IEEE P802.11
Wireless LANs

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| **11bk Spec Text for IFTM Expansion** |
| **Date:** 2023-08-05 |
| **Author(s):** |
| **Name** | **Affiliation** | **Address** | **Phone** | **Email** |
| Yanjun Sun | Qualcomm |  |  |  |
| Ali Raissinia |  |  |  |  |
| Steve Shellhammer |  |  |  |  |
| George Cherian |  |  |  |  |
|  |  |  |  |  |

Abstract

We propose the draft specification skeleton for NDP Announcement to help the creation of TGbk draft.

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Uploaded the same version to get around a system glitch
* Rev 2: Added format of the Ranging Parameters element in the discussion; Unified format of the discussion
* Rev 3: Added underscore for next text and strikethrough for deleted baseline text; use Nss instead of STS for 320 MHz to match 11be; added text to match the entry in 23/1253r1.
* Rev 4: Propagated changes on STS/Nss and 320 MHz to 11.21.6.3.3 and 11.21.6.4.8.3
* Rev 5: Revised the text based on inputs during the call. Revised Transmit Power Envelope element based on latest text from 11meD4.0.

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

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

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

***Discussion:***

*The text is prepared for the following motion:*

*Extends the IFTMR and IFTM frames with a new subelement to indicate information on the transmit power envelope of the BSS.*

*(11-23-48: 202301-15)*

*The use-case the group discussed during the motion is to help an*

 *unassociated ISTA learn an updated transmit power envelop using a new subelement in the Ranging Parameters element.*

*Although the Ranging Parameters element is present in both IFTMR and IFTM frames, the use-case only requires the transmit power envelop in an IFTM frame. So, this PDT leaves out IFTMR frame and focus only on IFTM frame.*

*In addition, new text has been added according to the new entry for 320 MHz introduced in 23/1253r1*

**Proposed spec text:**

***TGbk editor: Please note Baseline is REVme\_D4.0, 11az D7.0 and 11bk D0.2***

**9. Frame formats**

**9.4.2.298 Ranging Parameters element**

… …

***Discussion:***

*Similar to discussions in 11bf, 320 MHz may have a STS value different from that for 160 MHz, so we propose to rename* *Max R2I STS > 80 MHz subfield to Max R2I STS = 160 MHz subfield, and Max I2R STS > 80 MHz subfield to Max I2R STS = 160 MHz subfield.*

*We’ll also need new values for 320 MHz. As a reference, 11be D3.0 has the following to allow a different NSS for 320 MHz*





*As the Ranging Parameters field is not extensible based on the figure above and these new values are not expected to be transmitted frequently, we propose to add them as an optional subelement in the current draft, similar to transmit power envelop.*

The format of the Ranging Parameters field is shown in Figure [9-788edh](#F09o788edh) (Ranging Parameters field format)

***TGbk editor: Please rename the Max R2I STS > 80 MHz and Max I2R STS > 80 MHz subfields as follows (track change enabled):***

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 B1 | B2 B6 | B7 | B8 B9 | B10 B11 | B12 |  B13 | B14 |  B15 |
|  | StatusIndication | Value | I2R LMR Feedback | Reserved | RangingPriority | R2I TOA Type | I2R TOA Type | R2I AOA Request | I2R AOA Request |
| Bits: | 2 | 5 | 1 | 2 | 2 | 1 | 1 | 1 | 1 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B16 B21 | B22  | B23 | B24 B26 | B27 B29 | B30 B31 | B32 B34 | B35 B37 |
|  | Formatand Bandwidth | Immediate R2IFeedback | Immediate I2RFeedback | Max I2R Repetition | Max R2I Repetition | Reserved | Max R2ISTS ≤ 80 MHz | Max R2ISTS ~~> 80~~=160 MHz |
| Bits: | 6 | 1 | 1 | 3 | 3 | 2 | 3 | 3 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | B38 B39  | B40 B41 | B42 B44 | B45 B47 | B48 B55 |
|  | Max R2I LTF Total | Max I2R LTF Total | Max I2RSTS ≤ 80 MHz | Max I2RSTS ~~> 80~~=160 MHz | BSS ColorInformation |
| Bits: | 2 | 2 | 3 | 3 | 8 |

