



TSN FOR 802.3CG

AN OVERVIEW WITH SOME SPECIFIC APPLICATIONS

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WHAT IS THE PURPOSE OF THIS PRESENTATION?

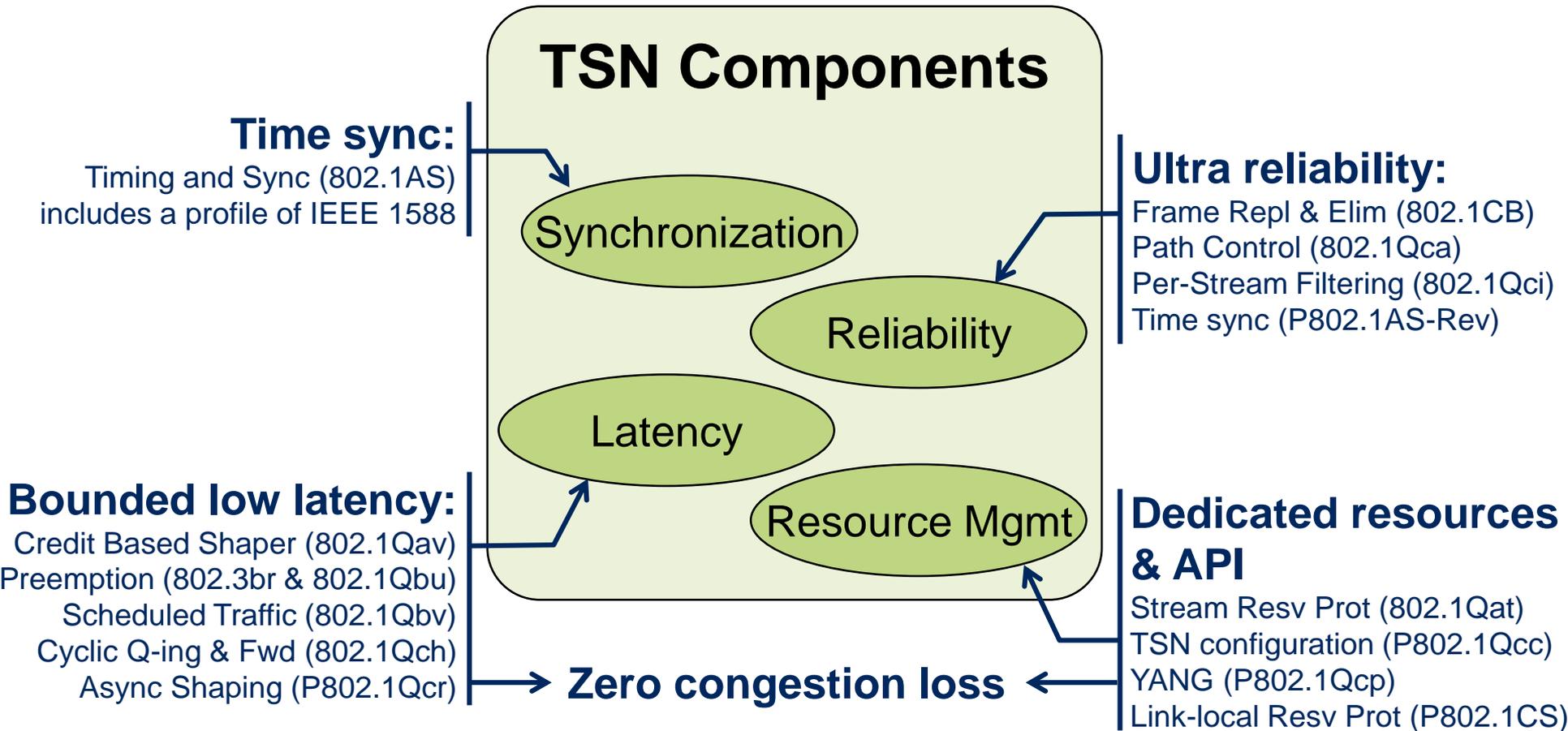
AVB (Audio Video Bridging) was easy to comprehend because it had no options. The complete protocol suite included: time synchronization (802.1AS), stream reservations(802.1Qat), shaping (802.1Qav) and AVB Systems (802.1BA). IEEE 1722 added a data transport layer on top and IEEE 1722.1 added a discovery, enumeration and control protocol.

TSN is much more flexible and has multiple options. Think of asking for TSN much like shopping for a car:

- 2 door or 4 door?
- Economy or performance?
- All wheel drive, 2 wheel drive, 4 wheel drive?
- Diesel, gas, hybrid, electric?
- Compact, luxury, SUV, truck?

There are choices with TSN. It is a set of tools that can be used individually or combined together for specific purposes.

For this presentation we will review the complete TSN toolset (as it exists today), and then talk about a few specific TSN tools that might be used with 802.3cg multidrop.



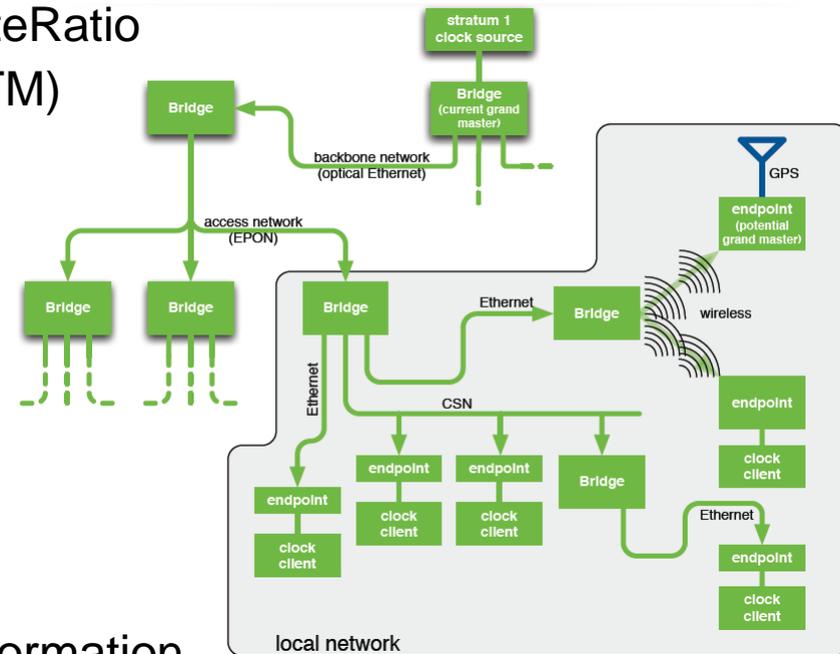
Guaranteed data transport with bounded low latency, low delay variation, and extremely low loss

