

IEEE 802.1 Time-Sensitive Networking Update



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DetNet – TSN Workshop

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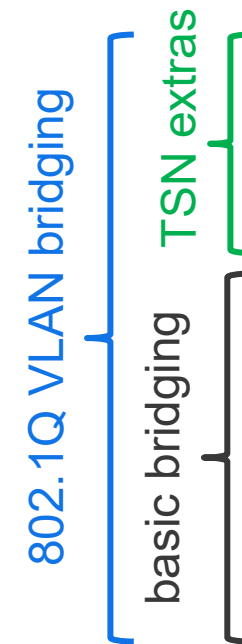
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Note

- previous DetNet – TSN workshop (November 11, 2018, Bangkok) <https://1.ieee802.org/november-2018-plenary-meeting-in-bangkok-thailand-tsn-tg-agenda/> provided overviews, incl. standardization procedures, e.g., <https://www.ieee802.org/1/files/public/docs2018/detnet-tsn-farkas-tsn-overview-1118-v01.pdf>
- This presentation takes the previous workshop as reference, e.g., reports on the progress since the previous workshop.

Demystifying TSN

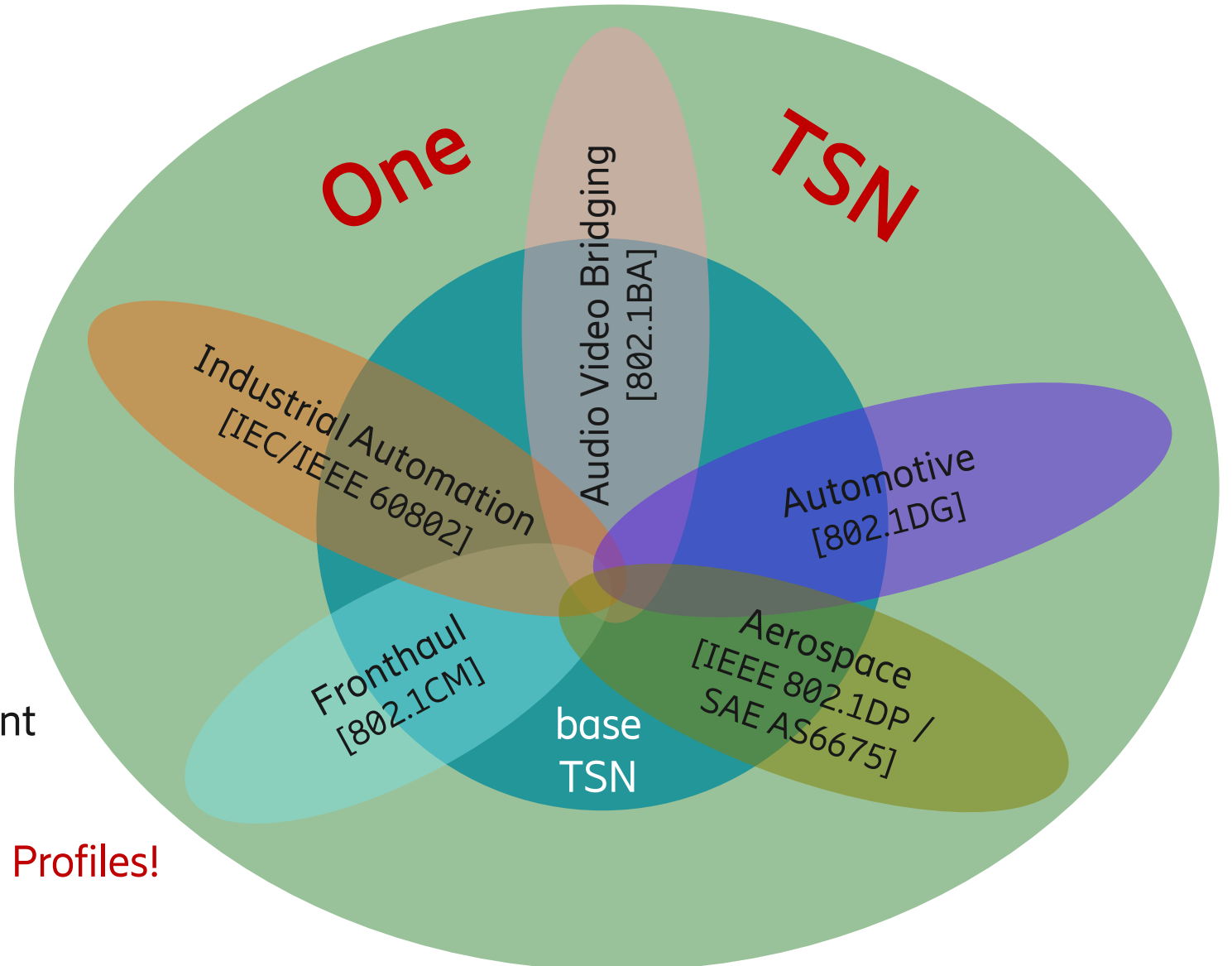
- **What is TSN?**
- **Essentially, TSN is 802.1Q VLAN bridging**
 - TSN is the newest part of 802.1Q VLAN bridging
 - stand-alone standards enable further usage
 - It is on a case-by-case basis how much and what kind of icing is put on the cake, i.e., which tools out of the TSN toolbox (shown in the following)
 - **There is no MUST in the TSN toolbox to call it TSN!**
 - For instance, strict priority with proper Traffic Engineering (TE) can be TSN, see, e.g., 802.1CM
- **To address some common misunderstandings:**
 - TSN $\neq$ time synchronization
 - TSN $\neq$ Time Aware Shaper (TAS)
 - TSN $\neq$ new bridging



