IEEE P802.11
Wireless LANs

|  |
| --- |
| High Resolution FTM |
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Abstract

Current FTM defines resolution of 100 ps for the time-stamps, which is insufficient for many use-cases. This contribution changes the FTM specifications to 1 ps resolution to address this issue.

It uses REVmcDraft 4.1 as baseline.

***Discussion:*** *The resolution for reporting the time stamps (0.1ns) in current FTM specification is insufficient for DMG applications. To fix, the resolution for the time-stamps and time stamp errors is globaly changed to 1ps (instead of 100ps). Additional encoding is done for the time stamp errors. In the range reporting, the resolution is also increased. This changes the service primitives (6.3.58.X), FTM range reporting (8.4.2.21.18) and FTM frame format (8.6.8.33) sections.*

***Note : Shown in black is the existing draft text from REVmcDraft 4.1, in red the changed text, and in strikethrough red the deleted text. Instructions to the editor are written in black italic with yellow highlights.***

* Semantics of the service primitive

The primitive parameters are as follows:

MLME-FINETIMINGMSMT.request(

Peer MAC Address,
Dialog Token,
Follow Up Dialog Token,
t1,
Max t1 Error,
t4,
Max t4 Error,
LCI Report, (M55)
Location Civic Report, (M55)
Fine Timing Measurement Parameters(#3465)(#6219(#3465), (M55)
VendorSpecific
)

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| Peer MAC Address | MACAddress | Any valid individual addressed MAC Address | The address of the peer MAC entity to which the Fine Timing Measurement frame is sent. |
| Dialog Token | Integer | 0–255 | The dialog token to identify the Fine Timing Measurement transaction. A value of 0 indicates the end of the transaction. |
| Follow Up Dialog Token | Integer | 0–255 | The dialog token of a Fine Timing Measurement frame which the current frame follows. See 10.24.6 (Fine timing measurement procedure(#46)(#3446)).(#2164) |
| t1 | Integer | 0–(248–1) | Set to the value of t1 (see Figure 6-17 (Fine timing measurement primitives and timestamps capture(#3338))(#2164)) expressed in ~~0.1 ns~~ units of picoseconds. |
| Max t1 Error | Integer | 0–32 767 (#2164) | ~~Maximum error in the t1 value expressed in 0.1 ns 1 ps units in case t1<2~~~~14~~~~, ; see 8.6.8.33 (Fine Timing Measurement frame format~~(#46)).(#2164) ~~A value of 0 indicates that the upper bound on the error is unknown. A value of 32 767~~ (#2164) ~~indicates that the upper bound on the error is greater than or equal to 3.2767 us 32.767 ns.~~ The maximum error in the t1 value is represented using a piecewise linear function of the Max t1 Error field defined in Equation (8-3)  |
| t4 | Integer | 0–(248–1) | Set to the value of t4 (see Figure 6-17 (Fine timing measurement primitives and timestamps capture(#3338))(#2164)) expressed in ~~0.1 ns~~ units of picoseconds. |
| Max t4 Error | Integer | 0–32 767 (#2164) | ~~Maximum error in t4 value expressed in 0.1 ns~~(#2164) ~~1 ps units. A value of 0 indicates that the upper bound on the error is unknown. A value of 32 767~~ (#2164) ~~indicates that the upper bound on the error is greater than or equal to 3.2767 us 32.767 ns.~~The maximum error in the t4 is represented using a piecewise linear function of the Max t4 Error defined in Equation (8-3). |
| LCI Report(M55) | As defined in 8.6.8.33 (Fine Timing Measurement frame format(#46)) | As defined in 8.6.8.33 (Fine Timing Measurement frame format(#46)) | Optional element to report LCI information of sender |
| Location Civic Report(M55) | As defined in 8.6.8.33 (Fine Timing Measurement frame format(#46)) | As defined in 8.6.8.33 (Fine Timing Measurement frame format(#46)) | Optional element to report location civic information(#3621) of sender |
| Fine Timing Measurement Parameters(M55) | As defined in 8.4.2.166 (Fine Timing Measurement Parameters(#3465) element(#2164)) | As defined in 8.4.2.166 (Fine Timing Measurement Parameters(#3465) element(#2164)) | Optional element containing the proposed fine timing measurement configuration |
| VendorSpecific  | A set of(#3421 )elements | As defined in 8.4.2.25 (Vendor Specific element) | Zero or more elements. |

