

INTRODUCTION TO IEEE 802.1

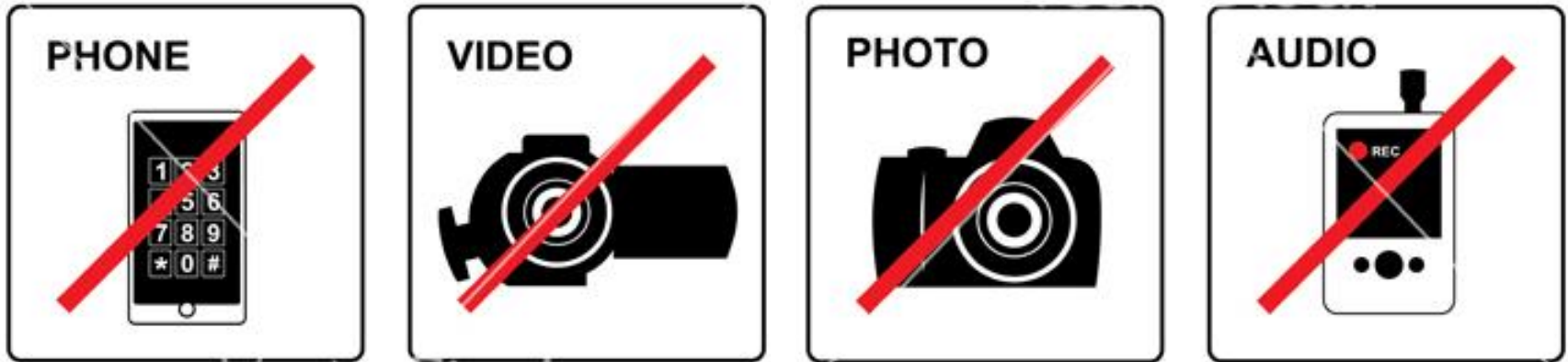
Focus on the Time-Sensitive
Networking Task Group

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November 7, 2016

WELCOME!

BEFORE WE START – DECORUM



- › Press (i.e., anyone reporting publicly on this meeting) are to announce their presence (SASB Ops Manual 5.3.3.5)
- › Photography or recording by permission only (SASB Ops Manual 5.3.3.4)
- › Cell phone ringers off please

BEFORE WE START – SECURITY ISSUES

- › **Please wear your badge** when in the meeting areas of the hotel
- › This will help the hotel security staff to improve the general security of the meeting rooms
- › **PCs HAVE BEEN STOLEN** at previous meetings –
DO NOT assume that meeting areas are secure

BEFORE WE START – PATENT SLIDES

› <http://standards.ieee.org/about/sasb/patcom/materials.html>

BEFORE WE START

- › This presentation should be considered as the personal views of the presenter not as a formal position, explanation, or interpretation of IEEE 802.1.

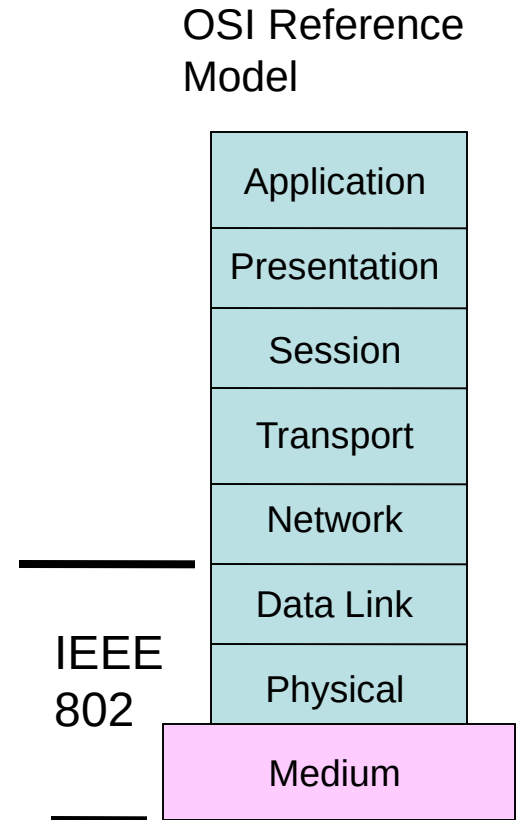
AGENDA

- › IEEE 802.1 Overview
- › IEEE 802.1 Time-Sensitive Networking (TSN)
 - Audio Video Bridging (AVB) and TSN
 - AVB standards
 - TSN standards
 - TSN projects
- › Background
 - Bridge architecture

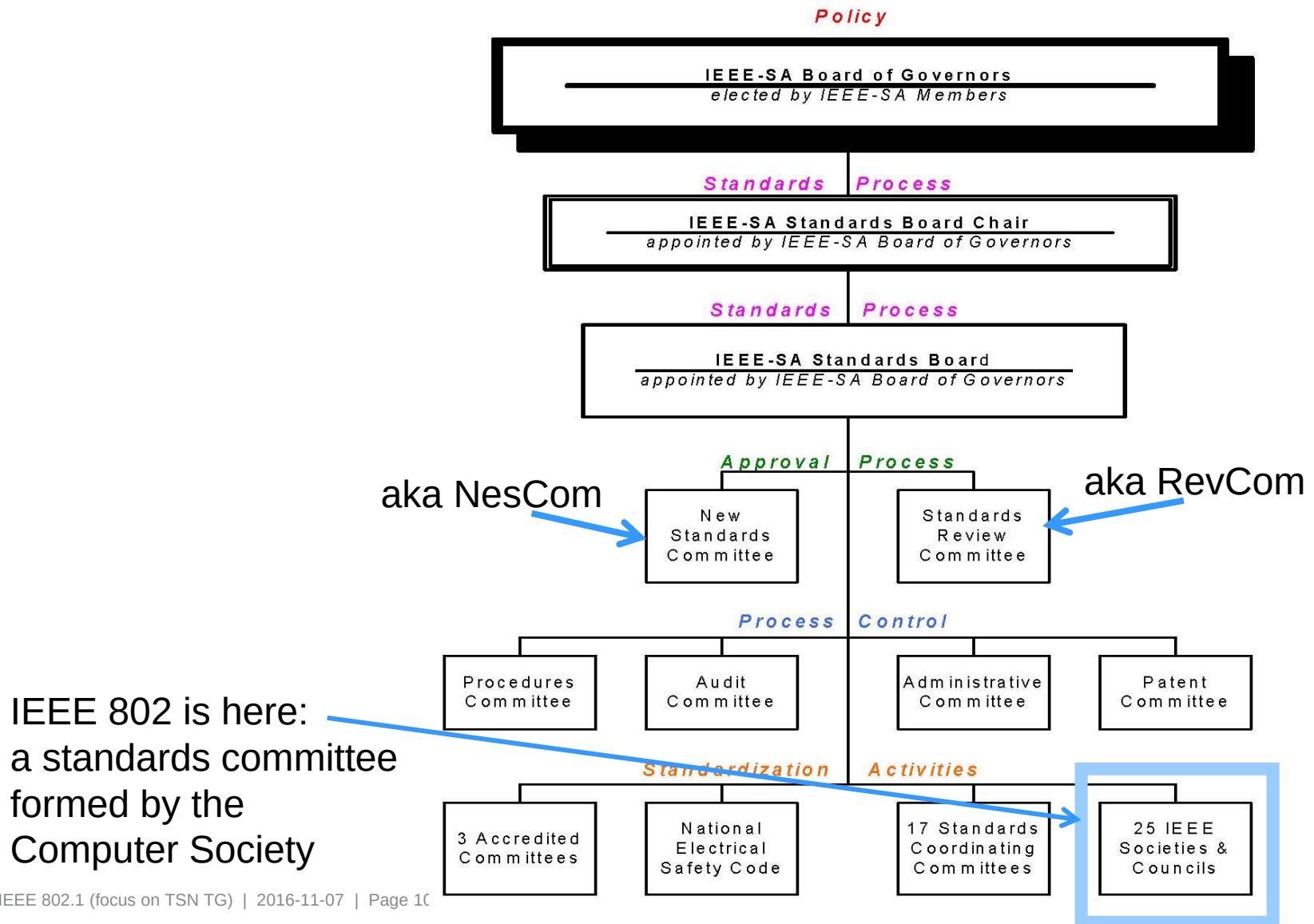
IEEE 802.1 OVERVIEW

IEEE 802 LAN/MAN STANDARDS COMMITTEE (AKA IEEE 802 OR LMSC)

- › Develop LAN and MAN standards
- › Mainly for link and physical layers of the network stack
- › In operation since March 1980



IEEE STANDARDS ORGANIZATION



SOME TERMS

- › PAR – Project Authorization Request – the document that authorizes work on a project.
- › CSD – Criteria for Standards Development – the basis for determining whether to forward a PAR.
- › WG – Working Group – responsible for developing standards in an area
- › TAG – Technical Advisory Group – experts on a topic area that crosses working groups – may develop a recommended practice.
- › Task Group (TG) or task force – a part of a Working Group which focuses on a particular project.