**Figure 9-788edh—Ranging Parameters field format**

***TGbk editor: Please insert one new subelment id for transmit power envelop and another new subelement id for the Max R2I STS =320 MHz and Max I2R STS = 320 MHz values as follows (track change enabled):***

**Table 9-322h23fd—Ranging Subelement IDs for Ranging Parameters**

|  |  |  |
| --- | --- | --- |
| Subelement ID | Name | Extensible |
| 0 | Non-TB Specific subelement | Yes |
| 1 | TB-specific subelement | Yes |
| 2 | Secure HE-LTF subelement | Yes |
| 3 | Transmit Power Envelope subelement | Yes |
| 4 | Max Nss subelement | Yes |
| 5-220 | Reserved |  |
| 221 | Vendor Specific |  |
| 222-255 | Reserved |  |

… …

***TGbk editor: Please change the following two paragraphs on page 77***

The Max R2I STS ~~> 80~~=160 MHz subfield indicates for the bandwidth~~s greater than 80~~ of 160 MHz the maximum number of space-time streams to be used in R2I NDP in the session.

… …

The Max I2R STS ~~> 80~~=160 MHz subfield indicates for the bandwidth~~s greater than 80~~ of 160 MHz the maximum number of space-time streams to be used in I2R NDP in the session.

… …

***TGbk editor: Please insert the following definitions for the two new sublements to the end of this subclause (track change enabled):***

The Transmit Power Envelope subelement has the same definition as the Transmit Power Envelope element (see 9.4.2.161 (Transmit Power Envelope element)).

The format of the Max Nss subelement is as shown in Figure 9-7xx (Max Nss subelement format).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | B0 B7 | B8 B15 | B16 B18 | B19 B21 | B22 B23 |
|  | Subelement ID | Length | Max R2INss =320 MHz | Max I2RNss =320 MHz | Reserved |
| Bits: | 8 | 8 | 3 | 3 | 2 |

**Figure 9-7xx—Max Nss subelement format**

The Subelement ID and Length fields are defined in 9.4.3 (Subelements).

The Max R2I Nss = 320 MHz field indicates for the bandwidth of 320 MHz the maximum number of spatial streams to be used in R2I NDP in the session.

The Max I2R Nss = 320 MHz field indicates for the bandwidth of 320 MHz the maximum number of spatial streams to be used in I2R NDP in the session.

***TGbk editor: Please update subclause 11.21.6.3.3 as follows (track change enabled):***

**11.21.6.3.3 Negotiation for TB and non-TB ranging measurement exchange**

… …

When a Ranging Parameters element is included in the IFTMR frame, the ISTA shall indicate the following parameters in the Ranging Parameters field:

* … …
* Maximum number of space-time streams it is capable of receiving in the R2I NDP for 160 MHz bandwidth~~s greater than 80 MHz~~, in the Max R2I STS ~~> 80~~=160 MHz subfield.
* Maximum number of space-time streams it is capable of transmitting in the I2R NDP for bandwidths less than or equal to 80 MHz, in the Max I2R STS ≤ 80 MHz subfield.
* Maximum number of space-time streams it is capable of transmitting in the I2R NDP for 160 MHz bandwidth~~s greater than 80 MHz~~, in the Max I2R STS ~~> 80~~=160 MHz subfield.
* … …

If the Format and Bandwidth subfield is set to a value of 6, the ISTA shall include a Max Nss subelement together with the Ranging Parameters element in the IFTMR frame. In the subelement:

* The Max R2I Nss =320 MHz field is set to the maximum number of spatial streams the ISTA is capable of receiving in the R2I NDP for 320 MHz bandwidth minus 1.
* The Max I2R Nss =320 MHz field is set to the maximum number of spatial streams the ISTA is capable of transmitting in the I2R NDP for 320 MHz bandwidth minus 1.

The ISTA shall not include a Transmit Power Envelope subelement in the IFTMR frame.