***To the editor: Please change the primitive description in 6.3.58.3.2, as follows:***

* Semantics of the service primitive

The primitive parameters are as follows:

MLME-FINETIMINGMSMT.confirm(

Peer MAC Address,

Dialog Token,

t1,

Max t1 Error,

t4,

Max t4 Error(#1015)(#3060)

)

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| Peer MAC Address | MACAddress | Any valid individual addressed MAC Address | The address of the peer MAC entity to which acknowledges the receipt of the Fine Timing Measurement frame. |
| Dialog Token | Integer | 0–255 | The dialog token to identify the Fine Timing Measurement transaction. A value of 0 indicates the end of the transaction. |
| t1 | 48-bit unsigned Integer | 0–(248–1) | Set to the value of t1 (see Figure 6-17 (Fine timing measurement primitives and timestamps capture(#3338))(#2164)) expressed in 0~~.1 ns~~ units of picoseconds. |
| Max t1 Error | Integer | 0–32 767 (#2164) | ~~Maximum error in the t1 value expressed in 0.1 ns~~(#2164) ~~1 ps units. A value of 0 indicates that the upper bound on the error is unknown. A value of 32 767~~ (#2164) ~~indicates that the upper bound on the error is greater than or equal to 3.2767 us 32.767 ns.~~ The maximum error in the t1 value is represented using a piecewise linear function of the Max t1 Error defined in Equation (8-3). |
| t4 | 48-bit unsigned Integer | 0–(248–1) | Set to the value of t4 (see Figure 6-17 (Fine timing measurement primitives and timestamps capture(#3338)))(#2164) expressed in ~~0.1 ns~~ units of picoseconds. |
| Max t4 Error (#1015)(#3060) | Integer | 0–32 767 (#2164) | ~~Maximum error in t4 value expressed in 0.1 ns~~(#2164) ~~1 ps units. A value of 0 indicates that the upper bound on the error is unknown. A value of 32 767~~ (#2164) ~~indicates that the upper bound on the error is greater than or equal to 3.2767 us 32.767 ns.~~The maximum error in the t4 value is represented using a piecewise linear function of the Max t4 Error defined in Equation (8-3). |

***To the editor: Please change the primitive description in 6.3.58.4.2, as follows:***

* Semantics of the service primitive

The primitive parameters are as follows:

MLME-FINETIMINGMSMT.indication(

Peer MAC Address,

Dialog Token,

Follow Up Dialog Token,

t1,

Max t1 Error,

t4,

Max t4 Error,

t2,

Max t2 Error,

t3,

Max t3 Error,

LCI Report,(M55)(#3060)

Location Civic Report,(M55)

Fine Timing Measurement Parameters(#3465),(M55)

VendorSpecific

)

