

# INTRODUCTION TO IEEE 802.1 AND P802.1CM TIME-SENSITIVE NETWORKING FOR FRONTHAUL

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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
  - Ongoing TSN projects
  - Some TSN tools
  
- › P802.1CM TSN for Fronthaul
  - Status update
  - Draft 0.2 insight  
<http://www.ieee802.org/1/files/private/cm-drafts/d0/802-1CM-d0-2.pdf>
  
- › Bridge architecture

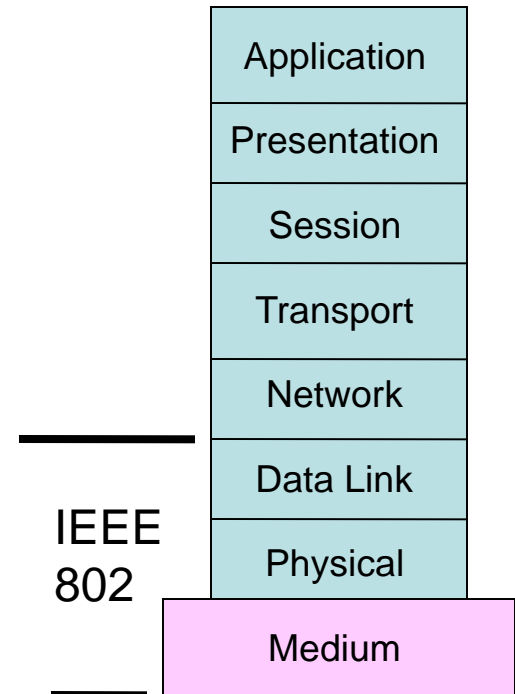
# IEEE 802.1 OVERVIEW



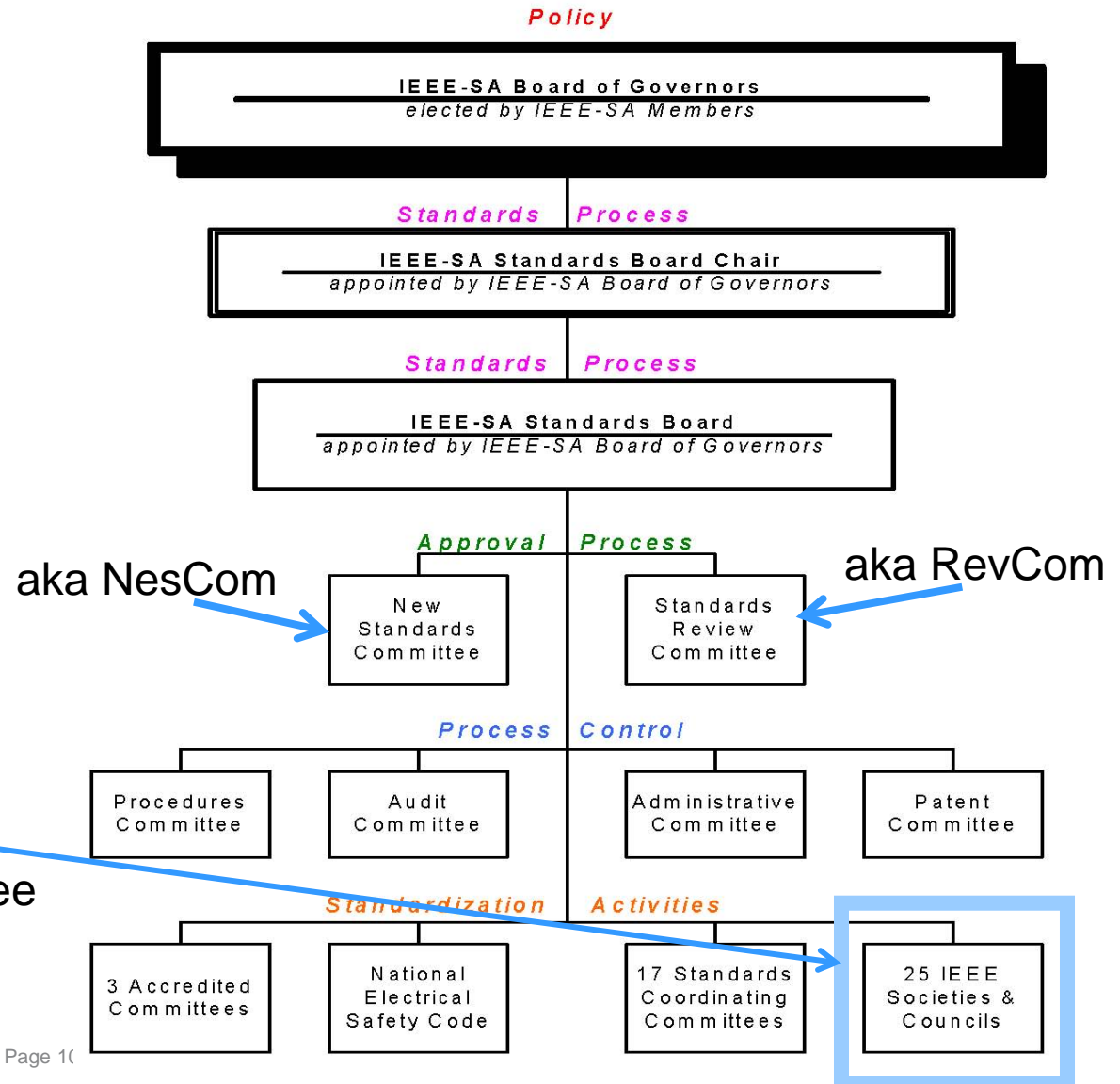
# IEEE 802 LAN/MAN STANDARDS COMMITTEE (AKA IEEE 802 OR LMSC)

