Zonal EE Architecture: Towards a Fully Automotive Ethernet–Based Vehicle Infrastructure

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• Summary
Visteon Product Portfolio

Comprehensive Cockpit Electronics Portfolio

Visteon Market Position

Top 5 Connected car Tier 1 supplier

#1 Rank Digital clusters

#2 Rank Center stack displays

Source: Rankings from 2016 ABI Research and IHS Markit.
Automotive Cockpit & ADAS/AD Technology Trends

MACRO TRENDS AUTOMOTIVE

Autonomous

Connected

Electric

Shared

COCKPIT AND ADAS TRENDS

Digital Cockpit

Connected Car

ECU Consolidation

Cockpit for Autonomous

New EE Architecture

2021
L2+/L3 Highway

2024
L3/Experimental L4

2027
L4 Motorways

2030
L4/L5

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ECU Consolidation Roadmap

Central Computing for Optimized Cost, Weight, Power Distribution, Security, Flexibility

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<td><strong>Modular</strong></td>
<td><strong>Domain ECUs</strong></td>
<td><strong>Redundant Computing Platform</strong></td>
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<td>30 - 100+ ECUs in a car</td>
<td>Consolidation of ECUs into domain controllers</td>
<td>Service-Oriented Architecture (SOA) direct memory access</td>
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<td>Reduces cost, weight and power consumption</td>
<td>Parallel computing carrier offer redundancy and safety</td>
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<td>Leverages silicon and software innovations</td>
<td>Open scalable platform for OEM system integration</td>
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Motivation for a New EE Architecture

• Current EE architectures with domain controllers and a central gateway have grown over time and became very complex:
  • 3rd heaviest part up to 80 kg
  • Absolute length of up to 5 km
  • 3rd highest cost component, with a high cost of labor (1000+ production minutes)

• Todays trends such as automated driving increase significantly the demand for the wiring harness:
  • Increasing number of actuators and sensors
  • Increasing data processing capabilities and required data bandwidth in the vehicle
  • Increasing need of intelligent power distribution
Impacts on EE Architecture

• System architecture:
  • Car wiring harness
  • Organization and design of ECUs
  • Peripheral devices: actuators and sensors
  • Cloud connection

• Software architecture:
  • Application and services
  • Middleware and OS/BSP (Adaptive AUTOSAR)

• Game changers:
  • Time Sensitive Networking (TSN)*
  • Conversion into pure IP-based end2end real-time communication network

• Intelligent power distribution will be aligned with data distribution in the new EE architecture at the same time
Vehicle Zonal EE Architecture Tomorrow

• Zonal approach including first level of consolidation in three domains:
  • ADAS Super Core
  • Body Super Core
  • Cockpit Super Core

• Automotive Ethernet TSN backbone with high bandwidth and deterministic real-time communication facilities

• Sensors and actuators are connected to zonal gateway ECUs
Vehicle Zonal EE Architecture Future

• Further consolidation of the processing units

• Processing blades provide scalable computational power

• Automotive Ethernet TSN backbone architecture reused

• Zonal architecture blends upcoming vehicle functions and technologies with savings in weight and cost
Vehicle Zonal Intelligent Power Distribution

- Dual battery scenario with hierarchical power distribution
- Promoting the application of electronic switches and fuses
- Integration in zonal gateways allow for novel applications:
  - Virtualizing the central fuse box
  - Tailored fuse characteristics
  - Intelligent power management: load optimization and power saving
  - Advanced fault prediction based on current and voltage sensing
- Additional savings due to fuse and load optimization
**Vehicle Zonal EE Architecture**

**Zonal Gateway ECU**
- Provides and distributes data & power and supports any feature available in this specific vehicle zone
- Zone is a local vehicle specific portion of the vehicle
- Supports any kind of interface for sensors, actuators, displays (network difference or signals)
- 10BaseT1s could replace other interfaces like CAN FD, FlexRay, etc.
- Act as gateway, switch and as smart junction box

**Super Core - Central Computing Platform**
- Acts as inCar application server supporting Service-Oriented Architecture (SOA)
- Multi SoCs-based control unit with Multi GiG interface
- Specific SoCs (e.g. for AI)
- Fully scalable and upgradable platform
- Connects to Edge and Cloud back-end
- May act also as zonal gateway

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Zonal Gateway ECU Design Approach

• Provide functionality for the vehicle zone
  • Switch for IP devices and backbone
  • Gateway for legacy devices (LIN, CAN, ...)
  • Power delivery (PoDL, power cables)
  • eSwitch/eFuse functionality
  • Additional computation power capability

• Scalable
  • MCU and application cores
  • eFuse/high side power distribution
  • Switch and gateway port count
  • ASIL levels

