IEEE P802.11  
Wireless LANs

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| PDT MAC and CR Coordinated Beamforming Protocol | | | | |
| Date: April 30, 2025 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | email |
| Jason Yuchen Guo | Huawei |  |  | guoyuchen@huawei.com |
| Mahmoud Hasabelnaby | Huawei |  |  | mahmoud.hasabelnaby@huawei.com |
| Giovanni Chisci | Qualcomm |  |  | gchisci@qti.qualcomm.com |
| Alice Chen | Qualcomm |  |  | alicel@qti.qualcomm.com |
| Insik Jung | LG |  |  | insik0618.jung@LGE.COM |
| Pei Zhou | TCL |  |  | zhoupei36@GMAIL.COM |
| Arik Klein | Huawei |  |  | arik.klein@huawei.com |
| Leonardo Lanante | Ofinno |  |  | llanante@ofinno.com |
| Kaiying Lu | Mediatek |  |  | Kaiying.Lu@mediatek.com |
| Mahmoud Kamel | InterDigital |  |  | mahmoud.kamel@interdigital.com |
| Tianyu Wu | Apple |  |  | tianyu@apple.com |
| Fangxin Xu | Longsailing Semiconductor |  |  | fzxy002763@GMAIL.COM |
| Qinglai Liu | Panasonic |  |  | qinglai.liu@SG.PANASONIC.COM |
| Yaoshen Cui | TP-Link |  |  |  |
| Yusuke Tanaka | Sony |  |  | Yusuke.YT.Tanaka@sony.com |
| Genadiy Tsodik | Huawei |  |  | genadiy.tsodik@huawei.com |
| Qisheng Huang | ZTE |  |  | huang.qisheng@ZTE.COM.CN |
| Daniel Verenzuela | Sony |  |  | Daniel.Verenzuela@sony.com |
| Dana Ciochina | Sony |  |  | Dana.Ciochina@sony.com |
| Yongho Seok | Apple |  |  | y\_seok@apple.com |
| Sindhu Verma | Broadcom |  |  | sindhu.verma@broadcom.com |
| Okan Mutgan | Nokia |  |  | okan.mutgan@nokia.com |
| Kosuke Aio | Sony |  |  | Kosuke.Aio@sony.com |
| Anand Jee | Samsung |  |  | anandjee7@GMAIL.COM |
| Alfred Asterjadhi | Qualcomm |  |  | asterjadhi@GMAIL.COM |
| Abhishek Patil | Qualcomm |  |  | appatil@qti.qualcomm.com |
| Aiguo Yan | Samsung |  |  | aiguo.yan@samsung.com |
| Sherief Helwa | Qualcomm |  |  | shelwa@qti.qualcomm.com |
| You-Wei Chen | Mediatek |  |  | You-Wei.Chen@mediatek.com |
| Wei Dong | OPPO |  |  |  |
| Hui Che | Ruijie |  |  | chehui@RUIJIE.COM.CN |
| Juan Fang | Intel |  |  | juan.fang@intel.com |
| Lyutianyang Zhang | Huawei |  |  | zhanglyutianyang@huawei.com |
| Yanjun Sun | Apple |  |  | yanjun.sun@apple.com |
| Zigui Yang | Samsung |  |  |  |
| Jiayi Zhang | Ofinno |  |  | jzhang@OFINNO.COM |
| Dibakar Das | Intel |  |  | dibakar.das@intel.com |
| Rubayet Shafin | Samsung |  |  | r.shafin@SAMSUNG.COM |
| Vishnu Ratnam | Samsung |  |  | vishnu.r@samsung.com |
| Lei Zhou | H3C |  |  | zhou.leiH@H3C.COM |
| Gaurang Naik | Qualcomm |  |  | gnaik@qti.qualcomm.com |
| Peshal Nayak | Samsung |  |  | p.nayak@samsung.com |
| Eunsung Jeon | Samsung |  |  | eunsung.jeon@samsung.com |
| Sigurd Schelstraete | Maxlinear |  |  | sschelstraete@maxlinear.com |
| Mahmoud Hasabelnaby | Huawei |  |  | mahmoud.hasabelnaby@huawei.com |
| Youhan Kim | Qualcomm |  |  | youhank@qti.qualcomm.com |
| George Cherian | Qualcomm |  |  | gcherian@qti.qualcomm.com |
| Yanchun Li | Huawei |  |  | liyanchun@huawei.com |
| Ron Porat | Broadcom |  |  | ron.porat@broadcom.com |
| Shimi Shilo | Huawei |  |  | Shimi.Shilo@huawei.com |
| Sameer Vermani | Qualcomm |  |  | svverman@qti.qualcomm.com |
| Shengquan Hu | Mediatek |  |  | Shengquan.hu@mediatek.com |
| Ross Jian Yu | Huawei |  |  | ross.yujian@huawei.com |
| Insun Jang | LG |  |  | insun.jang@LGE.COM |
| Rui Yang | InterDigital |  |  | Rui.Yang@InterDigital.com |
| Liuming Lu | OPPO |  |  | luliuming@oppo.com |
| Ying Wang | InterDigital |  |  | Ying.Wang@interdigital.com |
| Aniruddh Kabbinale | Samsung |  |  | aniruddh.kabbinale@IEEE.ORG |
| Yeon-Geun Lim | Newracom |  |  | chaind3@gmail.com |
| Mario Costa | Nokia |  |  | mario.costa@nokia.com |
| Juhyung Lee | Nokia |  |  | juhyung.lee@nokia.com |
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Abstract

This document contains Proposed Draft Text (PDT) for the coordinated beamforming protocol of the TGbn (UHR, Ultra High Reliability) amendment to the 802.11 standard.

