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

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Agenda

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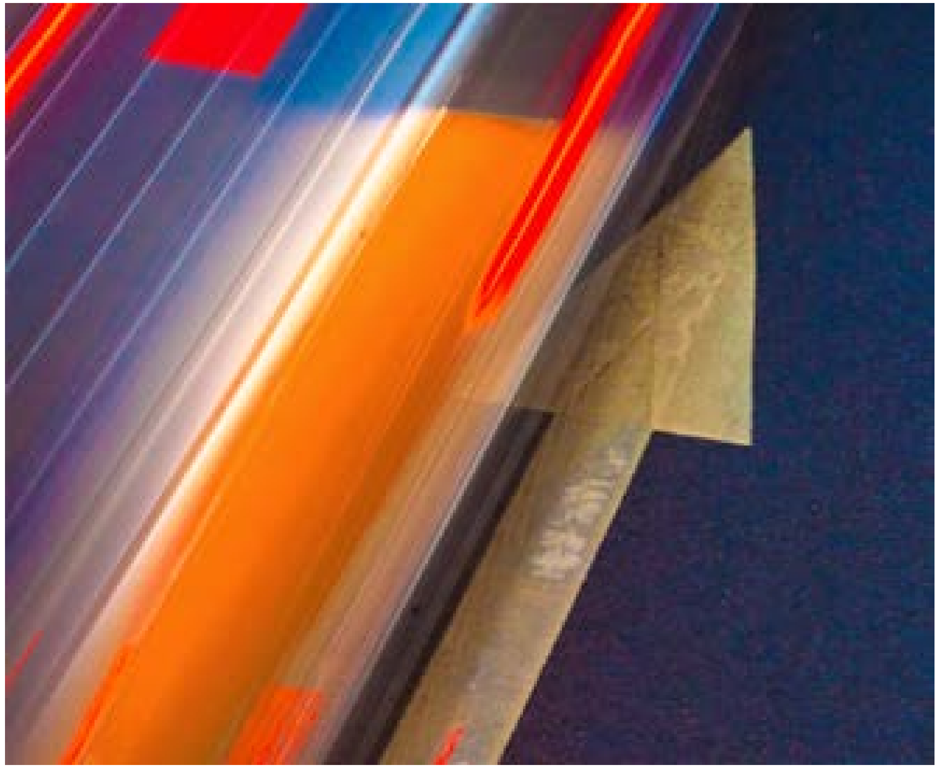
- Company Background
- Automotive Cockpit & ADAS/AD Technology Trends
- Motivation and Impacts for a New EE Architecture
- Zonal EE Architecture
  - Architecture Development
  - Power Distribution
  - Zonal Gateways and Super Cores
- Example for Topology Optimization
- Service-Oriented Architecture
- Challenges
- Summary



