IEEE TSN Standards Overview & Update

Don Pannell

Principal Systems Architect

dpannell@marvell.com

Ethernet & IP Automotive Tech Day

October 2015

MARVELL

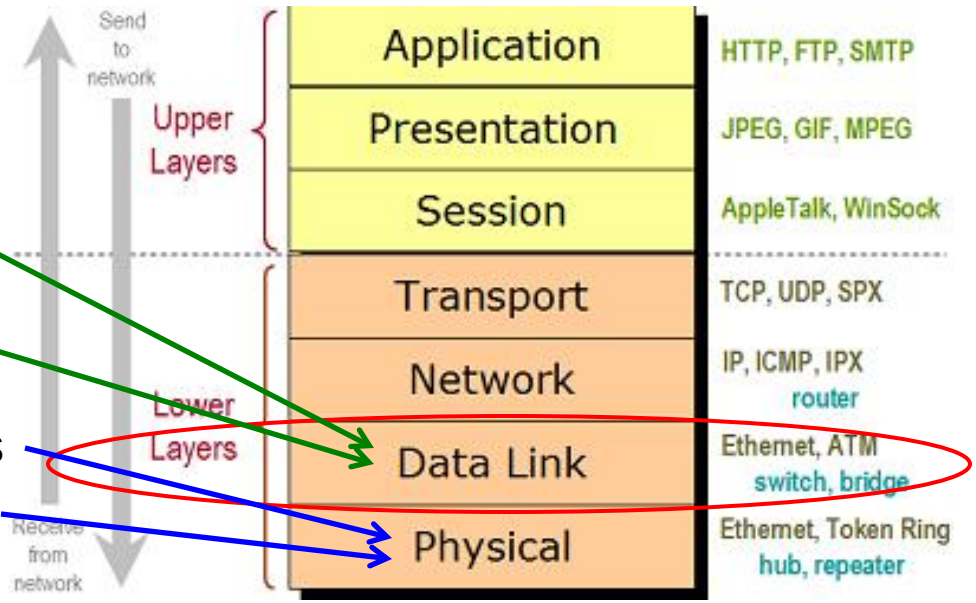
What is TSN?

- 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
- IEEE 802.3 works on standards at the Physical Layer

- Time Sensitive Networking (TSN)
- Audio Video Bridging (AVB)

- IEEE 802.3bp 1000BASE-T1 PHYs
- IEEE 802.3bw 100BASE-T1 PHYs

The OSI Model of Computer Networks



MARVELL

What is TSN & AVB?

- The charter of the TSN Task Group is to provide the specifications that will allow time-synchronized, low latency, streaming services through IEEE 802 networks
- TSN is unique in that its streams are delivered with guaranteed bandwidth and deterministic latency
- Sounds a lot like Audio Video Bridging (AVB)?
  - It should, as AVB was the previous name of the very same Task Group!
  - When the AVB Task Group was first formed in 2006, its target applications were Audio & Video, thus the AVB name
  - With the completion of the AVB standards in 2013, it became clear that streaming data can also be Control, like that used in Automotive & Industrial
  - So the Task Group changed its name to TSN to better reflect the new, enlarged, scope of its standards due to the expanded target applications
- TSN supports & works with all standard AVB devices

A Brief History of TSN

Ethernet & IP Automotive Tech Day

October 2015

MARVELL

History

- The AVB standards succeeded in reaching their time-synchronization and performance goals supporting Plug-and-Play in an arbitrary shaped network
- Organizations like AVnu.org have created Certification & Interoperability tests where products are currently being certified at test houses like UNH-IOL (iol.unh.edu)
- The initial set of “AVB” standards include:
  - IEEE 802.1AS-2011 – gPTP (generic Precise Timing Protocol)
  - IEEE 802.1Qav-2009 – Credit based shaper (now in Q-2014 section 34)
  - IEEE 802.1Qat-2010 – SRP (Stream Reservation Protocol – in Q section 35)
  - IEEE 802.1BA-2011 – AVB Systems
  - IEEE 1722-2011 – AVTP (Audio Video Transport Protocol)
  - IEEE 1722.1-2013 – AVDECC (Audio Video Discovery Enumeration Connection and Control)