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

OSI Reference Model



# 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  $\geq 75\%$
- › **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
- › 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
  - Chair: 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> (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
- › TSN agenda: <http://www.802tsn.org/agenda>
  - agenda request: <http://www.802tsn.org/agenda-for-next-meeting>
  - agenda request on a virtual meeting: <http://www.802tsn.org/weekly-call-agenda-requests>
- › 802 agenda (meeting rooms): <http://802world.org/attendee>
- › email list: <http://www.ieee802.org/1/email-pages>
- › f2f meetings: <http://www.ieee802.org/1/meetings>
- › attendance: <https://imat.ieee.org>
- › get program: <https://standards.ieee.org/about/get/802/802.1.html>
- › patent slides: <http://standards.ieee.org/about/sasb/patcom/materials.html>



# TSN VIRTUAL MEETINGS

<http://www.ieee802.org/1/pages/tsn.html>

› TSN general: Mondays at 8AM US-Pacific (5PM CET)

– WebEx 496 178 841

<https://broadcom.webex.com/broadcom/j.php?MTID=m674fe09b2b6eb5437765c831b223a406>

› AS-Revision: Mondays at 9AM US-Pacific (6PM CET)

– WebEx 496 178 841 (same as the TSN general call)

<https://broadcom.webex.com/broadcom/j.php?MTID=m674fe09b2b6eb5437765c831b223a406>

› P802.1CM TSN for Fronthaul

– <https://join.me/ieee802.1>

› <https://join.me/intphone/684645640/0>

– April 6 at 8AM PDT, 5PM CEST

– May 10 at 8AM PDT, 5PM CEST

– June 16 at 8AM PDT, 5PM CEST

– July 7 at 8AM PDT, 5PM CEST

# 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

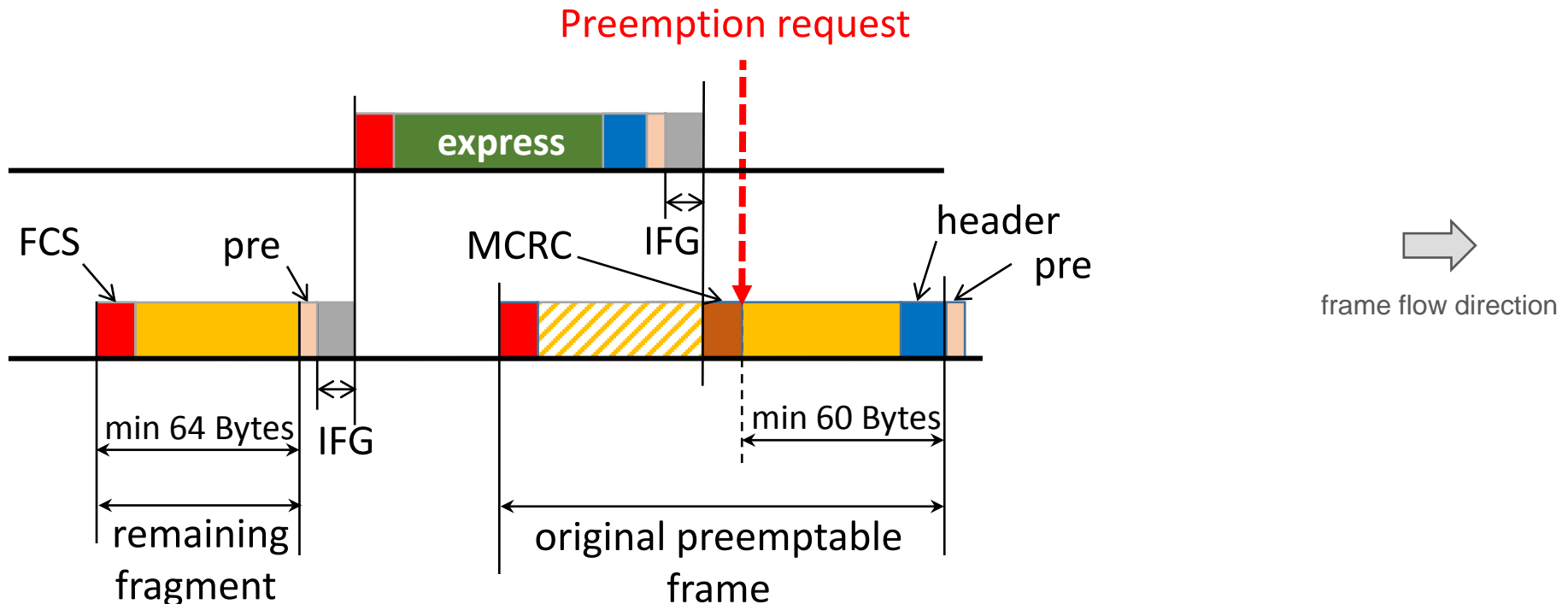
- › IEEE Std. 802.1AS-2011 – generalized Precision Time Protocol (gPTP)
  - A Layer 2 profile of the IEEE 1588 Precision Time Protocol (PTP)
- › IEEE Std. 802.1Qav – Forwarding and Queuing of Time-Sensitive Streams (FQTSS):
  - Specifies Credit-Based Shaper (CBS)
- › IEEE Std. 802.1Qat – Stream Reservation 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  $\mu$ s per bridge

