

IEEE 802.1 Time-Sensitive Networking (TSN) Task Group (TG) Overview



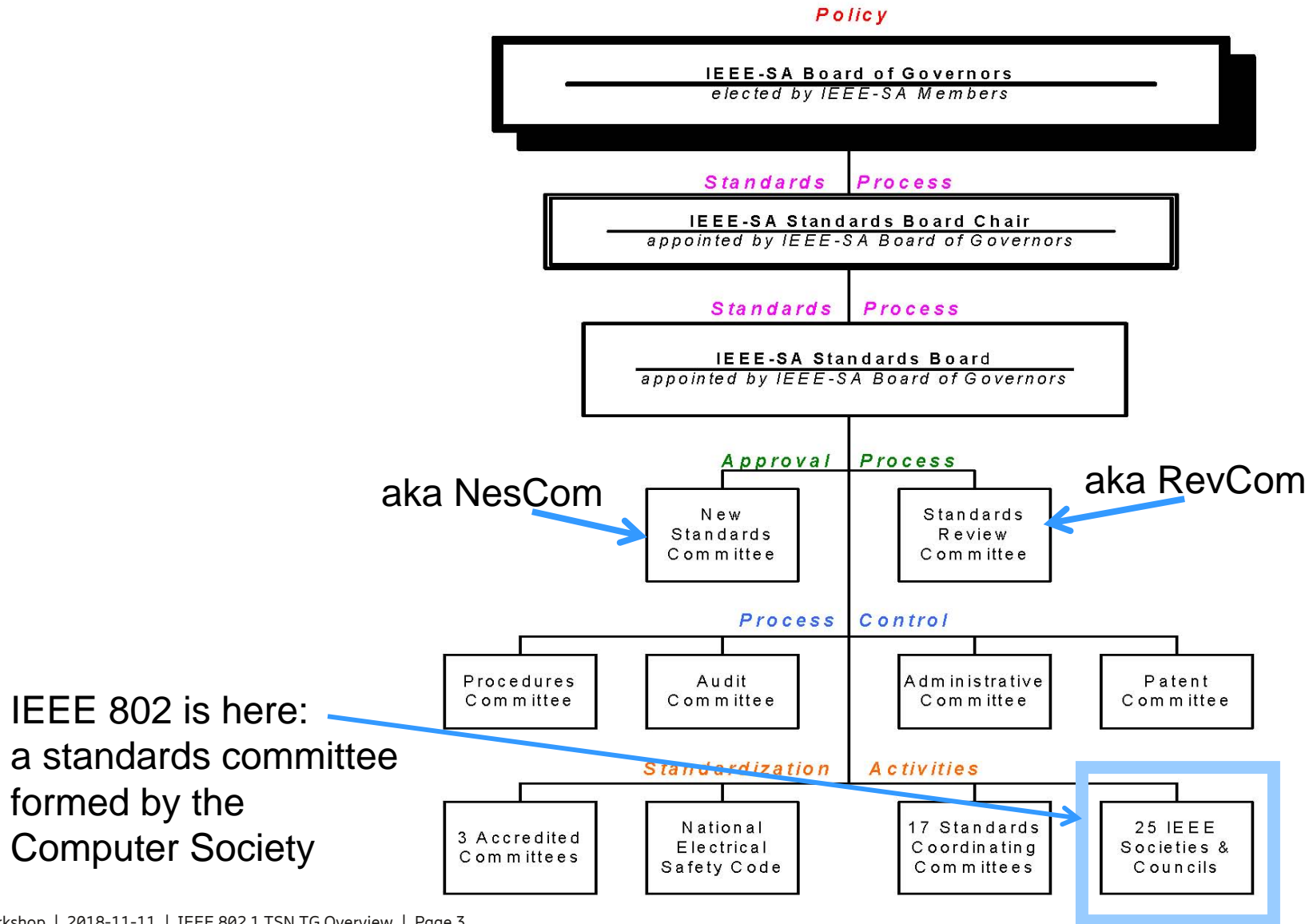
DetNet – TSN workshop

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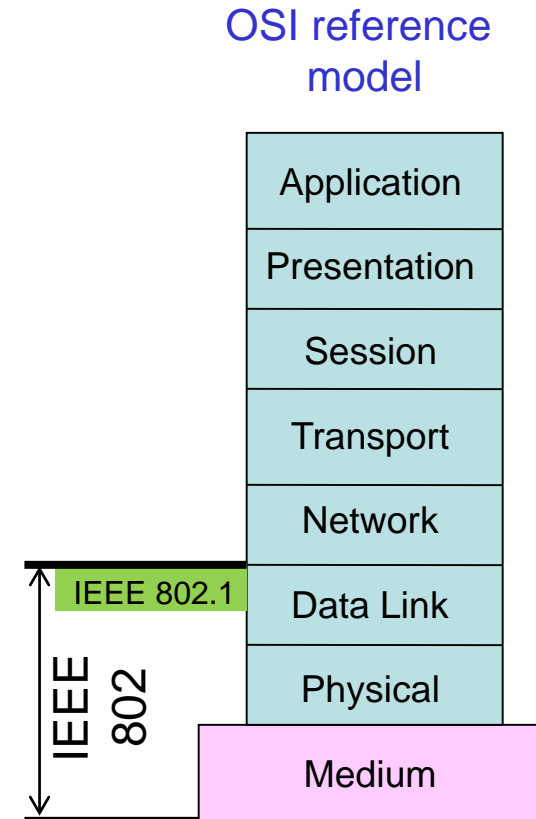
IEEE Standards Organization



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



Principles of the IEEE Standards Process



