Correction of Peer Delay Measurement for Frequency Offset of Responder Relative to Requestor Revision 1

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Introduction

- Comment #24 of the initial 802.1AS D4.0 comments indicates that the multiplication by neighborRateRatio r should be a division in Eq. (11-2), given that r is defined as the ratio of the rate of the responder to that of the requester.
- Eq. (11-2) in D4.0 is:

$$mean-propagation-delay = \frac{(t_4 - t_1) - r \cdot (t_3 - t_2)}{2}$$

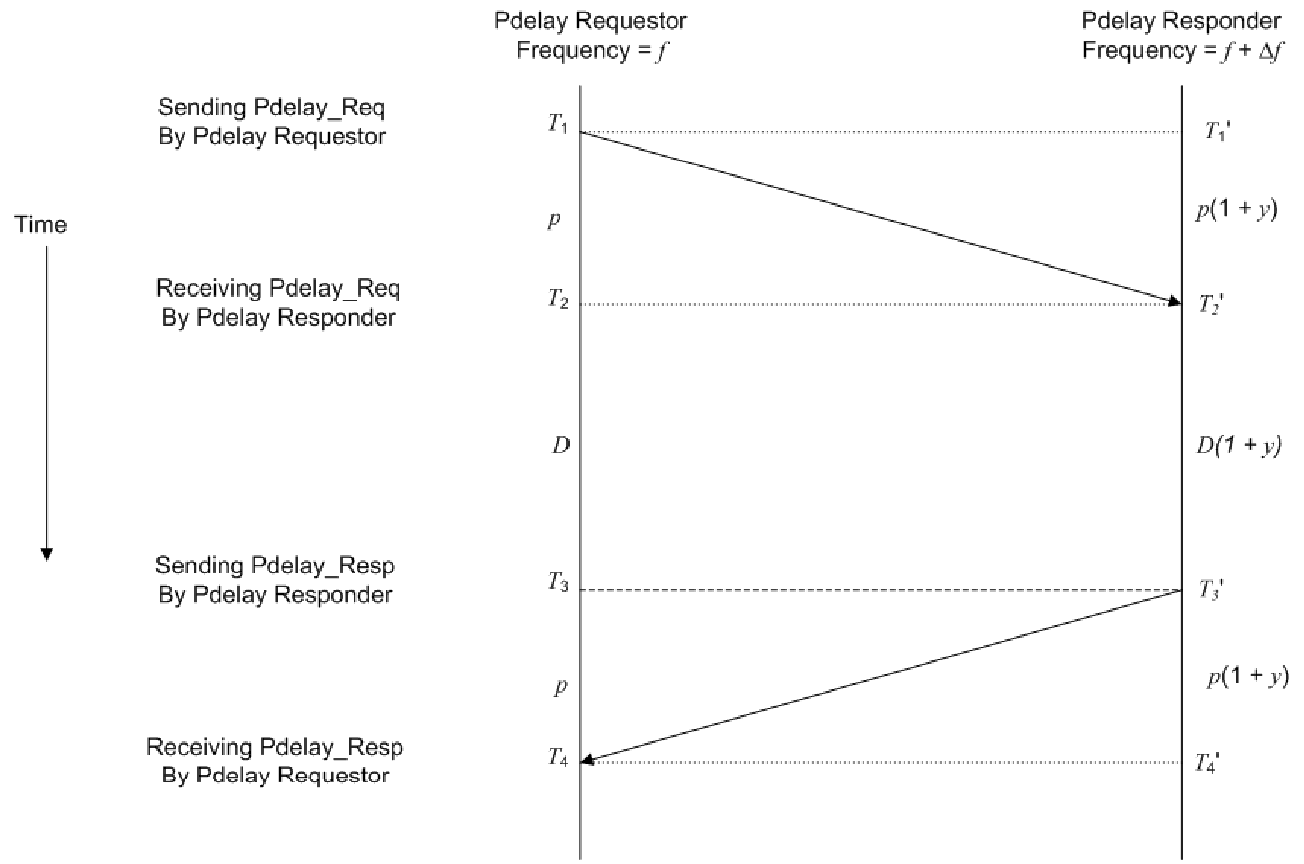
- According to comment #24, this equation should read

$$mean-propagation-delay = \frac{(t_4 - t_1) - (t_3 - t_2)/r}{2}$$

- The purpose of this presentation is to derive the correct form for this equation
  - The form given in the proposed resolution of comment #24 (i.e., with the division by r) is a very good approximation
  - The presentation derives an alternative good approximation, and also an exact for

