60802 Time Sync Ad Hoc 15th November Meeting

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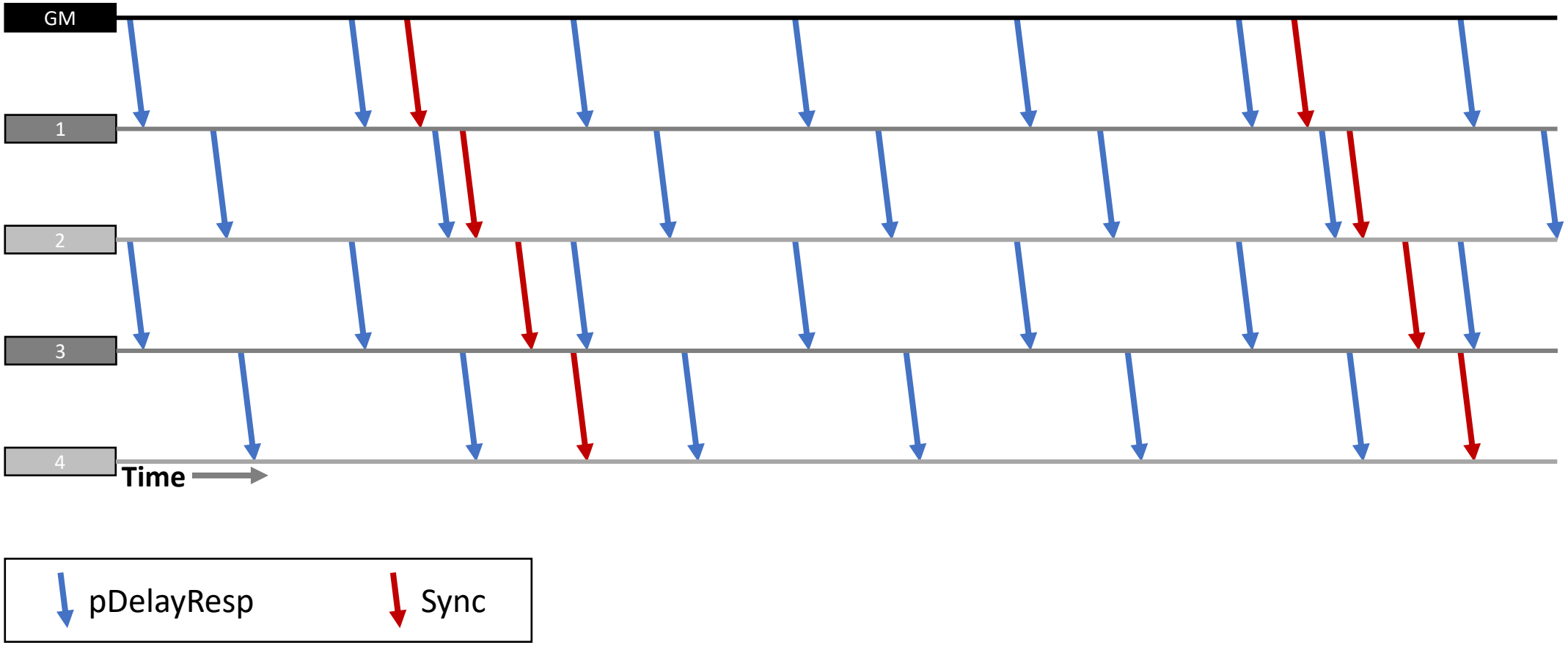
Version 1

