IEEE P802.11
Wireless LANs

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| --- |
| HE beamforming feedback subcarriers |
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Abstract

This submission proposes corrections and clarifications on the subcarriers used for HE beamforming feedback. It supersedes the resolutions to CID 16165, 16260, 16272 and 16743 in 18/1921r4.

|  |  |  |
| --- | --- | --- |
| Identifiers | Comment | Proposed change |
| CID 16165Mark RISON9.4.1.63120.42 | "For 40 MHz and 80 MHz, [...] when the S-tone and E-tone indices lie on different sides of DC, the following relationships hold separately for the two sides of DC." -- the case of 160 MHz and 80+80 MHz is missing | Describe how scidx(i) is derived from scidx(i-1) (or otherwise) for 160 and for 80+80, covering both the "S-tone and E-tone indices lie on different sides of DC" and "same sides of DC" cases |
| CID 16260Mark RISON9.4.1.63120.42 | "(S, E) for 80 MHz" is unclear, especially when the RU index is different (e.g. at 123.17, with 20M index 1, is the "(S, E) for 80 MHz" the one for the same row (i.e. 80M index 15) or the one for 80M index 1?) | Just give the value directly |
| CID 16272Mark RISON9.4.1.63120.42 | The rules for which subcarriers are in HE CBR is grotesquely complex (e.g. different rules for 20M and 40M+, outside subcarriers not necessarily Ng-separated from adjacent subcarrier, hand-waving for 160/80+80). Needs to be simplified both technically and editorially, especially for partial-BW's sake, otherwise there is essentially zero chance of interoperability | As it says in the comment |
| CID 16743Sigurd Schelstraete9.4.1.63122.14 | "For the left of DC, scidx(i) = scidx(i-1) + Ng, where 1 Γëñ i Γëñ L, L is the number of subcarriers on the left of DC for which feedback is sent to the beamformer and scidx(L) = -4."It looks like scidx(L) is defined twice. Once by "scidx(i) = scidx(i-1) + Ng, where 1 Γëñ i Γëñ L" and once explicitly as "scidx(L) = -4". Probably the range of i should be 1 Γëñ i < L. | Change "1 Γëñ i Γëñ L" to "1 Γëñ i < L" |

Discussion

The changes made for 160M/80+80M beamforming feedback under CID 16165 in 18/1921r4 are problematic for several reasons, including the fact that they result in the below-DC subcarriers not being a mirror of the above-DC subcarriers and the fact that they might be considered to change the number of subcarriers for which beamforming feedback is given.

Instead, to minimise the likelihood of interop issues, the same approach as in VHT should be adopted, where 160M and 80+80M beamforming feedback is treated as two independent and concatenated sets of 80M beamforming feedback (each with a “pseudo-DC” in the middle), and further, where the subcarriers for all channel widths and groupings are listed explicitly in tabular form (as they already are for HE20) rather than by equations. See Table 9-78 (Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back) in REVmd/D2.0:



…



…



…



In addition, D3.2 Table 9-94d (Feedback subcarrier indices indicating start 26-tone RU index and end 26-tone RU index for Ng = 16) has the wrong start and end subcarriers for some of the 20 MHz channel width RU indices. They are shown as having the same derivation as in Table 9-94c (Ng = 4):



but the correct ones are to be found in 16/0836r1 (see 16/0779r6):

|  |  |
| --- | --- |
| 0 | -122, -84 |
| 1 | = (S, E) for80 MHz |
| 2 | -68, -36 |
| 3 | = (S,E) for80 MHz |
| 4 |
| 5 |
| 6 | 36, 68 |
| 7 | = (S, E) for80 MHz |
| 8 | 84, 122 |

Proposed changes

***Editor: in D3.2 9.4.1.65 HE Compressed Beamforming Report field, replace everything from after Table 9‑94b—HE Compressed Beamforming Report information (at 127.61, starting “In Table 9-94b (HE Compressed Beamforming Report information), Ns is the number of subcarriers”) up to and including Table 9-94e—Feedback subcarrier indices for 20 MHz bandwidth for Ng = 4 and Ng = 16 inclusive (at 131.47, before “The Average SNR of Space-Time Stream i subfield in Table 9-94b”) with the following, changing hyphens to minuses in numbers and calculations:***