ALL THOSE DOTS

- › 802.1 Bridging and Architecture
 - generally the top of the link layer
- › 802.3 Ethernet
- › 802.11 Wireless LAN (WLAN)
- › 802.15 Wireless Personal Area Network (WPAN)
- › 802.16 Broadband Wireless Access (BWA)
- › 802.18 Radio Regulatory TAG
- › 802.19 Coexistence TAG
- › 802.21 Media Independent Handover
- › 802.22 Wireless Regional Area Networks (WRAN)
- › 802.24 Smart Grid TAG

PRINCIPLES OF THE IEEE STANDARDS PROCESS

- › **Due process** – procedures are publicly available and followed consistently
- › **Consensus** – requiring agreement of a majority or supermajority – for technical decisions here $\geq 75\%$
- › **Openness** – ensuring materially interested and affected parties can participate
- › **Balance** – representation from all interested parties without overwhelming influence from any one party
- › **Right of appeal** – process to ensure due process

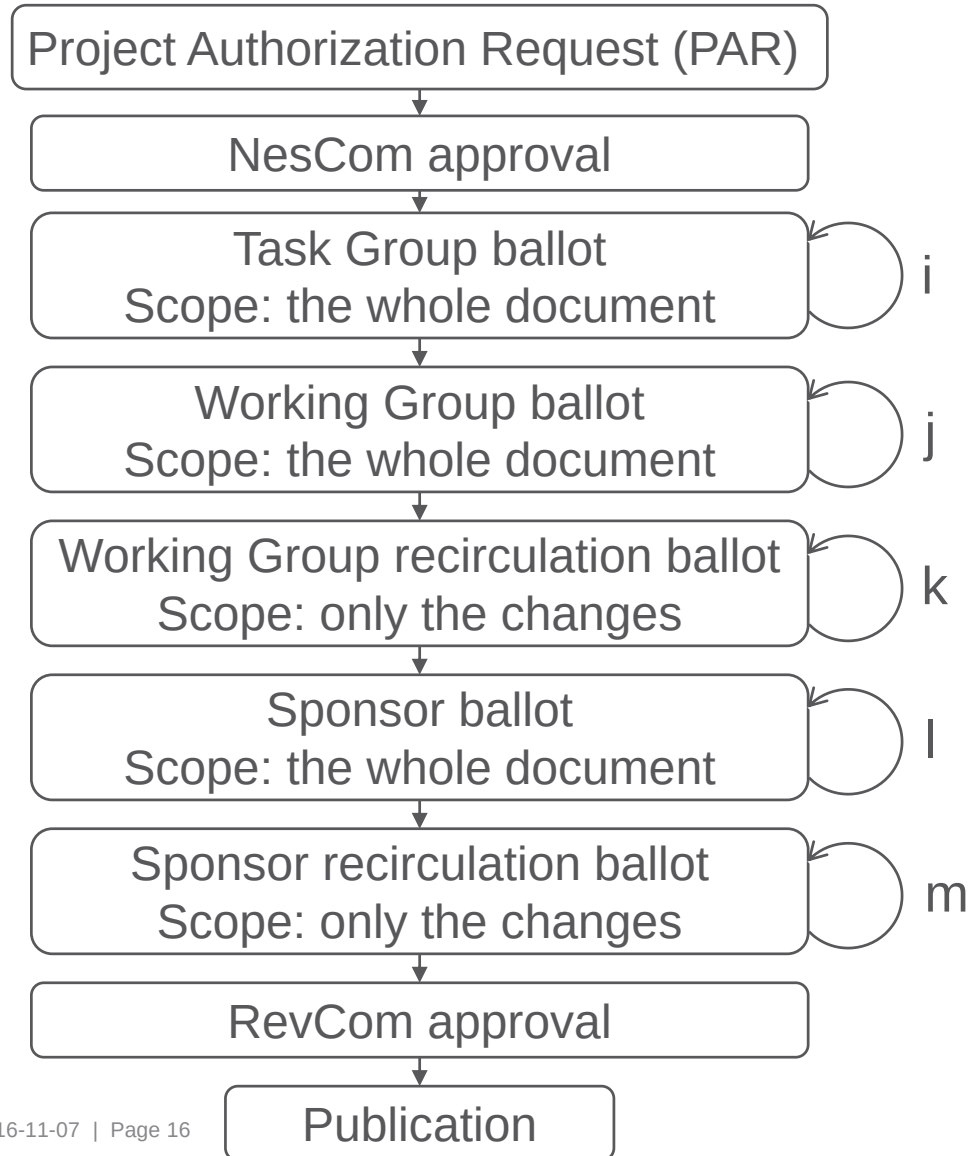
IEEE 802.1 WORKING GROUP

- › Chair: Glenn Parsons
- › Vice-chair: John Messenger
- › Data Center Bridging (DCB) and Addressing TG
 - Chair: Patricia Thaler
- › Maintenance TG
 - Chair: John Messenger
- › OmniRAN TG
 - Chair: Maximilian Rigel
- › Security TG
 - Chair: Michael Seaman
- › Time-Sensitive Networking (TSN) TG
 - Chair: János Farkas

IEEE 802.1 STANDARDS

- › The ones with capital letters, e.g. 802.1Q or 802.1AX are independent standards
- › Amendments to these standards are identified by lower case letters e.g. 802.1ah, 802.1Qbg or 802.1AEbn
- › Periodically the amendments get merged into a revision of the main standard, e.g. 802.1ah and 802.1Qay are part of 802.1Q-2014
- › 802.1Q can be considered as many individual standards integrated into a single document
 - Clauses 6 through 9 give a general overview of the 802.1Q bridge architecture
 - To get oriented on an additional area, it's best to read the Clause titled the "Principles of <area>"
 - Once oriented, references in the subclause of Clause 5 Conformance for the relevant device can be helpful

STANDARD DEVELOPMENT PROCESS (HIGH LEVEL)



BALLOTING HINTS

- › Please follow the instructions provided in the ballot invitation
 - Goal of the ballot
 - Ballot email body and subject (e.g., “Comments (with abstain)” from non-voting contributor)
 - xls for ballot comments:
<http://www.ieee802.org/1/files/private/commenting-tool/MyBallot-tools>
- › In the xls
 - Please fill in “First name”, “Surname”, and “Affiliation”
 - Please fill in each column including “Must Be Satisfied”
 - Please leave each cell empty in rows without comment
 - Please do not use anything else than the binary choices for “Category” and “Must Be Satisfied” (e.g., a dot at the end screws it)
 - Please do not go fancy with the line number, the Editor will figure it out
 - › Single number is enough
 - › Although, entries with two numbers seem to be OK, e.g., “19-25”, “19-25”, or “19, 25”
 - › Entries with more than two numbers screw it, e.g., “17-22, 29-42”
 - › The tool does not accept Figure number either in the Line or Sub-clause filed

› **Thank you!**

MEETINGS

› Face-to-face

- 802.1 f2f meetings: <http://www.ieee802.org/1/meetings>
- 802 agenda (meeting rooms): <http://802world.org/attendee>
- attendance: <https://imat.ieee.org>
- TSN agenda: <http://www.802tsn.org/agenda>
 - › agenda request: <http://www.802tsn.org/agenda-for-next-meeting>

› Virtual

- TSN virtual meetings: <http://www.ieee802.org/1/pages/tsn.html>
(<https://join.me/ieee802.1>)
 - › **Mondays: 8am PT: Generic TSN** – 9am PT: Synchronization
 - › agenda request by **Thursday**:
<http://www.802tsn.org/weekly-call-agenda-requests>
- Virtual meetings of each Task Group are announced on the 802.1 email list
 - › TSN agenda items or cancellation on **Friday**

FURTHER NAVIGATION

- › <http://www.ieee802.org/1> (projects, drafts, everything)
 - TSN: <http://www.ieee802.org/1/pages/tsn.html> (conference calls, etc.)
- › public folder: <http://www.ieee802.org/1/files/public>
- › file upload – at the bottom of <http://www.ieee802.org/1/filenaming.html>
 - Follow the file naming conventions please
- › email list: <http://www.ieee802.org/1/email-pages>
- › ongoing ballots: <http://www.ieee802.org/1/email-pages/ballots.html>
- › minutes & opening/closing plenary slides: <http://www.ieee802.org/1/pages/minutes.html>
- › get program: <https://standards.ieee.org/about/get/802/802.1.html>

IEEE 802.1 TIME-SENSITIVE NETWORKING (TSN)

FROM AVB TO TSN

- › IEEE 802.1 Audio Video Bridging (AVB) Task Group (TG)
 - Started in 2005
 - Address professional audio, video market
 - Consumer electronics
 - Automotive infotainment
 - AVnu Alliance: associated group for compliance and marketing
- › IEEE 802.1 Time-Sensitive Networking (TSN) TG
 - AVB features become interesting for other use cases, e.g.
 - › Industrial
 - › Automotive
 - AVB was not an appropriate name to cover all use cases
 - AVB TG was renamed to TSN TG in 2012
 - Interworking TG and TSN TG were merged in 2015

AVB STANDARDS

- › IEEE Std. 802.1AS-2011 – generalized Precision Time Protocol (gPTP)
 - A Layer 2 profile of the IEEE 1588 Precision Time Protocol (PTP)
- › IEEE Std. 802.1Qav – Forwarding and Queuing of Time-Sensitive Streams (FQTSS):
 - Specifies Credit-Based Shaper (CBS)
- › IEEE Std. 802.1Qat – Stream Reservation Protocol (SRP)
 - Registration and reservation of time-sensitive streams
- › IEEE Std. 802.1BA – AVB Systems
 - Provides an overall AVB architecture and AVB profiles
- › CBS + SRP to provide delays under 250 μ s per bridge

TSN *STANDARDS* AND PROJECTS

- › P802.1AS-Rev – Timing and Synchronization - Revision
- › *802.1Qbu – Frame Preemption* – published
- › *802.1Qbv – Enhancements for Scheduled Traffic* – published
- › *802.1Qca – IS-IS Path Control and Reservation (PCR)* – published
- › P802.1Qcc – Stream Reservation Protocol (SRP) Enhancements and Performance Improvements
- › P802.1Qch – Cyclic Queuing and Forwarding – based on Qci
- › P802.1Qci – Per-Stream Filtering and Policing
- › P802.1Qcj – Auto-attach to PBB services
- › P802.1Qcp – YANG Data Model
- › P802.1Qcr – Asynchronous Traffic Shaping (ATS)
- › P802.1CB – Frame Replication and Elimination for Reliability
- › P802.1CM – Time-Sensitive Networking for Fronthaul
- › P802.1CS – Link-local Registration Protocol (LRP) – PAR development

