[Sep., 2026]

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Relation between IEEE P802.1AS and IEEE Std 802.3 PHY delay – Part III

TSN Working Group

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contribution to IEEE

part I: https://www.ieee802.org/1/files/public/docs2026/as-Turner-PHYdelay-dot3-0526-V2.pdf
part II: https://www.ieee802.org/1/files/public/docs2026/as-Turner-PHYdelay-dot3-0826-V0.pdf

The (reduced) plan for today:

I had in previous e-mails and contributions conflated too many topics, problem statements, and potential solutions.

To not convolute this meeting:

- We start with aligning interfaces and nomenclature between IEEE 802.3cx and IEEE 802.1AS
- The call will focus on the consistency of time-units in IEEE P80211AS-2025-Rev: the assumption being that TIA, the GM, and the two local clocks on a link, are not syntonized and do not use the same time-units (each of their "ns" is of different actual duration)

We can have more discussions, if we find agreement and time allows!

Aligning Interfaces and Nomenclature

We will NOT debate now if or how Δ_{PHY} is measurable!

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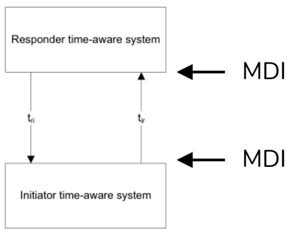

Figure 8-1—Propagation asymmetry

The meanLinkDelay is the mean value of t_{ir} and t_{ri}, i.e., meanLinkDelay = $(t_{ir} + t_{ri})$ / 2. The delayAsymmetry is defined as:

t_{ir} = meanLinkDelay – delayAsymmetry

t_{ri} = meanLinkDelay + delayAsymmetry

$dA = (t_{ri} - t_{ir})/2$

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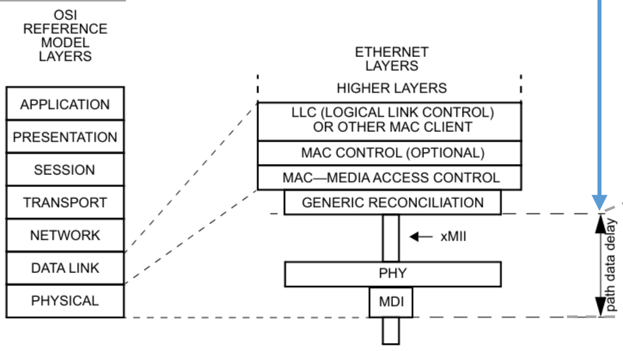

Figure 90–3—Path data delay measurement

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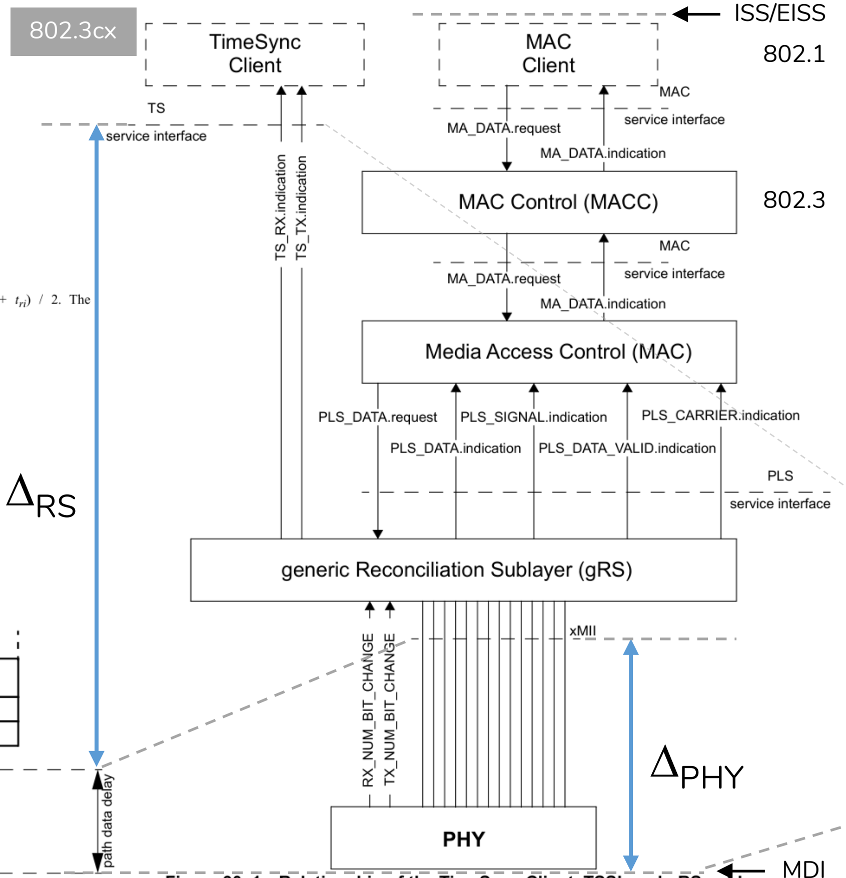