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Editorial changes.
* Rev 2: Editorial changes based on the comments received during the conference call and from offline. Change the definition to align with Co-SR.
* Rev 3: change Subclause number to align with D0.3. Add text for newly passed motions.
* **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 TGbn 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 TGbn 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 passed motions:**

**[Motion #29]**

**TGbn defines multi-AP Coordinated Beamforming (Co-BF).**

**[Motion #99]**

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

**[Motion #114]**

**In a Co-BF transmission, the maximum number of spatial streams given to one user will be 2.**

**[Motion #135]**

**The sharing AP, that transmits a Trigger frame as part of a transmission sequence in a Multi-AP coordinated transmission scheme, identifies the shared AP via an AP ID carried in the AID12 field of the User Info field of the frame**

* **Note: the name of "sharing AP" and "shared AP" are TBD**
* **Note: Multi-AP coordinated transmission schemes are Co-SR, Co-BF and Co-TDMA**

**[Motion #298]**

**802.11bn defines the concept of a sync-reference AP and a sync-follower AP for CFO correction in Co-BF**

* + **Sync-follower AP pre-corrections needed**
  + **For sequential sounding:**
    - **All the NDPs sent by it during sounding phase that are sent for the purpose of sounding the STAs in the other BSS (Mandatory)**
    - **For the NDPs sent by it for sounding the STAs in its own BSS, it is recommended but not mandatory that the sync follower AP pre-correct those NDPs**
  + **For joint sounding**
    - **All the NDPs sent by it during the sounding phase (Mandatory)**
    - **The Co-BF sync and COBF PPDU during transmission phase using the same frequency pre-correction value as the sounding phase, when it is the sharing AP**
  + **Sync-reference AP does not pre-correct during transmission phase when it is the sharing AP**

**[Motion #299]**

**The sync-follower AP shall use the NDPA frame sent by the sync-reference AP to pre-correct the NDP frequency to be within a TBD range (e.g., 350Hz) of the sync-reference AP’s frequency**

* + **Applies to sequential and joint sounding**
  + **The pre-correction of cross-BSS NDP and joint NDP is mandatory**
  + **The pre-correction of in-BSS NDPs is recommended but not a mandatory requirement**

**[Motion #300]**

**The sharing AP is the AP that transmits the final sync frame before the Co-BF PPDU**

* + **Regardless of who is the sync-reference**
  + **Note: This ensures a consistent protocol and a consistent behavior at sharing AP**

**[Motion #304]**

**The COBF PPDU’s GI+LTF support and signaling is as follows:**

* + **Support of following GI+LTF combinations to be mandatory at both AP and STA**
  + **2x LTF +0.8us, 2xLTF+1.6us, 4xLTF+3.2us**
  + **Additionally, 2x LTF+0.8us GI usage for a COBF pair is exchanged at the group formation stage**
  + **Each AP conveys if it can use 2x+0.8us GI for this COBF group or not**
  + **No further last-minute negotiation before COBF transmission**
  + **Invite frame from sharing AP dictates the LTF+GI combination keeping the shared AP’s ability to use 2x LTF+0.8us in mind**

**[Motion #301]**

**The shared AP always pre-corrects Co-BF PPDU based on the final sync**

* + **To bring the two APs within a TBD frequency range of each other (e.g., ~350Hz)**
  + **NOTE: Regardless of which AP is the sync-reference, this ensures consistent behavior at shared AP**

**[Motion #311]**

**The Co-BF Sync frame carries the following information**

* + **How to indicate the information is TBD**

|  |  |
| --- | --- |
| Category | Information |
| Control | ‘Co-BF Sync’ |
| PHY Common Info | Length |
| PHY Version Identifier |
| Bandwidth |
| Punctured Channel Information |
| BSS Color 1, BSS Color 2 |
| TXOP |
| Number of UHR-SIG Symbols |
| GI+LTF Size |
| Number Of UHR-LTF Symbols |
| Number of Co-BF Users |
| Per-User Info in Both BSS | STA ID |
| BSS Color Indication |
| MCS |
| Spatial Configuration |
| 2xLDPC |

**[Motion #312]**

**In each of the Co-BF Invite, Response and Sync frames, if there is information for more than one users, the users are ordered according to NSS in non-increasing order**

* + **The order of users in the sharing BSS in the Sync frame is aligned with that in the Invite frame.**
  + **The order of users in the shared BSS in the Sync frame is aligned with that in the Response frame.**

