PCIe® Technology in Automotive Applications

PCI-SIG® Educational Automotive Webinar Series

Presented by
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Speakers

Ron DiGiuseppe

Automotive IP Segment Manager, Synopsys

Ron DiGiuseppe is the Automotive IP Segment Manager at Synopsys. He is responsible for automotive segment marketing for Synopsys DesignWare Intellectual Property (IP) solutions for ADAS, Connected Car, & Infotainment applications. Ron brings more than 22 years of semiconductor experience to Synopsys.

Prior to joining Synopsys, Ron held a range of management positions at Xilinx for automotive connectivity IP products as well as engineering development and management roles for companies including Oki Semiconductor, NEC, and Raytheon Corporation.

Anwar Sadat

Product definer, Texas Instruments

Anwar Sadat is a product definer at TI's high speed signal conditioning team. He is with TI for 15 years and held various individual and management positions developing high speed products for PCIe, USB and Video interfaces. Prior to TI he worked as an analog designer at Conexant Systems.

He earned his MS and PhD in electrical engineering from University of Central Florida.

He is on USB-IF board of directors.

Edo Cohen

Director Strategic Innovation, Valens Semiconductor

Edo is Valens' Director for Strategic Innovation, spearheading automotive standardization. Edo brings more than 25 years of experience as a senior system engineer, with extensive knowledge in system architecture, technical specifications, definition and execution.

Prior to Valens, Edo held Senior System Architect positions in Intel Corporation and at Marvell Cellular Division, and held engineering managerial positions at NAMS, Alvarion, and Floware. Edo holds an MBA and a B.Sc. in Electrical Engineering from Tel Aviv University.

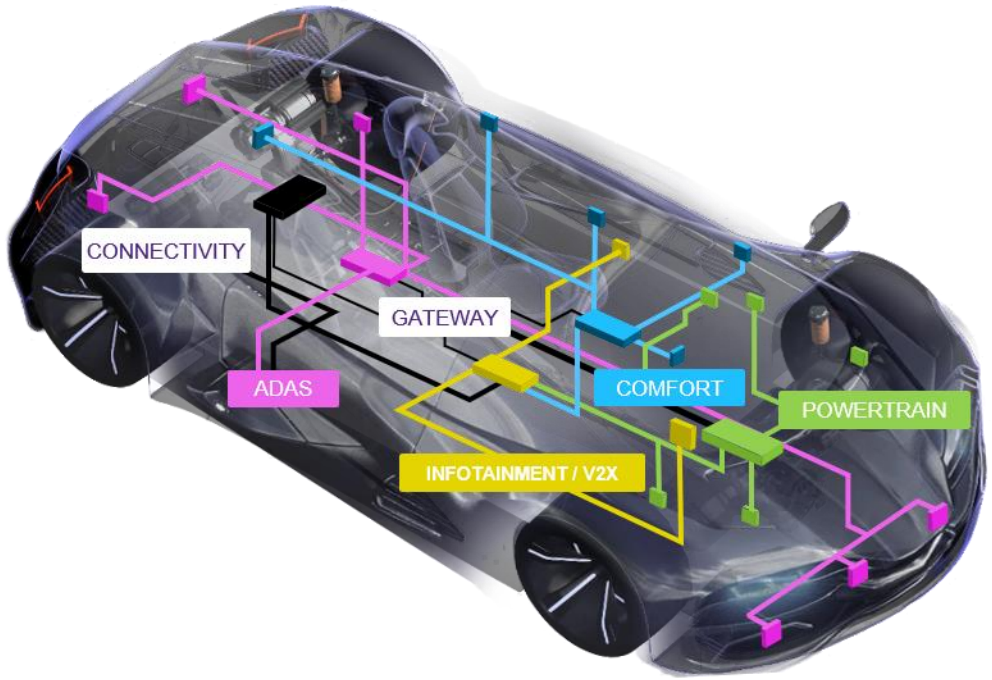
Agenda

- Introduction
- PCIe® Use cases in Automotive
- PCIe Technology benefits in Automotive
- Use Case #1 – Scaling Compute Processing
- Use Case #2 – Data backbone applications
- Use Case #3 – PCIe based Storage
- Use Case #4 – Vehicle to Vehicle (V2V) / Vehicle to Infrastructure (V2X)
- Summary
- Q&A

