Qbv Optional for Fronthaul over Ethernet

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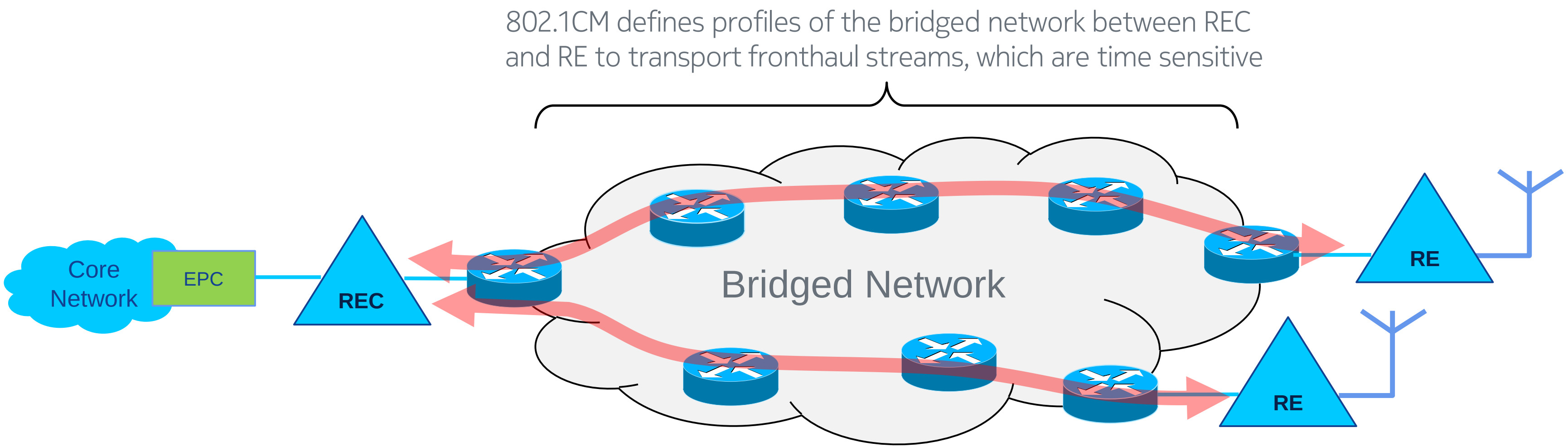
Fronthaul over Ethernet bridged network



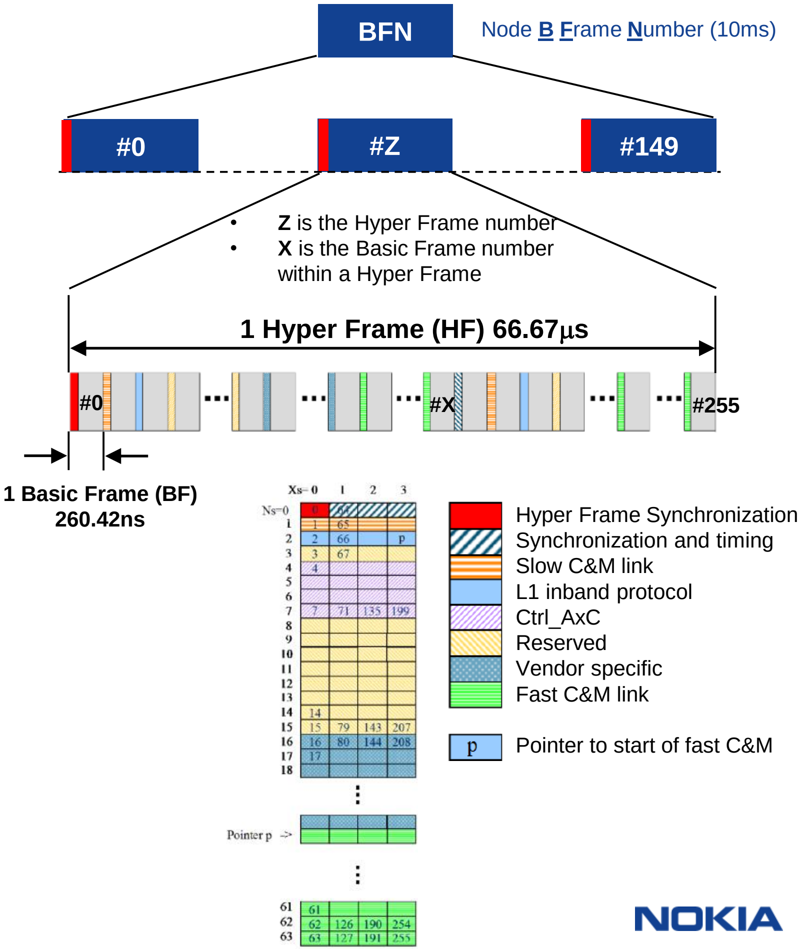
- The Common Public Radio Interface (CPRI) is commonly used radio interface for fronthaul
- The following CPRI IQ data requirements are currently specified in IEEE P802.1CM/D0.2 with a 10km minimum of the maximum geographical distance between REC and RE
  - Latency: 100µs
  - Frame Loss Ratio: 10^{-6} to 10^{-9}