# IEEE 802.1 TSN PROJECTS

- › P802.1Qbu – Frame Preemption – ready
  - › P802.1Qbv – Enhancements for Scheduled Traffic – ready
  - › P802.1Qcc – Stream Reservation Protocol (SRP) Enhancements and Performance Improvements
  - › P802.1Qci – Per-Stream Filtering and Policing
  - › P802.1Qch – Cyclic Queuing and Forwarding
  - › 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
- related
- related to each other

# 802.3br INTERSPERSING EXPRESS TRAFFIC (FRAME PREEMPTION) – ILLUSTRATION

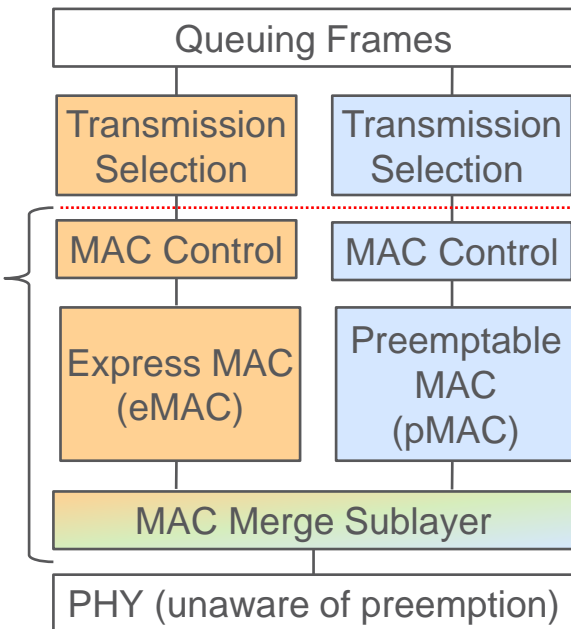
- Express frames can suspend the transmission of preemptable frames