In Table 9-94b (HE Compressed Beamforming Report information), *Ns* is the number of subcarriers for which a compressed beamforming feedback matrix is sent back to the beamformer. A beamformer or beamformee, depending on which of the two decides on the feedback parameters, reduces *Ns* by using a method referred to as grouping, in which only a single compressed beamforming feedback matrix is reported for each group of *Ng* adjacent subcarriers. *Ns* is a function of the BW, RU Start Index, RU End Index and Grouping subfields in the HE MIMO Control field (see 9.4.1.64 (HE MIMO Control field)).

Subcarrier indices *scidx*(0) and *scidx*(*Ns*-1) are identified by the RU Start Index and RU End Index subfields respectively, together with the BW and Grouping subfields, as defined in Table 9-xxy.

**Table 9-xxy—Subcarrier indices *scidx*(0) and *scidx*(*Ns*-1)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Ng* | RU index | 20 MHz | 40 MHz | 80 MHz | 160 MHz | 80+80 MHz |
| *S* | *E* | *S* | *E* | *S* | *E* | *S* | *E* | *S* | *E* |
| 4 | 0 | -122 | -96 | -244 | -216 | -500 | -472 | -1012 | -984 | -500(L) | -472(L) |
| 1 | -96 | -68 | -220 | -192 | -476 | -448 | -988 | -960 | -476(L) | -448(L) |
| 2 | -68 | -40 | -192 | -164 | -448 | -420 | -960 | -932 | -448(L) | -420(L) |
| 3 | -44 | -16 | -164 | -136 | -420 | -392 | -932 | -904 | -420(L) | -392(L) |
| 4 | -16 | 16 | -136 | -108 | -392 | -364 | -904 | -876 | -392(L) | -364(L) |
| 5 | 16 | 44 | -112 | -84 | -368 | -340 | -880 | -852 | -368(L) | -340(L) |
| 6 | 40 | 68 | -84 | -56 | -340 | -312 | -852 | -824 | -340(L) | -312(L) |
| 7 | 68 | 96 | -56 | -28 | -312 | -284 | -824 | -796 | -312(L) | -284(L) |
| 8 | 96 | 122 | -32 | -4 | -288 | -260 | -800 | -772 | -288(L) | -260(L) |
| 9 |  |  | 4 | 32 | -260 | -232 | -772 | -744 | -260(L) | -232(L) |
| 10 |  |  | 28 | 56 | -232 | -204 | -744 | -716 | -232(L) | -204(L) |
| 11 |  |  | 56 | 84 | -204 | -176 | -716 | -688 | -204(L) | -176(L) |
| 12 |  |  | 84 | 112 | -180 | -152 | -692 | -664 | -180(L) | -152(L) |
| 13 |  |  | 108 | 136 | -152 | -124 | -664 | -636 | -152(L) | -124(L) |
| 14 |  |  | 136 | 164 | -124 | -96 | -636 | -608 | -124(L) | -96(L) |
| 15 |  |  | 164 | 192 | -100 | -72 | -612 | -584 | -100(L) | -72(L) |
| 16 |  |  | 192 | 220 | -72 | -44 | -584 | -556 | -72(L) | -44(L) |
| 17 |  |  | 216 | 244 | -44 | -16 | -556 | -528 | -44(L) | -16(L) |
| 18 |  |  |  |  | -16 | 16 | -528 | -496 | -16(L) | 16(L) |
| 19 |  |  |  |  | 16 | 44 | -496 | -468 | 16(L) | 44(L) |
| 20 |  |  |  |  | 44 | 72 | -468 | -440 | 44(L) | 72(L) |
| 21 |  |  |  |  | 72 | 100 | -440 | -412 | 72(L) | 100(L) |