Introduction

New Electronics Architecture Required

Trends & Applications Moving Automotive SoC Design to Complex FinFet Class SoCs

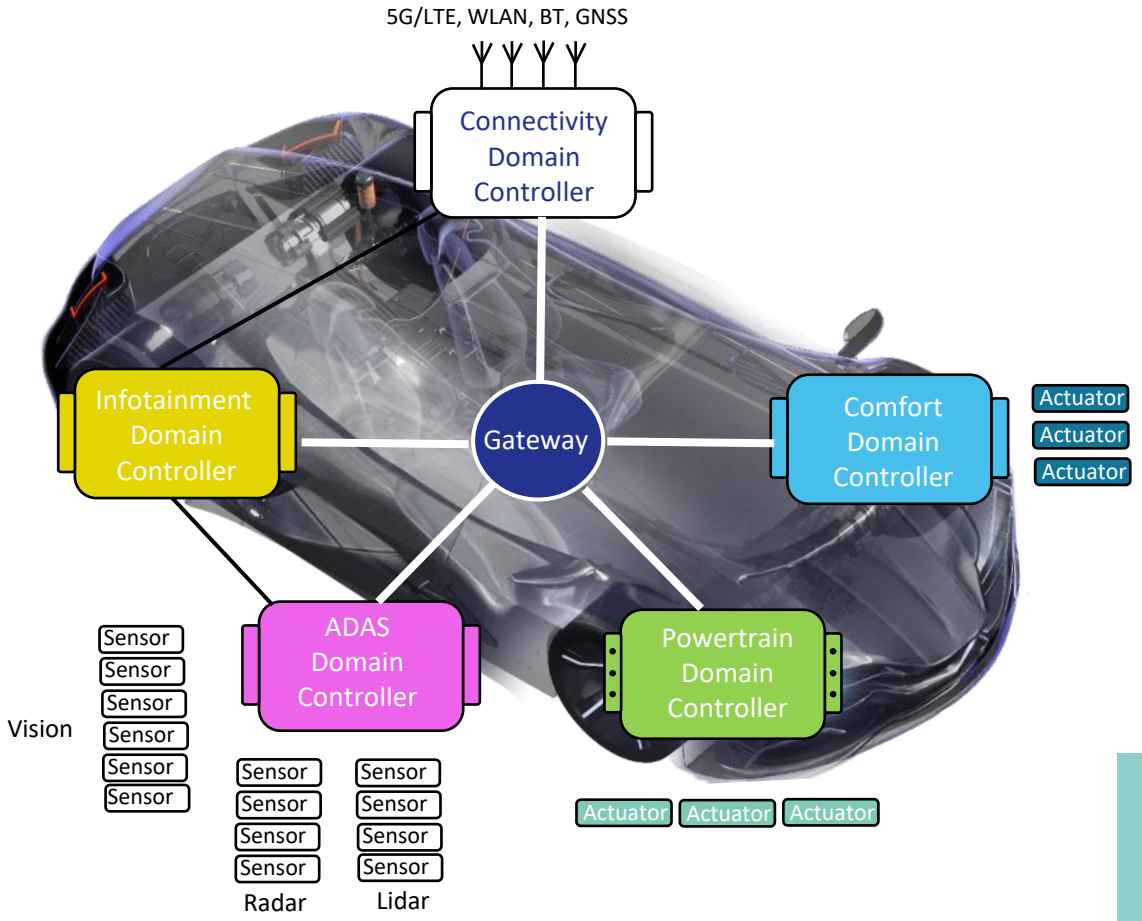


- Transition from Distributed ECUs to centralized Domain Compute Modules
- New applications for ADAS, Connected Car & V2X
- Growing number & types of Sensors: Imaging, Lidar, Radar, Infra-Red
  - Requires multi-core possessing & Interfaces
- System & SoC level Security
- System & SoC level Functional Safety

Requires High Performance FinFet Class Automotive SoCs

AI Algorithms for Automotive Domains

Requires Increase Compute Processing Performance

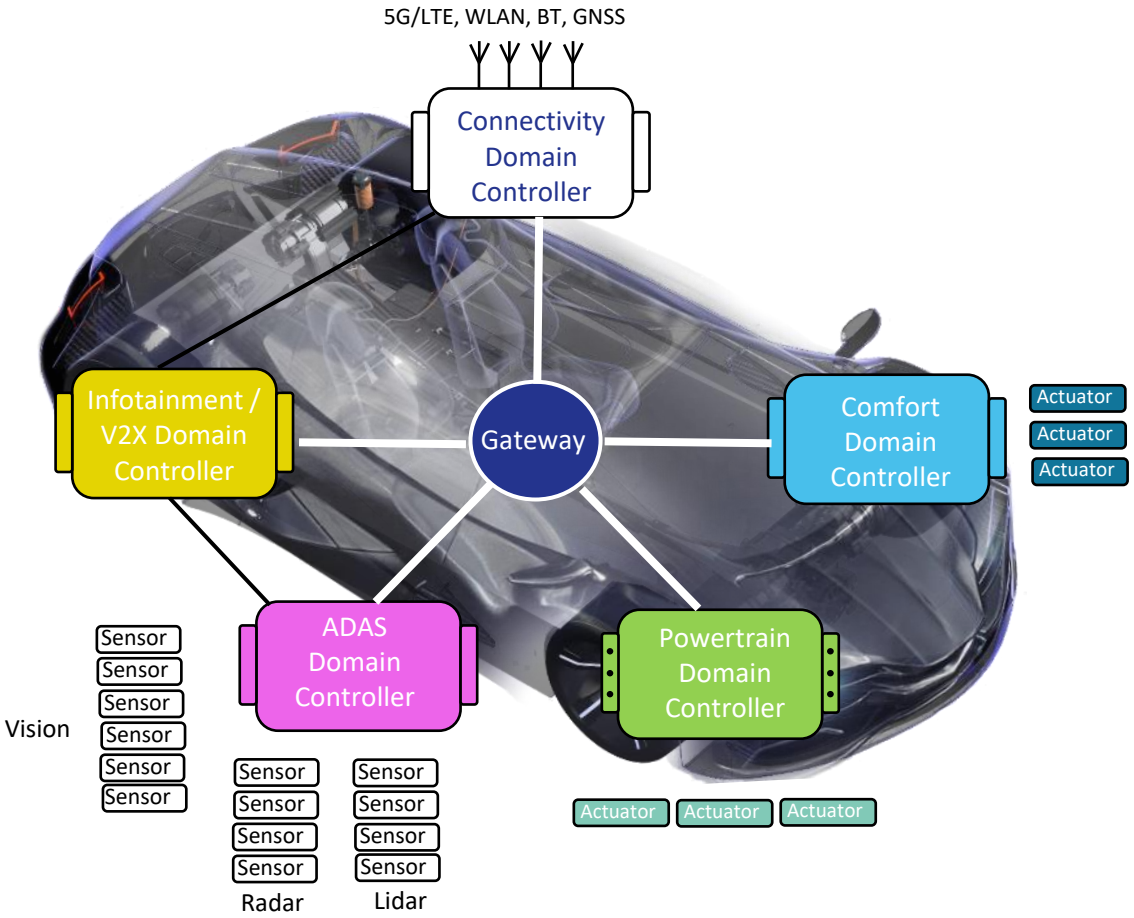


- Powertrain SoCs
  - Predictive analytics for sensor replacement
  - EV motor control
- ADAS SoCs
  - Embedded Vision acceleration for pedestrian detection/object detection
  - Automatic Emergency Braking (AEB)
  - Radar-Lidar DSP
- Infotainment SoCs
  - Heads Up Displays
  - Driver Drowsiness Detection