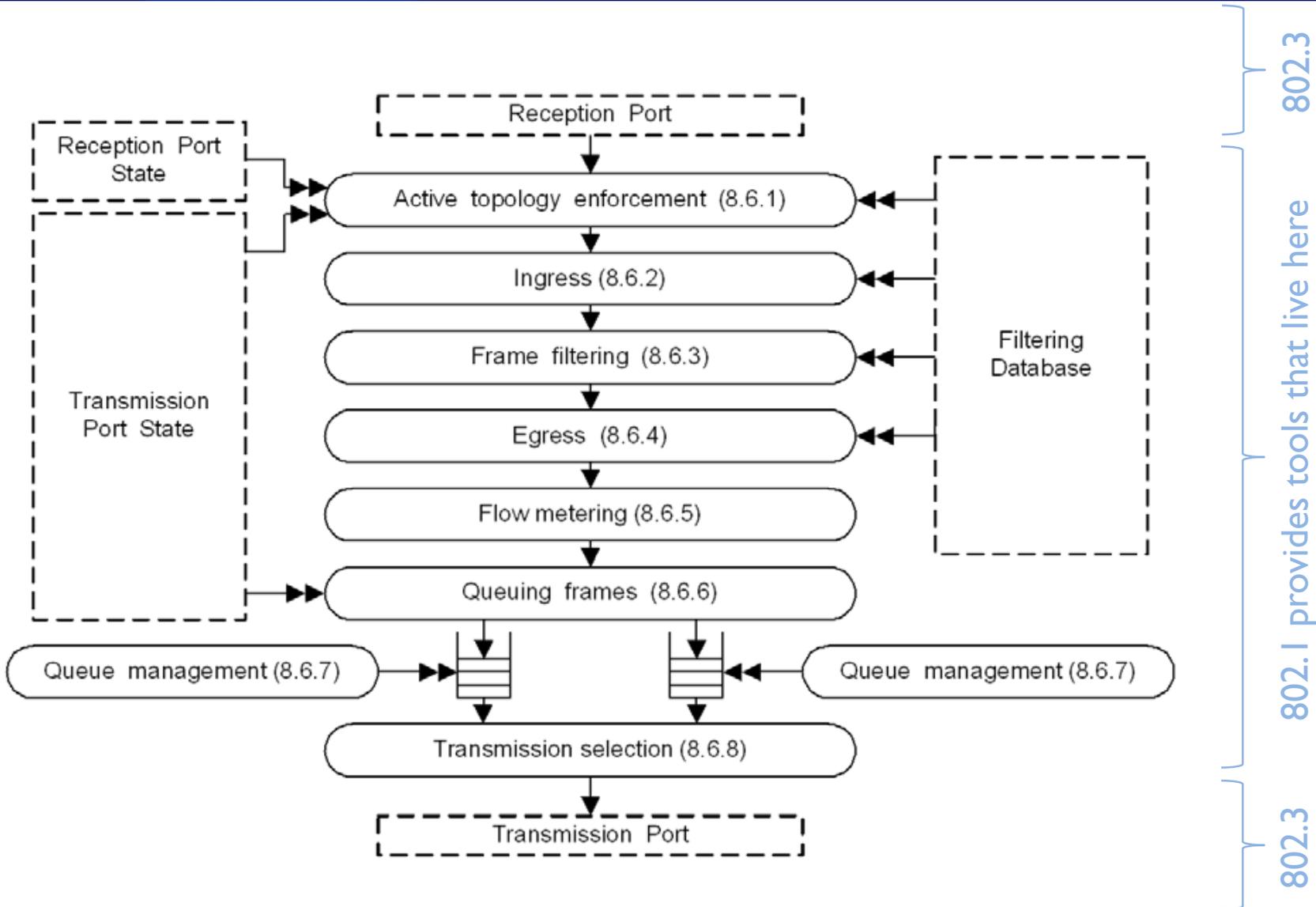
Standard / Project	Subject	Status	D #	Industry				
				P	A	I	M	
P802.1AS-Rev	Time synchronization	WG	5.1	█	█	█	█	M:Mobile
802.1Qbu-2016	Frame Preemption	Published		█	█	█	█	
802.1Qbv-2016	Scheduled Traffic	Published			█	█		
802.1Qca-2015	IS-IS Path Control & Rsv	Published				█		I:Industrial
P802.1Qcc	SRP Enhancements	Sponsor	2.0	█		█		
802.1Qch-2017	Cyclic Queuing & Fwding	Published		█	█	█		A:Automotive
802.1Qci-2017	Per-Stream Filtering	Published		█	█	█		
P802.1Qcj	Auto-attach to PBB	TG	0.2					
P802.1Qcp	YANG	Sponsor	1.4	█		█		A:Automotive
P802.1Qcr	Asynchronous Shaping	TG	0.2		█	█		
802.1CB-2017	Frame Repl. & Elim.	Published		█	█	█	█	P:Pro A/V
P802.1CM	TSN for Fronthaul	WG	1.0				█	
P802.1CS	LRP (Registration)	TG	1.1	█		█		

A profile of 1588 for Layer 2 Ethernet

The Revision includes:

- Common peer delay service for all domains, for measuring link delay and neighborRateRatio
- Support of Fine Timing Measurement (FTM) for IEEE 802.11 transport
- Support for Link Aggregation (802.1AX)
- Improved scalability
- One step processing
- Improved support for long chains, rings
- More responsive
- Faster Grand Master change over
- Reduce BMCA convergence time
- Multiple domains with synchronization information
- Redundancy: configure redundant paths and redundant GMs (further redundancy may be defined by a new project)

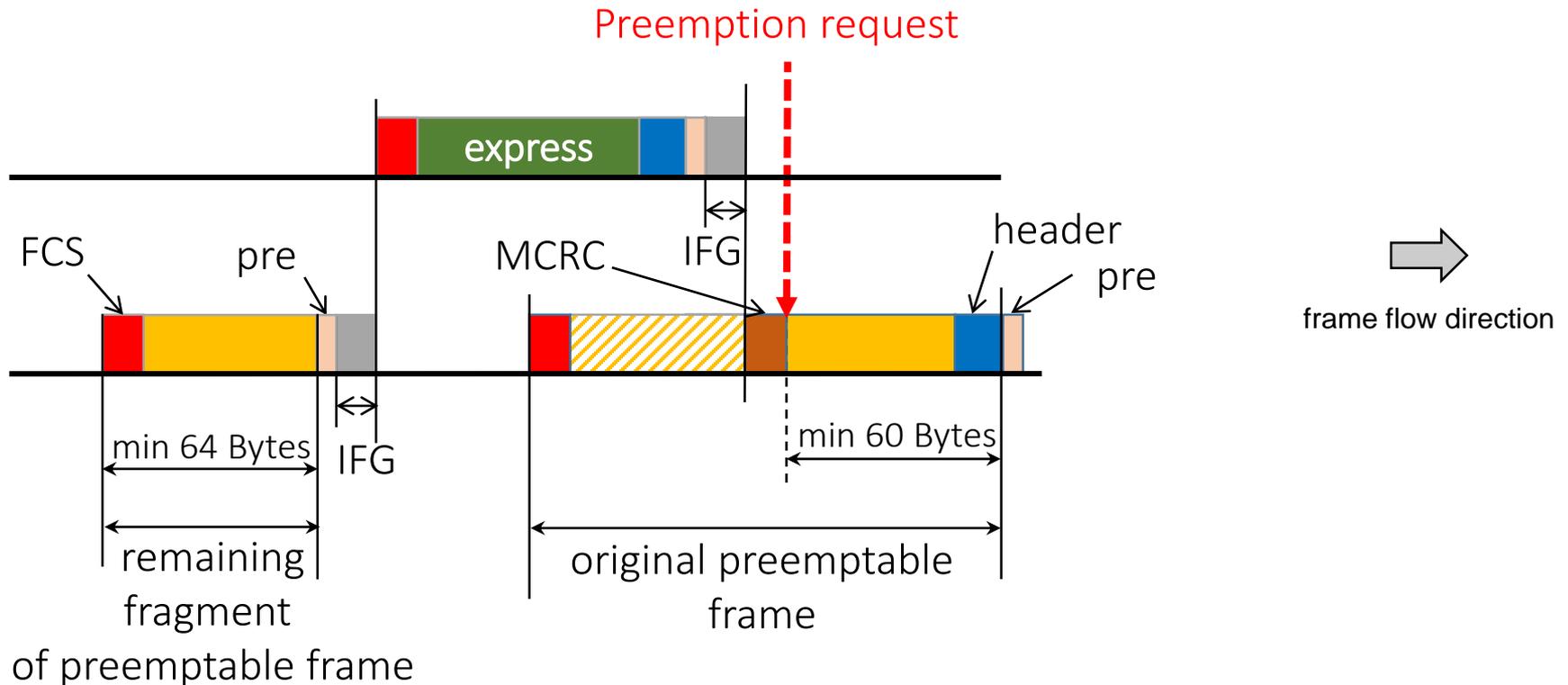




802.3BR + 802.1QBU: INTERSPERSING EXPRESS TRAFFIC

Express frames can suspend the transmission of preemptable frames. Minimum fragment size is 64 bytes including CRC.

(Note that in this diagram the first bit is on the right and last bit is on the left)



