APPLICABILITY OF Qbu AND Qbv TO FRONTHAUL

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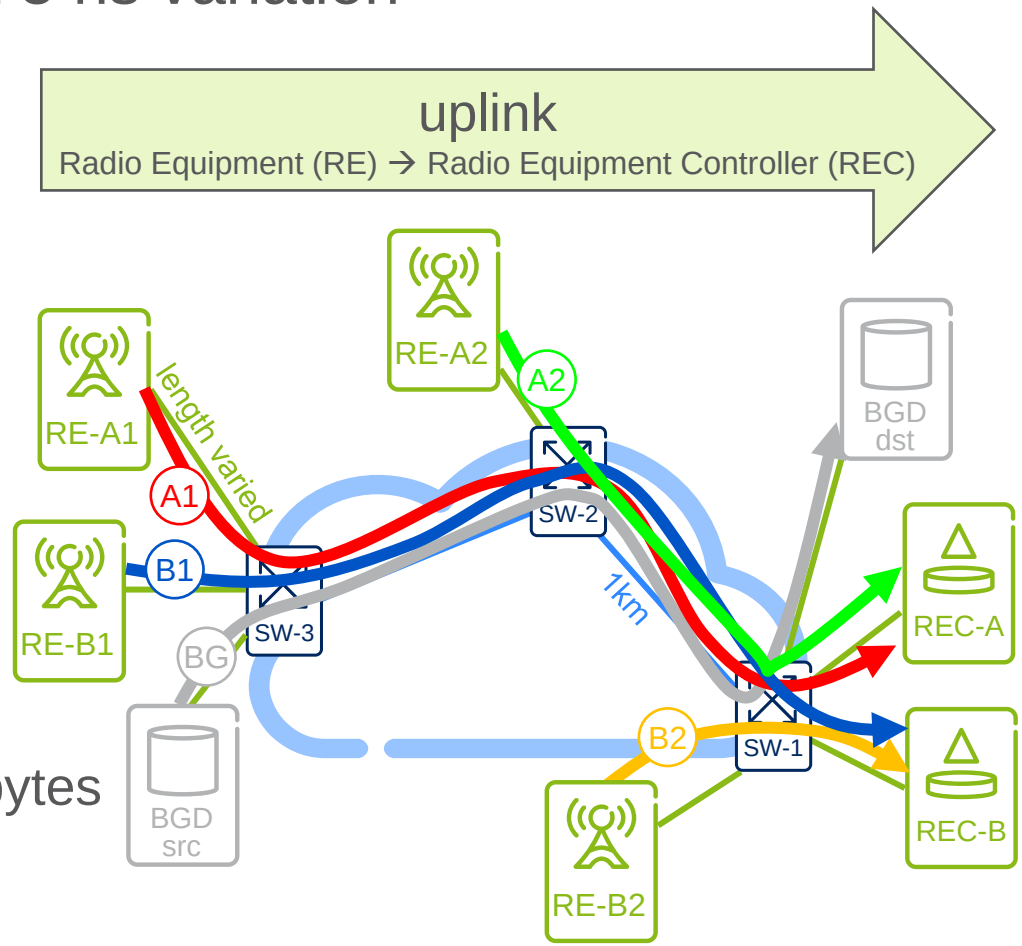
OUTLINE

- 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

EVALUATED USE CASE

- 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



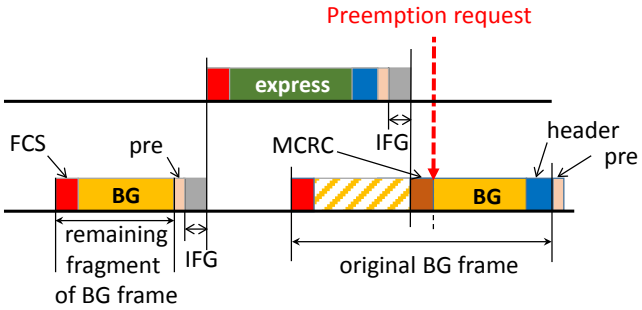
CPRI VS BACKGROUND TRAFFIC

- 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

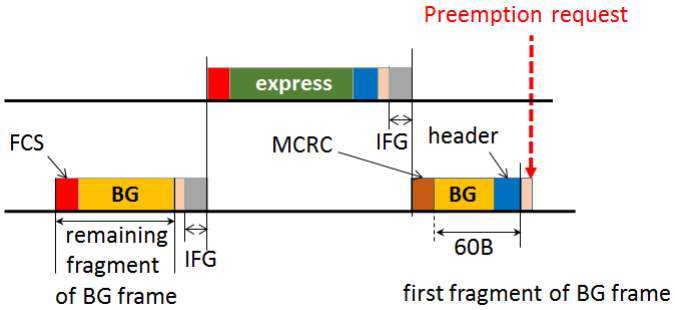
› 64-byte fragment size is used in all cases (10 Gbps link)