Computing power needed increases with the square of sensor data[1]
Ex: Tesla FSD ADAS SoC provide 140TOPs

[1]Source: Yole Development, March, 2020

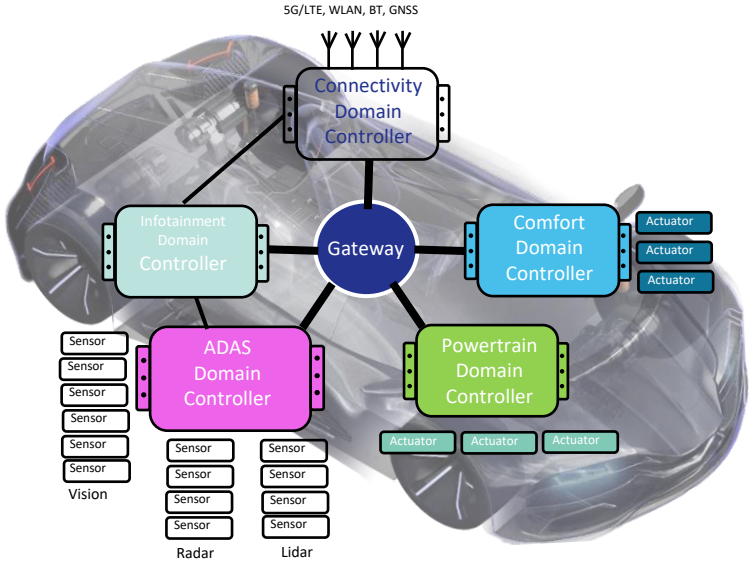
Domain Architecture & Sensor Data Traffic Increases Compute Processing

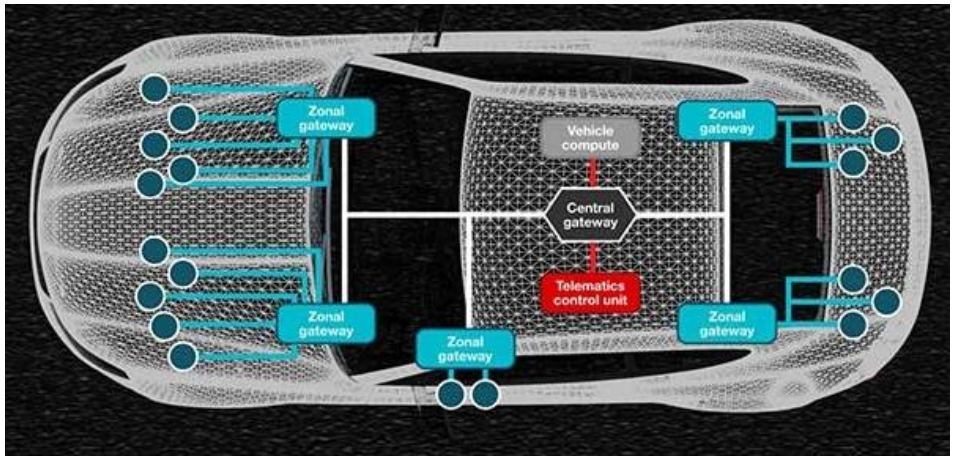


- Number/type of sensors increase data traffic
  - >15G data rate[2]
  - Waymo uses 29 cameras[1]
- Number of sensors increase compute processing
  - Computing required > 1000 TOPs[2]
- Increased need for packet processing in Gateway
  - Requires OTA SW management
- Increased need for Security

[1]Source: YooJung Ahn, Head of Design at Waymo, March, 2020, [2]Source: Yole Development, March, 2020

Market Dynamics: Zonal Architecture Reshaping Automotive SoCs





Source //e2e.ti.com/blogs_/b/behind_the_wheel/posts/processing-the-advantages-of-zone-architecture-in-automotive

