P802.1CM TIME-SENSITIVE NETWORKING FOR FRONTHAUL

Introduction

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WELCOME!

NOTE

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

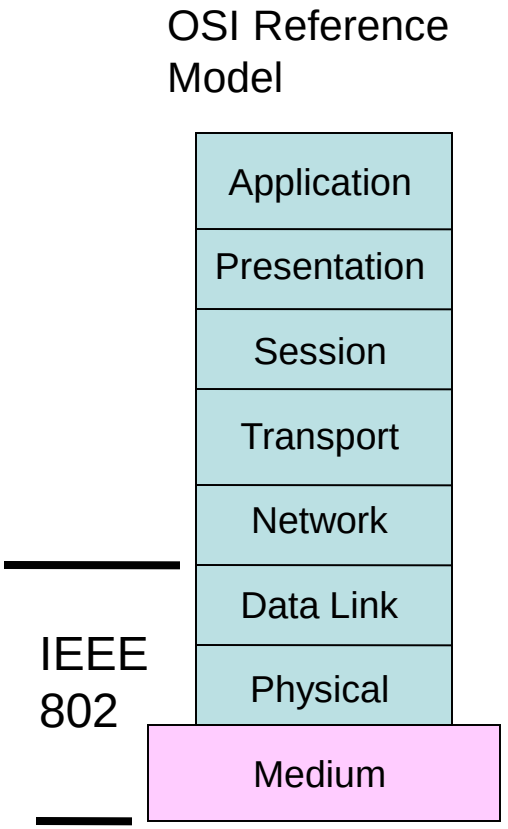
AGENDA

- IEEE 802.1 Overview
- IEEE 802.1 Time-Sensitive Networking (TSN)
  - Audio Video Bridging (AVB) and TSN
  - Ongoing TSN projects
  - Some TSN tools
- P802.1CM TSN for Fronthaul
  - Status update
  - Draft 0.0 overview
    http://www.ieee802.org/1/files/private/cm-drafts/d0/802-1CM-d0-0.pdf
- Bridge architecture