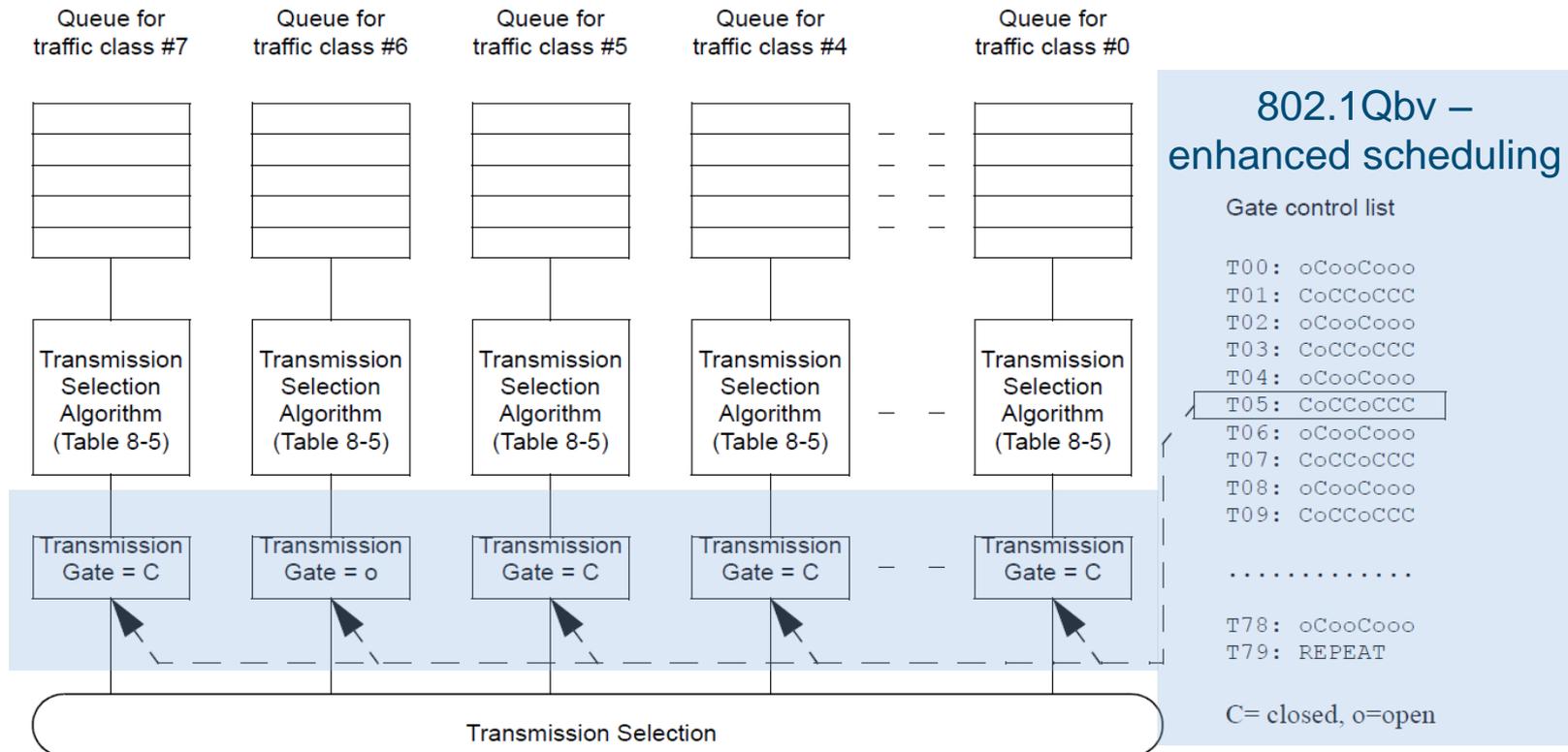
pre includes Preamble and Start mPacket delimiter (SMD)

802.1Qbv: ENHANCEMENTS FOR SCHEDULED TRAFFIC

Transmission from each queue is scheduled relative to a known timescale.

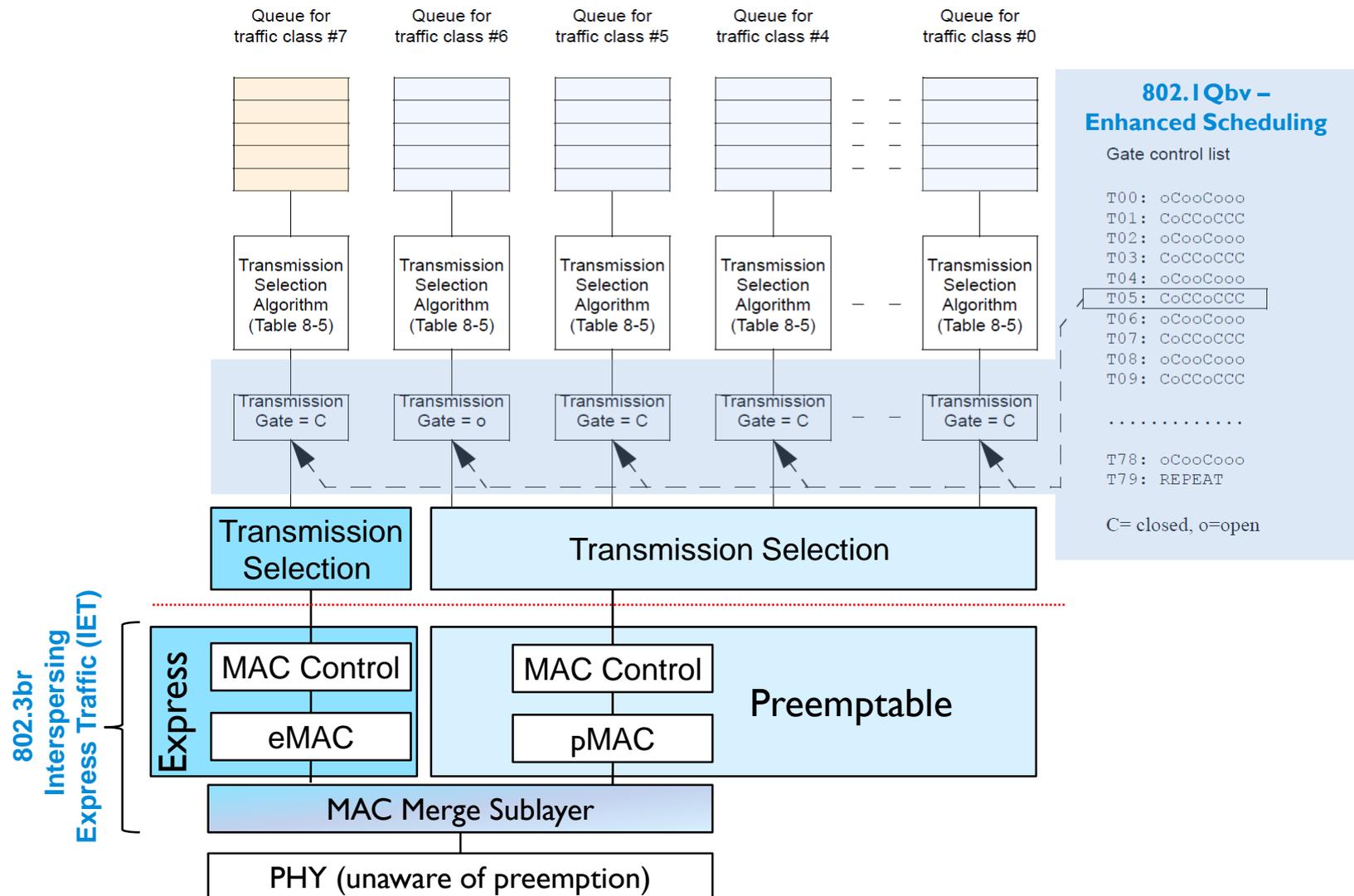
A transmission gate is associated with each queue

- the state of the gate determines whether or not queued frames can be selected for transmission
- **open (o)**: queued frames are selected for transmission, (according to the transmission selection algorithm associated with the queue)
- **Closed (C)**: queued frames are not selected for transmission



EX: COMBINING PREEMPTION AND SCHEDULED TRAFFIC

This is an example how two TSN tools can be combined:



802.1 QCI: PER STREAM FILTERING AND POLICING

Per-Stream Filtering and Policing (PSFP) allows filtering and policing decisions to be made on a per-stream basis