Yesterday
30- 100+ ECUs in a car

Mainstream MCUs

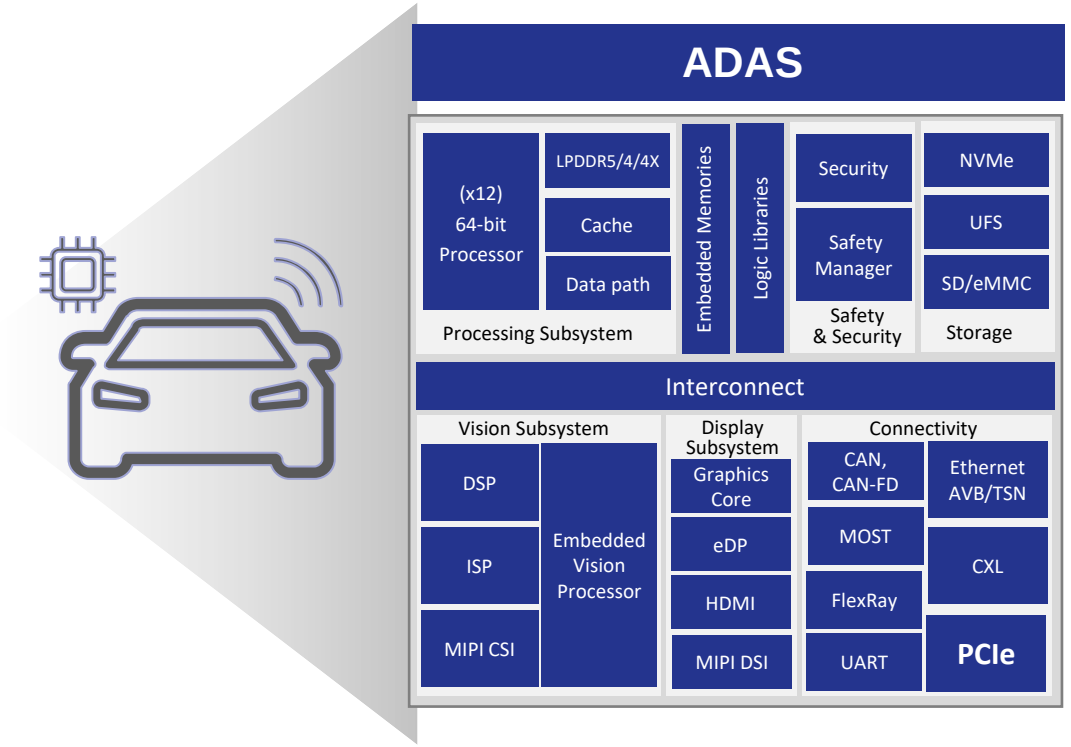
Today
Domain Logical Architecture

Consolidating of ECUs
Integration of Functions, AI & ICs require 16/14nm & 7nm FinFET Class SoC

Tomorrow/Future
Zonal Physical Architecture

Multi-Applications Central Processing
Multi-Chip & Higher Complexity/Performance 5nm SoC

PCIe® Architecture: Mission Critical for Automotive SoCs



- PCI Express® technology is mission critical for automotive SoCs
- Interfaces: LPDDR5/4/4X, Ethernet TSN, MIPI, HDMI, CXL, eDP, CAN
- Processing: AI Accelerators, Embedded Vision, DSP, Security
- Security & SoC Safety Manager
- Sensor Fusion
- 16-/14-nm → 8-/7-nm → 5-nm
- Functional Safety

PCI Express® Technology for Automotive Applications Use Cases

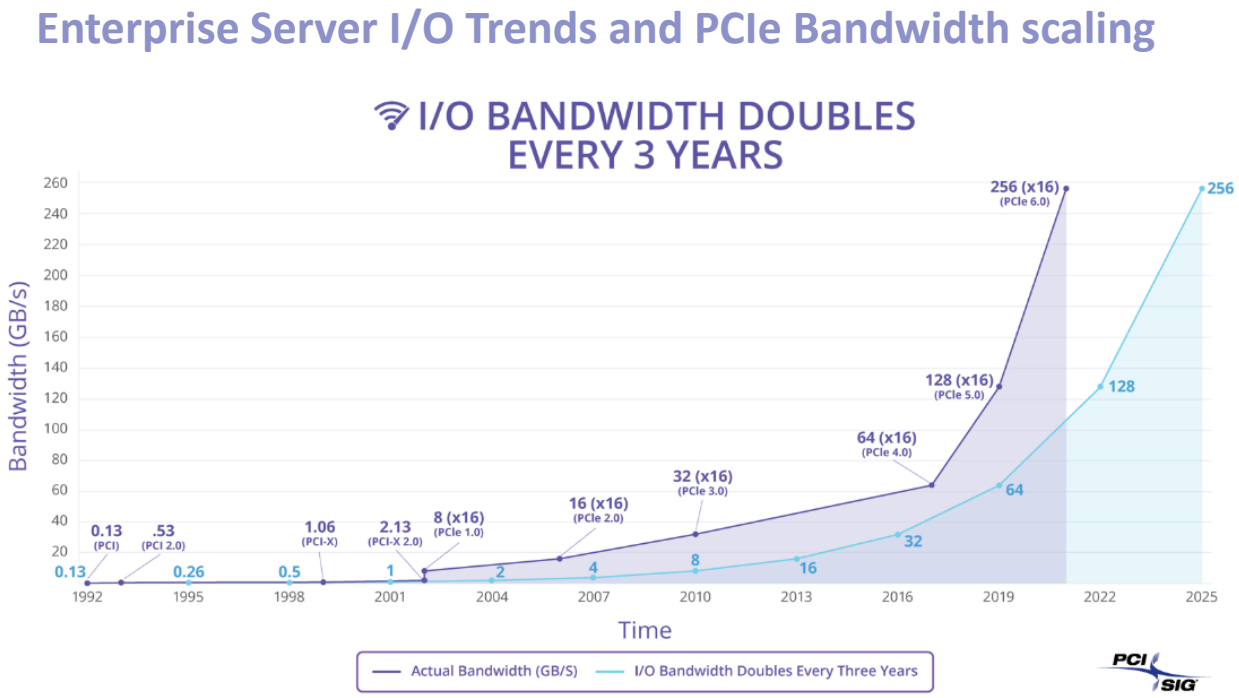
Use Case	Item	PCIe Use Model	Application
1	Scaling Compute Processing	Chip-to-Chip	ADAS & IVI Domain Controllers Autonomous Vehicle (AV) Zonal Architecture-Central Processing
2	Data Backbone	Long Reach	Zonal Architecture-In Car Network
3	PCIe Based Storage	Chip-to-Chip Module	BlackBox ADAS/AV Mapping Infotainment
4	Connectivity: Telematic Control Unit (TCU)	Chip-to-Chip Module Long Reach	Telematics: BT, WIFI, 4G & 5G V2X

PCIe® Technology Benefits

PCIe® Technology Benefits (1/2)

