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
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
  – 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
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 5 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 µs 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
Express frames can suspend the transmission of preemptable frames
Time-critical frames can suspend the transmission of non-time-critical frames while one or more time-critical frames are transmitted.

Specified by:
1. 802.3br – Interspersing Express Traffic (IET)
2. 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
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

New Part
Gate control list
T00: ccccccccc
T01: cccccccc
T02: cccccccc
T03: cccccccc
T04: cccccccc
T05: cccccccc
T06: cccccccc
T07: cccccccc
T08: cccccccc
T09: cccccccc

T78: cccccccc
T79: REPEAT

C= closed, o= open
Preemption and Enhanced Scheduling – Overview

Transmission Selection

- Queue for traffic class #7
- Queue for traffic class #6
- Queue for traffic class #5
- Queue for traffic class #4
- Queue for traffic class #0

802.1Qbv – Enhanced Scheduling
Gate control list:
- T00: cccccc
- T01: cccccccc
- T02: cccccc
- T03: cccccccc
- T04: cccccccc
- T05: cccccccc
- T06: cccccccc
- T07: cccccccc
- T08: cccccccc
- T09: cccccccc

................
- T78: cccccccc
- T79: REPEAT

C = closed, o = open

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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: [http://www.ieee802.org/1/pages/802.1ci.html](http://www.ieee802.org/1/pages/802.1ci.html)
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

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

Simplified “baggy pants” model

see Figure 8-2 – “VLAN-aware Bridge architecture” of 802.1Q for more details
Data Plane Actions (IEEE 802.1Q-2014)

- **Ingress Port (Action Set 1)**
  - Filtering (drop), (un)tagging, VID translation, de/en-capsulation

- **Relay (Action Set 2)**
  - Forwarding, filtering

- **Egress Port (Action Set 3)**
  - Filtering, (un)tagging, VID translation, de/en-capsulation, metering, queuing, transmission selection

Data Plane

- **MAC Bridge**
  - Ingress Port (Action Set 1)
  - Relay (Action Set 2)
  - Egress Port (Action Set 3)

Frame in → Ingress Port (Action Set 1) (Table 1)
Frame out → Relay (Action Set 2) (Table 2)
Frame in → Egress Port (Action Set 3) (Table 3)

“Baggy pants” is simple
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
- SPB, PCR, MMRP, SRP: source address learning
- SPB, PCR, MVRP, SRP
- SPB, PCR, MSTP, RSTP:
- Management controls (enable/disable port)

VLAN space:
- spanning tree VLANs
- shortest path VLANs
- software defined VLANs

Control:
- Multiple Spanning Tree Protocol
- IS-IS
- External Agent

Station Location (MAC address topology)
VLAN Topology
Active Topology (shortest path, spanning tree, TE path)
Physical Network Topology
NOTATIONS

Legend:
- Bridge ID
- Port ID
- Bridge
- end station
- LAN

Bridged network

Edge Bridge

Core Bridge

REC1

REC2

Notations:
- Bridged network
- REC1
- REC2
- Bridge ID
- Port ID
- End station
- LAN
SEE YOU!