Autonomous Vehicles: The Dawn of a New Era in Automotive

Challenges
- Technology
- Legislation
- Insurance
- Trust

Trust of humans in machine-driven car
The Path Towards Full Autonomy

Level 1-2
Simple Aid

Level 2-3
Decision Assistant

Level 4-5
Self Driving

Local Computing
"Behind" Every Sensor

Centralized Computing
Integrates Input From All Sensors (Sensor Fusion) Similar to a Human Driver’s Brain

High-Speed, Reliable & Secure Nervous System
High-Performance Brain

2010 - 2015
2015 - 2020
2020 - 2025

Compute Power (TFLOPS)
Networking Speed (Gbit/s)

0.1
1
10
100

0.1
1
10
25
Sensor Fusion & Rich Data Drive Bandwidth To Multi-Gig

Cameras
Increasing resolution from 720p to 4K and improving dynamic range

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= Multi-Gigabit/s of raw bandwidth

Sensor Fusion
Moving processing of data from sensors to a centralized GPU

= Multi-Gigabit/s data over the network

- Processing Unit
- Radar, Lidar, Sonar
## Autonomous Vehicles Networking Additional Requirements

### Security
- Prevent unauthorized remote control of the vehicle – whether physically on the vehicle or through the air
- Protection from data hacking
- Defend from system software harmful modifications

### Reliability/Safety
- Zero failures for critical-function systems
- Failsafe: failure doesn’t jam the network
- Failover: failure triggers backup device operation
- System operations under harsh conditions (temperature, humidity, dust, EMC, …)
- Reliable operation over long life cycle

### Solutions
- Encryption
- PHY-layer Security
- Secure boot

### Requirements
- Redundancy through multiple data paths
- Mature HW/SW stack
Redundancy in the Backbone
Redundancy to the Camera/Sensors

[Diagram showing redundancy between two GPUs and multiple camera/sensor connections through an Automotive Ethernet Switch]
Ethernet Supports All Topologies

- **Ring**
- **Mesh**
- **Tree**
- **Interconnected**
- **Star**
- **Daisy-chain**
In-Vehicle-Network (IVN) for ADAS

Redundancy

Switch with Multiple PHYs

Radar, Lidar, Sonar

Camera

Controller

PHYs/Bridges

Ethernet link – 2.5/5/10G

Ethernet link – 25G/…
Future IVN Required to Integrate a Broad Range of Applications

- ADAS
- Infotainment
- Telematics
- Storage
- Gateway

- Radar, Lidar, Sonar
- Camera
- Switch with Multiple PHYs
- Controller
- PHYs/Bridges
- Ethernet link – 2.5/5/10G
- Ethernet link – 25G/…

- Storage
- V2V/V2I
- Wi-Fi/BLE
- GPS
Ethernet Technologies that Benefit IVN

- VLAN (802.1Q)
- Security (MACsec)
- Switching (802.1)
- Synchronization (1588 PTP)
- QoS (AVB/TSN)
- Audio/Video Transport Protocol (1722)
- Multiple topologies (mesh, star, P2P, daisy-chain, ring)
- Asymmetrical transmission Power Saving (EEE)
- Multi-Gig MAC rates: 2.5G, 5G, 10G, 25G, 50G, 100G
- Time Triggered Ethernet (SAE AS6802)
- Power over cable (PoDL)
- Power Saving (EEE)
- Multi-Gig MAC rates: 2.5G, 5G, 10G, 25G, 50G, 100G
Why Other Technologies Emerged for High-Speed Interfaces?

- Ethernet PHYs only supported up to 100Mbps and later 1Gbps.
- IVN Network required higher speeds.
- Vacuum created → Proprietary technologies emerged to fill in the gap.
Why Ethernet Going to Take Over for High-Speed Interfaces

2016 – Automotive Ethernet PHY at 2.5G, 5G and 10Gbps introduced in the market (Aquantia)

2017 – New standard (IEEE 802.3ch) is emerging for 2.5G, 5G and 10Gbps Automotive Ethernet PHY
The Power of the Ethernet Ecosystem

Automotive Ethernet

- Multiple vendors
- Lower cost
- Knowledge / Know-how
- SW/Driver availability from many vendors/sources
- Tools for development and diagnostic
- Wide availability of Bridges from other protocols to Ethernet (e.g. USB, PCIe, CAN, …)
- Dominant network – Eliminates need for gateways to/from specialized networks

Next step: Adopting the Existing Ethernet Ecosystem into the Automotive World
• New alliance established by key players in the Automotive market
• “NAV” = Networking for Autonomous Vehicles
• Navigating the Future of Connectivity
The NAV Alliance

Founded by

**AQUANTIA**

**BOSCH**

**Continental**

**NVIDIA**

**VOLKSWAGEN GROUP OF AMERICA**

Leading car manufacturers, system and component suppliers in the automotive market

Purpose

To provide a platform for the automotive industry to develop the next generation of in-vehicle network infrastructure for autonomous vehicles and facilitate wide deployment of networking technologies and products, with a focus on interoperability, security and reliability of the network.
The Big Picture

Trust

Human trust in Machine-Driven car. Reliability: System is always ON.

Redundancy

Redundancy for critical-mission components, and traffic routes.

Network

Networking and switching elements are required to support redundancy.

Ethernet

Ethernet provides the speed, features, maturity and ecosystem for redundant network.
Thank you.