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Valid range | Description |
| Peer MAC Address | MACAddress | Any valid individual addressed MAC Address | The address of the peer MAC entity from which the Fine Timing Measurement frame was sent. |
| Dialog Token | Integer | 0–255 | The dialog token to identify the Fine Timing Measurement transaction. A value of 0 indicates the end of the transaction. |
| Follow Up Dialog Token | Integer | 0–255(M56) | The dialog token of a Fine Timing Measurement frame which the current frame follows. See 10.24.6 (Fine timing measurement procedure(#46)(#3446))(#2164). |
| t1 | 48-bit unsigned integer | 0–(248–1) | Set to the value of t1 (see Figure 6-17 (Fine timing measurement primitives and timestamps capture(#3338))) expressed in ~~0.1 ns~~(#2164) units of picoseconds. |
| Max t1 Error | Integer | 0–32 767 (#2164) | ~~Maximum error in the t1 value expressed in 0.1 ns~~(#2164) ~~1 ps units. A value of 0 indicates that the upper bound on the error is unknown. A value of 32 767~~(#2164) ~~indicates that the upper bound on the error is greater than or equal to 3.2767 us 32.767 ns.~~ The maximum error in the t1 value is represented using a piecewise linear function of the Max t1 Error defined in Equation (8-3). |
| t4 | 48-bit unsigned integer | 0–(248–1) | Set to the value of t4 (see Figure 6-17 (Fine timing measurement primitives and timestamps capture(#3338))) expressed in ~~0.1 ns~~(#2164) units of picoseconds. |
| Max t4 Error | Integer | 0–32 767 (#2164) | ~~Maximum error in t4 value expressed in 0.1 ns 1 ps units. A value of 0 indicates that the upper bound on the error is unknown. A value of 32 767 indicates that the upper bound on the error is greater than or equal to 3.2767 us 32.767 ns.~~The maximum error in the t4 value is represented using a piecewise linear function of the Max t4 Error defined in Equation (8-3). |
| t2 | 48-bit unsigned Integer | 0–(248–1) | Set to the value of t2 (see Figure 6-17 (Fine timing measurement primitives and timestamps capture(#3338)))(#2164) expressed in ~~0.1 ns~~(#2164)(#2164) units of picoseconds. |
| Max t2 Error | Integer | 0–32 767 (#2164) | ~~Maximum error in t2 value expressed in 0.1 ns 1 ps units. A value of 0 indicates that the upper bound on the error is unknown. A value of 32 767~~(#2164) ~~indicates that the upper bound on the error is greater than or equal to 3.2767 us 32.767 ns.~~The maximum error in the t2 value is represented using a piecewise linear function of the Max t2 Error defined in Equation (8-3). |
| t3 | 48-bit unsigned integer | 0–(248–1) | Set to the value of t3 (see Figure 6-17 (Fine timing measurement primitives and timestamps capture(#3338))) expressed in ~~0.1 ns~~(#2164) units of picoseconds. |
| Max t3 Error | Integer | 0–32 767 (#2164) | ~~Maximum error in t3 value expressed in 0.1 ns~~(#2164) ~~1 ps units. A value of 0 indicates that the upper bound on the error is unknown. A value of 32 767~~(#2164) ~~indicates that the upper bound on the error is greater than or equal to 3.2767 us 32.767 ns.~~The maximum error in the t3 value is represented using a piecewise linear function of the Max t3 Error defined in Equation (8-3). |
| LCI Report (M55)(#3060) | As defined in 8.6.8.33 (Fine Timing Measurement frame format(#46)) | As defined in 8.6.8.33 (Fine Timing Measurement frame format(#46)) | Optional element to report LCI information of sender |
| Location Civic Report(M55) | As defined in 8.6.8.33 (Fine Timing Measurement frame format(#46)) | As defined in 8.6.8.33 (Fine Timing Measurement frame format(#46)) | Optional element to report location civic information(#3621) of sender |
| Fine Timing Measurement Parameters(#3465)(M55) | As defined in 8.4.2.166 (Fine Timing Measurement Parameters(#3465) element(#2164)) | As defined in 8.4.2.166 (Fine Timing Measurement Parameters(#3465) element(#2164)) | Optional element containing the proposed fine timing measurement configuration |
| VendorSpecific  | A set of(#3421) elements | As defined in 8.4.2.25 (Vendor Specific element) | Zero or more elements.  |

***To the editor: Please change the primitive description in 6.5.4.2, as follows:***

* Semantics of the service primitive

The primitive provides the following parameters:

PLME-CHARACTERISTICS.confirm(

aSlotTime,

aSIFSTime,

aSignalExtension,

aCCATime,

aCCAMidTime,(11ac)

aRxPHYStartDelay(#1486),

aRxTxTurnaroundTime,

aTxPHYDelay,(#61)

aRxPHYDelay,(#61)

aRxTxSwitchTime,

aTxRampOnTime,(#1589)

aAirPropagationTime,

aMACProcessingDelay,

aPreambleLength,

aRIFSTime,

aSymbolLength,

aSTFOneLength,

aSTFTwoLength,

aLTFOneLength,

aLTFTwoLength,

aPHYHeaderLength,(#61)

aPHYSigTwoLength,(#61)

aPHYServiceLength,(#61)

aPHYConvolutionalTailLength,(#61)(#1585)(#3211)

aPSDUMaxLength,

aPPDUMaxTime,

aIUSTime,

aDTT2UTTTime,

aCWmin,

aCWmax,

aMaxCSIMatricesReportDelay

aMaxTODError,

aMaxTOAError,

aTxPHYTxStartRFDelay,(#61)

aTxPHYTxStartRMS,(#61)

aMaxTODFineError,(#46)

aMaxTOAFineError(#46)