History

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

- The AVB standards succeeded in reaching their time-synchronization and performance goals supporting Plug-and-Play in an arbitrary shaped network
- Organizations like AVnu.org have created Certification & Interoperability tests where products are currently being certified at test houses like UNH-IOL (iol.unh.edu)
- The initial set of "AVB" standards include:
  - IEEE 802.1AS-2011 – gPTP (generic Precise Timing Protocol)
  - IEEE 802.1Qav-2009 – Credit based shaper (now in Q-2014 section 34)
  - IEEE 802.1Qat-2010 – SRP (Stream Reservation Protocol – in Q section 35)
  - IEEE 802.1BA-2011 – AVB Systems
  - IEEE 1722-2011 – AVTP (Audio Video Transport Protocol)
  - IEEE 1722.1-2013 – AVDECC (Audio Video Discovery Enumeration Connection and Control)

History

"Good standards get added to - Bad standards die"

- The AVB standards must have been "Good" because they are being added to – and they are now called TSN
- TSN's Goals:
  - Support ALL data types (not just Audio and Video – add in Control)
  - Achieve better performance through lower latencies in non-engineered networks
  - Achieve the theoretical lowest possible latency in engineered networks
  - Achieve extraordinary low packet loss rates by supporting various levels of redundancy
  - Interoperate with devices that support the previous AVB standards