of preemptable frame

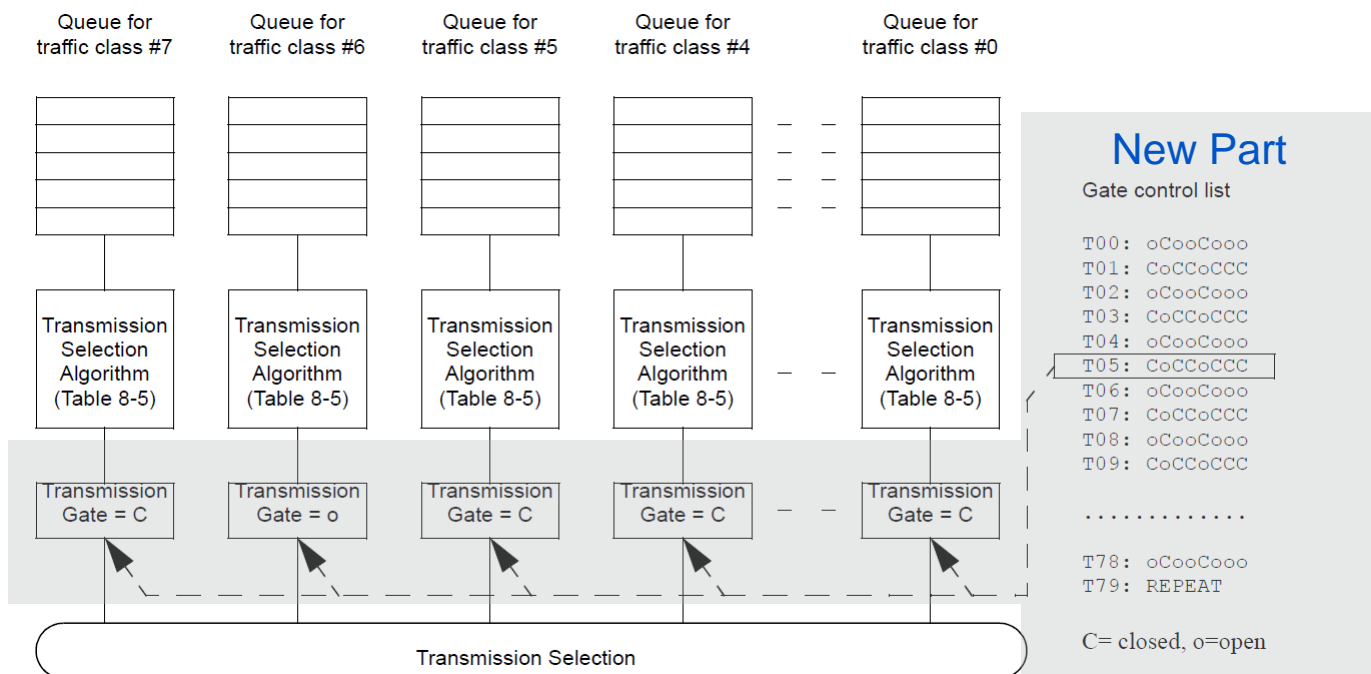
# FRAME PREEMPTION / INTERSPERSING EXPRESS TRAFFIC

- › 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



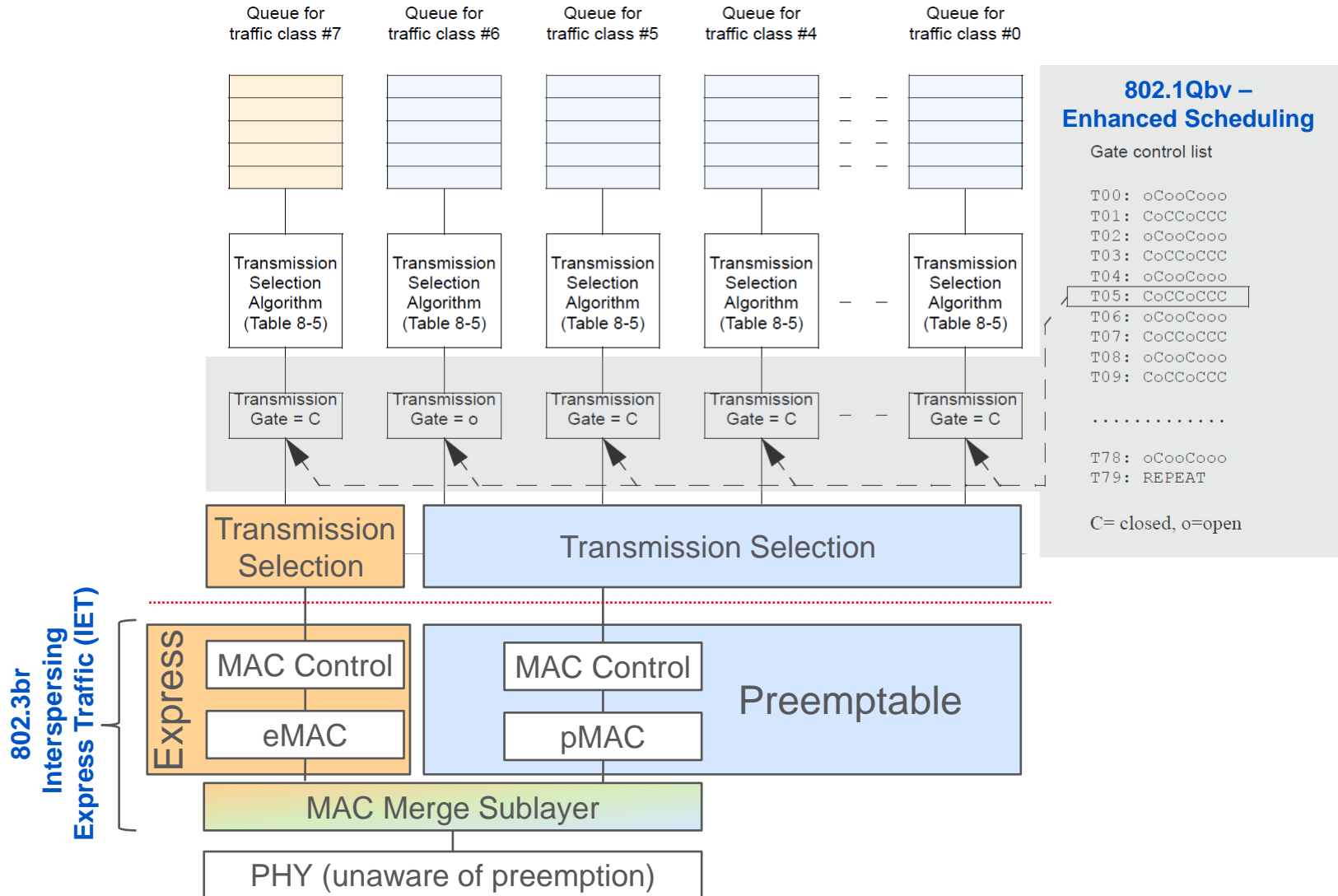
# 802.1Qbv – ENHANCEMENTS FOR SCHEDULED TRAFFIC

