Beyond 10Gb/s: Automotive Ethernet for the 2020’s

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Automotive Networking Evolution

1991
CAN (Controller Area Network) (500K - 2M)
Low-speed serial data bus (<1K)

2001
MOST (Media Oriented Systems Transport)
Shared ring topology: 25M (POF), 50M (Cu), 150M (POF, Coax)
LVDS (Low-voltage differential signaling) / SerDes (Serializer / De-serializer)
Point-to-point links (1-12G) for cameras and displays

2005
FlexRay (consortium of automotive companies)
10M serial data bus (single or dual channel)

2008
Ethernet
10M, 100M, 1G, 2.5/5/10G, & 10G+
Automotive Electrical PHYs in IEEE802.3

- 802.3bp - 1000BASE-T1

- 802.3bw - 100BASE-T1

- 802.3cg - 10BASE-T1S / (10BASE-T1L)
  - CFI 7/2016, Standard 2019 (est)

- 802.3ch - 2.5/5/10G BASE-T1
  - CFI 11/2016, Standard 2020 (est)
Trends in Automotive Ethernet

1 port


100BASE-TX 100BASE-T1 1000BASE-T1 2.5/5/10G BASE-T1 10G+

<10 ports

Low Res Cameras Connected Car, IVI, TCU, Gateway ADAS & Autonomous Driving

10-50 ports

>100 ports*

OBD

*Average Ethernet ports per vehicle
Transition from domain to zonal architectures will require 10G+ links between the zonal ECUs.
Very high bandwidth (10G+)
Full duplex traffic
> 6 links per car
Mixed data type
Redundant systems
Zonal effects on ECUs

Locally distributed processing resources

Cross domain distributed processing resources

Central integration of processing resources

Communication only between systems (ECUs)

Communication between systems via Ethernet Switches

Consolidation of processing resources requires 10G+ bandwidth

Consolidation of processing will require 10G+ links
Zonal effects on ECUs

Central integration of processing resources
- Cross domain distributed processing resources
- Locally distributed processing resources

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Communication only between systems (ECUs)

Communication between systems via Ethernet Switches

Consolidation of processing resources requires 10G+ bandwidth

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Consolidation of processing will require 10G+ links
Zonal effects on other Ethernet speeds

10G+ enables Zonal architectures ➔ more overall Ethernet links will be required (10Mbit/s -10Gbit/s)

- 2.5/5/10G BASE-T1
- 1000BASE-T1
- 100BASE-T1
- 10BASE-T1S
Zonal / Central Architecture Introduction

- OEMs who have publicly announced investigation into Zonal / Central architecture;
  - Audi
  - General Motors
  - Jaguar Land Rover
  - Toyota
  - Volkswagen
  - Volvo Cars
- Additional OEMs expected to publicly announce this year
Driverless cars are the future of Automotive

Source: Audi AG
Data Drives Autonomous Cars

Autonomous Vehicles

UTILIZE AVG

~4 TERABYTES

PER AVERAGE DAY

Source: Mashable January, 2017
Autonomous Driving systems incorporate camera’s that transmit uncompressed data requiring 10G+ bandwidth. Additional sensor (Lidar, radar, etc.) aggregation requires 10G+ bandwidth.
Autonomous Drive Interconnect

Redundant processing units needed to enable autonomous cars will require 10G+ connections.
‘Live Software Migration’ supporting the transfer of processes across compute nodes or ECUs will require low latency 10G+ connections.
Data Recorder

‘Black Box’ in the car will require significant bandwidth/capacity to store raw sensor data
~100 Million 10G+ ports by 2030

Source: McKinsey's "Automotive revolution – perspective towards 2030" study, 2016 and internal estimates
Why Now?

Car OEM test vehicles already using enterprise class Ethernet devices supporting 25 Gb/s & 50 Gb/s

OEMs require automotive variants before mass production for model year 2025
Disclaimer

Steve’s Industry Involvement

- Consultant, High Speed Design, Inc.
- Consulting Member, Ethernet Alliance
- Chair, IEEE P802.3ch Multi-Gigabit Automotive Ethernet PHY Task Force
- Chair, IEEE Beyond 10G Automotive Ethernet Electrical PHY Study Group
- Executive Secretary, IEEE 802.3 Working Group

The views I am expressing on IEEE standards and related products should NOT be considered the position, explanation, or interpretation of the Ethernet Alliance.

Per IEEE-SA Standards Board Bylaws, Dec 2016

“At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.”
IEEE Standardization

March 14, 2019 – IEEE 802 Vancouver BC plenary:

Move that the IEEE 802.3 Working Group request the formation of a Study Group to develop a Project Authorization Request (PAR) and Criteria for Standards Development (CSD) responses for Greater than 10 Gb/s Automotive Ethernet Electrical PHYs

M: Steve Carlson  S: Chris Mash
(>50%)
Y: 87  N: 0  A: 2
Study Group Function

- Study Groups create project documentation
- **Project Authorization Request (PAR)**
  - The PAR sets the scope of the project
- **Criteria for Standards Development (CSD)**
  - CSD is a set of questions:
    - Board Market Potential
    - Compatibility
    - Distinct Identity
    - Technical Feasibility
    - Economic Feasibility
    - Managed Objects
- **Objectives**
  - High level “bullet points” on what the project will deliver
- Study Group **non-function**—make technical decisions
Progress

May 2019
• Presentations on project documentation (PAR, CSD and objectives,) IEEE process and industry needs

July 2019
• Presentations on draft PAR, draft CSD, draft objectives, link segment technical feasibility and network topology including “asymmetric” use cases
• Adopted 8 objectives with more to come!

September 2019
• Adopted 25 Gb/s PHY objective (2 inlines, 11 m)

Study Group web page URL: http://ieee802.org/3/B10GAUTO/index.html
IEEE Timeline

Expected timeline to complete specification

- $t_0$ – Idea for CFI
- $t_1$ – SG approved. Start to work on PAR, CSD, objectives
- $t_2$ – PAR approved. Start TF meetings and select technology components
- $t_3$ – D1.0 complete. Refine draft standard
- $t_4$ – D2.0 complete. WG ballot begins
- $t_5$ – D3.0 complete. SA ballot
- $t_6$ – SA complete
- $t_7$ – Amendment published