INTRODUCTION TO IEEE 802.1

Focus on the Time-Sensitive Networking Task Group

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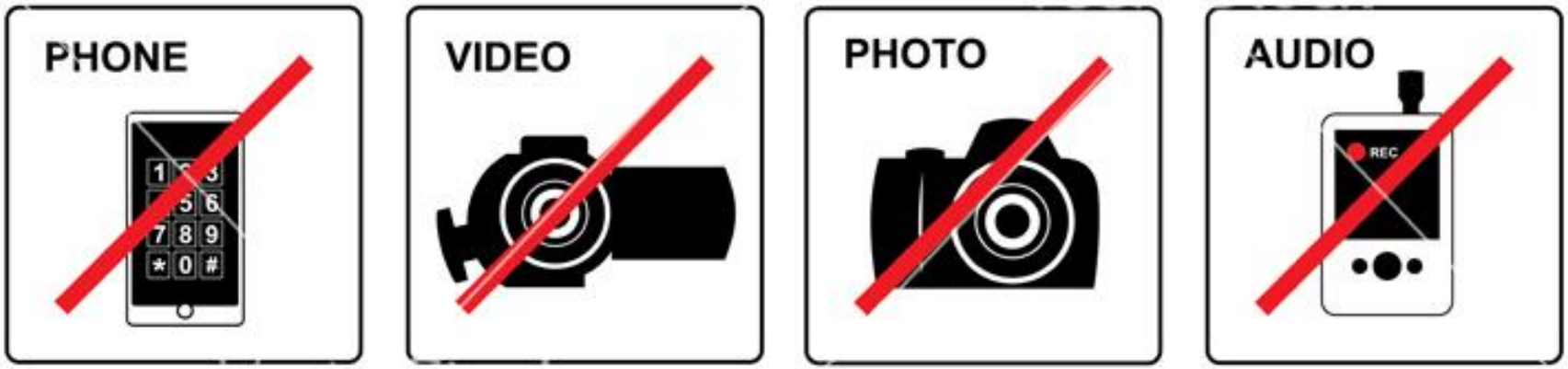
WELCOME!

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.

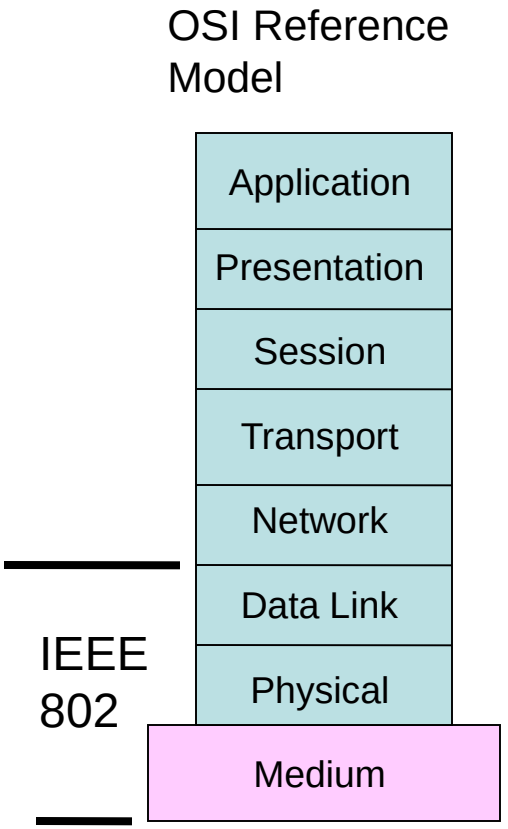
AGENDA

- 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

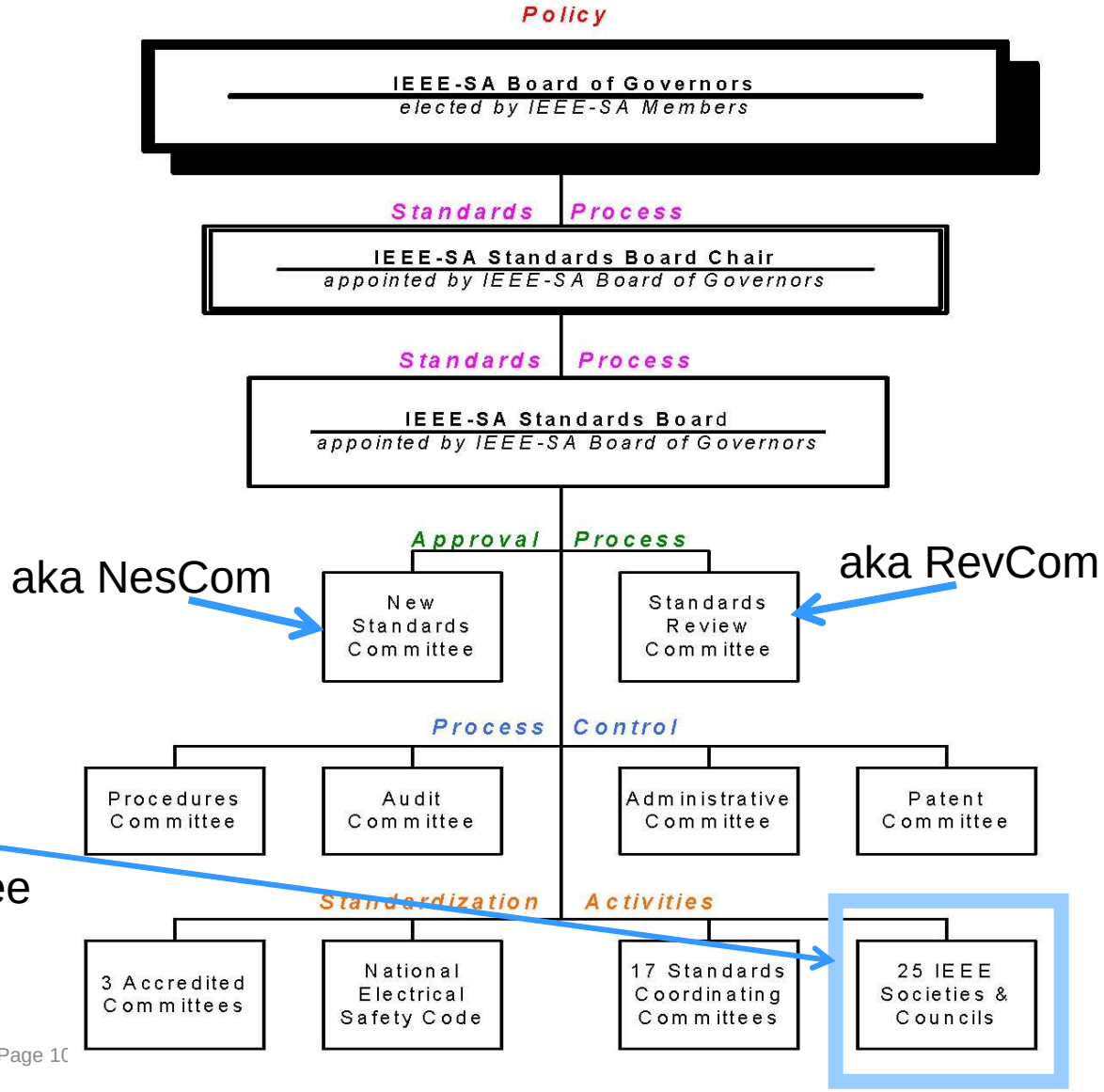
IEEE 802.1 OVERVIEW

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



IEEE 802 is here:
a standards committee formed by the Computer Society

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 ≥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