Figure 90–1—Relationship of the TimeSync Client, TSSI, and gRS sublayer relative to MAC and MAC Client and associated interfaces

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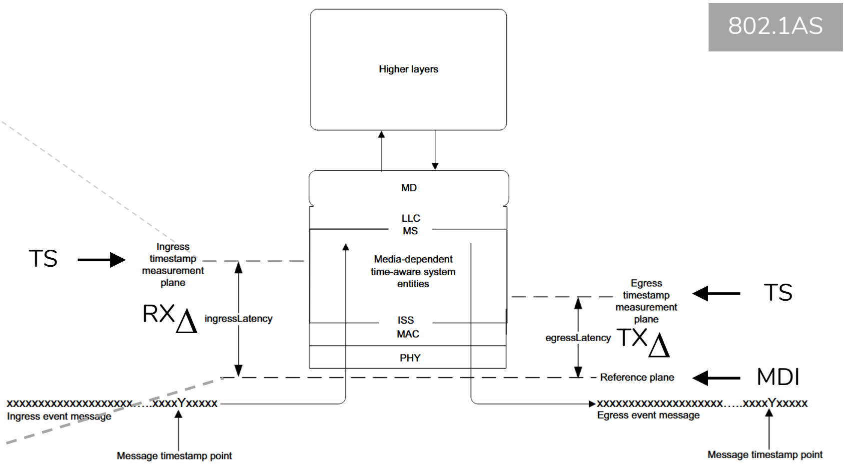

Figure 8-2—Definition of message timestamp point, reference plane, timestamp measurement plane, and latency constants

