IEEE P802.11
Wireless LANs

|  |
| --- |
| PDT Sounding Procedure |
| Date: 2024-12-15 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| You-Wei Chen | MediaTek | 2840 Junction Ave, San Jose, CA 95134 |  | you-wei.chen@mediatek.com |
| Jianhan Liu | MediaTek |  |  | Jianhan.Liu@mediatek.com |
| Shengquan Hu | MediaTek |  |  | shengquan.hu@mediatek.com |
| Alice Chen | Qualcomm  |  |  | alicel@qti.qualcomm.com |
| Alfred Asterjadhi | Qualcomm  |  |  | aasterja@qti.qualcomm.com |
| Sameer Vermani | Qualcomm |  |  | svverman@qti.qualcomm.com |
| Youhan Kim | Qualcomm  |  |  | youhank@qti.qualcomm.com |
| Ron Porat | Broadcom |  |  | ron.porat@broadcom.com |
| Shubhodeep Adhikari | Broadcom |  |  | shubhodeep.adhikari@broadcom.com |
| Tianyu Wu | Apple |  |  | tianyu@apple.com |
| Qinghua Li | Intel |  |  | Qinghua.li@intel.com |
| Anand Jee | Samsung |  |  | anandjee7@gmail.com |
| Eunsung Jeon | Samsung |  |  | eunsung.jeon@samsung.com |
| Aniruddh Rao Kabbinale | Samsung |  |  | aniruddh.rao@samsung.com |
| Seongho Byeon | Samsung |  |  | sh.byeon@samsung.com |
| Genadiy Tsodik | Huawei |  |  | Genadiy.tsodik@huawei.com |
| Jason Yuchen Guo | Huawei |  |  | guoyuchen@huawei.com |
| Ross Jian Yu | Huawei |  |  | ross.yujian@huawei.com |
| Dongguk Lim | LG Electronics |  |  | dongguk.lim@lge.com |
| Insik Jung  | LG Electronics |  |  | insik0618.jung@lge.com |
| Jiayi Zhang | Ofinno |  |  | jzhang@ofinno.com |
| Leonardo Lanante | Ofinno |  |  | llanante@ofinno.com |
| Bo Cao | ZTE |  |  | cao.bo4@zte.com.cn |
| Qisheng Huang | ZTE |  |  | Huang.qisheng@zte.com.cn |
| Yun Li | ZTE |  |  | li.yun3@zte.com.cn |
| Dana Ciochina | Sony |  |  | Dana.Ciochina@sony.com |
| Kosuke Aio | Sony |  |  | kosuke.aio@sony.com |
| Pei Zhou | TCL |  |  | zhoupei36@gmail.com |
| Hanqing Lou | InterDigital |  |  | Hanqing.lou@interdigital.com |
| Mahmoud Kamel | InterDigital |  |  | mahmoud.kamel@interdigital.com |
| Rui Yang | InterDigital |  |  | rui.yang@interdigital.com |
| Xiaofei Wang | InterDigital |  |  | Xiaofei.wang@interdigital.com |
| Ying Wang | InterDigital |  |  | Ying.Wang@interdigital.com |
| Bo Sun | Sanechips |  |  | sun.bo1@sanechips.com.cn |
| Juhyung Lee | Nokia |  |  | juhyung.lee@nokia.com |
| Mario Costa | Nokia |  |  | mario.costa@nokia.com |
| Okan Mutgan | Nokia |  |  | okan.mutgan@nokia.com |
| Yeon-Geun Lim | Newracom |  |  | chaind3@gmail.com |
| Rui Cao | NXP |  |  | rui.cao\_2@nxp.com |
| Liuming Lu | OPPO |  |  | luliuming@oppo.com |
|  |  |  |  |  |
|  |  |  |  |  |

Abstract

This document contains Proposed Draft Text (PDT) for the sounding procedure of the proposed TGbn (UHR, Ultra High Reliability) amendment to the 802.11 standard.

**Revision information**

The following is a summary of the important changes that occurred within each revision of this document:

|  |  |
| --- | --- |
| **Revision** | **Major changes** |
| 0 | Initial revision |
| 1 | Combine modifications and comments from Kosuke, Insik, Leonardo, Dana, and Ying  |
| 2 | Add motion 179 and 180 in 11-24/0171r25. Modify terminology of COBF to Co-BF.Combine modifications and comments from Ying and Liuming |
| 3 | Add suggestions during the Joint section. |
|  |  |
|  |  |

**Introduction**

Interpretation of a Motion to Adopt.

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGbe Draft. The abstract, revision information, introduction, explanation of the proposed changes and references sections are not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGbe Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

**Explanation of the proposed changes:**

The proposed changes to the 802.11 TGbn draft within this document are based on the following motions adopted by the TGbn task group:

**Relevant passing motions:**

[Motion #97, [1]]

* Both sequential NDP based and joint NDP based sounding options will be supported for COBF in 802.11bn.