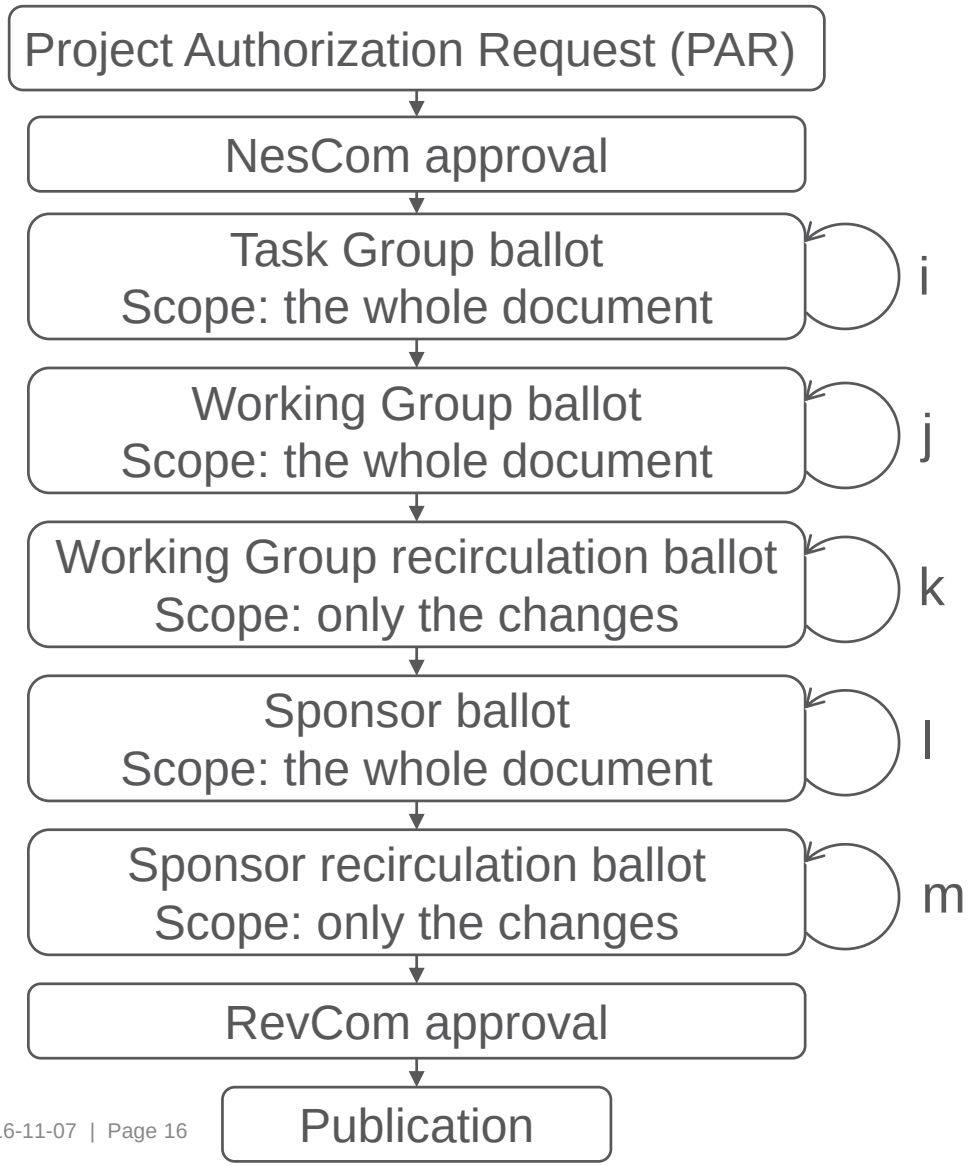
IEEE 802.1 WORKING GROUP

- 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 µs 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

related

- *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

STATUS & INDUSTRY INTEREST

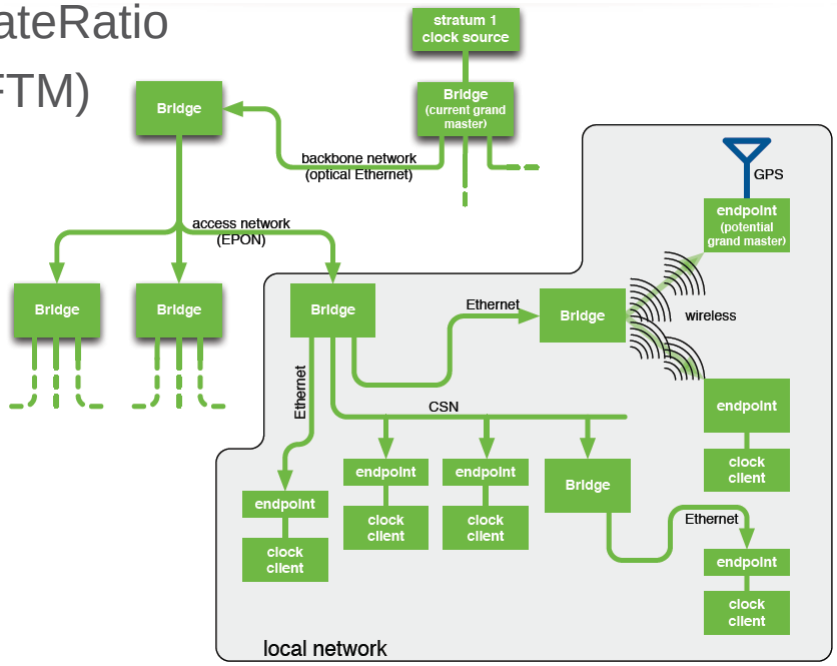
Standard / Project	Subject	Status	D #	Industry			
				P	A	I	M
P802.1AS-Rev	Time synchronization	TG	4.2				
802.1Qbu	Frame Preemption	Published					
802.1Qbv	Scheduled Traffic	Published					
802.1Qca	IS-IS Path Control & Rsv	Published					
P802.1Qcc	SRP Enhancements	WG	1.1				
P802.1Qch	Cyclic Queuing	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					

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

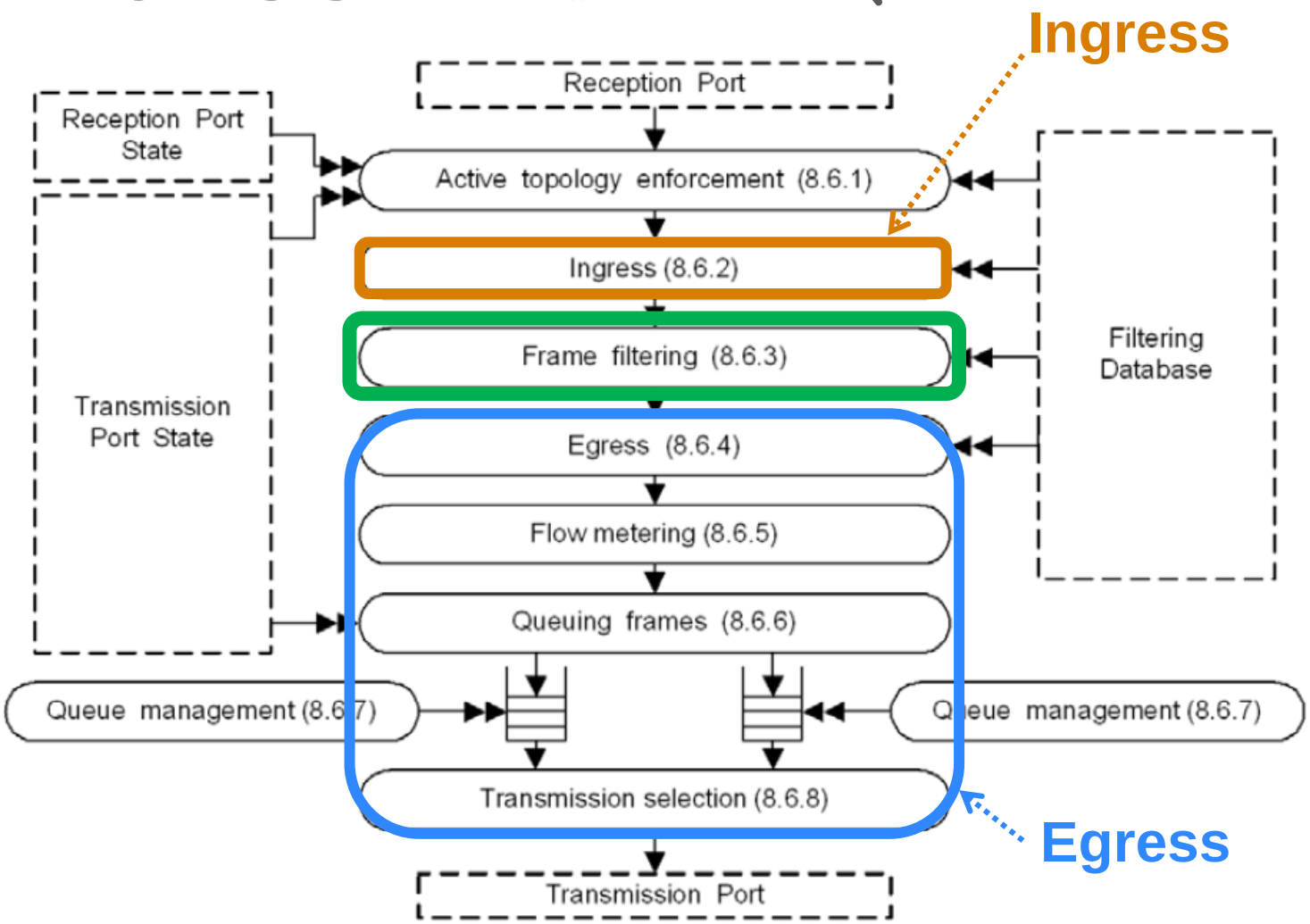
http://www.802tsn.org/home/project-list

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)