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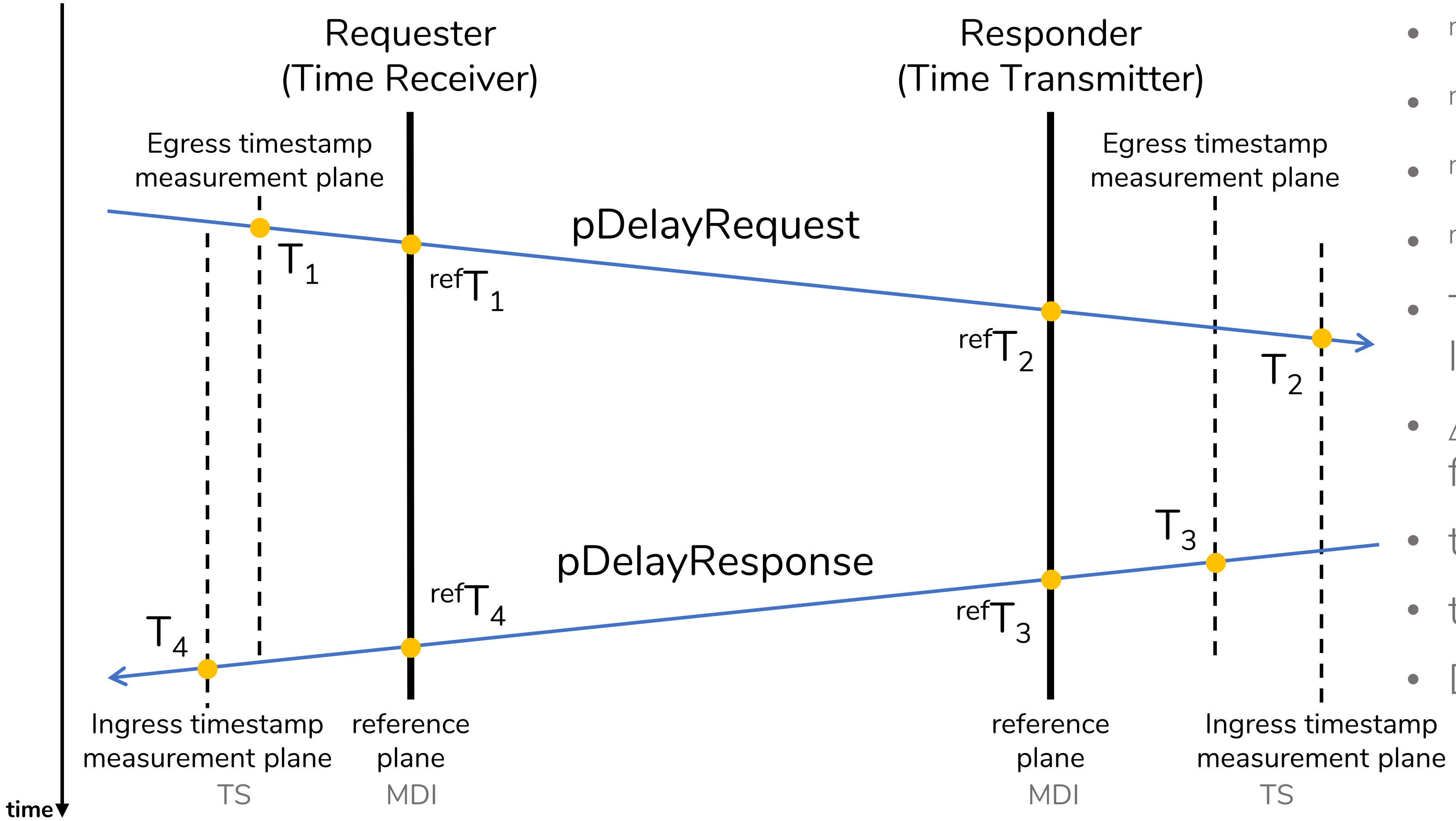
Multiple Rate Ratios

- **rateRatio**: Is the ratio of the frequency of the Grandmaster Clock to the frequency of the LocalClock entity of this PTP Instance.
- **neighborRateRatio**: The measured ratio of the frequency of the LocalClock entity of the time-aware system at the other end of the link attached to this port, to the frequency of the LocalClock entity of this time-aware system.
- **Frequency accuracy:** The fractional frequency offset of the LocalClock relative to the TAI frequency (see ISO 80000-3:2006) shall be within ±100 ppm.
  - This also holds for the GM!

pDelay Measurement – Concept



- ${}^{ref}T_1 = T_1 + {}^{TX}\Delta_{Req}$
- ${}^{ref}T_2 = T_2 - {}^{RX}\Delta_{Rsp}$
- ${}^{ref}T_3 = T_3 + {}^{TX}\Delta_{Rsp}$
- ${}^{ref}T_4 = T_4 - {}^{RX}\Delta_{Req}$
- T .. denotes time stamps in local clock units
- Δ, dA … are in TAI time units from data sheet or registers
- $t_{ir} = {}^{ref}T_2 - {}^{ref}T_1 = D - dA$
- $t_{ri} = {}^{ref}T_4 - {}^{ref}T_3 = D + dA$
- $D = (({}^{ref}T_4 - {}^{ref}T_1) - ({}^{ref}T_3 - {}^{ref}T_2))/2$