| 22 |  |  |  |  | 96 | 124 | -416 | -388 | 96(L) | 124(L) |
| 23 |  |  |  |  | 124 | 152 | -388 | -360 | 124(L) | 152(L) |
| 24 |  |  |  |  | 152 | 180 | -360 | -332 | 152(L) | 180(L) |
| 25 |  |  |  |  | 176 | 204 | -336 | -308 | 176(L) | 204(L) |
| 26 |  |  |  |  | 204 | 232 | -308 | -280 | 204(L) | 232(L) |
| 27 |  |  |  |  | 232 | 260 | -280 | -252 | 232(L) | 260(L) |
| 28 |  |  |  |  | 260 | 288 | -252 | -224 | 260(L) | 288(L) |
| 29 |  |  |  |  | 284 | 312 | -228 | -200 | 284(L) | 312(L) |
| 30 |  |  |  |  | 312 | 340 | -200 | -172 | 312(L) | 340(L) |
| 31 |  |  |  |  | 340 | 368 | -172 | -144 | 340(L) | 368(L) |
| 32 |  |  |  |  | 364 | 392 | -148 | -120 | 364(L) | 392(L) |
| 33 |  |  |  |  | 392 | 420 | -120 | -92 | 392(L) | 420(L) |
| 34 |  |  |  |  | 420 | 448 | -92 | -64 | 420(L) | 448(L) |
| 35 |  |  |  |  | 448 | 476 | -64 | -36 | 448(L) | 476(L) |
| 36 |  |  |  |  | 472 | 500 | -40 | -12 | 472(L) | 500(L) |
| 37 |  |  |  |  |  |  | 12 | 40 | -500(H) | -472(H) |
| 38 |  |  |  |  |  |  | 36 | 64 | -476(H) | -448(H) |
| 39 |  |  |  |  |  |  | 64 | 92 | -448(H) | -420(H) |
| 40 |  |  |  |  |  |  | 92 | 120 | -420(H) | -392(H) |
| 41 |  |  |  |  |  |  | 120 | 148 | -392(H) | -364(H) |
| 42 |  |  |  |  |  |  | 144 | 172 | -368(H) | -340(H) |
| 43 |  |  |  |  |  |  | 172 | 200 | -340(H) | -312(H) |
| 44 |  |  |  |  |  |  | 200 | 228 | -312(H) | -284(H) |
| 45 |  |  |  |  |  |  | 224 | 252 | -288(H) | -260(H) |
| 46 |  |  |  |  |  |  | 252 | 280 | -260(H) | -232(H) |
| 47 |  |  |  |  |  |  | 280 | 308 | -232(H) | -204(H) |
| 48 |  |  |  |  |  |  | 308 | 336 | -204(H) | -176(H) |
| 49 |  |  |  |  |  |  | 332 | 360 | -180(H) | -152(H) |
| 50 |  |  |  |  |  |  | 360 | 388 | -152(H) | -124(H) |
| 51 |  |  |  |  |  |  | 388 | 416 | -124(H) | -96(H) |
| 52 |  |  |  |  |  |  | 412 | 440 | -100(H) | -72(H) |
| 53 |  |  |  |  |  |  | 440 | 468 | -72(H) | -44(H) |
| 54 |  |  |  |  |  |  | 468 | 496 | -44(H) | -16(H) |
| 55 |  |  |  |  |  |  | 496 | 528 | -16(H) | 16(H) |
| 56 |  |  |  |  |  |  | 528 | 556 | 16(H) | 44(H) |
| 57 |  |  |  |  |  |  | 556 | 584 | 44(H) | 72(H) |
| 58 |  |  |  |  |  |  | 584 | 612 | 72(H) | 100(H) |
| 59 |  |  |  |  |  |  | 608 | 636 | 96(H) | 124(H) |
| 60 |  |  |  |  |  |  | 636 | 664 | 124(H) | 152(H) |
| 61 |  |  |  |  |  |  | 664 | 692 | 152(H) | 180(H) |
| 62 |  |  |  |  |  |  | 688 | 716 | 176(H) | 204(H) |
| 63 |  |  |  |  |  |  | 716 | 744 | 204(H) | 232(H) |
| 64 |  |  |  |  |  |  | 744 | 772 | 232(H) | 260(H) |
| 65 |  |  |  |  |  |  | 772 | 800 | 260(H) | 288(H) |
| 66 |  |  |  |  |  |  | 796 | 824 | 284(H) | 312(H) |
| 67 |  |  |  |  |  |  | 824 | 852 | 312(H) | 340(H) |