The TSN Standards

Ethernet & IP Automotive Tech Day

October 2015

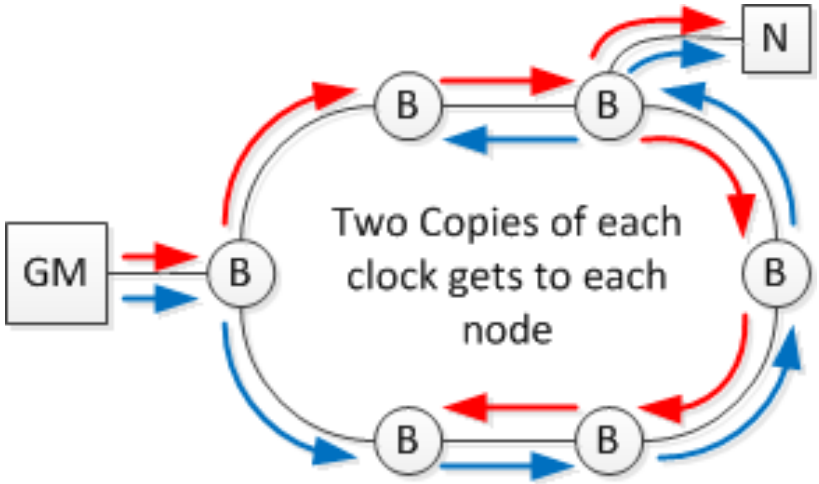
MARVELL

Enhance Generic Precise Timing Protocol

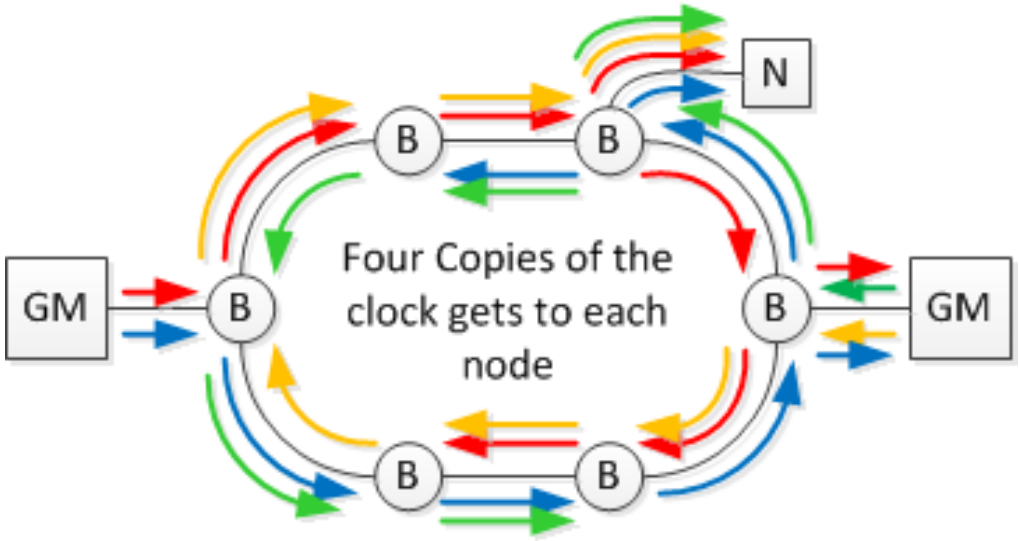
- Project: IEEE 802.1AS-Rev
- Status: In Task Group ballot @ Draft rev 2.0 Oct 2015
- Goals:

  - Improve Performance
  - Support Redundancy
  - Support Aggregated Links and other media
  - Took Bridge out of the title (as gPTP has more applications than that)
- Initial work (Phase 1) will add in the “knob & dial” controls needed to meet the goals
  - It is expected that some “Central Controller” or pre-defined “Engineered Configuration” will use these controls to define the desired redundancy in a given engineered network
  - Future gPTP standards, beyond this work, will add support for Plug-and-Play redundancy

Enhance Generic Precise Timing Protocol



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



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

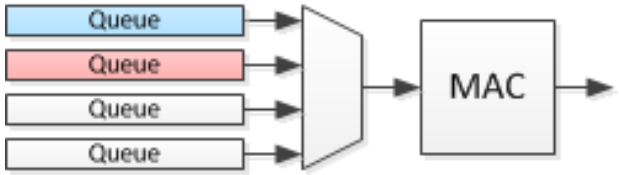
Add Preemption

- Project: IEEE 802.1Qbu & IEEE 802.3br
- 1Qbu Status: In Sponsor ballot @ Draft rev 3.1 Sept 2015
- 3br Status: In Work Group ballot @ Draft rev 2.2 Aug 2015
- Goals:

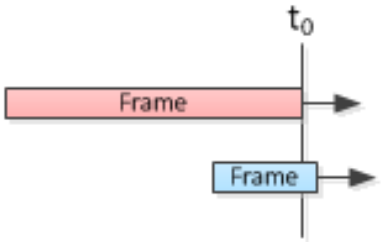
  - Reduce the latency of time-sensitive streams in non-engineered networks
- What it does:
  - Supports one level of preemption where a higher priority frame can interrupt the transmission of a lower priority frame
  - When the higher priority frame is done, the lower priority frame continues where it left off
  - Preemption is supported only if both side of a link agree (LLDP can be used)
  - Fragmented frames must be completely reassembled at the link's receiver before they can continue through a bridge – no fragments in the wild!
  - Minimum fragment size is 64 bytes

Add Preemption

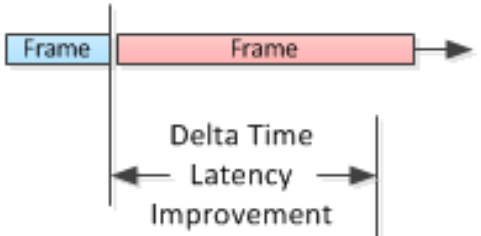
Non-Preemption
Queue Structure



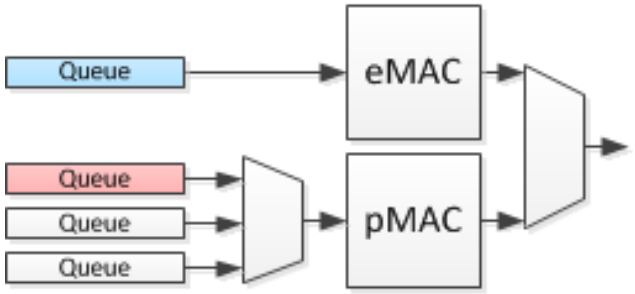
Example of Frames
Showing Up in the Queues
Red is in its queue 1st



