IEEE P802.11
Wireless LANs

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| 11az HE PHY Formats Amendment Text |
| Date: 2019-01-09 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Christian Berger  | Marvell |  |  |  |
| Liwen Chu | Marvell |  |  |  |
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Abstract

This submission proposes the text for the ranging NPD-A format.

Revisions:

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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 TGaz Draft. This introduction is not part of the adopted material.

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

***TGaz Editor: Editing instructions preceded by “TGaz Editor” are instructions to the TGax editor to modify existing material in the TGaz draft. As a result of adopting the changes, the TGaz editor will execute the instructions rather than copy them to the TGaz Draft.***

**The text preceded by “Discussion” is not part of the adopted changes.**

***TGaz Editor:*** *Please replace the terms “HE Ranging NDP PPDU” and “HE TB Ranging NDP PPDU” with “HE Ranging NDP” and “HE TB Ranging NDP” respectively throughout the draft.*

28.2.2 TXVECTOR and RXVECTOR parameters

***TGaz Editor:*** *Insert the following rows into Table 28-1:*

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| --- |
| Table 28-1—TXVECTOR and RXVECTOR parameters  |
| Parameter | Condition | Value | TXVECTOR | RXVECTOR |
| LTF\_REP | FORMAT is either HE\_SU or HE\_TB and APEP\_LENGTH is 0 | Indicates the number of LTF repetitions N\_REP in an HE Ranging NDP or HE TB Ranging NDP. If not present, indicates a repetition of 1.The use of LTF repetitions is defined in 28.3.17 (HE Ranging NDP). | O | N |
| Otherwise | Not present | N | N |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| LTF\_SEQUENCE | FORMAT is either HE\_SU or HE\_TB and APEP\_LENGTH is 0 | Indicates the LTF sequence generation information to generate the randomized LTF sequence used in the HE Ranging NDP and HE TB Ranging NDP. The LTF sequence generation information is defined in 9.4.2.251 (Secure LTF Parameters). | O | N |
| Otherwise | Not present | N | N |
| APEP\_LENGTH | FORMAT is HE\_SU or HE\_ER\_SU | IntegerIf 0 and FORMAT is HE\_SU, indicates an HE sounding NDP or HE Ranging NDP. If 0 and FORMAT is HE\_TB, indicates HE Randing TB NDP.Otherwise, indicates the number of octets in the range 1 to aPSDUMaxLength in the A-MPDU pre-EOF padding (see Table 28-51 (HE PHY characteristics)) that is carried in the PSDU. | Y | N |
| MU |
| FORMAT is HE\_MU or HE\_TB |
| Otherwise | See corresponding entry in Table 19-1 (RXVECTOR and RXVECTOR parameters) and Table 21-1 (RXVECTOR and RXVECTOR parameters). |
| PSDU\_LENGTH | FORMAT is HE\_SU, HE\_MU, HE\_ER, HE\_ER\_SU or HE\_TB | Indicates the number of octets in the PSDU in the range of 0 to aPDUMaxLength octets (see Table 28-51 (HE PHY characteristics)). A value of 0 indicates and HE NDP, HE Ranging NDP or HE TB Ranging NDP. | N | Y |
| Otherwise | See corresponding entry in Table 21-1 (RXVECTOR and RXVECTOR parameters). |
| NUM\_STS | FORMAT is HE\_SU | Indicates the number of space-time streams.Interger in the range 1-8. | Y | Y |
| FORMAT is HE\_ER\_SU | Indicates the number of space-time streams.Interger in the range 1-2. |  |  |
| FORMAT is HE\_MU | Indicates the number o space-time streams. Integer in the range:1-4 per user per MU-MIMO RU in the TXVECTOR1-4 per MU-MIMO RU in the RXVECTOR1-8 per RU assigned to no more than 1 user in the TXVECTOR and RXVECTORNUM\_STS summed over all users perRU is not greater than 8. | MU | Y |
| FORMAT is HE\_TB | Indicates the number of space-time streams. Integer in the range:1-4 for a MU-MIMO RU in the TXVECTOR 1-4 per user per MU-MIMO RU in the RXVECTOR 1-8 for an RU assigned to no more than 1 user in the TXVECTOR and RXVECTOR NUM\_STS summed over all users per RU is not greater than 8 | MU | MU |
| Otherwise | See corresponding entry in Table 21-1 (RXVECTOR and RXVECTOR parameters). |
| NUM\_USERS | FORMAT is HE\_SU, APEP\_LENGTH is 0, and LTF\_SEQUENCE is present | Indicating an HE Ranging NDP with randomized LTF sequenceIf NUM\_USERS is larger 1, NUM\_STS, LTF\_REP, and LTF\_SEQUENCE will be MU | O | N |
| FORMAT is HE\_SU, HE\_MU, HE\_ER, HE\_ER\_SU or HE\_TB | Not present.NOTE-number of users for an HE SU PPDU, HE ER SU PPDU or HE TB PPDU is otherwise 1. The number of users for an HE MU PPDU is determined by RU\_ALLOCATION. | N | N |
| Otherwise | See corresponding entry in Table 21-1 (RXVECTOR and RXVECTOR parameters). |
| PSDU\_LENGTH | FORMAT is HE\_SU, HE\_MU, HE\_ER, HE\_ER\_SU or HE\_TB | Indicates the number of octets in the PSDU in the range of 0 to aPDUMaxLength octets (see Table 28-51 (HE PHY characteristics)). A value of 0 indicates and HE sounding NDP, HE Ranging NDP or HE TB Ranging NDP. | N | Y |
| Otherwise | See corresponding entry in Table 21-1 (RXVECTOR and RXVECTOR parameters). |

