Maximum Cable Link Delay Considerations

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Supporters

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Background

- A contribution to the April TF Ad Hoc meeting (jonsson_3dm_01_04_25) had a tbd placeholder for the MultiG+100MBASE-V1 maximum link delay. This contribution proposes a recommended value.

- In the course of considering an appropriate link delay value for –V1, it raised questions regarding whether the –T1 delay value proposed by jonsson_3dm_01_04_25 may be too large. Consequently, this contribution also addresses that question.

- The contribution concludes with some key questions that need to be address in order to choose the maximum link delay values.

Link Propagation Delay

- **A contribution to the April TF Ad Hoc meeting (jonsson_3dm_01_04_25) proposed specifying in 200.11.1.6 that the the maximum link delay for T1 be based on 149.7.1.6 for 802.3ch with the V1 delay as tbd.**
  - 149.7.1.6: "The propagation delay of a link segment shall not exceed 94 ns at all frequencies between 2 MHz and F_{max} MHz" for single balanced pair cables up to 15 m and 10 Gbit/s with PAM4

- **The 94 ns limit appears to have been copied from 97.6.1.5 for 1000Base-T1? It seems unreasonably pessimistic for 3dm.**
  - 97.6.1.5 has no explanation regarding the choice of 94ns, but perhaps it was based on 14.4.2.4 for UTP with an added 10% margin?
  - For a more current example: In 165.7.1.6, 802.3cy specifies "The propagation delay of a link segment shall not exceed 60 ns at all frequencies between 2 MHz and 9000 MHz." for 11 m of SDP (shielded differential pair) cable with PAM4
  - 60 ns extrapolates to 82 ns max for the 15 m reach stated in the 3dm objectives

Link Propagation Delay

- For another example: 802.3 clause 80.4 (Delay constraints) specifies the following:

  "Equation (80–1) specifies the calculation of cable delay in nanoseconds per meter of fiber or electrical cable, based upon the parameter *n*, which represents the ratio of the speed of electromagnetic propagation in the fiber or electrical cable to the speed of light in a vacuum, $c = 3 \times 10^8$ m/s.

  $$\text{cable delay} = 10^9 / nc \qquad (80–1)$$

  "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."

  - The value of n is the velocity factor
    - 14.4.2.4 uses n = 0.585 for a twisted pair cable
    - Data sheets for the CX31 and CX174 coaxial cables typically cited for 3dm specify n = 0.66, consistent with 80.4. The resulting max delay is 76 ns for 15 m of coax.

Link Propagation Delay for –V1

- In a quick search for potential alternative coaxial cable, all the other cables had higher velocity factors (in the range of 0.69 – 0.84), so using 0.66 appears conservative and adequately futureproof

- Since coax has a single conductor, there is no need for margin to accommodate the added SDP length due to the cable twisting

- Coaxial cables typically have low group delay variation (e.g., <50 ps/m at 1 MHz), which implies that an associated added margin of 1% would be adequate

- While a margin of 10% has been suggested in previous work, it is not clear why this much margin would be needed for coaxial cables at these rates. A lower margin would appear more appropriate.

Link Propagation Delay for –T1

- It is important to reach a firm agreement on the target maximum length for –T1
  - During discussion, 10 m has sometimes been used as the maximum length target for SDP
- The velocity factors for twisted pair media in various clauses of IEEE 802.3 range from 0.532 for some UTP/STP (e.g., in clause 149) to 0.611 for SDP in clause 165
  - It is not clear whether these already take margin into account
  - The resulting range of cable delays is:

Max. length	Velocity Factor	Max. Cable Delay
11 m	0.532	63 ns
	0.611	52 ns
15 m	0.532	94 ns
	0.611	82 ns

- Consequently, if 15 m of clause 149 cable is the target, then 94 ns may be the correct choice. However, for either 10 m or the clause 165 cables, it is clearly too pessimistic.

Link Propagation Delay – Conclusions and Proposals

- **In summary, for 15 m coaxial cables:**
  - Based on the 0.66 velocity factor of the CX31 and CX174 coaxial cables typically cited for 3dm, 76 ns would be a reasonable worst-case value for V1 based on 80.4
  - In that case, the proposed text for 200.12.1.6 could be:
    "The propagation delay of a link segment shall not exceed 76 ns at all frequencies between 2 MHz and 4000 MHz."

- **In summary, for SDP cables:**
  - The key questions for SDP are:
    - Is the target maximum length 10 m or 15 m (or other)?
    - What cable type (and hence what velocity factor) should be assumed for the worst case?

- **For both cable types, what margin should be added?**
  - We request input from cable vendors on this point

Thank You