The icing/crème is on top of the cake,
not on its own!

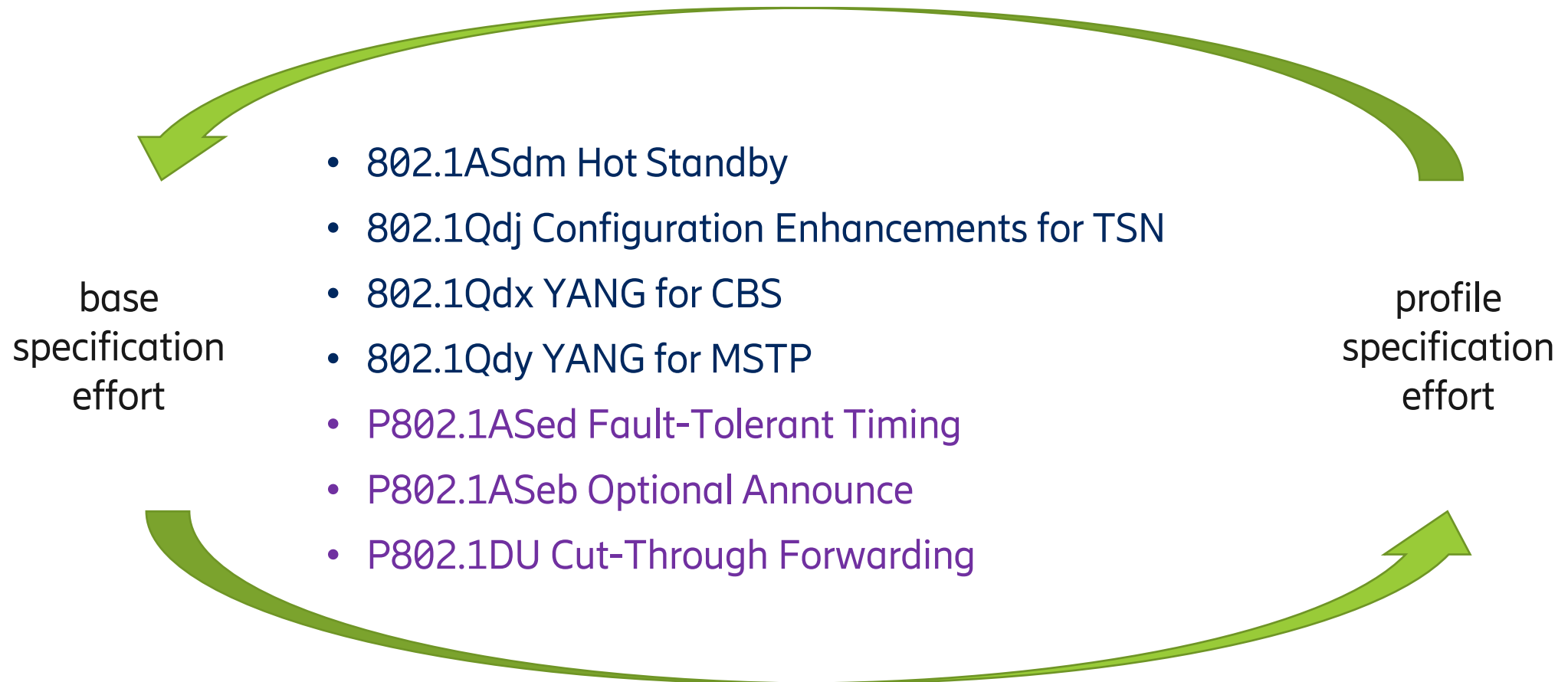
There Is Only One Common TSN

- silicon, bridges, infrastructure
as unified as possible
- A *TSN Profile specification* [e.g.]
selects features, options, defaults,
protocols, and procedures
to ease interoperability and deployment
- It is still the very same **One TSN** for all Profiles!



Collaborative Efforts

benefits of having various experts in the same meeting room



Time-Sensitive Networking (TSN) Profiles (Selection and Use of TSN tools)

developments
since 2018

Audio Video Bridging
[802.1BA]

Fronthaul
[802.1CM/de]

Industrial Automation
[IEC/IEEE 60802]

Automotive In-Vehicle
[802.1DG]

Aerospace Onboard
[IEEE 802.1DP / SAE AS6675]

Time synchronization:

Timing and Synchronization [802.1AS-2020]
(a profile of IEEE 1588)

Hot Standby [802.1ASdm]

YANG [802.1ASdn]

Inclusive Terminology [802.1ASdr]

Support for half-duplex [P802.1ASds]

Optional Announce [P802.1ASeb]

Fault-Tolerant Timing [P802.1ASed]

Bounded low latency:

Credit Based Shaper [802.1Qav]

