoder information where tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted with an additional tone from each adjacent RU outside of the bandwidth to be used. Wherein the adjacent tones outside of the bandwidth to be used may be Ng tones below the first tone of the one or more RUs to be used and Ng tones above the last tone of the one or more RUs to be used of the bandwidth to be used. The last tone may be defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone. The tone indices format may have the following parameterisation [lower adjacent tone by Ng: first tone: Ng: last tone in multiples of Ng: higher adjacent tone by Ng] .

[0149] In another embodiment, the definition for tone indices as provided in IEEE standard 802.11ax for BW of 20 and 40MHz and the definition for tone indices as provided in IEEE standard 802.11be for large RUs. However, the remaining tone indices for small RUs in BW larger than 80MHz may be defined as follows. Each RU may be defined by every Ng tone from tones of the current RU as defined in the tone plan of IEEE standard 802.11be with one additional edge tone of the current RU.

[0150] For example, the tone indices for 26-tone RU #21 in 80MHz are defined as [39-64] . Thus, the tone indices proposed herein for the precoder information for RU #21 may be [39: 4: 63, 64] . Where 39 is the first tone in RU #21, Ng is 4, 63 is the last tone in RU #21 in increments of 4 from 39, and 64 is the edge tone of RU #21, i.e. the last tone.

[0151] Accordingly, there is proposed a method as described above wherein the access point is configured to formulate the precoder information such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted to include one edge tone of the specified one or more RUs to be used. The method may comprise generating the tone indices format with the following parameterisation [first tone: Ng: last tone in multiples of Ng: edge tone] , where the last tone is defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone, and the edge tone is the last tone of the one or more RUs to be used.

[0152] Accordingly, there may be provided the access point described above configured to formulate the precoder information such that tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted to include one edge tone of the tones of the specified one or more RUs to be used as defined for data transmission. The access point may thus generate the feedback report frame with the tone indices format with the following parameterisation [first tone: Ng: last tone in multiples of Ng: edge tone] , where the last tone is defined as the last tone of the tones within the one or more RUs to be used as defined for data transmission which is a multiple of Ng tones above the first tone, and the edge tone is the last tone of the one or more RUs to be used.

[0153] Similarly, there may be provided the station device described herein above and configured to process the precoder information where tone indices for RUs with fewer than 242 tones in bandwidths 80MHz and above are formatted to include one edge tone of the specified one or more RUs to be used. The indices format may have the following parameterisation [first tone: Ng: last tone in multiples of Ng: edge tone] , where the last tone is defined as the last tone within the one or more RUs to be used which is a multiple of Ng tones above the first tone, and the edge tone is the last tone of the one or more RUs to be used.

[0154] The proposed access point as described above may be configured to generate a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each station device to whom the sounding feedback report frame was transmitted. Additionally, the physical layer protocol data unit may be a PPDU as defined in the Institute of Electrical and Electronics Engineers standard 802.11.

[0155] Thus, the method may similarly comprise generating, by the access point, a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each station device to whom the sounding feedback report frame was transmitted; and transmitting the sounding feedback report frame with the trigger frame contained within the physical layer protocol data unit. The physical layer protocol data unit may also be a PPDU as defined in the Institute of Electrical and Electronics Engineers standard 802.11.

[0156] The proposed station device described herein may thus be configured to receive a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each non-access point station device to whom the sounding feedback report frame was transmitted. Again, the physical layer protocol

data unit may be a PPDU as defined in the Institute of Electrical and Electronics Engineers 802.11 standard.

[0157] The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of the claims. The applicant indicates that aspects of the present invention may consist of any such individual feature or combination of features. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

Claims

[Claim 1] An access point for establishing an uplink trigger based data communication with one or more station devices across a plurality of tones in a radio band, the access point configured to generate and transmit a physical layer protocol data unit to one or more station devices that contains one or more sounding feedback report frames for each of the station devices including a first field comprising precoder information for establishing a single uplink data connection between the access point and the station device and a second field comprising a set of parameters to instruct processing of the precoder information in the first field.

[Claim 2] The access point of claim 1, wherein the first field of the feedback report frame is an uplink beamforming Precoder field and the second field of the feedback report frame is an uplink, UL, beamforming, BF, multiple input multiple output, MIMO, Control field.

[Claim 3] The access point of claim 1 or 2, wherein the precoder information is contained within the feedback report frame as a single MAC Protocol Data Unit, MPDU, and comprises one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data connection and the set of parameters in the second field correspond to processing only the segment of precoder information contained in the first field.

[Claim 4] The access point of any of claims 1 to 3, wherein the second field of the feedback report frame comprises the subfields: Grouping, Codebook Information, Remaining UL BF Feedback Segments, First UL BF Feedback Segment and Reserved.

[Claim 5] The access point of any of claims 1 to 4, wherein the second field comprises the subfields: Grouping, Codebook Information, and Reserved.