Stream filter

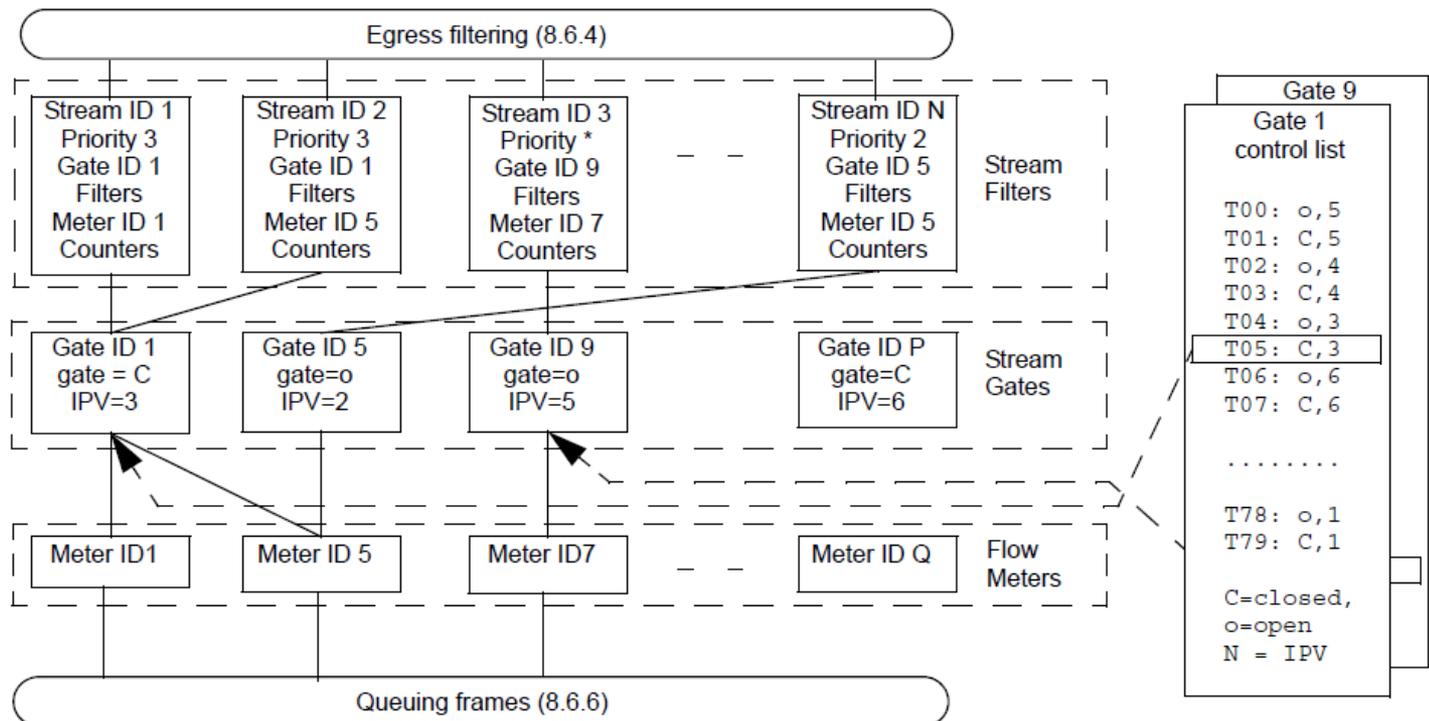
- Stream ID
- Priority
- Filters
- Meter ID
- Counters

Stream gate

- open (o)
- Closed (C)

Flow meter

- Parameters as specified in Bandwidth Profile Parameters and Algorithm in MEF 10.3, plus some additional parameters

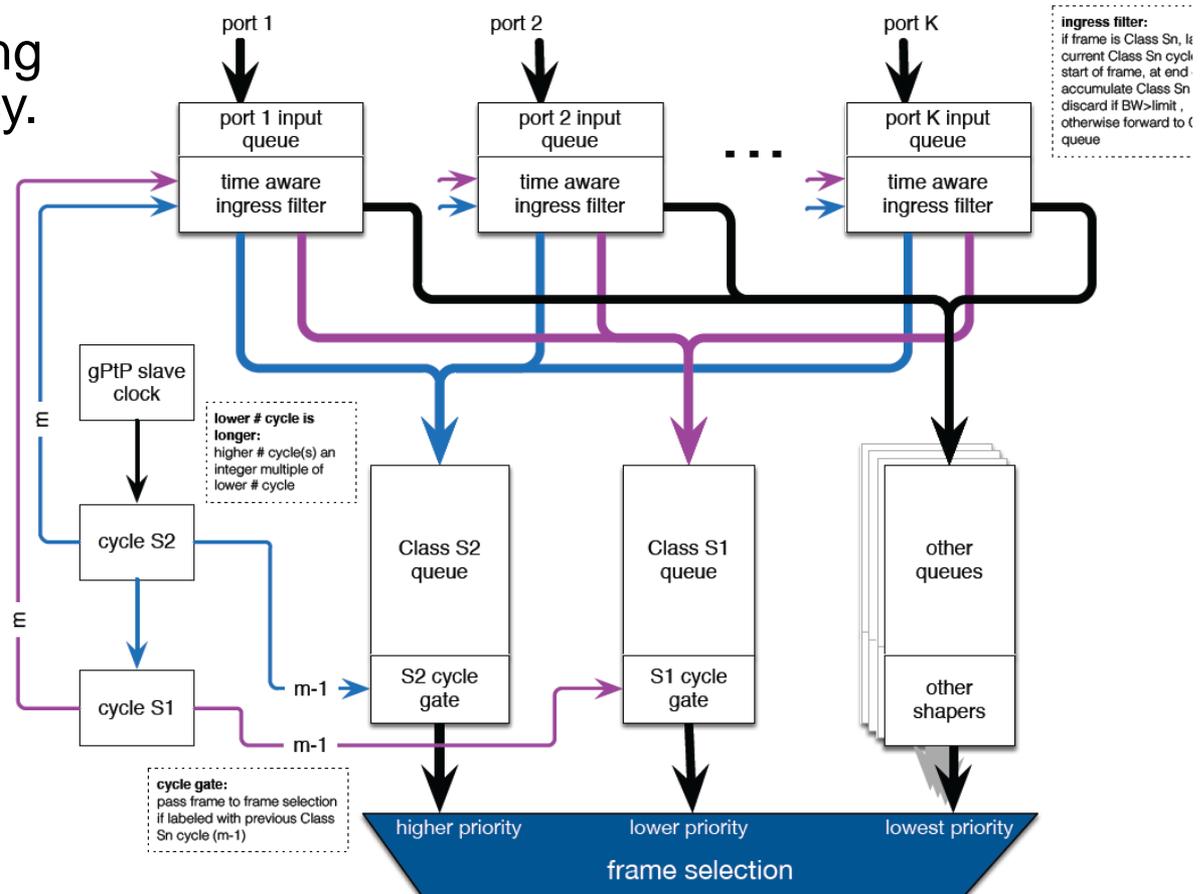


802.1QCH: CYCLIC QUEUEING AND FORWARDING

Synchronized cyclic enqueueing and queue draining achieve zero congestion loss and deterministic latency

Two buffers served alternated, e.g., that of S1 and S2. Each frame of a stream stays one cycle at each hop, thus creating a tighter bounded latency.

Example bridge with two delay classes, S1 and S2



802.1QCA: IS-IS PATH CONTROL & RESERVATION

Provide IS-IS control beyond Shortest Path Trees (SPTs)

- Augmenting IS-IS with non-shortest path capabilities

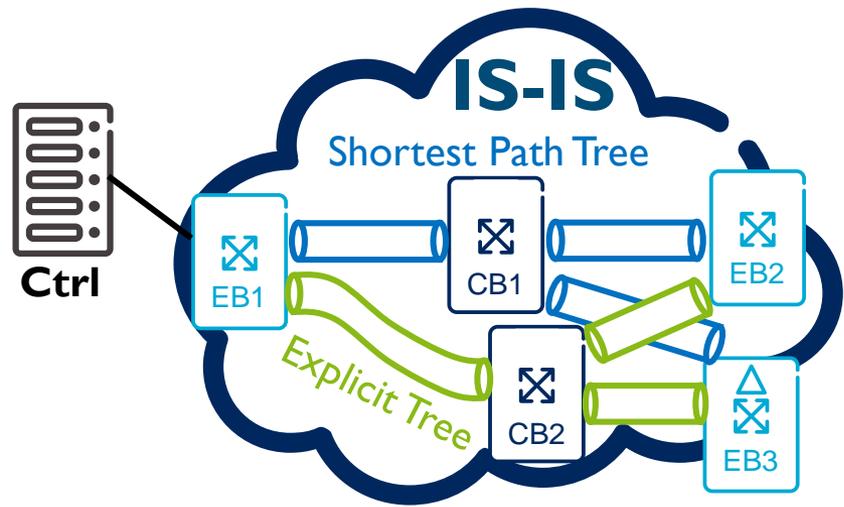
No protocol changes, only a couple of new sub-TLVs and reuse of existing ones as much as possible

A hybrid Software Defined Networking (SDN) approach

- IS-IS provides basic functions, e.g., topology discovery, default paths
- One or more controllers control Explicit Trees

Example

- Exception traffic steering
- SPT of Edge Bridge (EB) 1 is via Core Bridge (CB) 1
- Explicit Tree (ET) of EB 1 is via CB 2