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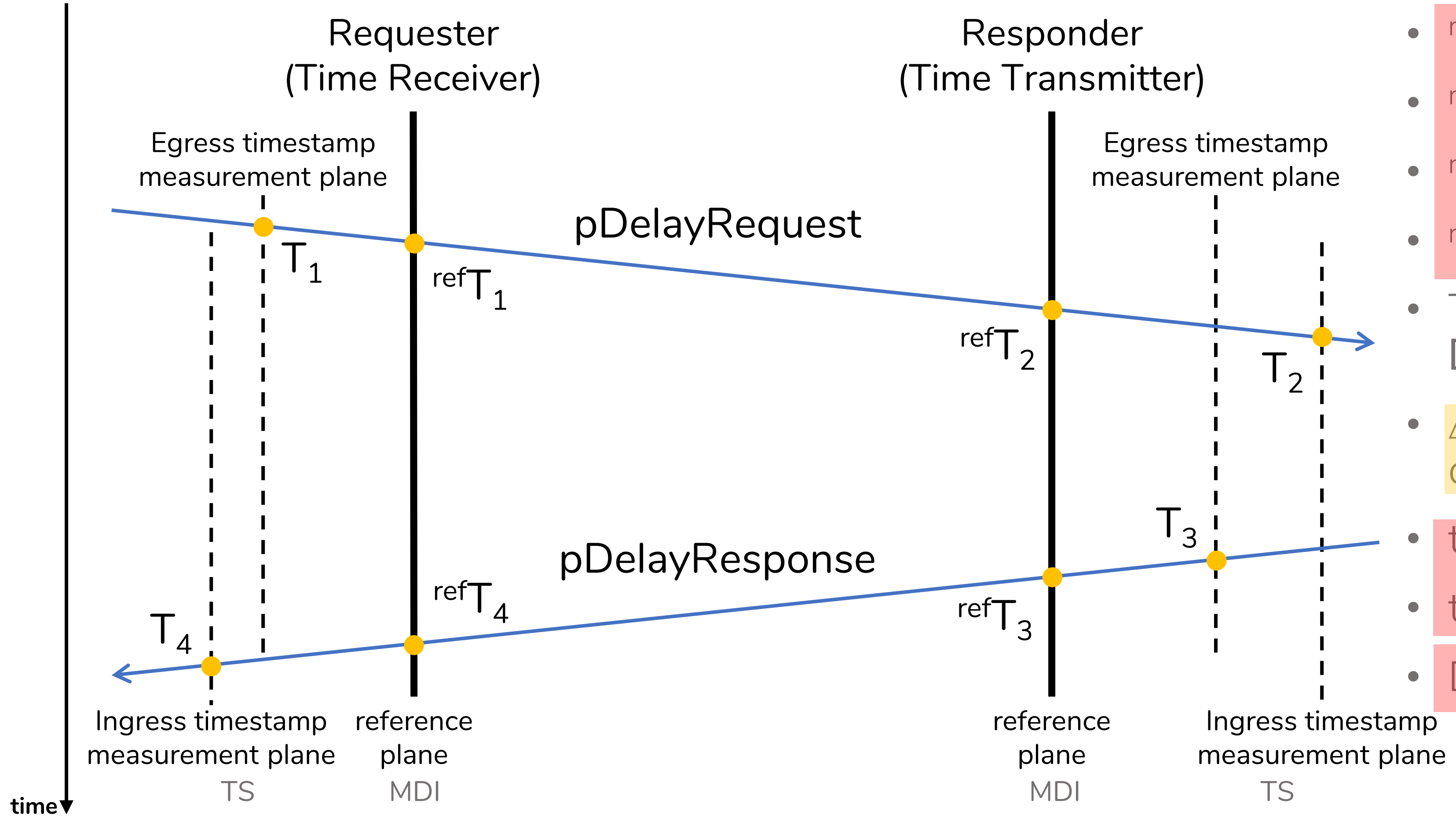
pDelay Measurement - Units



