

IEEE 802.1 TSN Standards Overview & Update

2017 IEEE Standards Association (IEEE-SA)
Ethernet & IP @ Automotive Technology Day

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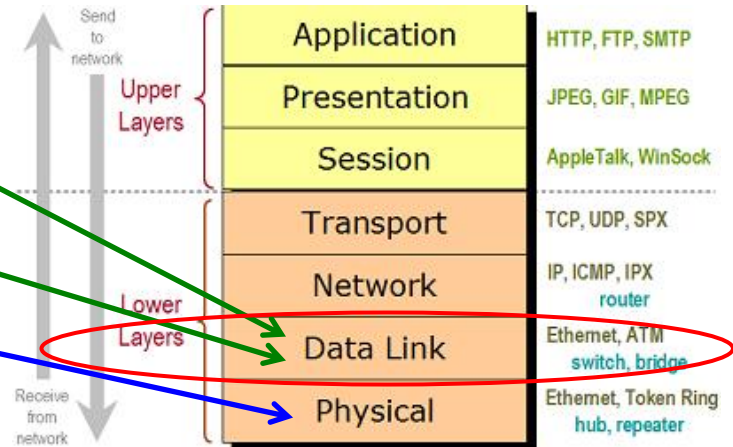


What is TSN?

- TSN stands for Time Sensitive Networking
- It is the name of the IEEE 802.1 Task Group responsible for standards at the Data Link Layer (above the PHYs)
 - <http://www.ieee802.org/1/pages/tsn.html> is the link to the group

- Location in the Stack:

Time Sensitive Networking (TSN)
Audio Video Bridging (AVB)
IEEE 802.3 Ethernet PHYs



The First Wave of the AVB/TSN Standards:

These standards are completed and products can be tested for compliance to these standards at UNH-IOL using Avnu certification tests


Audio Video Bridging (AVB) Systems

- Project: IEEE 802.1BA-2009

- Status: **Done!**

- Goals:

PAR	Task Group	Work Group	Sponsor Ballot
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 **Standard!**
 - Defines a profile of standard needed for Plug-and-Play systems
 - 802.1BA defines some limits to insure the target application's performance
 - These limits are applicable to the original target application – not others!
 - Prevents 99.99% of dropped frames caused by congestion by supporting stream reservations with guaranteed bandwidth & deterministic latency
 - TSN builds on the strong & proven AVB foundation to make it even better and applicable to more applications

Audio Video Bridging (AVB) Systems

- [IEEE 802.1BA-2009](#) Profiles the following standards for the specific use case of Plug-and-Play Audio & Video streams:
 - [IEEE 802.1AS-2011](#) – gPTP (generic Precise Timing Protocol)
 - [IEEE 802.1Qav-2009](#) – Credit based shaper (in Q-2014 section 34)
 - [IEEE 802.1Qat-2010](#) – SRP (Stream Reservation Protocol – in Q section 35)
- Other Applicable Standards:
 - [IEEE 1722-2011](#) – AVTP (Audio Video Transport Protocol)
 - [IEEE 1722.1-2013](#) – AVDECC (Audio Video Discovery Enumeration)

Audio Video Bridging (AVB) Systems

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 - **IEEE 802.1Qav-2009** – Credit based shaper (in Q-2014 section 34)
 - **IEEE 802.1Qat-2010** – SRP (Stream Reservation Protocol – in Q section 35)

All IEEE 802 Standards are FREE after 6 months
Go to: standards.ieee.org/about/get/802




The Second Wave of the AVB/TSN Standards:

These standards are completed or nearly completed in IEEE and certification tests are under development

Time Aware Shaper (Qbv)

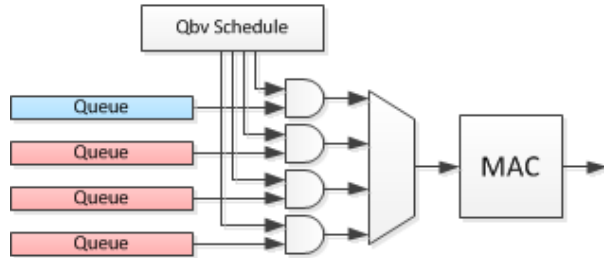
- Project: IEEE 802.1Qbv-2015
- Status: **Done!**
- Goals:

PAR	Task Group	Work Group	Sponsor Ballot
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 **Standard!**
 - Achieve the theoretical lowest possible latency in engineered networks
- What it does:
 - Adds time gates on each queue on a port
 - At specific pre-programmed intervals a port's lower priority queues can be blocked so that higher priority traffic can pass through unimpeded
 - **It delivers the lowest possible latency for a stream all the time**

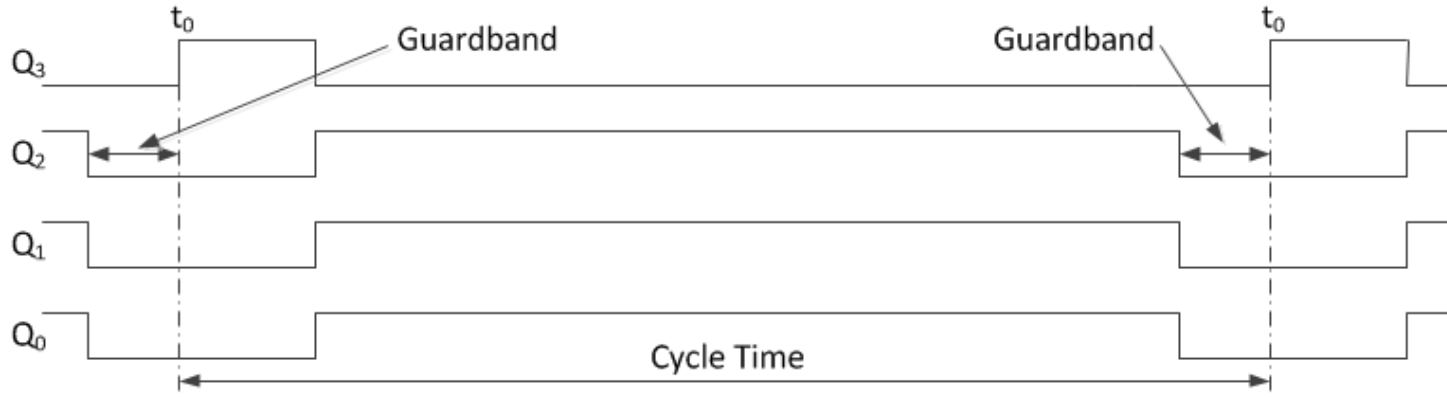
Time Aware Shaper (Qbv)

Time Aware Shaper
Queue Structure



Time Aware Shaper
Example Schedule

$t_{0-gb} = 0000$ $t_{0-gb} =$ Block non-Time Critical Data
 $t_0 = 1000$ $t_0 =$ Time Critical Queue is open
 $t_{0+d} = 0111$ $t_{0+d} =$ Time Critical Data is done
 & repeat each cycle



Preemption (Qbu & 3br)

- Project: IEEE 802.1Qbu-2016 & IEEE 802.3br-2016

- Status: **Done!**

- Goals:

PAR	Task Group	Work Group	Sponsor Ballot
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 **Standard!**

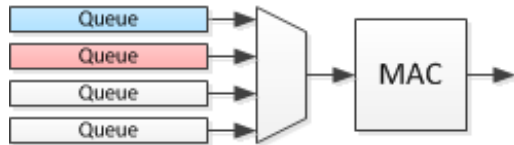
- Reduce latency of time-sensitive streams in **non-engineered networks**

- What it does:

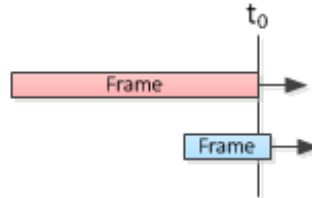
- Supports one level of preemption where a higher priority frame can interrupt the transmission of a lower priority frame
 - When the higher priority frame is done, the lower priority frame continues where it left off
 - Fragmented frames must be completely reassembled at the link's receiver before they can continue through a bridge or end node