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

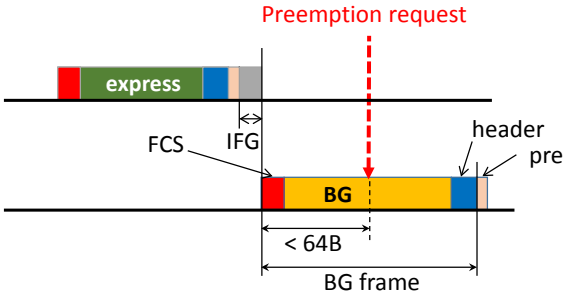


frame flow direction

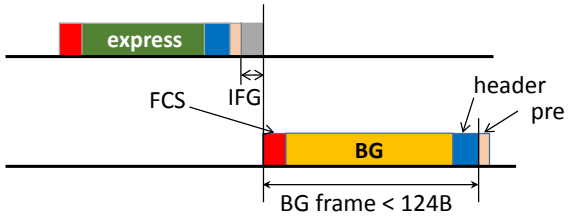
2. Preemption req. at the beginning
   - transmission of BG frame just started
   - Preemption Delay = 67.2ns



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



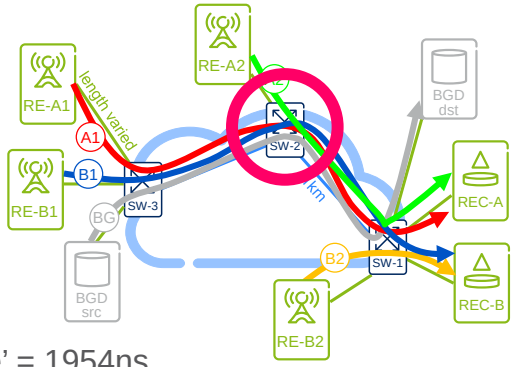
4. Preemption is not possible if frame < 124 bytes
   - Max Delay = 114.4ns

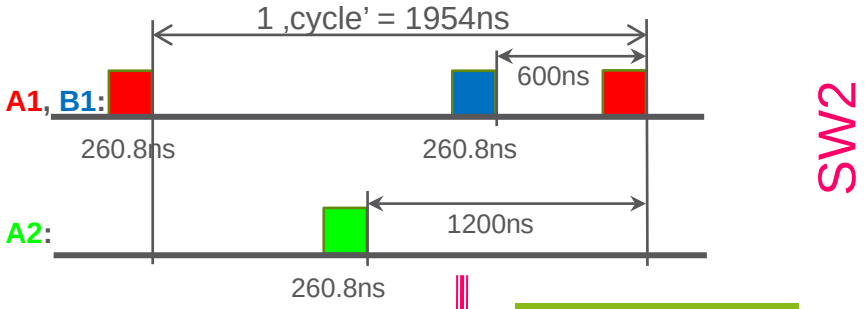


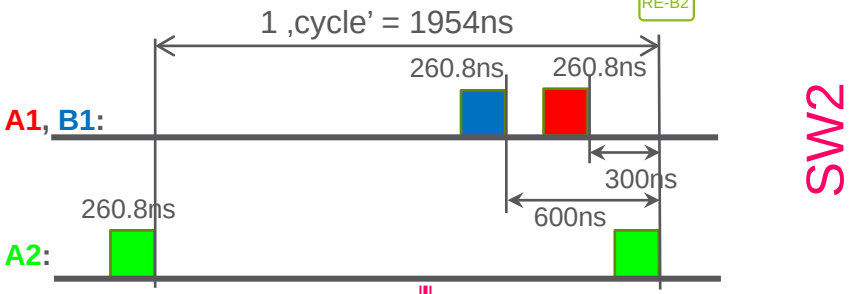
pre includes Preamble and Start mPacket delimiter (SMD)