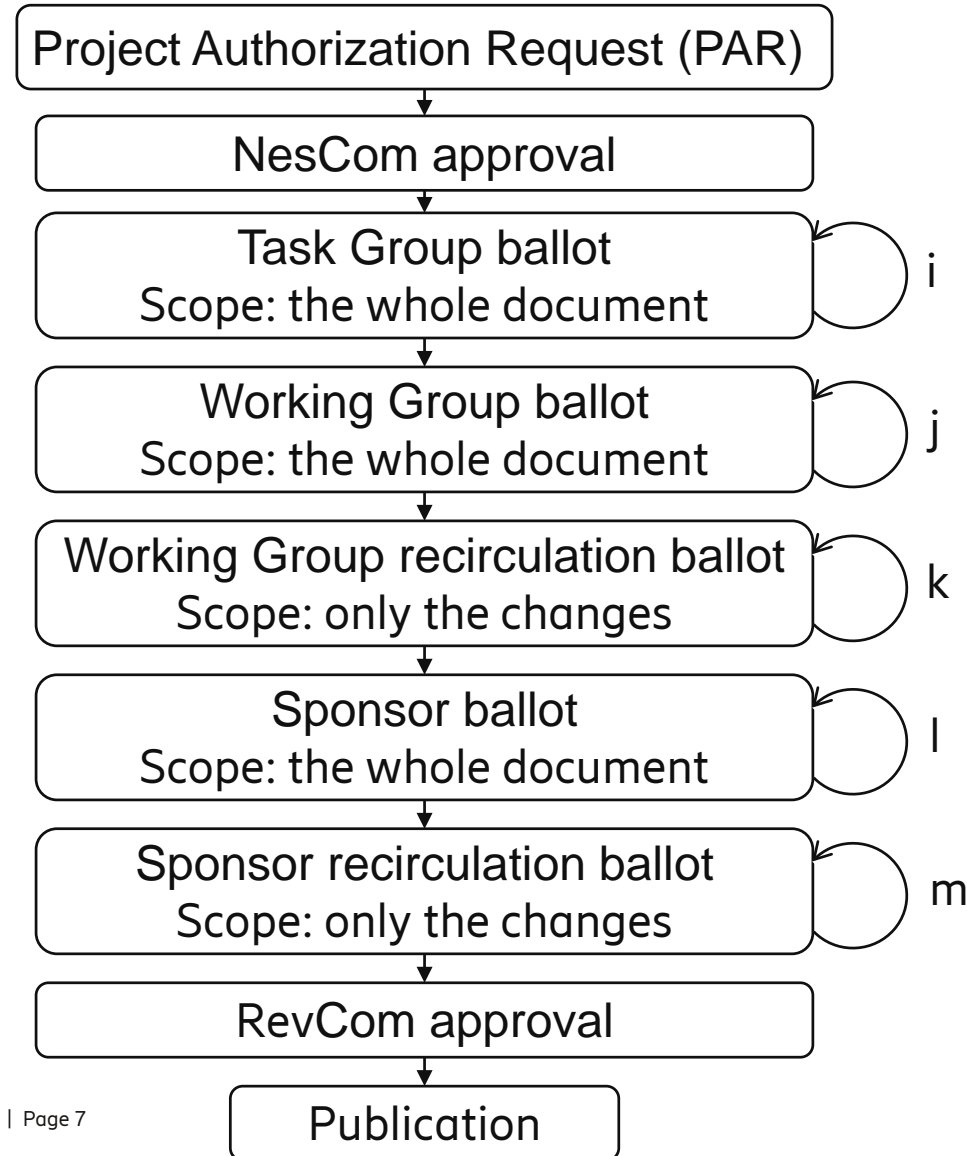
- **Due process** – procedures are publicly available and followed consistently
- **Consensus** – requiring agreement of a majority or supermajority – for technical decisions $\geq 75\%$
- **Openness** – ensuring materially interested and affected parties can participate
- **Balance** – representation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