Agenda

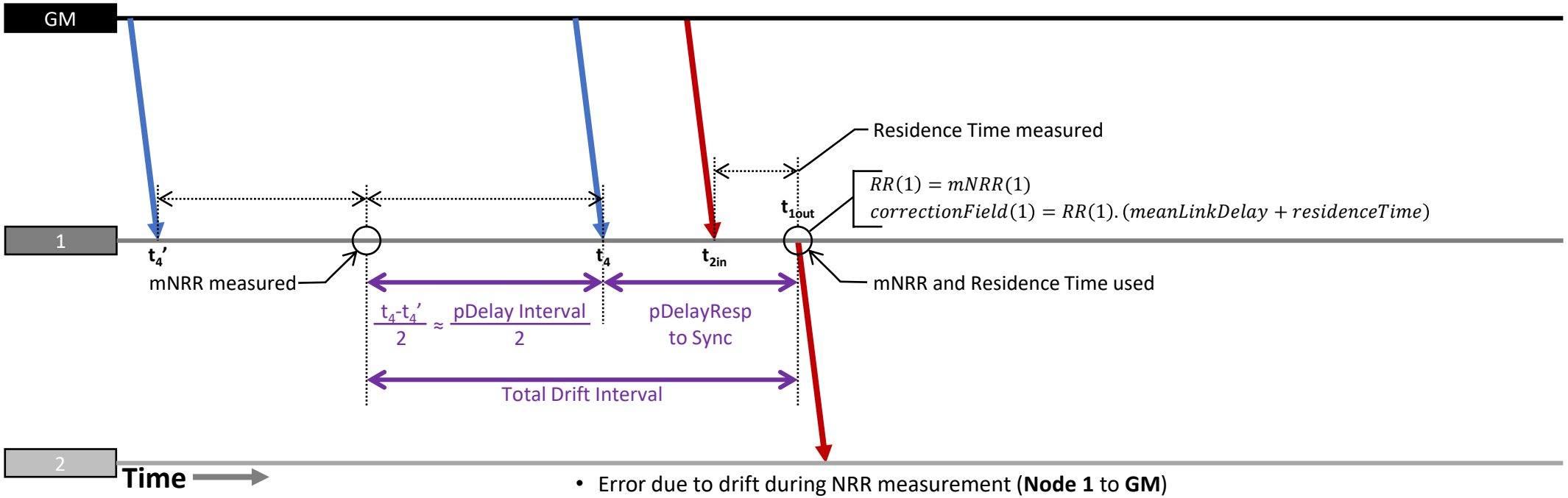
- Continue discussion regarding RR from Sync messages
  - Contribution from David McCall regarding RR calculation, data input and output, impact from “old” calculations/messages.
  - Clock Drift Error vs. Clock Drift Measurement / Compensation
  - Gain Peaking
- Topic for 60802 afternoon session (4-6pm)
  - TLV to pass down t_{1out} timestamp following Sync message.
  - Impacts on Startup / Recovery Time (following reconfiguration)
    - RR from NRR vs. RR from Sync messages
    - Measuring & Compensating for Clock Drift