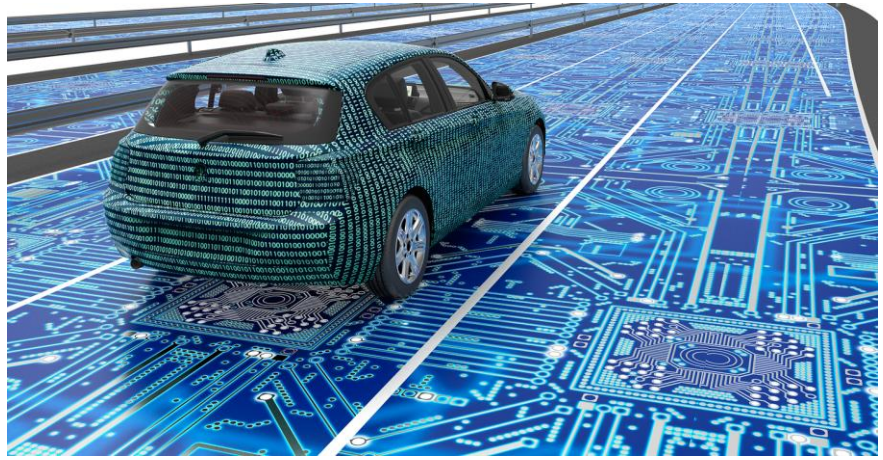
- **Bandwidth**
  - Bandwidth doubled each generation
  - Flexible link widths allow scalability
    - x1 to x2, x4, x8, or x16.

- **Ultra-Low Latency and Reliability**
  - Less protocol overhead
  - Guaranteed reliable transport on hardware level
  - Applications with real-time needs require short latency
  - PCIe latency =~ 1-100ns range



PCIe® Technology Benefits (2/2)

- **DMA Addressing**
  - Built-in DMA method without packetization
  - Allows processors to access shared memory efficiently
- **Automotive Functional Safety**
  - CRC, Advanced error reporting built into Transaction and Application layer
  - Message counter
- **Breadth of PCIe Technology Ecosystem**
  - Pervasiveness across the industry
  - Wide software base – Reduces cost of SW development
  - Flexible interoperability with off-the-shelf components, cables



https://www.electronicdesign.com/markets/automotive/article/21804925/compiling-for-automotive-safety-and-performance

Automotive Use Cases

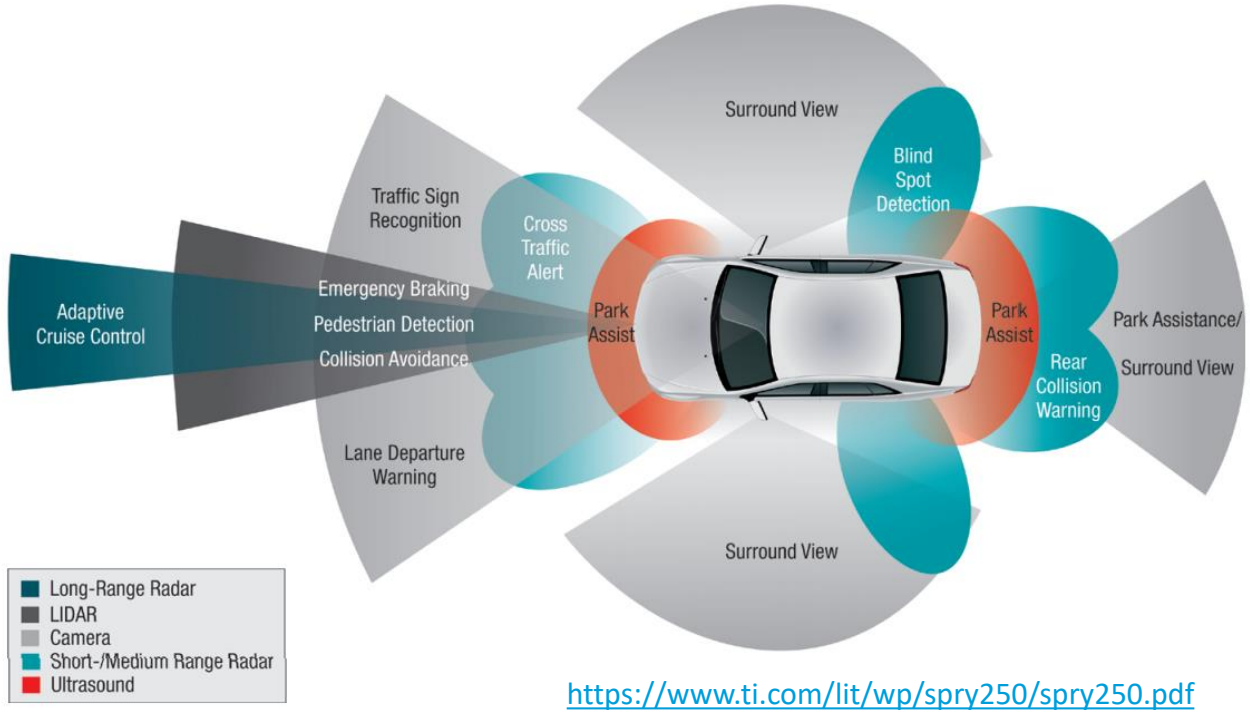
Use Case #1 – Compute Scalability (1/2)

Applications

- Autonomous Vehicles (AV)
- ADAS (Advanced Driver Assist Systems)
- IVI (Infotainment)

Trend

- Processors/Accelerators/GPU connectivity
  - Number of sensors increasing
  - Compute Processing needs increasing
  - 30 TOPS to 700+ TOPS (Self-driving cars)
- Compute scalability problem
  - Used in ADAS domain controllers today
  - Applicable to Domain or Zonal architectures