Timing of Pdelay Message Send and Receive Events

Times of various events, relative to the Pdelay Requestor and Pdelay Responder



p = propagagtion delay (assumed symmetric) relative to Pdelay Requestor

$p(1+y)$ = propagagtion delay (assumed symmetric) relative to Pdelay Responder

D = turnaround time (assumed symmetric) relative to Pdelay Requestor

$D(1+y)$ = turnaround time (assumed symmetric) relative to Pdelay Responder

Frequency offset of Pdelay Responder relative ot Pdelay requestor: $y = \Delta f/f$

Rate ratio of Pdelay Responder relative ot Pdelay requestor: $r = 1 + y$

Derivation of Propagation Delay - 1

- Initially, assume the Pdelay Requestor time is exact, i.e., is the same as the grandmaster time (this assumption will be relaxed later)
- The propagation delay is given by

$$p = T_2 - T_1 = T_4 - T_3$$

- Then

$$p = \frac{(T_2 - T)_1 + (T_4 - T_3)}{2} = \frac{(T_4 - T_1) - (T_3 - T_2)}{2}$$

- The turnaround time D is given by

$$D = T_3 - T_2 = \frac{T_3' - T_2'}{1 + y} = \frac{T_3' - T_2'}{r}$$

- Then

$$D = \frac{(T_4 - T_1) - (T_3' - T_2')/r}{2}$$

Derivation of Propagation Delay - 2

- The final equation on the previous slide is the desired result
  - With the notation of the figure of slide 3, the primed quantities denote the time relative to the Pdelay responder

More Exact Result - 1

- Next, assume that both the Pdelay requestor and responder are offset from grandmaster
- Define

$$r_1 = \frac{\text{grandmaster frequency}}{\text{Pdelaqy Requestor Frequency}}$$

$$r_2 = \frac{grandmasterfrequency}{\text{Pdelay Responder Frequency}}$$

- Then, with r defined as before (Pdelay responder frequency/Pdelay requestor frequency)

$$r_1 = r r_2$$

More Exact Result - 2

- Then the propagagtion delay relative to the grandmaster is given by

$$
\begin{aligned}
p &= \frac{(T_4 - T_1)r_1 - (T_3 - T_2)r_2}{2} \\
&= \frac{(T_4 - T_1)rr_2 - (T_3 - T_2)r_2}{2} \\
&= rr_2\left\{\frac{(T_4 - T_1)_2 - (T_3 - T_2)/r}{2}\right\} \cong \frac{(T_4 - T_1)_2 - (T_3 - T_2)/r}{2}
\end{aligned}
$$

- But, we can also write

$$
\begin{aligned}
p &= \frac{(T_4 - T_1)r_1 - (T_3 - T_2)r_2}{2} \\
&= \frac{(T_4 - T_1)rr_2 - (T_3 - T_2)r_2}{2} \\
&= r_2\left\{\frac{(T_4 - T_1)_2 r - (T_3 - T_2)}{2}\right\} \cong \frac{(T_4 - T_1)_2 r - (T_3 - T_2)}{2}
\end{aligned}
$$

More Exact Result - 3

- The exact result is

$$p = r_2 \left\{ \frac{(T_4 - T_1)_2 r - (T_3 - T_2)}{2} \right\}$$

- On links where r_2 is known (it is the cumulative rate ratio carried in Follow_Up, the exact result can be used. On other links (i.e., those not currently part of the synchronization spanning tree), one of the approximate forms can be used
  - Note that the approximations are very good, as r_2 differs from 1 by at most ±100 ppm = $\pm 10^{-4}$, and r differs from 1 by at most ±200 ppm = $\pm 2 \times 10^{-4}$
  - In addition, $r1 = rr_2$ differs from 1 by at most ±100 ppm = $\pm 10^{-4}$
  - This means the the error of each approximation is at most $\pm 10^{-4}$
  - E.g., for propagation delay of 100 ns, the error is of order 10 ps