} related

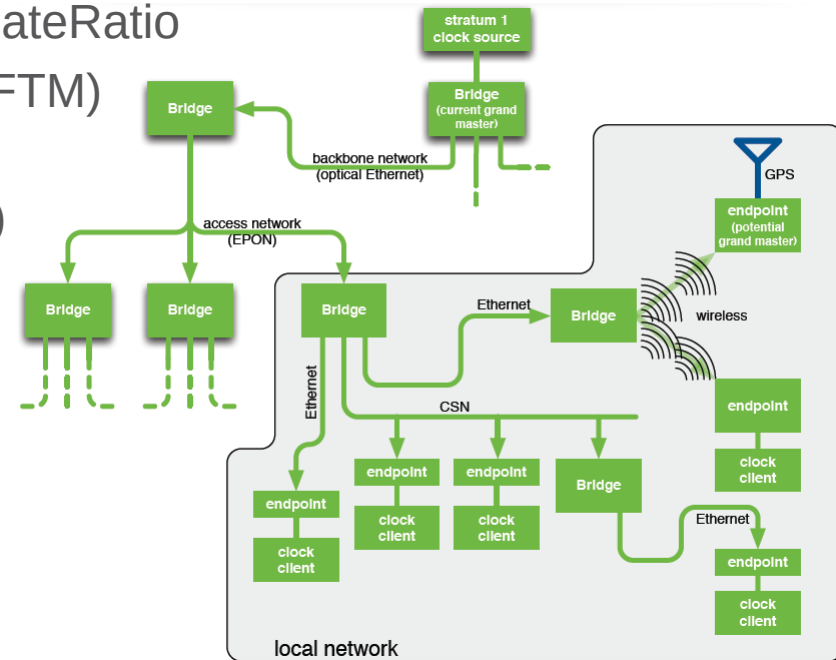
STATUS & INDUSTRY INTEREST

Standard / Project	Subject	Status	D #	Industry			
				P	A	I	M
P802.1AS-Rev	Time synchronization	TG	4.2				
802.1Qbu	Frame Preemption	Published					
802.1Qbv	Scheduled Traffic	Published					
802.1Qca	IS-IS Path Control & Rsv	Published					
P802.1Qcc	SRP Enhancements	WG	1.1				
P802.1Qch	Cyclic Queuing	WG recirc	1.1				
P802.1Qci	Per-Stream Filtering	Sponsor	2.0				
P802.1Qcj	Auto-attach to PBB	Editor	0.1				
P802.1Qcp	YANG	TG	0.6				
P802.1Qcr	Asynchronous Shaping	Editor					
P802.1CB	Frame Repl. & Elimin.	Sponsor	2.6				
P802.1CM	TSN for Fronthaul	TG	0.5				
P802.1CS	LRP (Registration)	PAR					

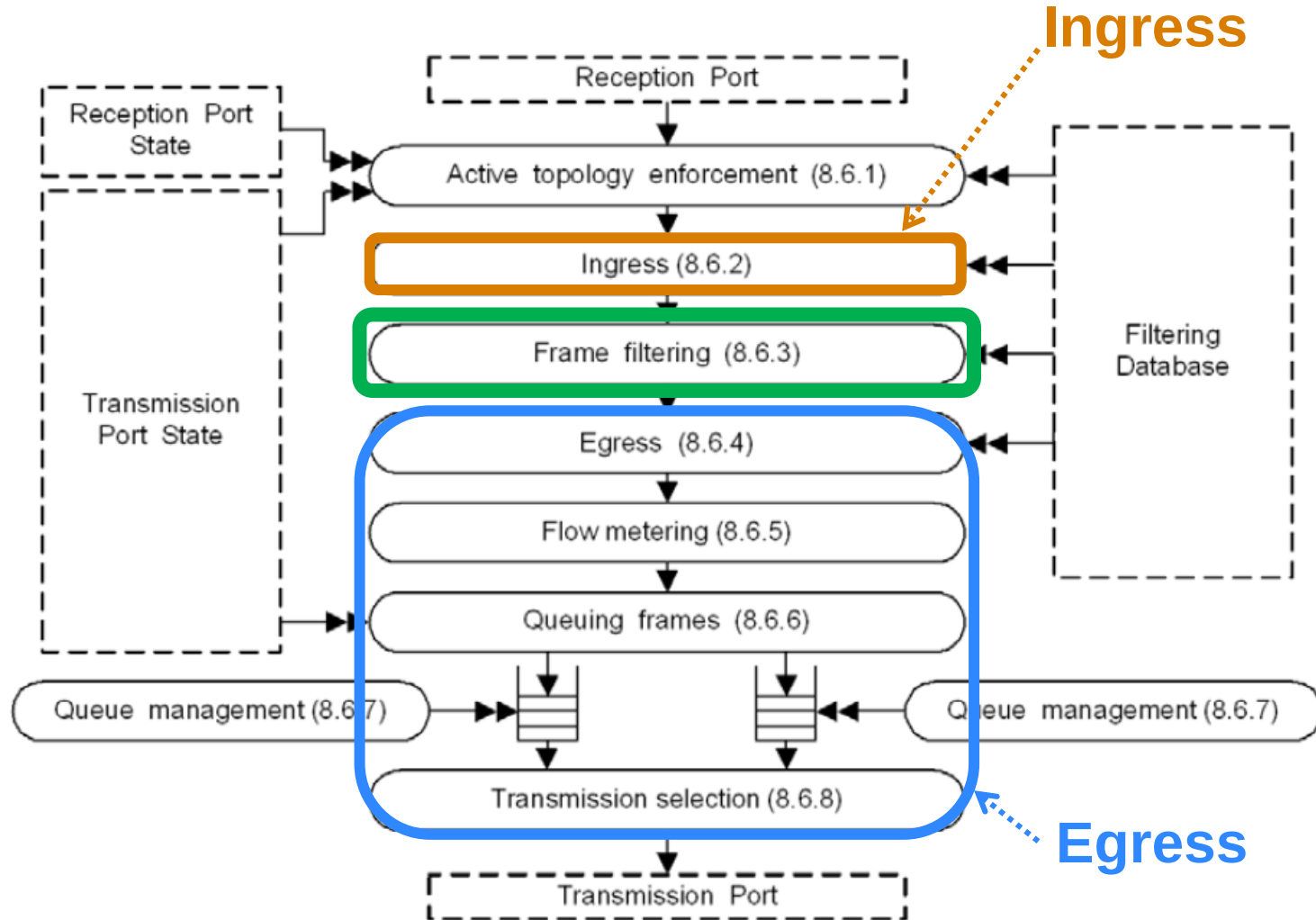
M: Mobile
I: Industrial
A: Automotive
P: pro A/V

P802.1AS-REV – TIMING AND SYNCHRONIZATION

- › 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)