TGaz Editor: Change the following paragraph of 28.3.4:

28.3.4 HE PPDU formats

Four HE PPDU formats are defined: HE SU PPDU, HE MU PPDU, HE ER SU PPDU and HE TB PPDU. The HE NDP PPDU ~~is a~~ and HE Ranging NDP are variants of the HE SU PPDU and defined in 28.3.16 (HE sounding NDP) and 28.3.17a (HE Ranging NDP) respectively. The HE TB NDP feedback ~~is a~~ and HE TB Ranging NDP are variants of the HE TB PPDU and defined in 28.3.17 (HE TB NDP feedback) and 28.3.17b (Ranging TB NDP) respectively.

***TGaz Editor:*** *Insert the following at the end of 28.3.17:*

28.3.17a HE Ranging NDP

The format of an HE Ranging NDP is shown in Figure 1 (HE Ranging NDP format).



Figure 1 – HE Ranging NDP format

The HE Ranging NDP has the following properties:

* Uses the HE SU PPDU format but without the Data field.
* No beamforming steering matrix is applied to the waveform, the Beamformed field in HE-SIG-A of a Ranging NDP is laways set to 0.
* Can use regular HE-LTFs or Secure HE-LTFs with randomized LTF sequence (see Section 28.3.17d).
* Has a Packet Extension (PE) field that is 4 µs in duration; when using Secure HE-LTFs with randomized LTF sequence, the PE will start with a zero-power GI.

It is mandatory to support the 2x HE-LTF with 0.8 µs GI and 2x HE-LTF with 1.6 µs GI. The other combinations of HE-LTF modes and GI duration are disallowed.

The number of HE-LTF symbols in an HE Ranging NDP depends on the number of space-time streams N\_STS, the number of LTF repetitions LTF\_REP, and, when Secure HE-LTFs with randomized LTF sequence are used, the number of users NUM\_USERS.



Figure 2 - Example of HE-LTFs in an HE Ranging NDP with N\_STS=2 and LTF\_REP =2.

When the TXVECTOR parameter LTF\_SEQUENCE is not present, regular HE-LTFs as defined in Section 28.3.10.10 (HE-LTF) are used in the HE Ranging NDP. The number of HE-LTF symbols is the product of the number of LTF repetitions LTF\_REP and the conventional number of HE-LTF, N\_HE-LTF, based on the number of space-time streams N\_STS, as defined in Table 21-13 (Number of VHT-LTFs required for different numbers of space-time streams). The construction of the HE-LTFs in an HE Ranging NDP is done by repeating the steps in Section 28.3.6.9 (Construction of HE-LTF) LTF\_REP times. If the TXVECTOR parameter LTF\_SEQUENCE is not present, neither is the TXVECTOR parameter NUM\_USERS, which is then assumed to be 1.

When the TXVECTOR parameter LTF\_SEQUENCE is present, Secure HE-LTFs as defined in Section 28.3.17d are used and the Packet Extension field will be partially replaced by a zero power GI in its first 0.8 µs or 1.6 µs, depending on the TXVECTOR parameter GI\_TYPE, see Figure 3 (HE Ranging NDP format with Secure HE-LTFs).



Figure 3 – HE Ranging NDP format with Secure HE-LTFs

When the TXVECTOR parameter LTF\_SEQUENCE is present and the NUM\_USERS parameter is larger 1, the TXVECTOR parameters LTF\_SEQUENCE, N\_STS and LTF\_REP will be in array form with NUM\_USERS entries. The number of Secure HE-LTF will depend on the sum of: N\_HE-LTF times LTF\_REP, across all users.