- $^{ref}T_1 = T_1 + {}^{TX}\Delta_{Req}$
- $^{ref}T_2 = T_2 - {}^{RX}\Delta_{Rsp}$
- $^{ref}T_3 = T_3 + {}^{TX}\Delta_{Rsp}$
- $^{ref}T_4 = T_4 - {}^{RX}\Delta_{Req}$
- T .. denotes time stamps in **DIFFERENT** local clock units (nRR)
- Δ, dA ... are in TAI time units from data sheet or registers
- $t_{ir} = {}^{ref}T_2 - {}^{ref}T_1 = D - dA$
- $t_{ri} = {}^{ref}T_4 - {}^{ref}T_3 = D + dA$
- $D = (({}^{ref}T_4 - {}^{ref}T_1) - ({}^{ref}T_3 - {}^{ref}T_2))/2$

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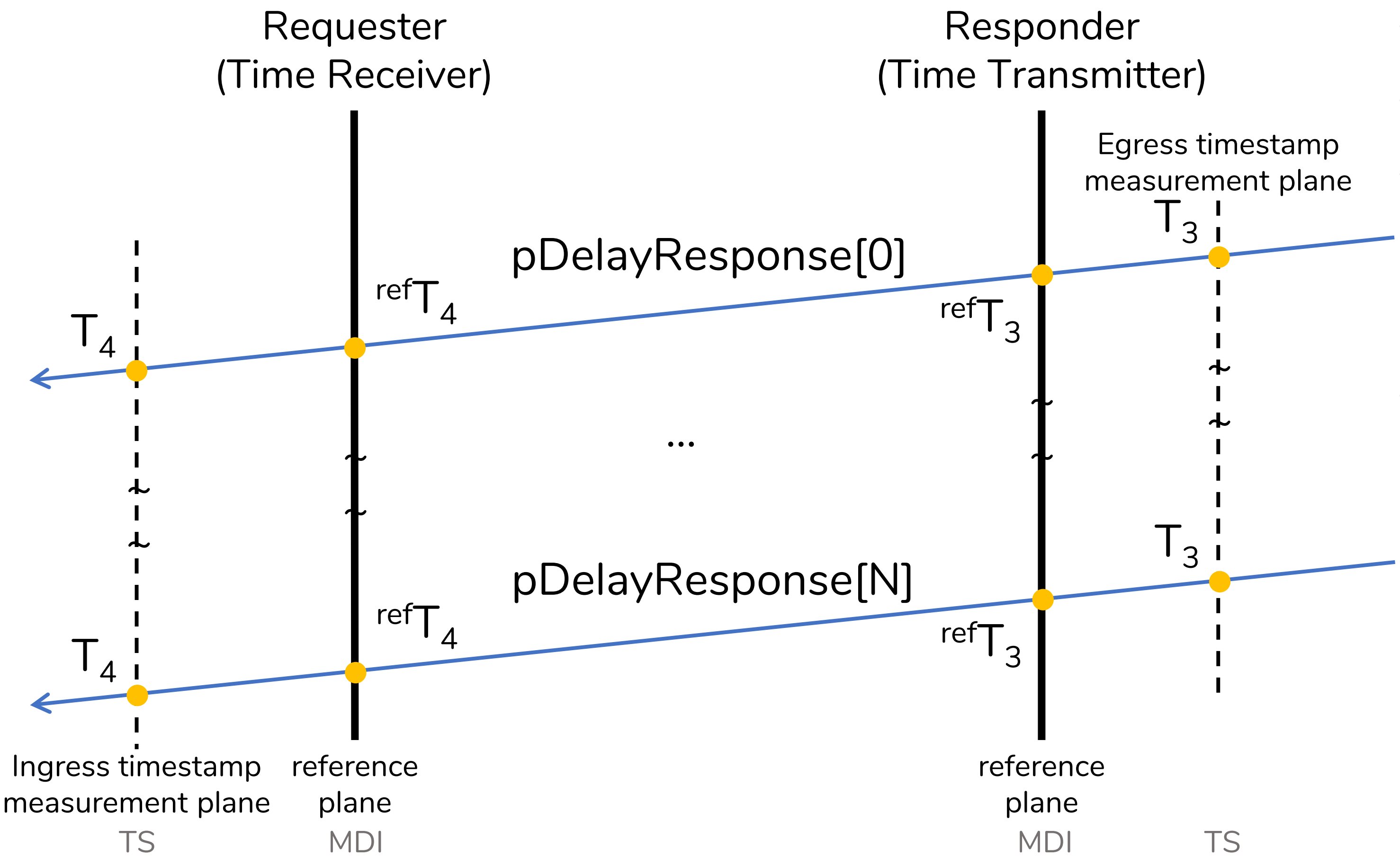
neighbour Rate Ratio (nRR)