RR from Sync messages

Clock Drift Error – Relevant Intervals
4 Hops – RR via NRR Accumulation



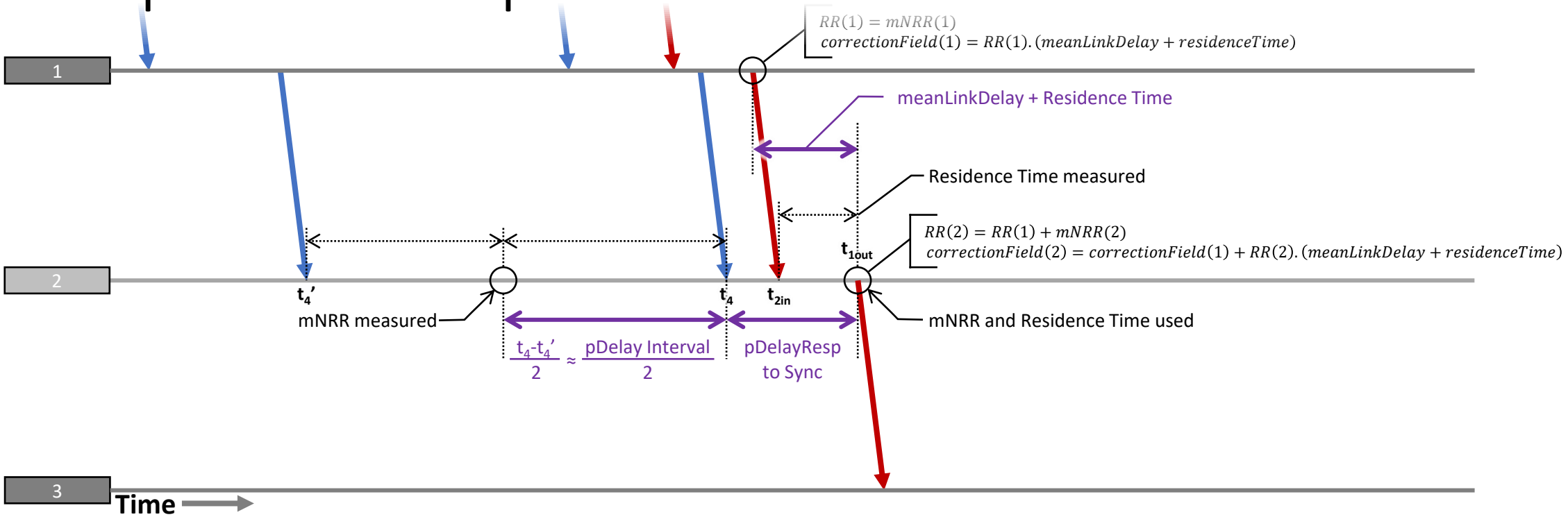
Clock Drift Error – Relevant Intervals
4 Hops – 1st Hop – RR via NRR Accumulation



pDelayResp Sync

- Error due to drift during NRR measurement (**Node 1** to **GM**)
  - Interval is half t_4-t_4' which is nominally half the pDelay Interval, but actual pDelay Interval varies.
- Error due to drift between measuring and using NRR (**Node 1** to **GM**)
  - Interval is between zero and the maximum pDelay Interval, which is larger than the nominal pDelay Interval.
  - Assumes that pDelayResp arriving between t2in and t1out will trigger new mNRR calculation; not unreasonable as information is included in Follow-up, not Sync, if 2-step Sync is used.
- Error due to drift during Residence Time measurement (**Node 1** to **GM**)
  - meanLinkDelay is measured separately, is much smaller, and can be averaged to remove errors, so is ignored.

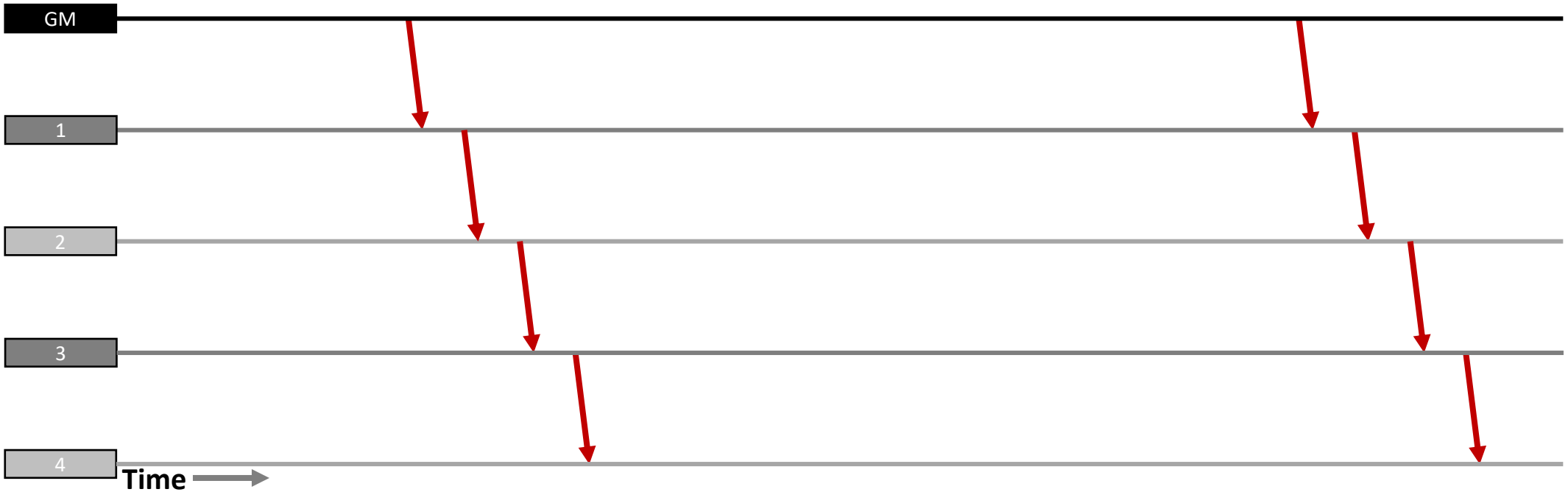
Clock Drift Error – Relevant Intervals
4 Hops – 2nd Hop – RR via NRR Accumulation