FRAME PREEMPTION RESULTS

no variation in switching delay

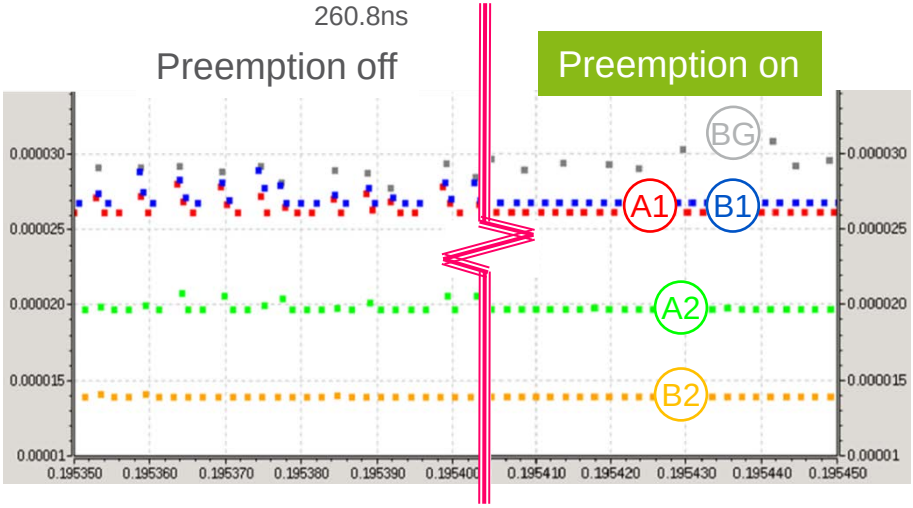






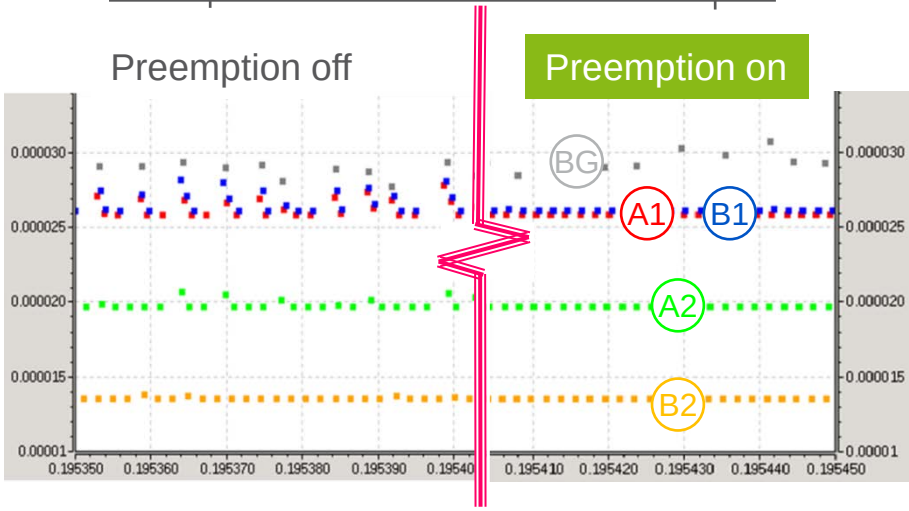
Preemption off

Preemption on



Preemption off

Preemption on

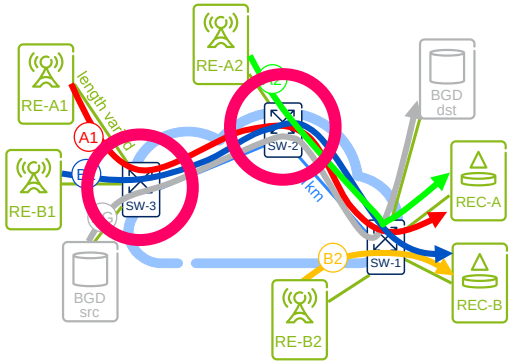


Flow	Min delay [ns]	Max delay [ns]	PDV [ns]
B2	13832.4	13832.4	**0**
A2	19693.2	19760.4	**67.2**
A1	26154.0	26227.5	**73.5**
B1	26754.0	26827.5	**73.5**

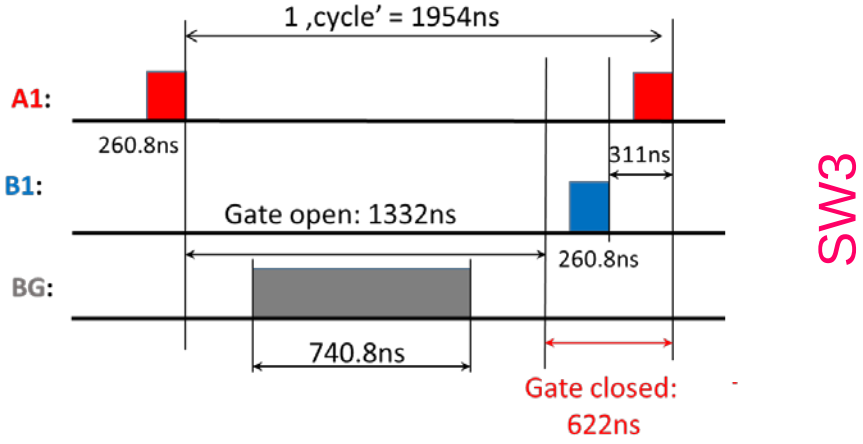
Flow	Min delay [ns]	Max delay [ns]	PDV [ns]
B2	13532.4	13532.4	**0**
A2	19693.2	19760.4	**67.2**
A1	25854.0	25953.5	**99.5**
B1	26154.0	26265.1	**111.1**

