Correction of Peer Delay Measurement for Frequency Offset of Responder Relative to Requestor Revision 2

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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:

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

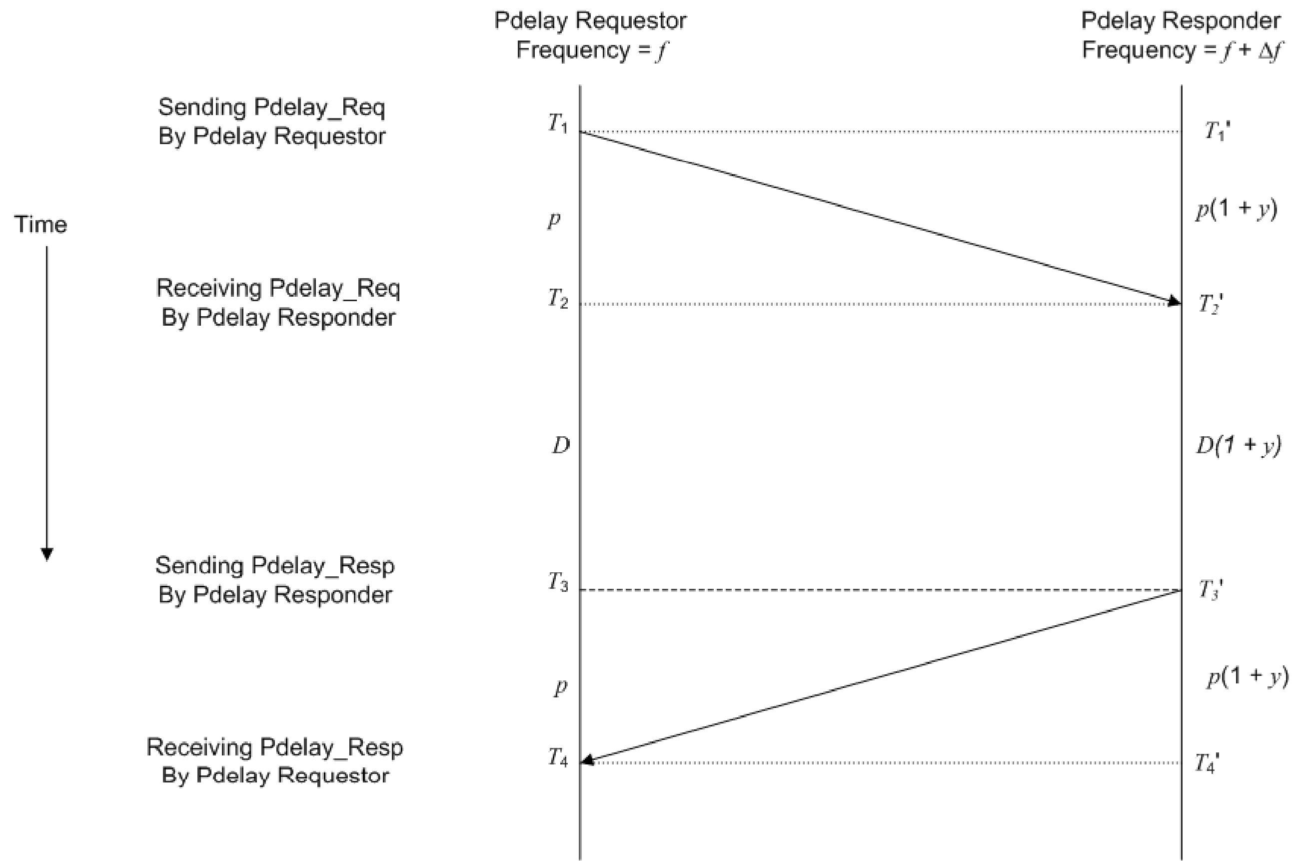
- According to comment #24, this equation should read

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

- 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
- **Note: the only difference between Revisions 1 and 2 is the correction of typos**

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

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

$$r_2 = \frac{\text{grandmaster frequency}}{\text{Pdelay Responder Frequency}}$$

- 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

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

- But, we can also write

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

More Exact Result - 3

- The exact result is

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

- 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 $\pm$100 ppm = $\pm 10^{-4}$, and r differs from 1 by at most $\pm$200 ppm = $\pm 2 \times 10^{-4}$
  - In addition, $r_1 = rr_2$ differs from 1 by at most $\pm$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