)

The values assigned to the parameters is as specified in the PLME SAP interface specification contained within each PHY subclass of this standard. Not all parameters are used by all PHYs defined within this standard.(#1644)

|  |  |  |
| --- | --- | --- |
| Name | Type | Description |
| aSlotTime | integer | The Slot Time (in microseconds) that the MAC uses for defining the PIFS and DIFSs(#156). See 9.3.7 (DCF timing relations). |
| aSIFSTime | integer | The nominal time (in microseconds) that the MAC and PHY require in order to receive the last symbol of a frame at the air interface, process the frame, and respond with the first symbol on the air interface of the earliest possible response frame. See 9.3.7 (DCF timing relations). |
| aSignalExtension | integer | Duration (in microseconds) of the signal extension (i.e., a period of no transmission) that is included at the end of certain PPDU formats; see 20.3.2 (PPDU format) and 9.3.8 (Signal Extension). |
| aCCATime | integer | For Clause 16 (DSSS PHY specification for the 2.4 GHz band designated for ISM -applications) through Clause 19 (Extended Rate PHY (ERP) specification) PHYs and Clause 21 (Directional multi-gigabit (DMG) PHY specification(11ad)) PHYs,(11ac) the maximum time (in microseconds) the CCA mechanism has available to assess the medium(#55) to determine whether the medium is busy or idle.For Clause 20 (High Throughput (HT) PHY specification) and Clause 22 (Very High Throughput (VHT) PHY specification(11ac)) PHYs, the maximum time (in microseconds) that the CCA mechanism has available to detect the start of a valid IEEE 802.11 transmission within the primary channel and to assess the energy on the medium within the primary, secondary, secondary40 (Clause 22 (Very High Throughput (VHT) PHY specification(11ac)) PHY only), and secondary80 (Clause 22 (Very High Throughput (VHT) PHY specification(11ac)) PHY only) channels that fall inside the operating channel, in order to determine the values of the STATE and channel-list parameters of the PHY-CCA.indication primitive.(11ac) |
| aCCAMidTime(11ac) | integer | For Clause 22 (Very High Throughput (VHT) PHY specification(11ac)) PHYs, the maximum time (in microseconds) the CCA mechanism has available to assess the medium to determine whether an IEEE 802.11 transmission is present on a (MDR)nonprimary channel. |
| aRxPHYStartDelay(#1486) | integer | The delay, in microseconds, from a point in time specified by the PHY to the issuance of the PHY-RXSTART.indication primitive. |
| aRxTxTurnaroundTime | integer | The maximum time (in microseconds) that the PHY requires to change from receiving to transmitting the start of the first symbol. The following equation is used to derive the RxTxTurnaroundTime:aTxPHYDelay + aRxTxSwitchTime + aTxRampOnTime(#61) |
| aTxPHYDelay(#61) | integer | The nominal time (in microseconds) that the PHY uses to deliver a symbol from the MAC interface to the air interface.(#61) |
| aRxPHYDelay | integer | The nominal time (in microseconds) that the PHY uses to deliver the last bit of a received frame from end of the last symbol at the air interface to the MAC.(#61) |
| aRxTxSwitchTime | integer | The nominal time (in microseconds) that the PHY(#61) takes to switch from Receive to Transmit. |
| aTxRampOnTime (#1589) | integer | The maximum time (in microseconds) that the PHY(#61) takes to turn the Transmitter on. |
| aAirPropagationTime | integer | Twice the propagation time (in microseconds) for a signal to cross the maximum distance between the most distant allowable STAs that are slot synchronized. |
| aMACProcessingDelay | integer | The maximum time (in microseconds) available for the MAC to issue a PHY-TXSTART.request primitive pursuant to a PHY-RXEND.indication primitive (for response after SIFS) or PHY-CCA.indication(IDLE) primitive (for response at any slot boundary following a SIFS). This constraint on MAC performance is defined as a PHY-specific parameter because of its use, along with other PHY-specific time delays, in calculating the two PHY characteristics of primary concern to the MAC: aSlotTime and aSIFSTime. The relationship between aMACProcessingTime and the IFS and slot timing is described in 9.3.7 (DCF timing relations) and illustrated in Figure 9-19 (DCF timing relationships(#61)(#1514)(#6626)). |