[Claim 6] The access point of any of claims 1 to 5, wherein the second field comprises the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame.

[Claim 7] The access point of any of claims 1 to 4, or 6, wherein the second field is a modified EHT MIMO Control Field where the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number are defined as reserved fields.

[Claim 8] The access point of claim 1 or 2, wherein the second field and precoder information are included within a Trigger Dependent User Info field of a trigger frame, TF.

[Claim 9] The access point of any of claims 1 to 8, wherein the access point is configured to generate a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each station device to whom the sounding feedback report frame was transmitted.

[Claim 10] A method for providing precoder information for establishing an uplink trigger-based data communication across a plurality of tones of a radio band between an access point and one or more station devices, the method comprising:

generating at the access point, in response to triggering a sounding null data physical layer protocol data unit from the one or more station devices, a physical layer protocol data unit for transmitting to the one or more station devices, the physical layer protocol data unit containing one or more sounding feedback report frames for each of the station devices including a first field comprising precoder information for establishing a single uplink data connection between the access point and one of the one or more the station devices and a second field comprising a set of parameters to instruct processing of the precoder information in the first field; and

transmitting the physical layer protocol data unit containing the sounding feedback report frame to the one or more station devices.

[Claim 11] The method of claim 10, wherein the method comprises generating the first field of the feedback report frame as an uplink beamforming Precoder field and the second field of the feedback report frame as an uplink, UL, beamforming, BF, multiple input multiple output, MIMO, Control field.

[Claim 12] The method of claim 10 or 11, wherein the method comprises including the precoder information in the first field within the feedback report frame as a single MAC Protocol Data Unit, MPDU, where the precoder information comprises one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data connection and the set of parameters in the second field correspond to processing only the segment of precoder information contained in the first field.

[Claim 13] The method of claim 10 or 11, wherein the second field comprises the subfields: Grouping, Codebook Information, and Reserved.

[Claim 14] The method of any of claims 10 to 12, wherein the second field comprises the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame.

[Claim 15] The method of any of claims 10 to 12, or 14, wherein the second field is a modified EHT MIMO Control Field where the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number are defined as reserved subfields.

[Claim 16] The method of claim 10 or 11, wherein the second field and precoder information are included within a Trigger Dependent User Info field of trigger frame, TF.

[Claim 17] The method of any of claims 10 to 16, wherein the method comprises generating, by the access point, a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each station device to whom the sounding feedback report frame was transmitted; and transmitting the sounding feedback report frame with the trigger frame contained within the physical layer protocol data unit.

[Claim 18] A non-access point station device for establishing an uplink trigger based data communication with an access point across a plurality of tones in a radio band, the station device configured to:
receive from the access point a sounding feedback report frame;
process the report frame including a first field comprising precoder information for establishing a single uplink data connection between the access point and the station device and a second field comprising a set of parameters to instruct processing of the precoder information in the first field; and
maintain the precoder parameters when triggered and indicated by the access point to transmit a trigger-based physical layer protocol data unit containing beam-formed uplink data frames.

[Claim 19] The station device of claim 18, wherein the first field of the sounding feedback report frame is an uplink beamforming Precoder field and the second field of the feedback report frame is an uplink, UL, beamforming, BF, multiple input multiple output, MIMO, Control field.

[Claim 20] The station device of claim 18 or 19, wherein the precoder information is contained within the feedback report frame as a single MAC Protocol Data Unit, MPDU, and comprises one of a plurality of segments of a total of the precoder information needed for establishing the single uplink data connection and the station device is configured to process only the segment of precoder information contained in the first field according to the set of parameters in the second field.

[Claim 21] The station device of any of claims 18 to 20, wherein the second field comprises the subfields: Grouping, Codebook Information, Remaining UL BF Feedback Segments, First UL BF Feedback Segment and Reserved.

[Claim 22] The station device of any of claims 18 to 21, wherein the second field comprises the subfields: Grouping, Codebook Information, and Reserved.

[Claim 23] The station device of any of claims 18 to 21, wherein the second field comprises the subfields Nc Index and Nr Index indicating the dimensions of each of a plurality of feedback matrices contained in the feedback report frame.

[Claim 24] The station device of any of claims 18 to 21, or 23, wherein the second field is a modified EHT MIMO Control Field where the subfields Bandwidth, Feedback Type, Partial Bandwidth Information and Sounding Dialog Token Number are defined as reserved subfields.

[Claim 25] The station device of claim 18 or 19, wherein the second field and precoder information are included within a Trigger Dependent User Info field of a trigger frame.

[Claim 26] The station device of any of claims 18 to 25, the station device configured to receive a physical layer protocol data unit containing the sounding feedback report frame and a trigger frame which includes the corresponding parameters to initiate an acknowledgement frame from each non-access point station device to whom the sounding feedback report frame was transmitted.