… …

When the negotiation is successful for TB ranging and non-TB ranging, the corresponding IFTM frame from the RSTA shall include a Ranging Parameters element with the parameters that defines the negotiated range measurement session. The RSTA shall indicate the following parameters in the Ranging Parameters field:

* … …
* In the Max R2I STS ~~> 80~~=160 MHz subfield, either the maximum number of space-time streams it is capable of transmitting in the R2I NDP for 160 MHz bandwidth~~s greater than 80 MHz~~, or the value in the corresponding IFTMR frame, whichever is smaller (referred to as RSTA Assigned R2I STS ~~> 80~~=160 MHz).
* In the Max I2R STS ~~> 80~~=160 MHz subfield, either the maximum number of space-time streams it is capable of receiving in the I2R NDP for 160 MHz bandwidth~~s greater than 80 MHz~~, or the value in the corresponding IFTMR frame, whichever is smaller (referred to as RSTA Assigned I2R STS ~~> 80~~=160 MHz).
* … …

If the Format and Bandwidth subfield is set to a value of 6, in the same IFTM frame, the RSTA shall include a Max Nss subelement together with the Ranging Parameters element. In the Max Nss subelement:

* The Max R2I Nss =320 MHz field is set to either the maximum number of spatial streams it is capable of transmitting in the R2I NDP for 320 MHz bandwidth minus 1, or the value in the corresponding IFTMR frame, whichever is smaller (referred to as RSTA Assigned R2I Nss =320 MHz).
* The Max I2R Nss =320 MHz field is set to either the maximum number of spatial streams it is capable of receiving in the I2R NDP for 320 MHz bandwidth minus 1, or the value in the corresponding IFTMR frame, whichever is smaller (referred to as RSTA Assigned I2R Nss =320 MHz).

… …

Upon reception of an IFTMR frame with the Format and Bandwidth subfield set to a value of 3, 4 or 5 representing the ISTA’s support for one of the 160 MHz BW options, the RSTA shall respond with the same requested value in the Format and Bandwidth subfield in the IFTM frame, if it supports the requested 160 MHz BW option, otherwise respond with a value less than 3. Upon reception of an IFTMR frame with the Format and Bandwidth subfield set to a value of 6 representing the ISTA’s support for the 320 MHz BW option, the RSTA shall respond with the same requested value in the Format and Bandwidth subfield in the IFTM frame, if it supports the requested 320 MHz BW option.

***Discussion (not part of the spec text):***

**TPE is included in Beacon frames by a standard power AP or an indoor standard power AP to indicate the authorized client transmit power limits required by the regulatory rules, such as an AFC system. As an ISTA that is not associated with an RSTA may not monitor the Beacon frames, the ISTA may violates the regulatory rules. To prevent such violation, it’s safer to update the ISTA about the latest TPE, not only in the initial IFTMR/IFTM negotiation, but also within a measurement exchange together with an LMR, as TPE may get updated after the initial negotiation and the RSTA knows the ISTA is in receiving state in the LMR phase.**

**For an existing AP that is *not* an (indoor) standard power AP, the inclusion of TPE is recommended but not required**.

**The non-AP STA’s behavior has already been clearly defined in baseline 11meD4.0P1899L29 as follows and no new rule is needed in 11bk:**

**“A STA that (11ax) is not operating in the 6 GHz band, is extended spectrum management capable, and(11ax) has dot11SpectrumManagementRequired or dot11RadioMeasurementActivated equal to true shall determine a local maximum transmit power from a Transmit Power Envelope element for which (11ax)the Maximum Transmit Power Interpretation subfield indicates EIRP.**

**(11ax)A STA that is operating in the 6 GHz band shall determine local and regulatory client maximum transmit powers from Transmit Power Envelope element(s) according to local regulations known at the STA ( see E.2.7 (6 GHz band(11ax)(#600))).**

**…**

**A STA that sends two or more Transmit Power Envelope elements in a frame shall order the elements by increasing values of their(11ax) Maximum Transmit Power Interpretation subfields.**

**Reference on different TPE flavors****”**

***TGbk editor: Please insert the following paragraphs to subclause 11.21.6.3.3 as follows (track change enabled):***

If an RSTA is a standard power AP or an indoor standard power AP, the RSTA shall include at least one Transmit Power Envelope subelement in an IFTM frame. If an RSTA is neither a standard power AP nor an indoor standard power AP, the RSTA should include Transmit Power Envelope subelement(s) in an IFTM frame.