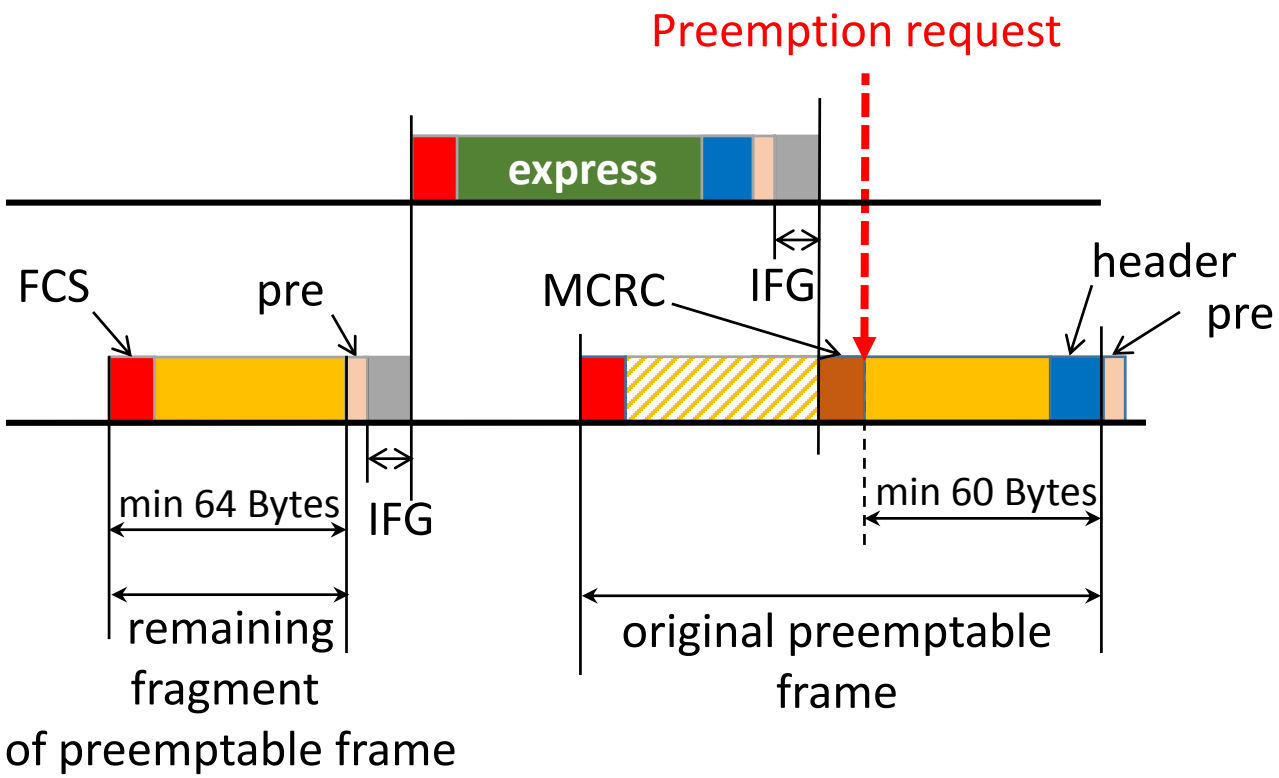
LOOKOUT – FORWARDING PROCESS IN 802.1Q



› We will refer to it very soon

802.3br INTERSPERSING EXPRESS TRAFFIC (FRAME PREEMPTION) – ILLUSTRATION

› Express frames can suspend the transmission of preemptable frames

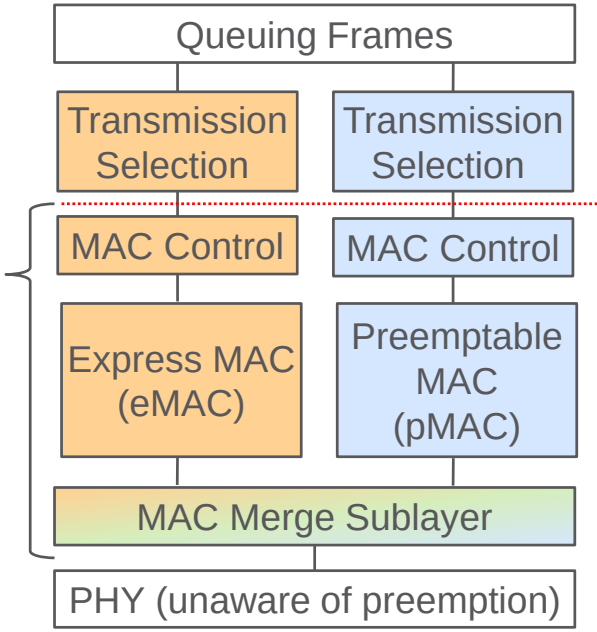


frame flow direction

pre includes Preamble and Start mPacket delimiter (SMD)