• Mechanics
  • Sealed and not sealed according build-in position
  • Small footprint
  • Moderate power dissipation
  • High power distribution capability

PoDL - Power over Data Line
Case Study Setup – Optimized EE Architecture

• Estimate the wiring harness of different zonal architectures
• Qualify the trade-off between savings in harness and expenses on zonal ECUs
• Therefore an environment was set up to
  • map the ECUs on the layout of the vehicle
  • automatically generate a wiring harness from the positions of the ECUs
  • analyze the harness and derive requirements for the design of the zonal ECU
  • apply constrained 2D routing algorithms, considering single wire, etc.
Case Study Result – Optimized EE Architecture

- Zonal architectures bear savings of 50% and more in length of the wiring harness for
  - Control and distribute data
  - Power distribution
  - Increase of savings with larger number of sensors/actuators

- Saving in wiring harness vs expenses on zonal gateway ECUs: trade-off can be solved with 6 to 11 zones

- Complexity of the sub-harnesses drops down to a level that allows automated manufacturing (max. wiring connection length < 3 m, excluding the backbone)

- Uniformed zonal ECUs in numbers and types of interfaces are potentially deployable across
  - Variants and trim levels
  - Platforms and car lines
Service-Oriented-Architecture in Zonal Settings

- Disruption in EE topology impacts the software ecosystem
  - Functions no longer associated by ECU, but by domain
  - A single function is constituted by services, provided by different ECUs
  - Several SW suppliers delivering services to the same ECU
  - Business logic of functions moved to a central application server

- Standards supporting SOA
  - Adaptive AUTOSAR
  - ARA::COM communication middleware
  - Common API is a base for SOA
  - Communication between domains via SOME/IP

- Key benefits
  - Allows portability of functions on different ECUs / domains
  - Enabler for realizing onboard / offboard function split
  - Increases potential for reusability of Software Components (SWC)
Applying the Advantages of SOA

- Abstract from physical to logical connections
- Services availability throughout the IP-based network
- Well-established experience from other industries are applicable
- Legacy communication mechanisms will remain
  - Mission critical ECUs (e.g. ESP) using signal-based communication
  - Services can be mapped on legacy ECUs, e.g. using Classic AUTOSAR
- Novel functions without changes on ECUs and on wiring harness
  - Decreased topology complexity
  - Increased potential of wiring optimizations
Overall Challenges of Zonal EE Architectures

• Conspicuous product and system requirements
  • Safety requirements, e.g. missing solutions in standards
  • EMC induced by combination of data and power distribution
  • Additional space requirements for installation in the vehicle
  • Heat dissipation on high performance computing units or power switching
  • Early start-up scenarios

• Implications on the system architecture
  • Partitioning of data processing: smart sensor vs cloud processing
  • Integration of high data rate sensor / actuator, such as raw data cameras, e.g. > 1Gbit/s
  • Integration of very low complexity and legacy device, e.g. “cheap” ECUs (LiN, CAN)
  • Interplay between multiple real-time communication channels, legacy traffic, class traffic, etc.

• Structural implications
  • Optimization of various cost trade-offs, such as production – material – labor
  • Organizational barriers between communication network vs power distribution departments on OEM and supplier side
  • Collaboration model in development and production in between OEM, Tier 1s and Tier 2s
  • Availability of cutting edge ECU components, e.g., TSN enabled switches, eFuses, etc.
  • Global deployment of uniformed zonal gateways at OEM production sites in dedicated car lines / trim levels
Partitioning of Data Processing in the Zonal Setting

- The data processing shall happen in real-time with low latency
- Sensors create data which can be processed either
  - next to the sensor (smart sensor),
  - in a zonal ECU with appropriate computational power,
  - in a central compute node such as Super Core or
  - off-board in Edge or Cloud computing facilities.

- Data processing is attributed by the
  - data rate at the input/output side,
  - computational power required to process the data
- Fusion of data can be done with
  - raw sensor data (early fusion) or with
  - processed data: object data (late fusion)
- Central fusion of raw data may make sense for novel “AI” techniques but requires significant bandwidth
Summary - New Zonal EE Architecture

- Automotive Ethernet TSN network approach is the common rail for the zonal architecture
  - 1 to n zones
  - High bandwidth and real-time communication
  - Reliability and fail operational

- Zonal ring approach with is fully scalable:
  - Entry to luxury segment
  - Automated driving Level 1 to Level 5 (SAE)
  - Combustion engine cars, EV’s and hybrid vehicles

- The zonal gateways will provide and distribute data & power across the vehicle

- Zonal ECU concept matches the demands of service-oriented architectures

- New developments in EE lead to a paradigm shift, requiring bold re-organization of the vehicle topology

Zonal EE Architecture Unleashes Significant Savings