**[Motion #316]**

**The order of user information in the Sync frame is aligned with the order of users in the UHR-SIG User field for Co-BF transmission.**

**[Motion #327]**

**The Co-BF Invite frame carries the following information.**

* + **How to indicate the information is TBD.**

|  |  |
| --- | --- |
| Category | Information |
| Control | ‘Co-BF Invite’ |
| PHY Common Info | Minimum Number of Data OFDM Symbols |
| Maximum Number of Data OFDM Symbols |
| PHY Version Identifier |
| Bandwidth |
| Punctured Channel Information |
| GI+LTF Size |
| Maximum Total Nss Allowed for shared AP |
| Number of Co-BF Users in sharing BSS |
| Per-User Info in Sharing BSS | STA ID |
| Nss |

**[Motion #328]**

**The Co-BF Response frame carries at least the following information.**

* + **How to indicate the information is TBD.**

|  |  |
| --- | --- |
| Category | Information |
| Control | ‘Co-BF Acceptance’ |
| PHY Common Info | Suggested Number of Data OFDM Symbols |
| PHY Version Identifier |
| Extra LTF Allowed |
| Number of CoBF Users in shared BSS |
| Per-User Info in Shared BSS | STA ID |
| MCS |
| Nss |
| 2xLDPC |

**[Motion #371]**

**The following information shall be exchanged before Co-BF PPDU:**

* + **Min-Nsym and Max-Nsym indication about the COBF PPDU length sent in the COBF invite frame**
  + **Suggested Nsym indication in the Co-BF response frame from shared AP** 
    - **Sharing AP is allowed to ignore the shared AP’s suggestion**
    - **Suggested value shall not be smaller than the Min-Nsym value from sharing AP**

**[Motion #421]**

**APs exchange the following 2-bit capability fields with values 1, 2, 3, or 4 at the time of group formation between the members of a Co-BF pair. The capabilities are defined for the AP declared BW and assume Nc=2 (# of columns in the feedback)**

* + **Field 1 – Total number of OBSS sounding reports that the AP can store for this Co-BF pair at a given time**
  + **Field 2 – Total number of OBSS joint sounding reports that the AP can store for this Co-BF pair at a given time (can’t be higher than number in field 1)**

**[Motion #445]**

**If an eMLSR non-AP MLD that receives an ICF addressed to one of its affiliated STAs during Co-BF sequences and if the affiliated STA responds with an ICR, then the eMLSR non-AP MLD shall follow the eMLSR procedure defined in 35.3.17, except that the STA shall use an extended time-out period prior to switching back upon inactivity:**

* + **The duration of the extended time-out period shall be sufficient to cover any inactivity period within the Co-BF sequence, e.g. (but not limited to), from the end of the ICR to the beginning of the data PPDU, or from the DL PPDU until the beginning of the MU-BAR frame from the shared AP for STAs associated with the shared AP**
  + **The duration of the extended timeout period is explicitly indicated to the STA in the ICF frame sent by its associated AP.**
  + **Once the eMLSR STA(s) switch back to listen mode, they start using the default time-out period (aSIFSTime + aSlotTime + aRxPHYStartDelay) in future TXOPs unless otherwise indicated in the ICF.**
  + **This is applicable to Co-BF transmission sequence**

**[Motion #446]**

**For DPS non-AP STA(s) scheduled with Co-BF in high capability mode, the same switch-back behavior as for eMLSR with extended time-out period is used**

* + **The RTS frame shall not be used as an ICF for DPS in the Co-BF Transmission sequence even when the DPS STA does not have any DPS padding required**

**NOTE: The RTS frame cannot be modified to include the extended timeout period usage and the extended timeout period duration indications.**

**[Motion #448]**

**An AP shall use the BSRP NTB Trigger frame variant for the CoBF Invite frame**

* + **The CoBF Response frame shall be M-BA**
  + **TBD whether there’s another frame variant allowed for the CoBF Invite/Response frame**

**[Motion #449]**

**An AP MLD that receives an ICR from a STA affiliated with an EMLSR non-AP MLD during Co-BF data frame exchange does not attempt to transmit to the eMLSR non-AP MLD on another link during the extended time-out periods, per baseline behavior.**

**[Motion #451]**

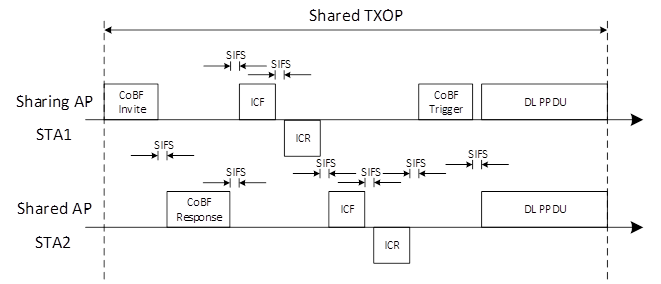
**In Co-BF transmission phase, the Feedback User Info field in the BSRP/MU-RTS Trigger addressed to EMLSR/DPS STA carries the extended timeout period duration.**