| aPreambleLength | integer | The current PHY’s preamble length (in microseconds). If the actual value of the length of the modulated preamble is not an integral number of microseconds, the value is rounded up to the next higher value. |
| aRIFSTime | integer | Value of the reduced interframe space (in microseconds), which is the time by which multiple transmissions from a single transmitter may be separated, when no SIFS-separated response transmission is expected. See 9.3.2.3.2 (RIFS) |
| aSymbolLength | integer | The current PHY’s Symbol length (in microseconds). If the actual value of the length is not an integral number of µs, the value is rounded up to the next higher value. |
| aSTFOneLength | integer | Length of the non-HT-STF (L-STF) for HT-mixed format, and the HT-greenfield STF (HT-GF-STF) for HT-greenfield format (in microseconds) |
| aSTFTwoLength | integer | Length of the HT-STF (in microseconds) |
| aLTFOneLength | integer | Length of the First HT-LTF (in microseconds)  |
| aLTFTwoLength | integer | Length of the Additional HT-LTFs (in microseconds)  |
| aPHYHeaderLength (#61) | integer | The current PHY’s header length (in microseconds), excluding aPHYSigTwoLength(#61) if present. If the actual value of the length of the modulated header is not an integral number of microseconds, the value is rounded up to the next higher value. |
| aPHYSigTwoLength (#61) | integer | Length of the HT SIGNAL field (HT-SIG) (in microseconds). |
| aPHYServiceLength (#61) | integer | The length of the PHY(#61) SERVICE field (in number of bits). |
| aPHYConvolutionalTailLength (#61) | integer | The length of the sequence of convolutional code tail bits (in number of bits).(#1585)(#3211) |
| aPSDUMaxLength  | integer | The maximum number of octets in a PSDU that can be conveyed by a PPDU. |
| aPPDUMaxTime  | integer | The maximum duration of a PPDU in milliseconds. |
| aIUSTime  | integer | The minimum time between the end of a PSMP-UTT and the start of the following PSMP-UTT in the same PSMP sequence. |
| aDTT2UTTTime  | integer | The minimum time between the end of a PSMP-DTT and the start of the PSMP-UTT addressed to the same STA. |
| aCWmin | integer | The minimum size of the CW, in units of aSlotTime. |
| aCWmax | integer | The maximum size of the CW, in units of aSlotTime. |
| aMaxCSIMatriesReportDelay  | integer | The maximum time (in milliseconds) between the reception of a frame containing a CSI Feedback Request or an null data packet (NDP)(#5273) announcement and the transmission of the first CSI frame containing channel state information measured from the received Sounding Complete frame. See 9.32.2.4.4 (CSI reporting for calibration). |
| aMaxTODError | Integer | An estimate of the maximum error (in 10 ns units) in the TX\_START\_OF\_FRAME\_OFFSET value in the PHY-TXSTART.confirm(TXSTATUS) primitive. The estimated maximum error includes any error due to implementation component and environmental (including temperature) variability. |
| aMaxTOAError | Integer | An estimate of the maximum error (in 10 ns units) in the RX\_START\_OF\_FRAME\_OFFSET value in the PHY-RXSTART.indication(#1487)(RXVECTOR) primitive. The estimated maximum error includes any error due to implementation component and environmental (including temperature) variability. |
| aTxPHYTxStartRFDelay (#61) | Integer | The delay (in units of 0.5 ns) between a PHY-TXSTART.request (MDR)primitive(#61) being issued and the first frame energy sent by the transmitting port, for the current channel. |
| aTxPHYTxStartRMS (#61) | Integer | The RMS time of departure error (in units of 0.5 ns), where the time of departure error equals the difference between TIME\_OF\_DEPARTURE and the time of departure measured by a reference entity using a clock synchronized to the start time and mean frequency of the local PHY entity’s clock. |
| aMaxTODFineError (#46) | Integer | An estimate of the maximum error (in ~~0.1 ns~~ (#2164)units of picoseconds) in the TX\_START\_OF\_FRAME\_OFFSET value in the PHY-TXSTART.confirm(TXSTATUS) primitive. The estimated maximum error includes any error due to implementation component and environmental (including temperature) variability. |
| aMaxTOAFineError (#46) | Integer | An estimate of the maximum error (in ~~0.1 ns~~ units of picoseconds) in the RX\_START\_OF\_FRAME\_OFFSET value in the PHY-RXSTART.indication(#1487)(RXVECTOR) primitive. The estimated maximum error includes any error due to implementation component and environmental (including temperature) variability. |