ENHANCEMENTS FOR SCHEDULED TRAFFIC

Traffic source synchronization inaccuracy: ± 10 ns

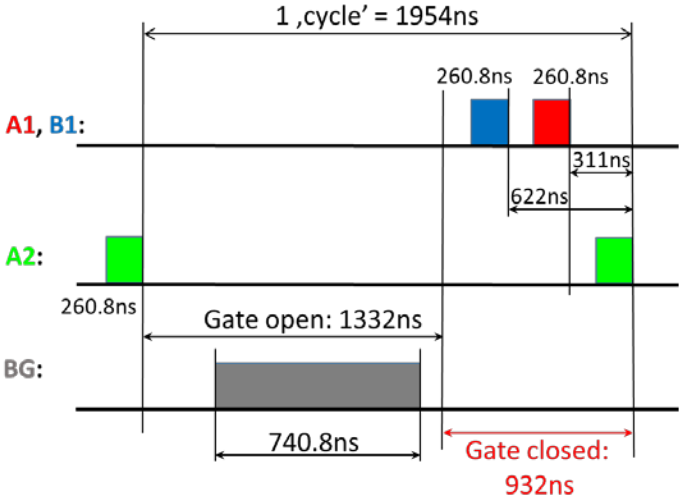


Gate on 900-byte background at SW3:

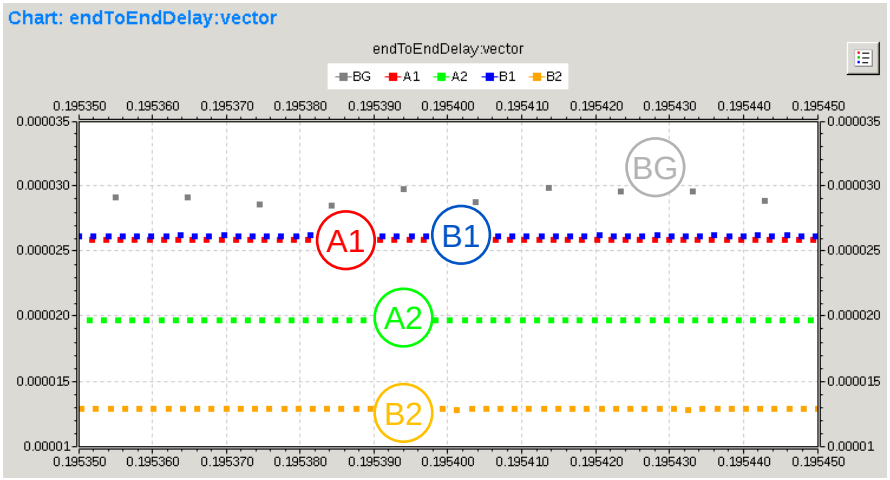


SW3

Gate on 900-byte background at SW2:

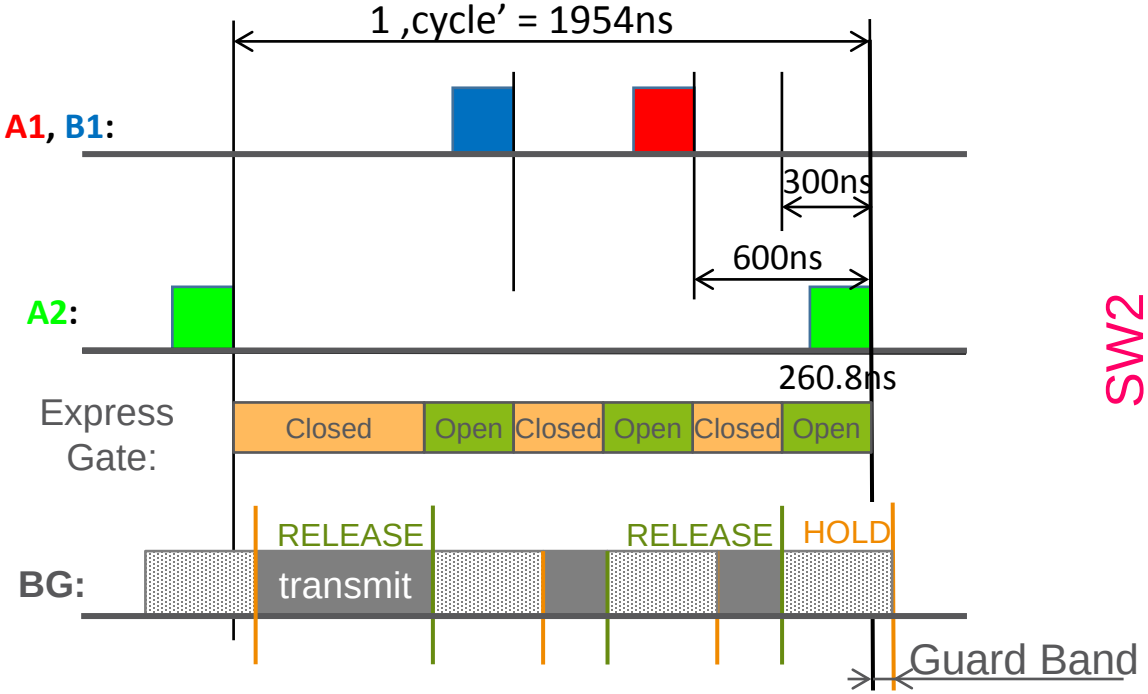


SW2

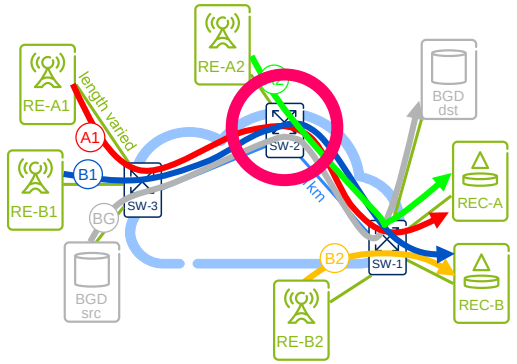


Flow	Min delay [ns]	Max delay [ns]	PDV [ns]
B2	12812	12842	**29.9**
A2	19680	19719	**39.5**
A1	25840	25888	**47.9**
B1	26150	26198	**47.9**
BG	28484.0	30453.1	**1970.3**

FRAME PREEMPTION AND ENHANCEMENTS FOR SCHEDULED TRAFFIC WITH GUARD BAND



SW2

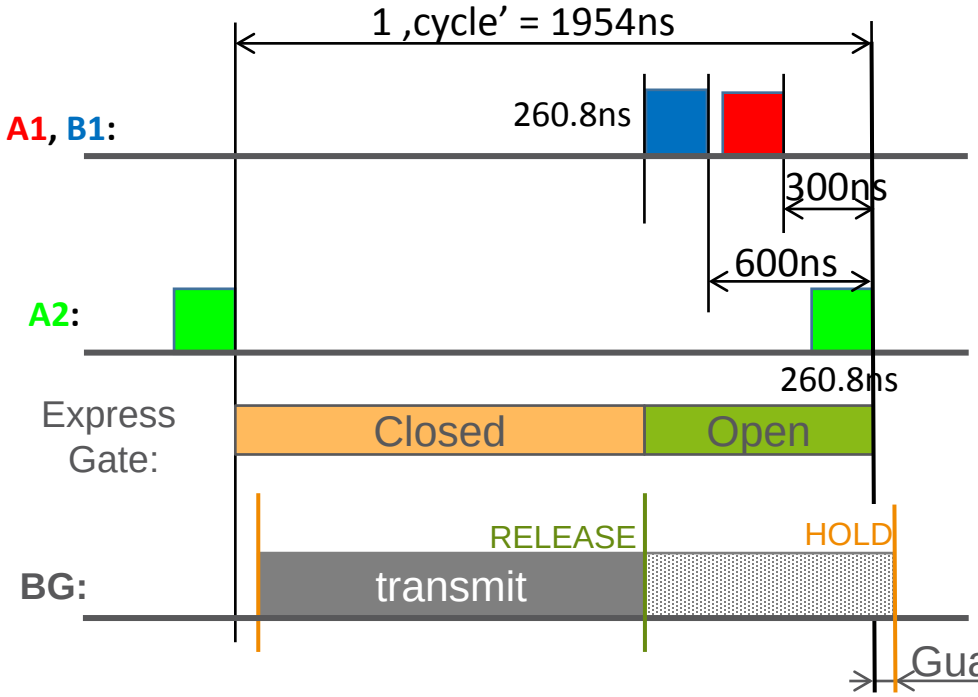


50 ns guard band

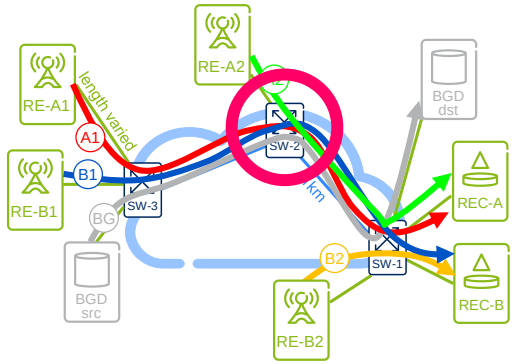
Flow	Min delay [ns]	Max delay [ns]	PDV [ns]
B2	13832.4	13832.4	**0**
A2	19702.4	19719.6	**17.2**
A1	26164.4	26181.6	**17.2**
B1	26764.4	26781.6	**17.2**