pDelayResp Sync

- Same errors in mNRR as 1st Hop.
  - Error due to drift during NRR measurement. (**Node 2** to **Node 1**)
  - Error due to drift between measuring and using NRR. (**Node 2** to **Node 1**)
  - Error due to drift during Residence Time measurement. (**Node 2** to **GM**)
- Additional error from drift between RR(1) calculation, at Node 1, and use in calculating RR(2). (**Node 1** to **GM**)
  - In the model the contribution from meanLinkDelay is ignored; only Residence Time is used.

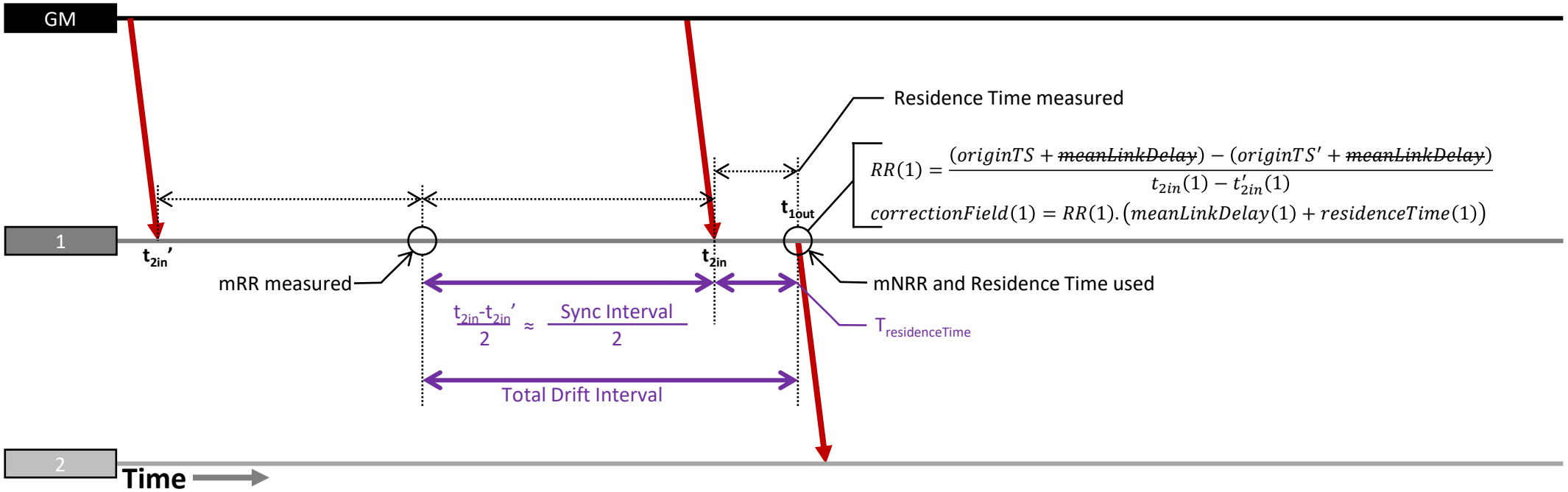
Clock Drift Error – Relevant Intervals
4 Hops – RR via Sync Messages