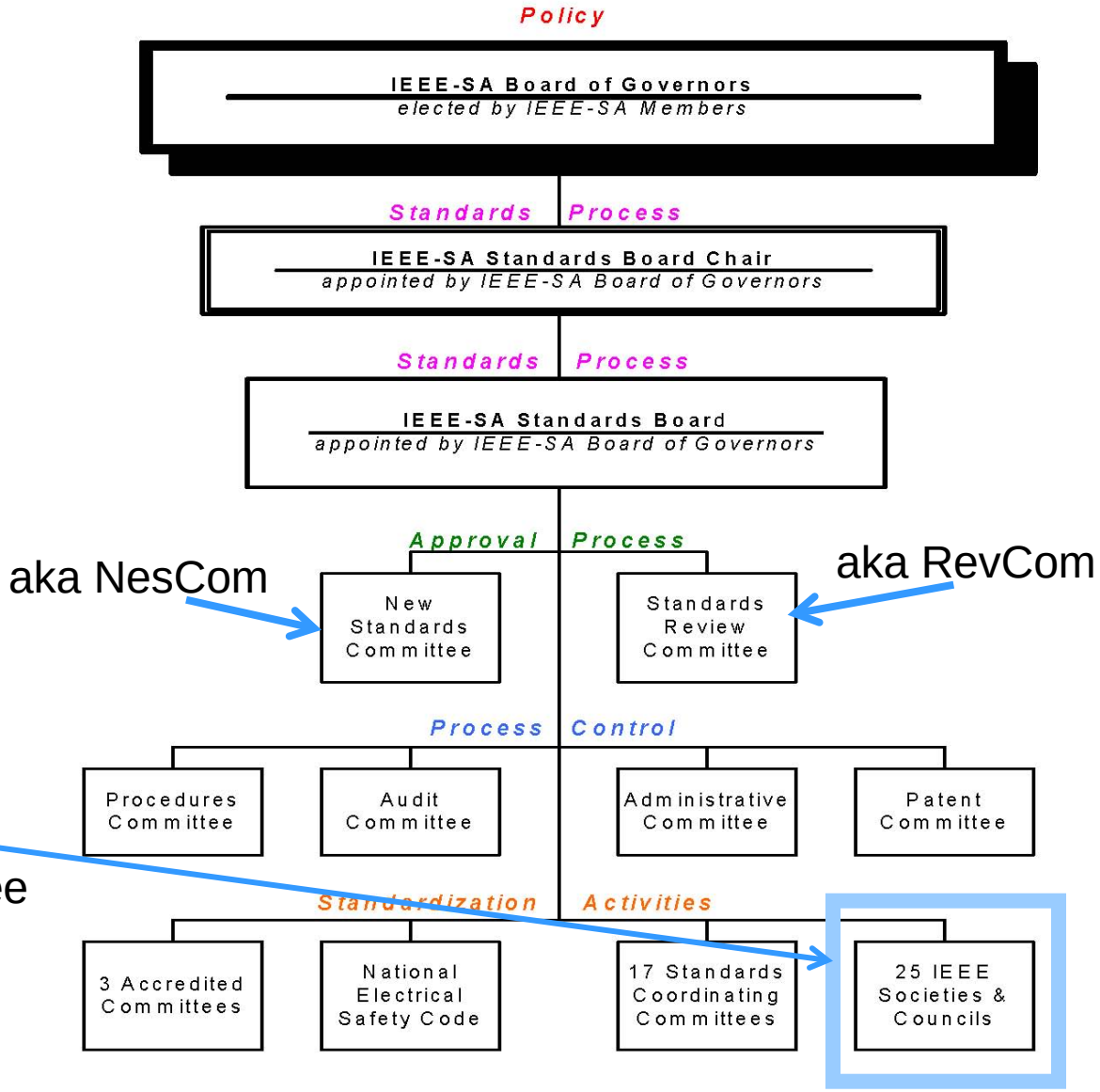
IEEE 802.1 OVERVIEW

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
- 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
- Time-Sensitive Networking (TSN) TG
  - Chair: Michael David Johas Teener
  - Vice-chair: János Farkas
- Security TG
  - Chair: Michael Seaman
- Data Center Bridging (DCB) TG
  - Chair: Patricia Thaler
- OmniRAN TG
  - Maximilian Rigel
- Maintenance TG
  - Chair: John Messenger

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

NAVIGATION

- http://www.ieee802.org/1 (projects, drafts, everything)
- http://www.ieee802.org/1/pages/tsn.html
- 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
- TSN agenda: http://www.802tsn.org/agenda
  - request: http://www.802tsn.org/agenda-for-next-meeting
- email list http://www.ieee802.org/1/email-pages
- f2f meetings: http://www.ieee802.org/1/meetings
- patent slides: http://standards.ieee.org/about/sasb/patcom/materials.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 – 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 us per bridge

IEEE 802.1 TSN PROJECTS

- P802.1Qbu – Frame Preemption – ready
- P802.1Qbv – Enhancements for Scheduled Traffic – ready

related

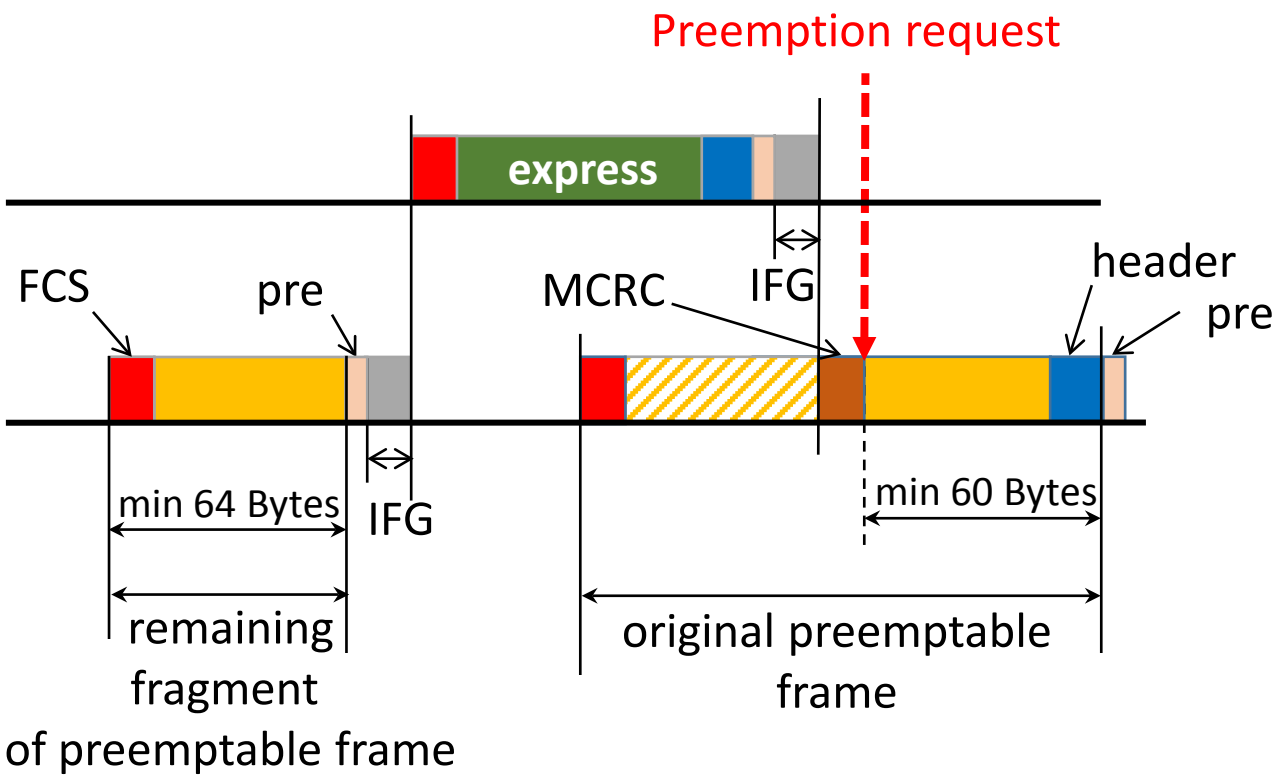
- P802.1Qcc – Stream Reservation Protocol (SRP) Enhancements and Performance Improvements
- P802.1Qci – Per-Stream Filtering and Policing
- P802.1Qch – Cyclic Queuing and Forwarding

related

- 802.1Qcj – Auto-attach to PBB services
- P802.1AS-Rev – Timing and Synchronization – Revision
- P802.1CB – Frame Replication and Elimination for Reliability
- P802.1CM – Time-Sensitive Networking for Fronthaul

FRAME PREEMPTION (ILLUSTRATION)