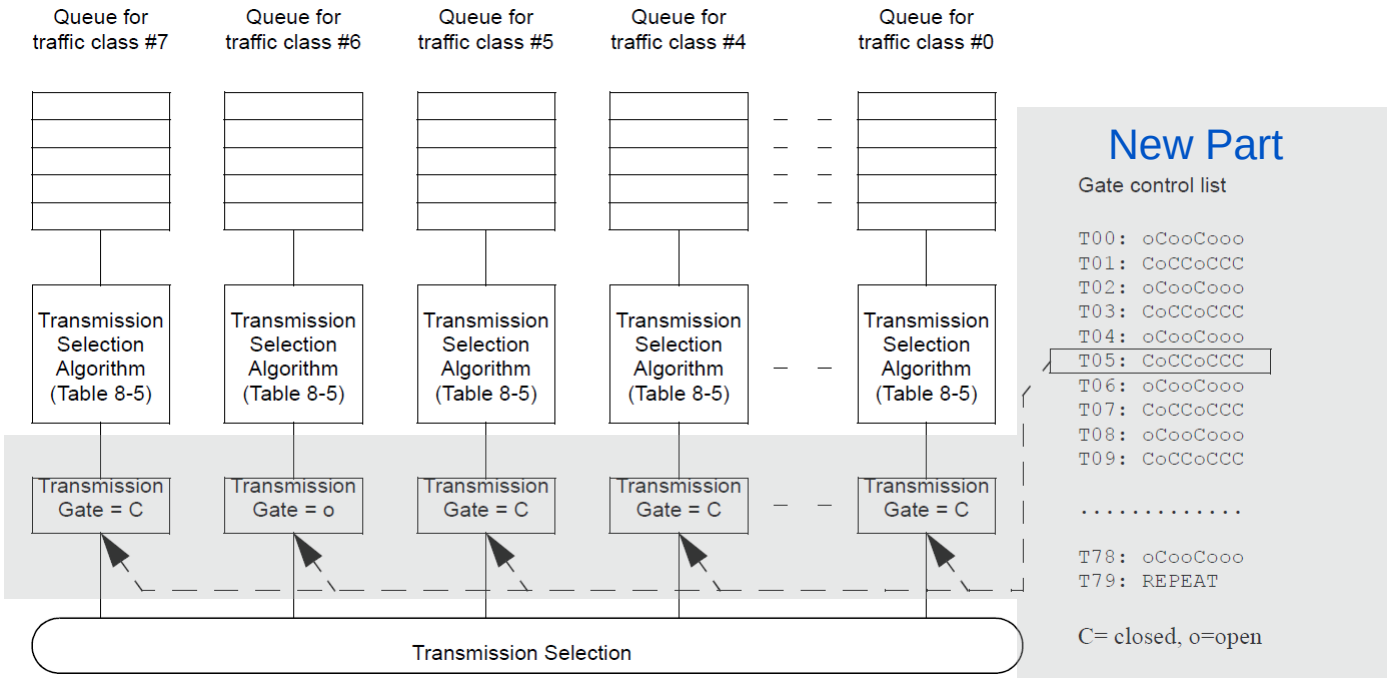
FRAME PREEMPTION / INTERSPERSING EXPRESS TRAFFIC

- 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

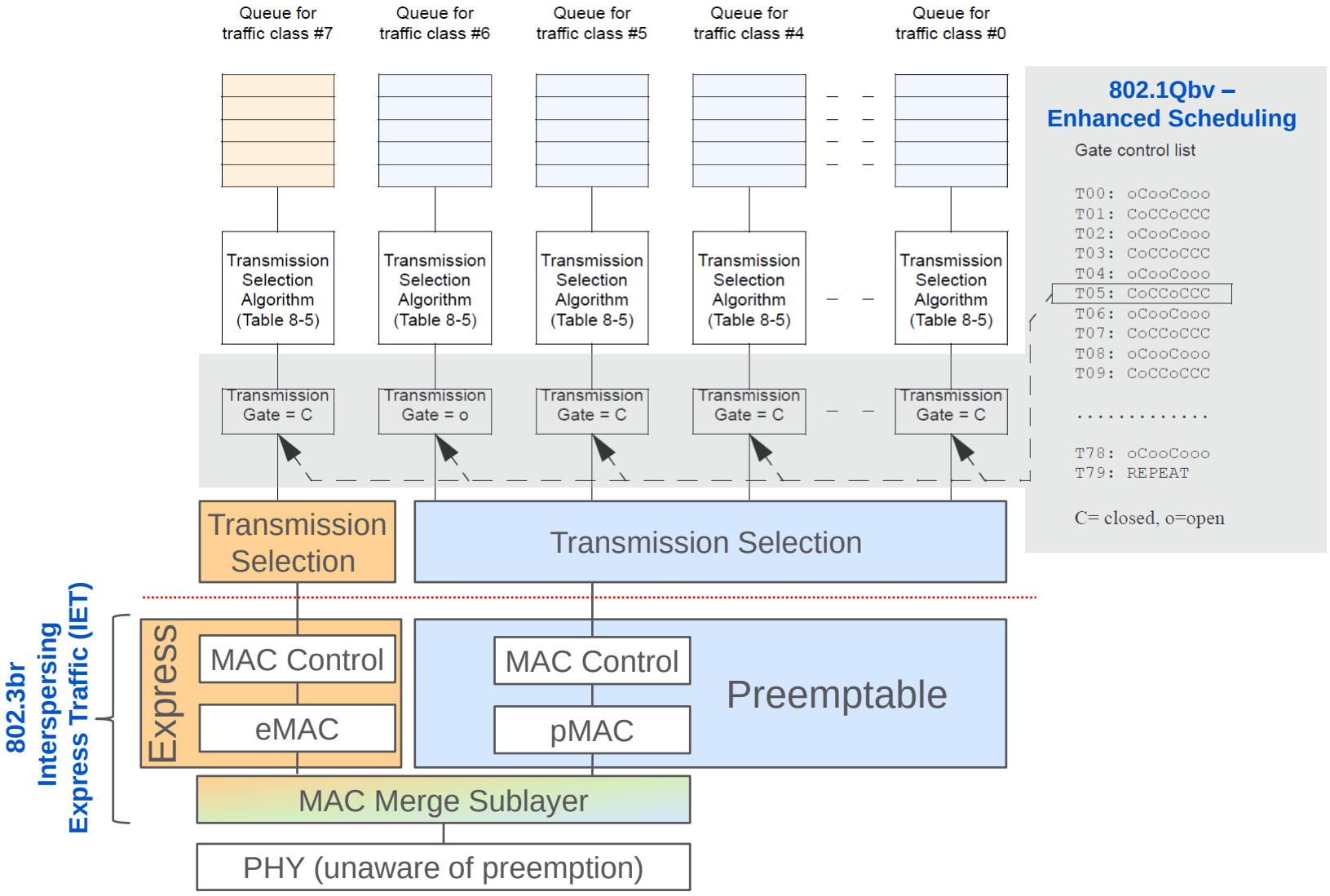


802.1Qbv – ENHANCEMENTS FOR SCHEDULED TRAFFIC

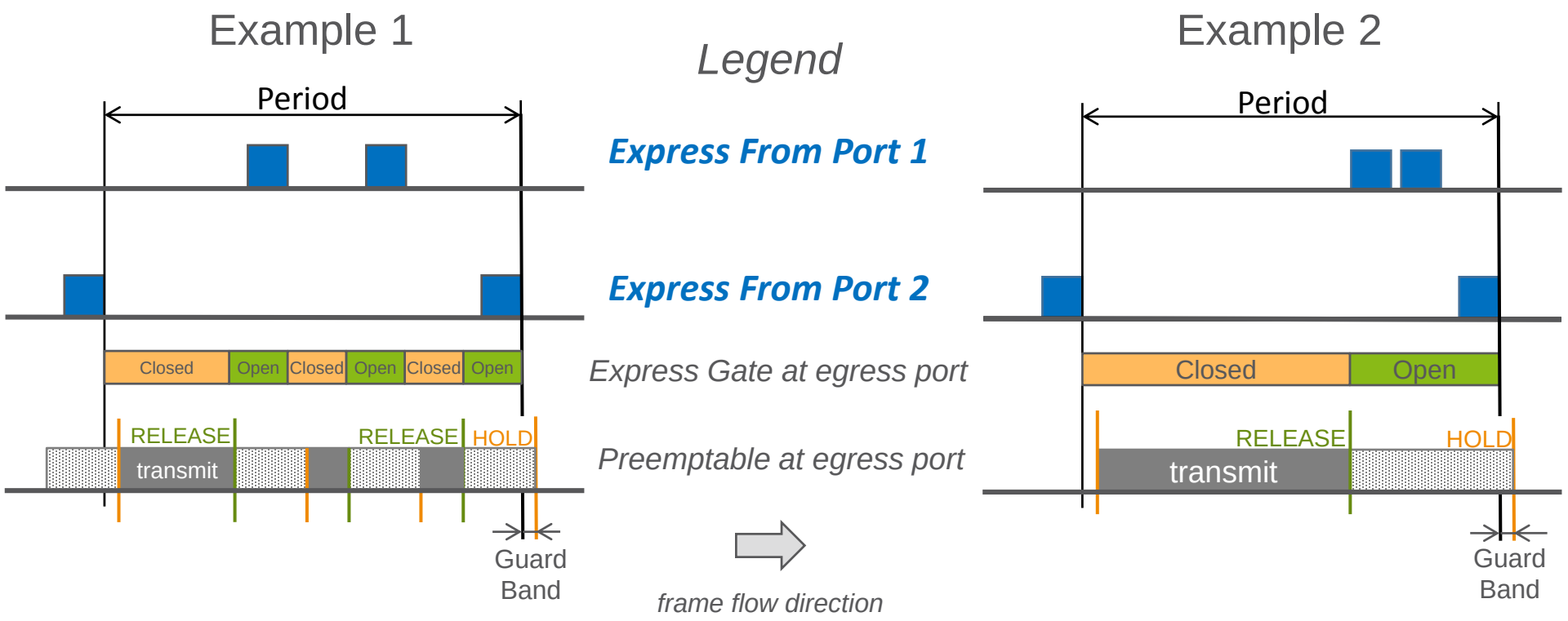
- Transmission from each queue to be scheduled relative to a known timescale
- A transmission gate is associated with each queue
  - the state of the gate determines whether or not queued frames can be selected for transmission
  - Open: queued frames are selected for transmission, (according to the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