Visteon Product Portfolio

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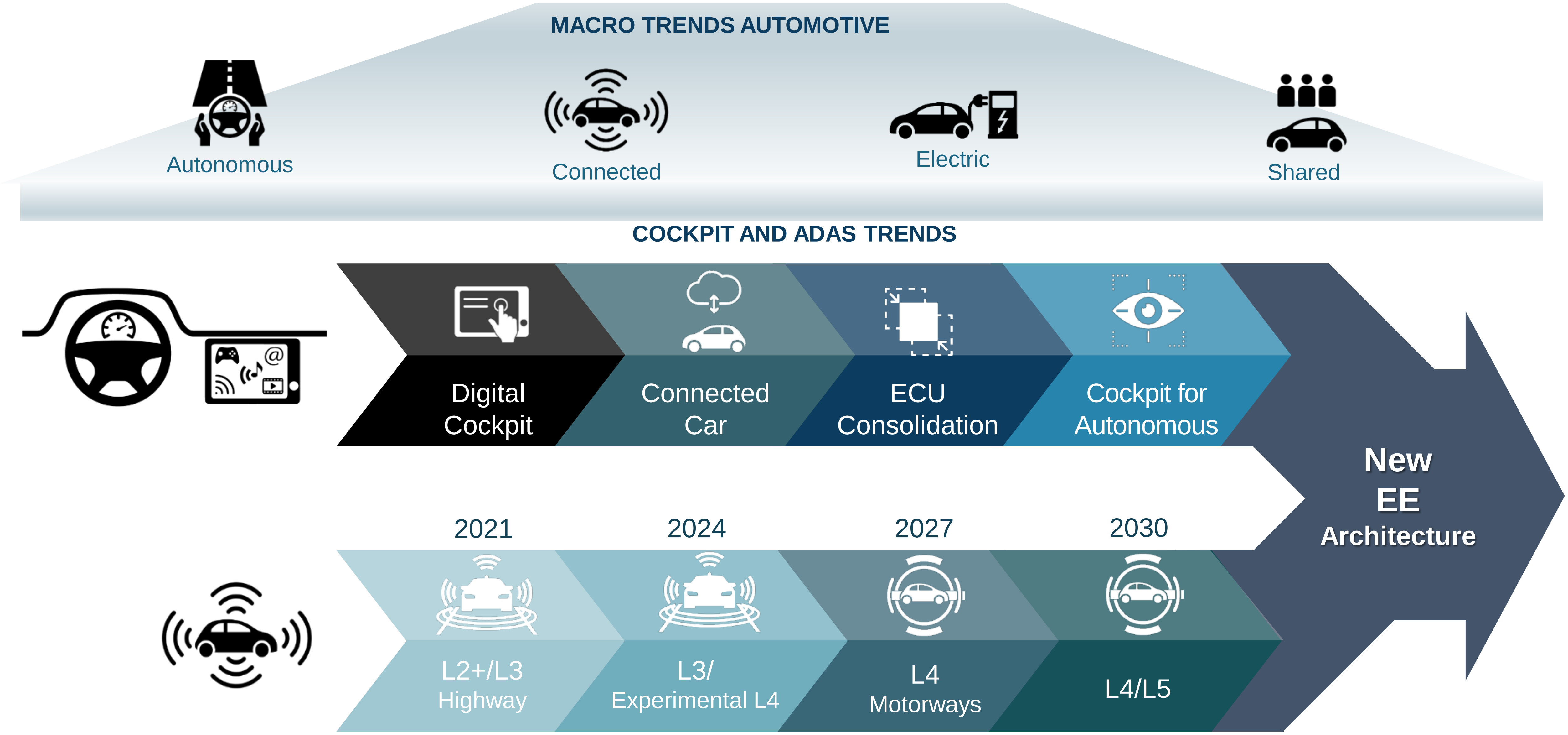
Visteon Market Position

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.

Comprehensive Cockpit Electronics Portfolio

Automotive Cockpit & ADAS/AD Technology Trends



ECU Consolidation Roadmap

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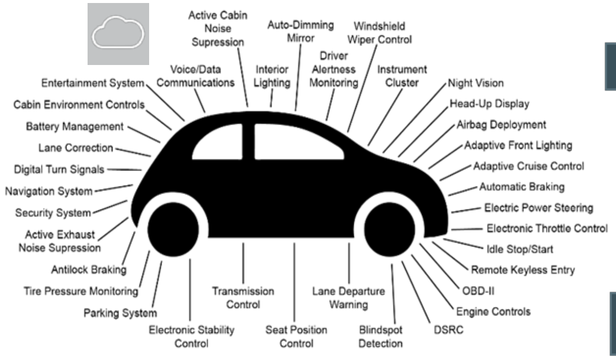
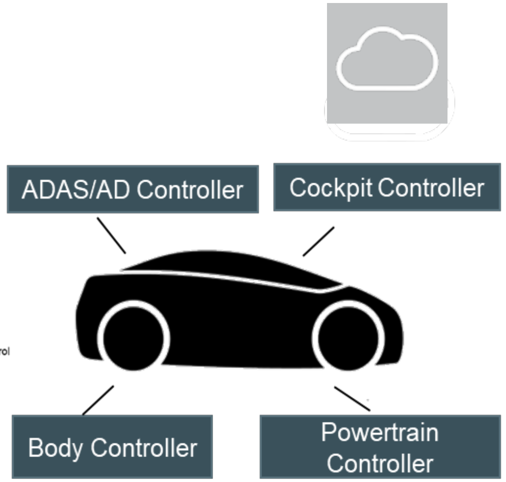
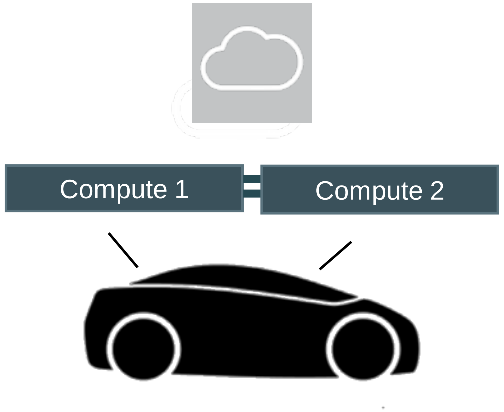
Yesterday