› Express frames can suspend the transmission preemptable frames

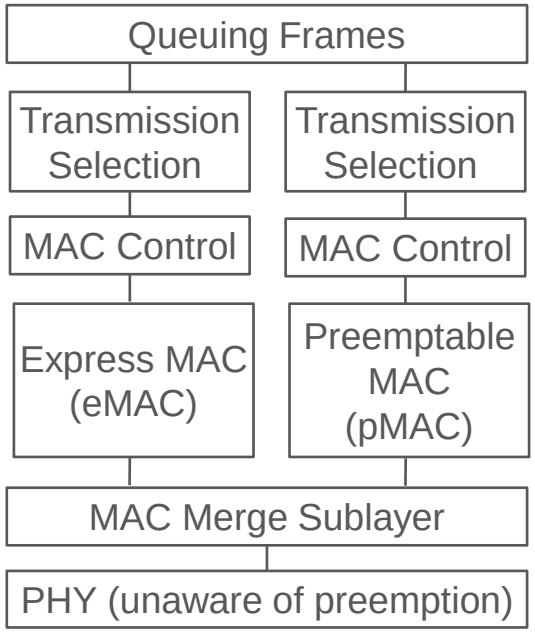


frame flow direction

pre includes Preamble and Start mPacket delimiter (SMD)

FRAME PREEMPTION

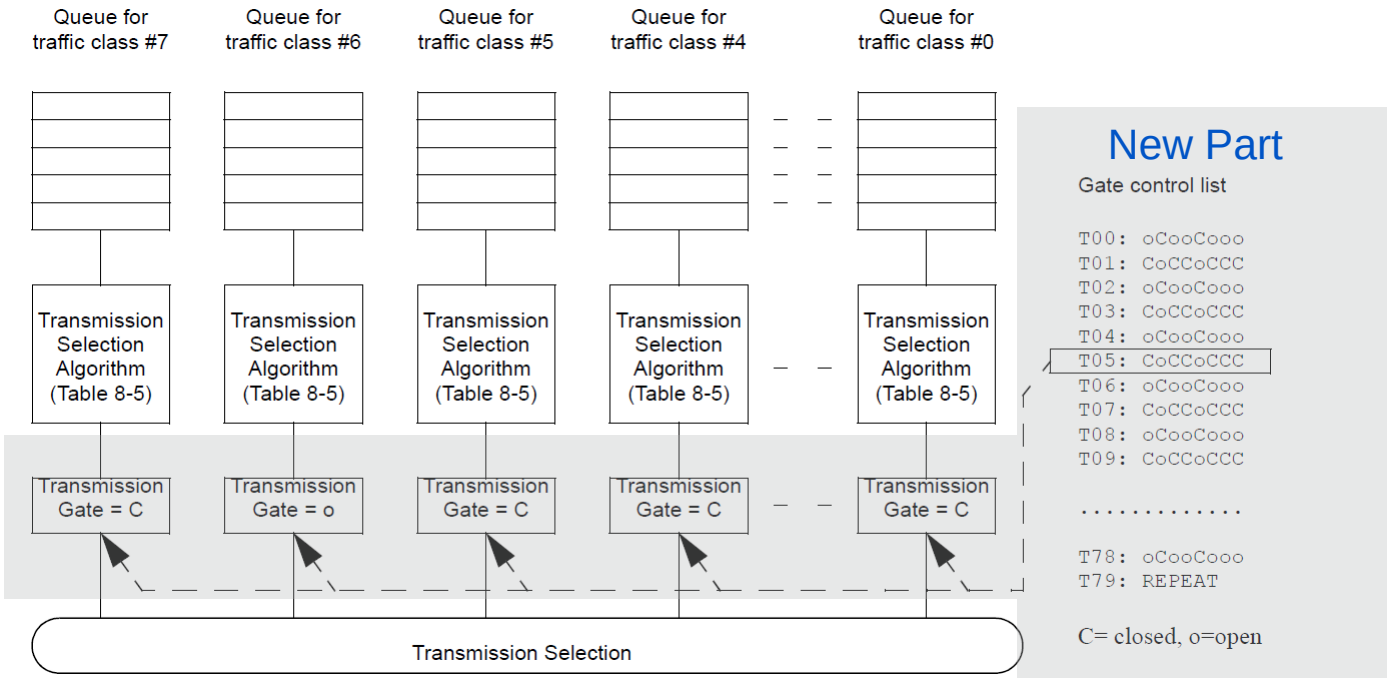
- Time-critical frames can suspend the transmission of non-time-critical frames while one or more time-critical frames are transmitted
- Specified by
  - 802.3br – Interspersing Express Traffic (IET)
  - 802.1Qbu – Frame Preemption
- 802.1Qbu makes the adjustments needed in 802.1Q in order to support 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*



