Using Strict Priority to meet latency targets

a method for cyclic traffic

Lihao Chen (lihao.chen@huawei.com)

HUAWEI

Inspired by

- Strict Priority with **proper** Traffic Engineering (TE) can be TSN - https://www.ieee802.org/1/files/public/docs2025/detnet-tsn-farkas-tsn-update-0725-v00.pdf
  - > IEEE Std 802.1CM™-2018 Clause 8.1.3 gives a guideline for worst-case delay calculation for the highest priority traffic based on SP.
  - > And Annex B gives an example (Route-based calculation).
    - *If the end-to-end latency budget is 100 µs for the high priority data, then the total propagation delay of these links can be 65.1968 µs, i.e., the distance between can be approximately 13 km.*

Table B-1—Bridge delays for Profile A

	Bridge 12	Bridge 13	Bridge 14	Bridge 15	Total
$t_{MaxBridge}$	9.9344 µs	9.9344 µs	7.4672 µs	7.4672 µs	34.8032 µs

- The latency guarantee of a specific TSN solution can be 'modularized' with preconditions and reservations.
  - > IEEE Std 802.1BA™-2011 Clause 6.5 specifies the way to meet latency targets for SR classes A and B.
  - > There is a calculation process behind, but users can focus solely on the outcome as in Table 6-2.

Table 6-2—Latency targets for SR classes A and B

SR class	Max end-to-end latency
A	2 ms
B	50 ms

- *NOTE 1—The choice of latency targets shown in Table 6-2 reflects the requirements of some typical deployment scenarios, and should not be taken as hard-and-fast limits on the end-to-end latency in an AV network. They do, however, form a useful basis for achieving "plug-and-play" interoperability.*
- *NOTE 2—The 2 ms figure for SR Class A can be met for 7 hops of 100 Mb/s Ethernet if the maximum frame size on the LAN is 1522 octets.*

- A significant portion of the most critical flows exhibit periodic characteristics in industrial automation, automotive, aerospace, etc. Can we find similar 'modularized' easy-to-compute solutions based on Strict Priority?
  - > E.g., in 60802 v2 for ccB.

High bandwidth brings feasibility

- An example:
  - > 21 end-stations, 20 pairs of 1ms control with a 200B packet.
  - > There are background flows with Max. 1500B packet.
  - > End-to-end Max. 5 hop with 5us fixed delay (includes all other elements) per hop, 1G bandwidth.
  - > End-to-end latency requirement: 3ms.

- Calculate the pessimistic worst-case delay:
  - > Imagine a packet, goes the longest way, and on every hop has to wait a 1500B lower priority packet, and is ranked last among the 20 packets. When everything can go wrong does go wrong, the e2e delay goes to 123.4µs, far less than 3ms.

$$5 * [\underline{5} + (\underline{1500} + \underline{200}) * 8/1000] + \underline{200 * 8 * 19/1000} = 123.4$$

propagation delay neglected

all other considered as a fixed delay

queuing delay

frame transmission / S&F delay

self-queuing delay

Benefits (from the perspective of 60802 v1)

- Still using centralized configuration, but can be much easier.

- No harm if the calculated result doesn’t meet the requirement.
  > Use other methods with less pessimism to calculate to see if they work.
  > Choose ccA.

Potential use cases

- Within a machine / production cell where the numbers of end-stations and networking hops aren't too high.
  > Even for control loops with very high frequencies, it may still be feasible.
  > Besides, we still have time synchronization in ccB.

- Within a factory where the important control traffics come across have a relatively low frequency.
  > https://www.ieee802.org/1/files/public/docs2025/60802-Steindl-Proell-IA-Controller-ConfDomain-Cloud-0725-v01.pdf
  > It may be feasible when there is no strong demand for placing the control that requires very high frequency and precision (such as motion control) on the edge controller (container).

- Others.

'It' in this page refers to the preliminary and vague concept of Strict Priority based simplified Traffic Engineering.

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Discuss

- Possible outcome: Maybe in 60802 v2, or a new Annex in .1Q. It’s too early to tell.
- The author wants to see if there is any comments or common interests on this matter.