IEEE 802.1 Working Group



- Standards and recommended practices in the following areas:
 - 802 LAN/MAN architecture
 - Internetworking among 802 LANs, MANs and other wide area networks
 - 802 Security
 - 802 overall network management, and protocol layers above the MAC & LLC layers
- The 802.1 Working Group (WG) includes the following groups:
 - Time-Sensitive Networking (TSN) Task Group (TG)
 - Deterministic services through IEEE 802 networks
 - Security TG
 - Specifies functionality to support secure communication between devices (end stations and bridges) attached to IEEE 802 LANs
 - OmniRAN TG
 - Network reference model and functional description of IEEE 802 access networks
 - Multicast and local address assignment
 - Maintenance TG
 - Maintenance activities throughout the IEEE 802.1 WG
 - IEEE 802 “Network Enhancements for the Next Decade” Industry Connections Activity (NENDica)
 - Facilitates industry consensus towards proposals to initiate new standards development efforts
 - YANGsters
 - Common practice for YANG models supporting IEEE 802 protocols

Standard Development Process (High Level)



NesCom: New Standards Committee

RevCom: Standards Review Committee

TSN TG



- The TSN TG specifies the tools of the TSN toolbox, as well as the use of the tools for a particular purpose
- TSN TG is chartered to provide deterministic services through IEEE 802 networks
 - Guaranteed packet transport
 - Low packet loss
 - Bounded low latency
 - Low packet delay variation
- The TSN TG has been evolved from the Audio Video Bridging (AVB) TG
- The TSN TG includes the former Interworking TG

Grouping of TSN Standards & Projects



Profiles:

802.1BA
Audio Video Bridging

802.1CM
Fronthaul (for cellular)

IEC/IEEE 60802
Industrial Automation



Configuration:

802.1Qcp
YANG
Data Model

802.1Qcc
TSN
Configuration

P802.1ABcu
YANG for
LLDP

P802.1Qcw
YANG for
Qbv, Qbu, & Qci

P802.1CBcv
YANG & MIB
for 802.1CB



Base technology:

802.1AS
Timing &
Synch

802.1Qat
Stream
Rsv. Prot.

802.1Qau
Credit Based
Shaper

802.1Qbu
Frame
Preemption

802.1Qbv
Scheduled
Traffic

802.1Qci
Per-Stream
Filtering

802.1CB
Frame
Repl. & Elim.

P802.1Qcr
Async. Traffic
Shaping

P802.1CS
Link-local
Rsv. Prot.



time

IEEE 802.1 TSN Tools and Configuration



TSN Components Common Standards

Synchronization

Reliability

Latency

Resource Mgmt

Zero congestion loss

Time synchronization:

Timing and Synchronization (802.1AS)
includes a profile of IEEE 1588
(revision ongoing: P802.1AS-Rev)

Ultra reliability:

Frame Replication and Elimination (802.1CB)
Path Control and Reservation (802.1Qca)
Per-Stream Filtering and Policing (802.1Qci)
Reliability for time sync (P802.1AS-Rev)

Bounded low latency:

Credit Based Shaper (802.1Qav)
Frame preemption (802.3br & 802.1Qbu)
Scheduled Traffic (802.1Qbv)
Cyclic Queuing and Forwarding (802.1Qch)
Asynchronous Traffic Shaping (P802.1Qcr)
QoS Provisions (P802.1DC)