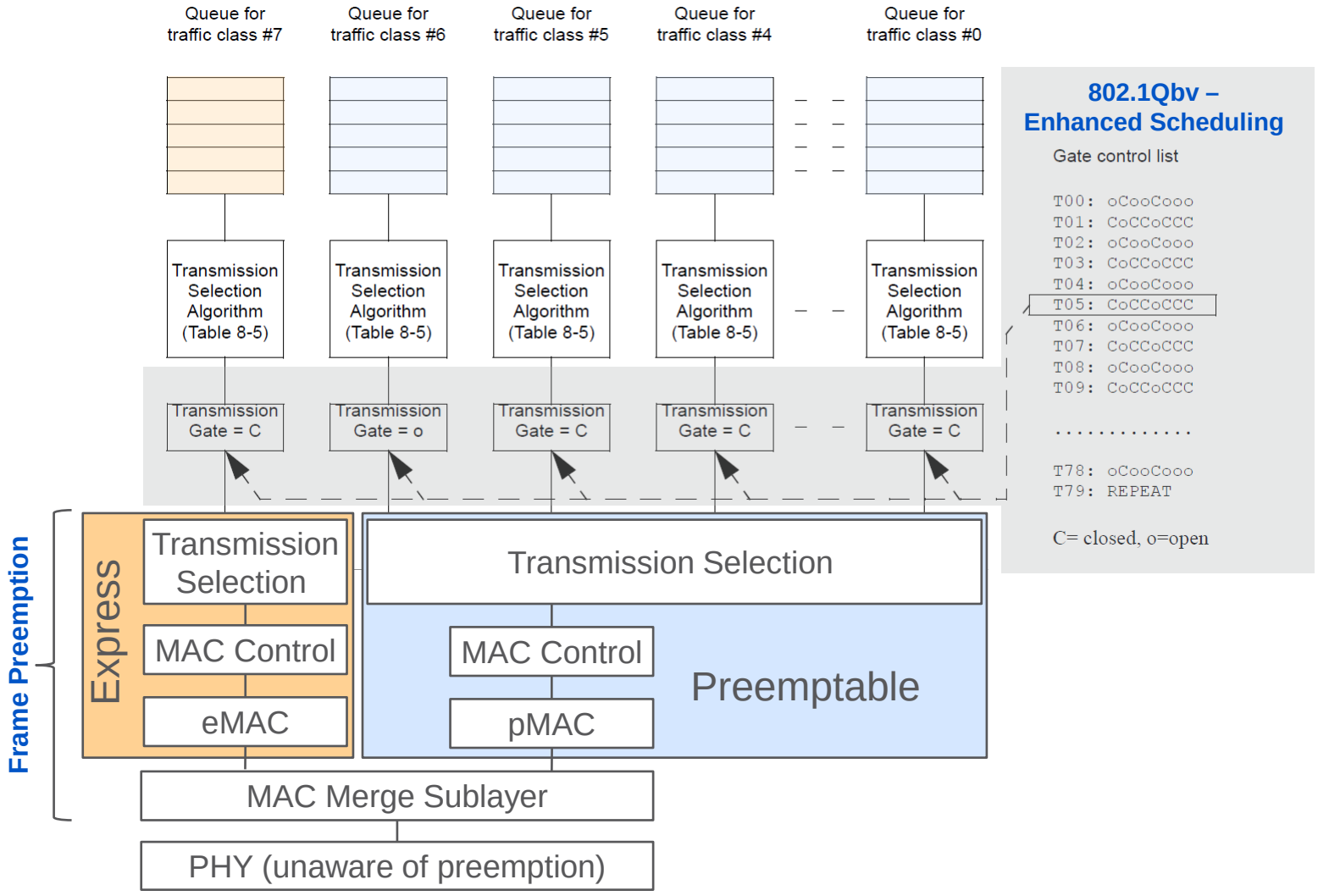
- Minimum fragment size is 64 bytes including CRC

802.1Qbv – ENHANCEMENTS FOR SCHEDULED TRAFFIC

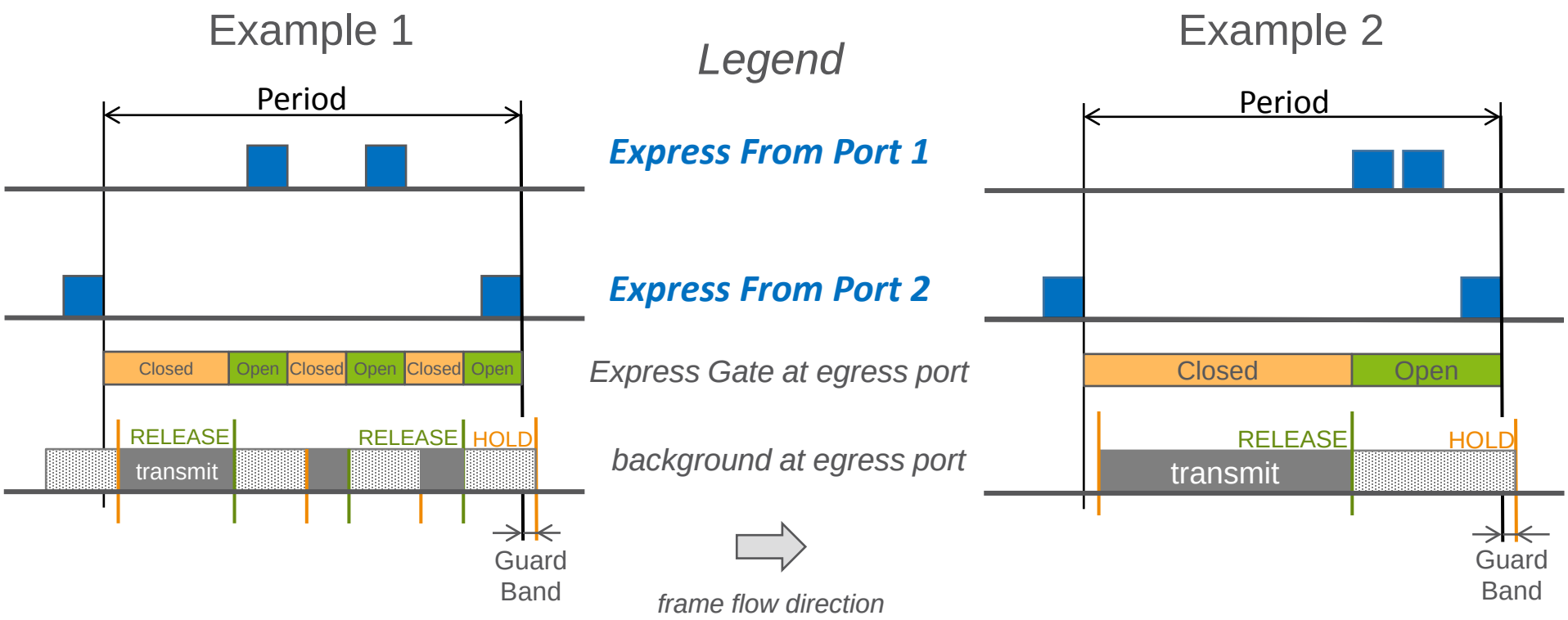
- Transmission from each queue to be scheduled relative to a known timescale
- A transmission gate is associated with each queue
  - the state of the gate determines whether or not queued frames can be selected for transmission
  - Open: queued frames are selected for transmission, (according to the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