* + **A new feedback type value is defined for Co-BF.**
  + **An “Extended Timeout Duration” field with a TBD length is included in the Feedback user Info field**
  + **The duration value is reported with granularity of 4 us.**
  + **A value 0 of the “Extended Timeout Duration” field is an indication to the STA to follow the default eMLSR/DPS switch back behavior, i.e., do not use an extended timeout period.**
  + **Whether the field indicates maximum value or actual value is TBD**

**[Some related SPs]**

**SP1:Do you support to use the following CoBF transmission sequence to support STAs requiring ICF/ICR before data frame exchanges?**

* **The frame sequence consists of:**
  + **A CoBF Invite/CoBF Response frame exchange between the sharing and shared APs.**
  + **Follows ICF/ICR frame exchanges between the APs and their associated STAs happening sequentially across the two APs; sharing AP then shared AP.**
    - **The presence of the ICF/ICR frame exchange from each AP is conditional on the CoBF PPDU being addressed to one or more STA.**
    - **The presence of the ICF/ICR frame exchange from each AP is indicated in the CoBF Invite/Response frames.**
    - **The duration of the ICF/ICR frame exchange from each AP is indicated in the CoBF Invite/Response frames**
    - **ICF1-ICR1 are exchanged between the sharing AP and its STAs**
    - **ICF2-ICR2 are exchanged between the shared AP and its STAs**
  + **Finally, a CoBF Trigger frame preceding the data PPDUs sent by the two APs simultaneously.**
  + **Frame sequence for Ack information polling is TBD.**
* **Whether the CoBF-invite and ICF1 can be merged and CoBF-response and ICF2 can be merged as below is TBD.**

****

**SP2:Do you support to use the following sequence for acknowledgement information polling from STAs scheduled in a CoBF transmission sequence?**

* **MU-BAR/BA frame exchanges are used by each AP separately, i.e., sequentially.**
* **The duration of MU-BAR/BA frame exchange between the Sharing AP and its associated non-AP STAs is indicated in the CoBF Trigger frame.**

**NOTE-The first MU-BAR frame (transmitted by the sharing AP) can be replaced with a basic trigger that is aggregated with the DL PPDU as in baseline.**

**A computer screen shot of a black screen

AI-generated content may be incorrect.**

**Relevant CIDs (Part I):**

**199 777 984 1578 2457 2802 3482**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CID | Commenter | Clause | Page | Comment | Proposed Change | Resolution |
| 199 | Chunyu Hu | 37.8.2.1 | 72.13 | What would be the Co-BFed PPDU that would achieve the goal of Co-BF as mentioned in 37.8.2.1.1 with the sounding results. Does an AP need to know the other AP's DL traffic info in order to properly construct the PPDU? If so, how exactly? | Need to provide text to address the questions raised in the comment. | Revised –  Agree in principle with the commenter. A polling phase is added for the AP to know the other AP’s intent to participate in the Co-BF transmission.  TGbn Editor:  Please implement the changes in this document tagged as #199 |
| 777 | Seongho Byeon | 37.8.2.1 | 72.21 | Since Co-BF aims to minimize mutual interference between two APs and their recipient STAs, the general term "interference to OBSS STA" may not be appropriate. Suggest modifying it to "interference between each other" or "interference in between each recipient STA". | As in comment. | Revised –  Agree in principle with the commenter.  TGbn Editor:  Please implement the changes in this document tagged as #777 |
| 984 | Arik Klein | 37.8.2.1.1 | 72.24 | Need to add a clear requirement for the required Channel state information/ Compressed Beamforming/CQI reports that are mandatory for each AP to obtain prior to its participation in a Co-BF transmission. Note: The sentence in P72L24) only refers to the UHR Sounding procedure as a means to obtain these reports. | As in comment | Revised –  Agree in principle with the commenter.  TGbn Editor:  Please implement the changes in this document tagged as #984 |
| 1578 | Jinsoo Choi | 37.8.2.1 | 72.26 | The Co-BF transmission needs to be initiated by an AP that obtains a TXOP (i.e. sharing AP) with a Co-trigger/Sync frame to notify and align the start of Co-Bfed PPDU transmission. Needs to describe how to initiate a Co-BF transmission. In addition, the overall procedure for Co-BF including discovery of candidate APs, parameters negotiation, initiating Co-BF transmission, and transmitting Co-BFed PPDUs, etc., also needs to be defined. Some part (e.g. discovery, negotiation) that is common for all multi-AP schemes may be covered as in general multi-AP coordinatio framework (37.8.1). | See the comment. | Revised –  Agree in principle with the commenter. A subclause for Co-BF negotiation is added and a place holder for the Co-BF transmission phase is added. The details of the data transmission procedure will be added after related motions are approved. Besides, terminologies of Co-BF coordinating AP and Co-BF coordinated AP are defined to describe the procedure more efficiently.  TGbn Editor:  Please implement the changes in this document tagged as #1578 |
| 2457 | Yanjun Sun | 37.8.2.1.1 | 72.19 | Suggest to change this to "STAs associated with each of the APs" | as in comment | Revised –  Agree in principle with the commenter.  TGbn Editor:  Please implement the changes in this document tagged as #2457 |
| 2802 | RUI YANG | 37.8.2.1.1 | 72.19 | "to each AP's associated STAs" and "to OBSS STAs" are confusing terms in the sentence. | Change the sentence to "The objective of coordinated beamforming (Co-BF) is to allow more efficient medium usage by enabling concurrent transmissions of two APs with multiple antennas to the designated receiving STAs associated with each AP while minimizing interference to the designated receiving STAs in the OBSS by using the CSI of the channels between each AP and all designated receiving STAs associated with one of the two APs." | Revised –  Agree in principle with the commenter.  TGbn Editor:  Please implement the changes in this document tagged as #2457 and #777 |
| 3482 | ron porat | 37.8.2.1.1 | 72.24 | In addition to maximum number of spatial streams per recipient STA being restricted to 2, the maximum total number of spatial streams across all recipient STAs of both participating APs is limited to 4 for CoBF (Motion #115). This should be captured here. | Include the following: "The maximum total number of spatial streams of the Co-BF transmission summed over all recipient STAs of both participating APs shall  be 4." | Accepted. |