- 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)

FRAME PREEMPTION AND ENHANCEMENTS FOR SCHEDULED TRAFFIC WITH GUARD BAND



SW2



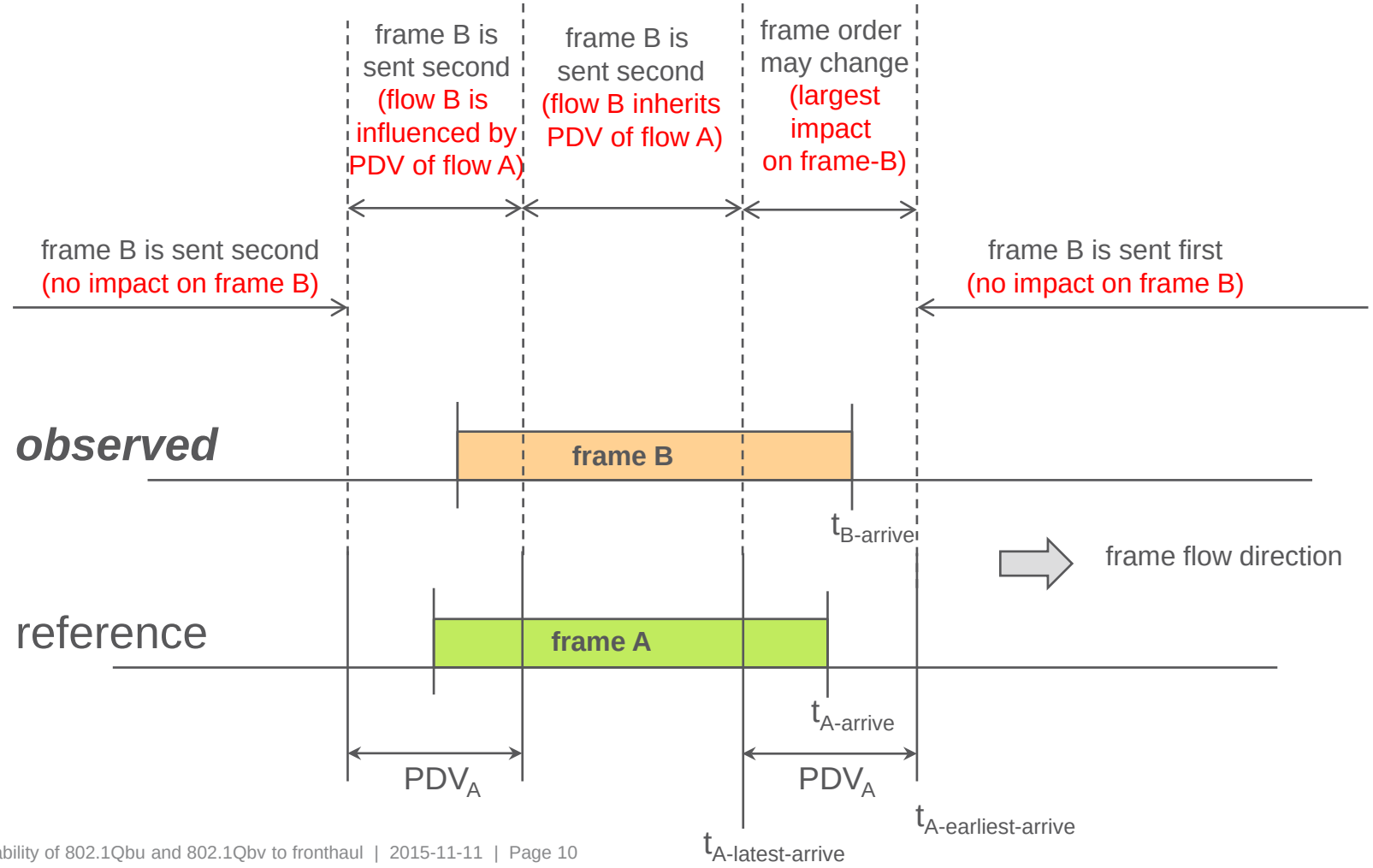
50 ns guard band

Flow	Min delay [ns]	Max delay [ns]	PDV [ns]
B2	13532.4	13532.4	0
A2	19702.4	19719.6	**17.2**
A1	25863.2	25880.4	**17.2**
B1	26154.0	25154.0	**0**

- 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)