pDelayResp Sync

In this example pDelay Interval is ¼ Sync Interval

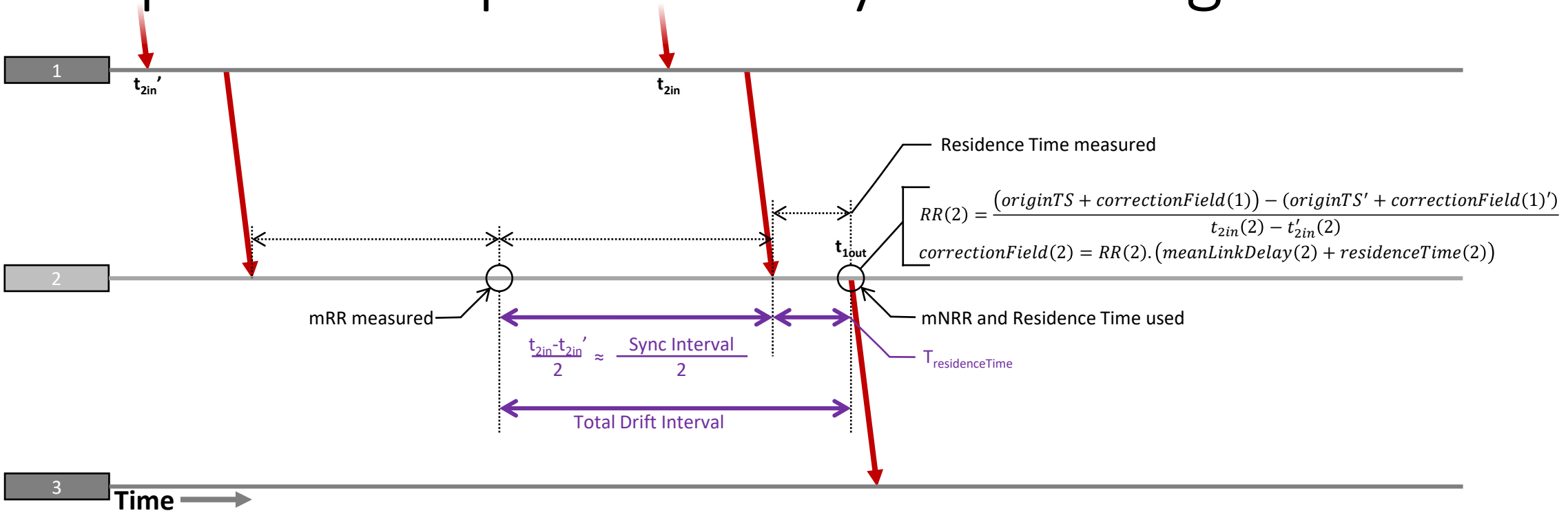
Clock Drift Error – Relevant Intervals
4 Hops – 1st Hop – RR via Sync Messages



pDelayResp Sync

- Error due to drift during RR measurement (**Node 1** to **GM**)
  - Interval is half t_{2in}-t_{2in}' which is nominally half the Sync Interval, but actual Sync Interval varies.
- Error due to drift between measuring and using RR (**Node 1** to **GM**)
  - Interval is $T_{residenceTime}$. (meanLinkDelay is a factor in can be ignored as it is small and constant.)
- Error due to drift during Residence Time measurement (**Node 1** to **GM**)
  - meanLinkDelay is measured separately, is much smaller, and can be averaged to remove errors, so is ignored.