Dedicated resources & API

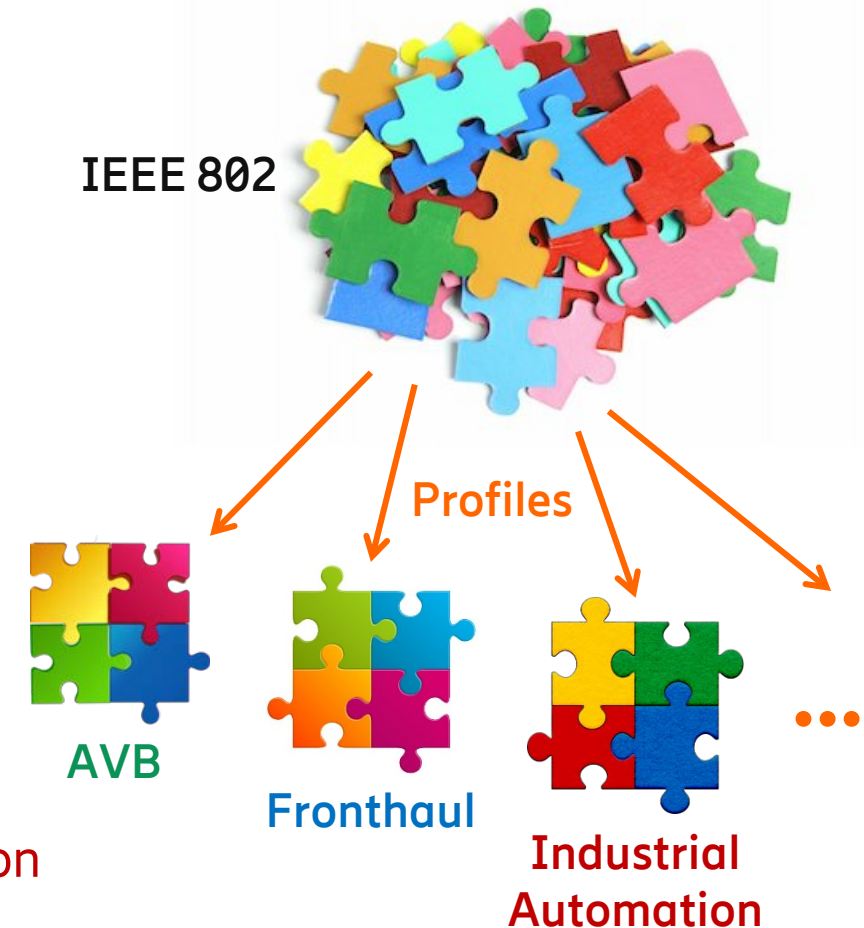
Stream Reservation Protocol (802.1Qat)
TSN configuration (802.1Qcc)
Basic YANG (802.1Qcp)
Link-local Registration Protocol (P802.1CS)
Resource Allocation Protocol (P802.1Qdd)
YANG for CFM (P802.1Qcx)
YANG for LLDP (P802.1ABcu)
YANG for Qbv, Qbu, and Qci (P802.1Qcw)
YANG & MIB for FRER (P802.1CBcv)
Extended Stream Identification (P802.1CBdb)

Note: P upfront of an ID indicates ongoing Project

TSN Profiles



- Wide breadth of choices in IEEE 802 standards
- A TSN Profile
 - Narrows the focus → ease interoperability and deployment
 - Selects features, options, defaults, protocols, and procedures
 - Describes how to build a network for a particular use
 - Provides configuration guideline if needed
- TSN Profiles so far
 - Published TSN Profiles:
 - IEEE Std 802.1BA for Audio-Video Bridging (AVB) networks
 - IEEE Std 802.1CM TSN for Fronthaul (for cellular networks)
 - Ongoing: IEC/IEEE 60802 TSN Profile for Industrial Automation
 - On the horizon:
 - P802.1DF TSN Profile for Service Provider Networks
 - P802.1DG TSN Profile for Automotive In-Vehicle Ethernet Communications



Hints to IEEE 802.1 Standards and Projects



- The ones with capital letters, e.g., 802.1Q or 802.1AB are independent standards
- Amendments to these standards are identified by lower case letters, e.g.,:
802.1Qcp or 802.1ABcu
- Periodically the amendments get merged into a revision of the main standard, e.g.,:
802.1Qbv and 802.1Qbu are part of 802.1Q-2018
- A standard without the year specified means the latest revision of that standard, e.g.,:
802.1Q = 802.1Q-2018 at the moment
- 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 is 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



TSN Standards That Are Also Referred to as AVB Standards

- [IEEE Std 802.1AS-2011](#) Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.
- [IEEE Std 802.1Qat-2010](#) Stream Reservation Protocol (SRP)
(part of [IEEE Std 802.1Q-2018](#))
- [IEEE Std 802.1Qav-2009](#) Forwarding and Queueing Enhancements for Time-Sensitive Streams, which specifies the Credit Based Shaper (CBS)
(part of [IEEE Std 802.1Q-2018](#))
- [IEEE Std 802.1BA-2011](#) Audio Video Bridging (AVB) Systems