LOOKOUT – FORWARDING PROCESS IN 802.1Q

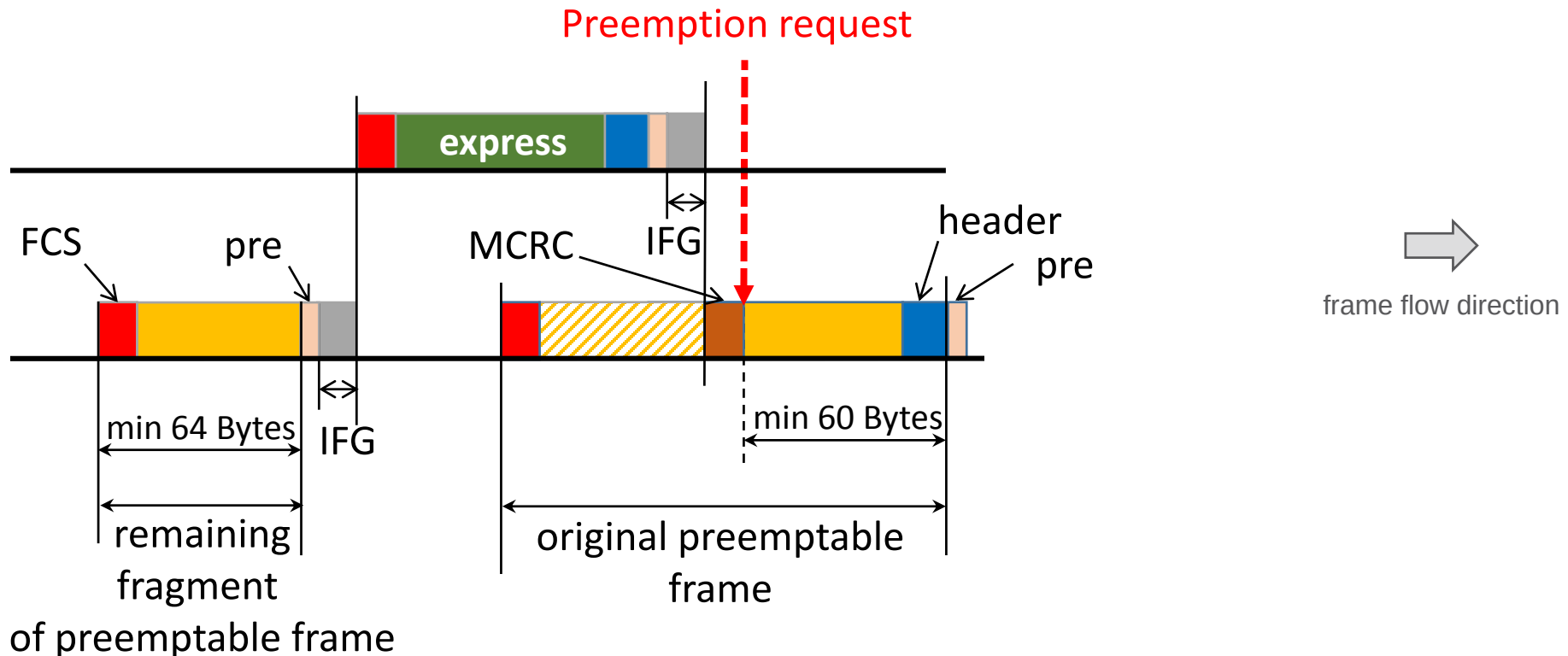


› We will refer to it very soon

802.3br

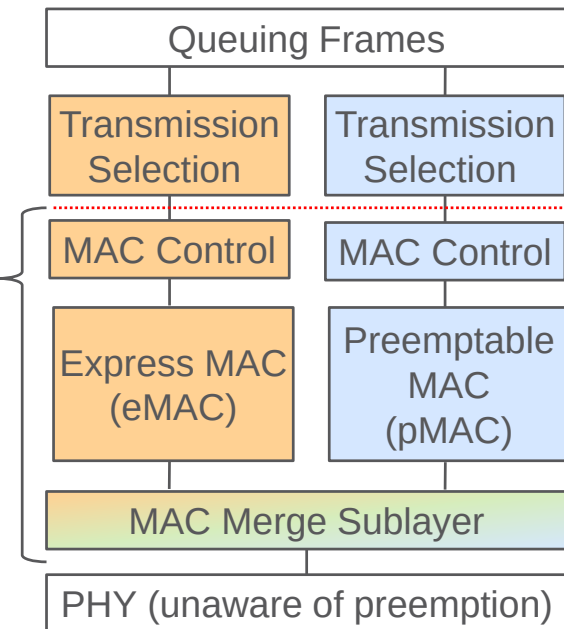
INTERSPERSING EXPRESS TRAFFIC (FRAME PREEMPTION) – ILLUSTRATION

- Express frames can suspend the transmission of preemptable frames



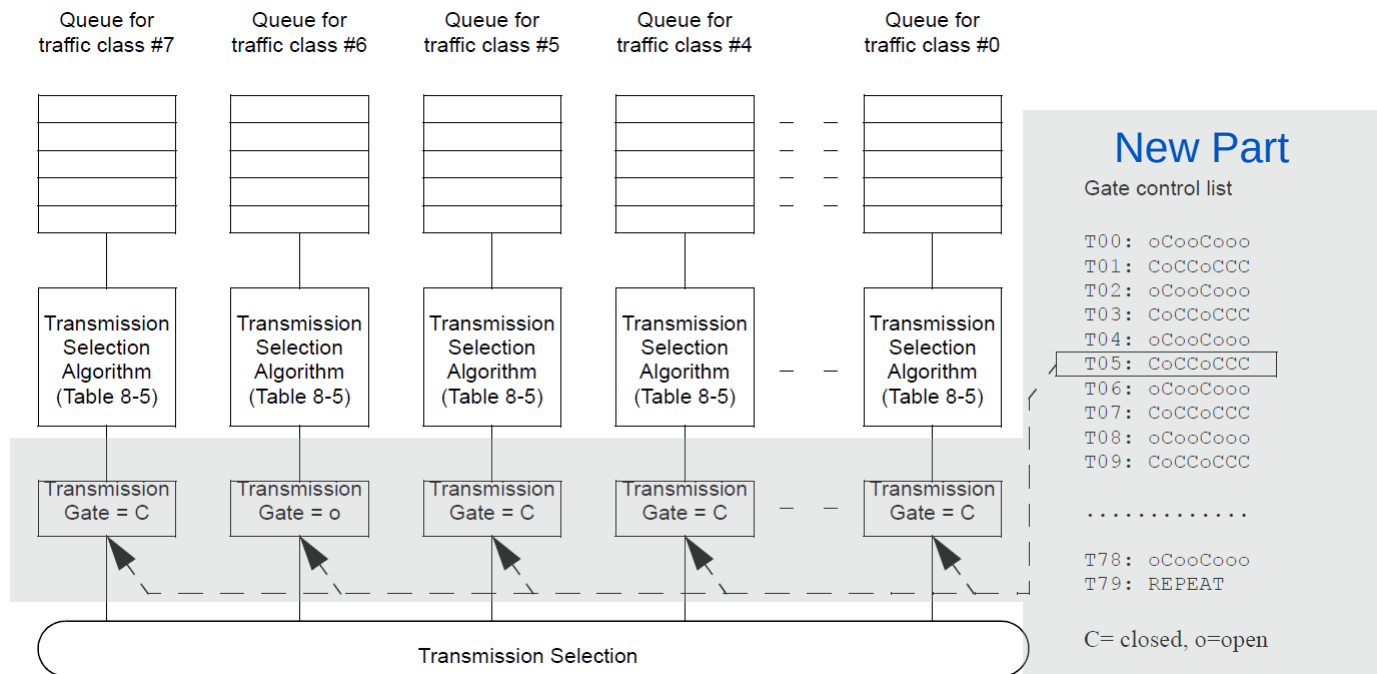
FRAME PREEMPTION / INTERSPERSING EXPRESS TRAFFIC

- › Time-critical frames can suspend the transmission of non-time-critical frames while one or more time-critical frames are transmitted
- › Specified by
 2. 802.1Qbu – Frame Preemption
 1. 802.3br – Interspersing Express Traffic (IET)
- › 802.1Qbu makes the adjustments needed in 802.1Q in order to support 802.3br, e.g.
 - each traffic class queue supported by the Port is assigned a value of frame preemption status
 - the possible values of frame preemption status are *express* or *preemptable*
- › Minimum fragment size is 64 bytes including CRC

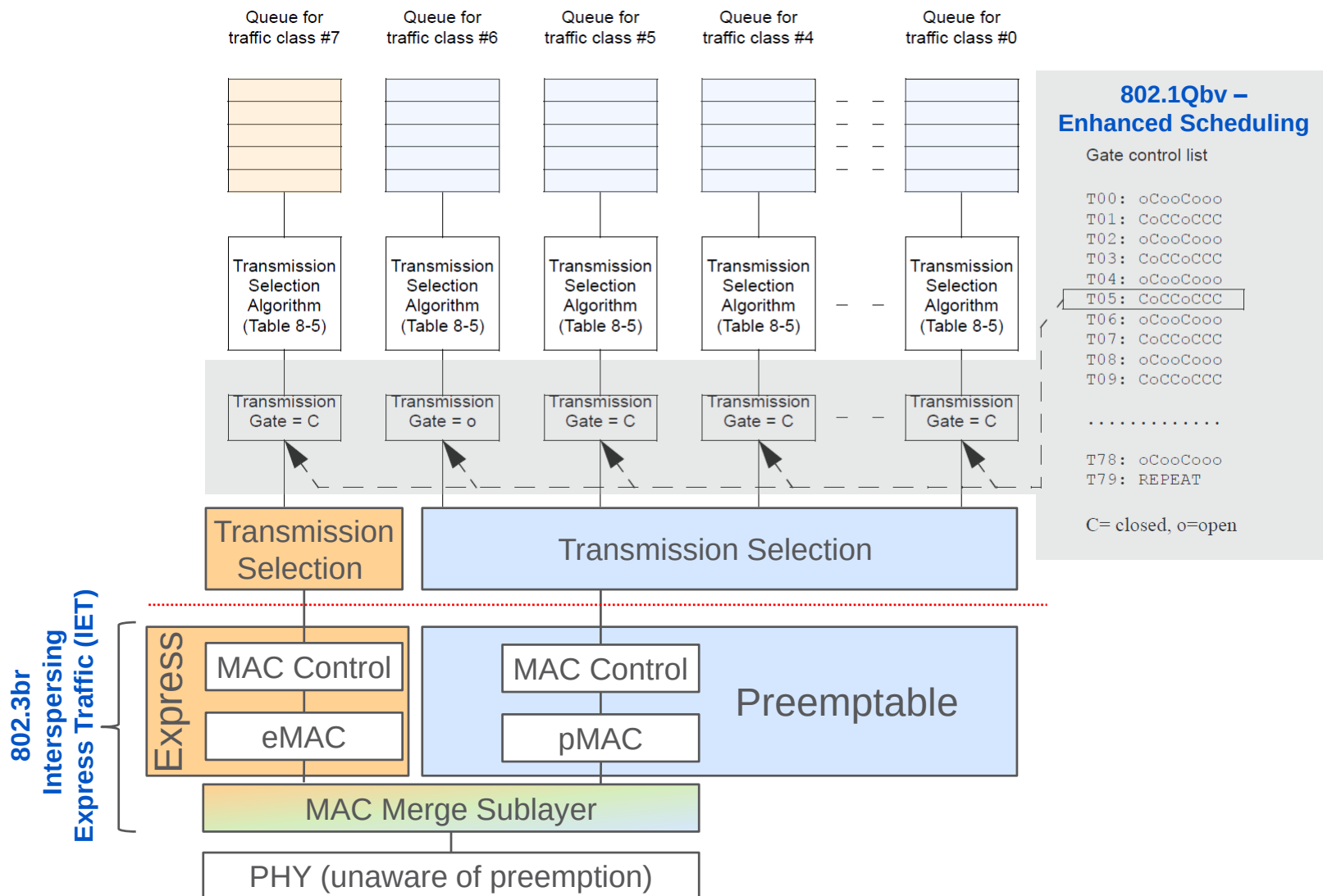


802.1Qbv – ENHANCEMENTS FOR SCHEDULED TRAFFIC

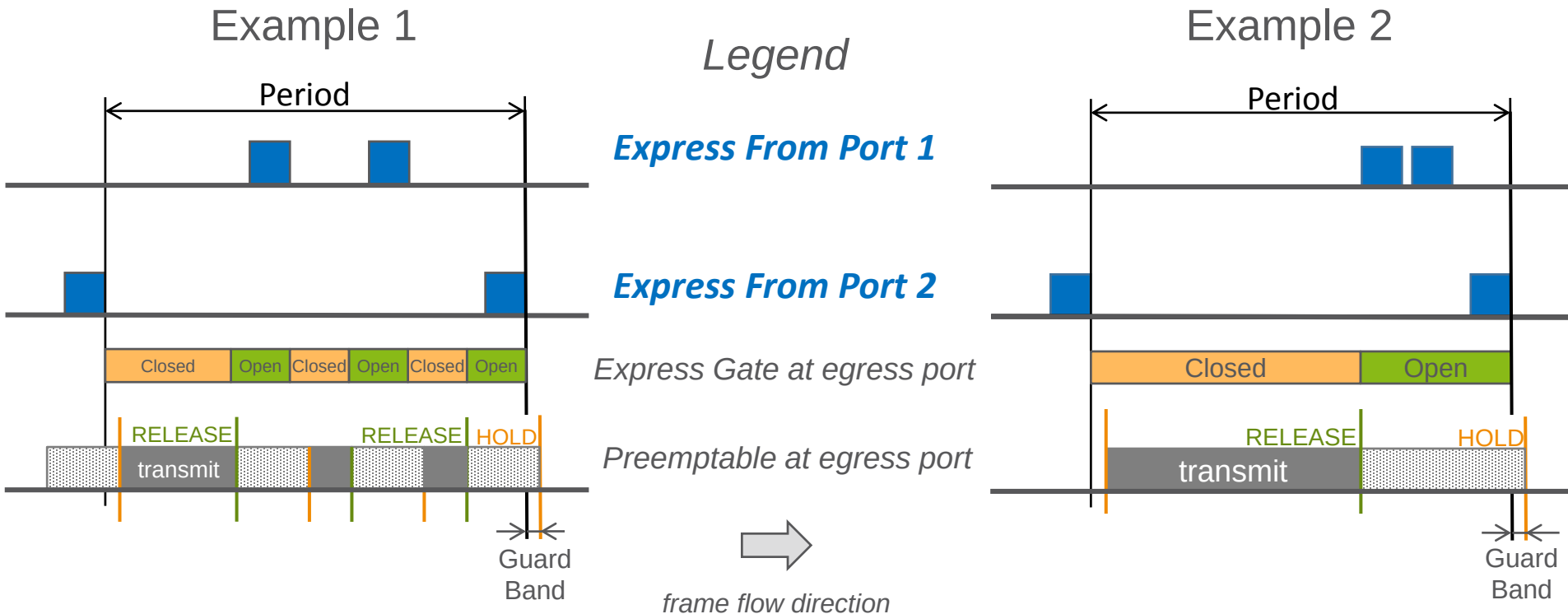
- › Transmission from each queue to be scheduled relative to a known timescale
- › A transmission gate is associated with each queue
 - the state of the gate determines whether or not queued frames can be selected for transmission
 - Open: queued frames are selected for transmission, (according to the transmission selection algorithm associated with the queue)
 - Closed: queued frames are not selected for transmission