[Motion #98, [1]]

* Two separate capabilities shall be defined for the maximum number of spatial streams supported for reception of a sounding NDP in UHR and the maximum total number of streams (across all users) supported for reception in UHR DL MU-MIMO and CoBF PPDUs
	+ The only possible values for each capability are 4 and 8.

[Motion #99, [1]]

* The Coordinated beamforming (COBF) transmission phase in 802.11bn shall be limited to 2 APs.

[Motion #100, [1]]

* The sequential NDP based sounding protocol will be as shown below for COBF
	+ Sounding happens one BSS at a time
	+ NDPA only addresses the in-BSS STAs
	+ MAC related additional frames are TBD.



[Motion #101, [1]]

* The joint NDP based sounding protocol will be as shown below for COBF
	+ Sounding happens for one BSS’s STAs at a time
	+ NDPA only addresses the in-BSS STAs
	+ MAC related additional frames are TBD
	+ Joint NDP based feedback will be based on large V-based feedback where the eigen-vectors span the antennas across both Aps



[Motion #102, [1]]

* For joint NDP based sounding, one AP will frequency synchronize to the other for both of its NDP transmissions
	+ For both the NDPs, the AP doing the correction brings its frequency within a certain TBD range of the reference AP

[Motion #103, [1]]

* In the UHR sounding process for COBF, for the joint sounding case as well as for the sequential sounding case, the NDP shall always carry the BSS color of the AP which transmitted the NDPA.

[Motion #115, [1]]

* For the maximum number of spatial streams supported for reception of sounding NDP in UHR and the maximum total number of streams (across all users) supported for reception in UHR DL MU-MIMO and COBF PPDUs:
	+ 4 is mandatory except for a non-AP STA with 20 MHz-Only Limited Capabilities Support subfield equal to 1.
	+ 8 is optional for DL MU-MIMO and sounding NDP (Note: More than 4 is not allowed for COBF PPDUs

[Motion #116, [1]]

* The COBF sequential sounding support to be conditional mandatory if the device supports COBF.

[Motion #118, [1]]

* For sequential NDP based sounding, one AP will frequency synchronize to the other for both of its NDP transmissions
	+ For both its NDPs, the AP doing the correction brings its frequency within a certain TBD range of the reference AP.

[Motion #179, [1]]

* There is no UHR sounding sequence for SU TxBF or DL MU-MIMO. UHR SU TxBF and UHR DL MU-MIMO uses EHT sounding sequence.

[Motion #180, [1]]

* UHR sounding sequence uses EHT NDP. I.e., there is no UHR NDP.
	+ UHR COBF sounding sequence is the only UHR sounding sequence

**Text to be adopted begins here.**

***TGbn editor: Please add the following new subclause for Sounding Procedure to the 802.11bn draft D0.1:***

**37.6 UHR sounding operation**

**37.6.1 General**

Transmit beamforming, DL MU-MIMO and DL Co-BF require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. UHR STAs use the EHT sounding protocol as defined in 35.7 (EHT sounding operation) to determine the channel state information for transmitting SU beamforming and DL MU-MIMO. UHR STAs use the UHR sounding protocol as defined in 37.6 (UHR sounding operation) to determine the channel state information for transmitting DL Co-BF. The UHR sounding protocol provides explicit feedback mechanism, defined as UHR trigger-based (TB) sounding sequences that include UHR TB sequential NDP sounding sequence and UHR TB joint NDP sounding sequence for DL Co-BF. In the UHR TB sounding sequences, the UHR beamformee measures the channel using a training signal as defined in 38.3.21 (EHT sounding NDP for UHR TB sounding sequence) transmitted by one or two UHR beamformers and sends back a transformed estimate of the channel state (see 37.6.3 (Rules for UHR sounding protocol sequences)). The UHR beamformer uses this estimate to derive the steering matrix.

**37.6.2 UHR sounding protocol**

**37.6.3 Rules for UHR sounding protocol sequences**

A UHR Co-BF beamformer that initiates a UHR TB sounding sequence shall transmit a UHR Co-BF NDP Announcement frame with TBD or more STA Info fields and the RA field set to the broadcast address. STA Info fields shall only address to the responding AP and the non-AP UHR STAs associated with the initiating AP.

The UHR Co-BF NDP Announcement frame shall be followed after a SIFS by EHT sounding NDP(s) transmitted from the responding AP in a UHR TB sequential NDP sounding sequence, or simultaneously from the initiating AP and the responding AP in a UHR TB joint NDP sounding sequence. The EHT sounding NDP(s) shall be followed after a SIFS by the BFRP Trigger frame from the initiating AP. Subsequent BFRP Trigger frames, if any, in the UHR TB sounding sequence shall be transmitted a SIFS after the UHR TB PPDU transmitted in response to the previous BFRP Trigger frame. Each UHR Co-BF beamformee that is addressed by a BFRP Trigger frame shall respond after a SIFS with a UHR TB PPDU containing one or more TBD Compressed Beamforming/CQI frames.