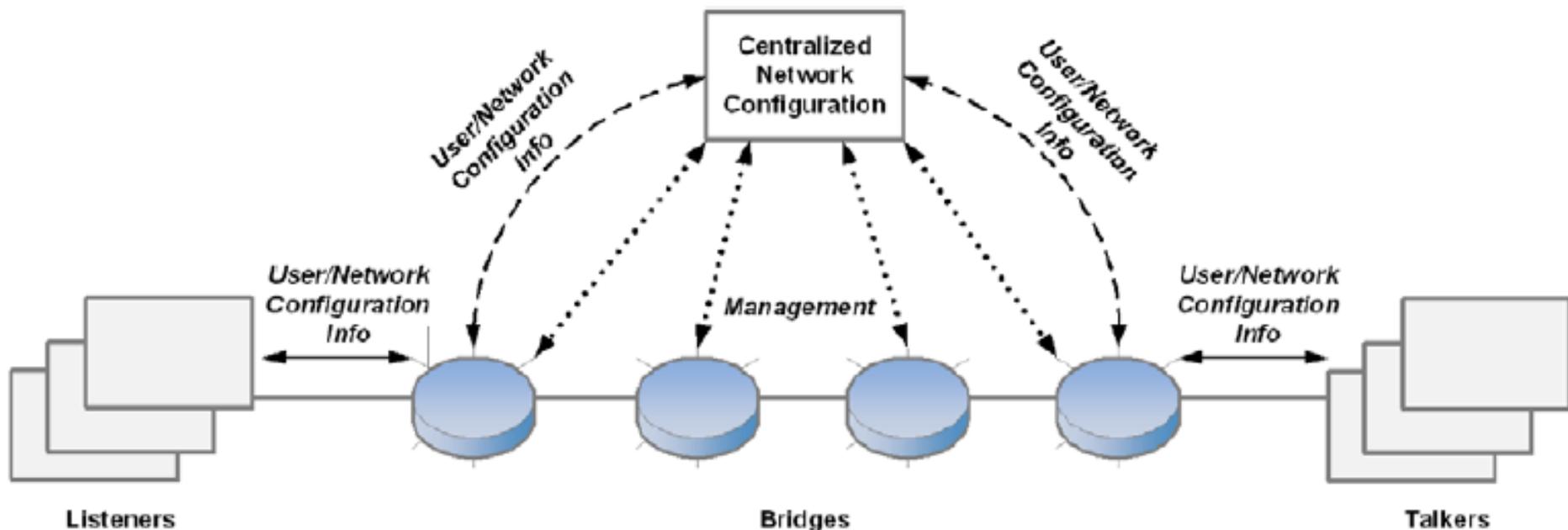


SRP enhancements

- New version: MSRPv1, which translates to MSRPv0
- New AttributeTypes that provide enhanced capabilities

TSN configuration

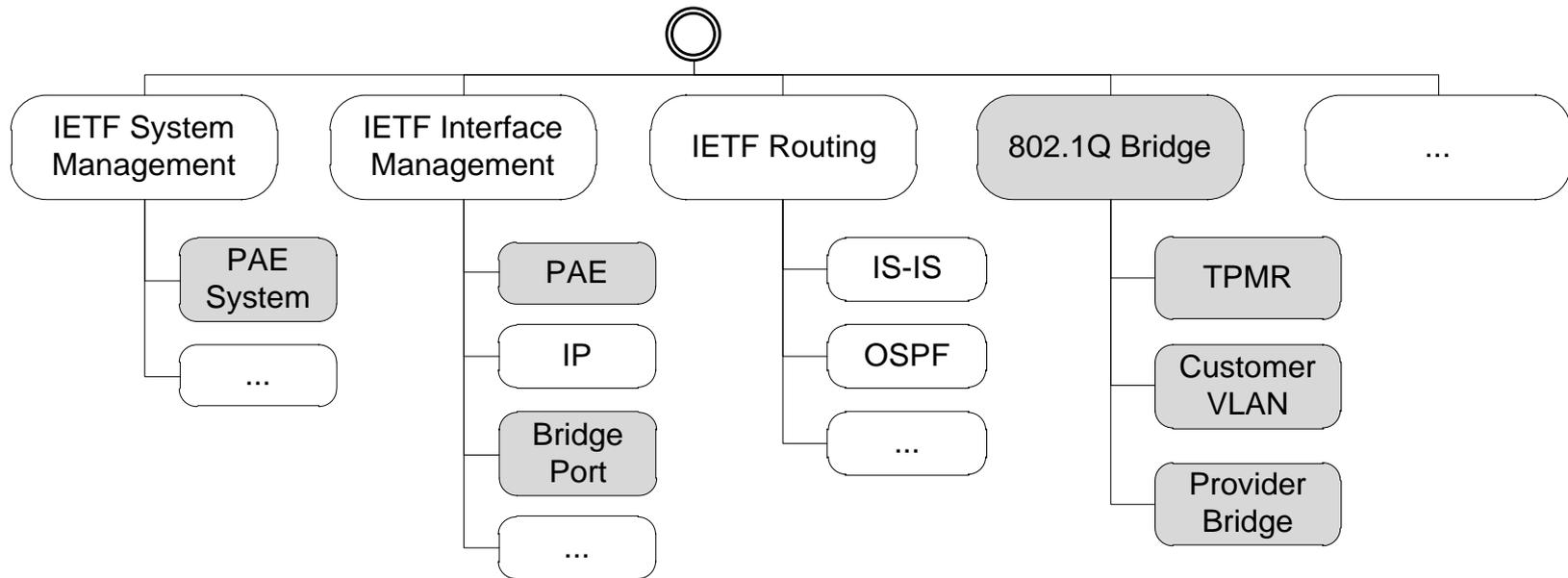
- Fully Distributed Model
- Fully Centralized Model
- Centralized Network / Distributed User Model



Scope: subset of 802.1Q features.

Model representation via UML.

YANG structure and relationships.



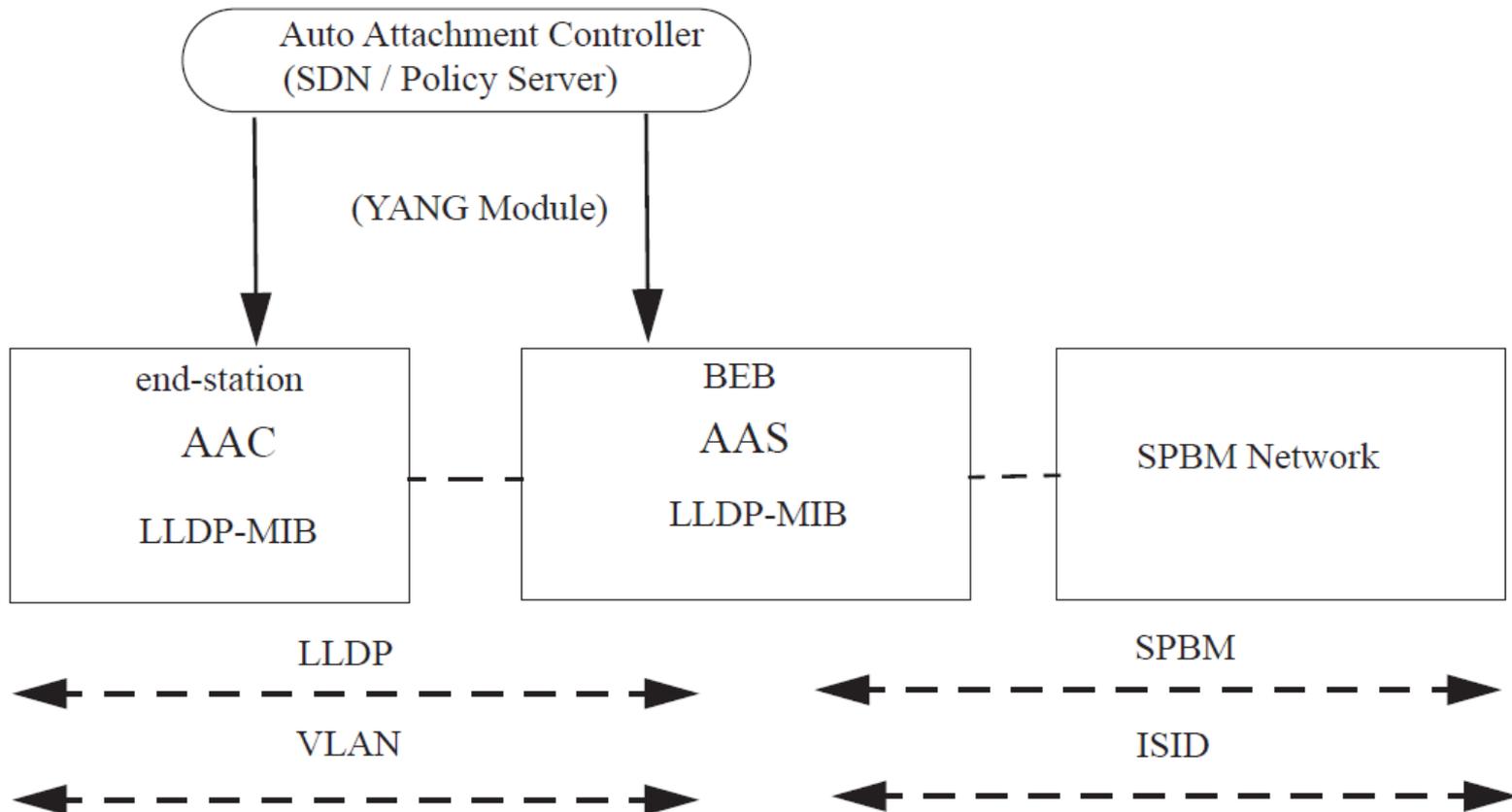
GitHub as a repository: <https://github.com/YangModels/yang/tree/master/standard/ieee>