Clock Drift Error – Relevant Intervals
4 Hops – 1st Hop – RR via Sync Messages



pDelayResp Sync

- Error due to drift during RR measurement (**Node 2** to **GM**)
  - Interval is half t_{2in}-t_{2in}' which is nominally half the Sync Interval, but actual Sync Interval varies.
- Error due to drift between measuring and using RR (**Node 2** to **GM**)
  - Interval is $T_{residenceTime}$. (meanLinkDelay is a factor in can be ignored as it is small and constant.)
- Error due to drift during Residence Time measurement (**Node 2** to **GM**)
  - meanLinkDelay is measured separately, is much smaller, and can be averaged to remove errors, so is ignored.

Impact from “Old” Calculations / Messages

$$correctionField(2) = RR(2).\left(meanLinkDelay(2) + residenceTime(2)\right)$$

$$RR(2) = \frac{\left(originTS + correctionField(1)\right) - (originTS' + correctionField(1)')}{t_{2in}(2) - t'_{2in}(2)}$$

$$correctionField(1) = RR(1).(meanLinkDelay + residenceTime)$$

$$RR(1) = \frac{originTS - originTS'}{t_{2in}(1) - t'_{2in}(1)}$$

$$correctionField(1)' = RR(1)'.(meanLinkDelay + residenceTime')$$

$$RR(1) = \frac{originTS' - originTS''}{t'_{2in}(1) - t''_{2in}(1)}$$

Impact from 2 previous Sync messages / calculations.

Impact from “Old” Calculations / Messages

$$cF(2) = RR(2).\left(mLD(2) + rT(2)\right)$$

$$RR(2) = \frac{\left(oTS + cF(1)\right) - (oTS' + cF(1)')}{t_{2in}(2) - t'_{2in}(2)}$$

$$cF(1) = RR(1).\left(mLD(1) + rT(1)\right)$$

$$RR(1) = \frac{oTS - oTS'}{t_{2in}(1) - t'_{2in}(1)}$$

$$cF(1)' = RR(1)'.(mLD(1) + rT(1)')$$

$$RR(1)' = \frac{oTS' - oTS''}{t'_{2in}(1) - t''_{2in}(1)}$$

Impact from “Old” Calculations / Messages

$$cF(3) = RR(3).\big(mLD(3) + rT(3)\big)$$

$$RR(3) = \frac{\big(oTS + cF(2)\big) - (oTS' + cF(2)')}{t_{2in}(3) - t'_{2in}(3)}$$

$$cF(2) = RR(2).\big(mLD(2) + rT(2)\big)$$

$$RR(2) = \frac{\big(oTS + cF(1)\big) - (oTS' + cF(1)')}{t_{2in}(2) - t'_{2in}(2)}$$

$$cF(2)' = RR(2)'.(mLD(2) + rT(2)')$$

$$RR(2)' = \frac{(oTS' + cF(1)') - (oTS'' + cF(1)'')}{t_{2in}(2)' - t''_{2in}(2)}$$