PREEMPTION AND ENHANCED SCHEDULING – OVERVIEW



FRAME PREEMPTION AND ENHANCEMENTS FOR SCHEDULED TRAFFIC WITH GUARD BAND



- › Guard band can protect the express traffic completely from interference from preemptable traffic

P802.1Qci – 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

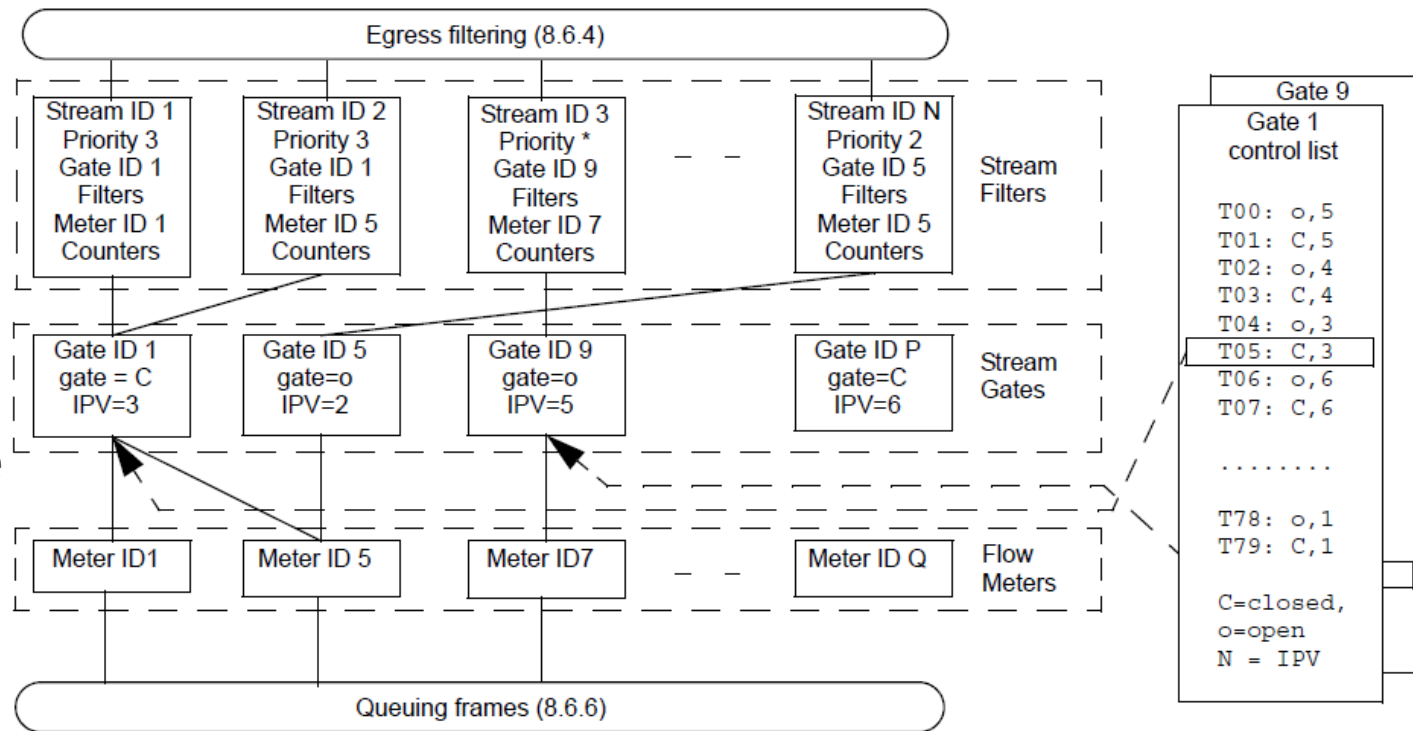
- Stream ID
- Priority
- Filters
- Meter ID
- Counters

- › Stream gate

- open (o)
- Closed (C)

- › Flow meter

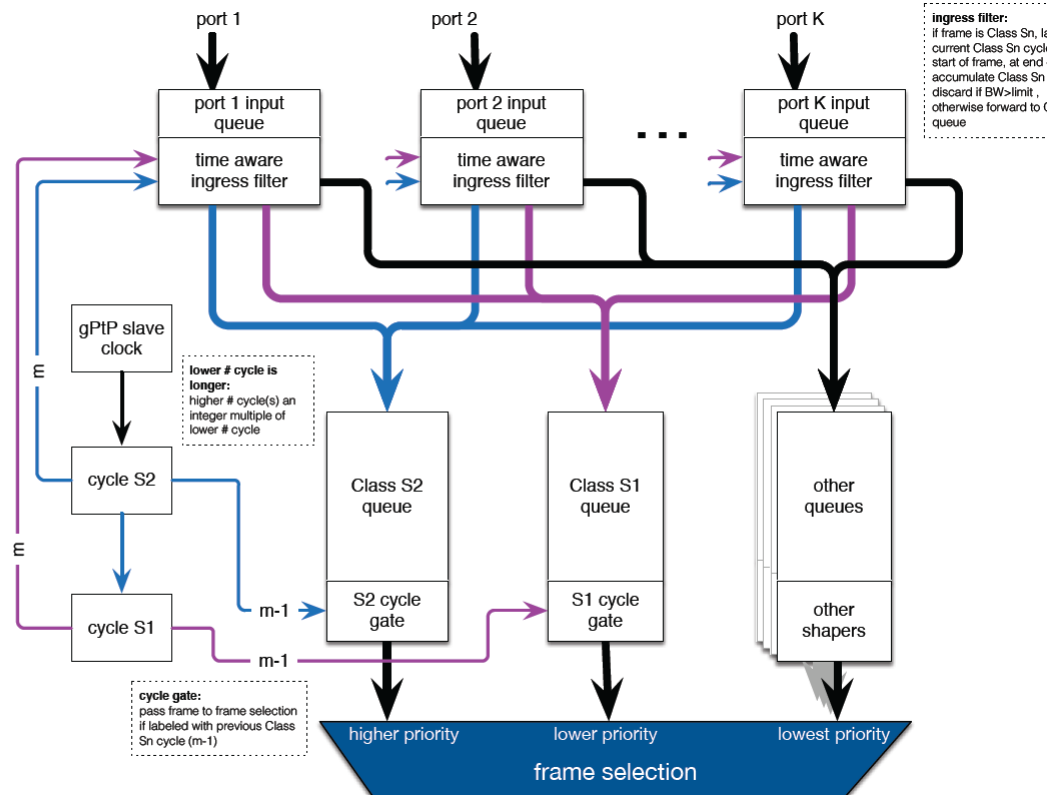
- Parameters as specified in Bandwidth Profile Parameters and Algorithm in MEF 10.3, plus some additional parameters



P802.1Qch – CYCLIC QUEUEING AND FORWARDING (CQF)

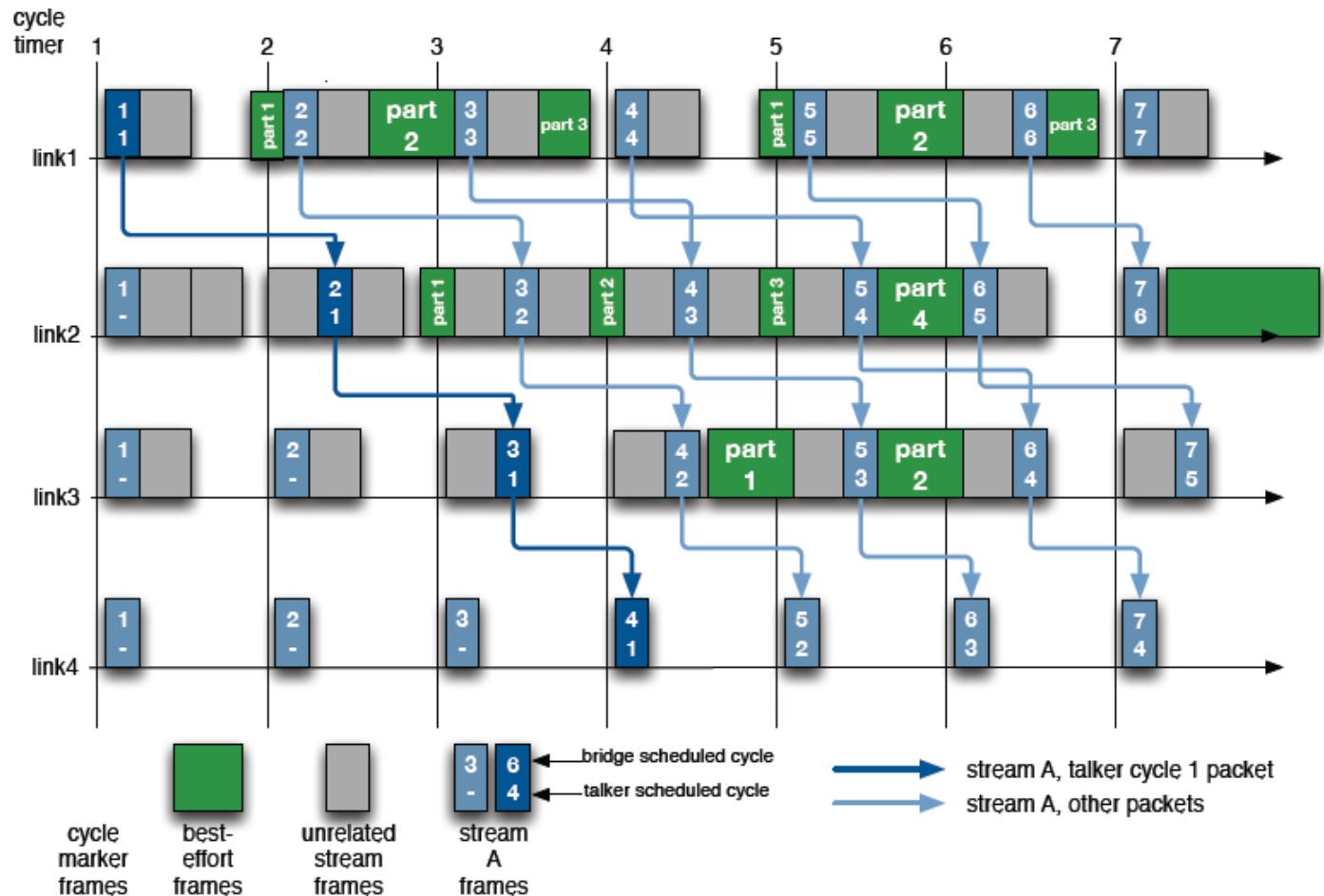
- › Synchronized cyclic enqueueing and queue draining achieve zero congestion loss and deterministic latency
 - › Two buffers served alternated, e.g., that of S1 and S2
 - › To be combined with frame preemption, see next slide
-
- The diagram illustrates a multi-queue system with K ports. Each port i (e.g., port 1, port 2, ..., port K) has an input queue and a time-aware ingress filter. The ingress filters are connected in a cyclic manner, where the output of the filter for port i is connected to the input queue of port $i+1$. This setup ensures that frames are served in a synchronized cyclic manner, achieving zero congestion loss and deterministic latency. A legend on the right defines the ingress filter logic: if the frame is Class S_n , it starts the current Class S_n cycle; at the end of the frame, it accumulates Class S_n ; it discards Class S_n if the bandwidth limit is reached; otherwise, it forwards the frame to the queue.