* Fine Timing Measurement (#3637)Range report(#2403)

The format of the Measurement Report field corresponding to a Fine Timing Measurement (#3637)Range report is shown in Figure 8-245 (Measurement Report field format for a Fine Timing Measurement Range report(#2403)).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Range Entry Count | Range Entry | Error Entry Count | Error Entry | Optional Subelements |
| Octets: | 1 | *M* x ~~15~~ 17(#3201) | 1 | *N* x 11 | variable |
| * Measurement Report field format for a Fine Timing Measurement Range report(#2403)
 |

The Range Entry Count field indicates the number of Range Entry fields (i.e., *M* in Figure 8-245 (Measurement Report field format for a Fine Timing Measurement Range report(#2403))).

The Range Entry field indicates parameters relating to a successful(M56) range measurement with a single AP, and is formatted according to Figure 8-246 (Range Entry field format(#2403)).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Measurement Start Time | BSSID | Range | Max Range Error | Reserved |
| Octets: | 4 | 6 | ~~2~~ 3~~(M56)~~ | ~~2~~ 3 | 1 |
| * Range Entry field format(#2403)
 |

The Measurement Start Time field contains the least significant 4 octets of the TSF (synchronized with the associated AP) at the time (± 32 µs) at which the initial(M56) Fine Timing Measurement frame was transmitted where the timestamps of both the frame and response frame were successfully measured.

The BSSID field contains the BSSID of the AP whose range is being reported.

***To the editor: Please change the following paragraphs:***

The Range field indicates the estimated range between the requested STA and the AP using the fine timing measurement procedure, in units of ~~1/64~~ 1/4096 m.(M56) A value of ~~216–1~~ 224–1 indicates a range of ~~(216–1)/64~~ (224–1)/4096 m or higher. See 10.11.9.11 (Fine Timing Measurement Range report(#2403)).

The Max Range Error field contains an upper bound for the error in the value specified in the Range field, in units of ~~1/64~~ 1/4096 m.(M56) A value of zero indicates an unknown error. A value of ~~216–1~~ 224–1 indicates a maximum range error of ~~(216–1)/64~~ (224–1)/4096 m(M56) or higher. For instance, a value of ~~128~~(M56) 8192 in the Max Range Error field indicates that the value in the Range field has a maximum error of ± 2 m.

* Fine Timing Measurement frame format(#46)

The Fine Timing Measurement frame is used to support the fine timing measurement procedure described in 10.24.6 (Fine timing measurement procedure(#46)(#3446)). The format of the Fine(Ed) Timing Measurement Action field(#2042) is shown in Figure 8-664 (Fine Timing Measurement Action field(#2042) format).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Category | Public(M56) Action | Dialog Token | Follow Up Dialog Token | TOD | TOA |
| Octets: | 1 | 1 | 1 | 1 | 6 | 6 |
|  |  |  |  |  |  |  |
|  | TOD Error | TOA Error | LCI Report(optional) | Location Civic Report (optional) | Fine Timing Measurement Parameters(#3465) (optional) |  |
| Octets: | 2 | 2 | variable (#2403) | variable (#2403) | variable (#2164) |  |
| * Fine Timing Measurement Action field(#2042) format
 |

The (M56)Category field is defined in 8.4.1.11 (Action field).(#6544)

