IEEE P802.11
Wireless LANs

|  |
| --- |
| Proposed Draft Text: Beamforming |
| Date: 2021-03-02 |
| Author(s): |
| Name | Affiliation | Address | Phone | Email |
| Genadiy Tsodik | Huawei |  |  | genadiy.tsodik@huawei.com |
| Wook Bong Lee | Samsung |  |  | wookbong.lee@ samsung.com |
| Ruchen Duan | Samsung |  |  | r.duan@samsung.com |
| Youhan Kim | Qualcomm |  |  | youhank@qti.qualcomm.com |
| Yujin Noh | Newracom |  |  | yujin.noh@newracom.com |

Abstract

This submission proposes the draft text on Beamforming for TGbe D0.4 and resolves CIDs #2027 2028 2029 2030 2031 2219 from CC34

Revisions:

* Rev 0: Initial version of the document – update for 802.11-20/1231r3 based on TGbe D0.3

36.3.16.1 General

SU-MIMO and DL MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an RU or MRU. With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 242-tones.

For SU-MIMO and DL MU-MIMO beamforming in RU or MRU $r$, the receive signal vector in subcarrier k (where subcarrier $k$ is one of the subcarriers in RU or MRU $r$, $k\in K\_{r}$) at beamformee $u$, $y\_{k,u}=\left[y\_{k,0},y\_{k,1},\cdots ,y\_{k,N\_{RX\_{u}}-1}\right]^{T}$, is shown in Equation (36‑85), where $x\_{k}=\left[x\_{k,0}^{T},x\_{k,1}^{T},\cdots ,x\_{k,N\_{user,r}-1}^{T}\right]^{T}$ denotes the transmit signal vector in subcarrier $k$ for all $N\_{user,r}$beamformees, with $x\_{k,u}=\left[x\_{k,0},x\_{k,1},\cdots ,x\_{k,N\_{STS,r,u}-1}\right]^{T}$ being the transmit signal for beamformee $u$.

|  |  |
| --- | --- |
| $$y\_{k,u}=H\_{k,u}×\left[Q\_{k,0},Q\_{k,1},\cdots ,Q\_{k,N\_{user,r}-1}\right]×x\_{k}+n$$ | (36‑85) |

where

$H\_{k,u}$ is the channel matrix from the beamformer to beamformee $u$ in subcarrier $k$ with dimensions $N\_{RX\_{u}}×N\_{TX}$

$N\_{RX\_{u}}$ is the number of receive antennas at beamformee $u$

$Q\_{k,u}$ is a steering matrix for beamformee $u$ in subcarrier k with dimensions $N\_{TX}×N\_{STS,r,u}$

$N\_{user,r}$ is the number of EHT MU PPDU recipients (see Table 34-X (Frequently used parameters)) in RU or MRU $r$

$n$ is a vector of additive noise and may include interference

The DL MU-MIMO steering matrix $Q\_{k}=\left[Q\_{k,0},Q\_{k,1},\cdots ,Q\_{k,N\_{user,r}-1}\right]$ can be determined by the beamformer using the beamforming feedback for subcarrier $k$ from beamformee $u$, where $u=0,1,\cdots ,N\_{user,r}-1$. The feedback report format is described in 9.4.1.67a (EHT Compressed Beamforming Report field) and 9.4.1.67c(EHT MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix$ Q\_{k}$for the next DL MU-MIMO data transmission.

For SU-MIMO beamforming, the steering matrix $Q\_{k}$ can be determined from the beamforming feedback matrix $V\_{k}$ that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.67b (EHT Compressed Beamforming Report field).

36.3.16.2 EHT Beamforming feedback matrix V

Upon receipt of an EHT sounding NDP, the beamformee computes a set of matrices for feedback to the beamformer as described in 27.3.16.2 (Beamforming Feedback Matrix V). The eligible beamformees shall remove the space-time stream CSD in 36.3.11.2.2, Cyclic shift for EHT modulated fields,from the measured channel before computing a set of matrices for feedback to the beamformer.

The beamforming feedback matrix, $V\_{k,u}$ found by the beamformee $u$ for subcarrier $k$ in RU or MRU $r$ shall be compressed in the form of angles using the method described in 19.3.12.3.6 (Compressed beamforming feedback matrix). The angles, $ϕ(k,u)$ and $ψ(k,u)$, are quantized according to Table 9-76 (Quantization of angles) with *b*ψ  and *b*ϕ  , respecetively, as defined by the Codebook Information field of the EHT MIMO Control field (see 9.4.1.67a (EHT MIMO Control field)). The compressed beamforming feedback matrix as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix) is the only Clause 34 (Extremely High Throughput (EHT) PHY specification) beamforming feedback matrix defined.

The beamformee shall generate the beamforming feedback matrices with the number of rows (*Nr*) equal to the *NSTS* of the EHT sounding NDP.

After receiving the angle information, $ϕ(k,u)$ and $ψ(k,u)$, the beamformer reconstructs $V\_{k,u}$ using Equation (19-79). For SU-MIMO beamforming, the beamformer uses $V\_{k,0}$, matrix to determine the steering matrix $Q\_{k}$. For DL MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q\_{k}=\left[Q\_{k,0},Q\_{k,1},\cdots ,Q\_{k,N\_{user,r}-1}\right]$ using $V\_{k,u}$ and $ΔSNR\_{k,u}, 0\leq u\leq N\_{user,r}-1$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix $Q\_{k}$ is implementation specific.

36.3.16.3 EHT CQI feedback

If the EHT NDP Announcement frame requests CQI feedback, then upon receipt of the EHT sounding NDP, the beamformee computes CQI feedback as described in 9.4.1.67d. The CQI feedback, $CQI\_{s,r,u}$, for beamformee $u$ in RU $r$ for space-time stream $s$ shall be estimated using the method described in 9.4.1.67d. The CQI values to be fed back are derived from quantized SNRs according to Table 9-91h (Average SNR of RU index k for space-time stream i subfield).. The beamformee shall transmit the CQI feedback for space-time stream $1,…,N\_{c}$ for each of the RU indices for which the CQI report is being requested by the beamformer. The beamformer may use the CQI feedback to determine the best range of RUs for a compressed beamforming/CQI report or for RU assignment during a subsequent MU transmissions. The actual use is implementation specific.