- › 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



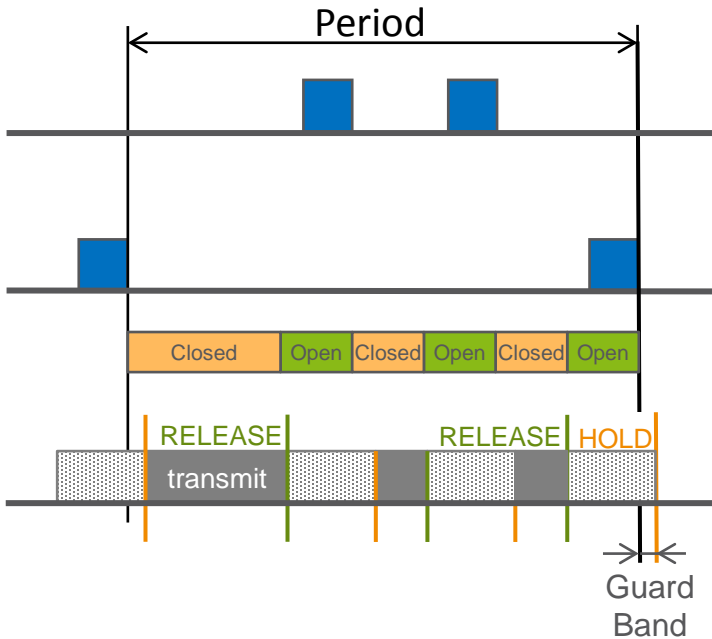


# PREEMPTION AND ENHANCED SCHEDULING – OVERVIEW



# FRAME PREEMPTION AND ENHANCEMENTS FOR SCHEDULED TRAFFIC WITH GUARD BAND

Example 1



Legend

*Express From Port 1*

*Express From Port 2*

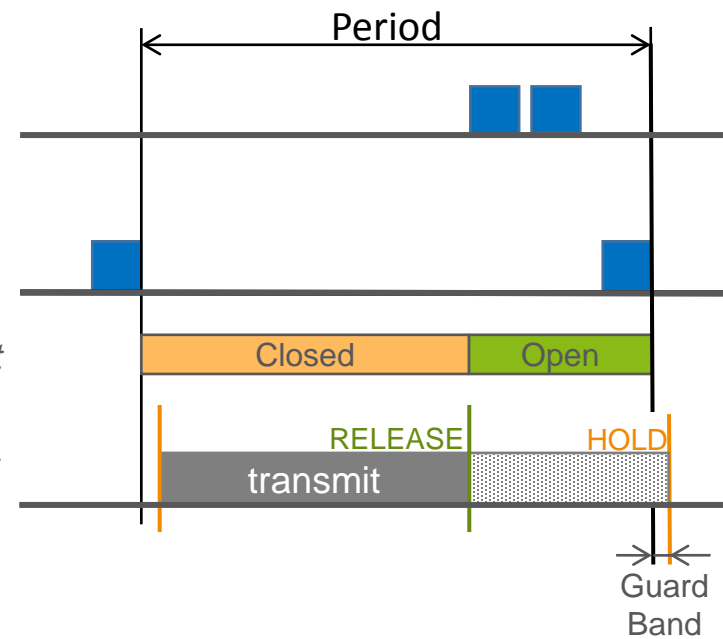
*Express Gate at egress port*

*Preemptible at egress port*



*frame flow direction*

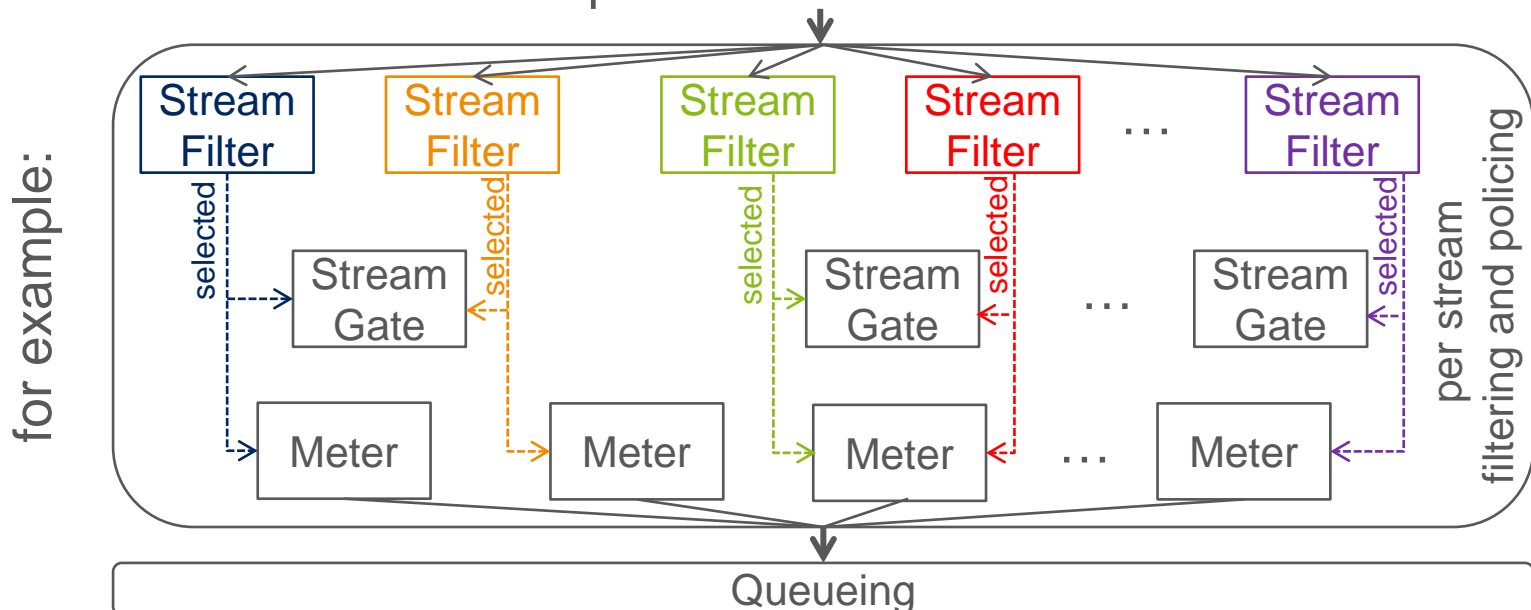
Example 2



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

# 802.1Qci – PER STREAM FILTERING AND POLICING

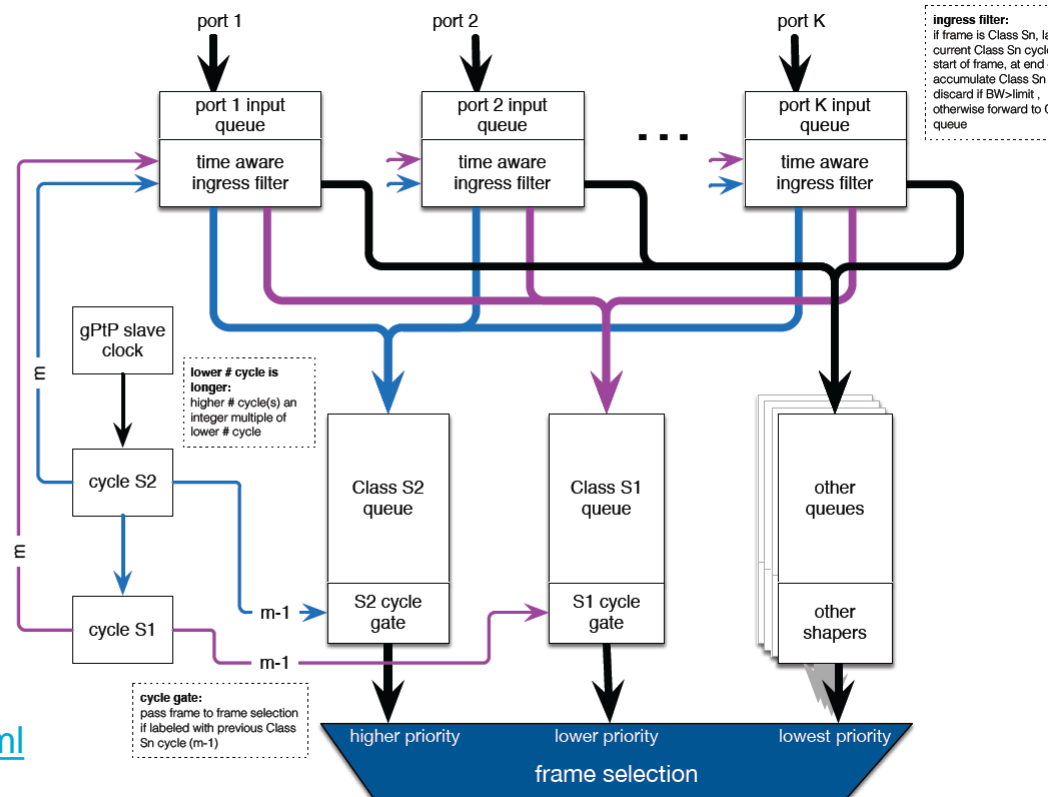
- › Perform frame counting, filtering, policing, and service class selection for a frame based on the particular data stream to which the frame belongs
- › A Stream Filter
  - Contains a Stream ID and Priority
  - Selects Stream Gate and Meter for a particular stream
- › A Stream Gate is either Open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