PREEMPTION AND ENHANCED SCHEDULING – OVERVIEW



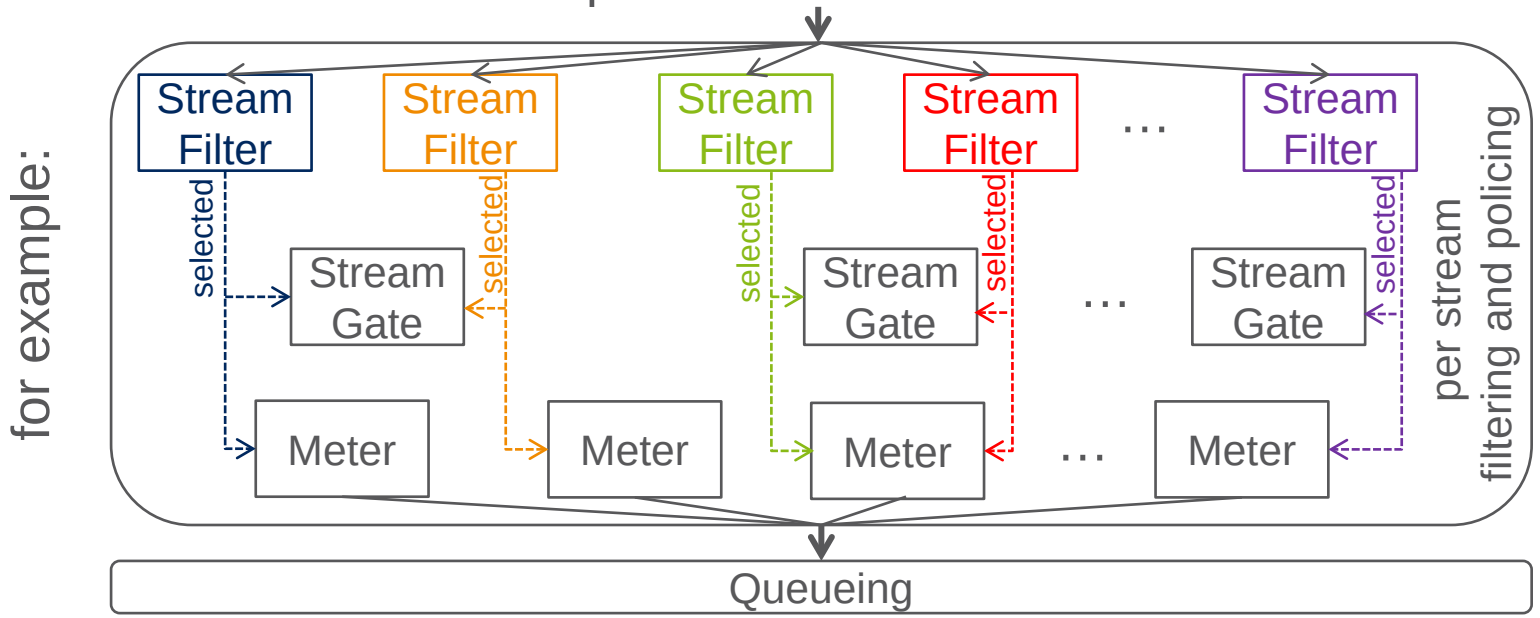
FRAME PREEMPTION AND ENHANCEMENTS FOR SCHEDULED TRAFFIC WITH GUARD BAND



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

802.1Qci – PER STREAM FILTERING AND POLICING

- Perform frame counting, filtering, policing, and service class selection for a frame based on the particular data stream to which the frame belongs
- A Stream Filter
  - Contains a Stream ID and Priority
  - Selects Stream Gate and Meter for a particular stream
- A Stream Gate is either Open or Closed