Frame Preemption [802.1Qbu & 802.3br]

Scheduled Traffic [802.1Qbv]

Cyclic Queuing and Forwarding [802.1Qch]

Asynchronous Traffic Shaping [802.1Qcr]

Shaper Parameter Settings [P802.1Qdq]

Enhancements to CQF [P802.1Qdv]

QoS Provision [802.1DC]

Cut-Through Forwarding [P802.1DU]

TSN Components

(Tools of the TSN toolset)

Synchronization

Reliability

Latency

Resource Management

Zero congestion loss =
Bounded latency

High availability / Ultra reliability:

Frame Replication and Elimination [802.1CB]

Sequence Recovery Configuration [P802.1CBec]

Path Control and Reservation [802.1Qca]

Per-Stream Filtering and Policing [802.1Qci]

Dedicated resources & API:

Stream Reservation Protocol [802.1Qat]

Link-local Registration Protocol [802.1CS]

TSN Configuration [802.1Qcc]

TSN Configuration Enhancements [802.1Qdj]

Foundational Bridge YANG [802.1Qcp]

YANG for CFM [802.1Qcx]

YANG for 802.1Qbv/Qbu/Qci [802.1Qcw]

YANG for CBS [802.1Qdx]

YANG for MSTP [802.1Qdy]

YANG for LLDP [802.1ABcu]

YANG for LAG [802.1AXdz]

YANG & MIB for FRER [802.1CBcv]

Extended Stream Identification [802.1CBdb]