If the IFTM frame or the FTM frame contains multiple Transmit Power Envelope subelements, the Transmit Power Envelope subelements shall be ordered based on the corresponding rules for Transmit Power Envelope element defined in 10.22.4 (Operation with the Transmit Power Envelope element).

***TGbk editor: Please insert the following paragraphs to subclause 11.21.6.5 as follows (track change enabled):***

**11.21.6.5 FTM parameter modification**

If an ISTA is not associated with the RSTA, the RSTA shall notify any change in local or regulatory maximum transmit powers by transmitting an A-MPDU containing an FTM frame that includes updated Transmit Power Envelope subelement(s) and an R2I LMR whenever the RSTA is permitted to transmit such an LMR to the ISTA.

***TGbk editor: Please update subclause 11.21.6.4.3.3 as follows (track change enabled):***

**11.21.6.4.3.3 Measurement sounding phase of TB ranging**

… …

If the TF Ranging Sounding frame is transmitted in a 320 MHz PPDU, the I2R NDP shall be an EHT TB Ranging NDP. If the TF Ranging Sounding frame is transmitted in a PPDU of 160 MHz or less, the I2R NDP shall be an HE TB Ranging NDP. In the TF Ranging Sounding, the RSTA shall set the SS Allocation subfield and the I2R Rep subfield of the User Info fields corresponding to each of the ISTAs triggered by the Trigger frame in the following way:

— The Number of Spatial Streams in each SS Allocation subfield shall not exceed:

* ~~t~~The RSTA Assigned I2R STS ≤ 80 MHz for the corresponding ISTA, if the UL BW subfield in the Common Info field indicated a bandwidth less than or equal to 80 MHz~~,~~.
* ~~and not exceed t~~The RSTA Assigned I2R STS ~~> 80~~=160 MHz for the corresponding ISTA if the bandwidth is 160 MHz~~,~~.
* The RSTA Assigned I2R Nss =320 MHz for the corresponding ISTA if the bandwidth is 320 MHz.

… …

After transmission of the TF Ranging Sounding, the RSTA’s MAC sublayer shall issue a PHY-RXLTFSEQUENCE.request primitive with an LTFVECTOR containing the following parameters:

— the SECURE\_LTF\_FLAG parameter set to 0, and

— the LTF\_NSTS and LTF\_REP parameter vectors set to the same values as indicated, respectively, by the SS Allocation and I2R Rep subfields of all the User Info fields.

Similarly, in the Ranging NDP Announcement frame, the RSTA shall set the R2I NSTS subfield and R2I Rep subfield of the STA Info fields corresponding to each of the ISTAs, addressed by that frame in the following way

— The R2I NSTS subfield value shall not exceed:

* ~~t~~The RSTA assigned R2I STS ≤ 80 MHz for the corresponding ISTA, if the TXVECTOR parameter CH\_BANDWIDTH for this Ranging NDP Announcement frame is less than or equal to 80 MHz~~,~~.
* ~~and not exceed~~ The RSTA ~~a~~Assigned R2I STS ~~> 80~~=160 MHz for the corresponding ISTA if the CH\_BANDWIDTH is equal to 160 MHz~~,~~.
* The RSTA Assigned R2I Nss =320 MHz for the corresponding ISTA if the CH\_BANDWIDTH is equal to 320 MHz ~~otherwise~~.

— The number of LTF repetitions in the R2I Rep subfield shall be set to a value not to exceed the RSTA Assigned R2I Rep, for the corresponding ISTA.

— The combination of the values of the R2I NSTS and the R2I Rep shall not lead to a total number of LTF that exceeds the RSTA Assigned R2I LTF Total for each corresponding ISTA.

… …

***TGbk editor: Please update subclause 11.21.6.4.4.2 as follows (track change enabled):***

**11.21.6.4.4.2 Measurement sounding phase of non-TB ranging**

… …

If the bandwidth is less than or equal to 80 MHz, the ISTA shall set the I2R NSTS subfield and the R2I NSTS subfield in the STA Info field of the Ranging NDP Announcement frame each to a value not to exceed the RSTA assigned I2R STS ≤ 80 MHz and RSTA assigned R2I STS ≤ 80 MHz respectively. If the bandwidth is ~~greater than 80~~160 MHz, the ISTA shall set these same subfields to values not to exceed the RSTA assigned I2R STS ~~> 80~~=160 MHz and RSTA assigned R2I STS ~~> 80~~=160 MHz respectively. If the bandwidth is 320 MHz, the ISTA shall set these same subfields to values not to exceed the RSTA assigned I2R Nss =320 MHz and RSTA assigned R2I Nss =320 MHz respectively.