CPRI fronthaul traffic

- CPRI generates a Basic Frame (BF) for each chip time ($T_C = 1/f_c = 1/3.84$ MHz = 260.42ns) with 1 Control Word (CW) and 15 Words of I/Q sample bits from different AxC's
- 256 BFs form a Hyper Frame (HF) which represents a Symbol (66.67us) and the 1st CW of a HF is used for synchronizing the sender and the receiver of the CPRI bit stream
- 150 HFs form a 10ms Radio Frame, each one denoted by a BFN
- CPRI line rate percentage over 10GE:

CPRI Line Rate	CPRI Line Bit Rate [Mbit/s]	Length of Word [bit]	Length of BF [bit]	BF % over 10GE
1	614.1	8	128	~5%
2	1228.8	16	256	~10%
3	2457.6	32	512	~20%
4	3072.0	40	640	~25%
5	4915.2	64	1024	~40%
6	6144.0	80	1280	~50%
7	9830.4	128	2048	~80%

* According to IEEE1904.3 D0.4, the mapper shall remove the 8B/10B line coding used by CPRI for line rate options 1 to 7



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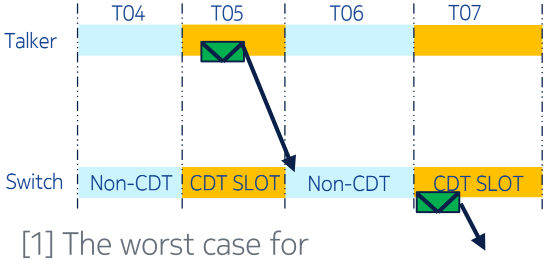
Quick background on 802.1Qbv Time Aware Shaper (TAS)

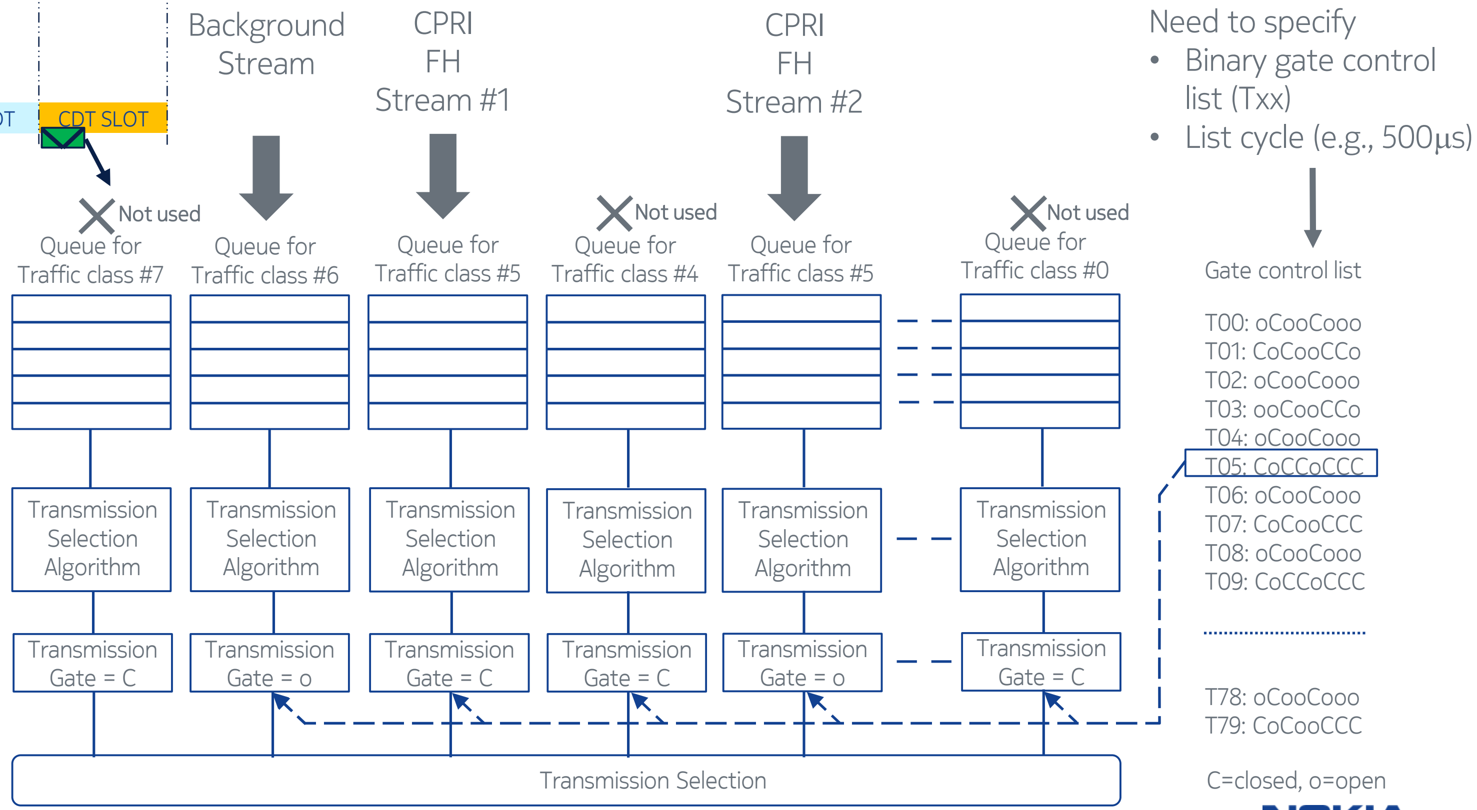
- Initial motivation of IEEE 802.1Qbv TAS is to protect time-critical, lower bandwidth, and highly predicable control traffic in industrial and automotive applications
- IEEE 802.1Qbv TAS uses time-aware scheduling to manage link access for different traffic classes
- For each traffic class, there is an associated Transmission Gate that allows frames to transmit when the gate is open and blocks frames from transmission when the gate is closed
- To prevent frames of a traffic class from being transmitted after its gate is closed, 802.1Qbv TAS defines guard bands. From the start of a guard band until the gate is closed, no new frames of the corresponding class are allowed to start transmission.
- In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the open state
- A programmable gate control list associated with each Port is used to set its associated gate open or close
- Centralized control or decentralized (e.g. hop-by-hop) control of Qbv configuration/scheduling is not specified in 802.1 TSN; in complex networks configuration becomes difficult