PREEMPTION AND ENHANCED SCHEDULING – OVERVIEW



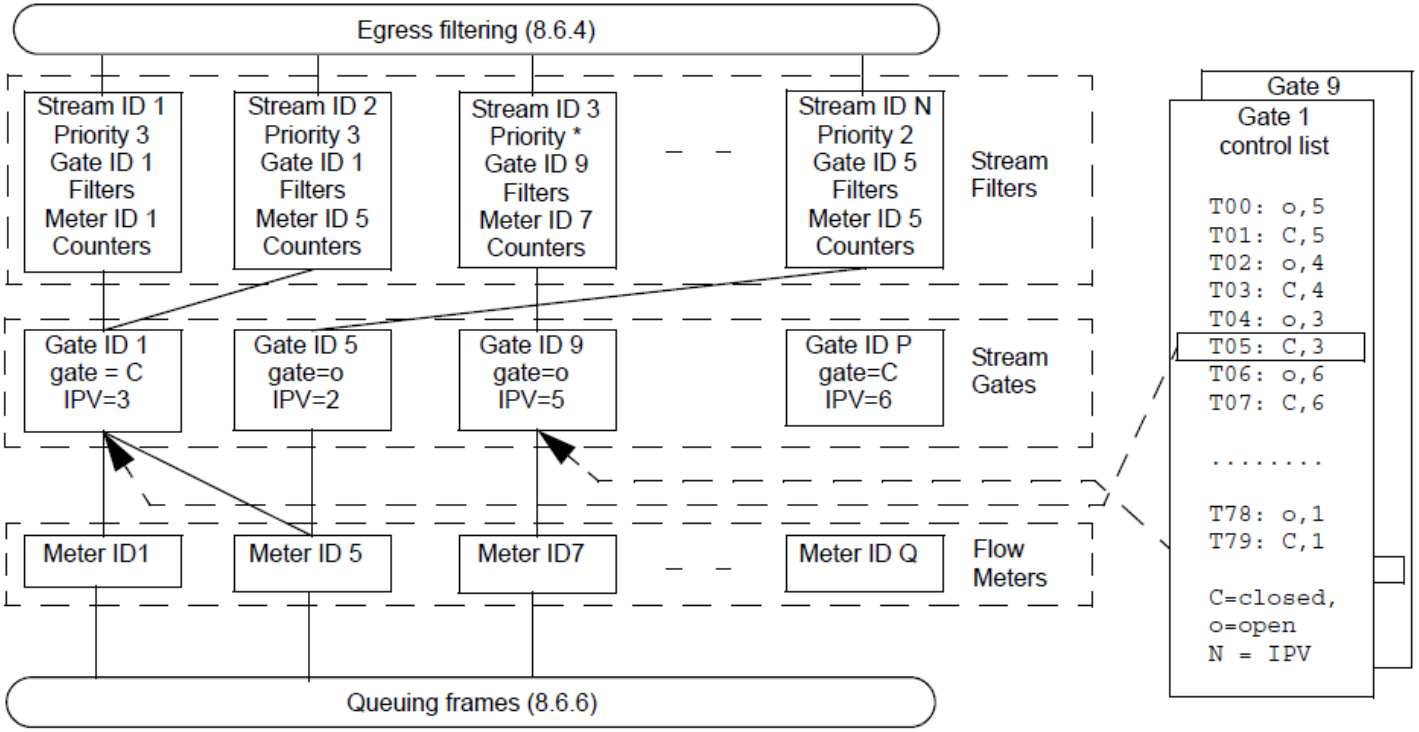
FRAME PREEMPTION AND ENHANCEMENTS FOR SCHEDULED TRAFFIC WITH GUARD BAND



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

P802.1Qci – PER STREAM FILTERING AND POLICING

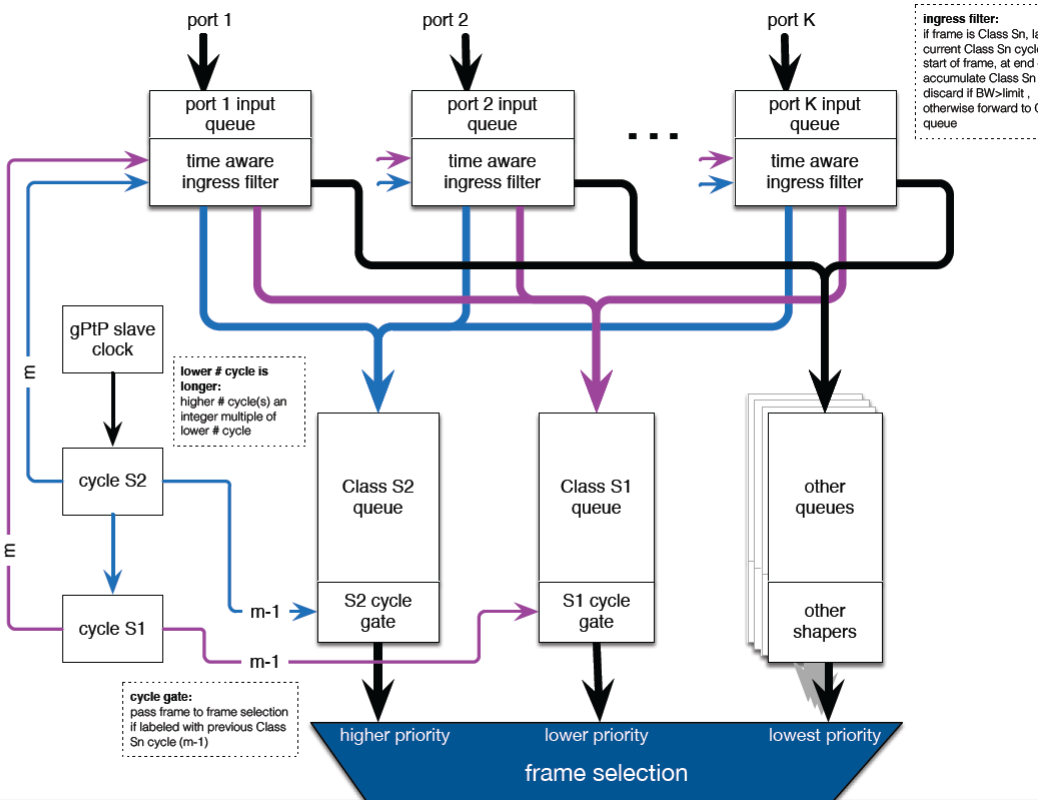
- Per-Stream Filtering and Policing (PSFP) allows filtering and policing decisions to be made on a per-stream basis
- Stream filter
  - Stream ID
  - Priority
  - Filters
  - Meter ID
  - Counters
- Stream gate
  - open (o)
  - Closed (C)
- Flow meter
  - Parameters as specified in Bandwidth Profile Parameters and Algorithm in MEF 10.3, plus some additional parameters



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

- Synchronized cyclic enqueuing 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

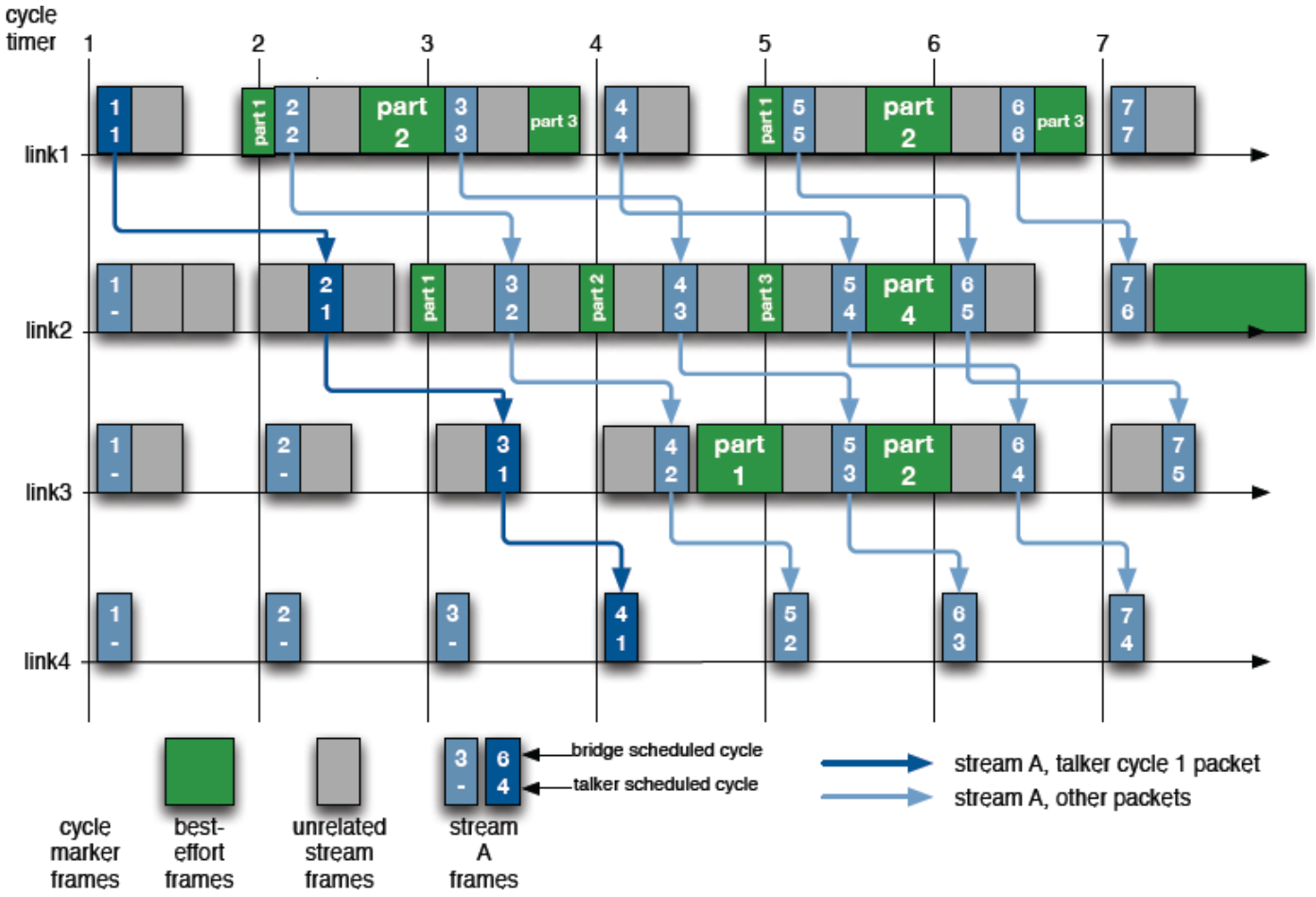
Example bridge with two delay classes, S1 and S2



 http://www.ieee802.org/1/files/public/docs2014/new-tsn-mjt-peristaltic-shaper-0114.pdf

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

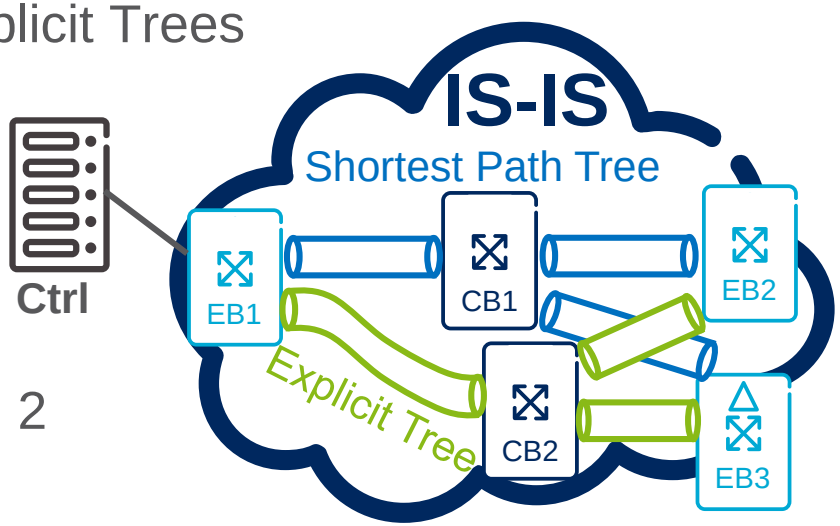
› Each frame of a Stream stays one cycle at each hop



 http://www.ieee802.org/1/files/public/docs2014/new-tsn-mjt-peristaltic-shaper-0114.pdf