| 68 |  |  |  |  |  |  | 852 | 880 | 340(H) | 368(H) |
| 69 |  |  |  |  |  |  | 876 | 904 | 364(H) | 392(H) |
| 70 |  |  |  |  |  |  | 904 | 932 | 392(H) | 420(H) |
| 71 |  |  |  |  |  |  | 932 | 960 | 420(H) | 448(H) |
| 72 |  |  |  |  |  |  | 960 | 988 | 448(H) | 476(H) |
| 73 |  |  |  |  |  |  | 984 | 1012 | 472(H) | 500(H) |
| 16 | 0 | -122 | -84 | -244 | -212 | -500 | -468 | -1012 | -980 | -500(L) | -468(L) |
| 1 | -100 | -68 | -228 | -180 | -484 | -436 | -996 | -948 | -484(L) | -436(L) |
| 2 | -68 | -36 | -196 | -164 | -452 | -420 | -964 | -932 | -452(L) | -420(L) |
| 3 | -52 | -4 | -164 | -132 | -420 | -388 | -932 | -900 | -420(L) | -388(L) |
| 4 | -20 | 20 | -148 | -100 | -404 | -356 | -916 | -868 | -404(L) | -356(L) |
| 5 | 4 | 52 | -116 | -84 | -372 | -340 | -884 | -852 | -372(L) | -340(L) |
| 6 | 36 | 68 | -84 | -52 | -340 | -308 | -852 | -820 | -340(L) | -308(L) |
| 7 | 68 | 100 | -68 | -20 | -324 | -276 | -836 | -788 | -324(L) | -276(L) |
| 8 | 84 | 122 | -36 | -4 | -292 | -260 | -804 | -772 | -292(L) | -260(L) |
| 9 |  |  | 4 | 36 | -260 | -228 | -772 | -740 | -260(L) | -228(L) |
| 10 |  |  | 20 | 68 | -244 | -196 | -756 | -708 | -244(L) | -196(L) |
| 11 |  |  | 52 | 84 | -212 | -164 | -724 | -676 | -212(L) | -164(L) |
| 12 |  |  | 84 | 116 | -180 | -148 | -692 | -660 | -180(L) | -148(L) |
| 13 |  |  | 100 | 148 | -164 | -116 | -676 | -628 | -164(L) | -116(L) |
| 14 |  |  | 132 | 164 | -132 | -84 | -644 | -596 | -132(L) | -84(L) |
| 15 |  |  | 164 | 196 | -100 | -68 | -612 | -580 | -100(L) | -68(L) |
| 16 |  |  | 180 | 228 | -84 | -36 | -596 | -548 | -84(L) | -36(L) |
| 17 |  |  | 212 | 244 | -52 | -4 | -564 | -516 | -52(L) | -4(L) |
| 18 |  |  |  |  | -20 | 20 | -532 | -492 | -20(L) | 20(L) |
| 19 |  |  |  |  | 4 | 52 | -508 | -460 | 4(L) | 52(L) |
| 20 |  |  |  |  | 36 | 84 | -476 | -428 | 36(L) | 84(L) |
| 21 |  |  |  |  | 68 | 100 | -444 | -412 | 68(L) | 100(L) |
| 22 |  |  |  |  | 84 | 132 | -428 | -380 | 84(L) | 132(L) |
| 23 |  |  |  |  | 116 | 164 | -396 | -348 | 116(L) | 164(L) |
| 24 |  |  |  |  | 148 | 180 | -364 | -332 | 148(L) | 180(L) |
| 25 |  |  |  |  | 164 | 212 | -348 | -300 | 164(L) | 212(L) |
| 26 |  |  |  |  | 196 | 244 | -316 | -268 | 196(L) | 244(L) |
| 27 |  |  |  |  | 228 | 260 | -284 | -252 | 228(L) | 260(L) |
| 28 |  |  |  |  | 260 | 292 | -252 | -220 | 260(L) | 292(L) |
| 29 |  |  |  |  | 276 | 324 | -236 | -188 | 276(L) | 324(L) |
| 30 |  |  |  |  | 308 | 340 | -204 | -172 | 308(L) | 340(L) |
| 31 |  |  |  |  | 340 | 372 | -172 | -140 | 340(L) | 372(L) |
| 32 |  |  |  |  | 356 | 404 | -156 | -108 | 356(L) | 404(L) |