Qbv defines a schedule of time-aware gates which opens/closes traffic queues for TX



[1] The worst case for Qbv TAS occurs when the schedule of a specific stream, e.g., Control-Data Traffic (CDT) like CPRI is not optimally allocated

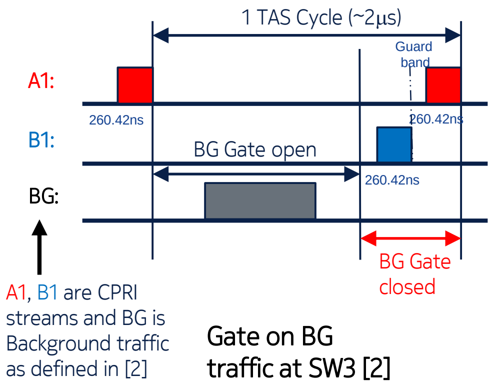
[1] Qbv TAS can offer the best low-latency and low jitter performance but it comes at a high cost for the configuration of the switch and the impact that CDT traffic has on the non-CDT streams



[1] Analysis of Ethernet-Switch Traffic Shapers for In-Vehicle Networking Applications, Sivakumar Thangamuthu, et al., 2015 Design, Automation & Test in Europe Conference & Exhibition (DATE)

Higher CPRI rate may not be Qbv friendly

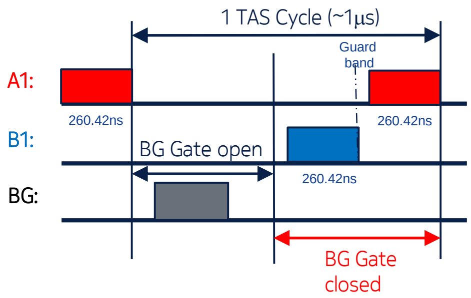
CPRI Line Rate 2: 1.2288 Gbps
Each CPRI stream occupies ~10% of a cycle (8B/10B line coding removed)



802.1Qbv may significantly reduce jitter [2]

Ingress delaying needed for CPRI streams not interfering each other.

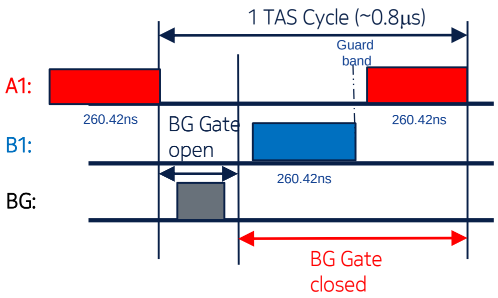
CPRI Line Rate 3: 2.4576 Gbps
Each CPRI stream occupies ~20% of a cycle (8B/10B line coding removed)



BG traffic squeezed

More ingress delaying to avoid CPRI racing/collision

CPRI Line Rate 4: 3.072 Gbps
Each CPRI stream occupies ~25% of a cycle (8B/10B line coding removed)



BG traffic further squeezed

Even more ingress delaying

[2] http://www.ieee802.org/1/files/public/docs2015/cm-farkas-applicability-of-bu-and-bv-1115-v01.pdf

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Conclusion

- As we discussed in [3], a lot can be done just with basic system level optimizations:
  - Using QoS
  - Desynchronize transmission
  - Packet size optimization
- Cost of deterministic behavior is complexity in configuration
  - The larger system – the more complex this becomes
- Ethernet fronthaul should also be kept simple
  - No difficult features in use
  - Adopt system to tolerate some amount delay variation
- Qbv should be an optional feature

[3] http://www.ieee802.org/1/files/public/docs2016/cm-rytty-practical-view-to-PDV-optimization0116-v01.pdf