Preemption (Qbu & 3br)

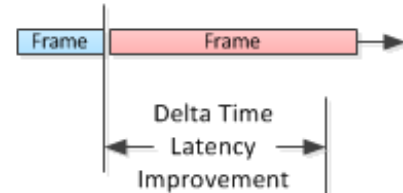
Non-Preemption Queue Structure



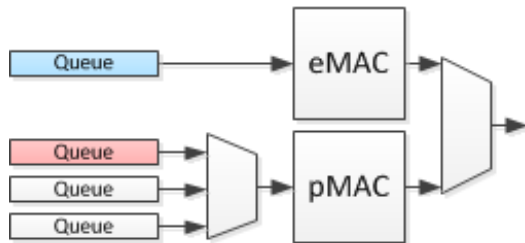
Example of Frames Showing Up in the Queues
Red is in its queue 1st



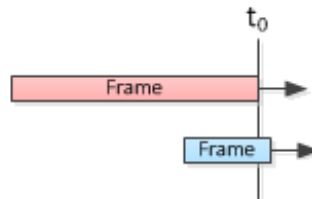
Resulting Frame Transmissions
Red 1st followed by Blue



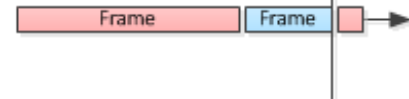
Preemption Queue Structure Example



Example of Frames Showing Up in the Queues
Red is in its queue 1st




Resulting Frame Transmissions
Red starts, but is pre-empted by Blue – then Red continues



Cyclic Queuing & Forwarding (Qch)

- Project: IEEE 802.1Qch-2017
- Status: **Done!**
- Goals:


PAR	Task Group	Work Group	Sponsor Ballot
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 **Standard!**
 - Supports known latencies regardless of the network topology
- What it does:
 - Works without the need of a “Central Controller”
 - Requires minimum delays per hop making the network latencies more consistent
 - Although closer to the worst case all the time
 - Uses a even/odd cycle time approach in the bridges
 - Frames are held for at least one cycle

Per Stream Filtering & Policing (Qci)

- Project: IEEE 802.1Qci-2017
- Status: **Done!**
- Goals:

PAR	Task Group	Work Group	Sponsor Ballot
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Standard!

 - Be able to identify flows by *other* than layer 2 fields
 - Assign these identified flows to a policer so reception rate is limited
 - This limit detects misbehaving link partners protecting the rest of the network
 - Per Stream functions can't be used everywhere - doesn't scale
 - We need to learn from the “best practices” used by ISPs to protect their networks – per stream at the edge, per class in the core
- Follows the MEF-10 (Metro Ethernet Forum) policers
- A “Reverse Qbv” Policing Mode was added too

Frame Replication & Elimination

- Project: IEEE 802.1CB-2017

- Status: **Done!**

- Goals:

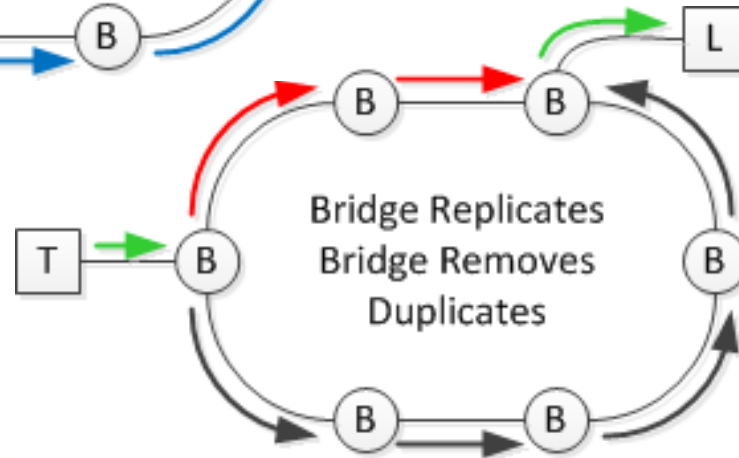
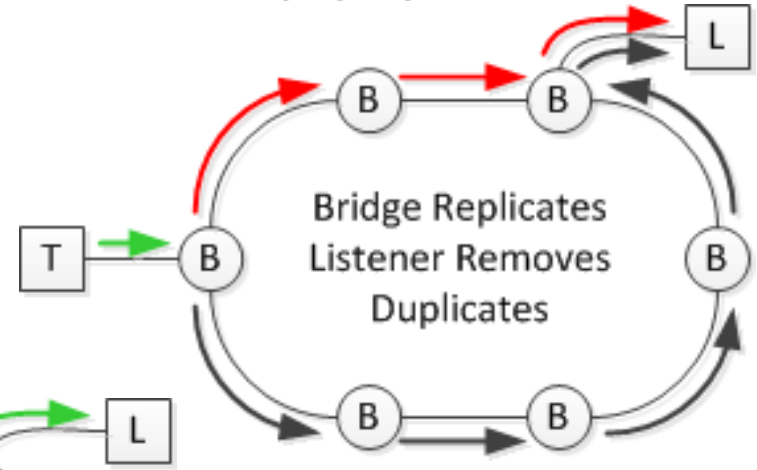
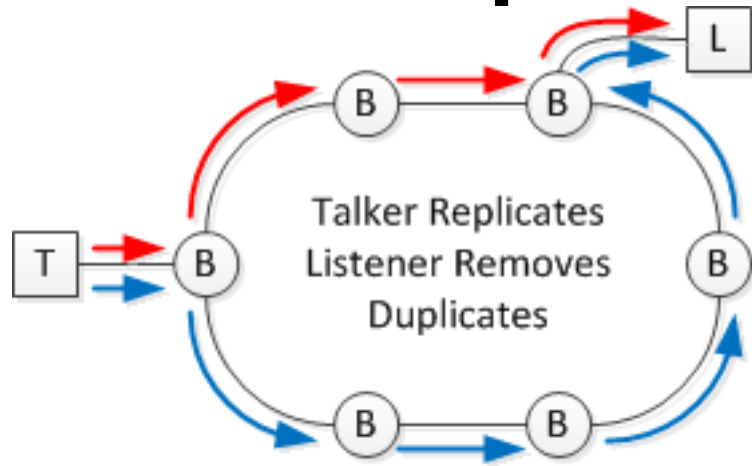
PAR	Task Group	Work Group	Sponsor Ballot
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 **Standard!**

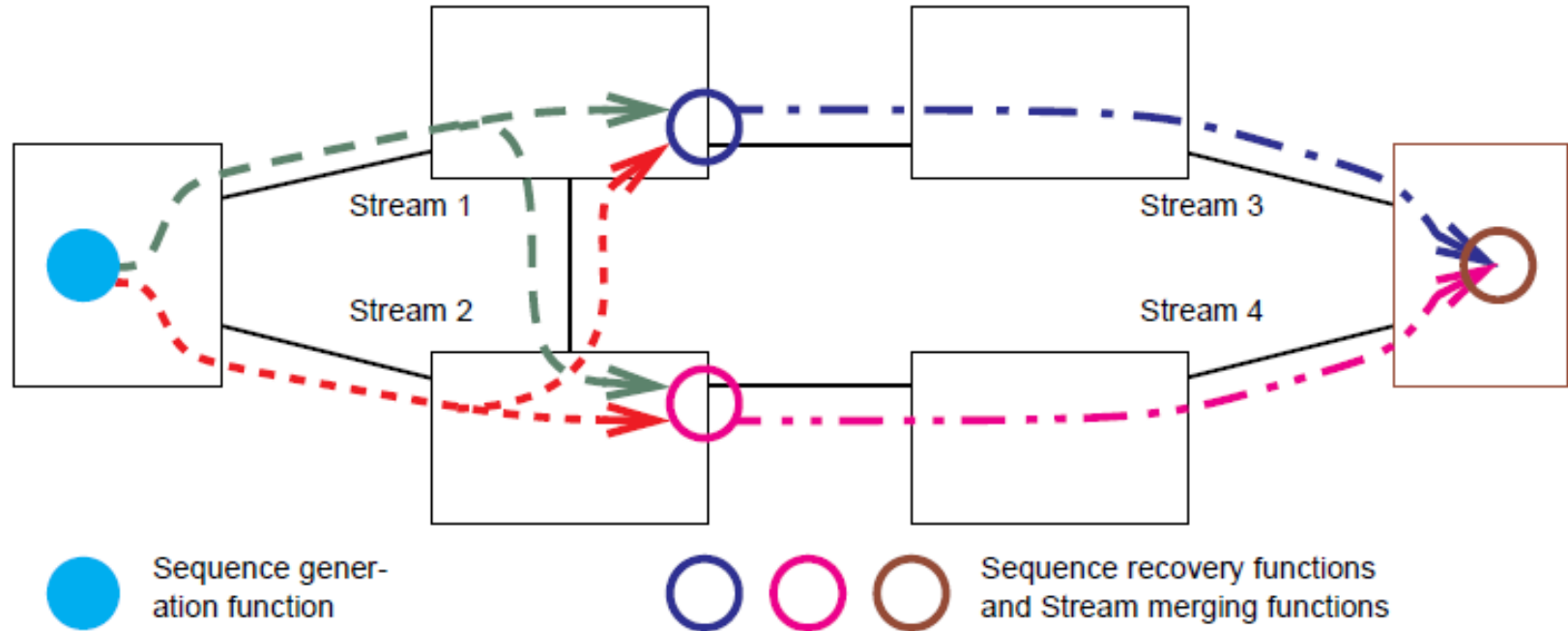
- Supports Data Redundancy “seamlessly” for the applications