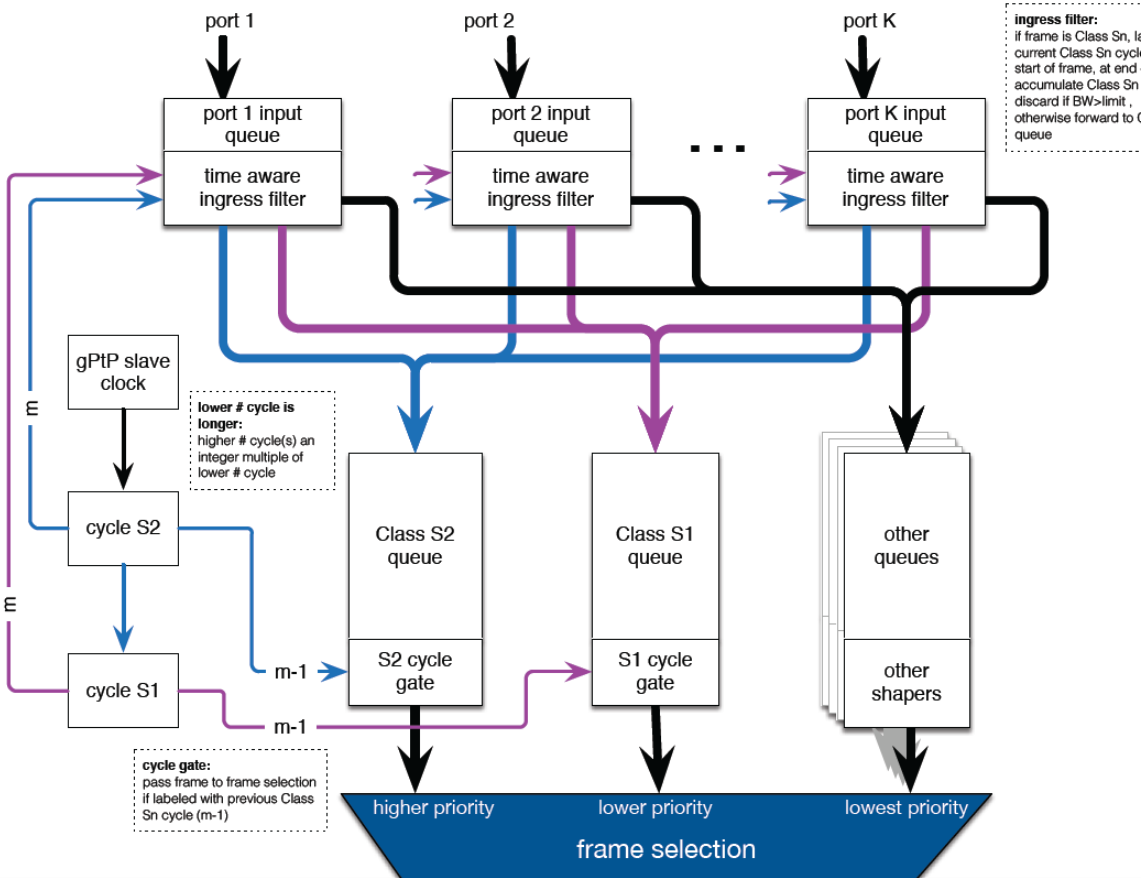


note: 802.1Qci is in an early stage

802.1Qch – 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

Example bridge with two delay classes, S1 and S2



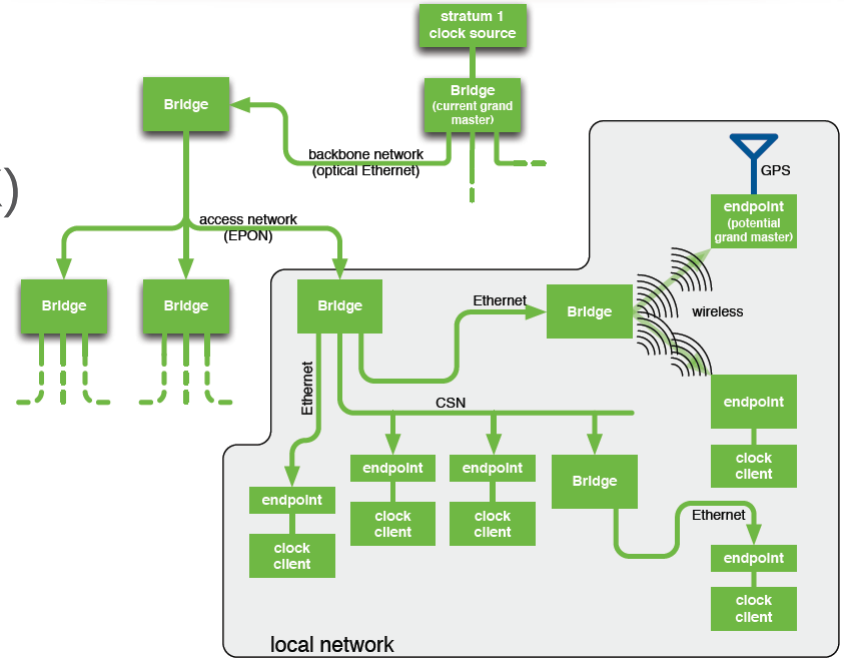
http://www.ieee802.org/1/files/public/docs2014/new-tsn-mjt-peristaltic-shaper-0114.pdf

PROFILE

- IEEE Std. 802.1BA specifies AVB profiles
- An AVB 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 AVB functionality for a specific class of user applications.
- One of the objectives of an AVB profile is to allow the construction of AVB networks that meet a common performance metric in terms of the worst-case end-to-end latency that a stream will experience in transmission between a Talker and a Listener.
- A profile identifies functionality defined in other standards
- TSN profile for fronthaul in the forthcoming slides

P802.1AS-REV – TIMING AND SYNCHRONIZATION

- A profile of 1588 for Layer 2 Ethernet
- The Revision includes:
- 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



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 IEEE 802.1Q http://www.ieee802.org/802_tutorials/2013-03/8021-IETF-tutorial-final.pdf
- Tutorial on Deterministic Ethernet http://www.ieee802.org/802_tutorials/2012-11/8021-tutorial-final-v4.pdf
- https://en.wikipedia.org/wiki/Audio_Video_Bridging