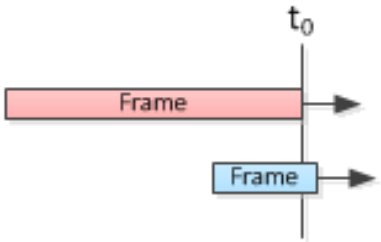
Resulting Frame
Transmissions
Red 1st followed by Blue



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

MARVELL

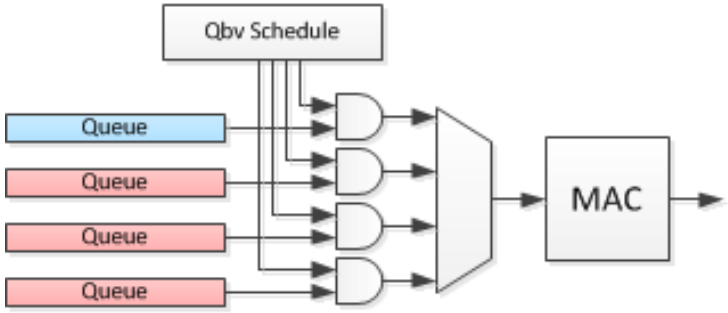
Add a Time Aware Shaper

- Project: IEEE 802.1Qbv
- Status: In Sponsor ballot @ Draft rev 3.1 Sept 2015
- Goals:

  - Achieve the theoretical lowest possible latency in engineered networks
- What it does:
  - Works with applications where time-critical data is sent on regular periodic intervals
  - Adds time gates on each queue on a port
  - At specific pre-programmed times a port's lower priority queues can be blocked so that higher priority traffic can pass through unimpeded
  - Time Aware Shaping bridges can support Cut-Through with a guaranteed performance of around 1 uSec of bridge latency regardless of frame size
  - Can be used with Preemption to reduce the "guard band" delays required when blocking the lower priority queues