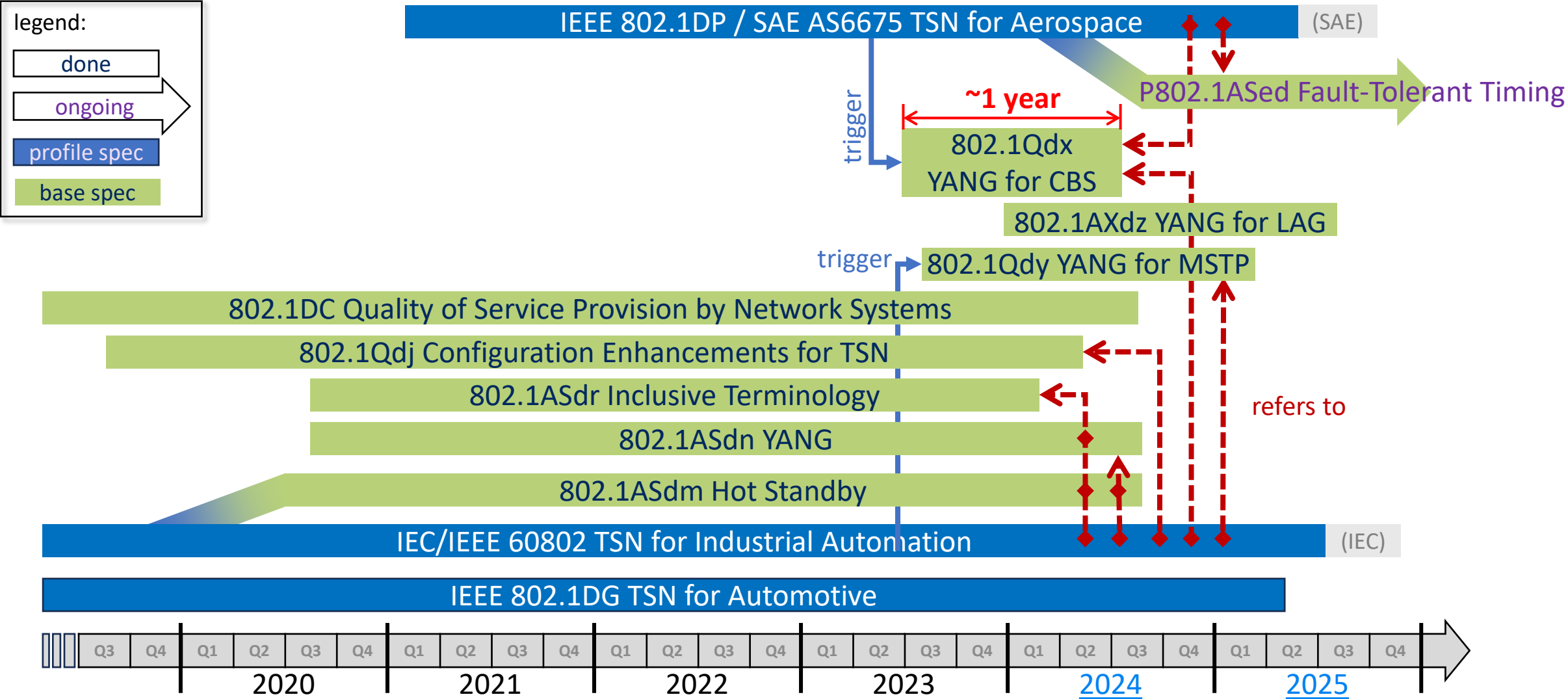
LLDPv2 for Multiframe Data Units [802.1ABdh]

Resource Allocation Protocol [P802.1DD]

Note: A 'P' in front of '802.1' indicates an ongoing Project.

More on [TSN standards](https://www.ieee802.org/1/tsn) and [ongoing projects](https://www.ieee802.org/1/tsn) at: <https://www.ieee802.org/1/tsn>

Done since 2018



Published since 2018



legend:

- base spec
- profile spec

- 802.1Q-2022 – *Bridges and Bridged Networks*
- 802.1Qcx – *YANG Data Model for Connectivity Fault Management*
- 802.1Qcr – *Asynchronous Traffic Shaping*
- 802.1Qcw – *YANG for Scheduled Traffic, Frame Preemption, and Per-Stream Filtering and Policing*
- 802.1Qdj – *Configuration Enhancements for Time-Sensitive Networking*
- 802.1Qdx – *YANG Data Models for the Credit-Based Shaper*
- 802.1Qdy – *YANG for the Multiple Spanning Tree Protocol*
- 802.1ABcu – *YANG Data Model (for LLDP)*
- 802.1ABdh – *Support for Multiframe Protocol Data Units* → **triggered by the IETF LSVR WG**
- 802.1AS-2020 – *Timing and Synchronization for Time-Sensitive Applications*
- 802.1ASdn – *YANG (for gPTP)*
- 802.1ASdm – *Hot Standby (for gPTP)*
- 802.1ASdr – *Inclusive Terminology (for gPTP)*
- 802.1AX-2020 – *Link Aggregation*
- 802.1BA-2021 – *Audio Video Bridging (AVB) Systems*
- 802.1CBcv – *Information Model, YANG Data Model, and Management Information Base Module*
- 802.1CBdb – *Extended Stream Identification Functions*
- 802.1CMde – *Enhancements to Fronthaul Profiles to Support New Fronthaul Interface, Synchronization, and Syntonization*
- 802.1CS – *Link-local Registration Protocol*
- 802.1DC – *Quality of Service Provision by Network Systems* → **very relevant for DetNet**
- 802.1DG – *TSN Profile for Automotive In-Vehicle Ethernet Communications*