- ${}^{ref}T_3 = T_3 + {}^{TX}\Delta_{Rsp}$
- ${}^{ref}T_4 = T_4 - {}^{RX}\Delta_{Req}$
- $nRR = ({}^{ref}T_3[N] - {}^{ref}T_3[0]) / ({}^{ref}T_4[N] - {}^{ref}T_4[0])$

  $= (T_3[N] - T_3[0]) / (T_4[N] - T_4[0])$
- nRR gives the ratio between the two local clocks!

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mean Link Delay with nRR

11.2.18.3.4 computePropTime(): Computes the mean propagation delay on the PTP Link attached to this MD entity, *D*, and returns this value. *D* is given by Equation (11-5).

$$D = \frac{r \times (t_4 - t_1) - (t_3 - t_2)}{2} \tag{11-5}$$

- ${}^{ref}T_1 = T_1 + {}^{TX}\Delta_{Req}$
- ${}^{ref}T_2 = T_2 - {}^{RX}\Delta_{Rsp}$
- ${}^{ref}T_3 = T_3 + {}^{TX}\Delta_{Rsp}$
- ${}^{ref}T_4 = T_4 - {}^{RX}\Delta_{Req}$
- $D = (nRR \times (T_4 - {}^{RX}\Delta_{Req} - (T_1 + {}^{TX}\Delta_{Req})) - ((T_3 + {}^{TX}\Delta_{Rsp}) - (T_2 - {}^{RX}\Delta_{Rsp}))) / 2$

  $= (nRR \times (T_4 - T_1) - (T_3 - T_2) - nRR \times ({}^{RX}\Delta_{Req} + {}^{TX}\Delta_{Req}) - ({}^{TX}\Delta_{Rsp} + {}^{RX}\Delta_{Rsp})) / 2$