<http://www.ieee802.org/1/files/public/docs2016/cp-mholness-Bridge-Port-YANG-0816-v053.pdf>

P802.1QcJ: AUTO-ATTACH TO PBB SERVICES

Auto Attach Model

- Auto Attach Clients (AAC): non-Provider Backbone Bridging (PBB) device
- Auto-Attach Server (AAS): PBB device, e.g., Backbone Edge Bridge (BEB)



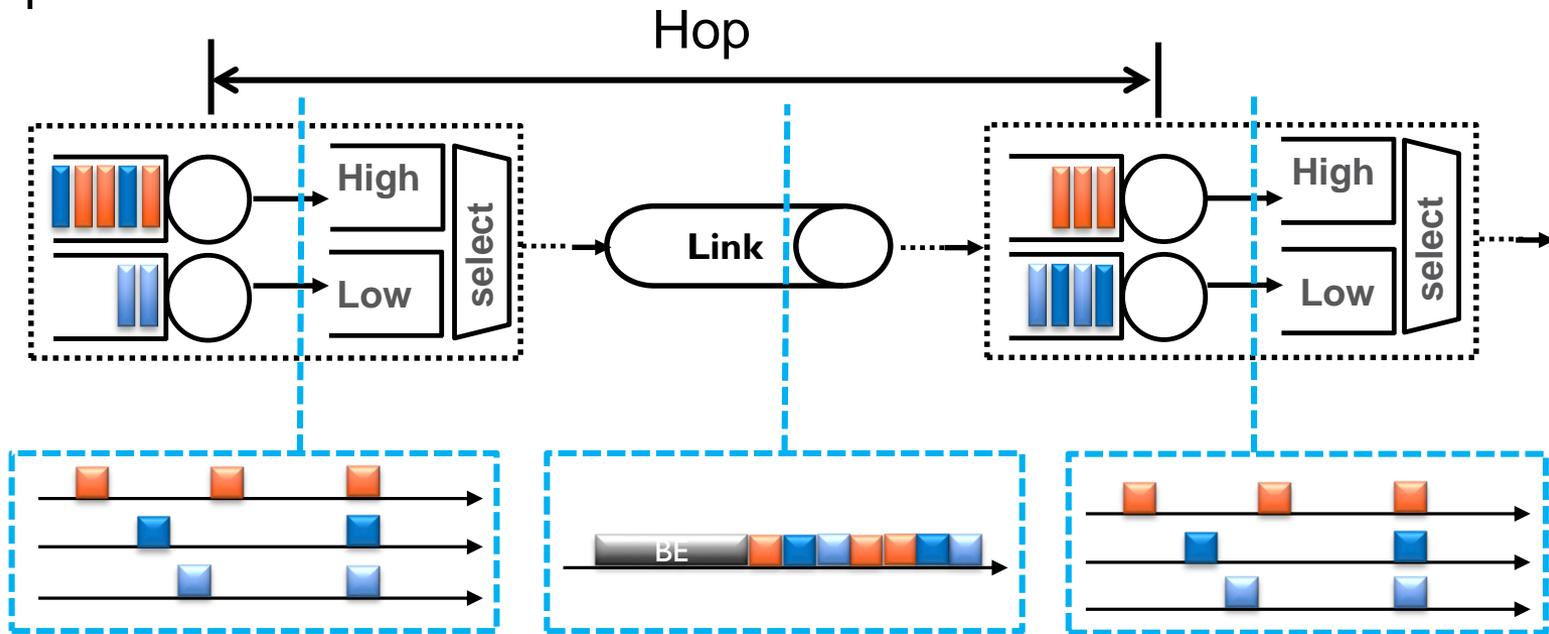
P802.1QCR: ASYNCHRONOUS TRAFFIC SHAPING (ATS)*

Asynchronous: no time synchronization needed

Basic idea

1. Smoothen traffic patterns by re-shaping per hop
2. Prioritize urgent traffic over relaxed traffic

Example

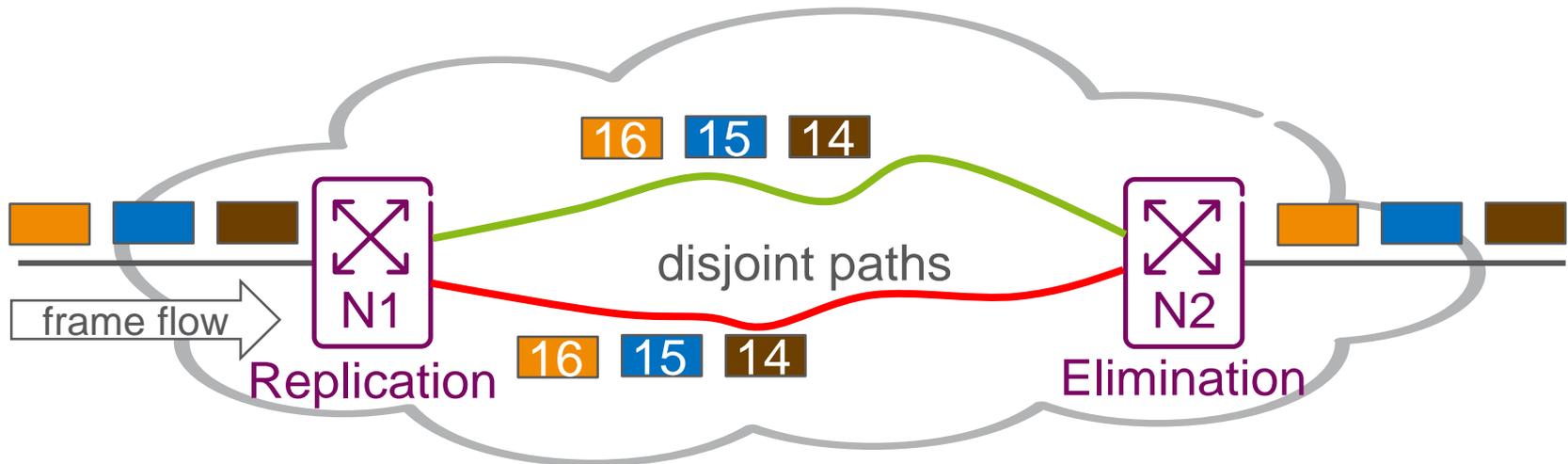


* formerly referred to as Urgency Based Scheduler (UBS)

802.1CB: FRAME REPLICATION & ELIMINATION FOR RELIABILITY

It is a per-frame 1+1 (or 1+n) redundancy

Serialize frames, send on 2 (or more) maximally disjoint paths, then combine and delete extras



Note: There are situations where frames may be delivered out of order depending on implementation options

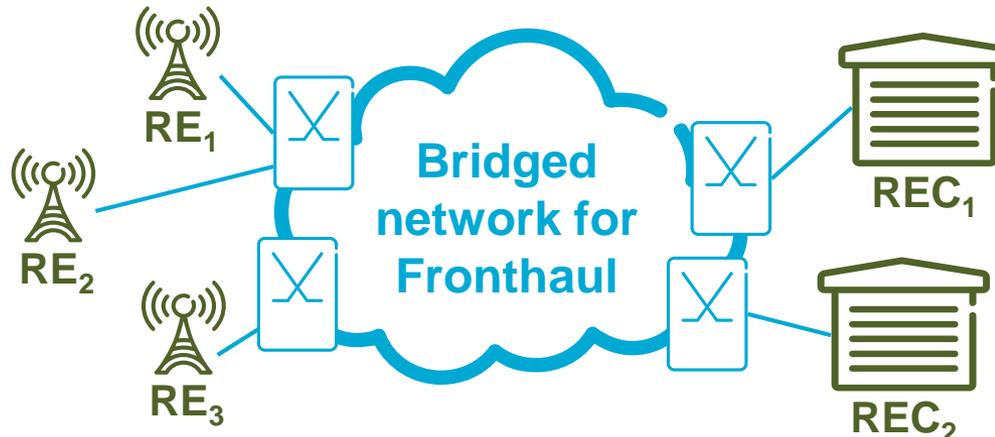
P802.1CM: TSN FOR FRONTHAUL

A TSN Profile for Fronthaul created to enable the transport of Fronthaul streams in a bridged network. This is a joint effort with the CPRI Cooperation.