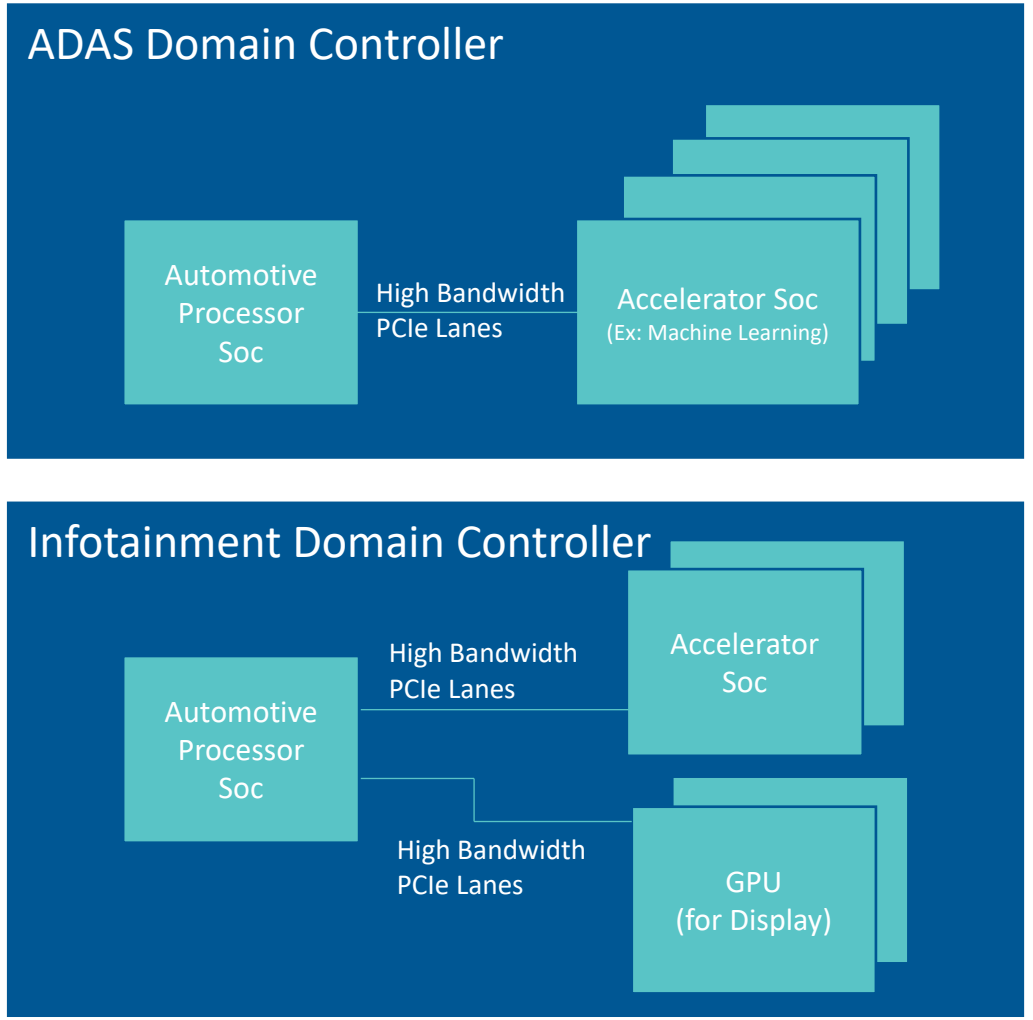


https://www.ti.com/lit/wp/spry250/spry250.pdf

Use Case #1 – Compute Scalability (2/2)

Technology Requirements

- High Bandwidth
- Scalability
- Low Latency
- Hypervisor / Virtualized applications
- Better usage of power/thermal
- Functional safety
- Security



Use Case #2 – Data Backbone Applications

Application

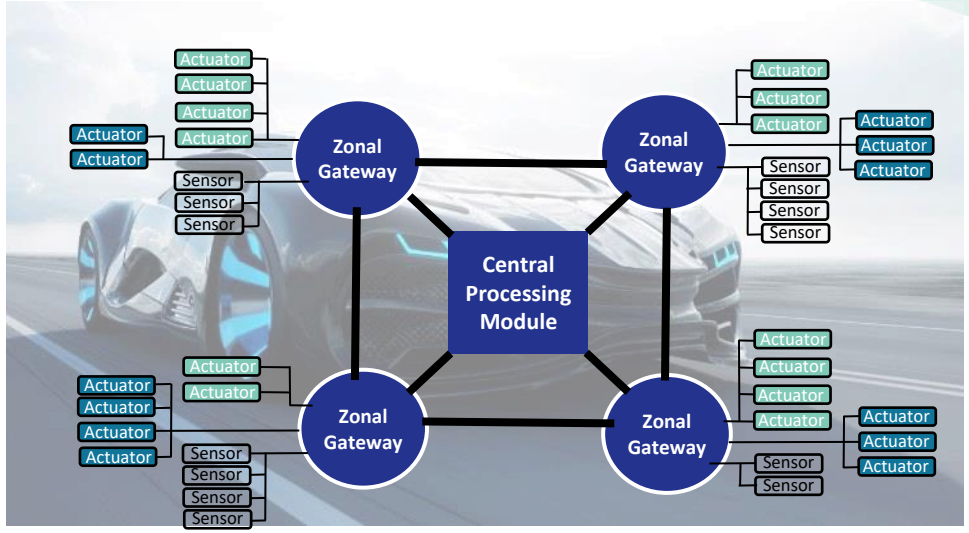
- ECU Processing Redundancy
- Sensor Fusion and Aggregation
- ECU Zone/Ring Architecture Data Transfer

Trend

- High bandwidth between Zonal ECU's (5Gbps-40Gbps+)
- Low latency requirement motivating native PCIe links over long reach

Technology Requirements

- High Bandwidth & Low latency
- EMC/EMI Reliability of long reach cable link
- Automotive Functional safety
- Security