- Solves the problem associated w/ CRC errors, broken wires & loose connections when Ring, or Rings connected to Ring networks are used
- Time-Critical frames are expanded to include a Sequence Number & they are Replicated where each copy follows a separate path in the network
- At any merge point in a network (where the separate paths join again) duplicate frames can be Eliminated from the stream
- Applications can receive frames out of order

Frame Replication & Elimination



Frame Replication & Elimination



Redundant Stream Path Ladder Model

Enhanced Generic Precise Timing Protocol

- Project: IEEE 802.1AS-Rev
- Status: In 1st Work Group ballot at Draft 5.0 June 2017



- Goals:

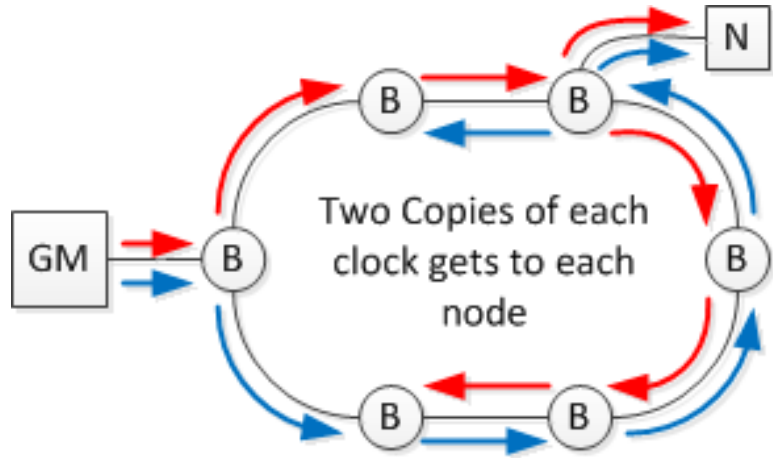
- Supports Clock Redundancy

- Via multiple Grand Masters each which can use multiple Domains/paths
 - Per Domain Port States are managed via a “Central Controller” (Qcc)
 - Plug-and-Play redundancy was not added in this revision

- Adds support for more than just Bridges (like Routers)