Current focus: Profile(s) for current ([CPRI 7.0](#)) Radio Base Station (RBS) split such that the different Fronthaul flows (IQ, C&M, and Sync) are supported **separately** from each other

The 802.1CM specification

- collects requirements for Fronthaul networks
- provide guidance for meeting Fronthaul requirements, which includes
 - selecting 802.1 TSN features in order to build networks capable of transmitting Fronthaul streams like decomposed CPRI
 - describing how the selected TSN features and components can be combined, configured and used in order to meet Fronthaul requirements



Additional reading materials can be found here:

- <http://www.ieee802.org/1>
- <http://www.802tsn.org>
- “A Time-Sensitive Networking Primer: Putting It All Together”
https://drive.google.com/file/d/0B6Xurc4m_PVsZ1lzWWoxS0pTNVE/view?usp=sharing
- “Heterogeneous Networks for Audio and Video: Using IEEE 802.1 Audio Video Bridging”
<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6595589>
- Tutorial on IEEE 802.3br Interspersing express traffic (IET) and IEEE 802.1 Time-Sensitive Networking
http://www.ieee802.org/802_tutorials/2015-03/8023-IET-TF-1501-Winkel-Tutorial-20150115_r06.pptx
- Tutorial on Deterministic Ethernet
http://www.ieee802.org/802_tutorials/2012-11/8021-tutorial-final-v4.pdf
- Tutorial on IEEE 802.1Q
http://www.ieee802.org/802_tutorials/2013-03/8021-IETF-tutorial-final.pdf
- SDN by 802.1Q: <https://arxiv.org/abs/1405.6953>
<http://www.ieee802.org/1/files/public/docs2014/Q-farkas-SDN-support-0314-v01.pdf>
- https://en.wikipedia.org/wiki/Audio_Video_Bridging

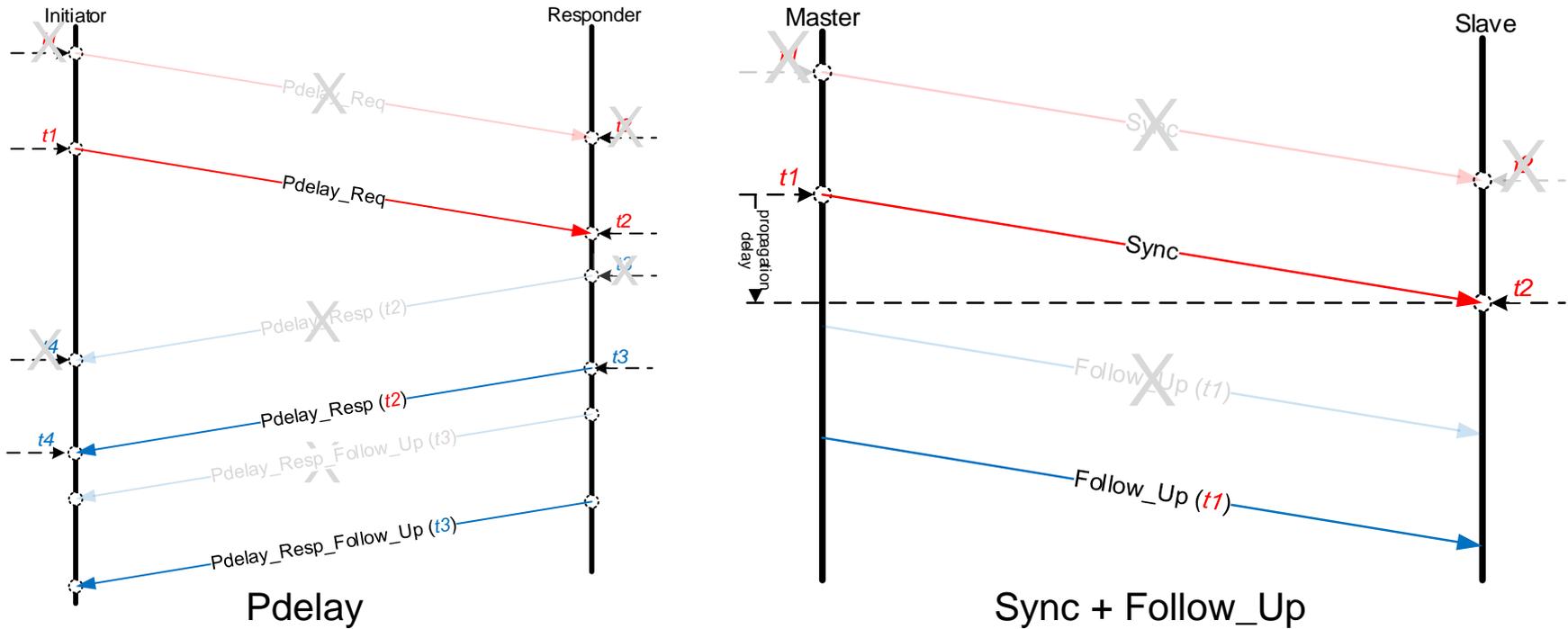
What about TSN for 802.3cg?

TIME SYNCHRONIZATION (802.1AS-REV)

802.3cg has already expressed interest in 802.1AS ([liaison-IEEE_802d3cg_mutidrop_and_TSN_0917.pdf](#)). Accurate time is important for:

- Control loops with commands and feedback that need to know when events occur (sub microsecond accuracy)
- Protocols such as IEEE 1722 use timestamps to force events to occur at exact times regardless of network jitter in the delivery of the associated packets
- The following 'Q' standards are dependent on a common time base:
 - Ingress policing (802.1Qci)
 - Cyclic Queuing and Forwarding (802.1Qch)
 - Scheduled Traffic (802.1Qbv)

My presentation* to 802.3cg shows how to make gPTP work in CSMA/CD:

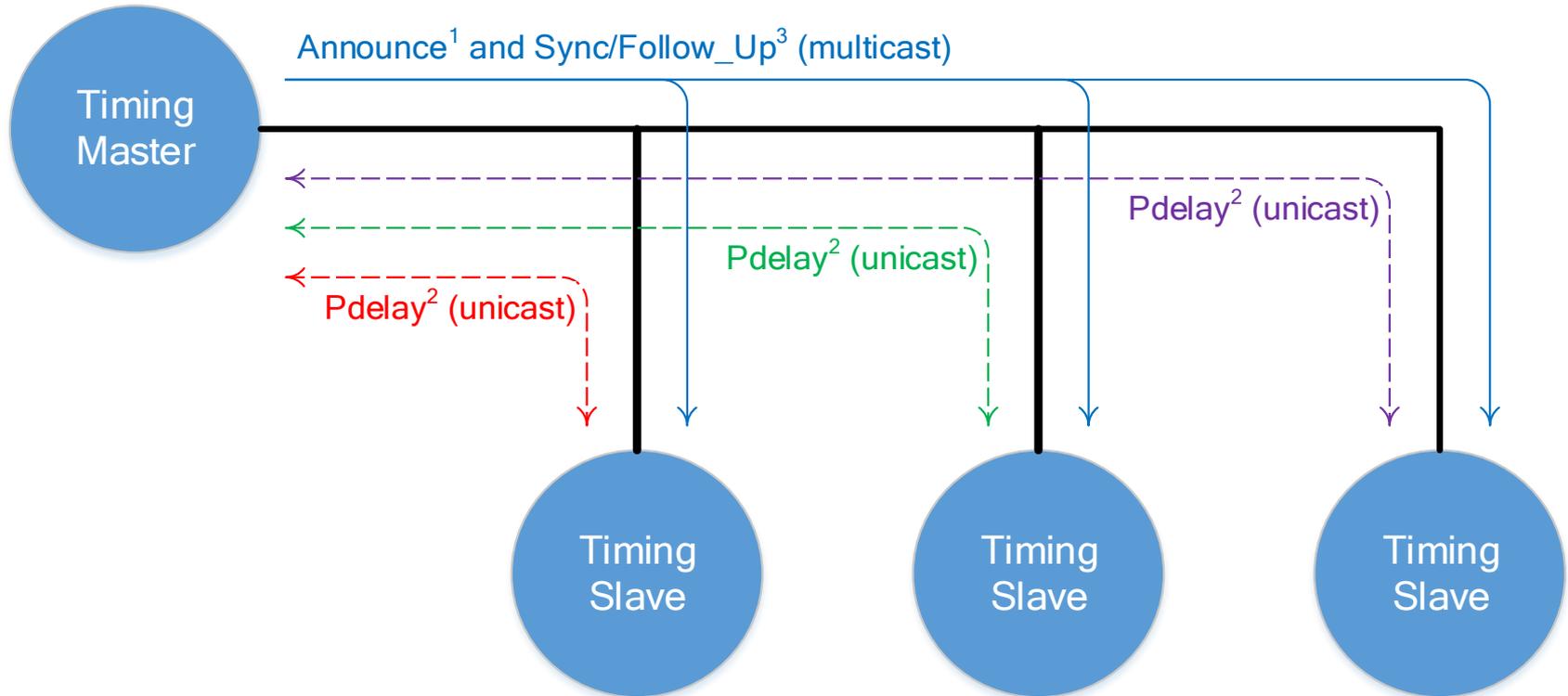


This solution has been demonstrated in a three station network of 10 Mbps half-duplex devices connected to a hub. This demonstration included flood pings running between all three stations; collision counters were constantly increasing.