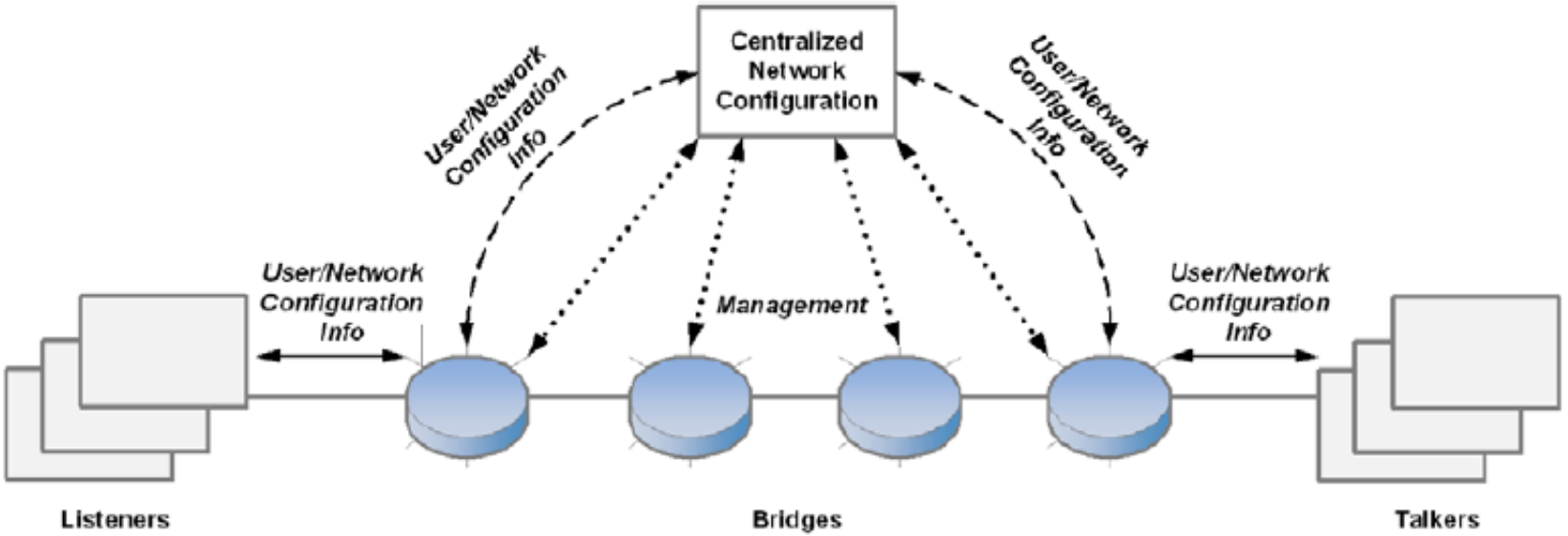
802.1Qca – IS-IS PATH CONTROL & RESERVATION

- 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



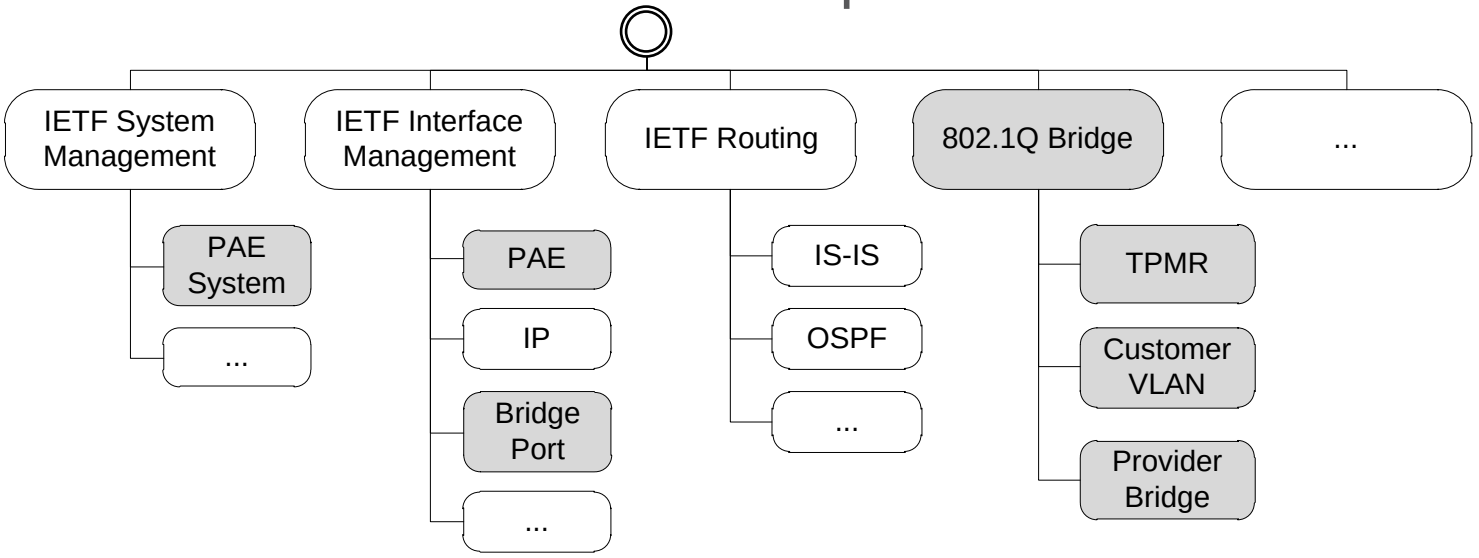
P802.1Qcc – STREAM RESERVATION PROTOCOL (SRP) ENHANCEMENTS

