The Inevitable - High Speed Ethernet in Automotive

Amir Bar-Niv

IEEE Ethernet & IP @ Automotive Technology Day
London, October 2018
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

<table>
<thead>
<tr>
<th>Compute Power (TFLOPS)</th>
<th>Networking Speed (Gbit/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>25</td>
</tr>
</tbody>
</table>
Sensor Fusion & Rich Data Drive Bandwidth To Multi-Gig

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

<table>
<thead>
<tr>
<th>Hres</th>
<th>Vres</th>
<th>Fps</th>
<th>8bit</th>
<th>12bit</th>
<th>16bit</th>
<th>20bit</th>
<th>24bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1280</td>
<td>720</td>
<td>30</td>
<td>0.22</td>
<td>0.33</td>
<td>0.44</td>
<td>0.55</td>
<td>0.66</td>
</tr>
<tr>
<td>1280</td>
<td>1080</td>
<td>30</td>
<td>0.33</td>
<td>0.50</td>
<td>0.66</td>
<td>0.83</td>
<td>1</td>
</tr>
<tr>
<td>1280</td>
<td>720</td>
<td>60</td>
<td>0.44</td>
<td>0.66</td>
<td>0.88</td>
<td>1.11</td>
<td>1.33</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>30</td>
<td>0.50</td>
<td>0.75</td>
<td>1.00</td>
<td>1.24</td>
<td>1.49</td>
</tr>
<tr>
<td>1280</td>
<td>1080</td>
<td>60</td>
<td>0.66</td>
<td>1.00</td>
<td>1.33</td>
<td>1.66</td>
<td>1.99</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>60</td>
<td>1.00</td>
<td>1.49</td>
<td>1.99</td>
<td>2.49</td>
<td>2.99</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>30</td>
<td>1.99</td>
<td>2.99</td>
<td>3.98</td>
<td>4.98</td>
<td>5.97</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>60</td>
<td>3.98</td>
<td>5.97</td>
<td>7.96</td>
<td>9.95</td>
<td>11.94</td>
</tr>
</tbody>
</table>

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

= Multi-Gigabit/s of raw bandwidth

= Multi-Gigabit/s data over the network

100M – 4 Gbps
2G – 8Gbps

Radar, Lidar, Sonar

Processing Unit

AQUANTIA
ACCELERATING CONNECTION

No Use Case
Available
Speed grades which are currently discussed
## Autonomous Vehicles Networking Additional Requirements

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Security</strong></td>
<td><strong>Reliability/Safety</strong></td>
</tr>
</tbody>
</table>
| • 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 | • 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** | **Redundancy** through multiple data paths  
• Mature HW/SW stack |
Redundancy in the Backbone
Redundancy to the Camera/Sensors

GPU

Automotive Ethernet Switch

Automotive Ethernet Switch

GPU
Ethernet Supports All Topologies

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

Redundancy

Radar, Lidar, Sonar
Camera

Switch with Multiple PHYs

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

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

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

Redundancy for critical-mission components, and traffic routes.

Networking and switching elements are required to support redundancy.

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