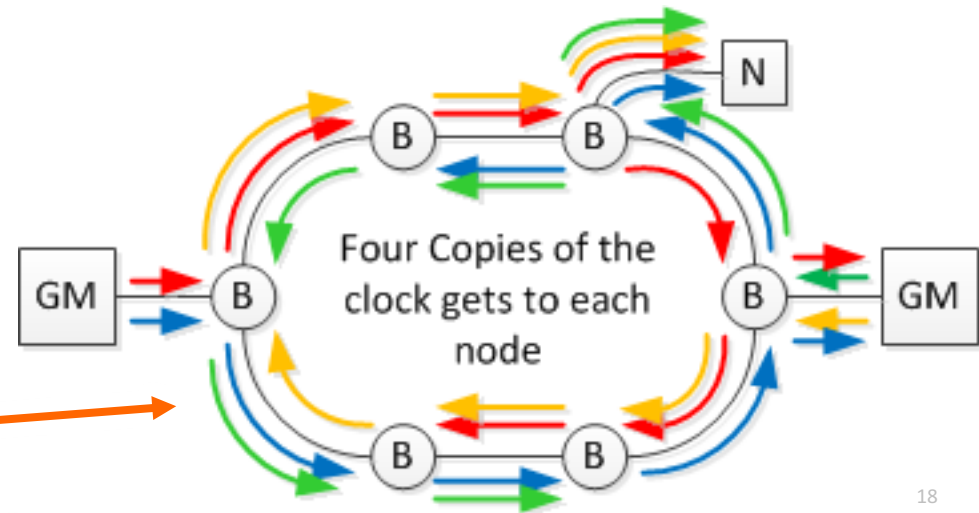
- Supports Aggregated Links and enhance accuracy in Wi-Fi

Enhanced Generic Precise Timing Protocol



- Single Grand Master transmitting 2 copies of its clock using separate paths

- Dual Active Grand Masters each transmitting 2 copies of their clock using separate paths



Stream Reservation Protocol Enhancements

- Project: IEEE 802.1Qcc
- Status: In 4th Work Group ballot at Draft 1.6 July 2017

- Goals:
 - Supports a “Central Controller” or pre-defined (Flashed) “Engineered Configuration” or both
 - Supports a standardized interface to make reservations without needing to use SRP (I call this the Stream Reservation part – or the SR part of SRP)
 - Used to configure the features of the previous standards



The Third Wave of the AVB/TSN Standards:

These standards are in their early stages of development in IEEE

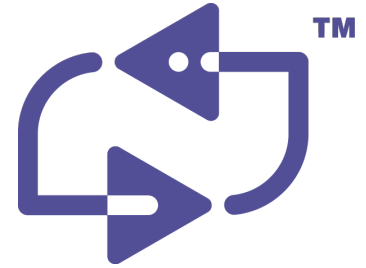
Asynchronous Traffic Shaping (Qcr)

- Project: IEEE 802.1Qcr
- Status: In 1st Task Group ballot at Draft 0.1 April 2017
- Goals:

PAR	Task Group	Work Group	Sponsor Ballot	Standard!
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 - Supports deterministic latency without using network topology info
 - Supports zero congestion loss for asynchronous traffic
- What it does:
 - This asynchronous traffic shaping provides an additional layer of shaped egress queues to merge flows into the existing queue structure. The required minimum number of independent queues at an egress port is adjustable and is at least the number of ingress ports of the particular bridge that require merging.