- 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

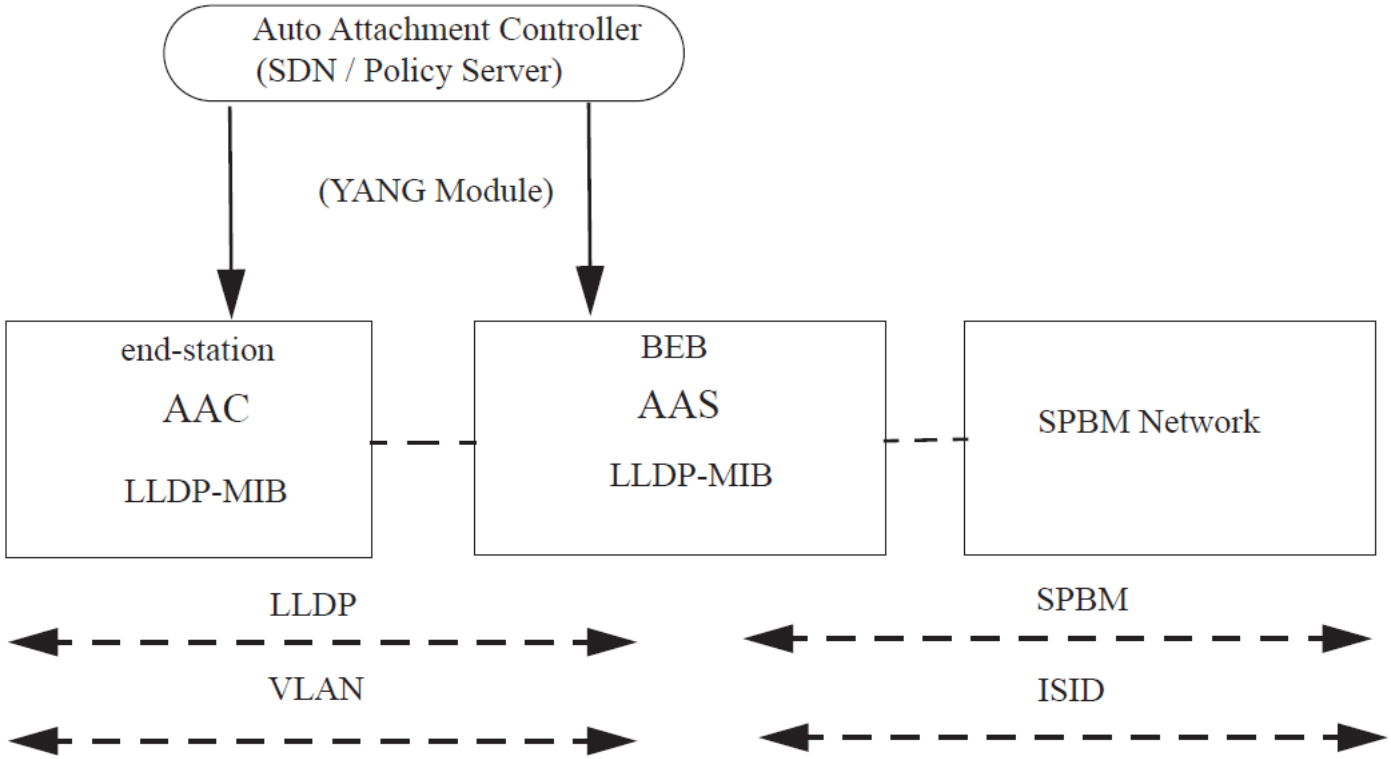


- GitHub as a repository

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

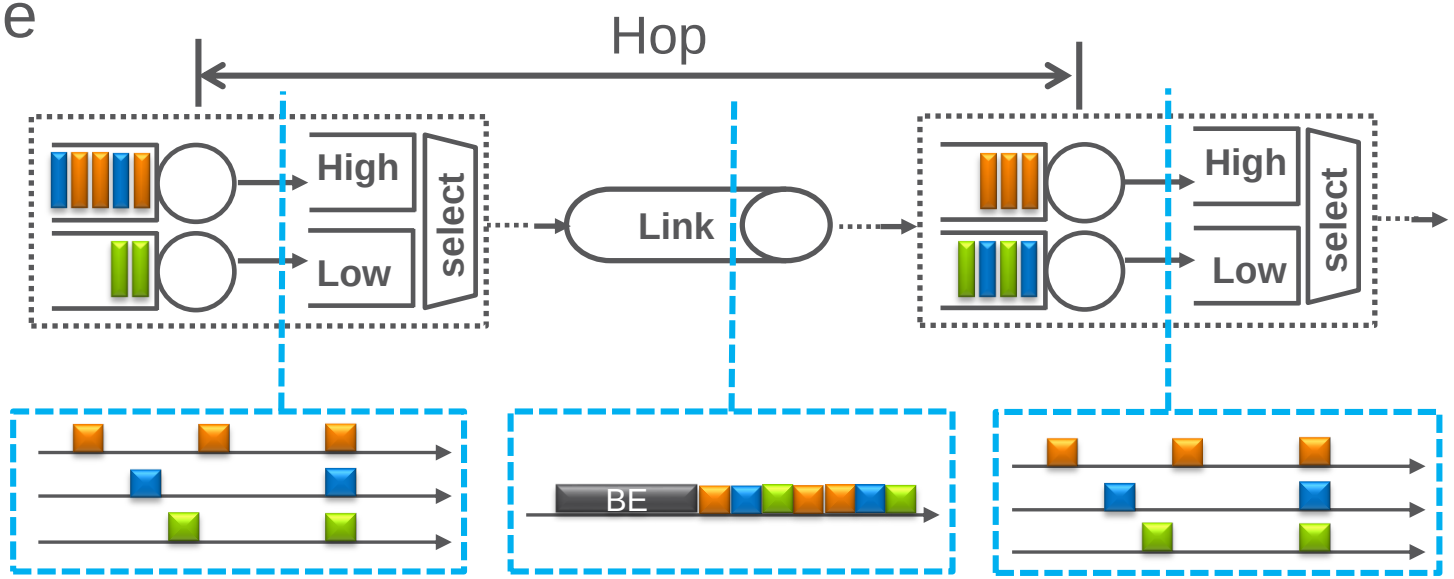
P802.1Qcj – AUTO-ATTACH TO PBB SERVICES

- 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

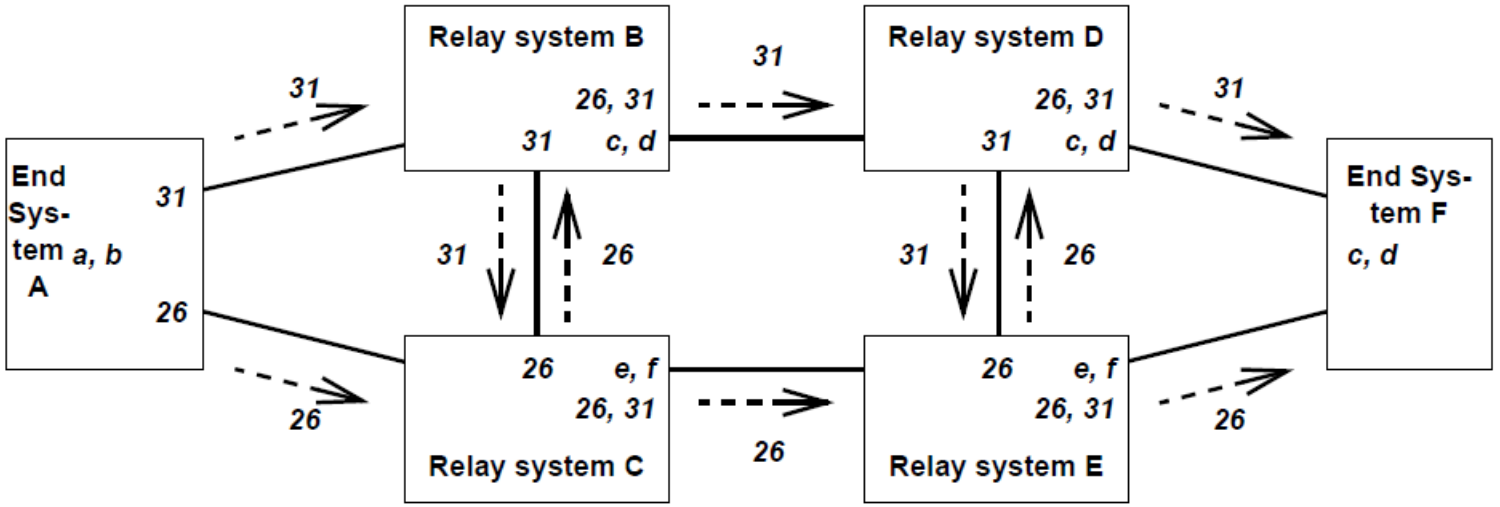


* formerly referred to as Urgency Based Scheduler (UBS)

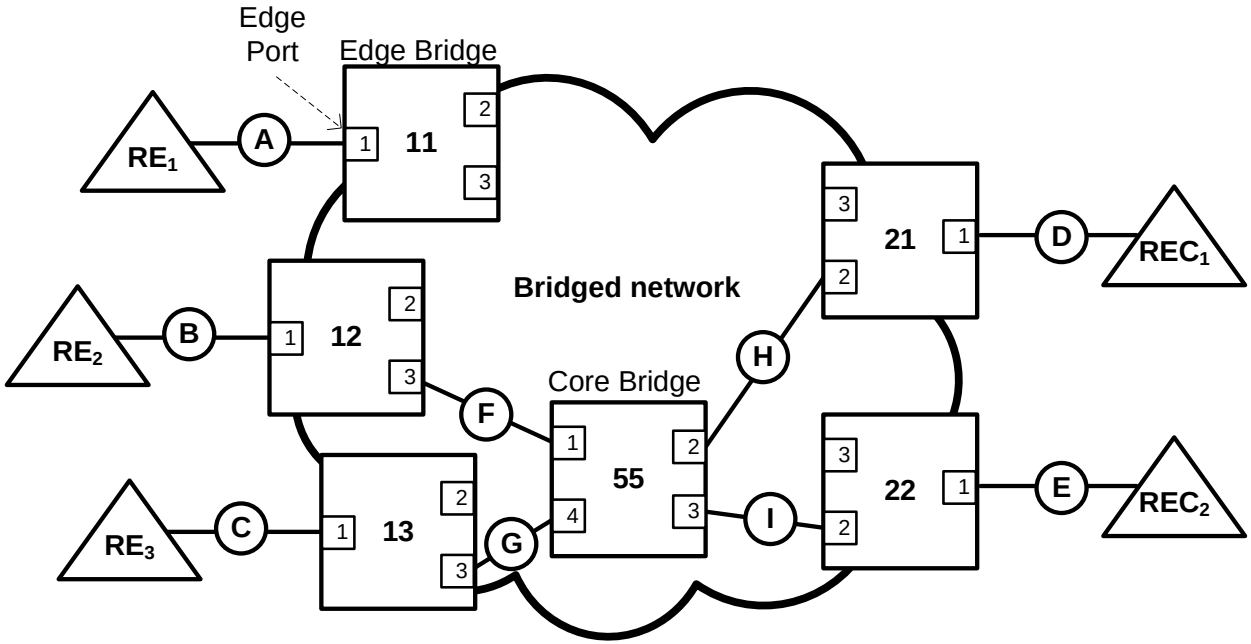
courtesy of Johannes Specht

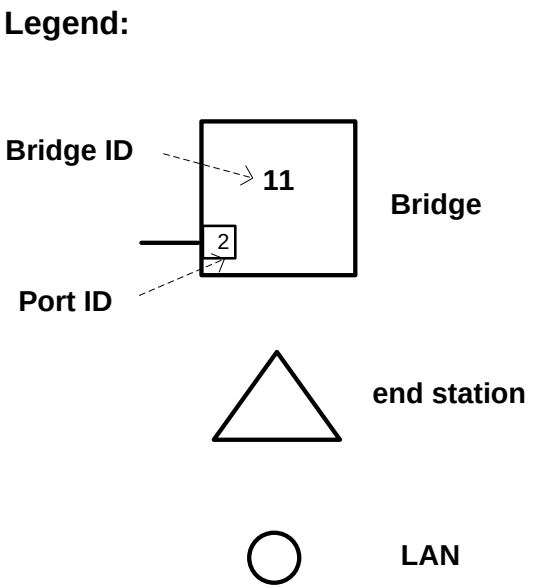
P802.1CB – FRAME REPLICATION AND ELIMINATION FOR RELIABILITY (FRER)