The Secure HE-LTF for each user are concatenated one after another to a maximum of 64 Secure HE-LTF



Figure 4 – Example of Secure LTFs with NUM\_USERS=2, N\_STS=[2,2] and LTF\_REP =[2,1].

28.3.17b HE TB Ranging NDP

The format of a HE TB Ranging NDP is shown in Figure 5 (HE TB Ranging NDP format).



Figure 5 – HE TB Ranging NDP format

The HE TB Ranging NDP has the following properties:

* Uses the HE TB PPDU format but without the Data field.
* No beamforming steering matrix is applied to the waveform.
* Can use regular HE-LTFs or Secure HE-LTFs with randomized LTF sequence (see Section 28.3.17d).
* Has a Packet Extension (PE) field that is 4 µs in duration; when using Secure HE-LTFs with randomized LTF sequence, the PE will start with a zero-power GI.

The only supported mode is the 2x HE-LTF with 1.6 µs GI. The other combinations of HE-LTF modes and GI duration are disallowed.

The number of HE-LTF symbols in an HE TB Ranging NDP is the product of the regular number of HE-LTF symbols NUM\_HE\_LTF and the number of LTF repetitions LTF\_REP.

When the TXVECTOR parameter LTF\_SEQUENCE is not present, regular HE-LTFs as defined in Section 28.3.10.10 (HE-LTF) are used.

When the TXVECTOR parameter LTF\_SEQUENCE is present, Secure HE-LTFs as defined in Section 28.3.17d are used and the Packet Extension field will be partially replaced by a zero power GI in its first 1.6 µs, see Figure 6 (HE TB Ranging NDP format with Secure HE LTFs).



Figure 6 – HE TB Ranging NDP with Secure HE-LTFs

28.3.17c Generation of Randomized LTF Sequence

When Secure HE-LTFs are used the regular HE-LTF sequence is replaced by a randomized LTF sequence. For each Secure HE-LTF symbol a separate randomized LTF sequence is generated from $4P+3 $input bits denoted by $b\_{i}$ for $i=0, …,4P+2$, which are obtained from the TX\_VECTOR parameter LTF\_SEQUENCE. The generation process is shown in Figure 7 (Generation of Randomized LTF Sequence).

 

Figure 7 - Generation of Randomized LTF Sequence

The number $P$ is 7, 8, 9, and 10 for 20, 40, 80, and 160/80+80 MHz transmissions, respectively. A CSD value $τ\_{CS}$ is given by

$τ\_{CS}=T\_{s}\sum\_{i=0}^{P-1}b\_{i}∙2^{i}$ (28-rr)

where $T\_{s}$ is 50, 25, 12.5, and 6.25 ns for 20, 40, 80, and 160/80+80 MHz transmissions, respectively; the bits $b\_{i}$ for $i=0,…,P-1$ are the first $P$ bits of the $4P+3 $input bits. A sequence of $2^{P}$ 8PSK symbols are generated by $P-1$ iterations. In the $p$-th iteration, two sequences $s\_{1}^{(p)}$ and $s\_{2}^{(p)}$are generated by concatenating two sequences $s\_{1}^{(p-1)}$ and $s\_{2}^{(p-1)}$ that were generated in the ($p-1)$-th iteration as

$s\_{1}^{(p)}=[s\_{1}^{\left(p-1\right)},s\_{2}^{(p-1)} ]$ and (28-ss)

$s\_{2}^{(p)}=[φ\_{p}∙s\_{1}^{\left(p-1\right)},-φ\_{p}∙s\_{2}^{(p-1)} ]$, for $p=1,…,P-1$ (28-tt)

where $[a,b ]$ denotes the concatenation of two sequences $a$and $b$; $c∙d$ denotes the multiplications of a scalar $c$ with each element of sequence $d$; the initial sequences $s\_{1}^{\left(0\right)}$and $s\_{2}^{\left(0\right)}$are two 8PSK symbols and are given by

$s\_{1}^{\left(0\right)}=exp\left(j\frac{π}{4}\sum\_{i=P}^{P+2}b\_{i}∙2^{i-P}\right)$ (28-uu)

$s\_{2}^{\left(0\right)}=exp\left(j\frac{π}{4}\sum\_{i=P+3}^{P+5}b\_{i}∙2^{i-P-3}\right)$ (28-vv)

where $b\_{i}$ is the $i$-th bit of the $4P+3 $input bits. The phase rotation scalar $φ\_{p}$ in Equation (28-tt) is given by 3 consecutive input bits as

$φ\_{p}=exp\left(j\frac{π}{4}\sum\_{i=P+3p+3}^{P+3p+5}b\_{i}∙2^{i-P-3p-3}\right)$, for $p=1,…, P-1$ (28-ww)

where $b\_{i}$ is the $i$-th bit of the $4P+3 $input bits.