The Public Action field is defined in 8.6.8.1 (Public Action frames).(#3403)

The TOD Error field is structured as shown in Figure 8-665 (Format of the TOD Error field(#2164)).

|  |  |  |
| --- | --- | --- |
|  | B0 B14(M56) | B15(M56) |
|  | Max TOD Error | TOD Not Continuous |
| Bits: | 15 | 1 |
| * Format of the TOD Error field(#2164)
 |

The TOA Error field is structured as shown in 8-666 (Format of the TOA Error field(#2164)).

|  |  |  |
| --- | --- | --- |
|  | B0 B14(M56) | B15(M56) |
|  | Max TOA Error | TOA Not Continuous |
| Bits: | 15 | 1 |
| * Format of the TOA Error field(#2164)
 |

The Dialog Token field is a nonzero value chosen by the responding(#2164) STA to identify the Fine(M56) Timing Measurement frame as the first of a pair, with the second or follow-up Fine(M56) Timing Measurement frame to be sent later. The Dialog Token field is set to 0 to indicate that the Fine(M56) Timing Measurement frame will not be followed by a subsequent follow-up Fine(M56) Timing Measurement frame.

The Follow Up Dialog Token field(Ed) is the nonzero value of the Dialog Token field of the last(#2164) transmitted Fine(M56) Timing Measurement frame to indicate that it is the follow up Fine(Ed) Timing Measurement frame and that the TOD, TOA, Max TOD Error and Max TOA Error fields contain the values of the timestamps captured with the first Fine Timing Measurement frame of the pair. The Follow Up Dialog Token field(Ed) is 0 to indicate that the Fine Timing Measurement frame is not a follow up to a last(#2164) transmitted Fine Timing Measurement frame. The value 0 in this field also indicates that TOD, TOA, (#3267)TOD Error, and (#3267)TOA Error fields are reserved. See 10.24.6 (Fine timing measurement procedure(#46)(#3446)).

***To the editor: Please change the following paragraph:***

The TOD~~,~~ and TOA~~, Max TOD Error, and Max TOA Error fields~~ are expressed in units of ~~0.1 ns~~ picoseconds.

The maximum errors in the TOD and TOA values are represented using a piecewise linear function of the Max Error as defined in Equation (8-3)

 (8-3)

where in Equation (8-3) is the integer value of Max TOD Error or Max TOA Error fields and is the maximum TOD or TOA error, respectively, in units of picoseconds.

 The TOD field contains a timestamp that represents the time, with respect to a time base,(#3267) at which the start of the preamble of the last(#2164) transmitted Fine(M56) Timing Measurement frame appeared at the transmit antenna connector(#1410).

The TOA field contains a timestamp that represents the time, with respect to a time base,(#3267) at which the start of the preamble of the (#190)(#1198)Ack frame to the last(#2164) transmitted Fine(M56) Timing Measurement frame arrived at the receive antenna connector(#1410).

NOTE—The values specified in the TOD and TOA fields are described in 6.3.70 (Fine timing measurement request(#46)).

The TOD Not Continuous field indicates that the TOD value is with respect to a different underlying time base than the last transmitted TOD value. It is set to 1 when a discontinuity is present. (#3267)Otherwise, it is set to 0.(#2164)

The Max TOD Error field contains an upper bound for the error in the value specified in the TOD field.

(#2164)***To the editor: Please change the following paragraph:***

NOTE—For instance, a value of 2 in the Max TOD Error field indicates that the value in the TOD field has a maximum error of ± ~~0.2 ns~~ 2 ps.

The TOA Not Continuous field indicates that the TOA value is with respect to a different underlying time base than the last transmitted TOA value. It is set to 1 when a discontinuity is present. (#3267)Otherwise, it is set to 0.(#2164)

The Max TOA Error field contains an upper bound for the error in the value specified in the TOA field. (#2164)

***To the editor: Please change the following paragraph:***

A value of 0 for the Max TOD Error or the Max TOA Error field indicates that the upper bound on the error in the corresponding TOD or TOA value is unknown. A value of 32 767(M56) indicates that the upper bound on the error is greater than or equal to ~~3.2767~~ ( µs. (M56)