* http://www.ieee802.org/3/cg/public/Sept2017/gunther_3cg_01a_0917.pdf

TIME SYNCHRONIZATION (802.1AS-REV) - CONTINUED

Question: Are Pdelays always required? If you have multiple hops you also want Pdelay for Rate Ratio calculations. If you don't have multiple hops and your network configuration never changes you may not need them.



The TSN group will include Pdelays in any gPTP solution; you might choose to ignore them in a particular implementation. This type of selective exclusion of standard-based behavior has already been applied to the use of BMCA in some automotive designs.

DOES PLCA SOLVE ALL USE CASES?

PLCA provides maximal bandwidth utilization while removing all chance of collisions. If that meets your requirements then you may have all the tools you require when running something like 802.1Q Strict Priority packet selection on top of PLCA.

But what about...

I consider PLCA to be similar to a weighted round robin solution where each station is given a turn to transmit a packet or not. The subtle side of this is the latency jitter:

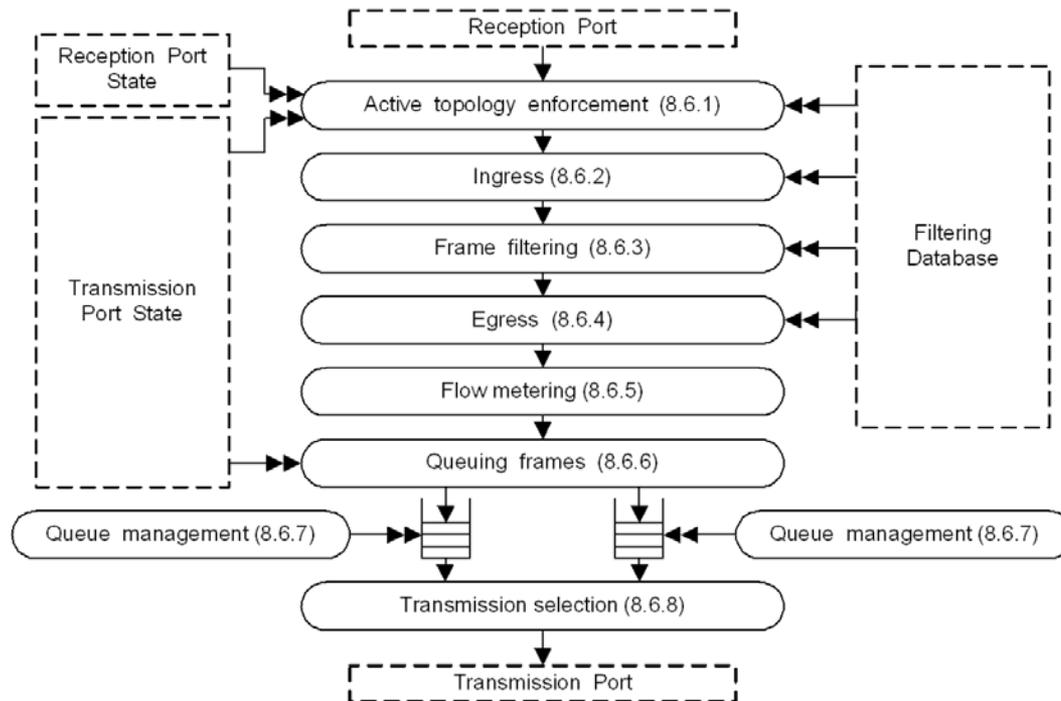
- Minimum latency = number of stations * PLCA timeout value
- Maximum latency = number of stations * maximum packet size
(~1250 usec/1500 bytes) = ~10 msec for an 8 station network.

Is this latency jitter and maximum latency acceptable for all 802.3cg use cases? For example, think about an automated controller sending a unique command to each of the slave devices.

What else can TSN provide assuming there are use cases where this latency jitter is not acceptable?

WHAT OTHER TSN STANDARDS MIGHT BE OF INTEREST?

As shown earlier in this presentation, 802.1 TSN has other solutions that might be of interest to users of 802.3cg. For example, if the Transmission selection (8.6.8) shown on slide 6 does not present a packet to the Transmission Port then this device cannot cause collisions. Coordinating this Transmission selection between all devices will solve the collision problems throughout the entire multidrop network.



PROS AND CONS OF QBV (SCHEDULED TRAFFIC)

One TSN tool that could be used by multidrop users is Qbv. Qbv can provide the support mentioned on the previous slide. What are the benefits and drawbacks of Qbv?

- **Benefit:** Deterministic latency with very low jitter
- **Benefit:** Configure transmission windows big enough to get multiple packets transmitted in one window; this is good for controllers configuring multiple stations in real time.
- **Benefit:** Can work with existing CSMA/CD networks.
- **Drawback:** Unused bandwidth is wasted. Use it or lose it.
- **Drawback:** Requires network designer to pre-engineer network.



Running Qbv, and perhaps other TSN solutions, on top of PLCA is going to add extra complexity especially since the PLCA “token” passing is not related to gPTP time.

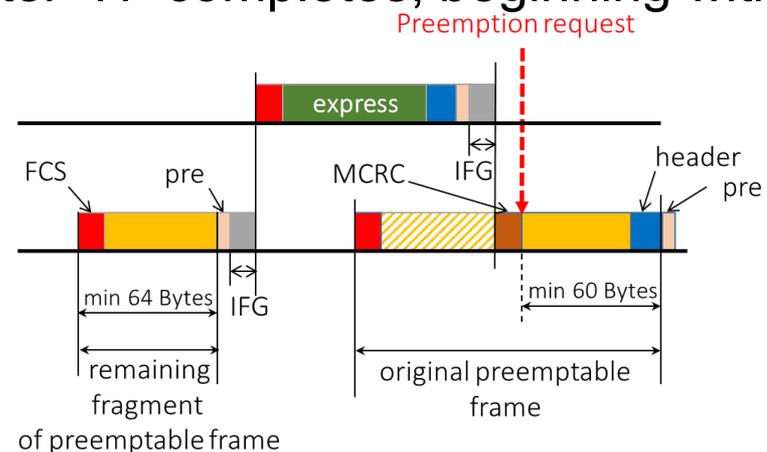
PLCA & EXPRESS TRAFFIC (PREEMPTION)

I think this is the most interesting use case that needs to be understood.

The receiving MAC only expects to receive a preemptable packet being preempted, followed by a preempting packet, then resumption of the preemptable packet as explained here:

1. Start receiving a preemptable packet, call it “L” for lower importance
2. Packet “L” gets preempted
3. The preempting packet “H” (for higher importance) begins transmitting with IFG, preamble, etc; i.e. it looks like the beginning of a second packet transmission
4. Packet “L” resumes transmission after “H” completes, beginning with the IFG, preamble, etc.
5. Possibly repeat steps 2 through 4 multiple times.

PLCA should understand this pattern and not let the “next” device begin transmitting when step 3 or 4 occur.



“Time Sensitive” Networking cannot meet its goals when run on a collision domain; therefore we need a solution like PLCA or a Qbv-like tools to remove the possibility of collisions.

- All the TSN tools can run on top of PLCA; however the behavior may be less well defined
- How time-sensitive are your needs?
- TSN tools, especially the following, may not perform as well as you would expect when run over PLCA:
 - Ingress policing (802.1Qci)
 - Cyclic Queuing and Forwarding (802.1Qch)
 - Scheduled Traffic (802.1Qbv)
- Adding preemption into the mix will certainly have an impact on the time-sensitive performance of TSN over PLCA, especially when not using other TSN tools like Qbv
- If your traffic truly is time-sensitive it may make sense to turn off PLCA and implement a Qbv-like solution; but understand the trade-offs

How do we move forward together?

- Support timestamping and ability to (at least) associate timestamps with non-collision packets
- Understand the interactions of PLCA and preemption (Express Traffic)
- Add ability in 802.3cg to enable/disable PLCA ✓
- Share 802.3cg use cases with 802.1 TSN so TSN can see where we have solutions to offer or if new tools are required
- Meet together as required to further the project(s)

Thanks!