# Text to be adopted begins here:

**3.2 Definitions specific to IEEE Std 802.11**

**(#1578) coordinated beamforming coordinating access point:** [Co-BF coordinating AP] A coordinating AP that initiates Co-BF transmission with other APs.

**(#1578) coordinated beamforming coordinated access point:** [Co-BF coordinated AP] A coordinated AP that participates in Co-BF transmission initiated by the Co-BF coordinating AP.

**37.13 Multi-AP coordination framework**

**37.13.2 Procedures for specific Multi-AP coordination schemes**

**37.13.2.1 Coordinated beamforming**

**37.13.2.1.1 General**

The objective of coordinated beamforming (Co-BF) is to allow more efficient medium usage by enabling concurrent transmissions of two APs with multiple antennas to (#2457)non-AP STAs associated with the two APs, whereby each AP transmits to the non-AP STA(s) within its BSS while minimizing interference to (#777) the non-AP STA(s) associated with the other AP by using the CSI of the channels between each AP and the recipient STAs of the other AP of the Co-BF transmission. The number of participating APs in a Co-BF transmission shall be 2. The maximum number of spatial streams for each recipient STA of the Co-BF transmission shall be 2. (#984)The APs shall obtain the CSI required for performing the Co-BF transmission as described in 37.7 (UHR sounding operation).

(#1578)(M#300)A Co-BF coordinating AP is an AP with dot11CoBFOptionImplemented equal to true that obtains a TXOP and transmits a Co-BF Invite frame to invite another AP to perform Co-BF transmission. A Co-BF coordinated AP is an AP with dot11CoBFOptionImplemented equal to true that receives a Co-BF Invite frame from the Co-BF coordinating AP to perform Co-BF transmission. The Co-BF transmission sequence shall be initiated by the Co-BF coordinating AP. An AP shall not perform a Co-BF transmission to a STA with dot11CoBFOptionImplemented equal to false.

(#1578)An AP shall not initiate Co-BF transmission sequence with another AP unless the two APs have established a MAPC agreement for Co-BF according to the procedure defined in 37.13.2.1.2 (Co-BF negotiation) or by other means outside of the scope of this standard.

**(#1578) 37.13.2.1.2 Co-BF negotiation**

A MAPC requesting AP that follows the rules defined in 37.13.1.3 (MAPC agreement negotiation) to establish, update, or tear down a Co-BF agreement with a MAPC responding AP shall additionally follow the rules defined in this subclause. An AP that responds to a MAPC requesting AP in a MAPC agreement negotiation for a Co-BF agreement that follows the rules defined in 37.13.1.3 (MAPC agreement negotiation) shall additionally follow the rules defined in this subclause.

In the MAPC Negotiation Request frame and the MAPC Negotiation Response frame, the Co-BF profile shall include one MAPC Scheme Request field that includes the following information:

* (M#421)Total number of OBSS sounding reports that the AP can store for this Co-BF pair at a given time.

NOTE-this information is carried in a 2-bit field

* (M#421) Total number of OBSS joint sounding reports that the AP can store for this Co-BF pair at a given time.

NOTE-this information is carried in a 2-bit field. The shall shall not indicate a value in this field that is larger than the value of the total number of OBSS sounding reports.

* (M#304)whether the AP supports the use of 2 x LTF + 0.8 GI or not.

