APPLICABILITY OF Qbu AND Qbv TO FRONTHAUL

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Common Public Radio Interface (CPRI) traffic vs background (BG) traffic
- IEEE 802.1Qbu - Frame Preemption (with IEEE 802.3br IET)
- IEEE 802.1Qbv - Enhancements for Scheduled Traffic
- 802.1Qbu and 802.1Qbv with guard band

Concurring CPRI flows
Tree topology comprised of 10 Gbps links

Switching delay: 1500 ns ± 5 ns variation

CPRI traffic
- Rate: 1.228 Gbps
- Payload: 300 bytes
- Period: 1954 ns

Background traffic
- CBR
  - Payload: 1500 bytes
  - Period: 9770 ns
- VBR
  - Payload: rnd 1000-1500 bytes
  - Period: 5000 ns ± 500 ns
CPRI VS BACKGROUND TRAFFIC

› The effects of background traffic on CPRI are investigated first

› There is no race condition between CPRI flows in these cases
  – The simulation set-up is designed to avoid CPRI race conditions
  – Frames of CPRI flows always arrive at the switches in the same order and they are always served by the switches in the same order

› Packet Delay Variation (PDV) is determined as the difference between the largest and the smallest delay that frames of a given flow suffer
Frame Preemption Event Possibilities

1. Preemption req. in the middle
   - Preemption Delay = 13.6ns
   - FCS + IFG + remaining bits of current octet

2. Preemption req. at the beginning
   - transmission of BG frame just started
   - Preemption Delay = 67.2ns

3. Preemption req. too late
   - Max Delay = 60.8ns

4. Preemption is not possible if frame < 124 bytes
   - Max Delay = 114.4ns

64-byte fragment size is used in all cases (10 Gbps link)

Preemption request

frame flow direction

pre includes Preamble and Start mPacket delimiter (SMD)
Frame Preemption Results

No variation in switching delay

<table>
<thead>
<tr>
<th>Flow</th>
<th>Min delay [ns]</th>
<th>Max delay [ns]</th>
<th>PDV [ns]</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2</td>
<td>13832.4</td>
<td>13832.4</td>
<td>0</td>
</tr>
<tr>
<td>A2</td>
<td>19693.2</td>
<td>19760.4</td>
<td>67.2</td>
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<tr>
<td>A1</td>
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<td>26227.5</td>
<td>73.5</td>
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<td>B1</td>
<td>26754.0</td>
<td>26827.5</td>
<td>73.5</td>
</tr>
</tbody>
</table>
Enhancements for Scheduled Traffic

Traffic source synchronization inaccuracy: ± 10 ns

Gate on 900-byte background at SW3:

- A1: 260.8 ns, 311 ns
- B1: Gate open: 1332 ns, Gate closed: 622 ns
- BG: 740.8 ns

Gate on 900-byte background at SW2:

- A1, B1: 260.8 ns, 260.8 ns, 311 ns
- A2: 260.8 ns, Gate open: 1332 ns
- B1: 26150 ns, 26198 ns
- BG: 28484.0 ns, 30453.1 ns

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<tbody>
<tr>
<td>B2</td>
<td>12812</td>
<td>12842</td>
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<tr>
<td>A2</td>
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<td>19719</td>
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<td>25888</td>
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<tr>
<td>B1</td>
<td>26150</td>
<td>26198</td>
<td>47.9</td>
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<tr>
<td>BG</td>
<td>28484.0</td>
<td>30453.1</td>
<td>1970.3</td>
</tr>
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FRAME PREEMPTION AND ENHANCEMENTS FOR SCHEDULED TRAFFIC WITH GUARD BAND

- No variation in switching delay
- VBR background
- 50ns guard band: max PDV = 17.2ns
- 70ns guard band: PDV = 0 (no PDV due to BG traffic)

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<tbody>
<tr>
<td>B2</td>
<td>13832.4</td>
<td>13832.4</td>
<td>0</td>
</tr>
<tr>
<td>A2</td>
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<tr>
<td>A1</td>
<td>26164.4</td>
<td>26181.6</td>
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<tr>
<td>B1</td>
<td>26764.4</td>
<td>26781.6</td>
<td>17.2</td>
</tr>
</tbody>
</table>
No variation in switching delay
VBR background
50ns guard band: max PDV = 17.2ns
70ns guard band: PDV = 0 (no PDV due to BG traffic)
Effect of frame A on frame B depending on the relative arrival of frame B to frame A

- Frame B is sent second (flow B is influenced by PDV of flow A)
- Frame B is sent second (flow B inherits PDV of flow A)
- Frame order may change (largest impact on frame-B)

Observed:
- Frame B is sent second (no impact on frame B)
- Frame B is sent second (flow B inherits PDV of flow A)
- Frame B is sent first (no impact on frame B)

Reference:
- Frame A

PDVA

- $t_{A-arrive}$
- $t_{A-latest-arrive}$
- $t_{A-earliest-arrive}$
- Frame flow direction
CPRI FLOWS MAY RACE AT EACH HOP

› Racing shuffles order
› This causes PDV

Traffic source synchronization inaccuracy: ± 10 ns
Traffic source synchronization inaccuracy: ± 10 ns

Indeterminate order: PDV = 280ns

Deterministic order: PDV = 0ns
SUMMARY

› 802.1Qbu – Frame Preemption (with 802.3br)
   - It is essential for being able to cope with large background frames
   - Its worst-case PDV can be calculated

› 802.1Qbv – Enhancements for Scheduled Traffic
   - It can be used to cope with background traffic

› 802.1Qbu and 802.1Qbv with guard band
   - Zero PDV can be achieved

› Concurrent CPRI flows
   - Indeterminate order can cause significant PDV
   - This effect can be avoided by assuring deterministic order, e.g., by intentional delaying
ACKNOWLEDGEMENTS

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