TSN Standards



- [IEEE Std 802.1Qbu-2016](#) Frame Preemption
(amends [IEEE Std 802.1Q-2014](#); has been rolled into [IEEE Std 802.1Q-2018](#))
- [IEEE Std 802.1Qbv-2015](#) Enhancements for Scheduled Traffic
(amends [IEEE Std 802.1Q-2014](#); has been rolled into [IEEE Std 802.1Q-2018](#))
- [IEEE Std 802.1Qca-2015](#) Path Control and Reservation
(amends [IEEE Std 802.1Q-2014](#); has been rolled into [IEEE Std 802.1Q-2018](#))
- [IEEE Std 802.1Qch-2017](#) Cyclic Queuing and Forwarding
(amends [IEEE Std 802.1Q-2014](#); has been rolled into [IEEE Std 802.1Q-2018](#))
- [IEEE Std 802.1Qci-2017](#) Per-Stream Filtering and Policing
(amends [IEEE Std 802.1Q-2014](#); has been rolled into [IEEE Std 802.1Q-2018](#).)
- [IEEE 802.1Qcc-2018](#): Stream Reservation Protocol (SRP) Enhancements and Performance Improvements (amends [IEEE Std 802.1Q-2018](#))
- [IEEE 802.1Qcp-2018](#) YANG Data Model (amends [IEEE Std 802.1Q-2018](#))
- [IEEE Std 802.1CB-2017](#) Frame Replication and Elimination for Reliability
- [IEEE Std 802.1CM-2018](#) Time-Sensitive Networking for Fronthaul

TSN Projects



- Stand alone (specifying new stand alone TSN base standards):
 - [IEC/IEEE 60802 TSN Profile for Industrial Automation](#)
It is a Joint Project between IEC and IEEE 802
 - [P802.1CS – Link-local Registration Protocol](#)
 - [P802.1DC – Quality of Service Provision by Network Systems](#)
- Revisions (of a base standard):
 - [P802.1AS-Rev – Timing and Synchronization for Time-Sensitive Applications](#)
 - [P802.1AX-Rev – Link Aggregation Revision](#)

TSN Projects – Cont'd



- 802.1Q amendments (amending [IEEE Std 802.1Q-2018](#)):
 - [P802.1Qcj – Automatic Attachment to Provider Backbone Bridging \(PBB\) services](#)
 - [P802.1Qcr – Asynchronous Traffic Shaping](#)
 - [P802.1Qcw – YANG Data Models for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing](#)
 - [P802.1Qcx – YANG Data Model for Connectivity Fault Management](#)
 - [P802.1Qcz – Congestion Isolation](#)
 - [P802.1Qdd – Resource Allocation Protocol](#)
- 802.1AB amendments (amending [IEEE Std 802.1AB-2016](#))
 - [P802.1ABcu – LLDP YANG Data Model](#)
- 802.1CB amendments (amending [IEEE Std 802.1CB-2017](#))
 - [P802.1CBcv – FRER YANG Data Model and Management Information Base Module](#)
 - [P802.1CBdb – FRER Extended Stream Identification Functions](#)

TSN Project Proposals (not approved yet)



- P802.1CMde Enhancements for Fronthaul Interface, Synchronization, and Synchronization Standards ([PAR](#) and [CSD](#))
- P802.1DF Time-Sensitive Networking Profile for Service Provider Networks ([PAR](#) and [CSD](#))
- P802.1DG Time-Sensitive Networking Profile for Automotive In-Vehicle Ethernet Communications ([PAR](#) and [CSD](#))

Further Reading



- <http://www.ieee802.org/1>
- [TSN feature topic of the June 2018 Issue of IEEE Communications Standards Magazine](#)
<https://ieeexplore.ieee.org/document/8412457>
- Tutorial on TSN at IETF 99
<https://datatracker.ietf.org/meeting/99/materials/slides-99-edu-sessf-time-sensitive-networking-tutorial-english-language-janos-farkas-norman-finn-patricia-thaler>
- Tutorial on IEEE 802 Ethernet Networks for Automotive
http://www.ieee802.org/802_tutorials/2017-07/tutorial-Automotive-Ethernet-0717-v02.pdf
- IEEE 802.1 TSN for Industrial Networks – flyer <https://ieee.box.com/v/TSNIndustrial>
- IEEE 802.1 TSN for Automotive Networks – flyer <https://ieee.box.com/v/TSNAuto>
- “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 at IETF 86 <https://www6.ietf.org/meeting/86/tutorials/86-IEEE-8021-Thaler.pdf>
- Paper on 802.1Q bridging <https://arxiv.org/ftp/arxiv/papers/1405/1405.6953.pdf>



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