**37.13.2.1.3 Co-BF transmission phase**

(#199)A Co-BF coordinating AP shall initiate Co-BF transmission with a Co-BF coordinated AP by transmitting a Co-BF Invite frame to the Co-BF coordinated AP. The Co-BF Invite frame shall be a BSRP NTB Trigger frame. The TA field of the Co-BF Invite frame shall be set to the MAC address of the Co-BF coordinating AP, and the RA field of the Co-BF Invite frame shall be set to the MAC address of the Co-BF coordinated AP. (M#327)The Co-BF Invite frame shall include the following information:

* The minimum number of data OFDM symbols of the Co-BF transmission
* The maximum number of data OFDM symbols of the Co-BF transmission
* The PHY version of the Co-BF transmission
* The bandwidth of the Co-BF transmission
* The puncturing pattern of the Co-BF transmission
* The GI and the LTF size of the Co-BF transmission
* The maximum total number of spatial streams allowed for the Co-BF coordinated AP of the Co-BF transmission
* The number of recipient STAs of the Co-BF transmission that are associated with the Co-BF coordinating AP
* The STA ID of each recipient STA of the Co-BF transmission that is associated with the Co-BF coordinating AP
* The number of spatial streams for each recipient STA of the Co-BF transmission that is associated with the Co-BF coordinating AP
* Whether ICF and ICR frame exchange is needed before Co-BF transmission between the Co-BF coordinating AP and its associated recipient STAs
* The duration of the ICF and ICR frame exchange before Co-BF transmission between the Co-BF coordinating AP and its associated recipient STAs, if needed.

(#199)A Co-BF coordinated AP that receives a Co-BF Invite frame shall transmit a Co-BF Response frame to the Co-BF coordinating AP SIFS after the end of the PPDU carrying the Co-BF Invite frame. The Co-BF Response frame shall be a Multi-STA BlockAck frame. The TA field of the Co-BF Response frame shall be set to the MAC address of the Co-BF coordinated AP, and the RA field of the Co-BF Response frame shall be set to the MAC address of the Co-BF coordinating AP. (M#328)If the Co-BF coordinated AP accepts the Co-BF invite, the Co-BF Response frame shall include the following information:

* The suggested number of data OFDM symbols of the Co-BF transmission. (M#371)The suggested value shall not be smaller than the minimum number of data OFDM symbols indicated by the Co-BF coordinating AP in the Co-BF Invite frame.

NOTE-The Co-BF coordinating AP might ignore the shared AP’s suggestion

* The PHY version of the Co-BF transmission
* Whether extra LTF to be used in the Co-BF transmission is allowed by the Co-BF coordinated AP
* The number of recipient STAs of the Co-BF transmission that are associated with the Co-BF coordinated AP
* The STA ID of each recipient STA of the Co-BF transmission that is associated with the Co-BF coordinated AP
* The MCS for each recipient STA of the Co-BF transmission that is associated with the Co-BF coordinated AP
* The number of spatial streams for each recipient STA of the Co-BF transmission that is associated with the Co-BF coordinated AP
* Whether 2xLDPC will be used for each recipient STA of the Co-BF transmission that is associated with the Co-BF coordinated AP
* Whether ICF and ICR frame exchange is needed before Co-BF transmission between the Co-BF coordinated AP and its associated recipient STAs
* The duration of the ICF and ICR frame exchange before Co-BF transmission between the Co-BF coordinated AP and its associated recipient STAs, if needed.

(M#312)In each of the Co-BF Invite and Co-BF Response frames, if there is information for more than one user, the users are ordered according to the number of spatial streams in non-increasing order.

Each of the Co-BF coordinating and Co-BF coordinated APs shall include an ICF-ICR frame exchange in the Co-BF transmission frame sequence whenever any of the AP’s associated STAs being scheduled for Co-BF transmission in the current TXOP operates in a mode that requires preceding frame exchanges with an ICF transmission. This is the case for DPS enabled non-AP STAs, and for non-AP STAs affiliated with an EMLSR non-AP MLD that the Co-BF transmission is taking place will immediately follow on any of its EMLSR links.

If the ICF and ICR frame exchange is needed before Co-BF transmission between the Co-BF coordinating AP and its associated recipient STAs, the Co-BF coordinating AP shall transmit the ICF a SIFS after the end of the PPDU carrying the Co-BF Response frame that accepts the Co-BF invite. The non-AP STAs associated with the Co-BF coordinating AP that received the ICF shall follow the baseline rules to respond ICR.

If the ICF and ICR frame exchange is needed before the Co-BF transmission between the Co-BF coordinated AP and its associated recipient STAs, the Co-BF coordinated AP shall transmit the ICF 2\*aSIFSTime plus the duration of the ICF and ICR frame exchange between the Co-BF coordinating AP and its associated recipient STAs after the end of the PPDU carrying the Co-BF Response frame that accepts the Co-BF invite. The non-AP STAs associated with the Co-BF coordinated AP that received the ICF shall follow the baseline rules to respond ICR.

A Co-BF coordinating or a Co-BF coordinated AP transmitting any ICF frame during the Co-BF transmission phase to an associated non-AP STA shall include an indication to that STA to use an extended timeout period for the following cases:

* The STA is a DPS enabled non-AP STA in which case the extended timeout period corresponds to the time the DPS STA stays in the HC mode before switching to LC mode when it is not included in any frame transmission or reception.
* The STA is operating on an EMLSR link of its affiliated non-AP MLD in which case the extended timeout period corresponds to the non-AP MLD’s switch back to listening operation event on that EMLSR link(s).