# 802.1Qch – 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

Example bridge with two delay classes, S1 and S2



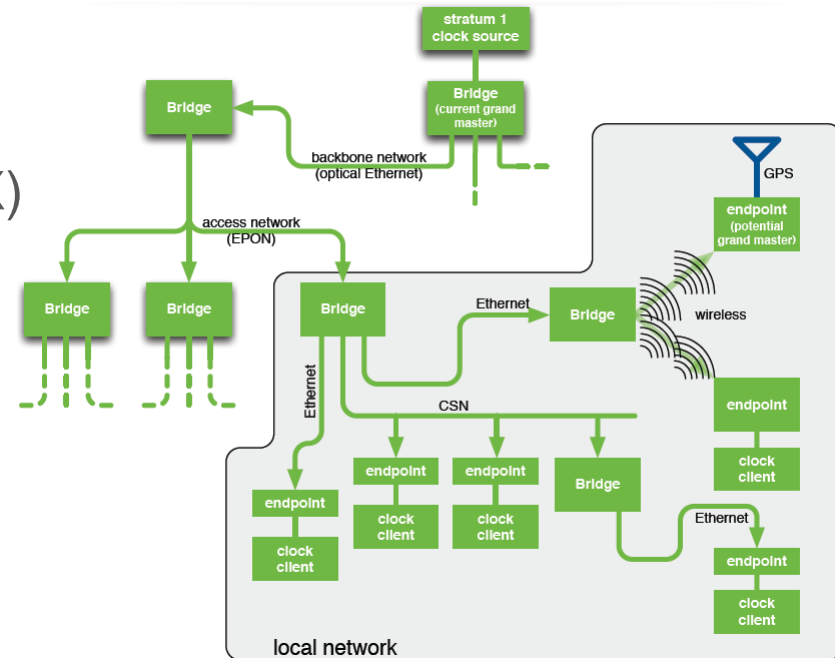
Note – 802.1Qch is in an early stage:  
<http://www.ieee802.org/1/pages/802.1ch.html>

# 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](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](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](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](http://www.ieee802.org/802_tutorials/2013-03/8021-IETF-tutorial-final.pdf)
- › SDN by 802.1Q: <http://www.ieee802.org/1/files/public/docs2014/Q-farkas-SDN-support-0314-v01.pdf>
- › [https://en.wikipedia.org/wiki/Audio\\_Video\\_Bridging](https://en.wikipedia.org/wiki/Audio_Video_Bridging)

# P802.1CM TSN FOR FRONTHAUL

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



# GOALS

- › Develop standard TSN profiles for Fronthaul in order to enable the transport of Fronthaul streams in a bridged network
- › The 802.1CM specification
  - collect 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 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

## › What happened so far

- 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)
- f2f and virtual meetings

## › Ongoing

- Gathering requirements, use cases
- f2f and virtual meetings
- D0.2 (March 13, 2016) <http://www.ieee802.org/1/files/private/cm-drafts/d0/802-1CM-d0-2.pdf>