CONCURRENT EXPRESS FRAMES

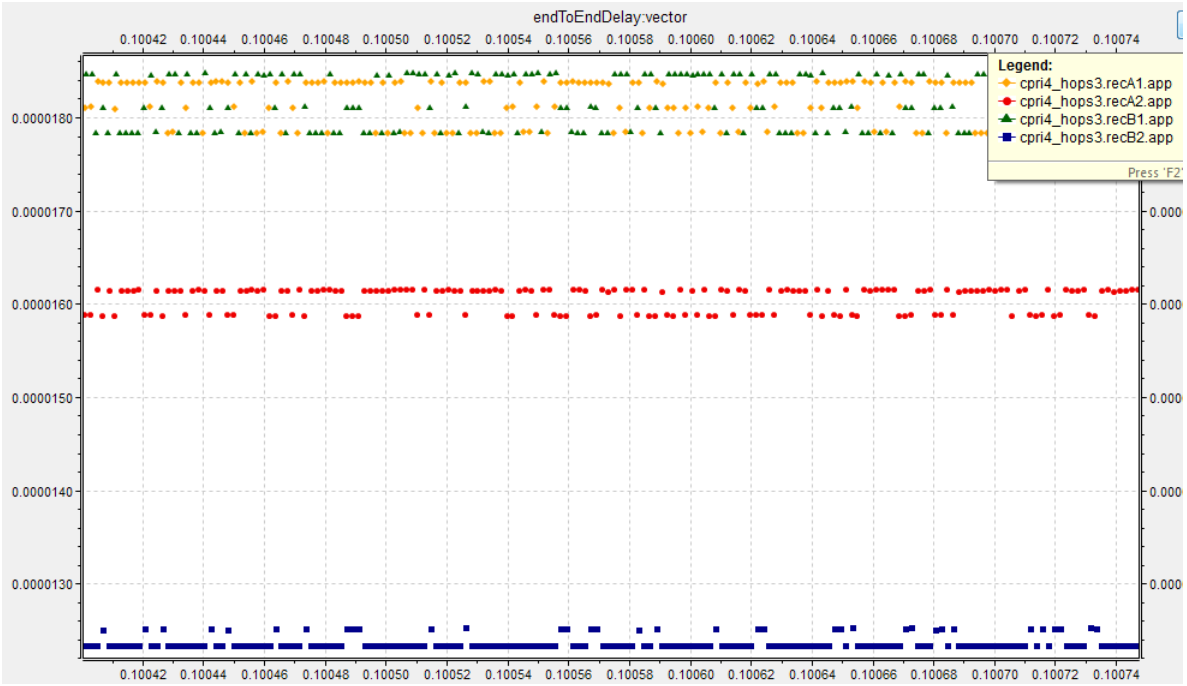
Effect of frame A on frame B depending on the relative arrival of frame B to frame A

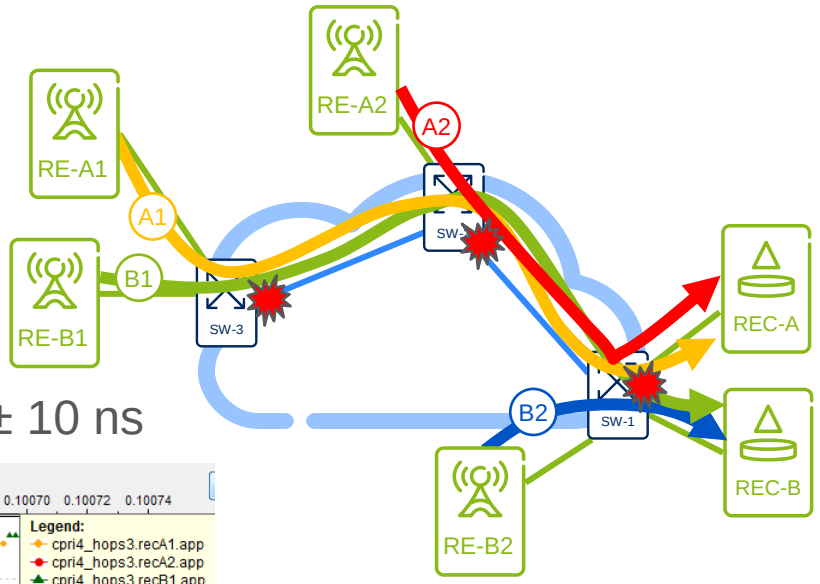


CPRI FLOWS MAY RACE AT EACH HOP

- Racing shuffles order
- This causes PDV

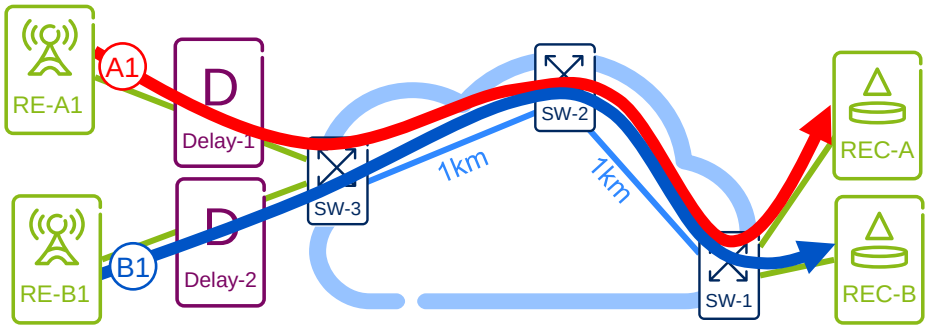
Traffic source synchronization inaccuracy: ± 10 ns