Example bridge with two delay classes, S1 and S2



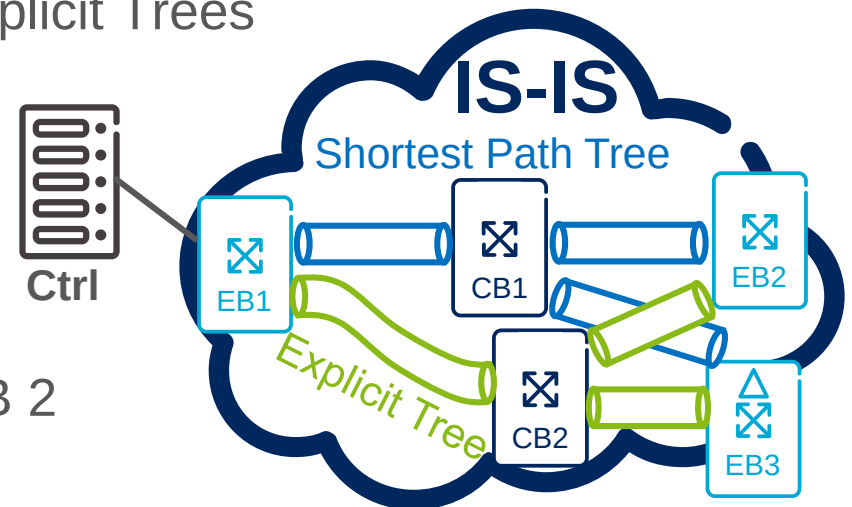
P802.1Qch – CYCLIC QUEUEING AND FORWARDING WITH FRAME PREEMPTION

- › Each frame of a Stream stays one cycle at each hop



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



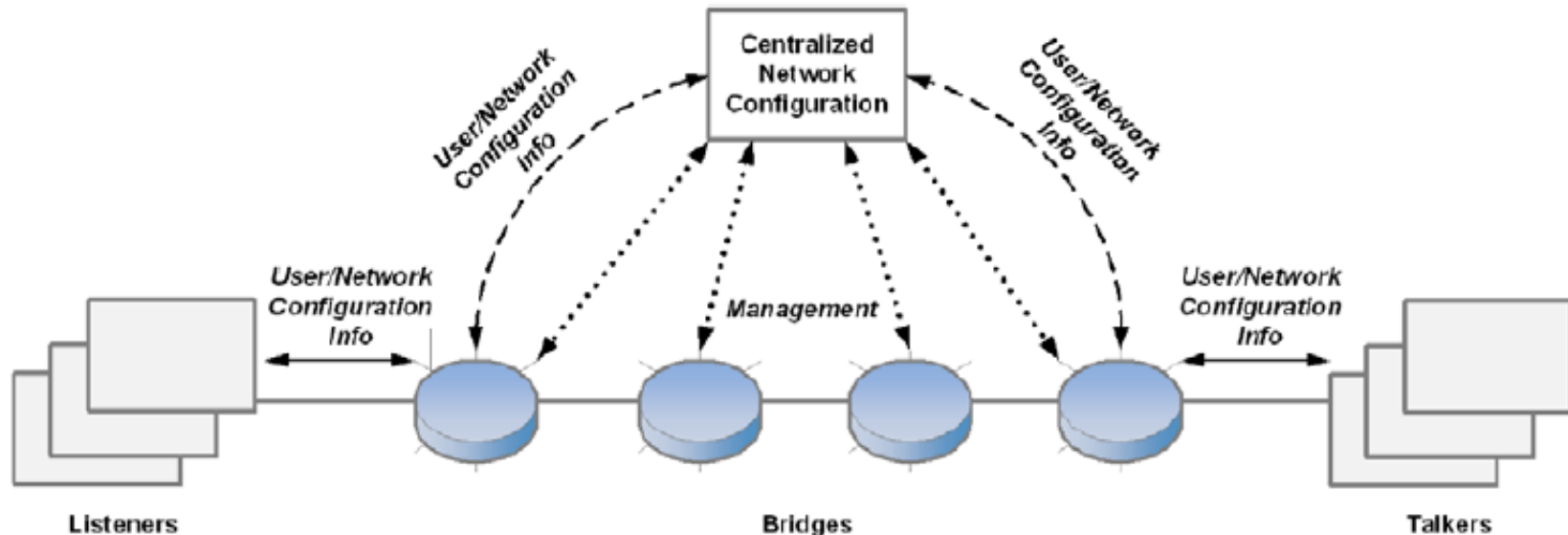
P802.1Qcc – STREAM RESERVATION PROTOCOL (SRP) ENHANCEMENTS

› SRP enhancements

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

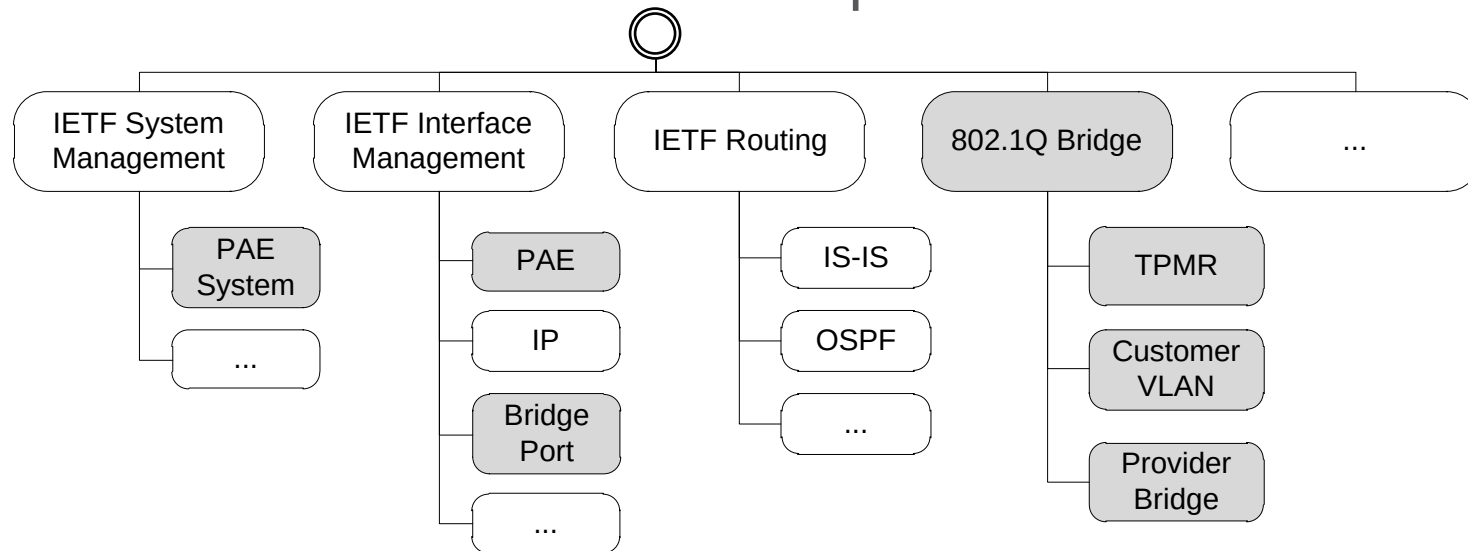
› TSN configuration

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



P802.1Qcp – YANG DATA MODEL

- › Scope: subset of 802.1Q features
- › Model representation via UML
- › YANG structure and relationships