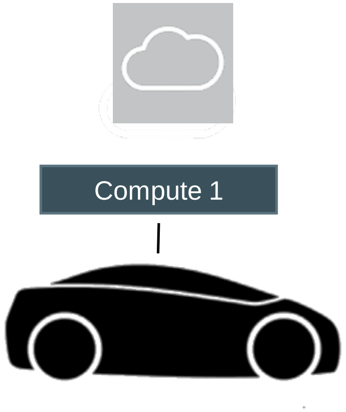
Today



Tomorrow



Future



Modular	Domain ECUs	Redundant Computing Platform	Central Computing Platform
30 - 100+ ECUs in a car	Consolidation of ECUs into domain controllers	Service-Oriented Architecture (SOA) direct memory access	Service-Oriented Architecture (SOA) network access oriented
	Reduces cost, weight and power consumption	Parallel computing carrier offer redundancy and safety	Dynamic configuration and seamless redundancy
	Leverages silicon and software innovations	Open scalable platform for OEM system integration	Blade upgradeable concept

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

Motivation for a New EE Architecture

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- 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

EE Architecture Is About to Change

Impacts on EE Architecture

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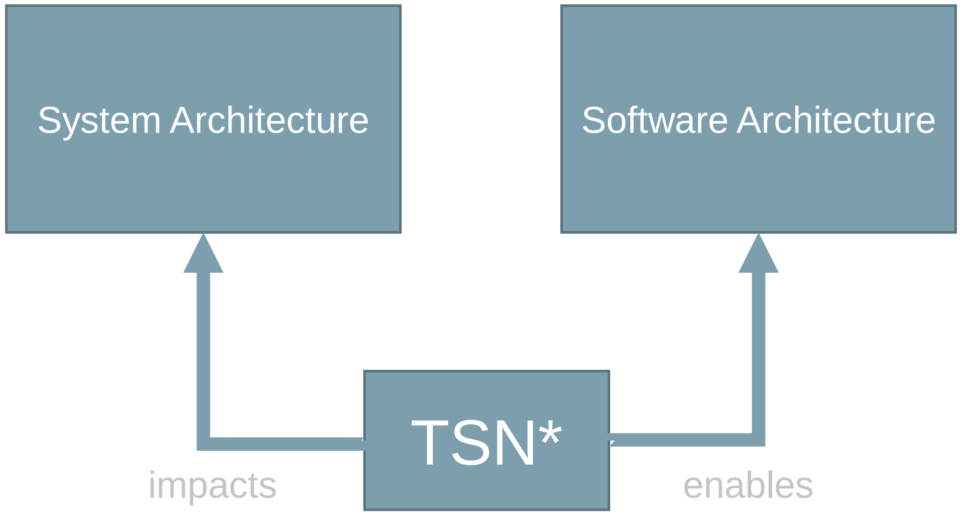
- System architecture:
  - Car wiring harness
  - Organization and design of ECUs
  - Peripheral devices: actuators and sensors
  - Cloud connection
- Software architecture:
  - Application and services
  - Middleware and OS/BSP (Adaptive AUTOSAR)
- Game changers:
  - Time Sensitive Networking (TSN)*
  - 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