Use Case #3 – PCIe® Based Storage (1/3)

Applications

- Blackbox Recorders
  - Record last 30 sec of video & sensor data
  - Vehicle speed, acceleration, braking, steering wheel angle, engine rpm & restraint deployment
  - Determine the root cause of an accident
  - According to IIHS 100% of new cars have Event Data Recorders added by OEMs
- Mapping for Navigation and Real-Time Mapping for AVs
- Cockpit/Infotainment
- Central Processing

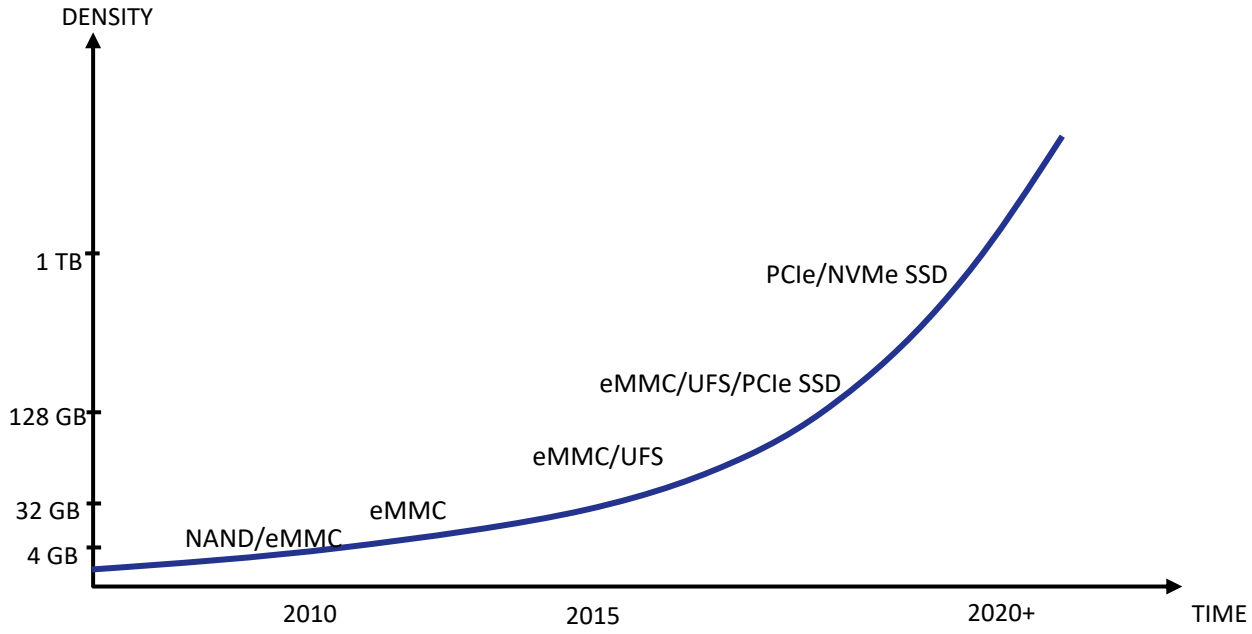
Technology Requirements

- Very High Endurance
- Extended data retention at high temperatures
- Very High Density
- Very Low latency
- 15+ year lifetime
- High bandwidth and fast startup/boot
- Guaranteed minimum write performance
- Automotive Grade 2 & Grade 1 Temp with multiple mission profiles
- Stable performance over time, over temperature
- SRIOV

Use Case #3 – PCIe® Based Storage (2/3)

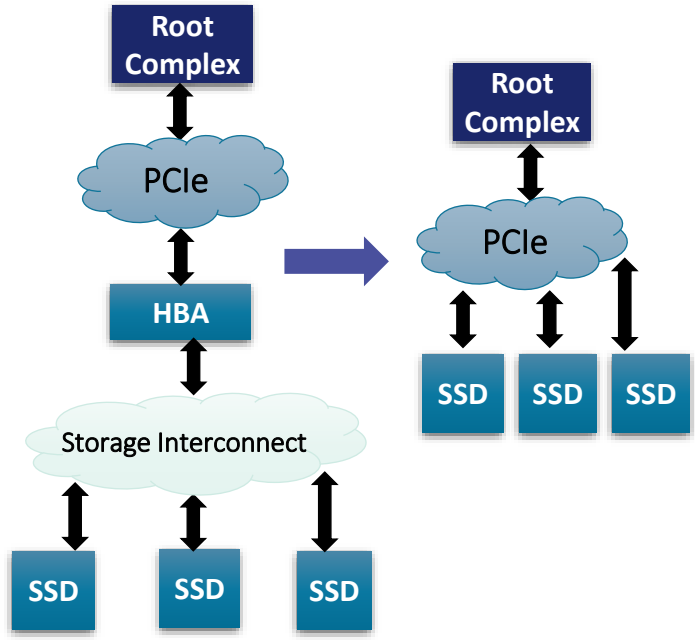
Storage Evolution for Automotive Applications

- Automotive Storage moving toward SSDs
- Spinning HD not as reliable
- SSD based storage moving from eMMC/UFS to PCIe/NVME SSDs



Use Case #3 – PCIe® Based Storage (3/3)
PCIe Support for SSD Applications

- PCIe RAS features used for NVMe Based SSDs
  - LCRC + ACK/NAK + Replay
    - Receiving device checks LCRC, NAKs if not correct
    - Ensures data is correct
  - ACK/NAK timeouts
    - Retrain the link if you haven't seen an ACK or NAK in a long time
    - Ensures silence isn't disaster
  - End-to-end CRC (ECRC)
- Low power L1SS
- ECNs to Enable Storage SSDs
  - Downstream Port Containment
    - Removed Host Bus Adaptor isolation requirements
    - Improved Error containment and recovery
    - Support for Hot Swap
  - Separate RefClk Independent SSC (SRIS)