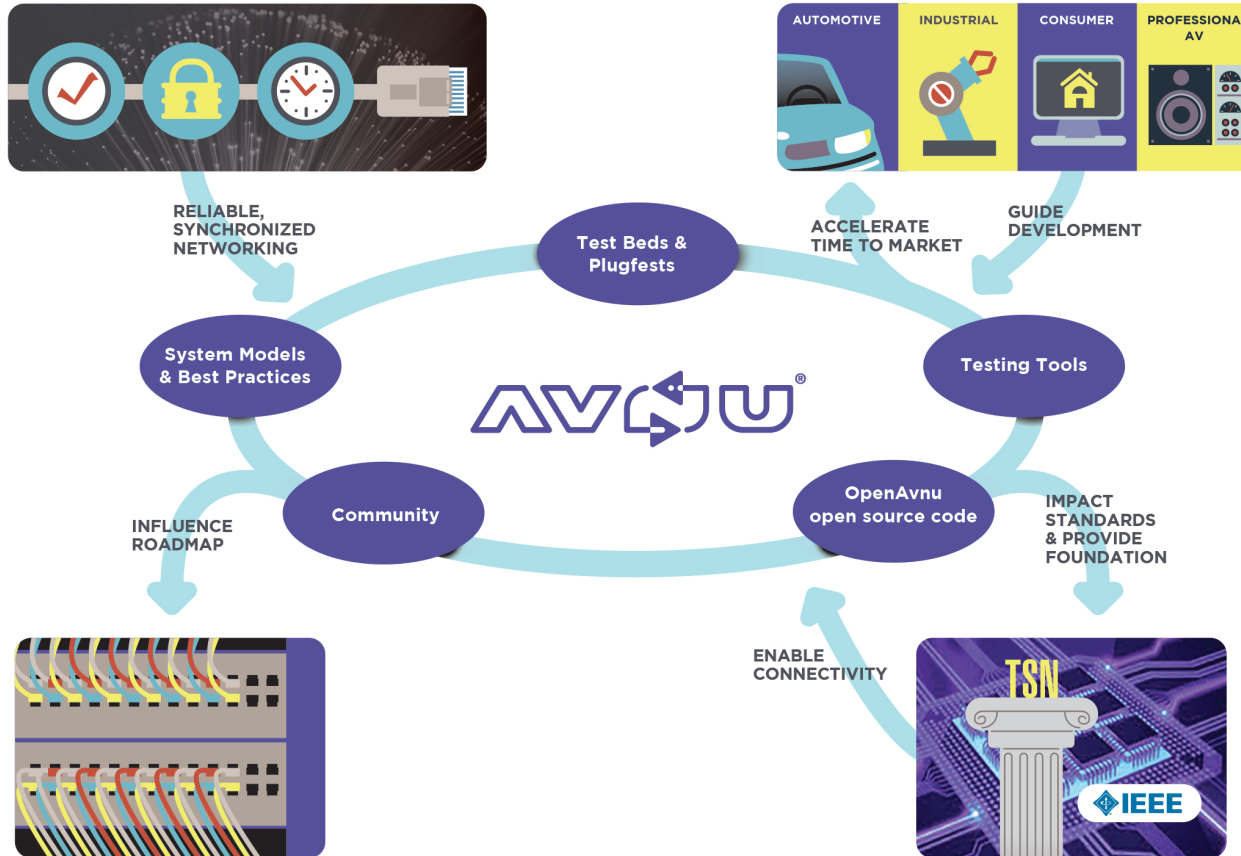
What is Avnu Alliance?



Creating a certified ecosystem to bring **precise timing, reliability and compatibility** to networks

- Team of 80+ companies promoting open standards for deterministic networking, such as AVB/TSN
- Spans many industries: pro A/V, consumer A/V, automotive, energy, manufacturing, and more
- Certifies products to ensure interoperability and compatibility among brands

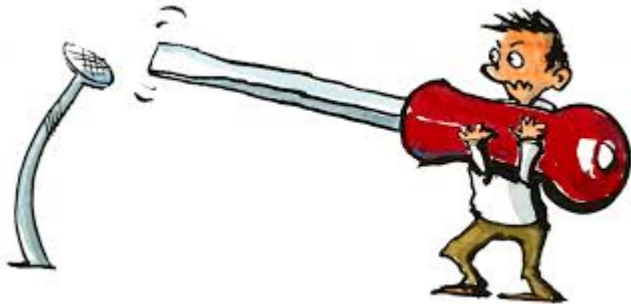
AVNU: Converged AVB/TSN Ecosystems



Summary

Summary

- The IEEE 802.1 TSN Task Group creates standards which are like tools in a tool box – with more being added all the time
 - 1st you need to know what tools are available, and then you need to learn what each tool does and what its “cost” is
 - Only then can you decide which tools are appropriate for your application





Thank
You

Questions?

This was only a brief overview – These are not the only TSN Tools
– and more tools will be added in the future.

The TSN standards will progress faster with your help and
involvement. Come join the IEEE 802.1 TSN meetings and Avnu
Alliance to help shape the industry.