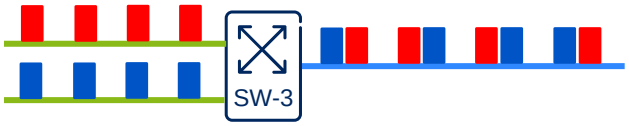


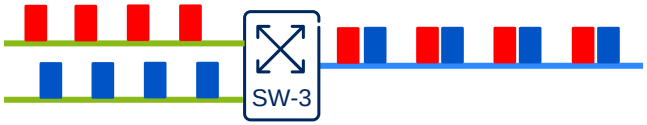


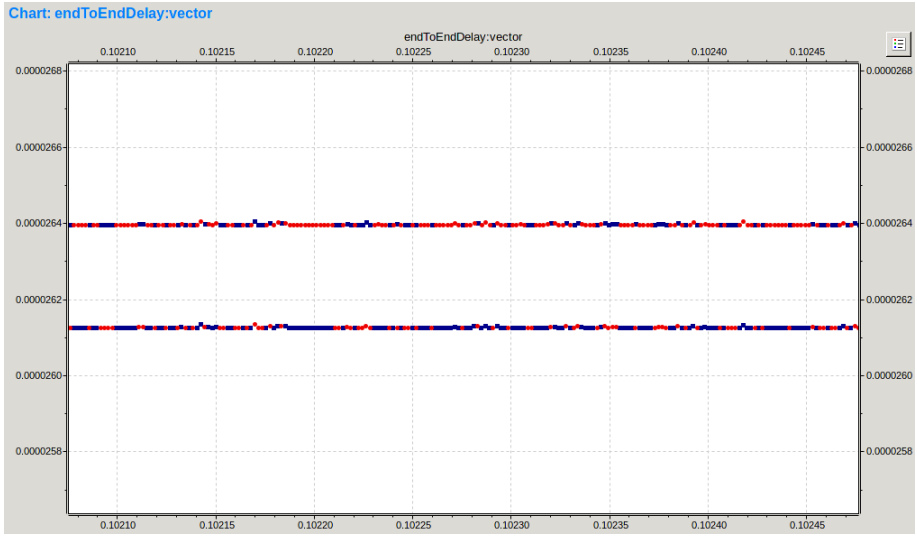
DELAYING AT INGRESS TO THE NETWORK

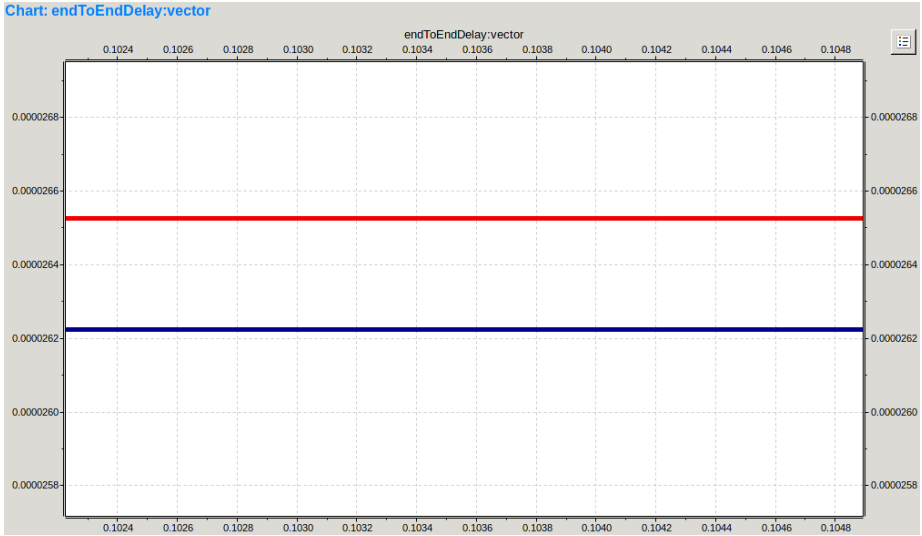
Traffic source synchronization inaccuracy: ± 10 ns











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

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