A UHR TB sequential NDP sounding sequence initiated from one AP comprises an EHT TB sounding sequence to collect channel states from its associated STAs, and a cross-BSS UHR TB sounding sequence for the responding AP to collect channel states from the same STAs. An example of a UHR TB sequential NDP sounding sequence initiated from AP1 is shown in Figure 37-x (UHR TB sequential NDP sounding sequence initiated from AP1). AP1, the UHR Co-BF beamformer that initiates a cross-BSS UHR TB sounding, shall transmit the UHR Co-BF NDP Announcement frame to solicit the EHT sounding NDP from AP2, the responding AP. The UHR Co-BF NDP Announcement frame shall only address to the responding AP and the non-AP UHR STA associated with the initiating AP. To collect the channel state to compute a steering matrix for DL Co-BF transmission, both APs need to initiate an EHT TB sounding sequence and a cross-BSS UHR TB sounding sequence sequentially, i.e., total four sounding sequences. For all the sounding sequences, one AP conducts the frequency correction on its EHT sounding NDPs to a TBD range of the reference AP, which may be either AP1 or AP2.

 

#### Figure 37-x—UHR TB sequential NDP sounding sequence initiated from AP1

NOTE — It is TBD whether EHT TB sounding sequence and Cross-BSS UHR TB sounding sequence in a UHR TB sequential NDP sounding sequence are allowed to be in different TXOPs or in the same TXOP.

An example of a UHR TB joint NDP sounding is shown in Figure 37-y (UHR TB joint NDP sounding). A UHR Co-BF beamformer that initiates a UHR TB joint NDP sounding shall transmit the UHR Co-BF NDP Announcement frame followed after a SIFS by EHT sounding NDPs transmitted simultaneously from the initiating AP and responding AP. The UHR Co-BF NDP Announcement frame shall only address to the responding AP and the non-AP UHR STAs associated with the initiating AP. To collect the channel state to compute a steering matrix for DL Co-BF transmission, both APs need to initiate a UHR TB joint NDP sounding sequentially, i.e., total two sequences. For both UHR TB joint NDP sounding sequences, one AP conducts the frequency correction on its EHT sounding NDPs to a TBD range of the reference AP, which may be either AP1 or AP2.



#### Figure 37-y—UHR TB joint NDP sounding

An UHR Co-BF beamformer initiates an UHR TB sounding sequence to solicit feedback only if the feedback is computed based on parameters (see 9.4.2.aab.1 (UHR PHY Capabilities Information field)) supported by the UHR Co-BF beamformee. An UHR Co-BF beamformer shall not initiate an UHR TB sounding sequence if the feedback would be computed based on parameters not supported by the UHR Co-BF beamformee (see 37.6.2 (UHR sounding protocol)).

A UHR Co-BF beamformer that transmits an UHR Co-BF NDP Announcement frame to one or more UHR Co-BF beamformees shall set the AID11 subfield to the 11 LSBs of the AID of each UHR Co-BF beamformee. A UHR Co-BF NDP Announcement frame shall not include multiple STA Info fields that have the same value in the AID11 subfield.

**37.6.4 Rules for generating segmented feedback**

**37.6.5 Sounding NDP transmission for UHR TB sounding sequence**

The TXVECTOR parameters for an EHT sounding NDP shall be set as follows:

* FORMAT is set to EHT\_MU.
* APEP\_LENGTH is set to 0.
* SPATIAL\_REUSE is set to PSR\_AND\_NON\_SRG\_OBSS\_PD\_PROHIBITED (see 35.11.2 (SPATIAL\_REUSE)).
* TXOP\_DURATION set to either 127 or a value defined in Equation (35-3).
* Other parameter settings are TBD.

The intended recipient(s) of an EHT sounding NDP is the STA(s) addressed by the STA Info field(s) in the immediately preceding UHR Co-BF NDP Announcement frame.

**Text to be adopted ends here.**

Note to TTT members and editor:

[37.8 Coordinated beamforming is covered in 24/2030 PDT-MAC-Coordinated-Beamforming, Jason Yuchen Guo (Huawei)]

[38.1 Introduction, 38.1.1 Introduction to the UHR PHY, 38.3.21 Sounding NDP for UHR are covered in 24/2015 PDT-PHY-CoBF, Ron Porat (Broadcom)]

**References:**

1. [11-24-0171r25](https://mentor.ieee.org/802.11/dcn/24/11-24-0171-25-00bn-tgbn-motions-list-part-1.pptx): 11-24-0171-25-00bn-tgbn-motions-list-part-1, Alfred Asterjadhi (Qualcomm Inc.)