Summary of Assumptions for Next Simulations, based on Presentation and Subsequent Discussion of [1]

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Introduction

- Reference [1] obtained time histories for frequency offset, frequency drift rate, and phase offset for the LocalClock entity, based on previous frequency stability data presented in Reference [3] of [1] and a temperature profile described in Reference [1] of [1]
- In the discussion of [1] following its presentation, a set of assumptions was decided on for the next simulations
- The current presentation summarizes these assumptions

Assumptions for Temperature Profile

- The temperature history of [1] is assumed to vary between – 40°C and +85°C, at a rate of 1°C /s
- When the temperature is increasing and reaches +85°C, it remains at +85°C for 30 s
- The temperature then decreases from +85°C to – 40°C at a rate of 1°C /s; this takes 125 s
- The temperature then remains at – 40°C for 30 s
- The temperature then increases to +85°C at a rate of 1°C /s; this takes 125 s
- The duration of the entire cycle (i.e., the period) is therefore 310 s (5.166667 min)
  - This compares with the 1200 s cycle duration for the assumptions described in [1]

Assumptions for Frequency Stability due to Temperature Variation

- The dependence of frequency offset on temperature is assumed to be as described in [1]
  - Specifically, the values a_0, a_1, a_2, and a_3 computed in [1] will be used in the cubic polynomial fit, and the resulting frequency offset will be multiplied by 1.1 (i.e., a margin of 10% will be used).
- The frequency stability data that this polynomial fit is based on is contained in the Excel spreadsheet attached to [1]
  - This data was provided by the author of Reference [3] of [1]
- The time variation of frequency offset will be obtained from the cubic polynomial frequency dependence on temperature, and the temperature dependence on time described in the previous slide
  - The time variation of phase/time error at the LocalClock entity will be obtained by integrating the above frequency versus time waveform
  - The time variation of frequency drift rate at the LocalClock entity will be obtained by differentiating the above frequency versus time waveform

- Two types of assumptions will be used for relative time offsets of the phase error histories at each node (separate cases will be run for each assumption):
  - Choose the phase of the LocalClock time error waveform at each node randomly in the range [0,T], at initialization, where T is the period of the phase and frequency variation waveforms (i.e., 310 s, see slide 3)
  - Choose the phase of the LocalClock time error waveform at each node randomly in the range [0, 0.1T], at initialization, where T is the period of the phase and frequency variation waveforms (i.e., 310 s, see slide 3)
    - A uniform probability distribution is used for the random choice
    - 0.1T = 31 s, i.e., any periodic LocalClock time error waveform will be offset from any other such waveform by at most 31 s

Other Assumptions - 1

- Some other assumptions were briefly suggested in email discussion
  - Mean Sync interval: 125 ms
  - Mean Pdelay interval: 31.25 ms
  - Timestamp granularity: 8 ns, 4 ns (both cases)
  - Residence times: 1 ms, 4 ms, 10 ms (all 3 cases)
  - Timestamp error ($\pm$8 ns, each with 0.5 probability)
- The above, along with the two different assumptions for random offsets for phase error waveform implies 12 simulation cases ($2 \times 2 \times 3$)
- Other assumptions can be taken from the most recent simulations [2], and are summarized on the following slides
  - Note that initial simulations will assume GM error of zero; GM error will be added after other assumptions are settled on

Other Assumptions - 2

Assumption/Parameter	Description/Value
Hypothetical Reference Model (HRM), see note following the tables	101 PTP Instances (100 hops; GM, followed by 99 PTP Relay Instances, followed by PTP End Instance
Computed performance results	(a) max|$dTE_{R(k,\ 0)}$| (i.e., maximum absolute relative time error between node k ($k > 0$) and GM; here, GM time error is 0, so max|$dTE_{R(k,\ 0)}$| = max|dTE|) (b) Measured LocalClock rateRatio (frequency offset) relative to GM, for comparison with actual LocalClock frequency offset
Use syncLocked mode for PTP Instances downstream of GM	Yes
Endpoint filter parameters	$K_pK_o = 11$, $K_iK_o = 65$ ($f_{3dB} = 2.5998$ Hz, 1.288 dB gain peaking, $\zeta = 0.68219$)
Simulation time	(a) For single replication cases: 3150 s; discard first 50 s to eliminate any startup transient before computing max|$dTE_{R(k,\ 0)}$| (i.e., 10 cycles of frequency variation after discard) (b) For multiple replication cases, may need to be shorter than 3150 s depending on run times

Other Assumptions - 3

Assumption/Parameter	Description/Value
Number of independent replications, for each simulation case	(a) Single replication cases (i.e. 1) (b) Multiple replication cases (300, subject to acceptable run times; these cases will be run later, after presenting and discussing results for single-replication cases)
GM rateRatio and neighborRateRatio computation granularity	0
Mean link delay	500 ns
Link asymmetry	0
Dynamic timestamp error for event messages (Sync, Pdelay-Req, Pdelay_Resp) due to variable delays within the PHY	±8 ns; for each timestamp taken, a random error is generated. The error is + 8 ns with probability 0.5, and – 8 ns with probability 0.5. The errors are independent for different timestamps and different PTP Instances.

Additional Questions on Assumptions - 1

- In cases 9 – 11 of [5], which used neighborRateRatio accumulation to measure GM rateRatio, neighborRateRatio was measured using a methodology similar to that used for GM rateRatio via successive Sync messages
- In these cases, a window size of 7 was used, i.e., the difference was taken between respective timestamps of current Pdelay exchange and 7th previous Pdelay exchange
  - In addition, the current estimate of neighborRateRatio was taken as the median of the most recent 7 measurements (including the current measurement)
- In cases 12 – 14 of [5], which measured GM rateRatio using successive Sync messages, this same approach was used for both the measurement of GM rateRatio (using Sync messages) and neighborRateRatio (using Pdelay exchanges)
  - neighborRateRatio measurements were needed for compensation of different rates of Pdelay requestor and responder in accounting for Pdelay turnaround time
  - However, in these cases the window size was 11 rather than 7

Additional Questions on Assumptions - 2

- Should this approach be used in the new simulations for the computation of neighborRateRatio?
  - If so, should the window size be 7, 11, or something else?
- On a related point, should the successive link delays measured using Pdelay be averaged over a sliding window?
  - Reference [2] indicates that the link delay measurements for all the cases there (cases 1 – 14) are averaged over a sliding window of size 16
  - However, the sliding window apparently was not used in the simulations, i.e., the window size was 1
  - In any case, should a sliding window be used and, if so, what should its size be?

Thank you

References - 1

[1] Geoffrey M. Garner, *Phase and Frequency Offset, and Frequency Drift Rate Time History Plots Based on New Frequency Stability Data*, IEC/IEEE 60802 presentation, March 8, 2021 call (available at https://www.ieee802.org/1/files/public/docs2021/60802-garner-temp-freqoffset-plots-based-on-new-freq-stabil-data-0321-v00.pdf)

[2] Geoffrey M. Garner, *Further Simulation Results for Dynamic Time Error Performance for Transport over an IEC/IEEE 60802 Network Based on Updated Assumptions*, Revision 2, December 14, 2020 call (available at https://www.ieee802.org/1/files/public/docs2020/60802-garner-further-simulation-results-time-sync-transport-1120-v02.pdf)