| 33 |  |  |  |  | 388 | 420 | -124 | -92 | 388(L) | 420(L) |
| 34 |  |  |  |  | 420 | 452 | -92 | -60 | 420(L) | 452(L) |
| 35 |  |  |  |  | 436 | 484 | -76 | -28 | 436(L) | 484(L) |
| 36 |  |  |  |  | 468 | 500 | -44 | -12 | 468(L) | 500(L) |
| 37 |  |  |  |  |  |  | 12 | 44 | -500(H) | -468(H) |
| 38 |  |  |  |  |  |  | 28 | 76 | -484(H) | -436(H) |
| 39 |  |  |  |  |  |  | 60 | 92 | -452(H) | -420(H) |
| 40 |  |  |  |  |  |  | 92 | 124 | -420(H) | -388(H) |
| 41 |  |  |  |  |  |  | 108 | 156 | -404(H) | -356(H) |
| 42 |  |  |  |  |  |  | 140 | 172 | -372(H) | -340(H) |
| 43 |  |  |  |  |  |  | 172 | 204 | -340(H) | -308(H) |
| 44 |  |  |  |  |  |  | 188 | 236 | -324(H) | -276(H) |
| 45 |  |  |  |  |  |  | 220 | 252 | -292(H) | -260(H) |
| 46 |  |  |  |  |  |  | 252 | 284 | -260(H) | -228(H) |
| 47 |  |  |  |  |  |  | 268 | 316 | -244(H) | -196(H) |
| 48 |  |  |  |  |  |  | 300 | 348 | -212(H) | -164(H) |
| 49 |  |  |  |  |  |  | 332 | 364 | -180(H) | -148(H) |
| 50 |  |  |  |  |  |  | 348 | 396 | -164(H) | -116(H) |
| 51 |  |  |  |  |  |  | 380 | 428 | -132(H) | -84(H) |
| 52 |  |  |  |  |  |  | 412 | 444 | -100(H) | -68(H) |
| 53 |  |  |  |  |  |  | 428 | 476 | -84(H) | -36(H) |
| 54 |  |  |  |  |  |  | 460 | 508 | -52(H) | -4(H) |
| 55 |  |  |  |  |  |  | 492 | 532 | -20(H) | 20(H) |
| 56 |  |  |  |  |  |  | 516 | 564 | 4(H) | 52(H) |
| 57 |  |  |  |  |  |  | 548 | 596 | 36(H) | 84(H) |
| 58 |  |  |  |  |  |  | 580 | 612 | 68(H) | 100(H) |
| 59 |  |  |  |  |  |  | 596 | 644 | 84(H) | 132(H) |
| 60 |  |  |  |  |  |  | 628 | 676 | 116(H) | 164(H) |
| 61 |  |  |  |  |  |  | 660 | 692 | 148(H) | 180(H) |
| 62 |  |  |  |  |  |  | 676 | 724 | 164(H) | 212(H) |
| 63 |  |  |  |  |  |  | 708 | 756 | 196(H) | 244(H) |
| 64 |  |  |  |  |  |  | 740 | 772 | 228(H) | 260(H) |
| 65 |  |  |  |  |  |  | 772 | 804 | 260(H) | 292(H) |
| 66 |  |  |  |  |  |  | 788 | 836 | 276(H) | 324(H) |
| 67 |  |  |  |  |  |  | 820 | 852 | 308(H) | 340(H) |
| 68 |  |  |  |  |  |  | 852 | 884 | 340(H) | 372(H) |
| 69 |  |  |  |  |  |  | 868 | 916 | 356(H) | 404(H) |
| 70 |  |  |  |  |  |  | 900 | 932 | 388(H) | 420(H) |
| 71 |  |  |  |  |  |  | 932 | 964 | 420(H) | 452(H) |
| 72 |  |  |  |  |  |  | 948 | 996 | 436(H) | 484(H) |
| 73 |  |  |  |  |  |  | 980 | 1012 | 468(H) | 500(H) |
| NOTE 1—*S* denotes subcarrier index *scidx*(0), identified by the RU Start Index subfield; *E* denotes subcarrier index *scidx*(*Ns*-1), identified by the RU End Index subfield.NOTE 2—*x*(L) denotes subcarrier index *x* in the frequency segment lower in frequency, and *x*(H) denotes subcarrier index *x* in the frequency segment higher in frequency. |