The sequences $s\_{1}^{\left(P-1\right)}$and $s\_{2}^{(P-1)}$ are mapped to the non-zero subcarriers that are used by the 2x HE-LTF transmission defined in subclause 28.3.10.10, where the subcarrier index is symmetric about 0 and defined for 4x HE-LTF. The secure LFT symbol uses only every other subcarrier in the same way as 2x HE-LTF. The subcarrier mapping is as the following:

* In a 20 MHz transmission, the mapping is given by:
	+ $LTF\left(-122:2:-2\right)=s\_{1}^{\left(P-1\right)}\left(3:1:63\right)$ and
	+ $LTF\left(2:2:122\right)=s\_{2}^{\left(P-1\right)}\left(2:1:62\right)$,
	+ where *A*(*l:m:n*) denotes the vector formed sequentially by the *l*-th, (*l+m*)-th, (*l+*2*m*)-th,…, and *n*-th elements of vector *A*; *l* is the initial index; *m* is the index increment; and *n* is the last index.
* In a 40 MHz transmission, the mapping is given by:
	+ $LTF\left(-244:2:-4\right)=s\_{1}^{\left(P-1\right)}\left(5:1:125\right)$ and
	+ $LTF\left(4:2:244\right)=s\_{2}^{\left(P-1\right)}\left(4:1:124\right)$,
	+ where *A*(*l:m:n*) denotes the vector formed sequentially by the *l*-th, (*l+m*)-th, (*l+*2*m*)-th,…, and *n*-th elements of vector *A*; *l* is the initial index; *m* is the index increment; and *n* is the last index.
* In an 80 MHz transmission, the mapping is given by:
	+ $LTF\left(-500:2:-4\right)=s\_{1}^{\left(P-1\right)}\left(5:1:253\right)$ and
	+ $LTF\left(4:2:500\right)=s\_{2}^{\left(P-1\right)}\left(4:1:252\right)$,
	+ where *A*(*l:m:n*) denotes the vector formed sequentially by the *l*-th, (*l+m*)-th, (*l+*2*m*)-th,…, and *n*-th elements of vector *A*; *l* is the initial index; *m* is the index increment; and *n* is the last index.
* In a 160/80+80 MHz transmission, the mapping is given by:
	+ - TBD

After the subcarrier mapping, a linear phase shift for a time-domain cyclic shift is applied to each subcarrier. The phase of the $k$-th subcarrier is rotated by $exp\left(j2πk∆\_{F}τ\_{CS}\right)$, where $∆\_{F}=156.25 kHz$ is the subcarrier spacing for 2x HE-LTF and $τ\_{CS}$ is given by Equation (28-rr). ~~After the phase shift, the frequency domain signal is transformed to the time domain. A zero power guard interval is added to the transformed time domain signal as a prefix for each LTF symbol.~~

28.3.17d Construction of Secure HE-LTF

The Secure HE-LTF field is largely like the regular HE-LTF field defined in 28.3.10.10 (HE-LTF), the main differences are as follows:

* The HE-LTF sequence is replaced by the randomized LTF sequence described in Section (YYYY)
* The conventional GI is replaced by a zero-power GI.
* There are no single stream pilot subcarriers in the secure HE-LTFs, all subcarriers are mapped using the full P\_HE-LTF matrix
* No CSD is applied to the space-time streams.

The construction of the Secure HE-LTF field is as follows:

1. Sequence generation: Generate the randomized LTF sequence in frequency domain over the bandwidth indicated by CH\_BANDWIDTH as described in Section 28.3.17c (Generation of Randomized LTF).
2. A\_HE-LTF matrix mapping: Apply the P\_HE-LTF matrix to all tones of the HE-LTF sequence.
3. There is no CSD per space-time stream.
4. There is no spatial mapping, the Q matrix is a full or partial identity matrix.
5. IDFT: Compute the inverse discrete Fourier transform.
6. Insert zero-power GI and apply windowing: Prepend values of zero of length indicated by the TXVECTOR parameter GI\_TYPE and apply windowing as described in 28.3.9 (Mathematical description of signals).
7. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 28.3.9 (Mathematical description of signals) and 28.3.10 (HE preamble) for details.