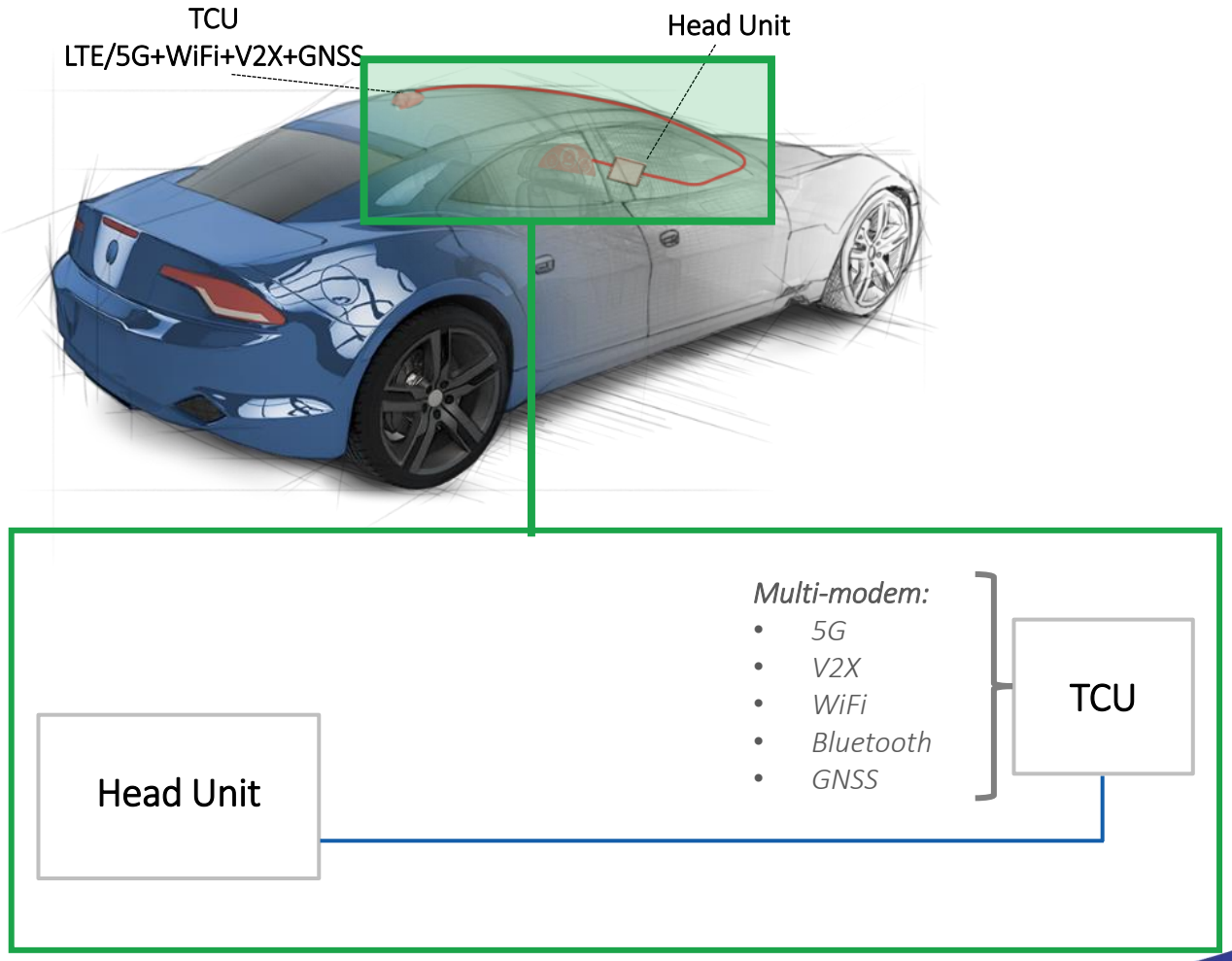


Use case #4 – V2X/V2V
Telematics Connectivity Unit

- **Applications**
  - LTE/5G Modem
  - WIFI + BT + GNSS
  - V2X

- **Trend**
  - Higher Bandwidth driven by introduction of 5G
  - Simplified Integrated architecture

- **Technology Requirements**
  - Scalable Multi-Gig throughput
  - Security
  - Automotive Functional Safety
  - Data Reliability and Integrity
  - EMC/EMI Reliability of long reach cable link



Summary

PCIe® Technology in Automotive – Summary (1/2)

- Standardized solutions are preferable in Automotive market
  - Clear Roadmap
  - Economy of scale driven by multiple players
  - Long term availableity (as required in this market)
  - Interoperability
- Certification and qualification process is stricter than in commercial markets
  - Longer processes
  - Harder environmental requirements (e.g. temperature, vibration)
  - Harsh EMC/EMI environment
- Automotive Functional Safety and Security solutions are required as End to End measures to maintain vehicle safety
- Support for vehicle lifetime
  - Backward and forward compatibility
  - Easy migration and components upgrades

PCIe® Technology in Automotive – Summary (2/2)

- PCIe architecture has a well-established eco-system with strong technical leadership
- It is optimal for closed highly integrated systems with limited scale
- Low latency fast and flexible power efficient PHY
- Hardware focused protocol with low overhead and Direct Memory Access
- End-to-End reliability and security
- PCIe technology is flexible and scalable to allow system to increase BW with no major architecture changes
- Large software base to support the developer community
- Compliance program to ensure interoperability

Always use
The Right Tool - The Right Way

Questions

Thank you for attending the first entry in the PCI-SIG® Automotive Webinar series.

Information about upcoming automotive webinars will be available soon.

For more information please go to www.pcisig.com