Effective Performance Management in TSN

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Introduction

- OAM traditional methods cannot meet accurate and verbose monitoring requirements.
- Issue notifications can be used to verify network performance in real-time.
- Network telemetry techniques are emerged to provide high precision in stream insight.
- Granular network visibility facilitates violation detection of TSN QoS guarantees.

- **What about beyond Ethernet OAM ?** 802.1ag does not cover most of ITU-T Y.1731 functions.
- Detailed statistics extraction is missing in 802.1Q (e.g., E2E/per hop delay, Frame discard counts).
- Performance measurements can be collected in a centralized controller (i.e., CNC) to be analyzed further.
- Such mechanism can work complementarily to other domain controller management functions.

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Existing solutions in standards – Main drawbacks

IEEE 802.1Q-2022: Bridge management – Clause 12

- Performance management is not quite advanced to support end-to-end delay measurements or frame discards.
- Bridge measurements do not consider traffic shaping, traffic scheduling and queuing delay (see 12.32.1, 12.1.3).

ITU-T Y.1731: OAM functions and mechanisms for Ethernet based networks [1]

- While Y.1731 is actively injecting frames into the network, TSN service continuity can be impacted.
- It may also consume network bandwidth and create significant backend data handling.
- Delay measurements based on Y.1731 frames cannot reflect the TSN frames delay experience.

IETF IFIT: In-situ Flow Information Telemetry [2]

- IETF provides working documents on IFIT that supports delay or loss measurements at packet level.
- IFIT is an L3 (IPv4, IPv6, MPLS) measurement method and hence cannot be directly applied to L2 networks.

[1] https://www.itu.int/rec/T-REC-Y.1731/en

[2] https://www.ietf.org/staging/draft-song-opsawg-ifit-framework-14.html

Additions to Ethernet Header: Measurement TAG

6B	6B	4B	7B	2B	35-1500B	4B
Destination address	**Source address**	**802.1Q Tag**	**Measurement Tag**	**Ethertype/ Length**	**Payload**	**FCS**

16 bits	3 bits	2 bits	1 bit	1 bit	1 bit	32 bits
TPID	**Length**	**Reserved**	**Frame discard**	**Delay mode**	**Measurement Mode**	**Timestamp (ns)**

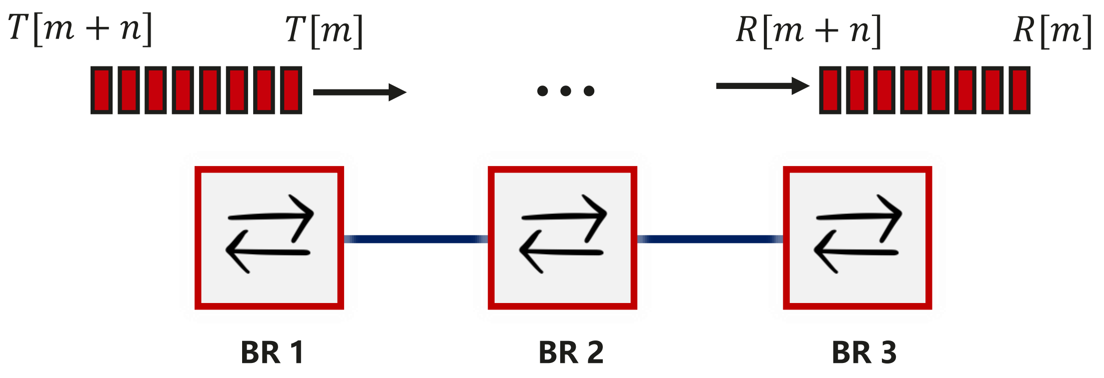
How to deal with delay measurements in TSN ?

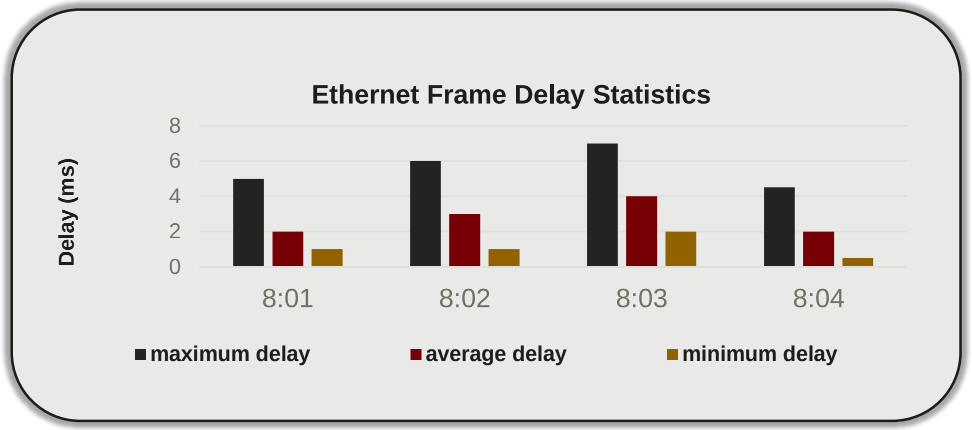
A measurement tag can be placed in the Ethernet header including the following fields:

1) **Tag protocol identifier (TPID):** A 16-bit field set to a value, e.g., 0x8244, in order to identify the frame as a "measurement-tagged" frame.
2) **Length:** It represents the length of the measurement tag (in bytes).
3) **Reserved:** Bits are kept for future use.
4) **Frame discard:** This field is used for frame discard counts from source to destination [3].
5) **Delay mode:** This field is used to configure the delay measurement mode. It can be synchronous or asynchronous (i.e., with 1588 or without 1588 support).
6) **Measurement mode:** This field is used to define if the measurement is performed end-to-end or per hop.
7) **Timestamp:** This field is used for the time spends a frame to traverse the network, i.e., from its source to destination.

[3] Proposed methodology can be found in: https://www.rfc-editor.org/rfc/rfc9341.pdf

Proposal : Synchronous delay mode





Operating Procedure

1. Upon ingress to BR 1, the measurement tag is added to the TSN frame.
2. The timestamp field is filled in with the TSN frame arrival time $T[m]$.
3. Upon egress to BR 3, the TSN frame arrival time $R[m]$ is obtained.
4. The E2E delay is calculated as :

$$D[m] = R[m] - T[m]$$

Delay Statistics

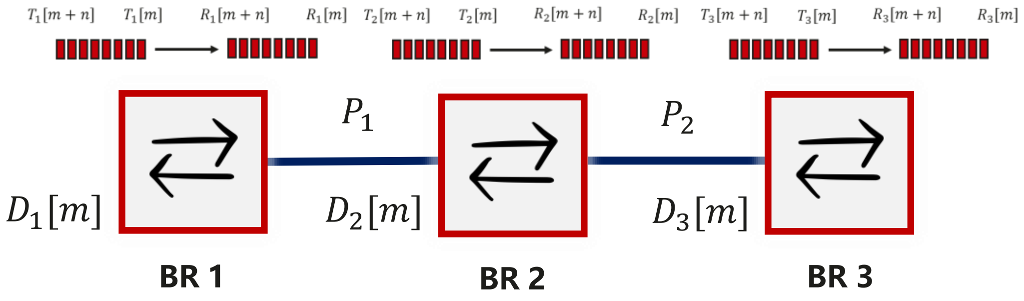
1. Upon egress to BR 3, statistics are collected as "max/min/avg" delay within a period of time.

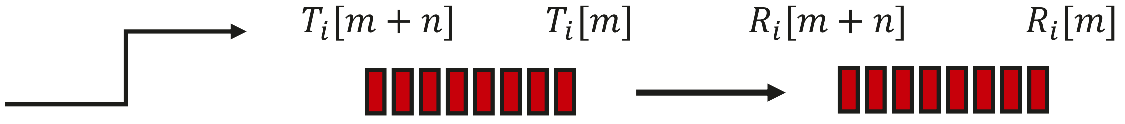
2. Periodically, statistics are sent to the CNC.

Synchronization is needed !

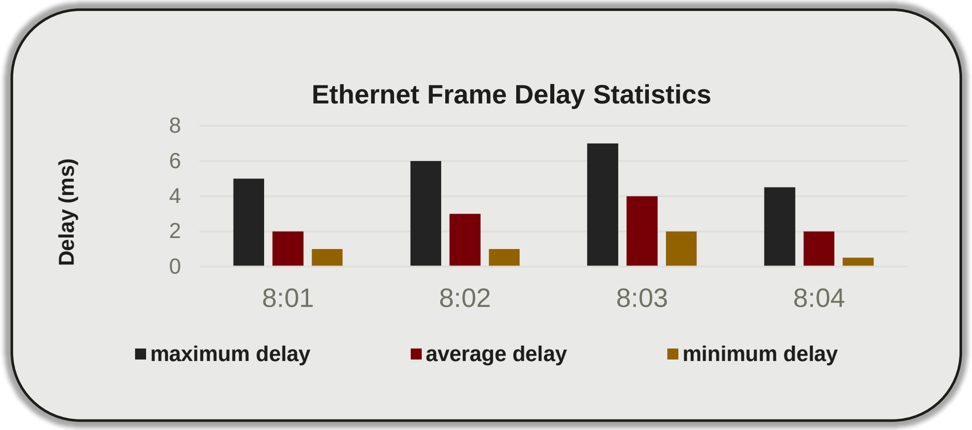
1588 or .1AS can be used for synchronization.