80.4 Delay constraints

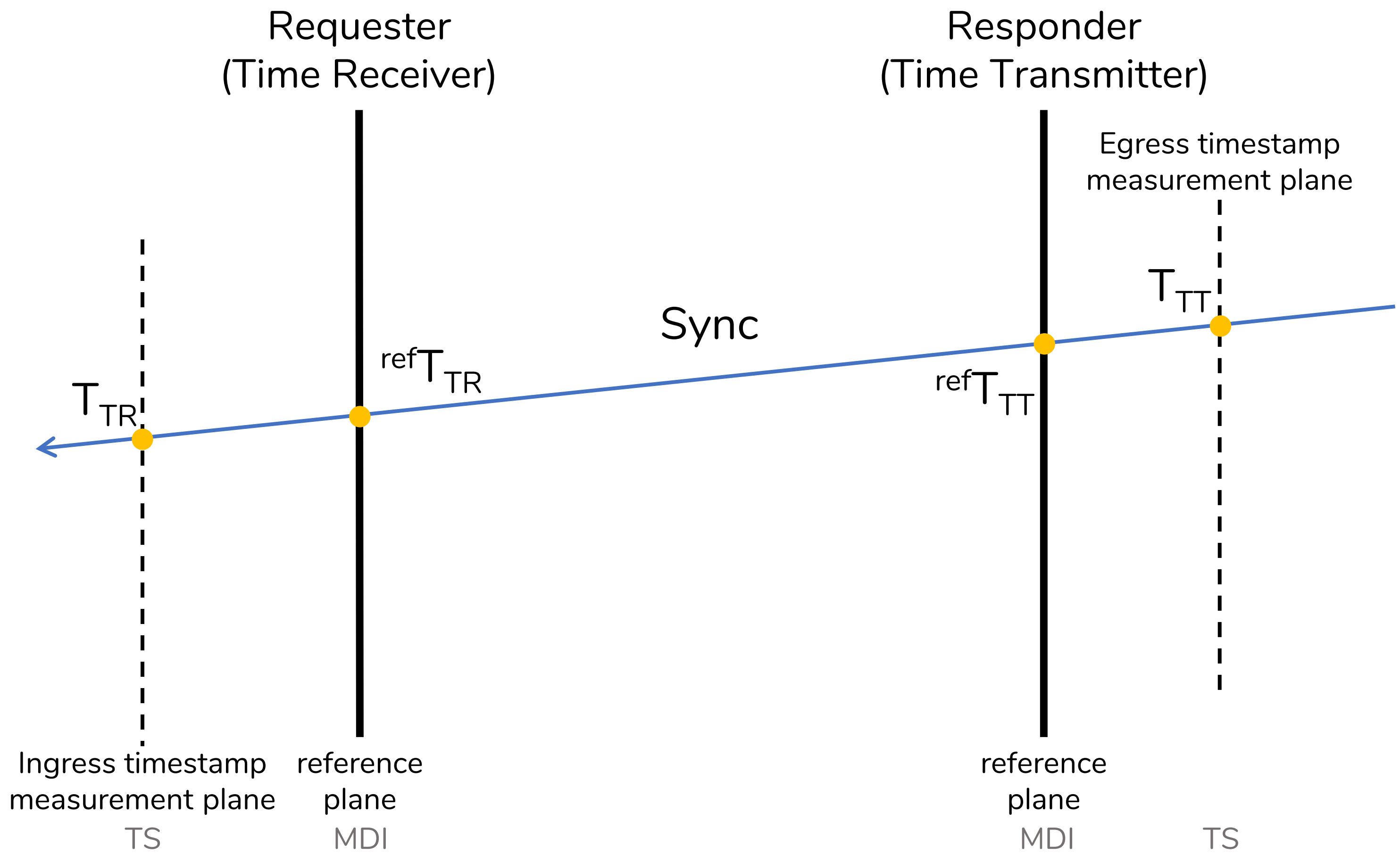
$$\text{cable delay} = \frac{10^9}{nc}\ \text{ns/m} \tag{80–1}$$

The value of *n* should be available from the fiber or electrical cable manufacturer; but if no value is known, then a conservative delay estimate can be calculated using a default value of *n* = 0.66, which yields a default cable delay of 5 ns/m.

