DELAYS AND PDV IN AN ETHERNET FRONTHAUL NETWORK

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Assumptions

- Only frame preemption is used out of the TSN tools (no 802.1Qbv)
  - Express: CPRI traffic
  - Preemptable: all the rest of the traffic
- CPRI flows are allowed to race each other at every hop
- Playout buffer is used for outbound traffic at the edge bridge in order to cope with Packet Delay Variation (PDV)
  - Note: *Packet* Delay Variation is used for Ethernet *frames* as PDV is a well-known term and acronym

This presentation investigates the calculation possibilities of delay and PDV in the Ethernet transport network for frames of CPRI flows
EFFECTS OF FRAME PREEMPTION

- Worst case delay: 124 Bytes
  - The serving time of 124 Bytes is the worst case delay that an express frame carrying CPRI traffic can suffer in a bridge due to preempting background traffic
  - It is 114.4 ns for 10 Gbps outbound link, it is 11.44 ns for 100 Gbps link
- Best case is 0, if no need to preempt
- Therefore, frame preemption delay causes PDV
- The per hop frame preemption delays are accumulated
- PDV due to frame preemption can be calculated

\[ PDV_{\text{preemption}} = \sum_{j} t_j^{124B} \]

i.e. by summing the service time of 124 Bytes for the outbound link of each hop \( j \)

- Frame preemption may cause 572 ns PDV in a 5-hop diameter network comprising 10 Gbps links
Delay calculation per CPRI flow:

- **Propagation delay:** on passed link (inc. serialization); depends on link length (5usec/km)
- **Bridging delay:** on passed bridge; depends on bridge implementation (non-blocking!)
  
  Note: no queuing delay for CPRI

- **Racing delay:** racing event may occur at an egress port; depends on relative arrival time of racing frames and their size
  
  Note: racing can be treated as a special queuing delay.

- **Playout buffer delay:** re-shaper/de-PDV buffer; depends on configuration ($T_{buffer}$)

\[ Delay_{tr} = \sum_i d_{link_i} + \sum_j d_{sw_j} + \sum_r d_r + T_{buffer} \]

**Assumptions:**

- Symmetric up/down
- Static value
- Change only
  - if network topology or nodes changed
  - rerouting (skew)

# of racing may differ up/down
PDV calculation per CPRI flow:

- Propagation: no PDV caused
- Bridging: implementation specific (non-blocking bridge is assumed)
  Note: no queuing PDV for time critical traffic. If TSN function(s) cause PDV it should be added for a given solution.
- Racing: depends on solution characteristics
  Note: Racing can be treated as a factor causing special queuing PDV.
- Playout: can eliminate PDV partly / entirely

\[
PDV_{tr}^{max} = 0 + \sum_j PDV_{sw}^{max} + \sum_j t_j^{124B} + \sum_r PDV_r^{max} - T_{de-PDV}
\]

- Propagation
- Bridging
- Racing
- Playout

depends on bridge implementation