***TGbk editor: Please update subclause 11.21.6.4.8.3 as follows (track change enabled):***

**11.21.6.4.8.3 Passive TB ranging measurement sounding phase**

The passive TB ranging measurement sounding follows the same rules and procedures for the measurement sounding for TB ranging described in [11.21.6.4.3.3](#H11o21o6o4o3o3) (TB ranging Measurement Sounding phase), unless explicitly stated otherwise.

The second phase of the passive TB ranging measurement sequence, after the passive TB ranging Polling phase, is called the passive TB ranging measurement sounding phase. The passive TB ranging measurement sounding phase may include one or more Passive Sounding Ranging Trigger frames and HE/EHT Ranging NDP exchanges, a Ranging NDP Announcement frame, and an HE/EHT Ranging NDP transmission; see Figure [11-37v](#F11o37v) (Passive TB ranging polling, Measurement Sounding, and Measurement Reporting phases).



**Figure 11-37v—Passive TB ranging polling, measurement sounding, and measurement reporting phases.**

In passive TB ranging, for each ISTA, the RSTA shall transmit a Passive Sounding Ranging Trigger frame, which includes a single User Info field.

An RSTA shall transmit one or more Passive Sounding Ranging Trigger frames, each of which is addressed to a single ISTA, the first one coming a SIFS time after the TB Polling phase.

An ISTA addressed by the AID/RSID in the Passive Sounding Ranging Trigger frame shall transmit an HE/EHT Ranging NDP a SIFS time after the reception of the Passive TB Ranging Ranging Trigger frame.

An RSTA transmitting a Passive Sounding Ranging Trigger frame shall not use a bandwidth wider than that indicated in the IFTM frame sent to the ISTA.~~, and~~ If the Passive Sounding Ranging Trigger frame is soliciting an HE Ranging NDP, the RSTA shall set the TXVECTOR parameter CH\_BANDWIDTH to be the same value as the UL BW subfield of the Common Info field in the Passive Sounding Ranging Trigger frame. Otherwise, the RSTA shall set the TXVECTOR parameter CH\_BANDWIDTH of the Passive Sounding Ranging Trigger frame to CBW320.

NOTE—Generally a PSTA benefits from consistent ranging measurement performance when an RSTA initiates a passive TB ranging sequence with the nominal advertised bandwidth in every TXOP.

An RSTA transmitting a Ranging NDP Announcement frame and an HE/EHT Ranging NDP after receiving an HE/EHT Ranging NDP as a response to a Passive Sounding Ranging Trigger frame shall set the TXVECTOR parameter CH\_BANDWIDTH to be the same value as the BW subfield of the Common Info field in the Passive Sounding Ranging Trigger frame whose bandwidth is less than or equal to 160 MHz. If the bandwidth of the Passive Sounding Ranging Trigger frame is equal to 320 MHz, the RSTA shall set the TXVECTOR parameter CH\_BANDWIDTH to CBW320.

An ISTA transmitting an HE/EHT Ranging NDP as a response to a Passive Sounding Ranging Trigger frame shall set the TXVECTOR parameter CH\_BANDWIDTH to be the same value as the UL BW subfield of the Common Info field in the Passive Sounding Ranging Trigger frame whose bandwidth is less than or equal to 160 MHz. If the bandwidth of the Passive Sounding Ranging Trigger frame is equal to 320 MHz, the ISTA shall set the TXVECTOR parameter CH\_BANDWIDTH to CBW320..

If the CH\_BANDWIDTH of the Ranging NDP, either the I2R NDP or the R2I NDP, is equal to 320 MHz, the corresponding NDP shall be an EHT Ranging NDP and the R2I LMR in the corresponding measurement exchange sequence shall be transmitted in an EHT MU PPDU. Otherwise, the corresponding NDP shall be an HE Ranging NDP and the R2I LMR shall be transmitted in an HE MU PPDU.