The duration of the extended timeout period shall be explicitly indicated by the Extended Timeout Duration field in the Feedback user Info field included in the ICF frame. The AP shall indicate a duration for the extended timeout period that is longer than the longest inactivity period the associated non-AP STA(s) will experience within the Co-BF transmission sequence.

A STA that is operating on an EMLSR link of its affiliated non-AP MLD during the Co-BF transmission phase shall follow the rules defined in 35.3.17 (Enhanced multi-link single-radio (EMLSR) operation) for switching back to listening operation except for the following:

* It uses extended timeout period instead of aSIFSTime + aSlotTime + aRxPHYStartDelay as timeout interval starting at the end of the PPDU transmitted by the non-AP STA affiliated with the non-AP MLD as a response to the most recently received frame from the AP affiliated with the AP MLD or starting at the end of the reception of the PPDU containing a frame for the non-AP STA from the AP affiliated with the AP MLD that does not require immediate acknowledgement.
* During the extended timeout period, it does not switch back to listen mode.

After the Co-BF coordinating or Co-BF coordinated AP receives an ICR from its associated non-AP STA operating on an EMLSR link during the Co-BF transmission phase, the other AP(s) affiliated with the AP MLD shall not transmit frames to the other non-AP STA(s) affiliated with the non-AP MLD on the other EMLSR link(s) during the extended time-out period.

When an AP transmits an ICF frame to a DPS STA that is scheduled in a Co-BF sequence, the ICF shall not be an RTS frame.

(#1578) The Co-BF coordinating AP shall transmit a Co-BF Trigger frame to the Co-BF coordinated AP prior to the two data PPDUs transmitted simultaneously by the Co-BF coordinating and Co-BF coordinated APs. The Co-BF Trigger frame is used to ensure time and frequency synchronization between the two data PPDUs, and conveys the information needed to construct a common preamble for the two data PPDUs.

If the ICF and ICR frame exchange is not needed before Co-BF transmission between the Co-BF coordinating AP and its associated recipient STAs, and the ICF and ICR frame exchange is not needed before the Co-BF transmission between the Co-BF coordinated AP and its associated recipient STAs, the Co-BF coordinating AP shall transmit the Co-BF Trigger frame SIFS after the end of the PPDU carrying the Co-BF Response frame that accepts the Co-BF invite.

If the ICF and ICR frame exchange is needed before Co-BF transmission between the Co-BF coordinating AP and its associated recipient STAs, and the ICF and ICR frame exchange is not needed before the Co-BF transmission between the Co-BF coordinated AP and its associated recipient STAs, the Co-BF coordinating AP shall transmit the Co-BF Trigger frame SIFS after the end of the PPDU carrying the ICR transmitted by the non-AP STA(s) associated with the Co-BF coordinating AP.

If the ICF and ICR frame exchange is needed before the Co-BF transmission between the Co-BF coordinated AP and its associated recipient STAs, the Co-BF coordinating AP shall transmit the Co-BF Trigger frame 2\*aSIFSTime plus the duration of the ICF and ICR frame exchange between the Co-BF coordinated AP and its associated recipient STAs after the end of the PPDU carrying the Co-BF Response frame that accepts the Co-BF invite.

(M#311)The Co-BF Trigger frame shall include the following information:

* The value to be set in the Length field in the L-SIG field of the PPDU of the Co-BF transmission
* The PHY version of the Co-BF transmission
* The bandwidth of the Co-BF transmission
* The puncturing pattern of the Co-BF transmission
* The BSS color of the Co-BF coordinating AP
* The BSS color of the Co-BF coordinated AP
* The TXOP duration to be set in the TXOP field in the U-SIG of the Co-BF transmission
* The number of UHR-SIG symbols of the Co-BF transmission
* The GI and the LTF size of the Co-BF transmission
* The number of UHR-LTF symbols of the Co-BF transmission
* The total number of recipient STAs of the Co-BF transmission
* The STA ID of each recipient STA of the Co-BF transmission
* Which BSS each recipient STA of the Co-BF transmission belongs to
* The MCS of each recipient STA of the Co-BF transmission
* The spatial configuration of each recipient STA of the Co-BF transmission
* Whether 2xLDPC will be used for each recipient STA of the Co-BF transmission
* The duration of the MU-BAR/BA frame exchange between the Co-BF coordinating AP and its associated non-AP STAs

(M#316)The order of user information in the Co-BF Trigger frame shall be the same with the order of users in the UHR-SIG User field for the Co-BF transmission. The ordering of user information follows the rules described in 38.3.15.9.6 (User Specific field). In addition to the above rules, the order of user information of the users associated with the Co-BF coordinating AP in the Co-BF Trigger frame shall be the same with that in the Co-BF Invite frame. The order of user information of the users associated with the Co-BF coordinated AP in the Co-BF Trigger frame shall be the same with that in the Co-BF Response frame.