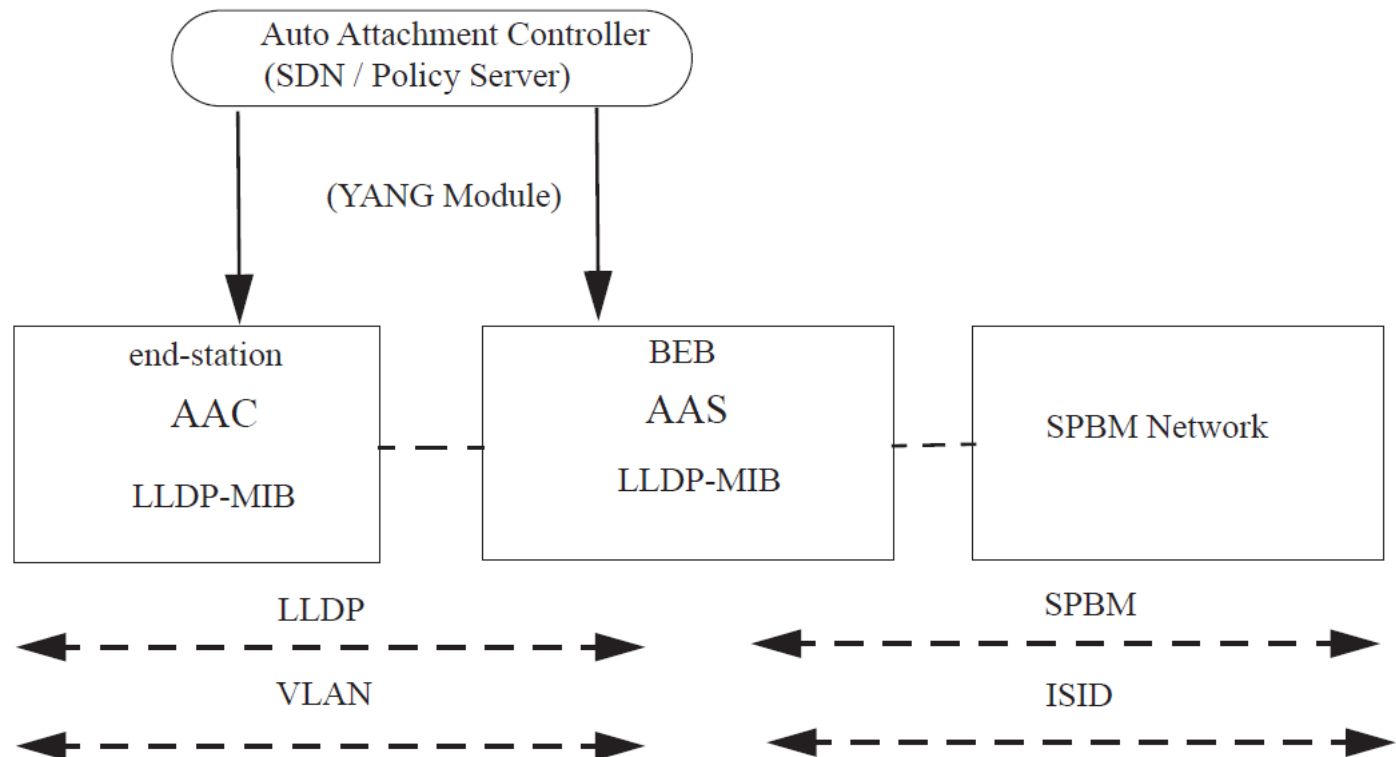
- › GitHub as a repository

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

P802.1Qcj – AUTO-ATTACH TO PBB SERVICES

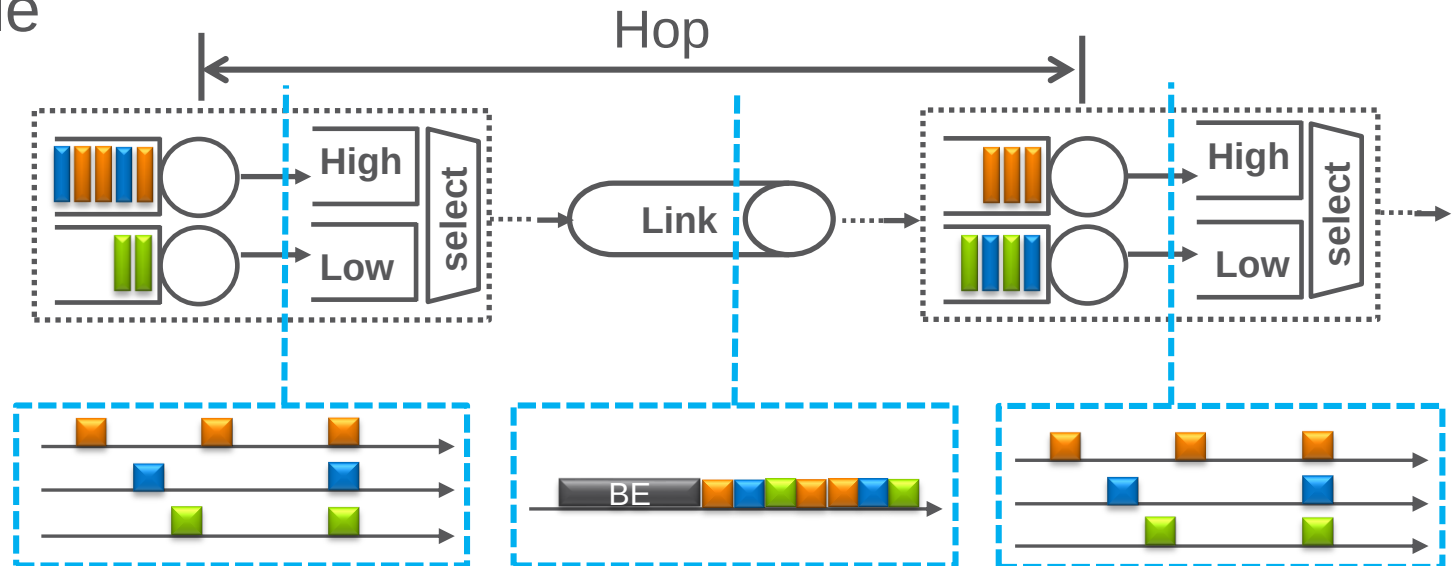
› Auto Attach Model

- 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)*

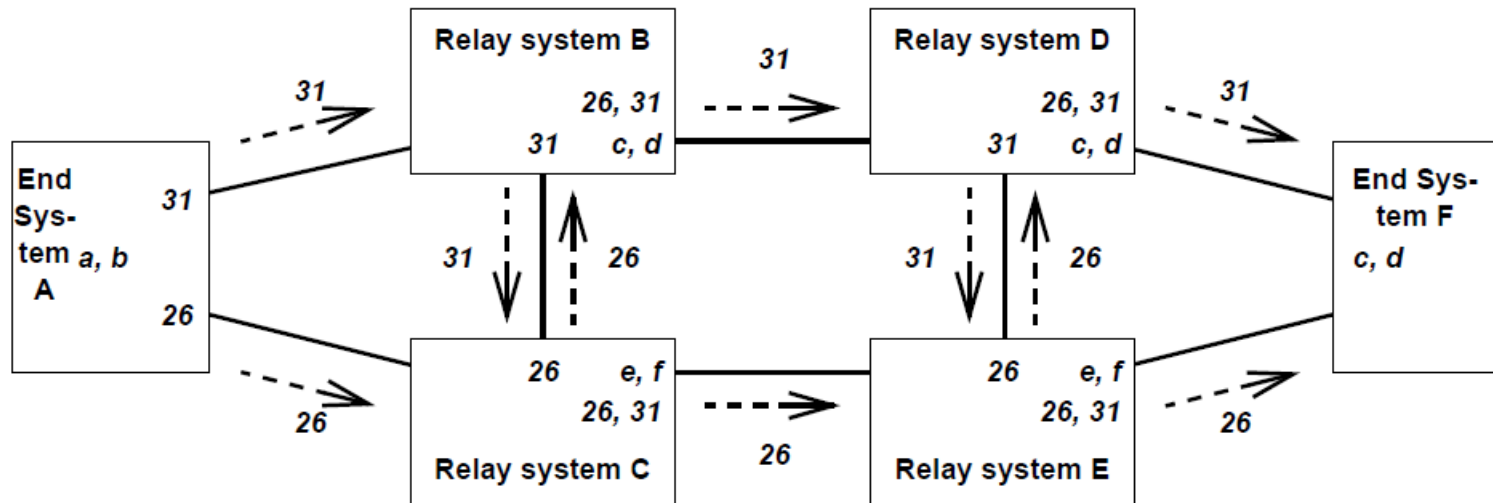
- › Asynchronous: no time synchronization needed
- › Basic idea
 1. Smoothen traffic patterns by re-shaping per hop
 2. Prioritize urgent traffic over relaxed traffic
- › Example



* formerly referred to as Urgency Based Scheduler (UBS)

P802.1CB – FRAME REPLICATION AND ELIMINATION FOR RELIABILITY (FRER)

- › It is a per-packet 1+n redundancy
- › Serialize packets, send on 2 (or more) maximally disjoint paths, then combine and delete extras

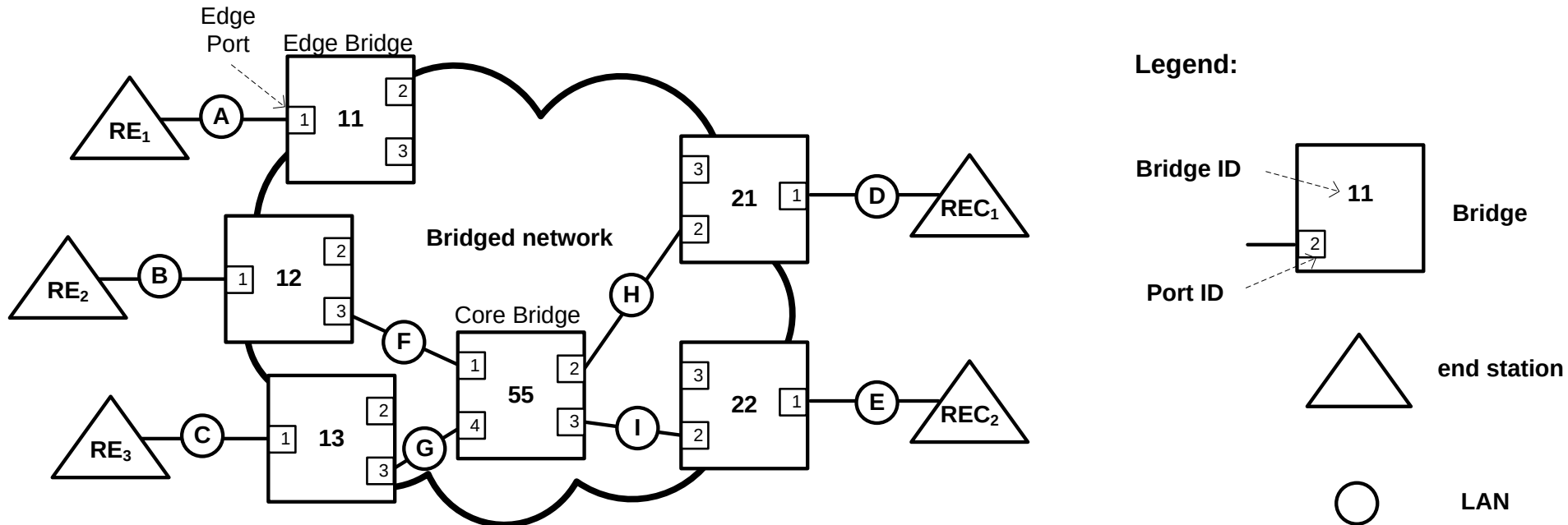


Key:

- a:** Add sequence numbers to Stream 31.
- b:** Split Stream 31 into Streams 26 and 31.
- c:** Merge Streams 26 and 31 into Stream 31.
- d:** Eliminate duplicates on Stream 31.

- e:** Merge Streams 26 and 31 into Stream 26.
 - f:** Eliminate duplicates on Stream 26.
- Each system's output ports marked with Streams transmitted and functions performed.