Table 149–20—Delay Limits

Mode	Interleave	Bit times	Pause Quanta	Delay (ns)
2.5GBASE-T1	1x	10 240	20	4096
5GBASE-T1	1x	10 240	20	2048
5GBASE-T1	2x	13 824	27	2764.8
10GBASE-T1	1x	10 240	20	1024
10GBASE-T1	2x	13 824	27	1382.4
10GBASE-T1	4x	20 480	40	2048

Sync Message - Units



- $^{ref}T_{TT} = T_{TT} + {}^{TX}\Delta_{Rsp}$
- $^{ref}T_{TR} = T_{TR} - {}^{RX}\Delta_{Req}$
- T .. denotes time stamps in **DIFFERENT** local clock units (nRR)
- Δ, dA … are in TAI time units from data sheet or registers
- $D = (t_{ir} + t_{ri}) / 2$
- $^{ref}T_{TR} = t_{ri} + {}^{ref}T_{TT}$
  $= D + dA + {}^{ref}T_{TT}$
- $T_{TR} = {}^{ref}T_{TR} + {}^{RX}\Delta_{Req}$
  $= D + dA + T_{TT} + {}^{TX}\Delta_{Rsp} + {}^{RX}\Delta_{Req}$

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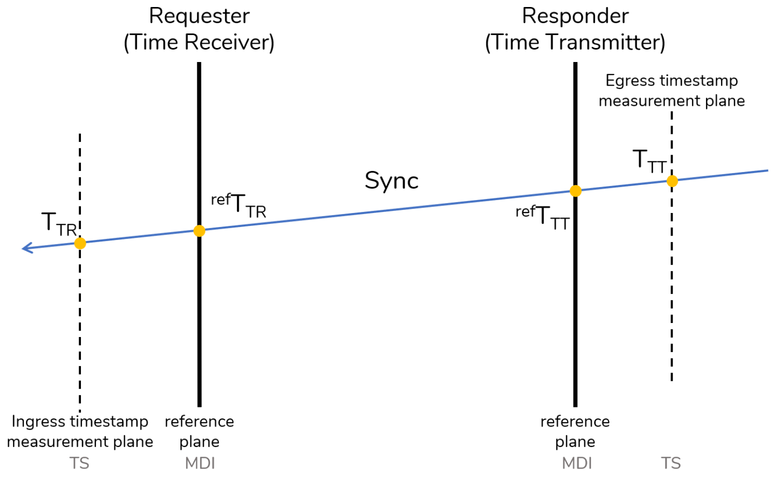
11.2.13.2.1 setMDSyncReceiveMDSR()

i) upstreamTxTime is set equal to the syncEventIngressTimestamp for the most recently received Sync message (see 11.4.3), minus the mean propagation time on the PTP Link attached to this PTP Port (meanLinkDelay; see 10.2.5.8) divided by nrrPdelay (see 11.2.12.14), minus delayAsymmetry (see 10.2.5.9) for this PTP Port divided by the sum of rateRatio [see item e) in this subclause] and the quantity neighborRateRatio – 1. The syncEventIngressTimestamp is equal to the timestamp value measured relative to the timestamp measurement plane, minus any ingressLatency (see 8.4.3). The upstreamTxTime can be written as follows:

upstreamTxTime = syncEventIngressTimestamp – (meanLinkDelay/nrrPdelay) – (delayAsymmetry/(rateRatio × neighborRateRatio))



$$^{ref}T_{TT} = {}^{ref}T_{TR} - (D / nRR) - (dA / (rR \times nRR))$$

$$T_{TT} + {}^{RX}\Delta_{Req} = T_{TR} - {}^{RX}\Delta_{Req} - (D / nRR) - (dA / (rR \times nRR))$$

$$D = (nRR \times (T_4 - T_1) - (T_3 - T_2) - nRR \times ({}^{RX}\Delta_{Req} + {}^{TX}\Delta_{Req}) - ({}^{TX}\Delta_{Rsp} + {}^{RX}\Delta_{Rsp})) / 2$$

CI **10** *SC* **10.2.5.9** *P* **95** *L* **38** # 20

"The delayAsymmetry is not measured at runtime, and therefore, it is not in the units of the LocalClock, nor of the grandmaster time base for that domain."

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