$$cF(1) = RR(1).\big(mLD(1) + rT(1)\big)$$

$$RR(1) = \frac{oTS - oTS'}{t_{2in}(1) - t'_{2in}(1)}$$

$$cF(1)' = RR(1)'.(mLD(1) + rT(1)')$$

$$RR(1)' = \frac{oTS' - oTS''}{t'_{2in}(1) - t''_{2in}(1)}$$

$$cF(1)' = RR(1)'.(mLD(1) + rT(1)')$$

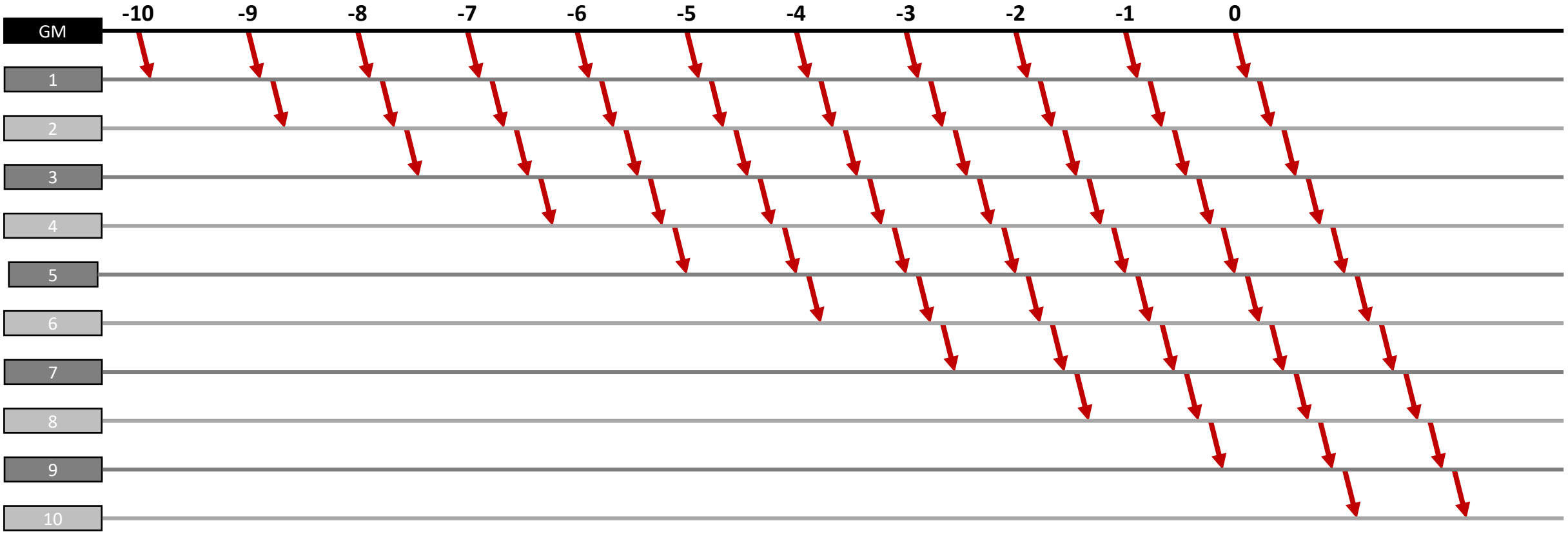
$$RR(1') = \frac{oTS' - oTS''}{t'_{2in}(1) - t''_{2in}(1)}$$

$$cF(1)'' = RR(1)''.(mLD(1) + rT(1)'')$$

$$RR(1)'' = \frac{oTS'' - oTS'''}{t''_{2in}(1) - t'''_{2in}(1)}$$

Impact from 3 previous Sync messages / calculations.

Impact from “Old” Calculations / Messages



Summary

- When using Sync messaging to calculate RR, if there are X hops then the X^{th} previous Sync message has an impact, but the K^{th} oldest Sync message is only relevant for (X - K + 1) hops.

Impact of Using Older Sync Messages

- Already discussed calculating NRR using (N^{th})older pDelayResp messages and taking an average of (A) previous calculations.
  - See "60802 Time Sync Ad Hoc mNRRsmoothing Optimisation Results" https://www.ieee802.org/1/files/public/docs2022/60802-McCall-Time-Sync-mNRRsmoothingN-Optimisation-Results-1122-v2.pdf
- Same principle can be applied to calculating RR (calculated using N^{th} older Sync message; take average of A previous calculations).
- Effect on relevance of "old" Sync messages:
  - X.$(N+A)^{th}$ previous Sync message is relevant.

Inclusion / Compensation for Clock Drift in Calculation?

- The amount of Clock Drift error will change depending on the number of hops (oldest Sync message that has an impact), but without additional measures, this approach does not compensate for any Clock Drift.
- Whether calculating RR from accumulation of NRR or from Sync messages, you need to take at least two measurements...calculate the clock drift between the two...and then compensate.

Discussion Topic for Afternoon 60802 Session?

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- TLV to pass down t_{1out} timestamp following Sync message.
- Impacts on Startup / Recovery Time (following reconfiguration)
  - RR from NRR vs. RR from Sync messages
  - Measuring & Compensating for Clock Drift

- Discussion...

Thank you!