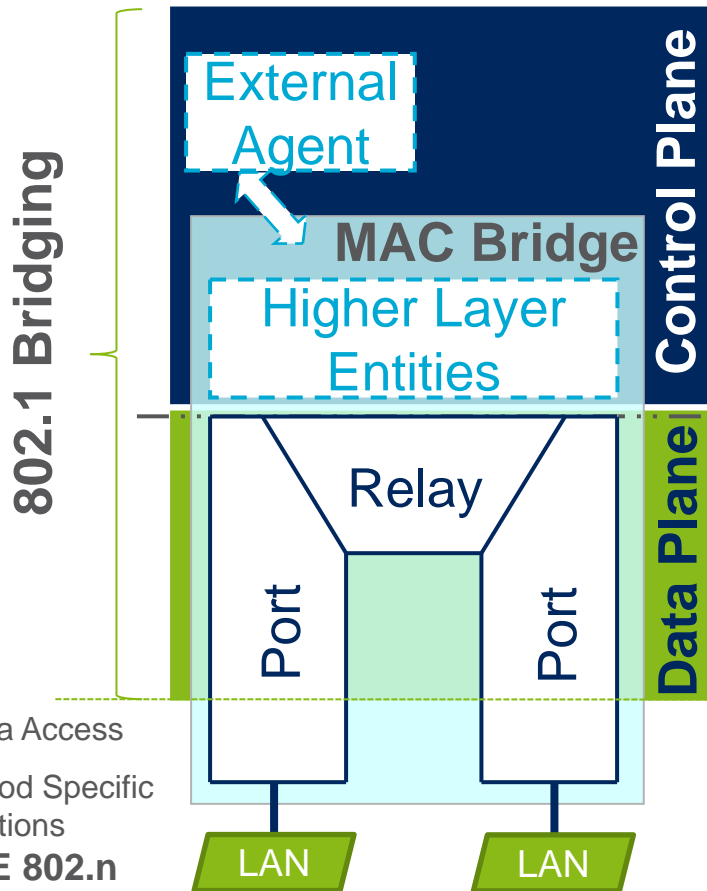
## › Future steps

- 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

Simplified “baggy pants” model

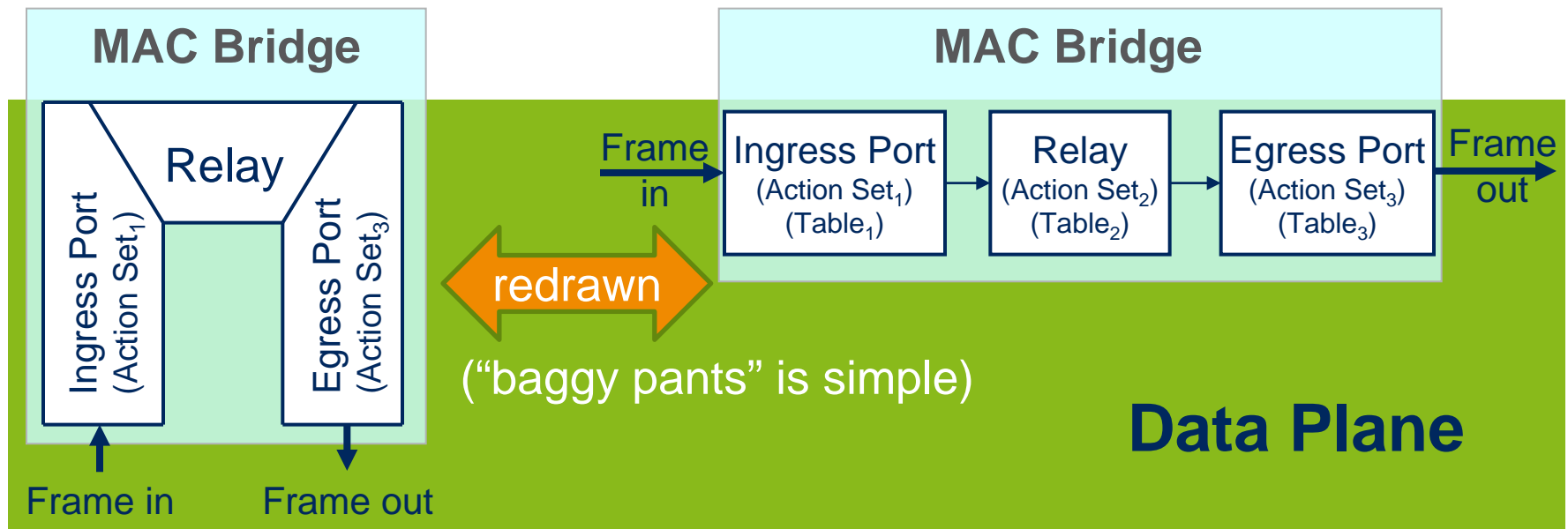


- › Control protocols are implemented as Higher Layer Entities
- › External Agent may provide control instead of the distributed protocols

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

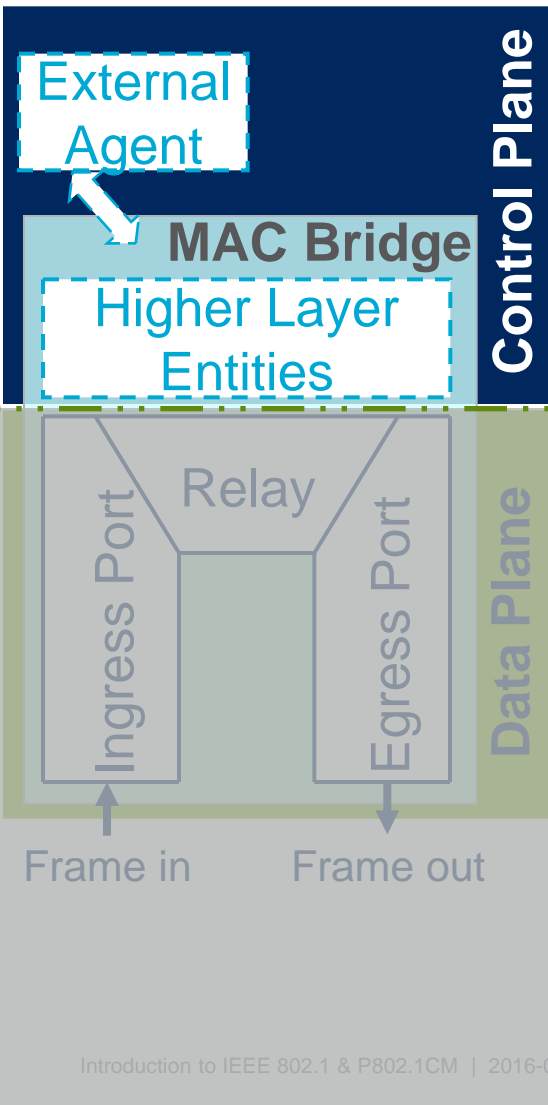
see Figure 8-2 – “VLAN-aware Bridge architecture” of 802.1Q for more details