P802.1CM
TSN FOR FRONTHAUL

GOALS

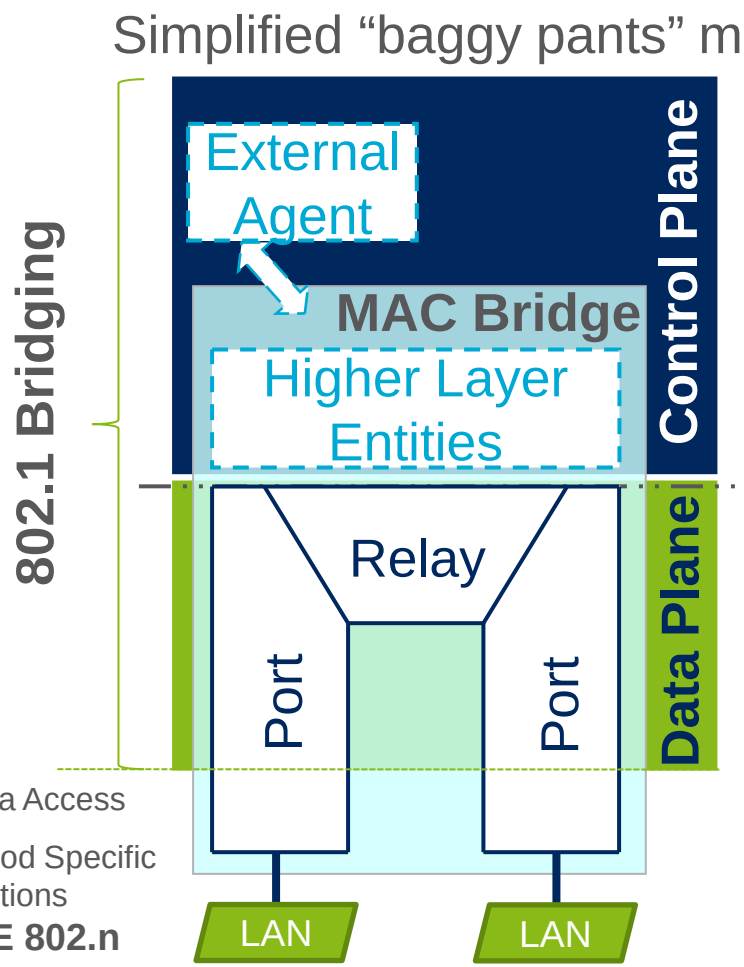
- Develop standard TSN profiles for Fronthaul in order to enable the transport of Fronthaul streams in a bridged network
- The 802.1CM specification
  - will collect requirements for Fronthaul networks
  - will provide guidance for meeting Fronthaul requirements, which includes
    - selecting 802.1 TSN features in order to build networks capable of transmitting Fronthaul streams like CPRI
    - describing how the selected TSN features and components can be combined, configured and used in order to meet Fronthaul requirements
- The P802.1CM project may identify additional TSN functions that would be useful

ROUGH TIMELINE

- Project Authorization Request (PAR) approved by IEEE 802 (July 17, 2015)
- PAR approved by IEEE SA NesCom (New Standards Committee) (September 3, 2015)
- P802.1CM project started: D0.0 (September 8, 2015) http://www.ieee802.org/1/files/private/cm-drafts/d0/802-1CM-d0-0.pdf
  - 1st step: gathering requirements, use cases
- Task Group Ballots
- Initial Working Group Ballot
- Working Group Recirculation Ballot(s)
- Initial Sponsor Ballot (latest by PAR: July 2018)
- Sponsor Recirculation Ballot(s)
- Submission for IEEE SA RevCom (Review Committee) approval (May 2019)