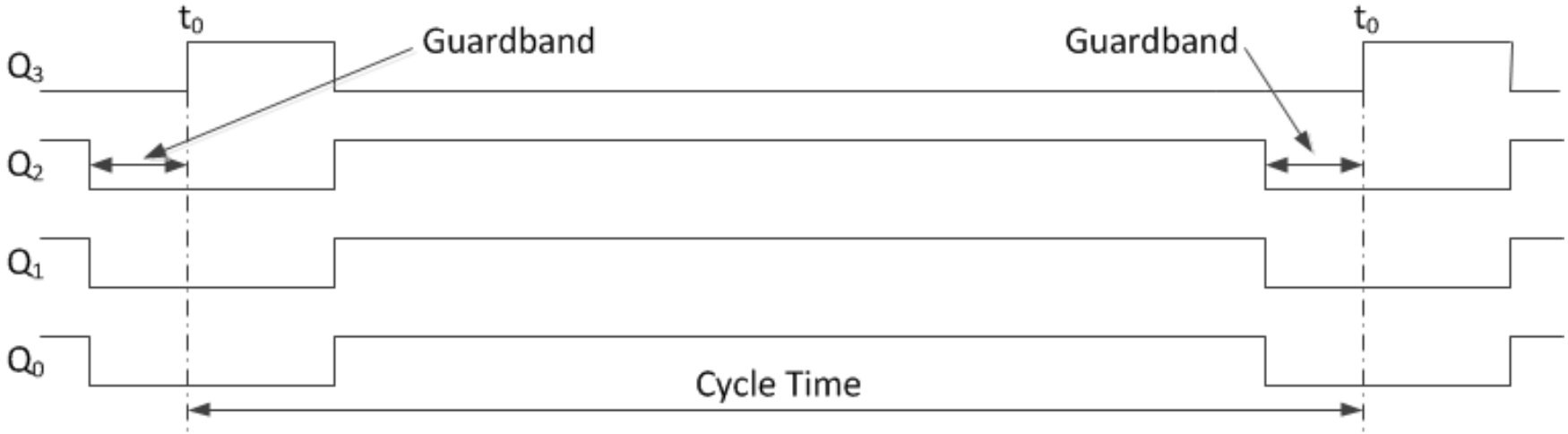
Add a Time Aware Shaper

Time Aware Shaper
Queue Structure



Time Aware Shaper
Example Schecule

$t_{0\text{-}gb}$ = 0 0 0 0 — $t_{0\text{-}gb}$ = Block non-Time Critical Data
t_0 = 1 0 0 0 — t_0 = Time Critical Queue is open
t_{0+d} = 0 1 1 1 — t_{0+d} = Time Critical Data is done
& repeat each cycle