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



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

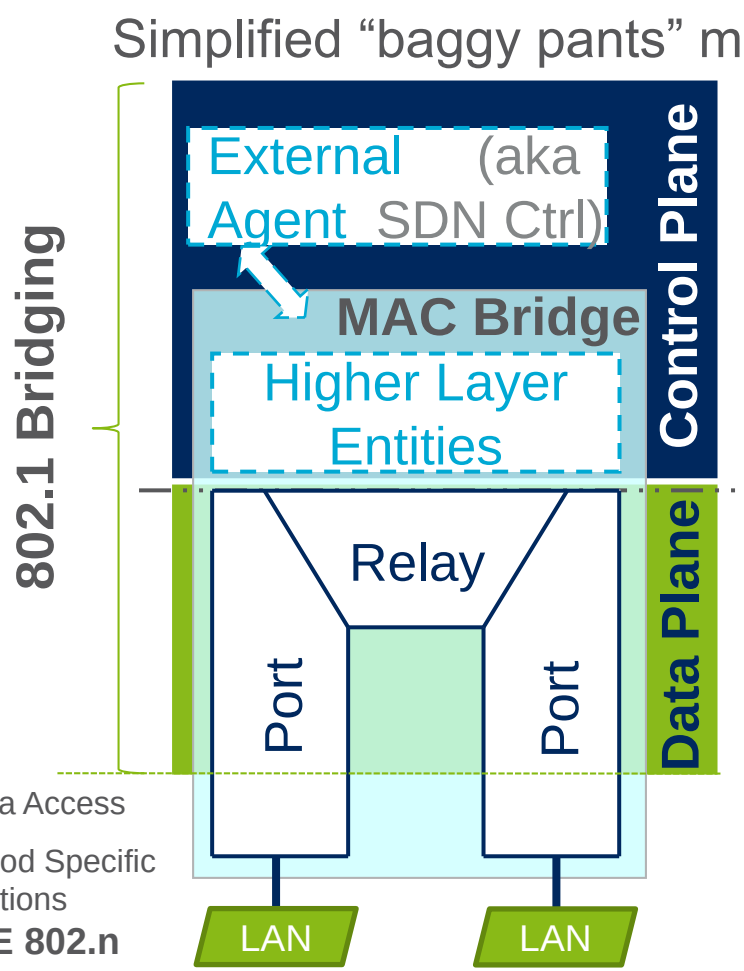
http://www.ieee802.org/1/pages/802.1cm.html

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

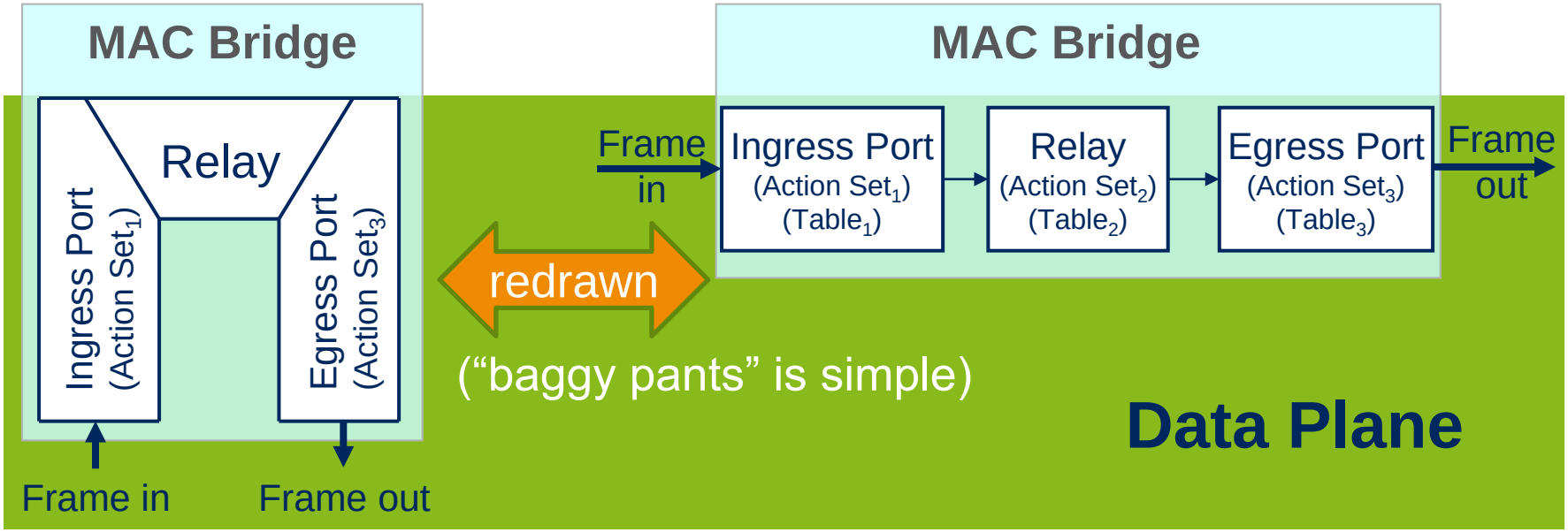
CONTROL PLANE SEPARATED FROM DATA PLANE (BASIC SDN CHARACTERISTICS)



- 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

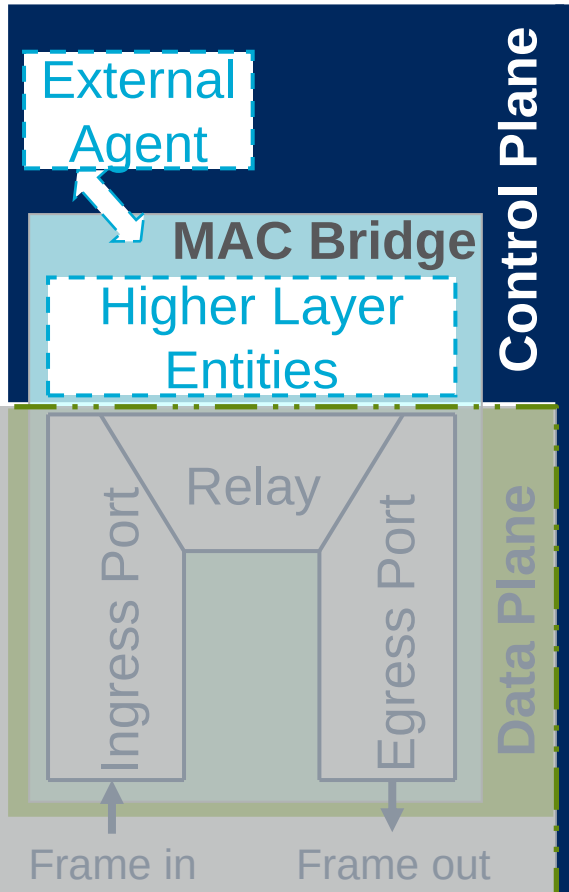
see Figure 8-2 – “VLAN-aware Bridge architecture” of 802.1Q for more details

DATA PLANE ACTIONS (IEEE 802.1Q-2014)

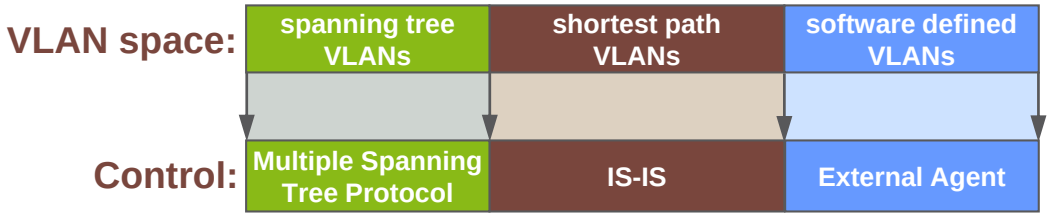


- Ingress Port (Action Set1)
  - Filtering (drop), (un)tagging, VID translation, de/en-capsulation
- Relay (Action Set2)
  - Forwarding, filtering
- Egress Port (Action Set3)
  - Filtering, (un)tagging, VID translation, de/en-capsulation, metering, queuing, transmission selection

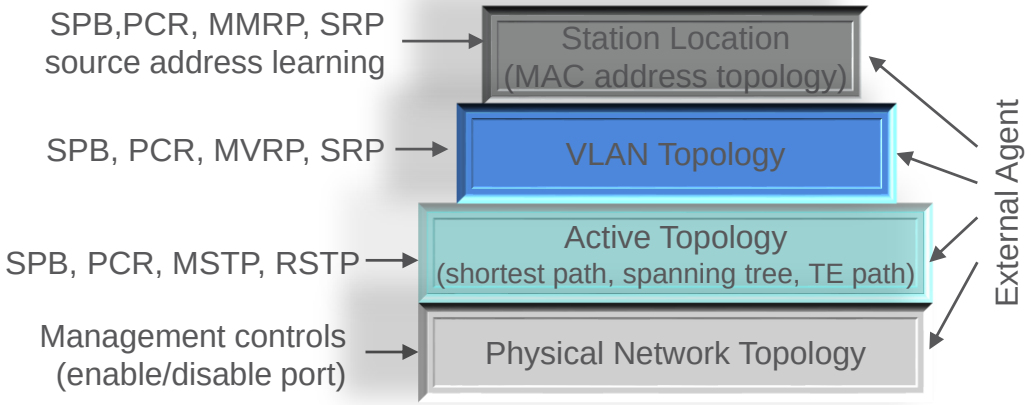
CONTROL PLANE OVERVIEW



- 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!