IEEE P802.11
Wireless LANs

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| PDT MAC and CR Coordinated Beamforming Protocol |
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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.
* **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 #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 #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**

**Relevant CIDs (Part I):**

**199 777 984 1578 2457 2802 3482**

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| --- | --- | --- | --- | --- | --- | --- |
| 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 enablingconcurrent transmissions of two APs with multiple antennas to the designated receiving STAs associated with each AP whileminimizing 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 AP:** [Co-BF coordinating AP] An AP that invites a Co-BF coordinated AP to initiate Co-BF transmission.

**(#1578) coordinated beamforming coordinated AP:** [Co-BF coordinated AP] An AP that is invited by a Co-BF coordinating AP to initiate Co-BF transmission.

**37.8 Multi-AP coordination framework**

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

**37.8.2.1 Coordinated beamforming**

**37.8.2.1.1 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)STAs associated with each of the APs while minimizing interference to (#777) the other AP’s recipient STAs 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 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 invites a Co-BF coordinated AP to participate in Co-BF operation within the TXOP by sending a Co-BF invite frame. A Co-BF coordinated AP is an AP with dot11CoBFOptionImplemented equal to true that receives the Co-BF invite frame from the Co-BF coordinating AP to participate in Co-BF transmission and responds with a Co-BF response frame. The Co-BF transmission shall be initiated by the Co-BF coordinating AP.

(#1578)An AP shall not initiate Co-BF transmission with another AP unless the two APs have established a MAPC agreement for Co-BF according to the procedure defined in 37.8.2.1.2 (Co-BF negotiation).

**(#1578) 37.8.2.1.2 Co-BF negotiation**

A MAPC requesting AP shall follow the rules defined in 37.8.1.3 (MAPC agreement negotiation) to establish, update, or tear down a Co-BF agreement with a MAPC responding AP and with additional rules defined in this subclause. An AP that responds to a MAPC requesting AP in a MAPC agreement negotiation for Co-BF agreement shall follow the rules defined in 37.8.1.3 (MAPC agreement negotiation) with additional rules defined in this subclause.

In order to perform Co-BF transmission, a MAPC requesting AP shall transmit a MAPC Negotiation Request frame carrying a MAPC element including a Co-BF profile to a MAPC responding AP. The MAPC Operation Type field in the Co-SR profile shall be set to 0 to establish a new Co-BF agreement, to 1 to update an existing Co-BF agreement, or to 2 to teardown an existing Co-BF agreement.

After receiving the MAPC Negotiation Request frame, the MAPC responding AP shall transmit a MAPC Negotiation Response frame carrying a MAPC element including a Co-BF profile to the MAPC requesting AP. The MAPC Operation Type field in the Co-SR profile shall be set to 3.

**37.8.2.1.4 Co-BF transmission phase**

(#1578)A Co-BF coordinating APshall 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 coordinating AP shall use the BSRP GI3 Trigger frame variant for the Co-BF invite frame. The TA field of the this frame shall be set to the MAC address of the Co-BF coordinating AP, the RA shall be set to the MAC address of the Co-BF coordinated AP. The Co-BF invite frame solicits a Co-BF response frame from the Co-BF coordinated AP addressed by the Co-BF invite frame. The Multi-STA BA frame shall be used for the Co-BF response frame.

ICF-ICR frame exchanges between the Co-BF coordinating and Co-BF coordinated APs and their associated non-AP STAs may be done sequentially after the transmission of the Co-BF response frame. The ICF-ICR frame exchange between the Co-BF coordinating AP and its associated STA(s) shall be done first. 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 its associated STAs being scheduled in the Co-BF transmission operates in a mode that requires initiating frame exchanges with ICF transmission. This is the case of DPS enabled non-AP STAs or for non-AP STAs affiliated with an EMLSR non-AP MLD and the Co-BF transmission is taking place on any of its EMLSR links.

When a Co-BF coordinating or a Co-BF coordinated AP transmits an ICF to either a DPS enabled non-AP STA or an EMLSR STA, then it shall include an indication to that STA to start using an extended timeout period before switching back to LC mode for DPS STAs or to listen mode for ELMSR STAs upon inactivity. The duration of the extended timeout period shall be indicated in the ICF frame. Each AP shall indicate a duration for the extended timeout period that is longer than the longest inactivity period its associated STA(s) experiences within the Co-BF transmission sequence.

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

The Co-BF coordinating AP shall transmit a sync frame prior to the data PPDUs transmitted simultaneously by the Co-BF coordinating and Co-BF coordinated APs. The sync frame is used to ensure time and frequency synchronization between the two data PPDUs simultaneously transmitted by the Co-BF coordinating and Co-BF coordinated APs, and conveying any information needed to construct a common preamble for both data PPDUs.

(M#298)If the Co-BF coordinating AP is a sync-follower AP, then the Co-BF coordinating AP shall transmit the Trigger frame and the Co-BF PPDU using the same frequency pre-correction value as the sounding phase, otherwise, the frequency pre-correction shall not be applied to the transmitted Trigger frame and Co-BF PPDU.

(M#301)After receiving the Trigger frame, the Co-BF coordinated AP shall pre-correct the frequency of the Co-BF PPDU based on the Trigger frame to bring the two APs within a TBD frequency range of each other.

After simultaneously transmitting the two data PPDUs, the Co-BF coordinating and Co-BF coordinated APs may use the existing acknowledgment information polling mechanisms except that it is done sequentially in the two BSSs. The acknowledgment information polling process shall be done by the Co-BF coordinating AP first.The Co-BF transmission frame sequence described in this subclause is also used for Co-SR transmissions.