BRIDGE
ARCHITECTURE

CONTROL PLANE SEPARATED FROM DATA PLANE

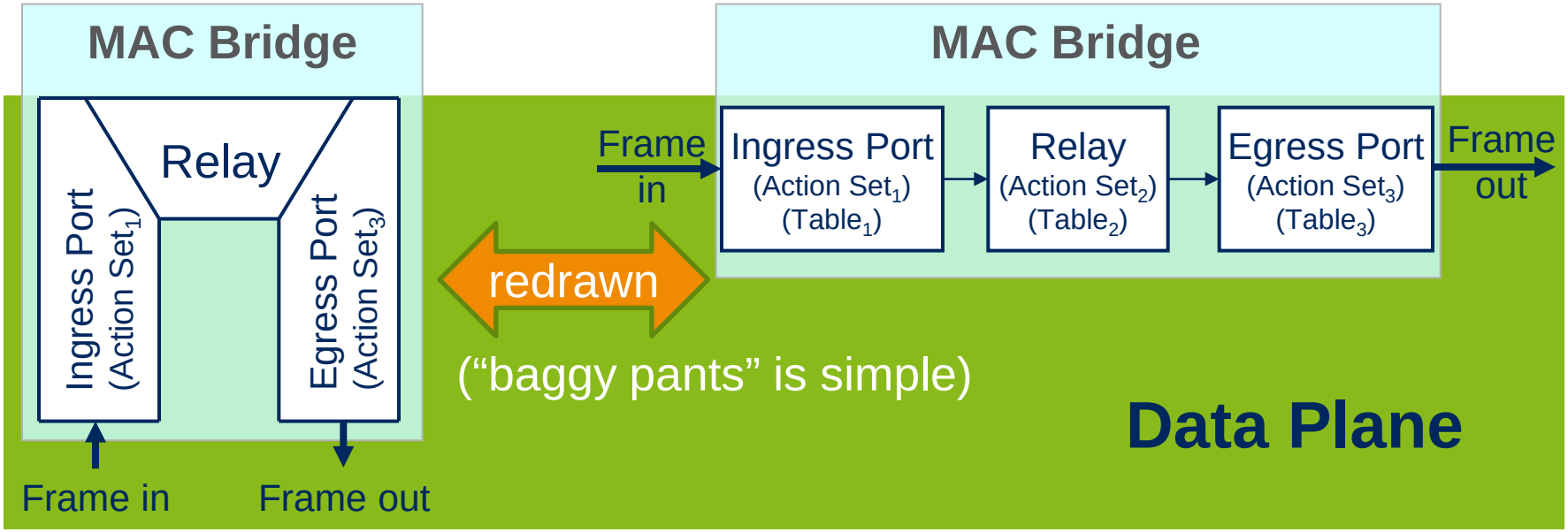


- Control protocols are implemented as Higher Layer Entities
- External Agent may provide control instead of the distributed protocols

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

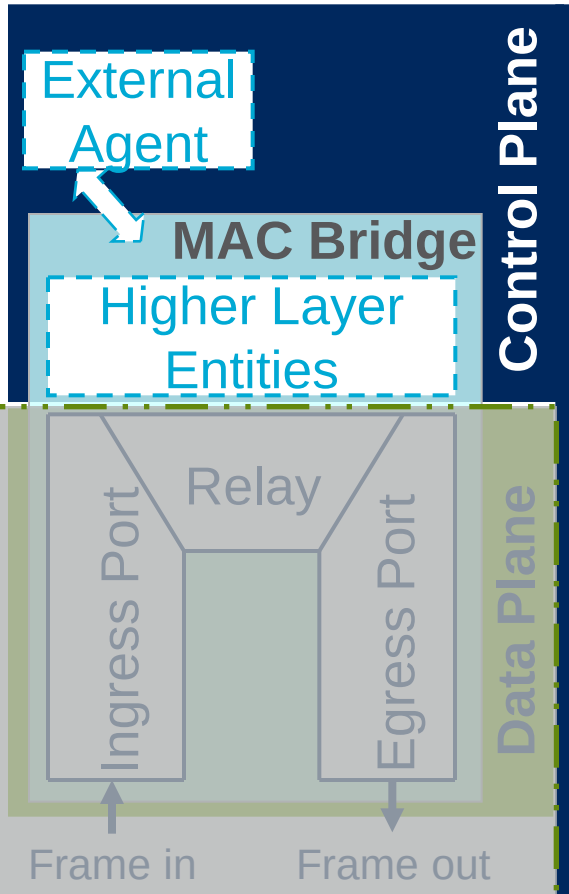
see Figure 8-2 – “VLAN-aware Bridge architecture” of 802.1Q for more details

DATA PLANE ACTIONS (IEEE 802.1Q-2014)

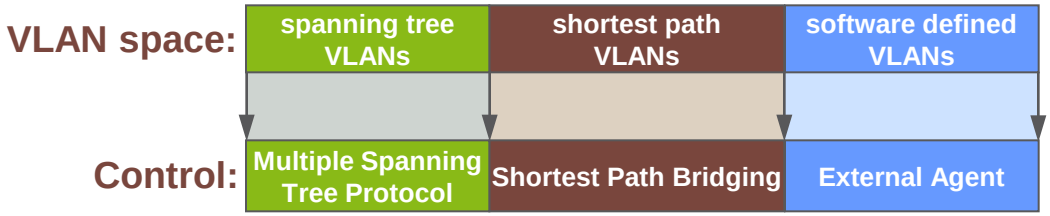


- Ingress Port (Action Set1)
  - Filtering (drop), (un)tagging, VID translation, de/en-capsulation
- Relay (Action Set2)
  - Forwarding, filtering
- Egress Port (Action Set3)
  - Filtering, (un)tagging, VID translation, de/en-capsulation, metering, queuing, transmission selection

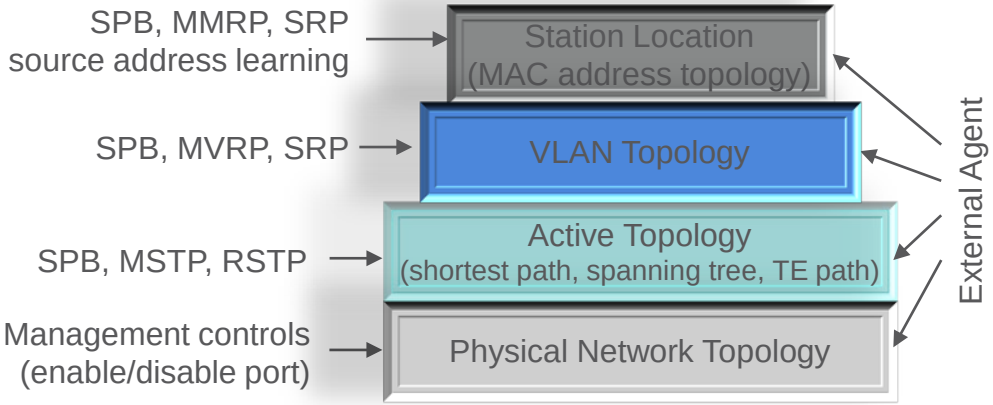
CONTROL PLANE OVERVIEW



- 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. and SDN controller for TE paths
  - External control can be a non-802.1 protocol: PCE, GMPLS



- Summary of control options



SEE YOU!