Proposal : Asynchronous delay mode





$$D_i[m] = R_i[m] - T_i[m]$$



Operating Procedure

1. Upon ingress to BR 1, the measurement tag is added to the TSN frame.
2. Upon egress to BR 1, the timestamp field is filled in with delay $D_1[m]$.
3. Upon egress to intermediate BR 2, we add to the timestamp the delay $D_2[m]$.
4. Upon egress to BR 3, we add to the timestamp the delay $D_3[m]$.
5. This way, we obtain the E2E delay $D[m]$ as:

$$D[m] = D_1[m] + P_1 + D_2[m] + P_2 + D_3[m]$$

Note: P_i stands for the frame delivery time in the network media (optionally added).

Delay Statistics

1. Upon egress to BR 3, statistics are collected as “max/min/avg” delay within a period of time.

2. Periodically, statistics are sent to the CNC.

Synchronization is NOT needed !

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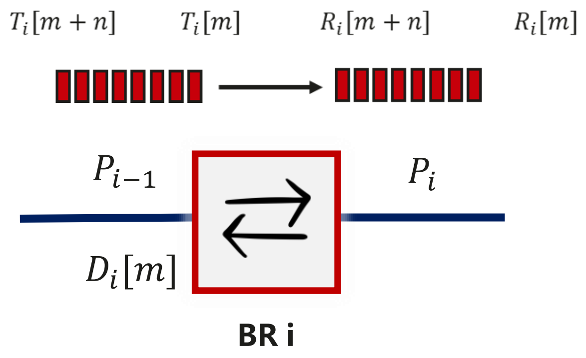
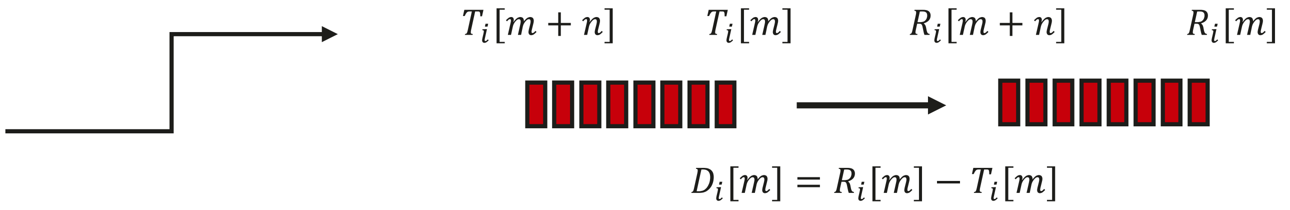
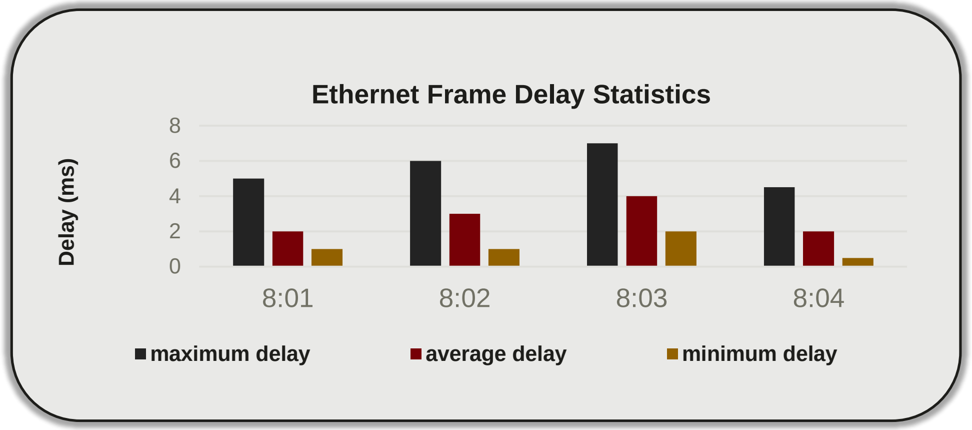
Proposal : E2E vs Hop measurement mode







<u>Operating Procedure</u>

1. Upon egress to BR i, the delay is measured as $D_i[m] = R_i[m] - T_i[m]$.

<u>Delay Statistics</u>

1. Upon egress to BR i, statistics are collected as "max/min/avg" delay within a period of time.
2. Periodically, statistics are sent to the CNC.

<u>Synchronization is NOT needed !</u>

Conclusion

- With the addition of the measurement tag to the Ethernet header:

    1. Network performance can be measured with high precision.
    2. No need to inject additional L2 protocol packets (e.g., Y.1731) and overload the network.

- Ideal for detecting any faulty behavior location at the network side (per bridge/port).

- YANG models to report performance metrics to the CNC can be also added.

<u>Next steps:</u>

1. Do we need a 802.1 project on that ? How to proceed ?

2. Any questions ?

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Thank you.