# 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

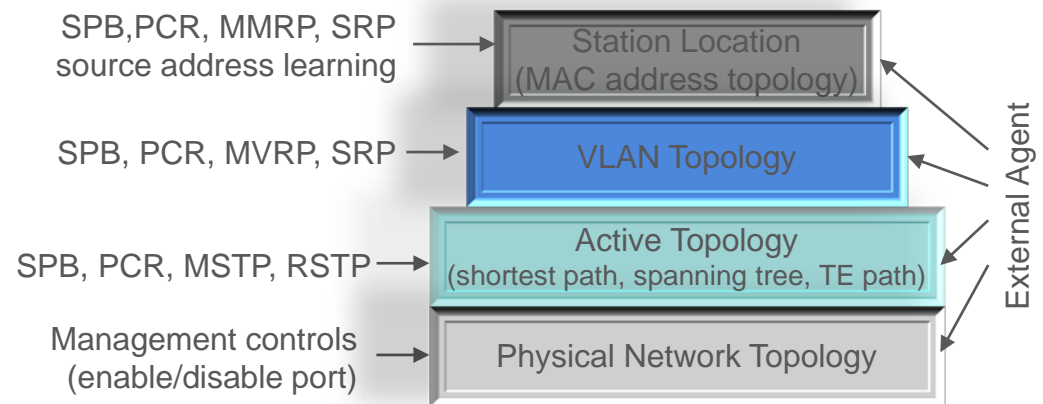
# CONTROL PLANE OVERVIEW



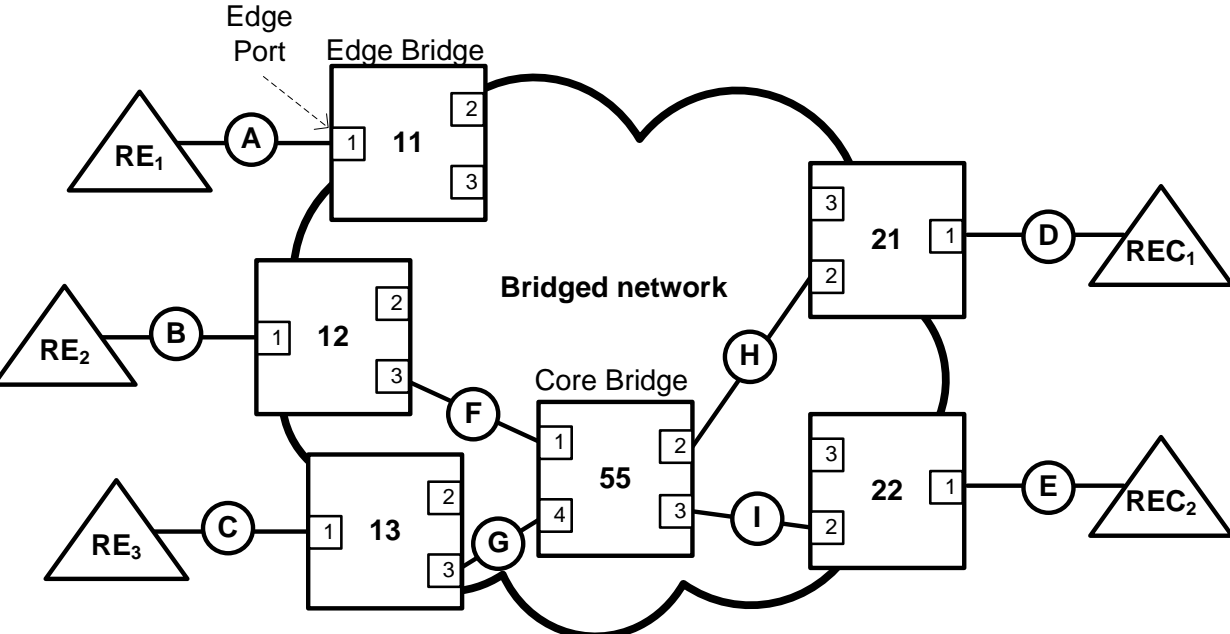
- › A VLAN is assigned to a control mode
  - Multiple control modes may co-exist in the same network
  - Hybrid control by distributed protocols and an External Agent, e.g. and SDN controller for TE paths
  - External control can be a non-802.1 protocol: PCE, GMPLS

<b>VLAN space:</b>	spanning tree VLANs	shortest path VLANs	software defined VLANs
<b>Control:</b>	Multiple Spanning Tree Protocol	IS-IS	External Agent

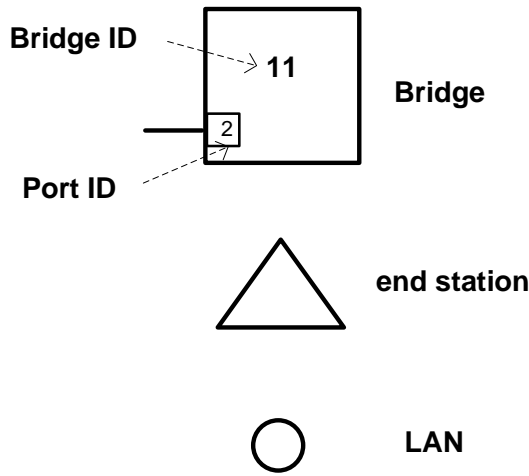
## › Summary of control options



# NOTATIONS



**Legend:**



SEE YOU!