As in TB ranging, an ISTA participating in a passive TB ranging exchange shall measure the TOD of its own HE/EHT Ranging NDP and either the TOAs, or both the TOAs and the phase shift feedback TOAs (PSTOAs), when it receives the RSTA’s HE/EHT Ranging NDP. In addition, optionally the ISTA may also measure and report either the TOAs, or both the TOAs and the PSTOAs, when it receives the HE/EHT Ranging NDPs transmitted by the other ISTAs participating in the passive TB ranging exchange. By reporting the timestamps for when it received the other ISTAs NDP transmissions, the quality of the location estimate for a PSTA listening in to the passive TB ranging exchanges can be improved.

The number of NSTS/Nss used in the passive TB ranging exchanges shall be less than or equal to 4.

When phase shift feedback is negotiated between an ISTA and an RSTA in passive TB ranging, the protocol for the measurement sounding phase differs from passive TB ranging with TOA feedback on the following points:

* The RSTA shall measure phase shift feedback TOA (PSTOA), in addition to measuring the TOA, on the I2R NPD it receives from the ISTA.
* The ISTA shall measure:

	+ the phase shift TOA (PSTOA), in addition to measuring the TOA, for the R2I NDP it receives from the RSTA.
	+ and may also measure phase shift TOA(s) (PSTOAs), in addition to measuring the TOA(s), for the I2R NDP(s) it receives from other ISTA(s).

See Figure [11-37w](#F11o37w) (Example Timing diagram of a Measurement Sounding phase in passive TB ranging) for an example of timestamps measured by the RSTA, ISTA and a PSTA in a passive TB ranging measurement exchange. The timestamp values t1, t2, t3 and t4 are analogous to the corresponding labeled timestamps in [11.21.6.4.3.3](#H11o21o6o4o3o3) (Measurement Sounding phase of TB ranging). The timestamps t5 and t6 are the times at which the I2R NDP and R2I NDPs arrive at the PSTA, respectively.



**Figure 11-37w—Example timing diagram of a measurement sounding phase in passive TB ranging**

The PSTA may use the ISTA’s and RSTA’s timestamps, together with its own measured TOAs of the ranging NDPs, t5 and t6, to calculate its differential time of flight to the RSTA and the ISTA.

The differential time-of-flight (DToF) from PSTA to RSTA and ISTA (DToF\_PRI) is defined by Equation [(11-6g)](#E11o6g).

DToF\_PRI = ToF\_PR – ToF\_PI, (11-6g)

Where, ToF\_PR is the time of flight between the PSTA and the RSTA, and ToF\_PI is the time of flight between the PSTA and the ISTA. The differential time of flight DToF\_PRI can be computed as per Equation [(11-6h)](#E11o6h):

DToF\_PRI = t6 – t5 – 0.5 × t3’ + 0.5 × t2’ – 0.5 × t4’ + 0.5 × t1’, (11-6h)

where,

t1’ and t4’ are the time at which the I2R NDP was transmitted from the ISTA and the time at which the R2I NDP was received by the ISTA, respectively, converted by the PSTA from the ISTA’s time basis to the PSTA’s time basis.

t2’ and t3’ are the time at which the I2R NDP was received by the RSTA and the time at which the R2I NDP was transmitted by the RSTA, respectively, converted by the PSTA from the RSTA’s time basis to the PSTA’s time basis.

At the PSTA, the mechanism by which t1’ and t4’ is derived from t1, t4, the ISTA’s reported CFO, and the PSTA’s CFO measured with respect to the RSTA, is implementation dependent.

At the PSTA, the mechanism by which t2’ and t3’ is derived from t2, t3, and the PSTA’s CFO measured with respect to the RSTA, is implementation dependent.

By multiplying the differential time of flight, DToF\_PRI, with the speed of light, the differential distance from PSTA to RSTA and ISTA can be computed.

See [11.21.6.4.8.5](#H11o21o6o4o8o5) (Passive TB ranging differential time-of-flight calculations using phase shift TOA timestamps) for how the PSTA’s differential distance to the RSTA and the ISTA can be computed using PSTOAs measured by the RSTA and the ISTA.