Very Recently Done

- **802.1AXdz – YANG for Link Aggregation**
(technically done, sending to IEEE SA Review Committee (RevCom))
- **IEC/IEEE 60802 – TSN Profile for Industrial Automation**
(technically done, sending to IEEE SA RevCom and IEC final ballot)
- **IEEE 802.1DP / SAE AS6675 – TSN for Aerospace Onboard Ethernet Communications**
(technically done, sending to IEEE SA RevCom and SAE final ballot)

Ongoing

(started after 2018)

- **P802.1DD** – *Resource Allocation Protocol (P802.1Qdd “rebranded”)*
- **P802.1DU** – *Cut-Through Forwarding Bridges and Bridged Networks*
- **P802.1Qdq** – *Shaper Parameter Settings for Bursty Traffic Requiring Bounded Latency*
- **P802.1Qdt** – *Priority-based Flow Control Enhancements*
- **P802.1Qdv** – *Enhancements to Cyclic Queuing and Forwarding*
- **P802.1Qdw** – *Source Flow Control*
- **P802.1ASds** – *Support for the IEEE Std 802.3 Clause 4 Media Access Control operating in half-duplex*
- **P802.1ASeb** – *Optional Announce*
- **P802.1ASed** – *Fault-Tolerant Timing with Time Integrity*
- **P802.1CBec** – *Guidance for Sequence Recovery Function Parameter Configuration*

What Is Next?

- Being started
 - **P802.1Qee** – *Traffic Engineering for Bridged Networks with Significant Delay Variance*
 - Primarily, in support of wireless technologies, see draft [PAR](#) & [CSD](#), and [more background](#)
- Some individual proposals for future work
 - see the [TSN agendas](#) for what is going on
 - e.g., brainstorming for industrial automation in [May](#) and [next week](#), incl. [multiple configuration domains](#)

IEEE SA Emerging Technology Award

- The [IEEE 802.1 Working Group](#) was [awarded](#) the [2020 IEEE SA Emerging Technology Award](#) — *for the development of [IEEE Std 802.1CM™-2018](#) Time-Sensitive Networking for Fronthaul as amended by [IEEE Std 802.1CMde™-2020](#), the first IEEE standard to connect a cellular network's radio equipment to its remote controller via a packet network, in particular, over a bridged IEEE 802.3™ Ethernet network.*
- IEEE SA blogpost: <https://standards.ieee.org/beyond-standards/how-time-sensitive-networking-benefits-fronthaul-transport/>



Further Information

- <http://www.ieee802.org/1> / <https://1.ieee802.org/>
- <http://ieee802.org/1/tsn> / <https://1.ieee802.org/tsn/>
- Tutorial – Time-Sensitive Networking For New Ethernet Bridging Applications
<https://1.ieee802.org/tutorial-tsn-for-ethernet-bridging/>
- Time-Sensitive Networking Webinar Series
<https://engagestandards.ieee.org/TSN-Webinar-Series.html>
(<https://1.ieee802.org/?s=webinar>)
- TSN/A Conference
<https://tsnaconference.de/frontend/index.php>
- Ethernet & IP @ Automotive Technology Day
<https://standards.ieee.org/events/automotive/>
- and more at the end of
<https://www.ieee802.org/1/files/public/docs2018/detnet-tsn-farkas-tsn-overview-1118-v01.pdf>

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