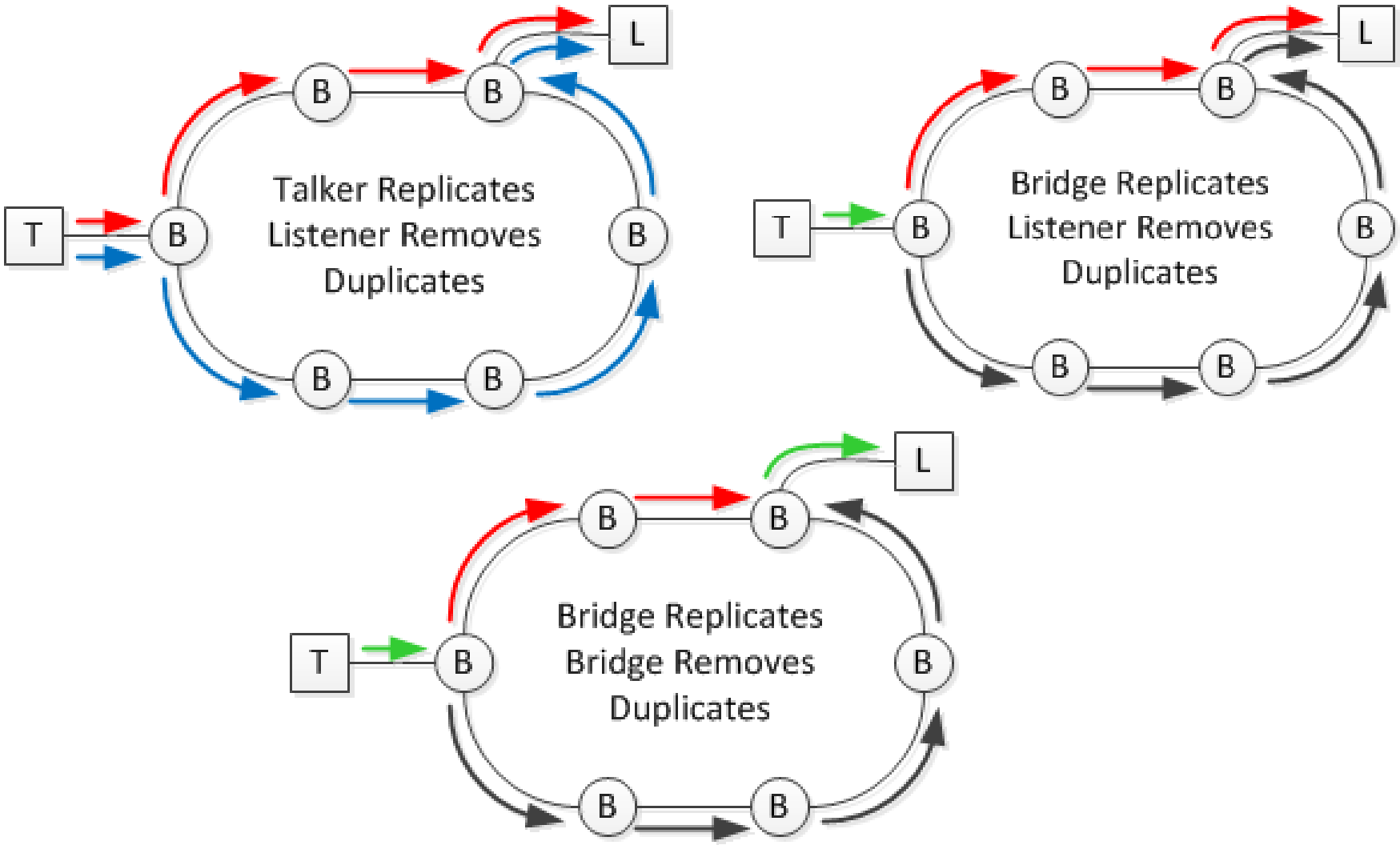


Add Frame Replication & Elimination

- Project: IEEE 802.1CB
- Status: In Task Group ballot @ Draft rev 2.0 Oct 2015
- Goals:

  - Support zero switch over time when a link fails or frames are dropped
  - This is sometimes called Seamless Redundancy
- What it does:
  - It solves the problem associated with random CRC errors, broken wires and loose connections when Ring or Rings connected to Ring networks are used
  - Time-Critical frames are expanded to include a Sequence Number and then 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
  - The receiving application of the stream gets every frame from either the primary or the secondary flow (or both) – but the frames may be out of order

Add Frame Replication & Elimination



Enhance Stream Reservation Protocol

- Project: IEEE 802.1Qcc
- Status: In Task Group ballot @ Draft rev 0.5 Sept 2015
- Goals

  The ones related to Automotive are:
  - Support configurable SR Classes and Streams (like the AVnu Auto CDS)
  - Support ‘Flashed’ or ‘Pre-Configured’ reservations (like the AVnu Auto CDS)
  - Support a standardized ‘Network Interface’ for new reservations
  - Add support for the new Shapers – Time Aware & Preemption
  - Add support for Frame Replication and Elimination
- What it does:
  - Supports a “Central Controller” or pre-defined “Engineered Configuration”
  - 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)

Enhance the Stream Transport Protocol

- Project: IEEE 1722-Rev
- Status: In Sponsor ballot @ Draft rev 15 Oct 2015
- Goals

  The ones related to Automotive are:
  - Adds frame support for LIN, CAN, FlexRay & Most
  - Adds enhanced Video & Audio formats (like the AVnu Auto CDS)
  - Adds encrypted frame format support
  - Adds House Clock definition (for any clock type: audio, video, control, etc.)
  - Adds Event bits for application dependent real time event information
  - Adds 1722 over UDP-IP Encapsulation
- What it does:
  - Supports automotive audio, video and control frame formats
  - Networks can be designed to transport/tunnel CAN, etc. over Ethernet
  - Supports a “Central Controller” or pre-defined “Engineered Configuration”

Questions?

This was only a brief overview – there is so much more to TSN!

For example: 802.1Qci – Per Stream Filtering & Policing

and 802.1Qch – Cyclic Queuing & Forwarding

as these are in their early stages of development

Backup Material

Ethernet & IP Automotive Tech Day

October 2015

MARVELL

Progression of IEEE 802.1 Standards

- Idea → PAR (Project Authorization Request)
- PAR approval → Project letters are assigned & work begins
- Task Group phase → Drafts are created & balloted – once the Task Group feels the standard is complete it starts Work Group ballots
- Work Group phase → The full 802.1 Work Group now reviews the draft to insure it is consistent with past 802.1 work – here changes can be made to fix inconsistencies
- Sponsor ballot phase → The full IEEE now reviews the draft. Mainly editorial changes are made here
- STD! → After Sponsor ballots pass, the overall process is reviewed by the IEEE and then approves the standard!