P802.1CM – TSN FOR FRONTHAUL



- › Develop standard TSN Profiles for Fronthaul in order to enable the transport of Fronthaul streams in a bridged network
- › 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 separate from each other
- › Further profiles may be specified, e.g., for future RBS split

P802.1CM – TSN FOR FRONTHAUL – CONT'D

- › A Profile is a set of feature and option selections that specifies aspects of bridge and end station operation, and states the conformance requirements for support of a specific class of user applications
- › 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

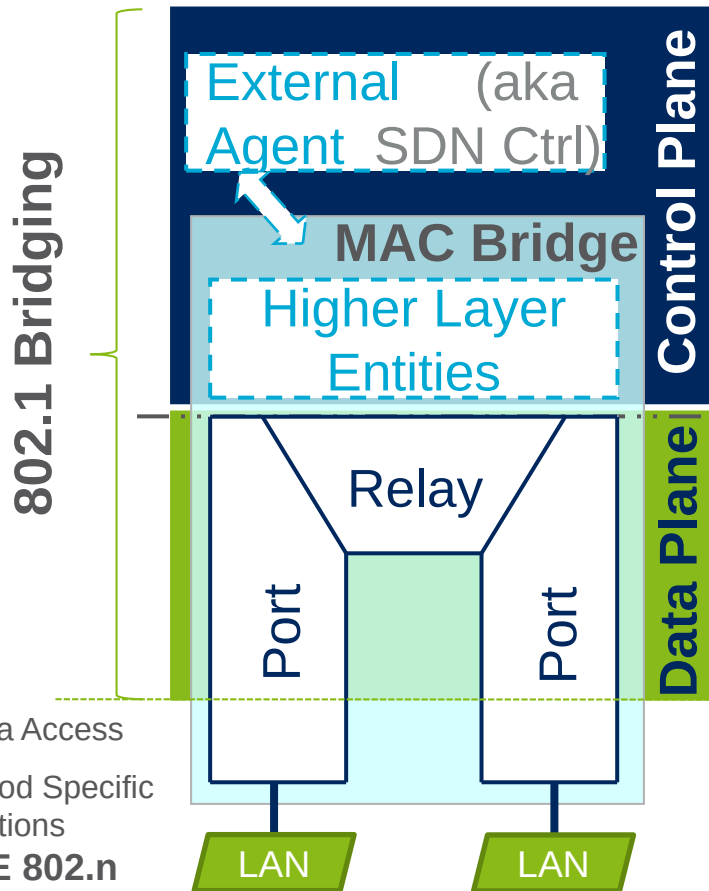
FURTHER READING

- › <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

BRIDGE ARCHITECTURE

CONTROL PLANE SEPARATED FROM DATA PLANE (BASIC SDN CHARACTERISTICS)

Simplified “baggy pants” model



- › Control protocols are implemented as Higher Layer Entities
- › External Agent may provide control instead of the distributed protocols

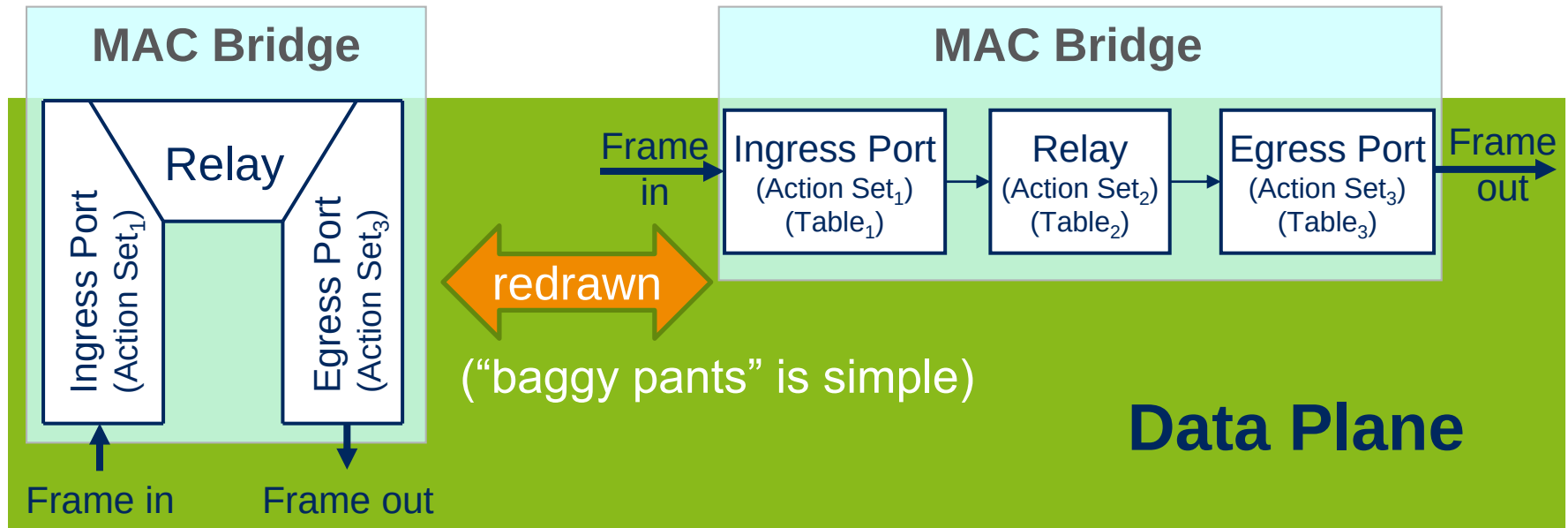
- › The data plane is comprised of
 - A MAC Relay and
 - At least two ports

Media Access
Method Specific
Functions
IEEE 802.n

e.g. 802.3
Ethernet

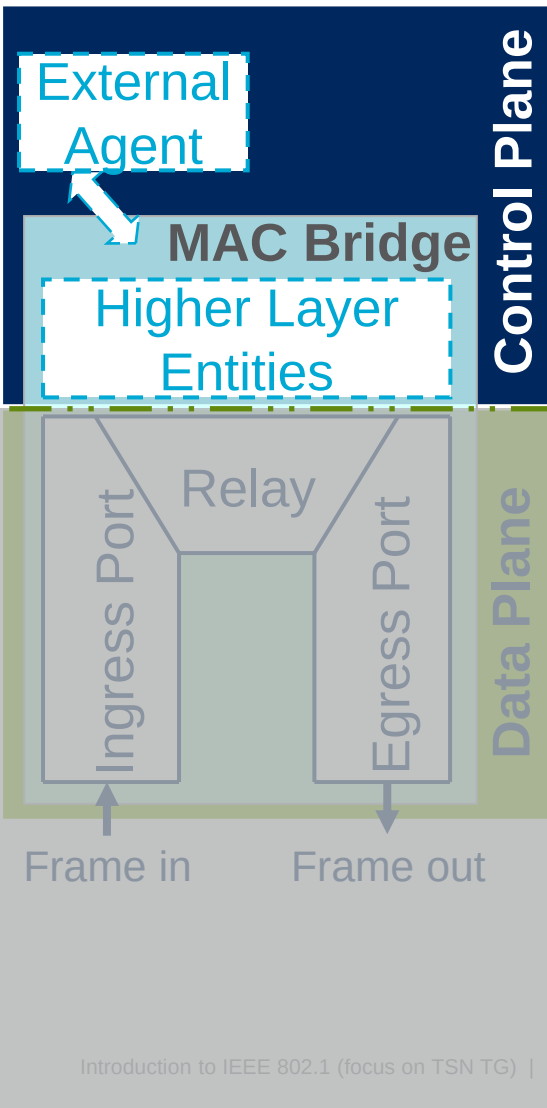
see Figure 8-2 – “VLAN-aware Bridge architecture” of 802.1Q for more details

DATA PLANE ACTIONS (IEEE 802.1Q-2014)



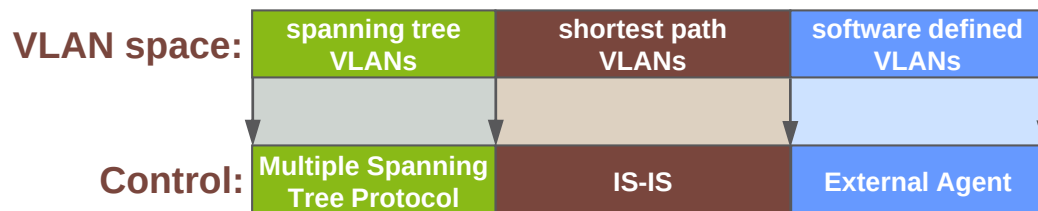
- › Ingress Port (Action Set1)
 - Filtering (drop), (un)tagging, VID translation, de/en-capsulation
- › Relay (Action Set2)
 - Forwarding, filtering
- › Egress Port (Action Set3)
 - Filtering, (un)tagging, VID translation, de/en-capsulation, metering, queuing, transmission selection

CONTROL PLANE OVERVIEW

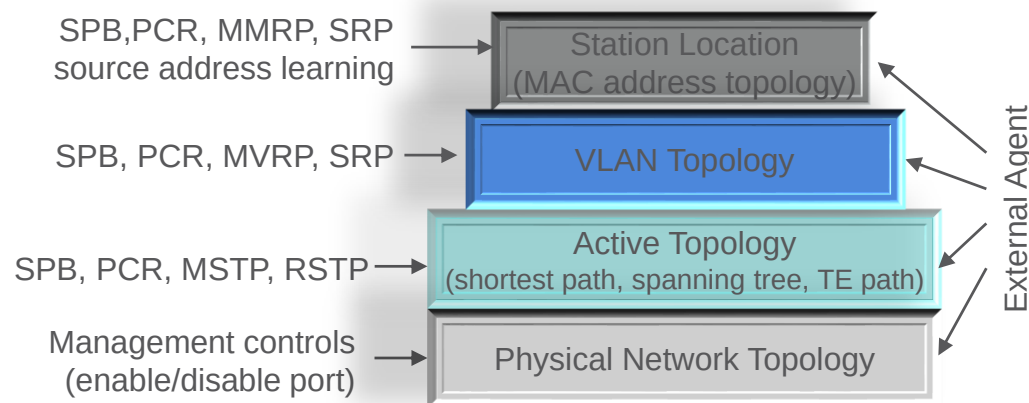


> A VLAN is assigned to a control mode

- Multiple control modes may co-exist in the same network
- Hybrid control by distributed protocols and an External Agent, e.g., an SDN controller
- External control can be a non-802.1 protocol: PCE, GMPLS



> Summary of control options



SEE YOU!