(M#298)The Co-BF coordinating AP and the Co-BF coordinated AP shall follow the rules defined in 38.3.24 (Transmit requirement for UHR Co-BF sounding sequence and Co-BF transmission) to apply frequency pre-correction to the PPDUs containing the Co-BF Trigger frame and the Co-BF data frames.

After simultaneously transmitting the two data PPDUs, the Co-BF coordinating AP and the Co-BF coordinated AP may use a sequential acknowledgement procedure to solicit the receiving status of the MSDUs/A-MSDUs in the data PPDUs from the recipient STA(s).

In the sequential acknowledgement procedure, the Co-BF coordinating AP shall transmit an MU-BAR to its associated recipient STA(s) if the ACK policy of the A-MPDU in the data PPDU transmitted by the Co-BF coordinating AP is Block Ack SIFS after the end of the data PPDU. The ACK policy of the A-MPDU in the data PPDU transmitted by the Co-BF coordinated AP shall be set to Block Ack. The Co-BF coordinated AP shall transmit an MU-BAR to its associated recipient STA(s) 2\*aSIFSTime plus the duration of the MU-BAR/BA frame exchange between the Co-BF coordinating AP and its associated non-AP STAs after the end of the data PPDU. The recipient STAs associated with the Co-BF coordinating AP and the Co-BF coordinated AP shall follow the baseline rules to respond Block Ack frames.

**9.3.1.8.6 Multi-STA BlockAck variant**

|  |  |
| --- | --- |
| * Feedback Type subfield encoding | |
| Feedback Type | Feedback subfield type |
| 0 | Unavailability feedback |
| 1 | Low latency feedback |
| 2 | Co-BF feedback |
| 3 | Co-TDMA feedback |
| 4-15 | Reserved |

**9.3.1.22.7 Feedback User Info field**

The Feedback type field indicates the type of feedback information included in the Feedback user Info field and follows the encoding shown in Table 9-45m5.

|  |  |
| --- | --- |
| Table 9-46m5 Feedback Type subfield encoding | |
| Feedback Type | Feedback subfield type |
| 0 | Unsolicited Unavailability feedback |
| 1 | Reserved |
| 2 | Co-BF feedback |
| 3 | Co-TDMA feedback |
| 4-15 | Reserved |

**9.3.1.22 Trigger Frame Format**

**9.3.1.22.7 Feedback User Info field**

A Feedback User Info field having the format shown in Figure 9-aa shall be included in the BSRP Trigger frame and MU-RTS Trigger frame that is addressed to one or more STAs within a Co-BF transmission frame sequence. The AID12 field value is set to 2008. The Feedback Type field is set to 2 indicating to the recipient STA(s) that this BSRP Trigger frame or MU-RTS Trigger frame is sent within a Co-BF transmission sequence. The format of the Feedback Information field is shown in Figure 9-bb that includes an Extended Timeout Duration field indicating the duration that the recipient STA(s) shall wait before initiating a switch back procedure. Switch back procedures can be either switching back to listen mode on the link of operation for EMLSR STAs or switching back to LC mode for DPS STAs. The Extended Timeout Duration is reported with a granularity of 4 us. The value 0 indicates that an EMLSR STA should follow normal EMLSR switch back procedures and a DPS STA should follow the normal DPS switch back procedures.

|  |  |  |  |
| --- | --- | --- | --- |
|  | B0   B11 | B12  B15 | B16    B39 |
|  | AID12 | Feedback Type | Feedback Information |
| Bits: | 12 | 4 | 24 |

**Figure 9-aa Feedback user Info field**

|  |  |  |
| --- | --- | --- |
|  | B0   TBD | TBD    B23 |
|  | Extended Timeout Duration | Reserved |
| Bits: | TBD | TBD |

**Figure 9-bb Feedback Information**

**9.4.2.1 General**

**9.4.2.aa3 MAPC element**

**9.4.2.aa3.2.2 Co-BF profile**

The MAPC Scheme Type field is set to the value for Co-BF as indicated in Table 9-349f (MAPC Scheme Type field values).

The MAPC Info field and the Last MAPC Request field are reserved

The MAPC Scheme Parameter Set field of the Co-BF profile is defined in Figure 9-aaX.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | B0     B1 | B2     B3 | B4 | B5     B7 |
|  | Number of Supported Sounding Reports | | Number of Supported Joint Sounding Reports | 2x LTF + 0.8 us GI Supported | Reserved |
| Bits: | | 2 | 2 | 1 | 3 |

Figure 9-aaX— MAPC Scheme Parameter Set field of the Co-BF profile format

The Number of Supported Sounding Reports field indicates a value among 1, 2, 3, or 4, that is the maximum number of OBSS Sounding Reports that the AP can store for this Co-BF pair.

The Number of Supported Joint Sounding Reports field indicates a value among 1, 2, 3, or 4 that is the maximum number of Joint Sounding Reports that the AP can store for this Co-BF pair. The value of the Number of Supported Joint Sounding Reports field is not larger than the value of the Number of Supported Sounding Reports field.

The 2x LTF + 0.8 us GI Supported field indicates whether the AP supports the use of 2 x LTF + 0.8 GI or not.