Subcarrier indices *scidx*(*i*), *i* = 0..*Ns*-1 are the subset of the subcarrier indices identified by the BW and Grouping subfields, as defined in Table 9-xxx, starting with *scidx*(0) and ending with *scidx*(*Ns*-1), in the order given.

NOTE 1—This implicitly defines *Ns*.

NOTE 2—For full bandwidth feedback, subcarrier indices *scidx*(*i*), *i* = 0..*Ns*-1 are the entire superset shown in Table 9-xxx, in the order given.

**Table 9-xxx—Subcarrier indices for compressed beamforming feedback matrix**

|  |  |  |
| --- | --- | --- |
| Channel width | *Ng* | Superset of subcarrier indices (*scidx*) |
| 20 MHz | 4 | -122, -120, -116, …, -8, -4, -2, 2, 4, 8, …, 116, 120, 122 |
| 16 | -122, -116, -100, …, -20, -4, -2, 2, 4, 20, …, 100, 116, 122 |
| 40 MHz | 4 | -244, -240, …, -8, -4, 4, 8, …, 240, 244 |
| 16 | -244, -228, …, -20, -4, 4, 20, …, 228, 244 |
| 80 MHz | 4 | -500, -496, …, -8, -4, 4, 8, …, 496, 500 |
| 16 | -500, -484, …, -20, -4, 4, 20, …, 484, 500 |
| 160 MHz | 4 | -1012, -1008, …, -520, -516, -508, -504, …, -16, -12,12, 16, …, 504, 508, 516, 520, …, 1008, 1012 |
| 16 | -1012, -996, …, -532, -516, -508, -492, …, -28, -12,12, 28, …, 492, 508, 516, 532, …, 996, 1012 |
| 80+80 MHz | 4 | -500(L), -496(L), …, -8(L), -4(L), 4(L), 8(L), …, 496(L), 500(L),-500(H), -496(H), …, -8(H), -4(H), 4(H), 8(H), …, 496(H), 500(H) |
| 16 | -500(L), -484(L), …, -20(L), -4(L), 4(L), 20(L), …, 484(L), 500(L),-500(H), -484(H), …, -20(H), -4(H), 4(H), 20(H), …, 484(H), 500(H) |
| NOTE 1—*x*(L) denotes subcarrier index *x* in the frequency segment lower in frequency, and *x*(H) denotes subcarrier index *x* in the frequency segment higher in frequency.NOTE 2—“…” denotes an arithmetic progression in *Ng* increments.NOTE 3—Pilot subcarriers are not skipped. |

Proposed resolution for CID 16165, CID 16260 and CID 16272:

REVISED

Make the changes shown under “Proposed changes” in <this document>, which address the issues raised and also fix an error for 20 MHz partial-BW feedback with Ng=16.

Proposed resolution for CID 16743:

REVISED

Make the changes shown under “Proposed changes” in <this document>, which reformulate the determination of subcarrier indices without needing a variable L.

**References:**

802.11ax/D3.2 except where otherwise specified