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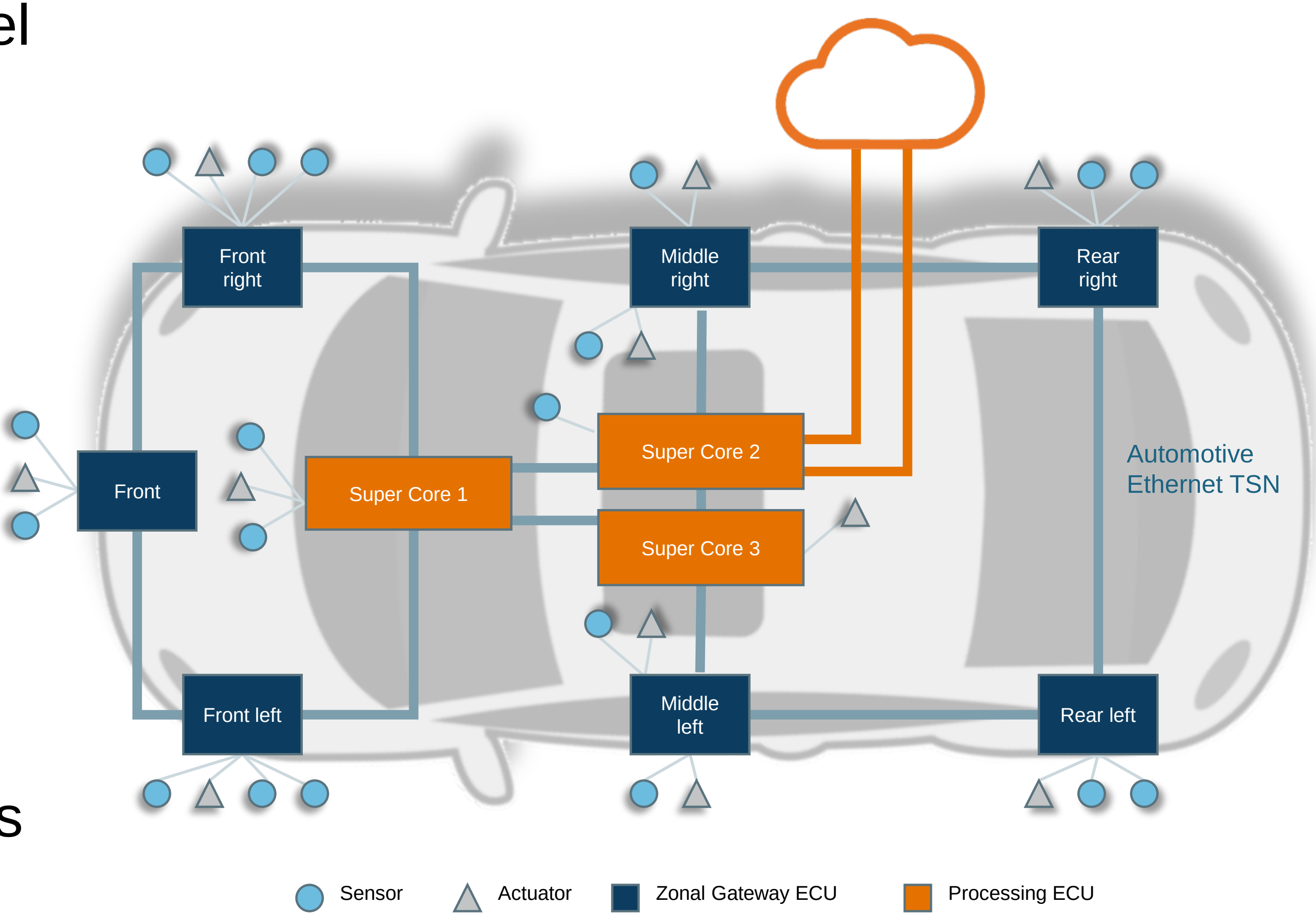
- Zonal approach including first level of consolidation in three domains:
  - ADAS Super Core
  - Body Super Core
  - Cockpit Super Core
- Automotive Ethernet TSN backbone with high bandwidth and deterministic real-time communication facilities
- Sensors and actuators are connected to zonal gateway ECUs



Vehicle Zonal EE Architecture Future

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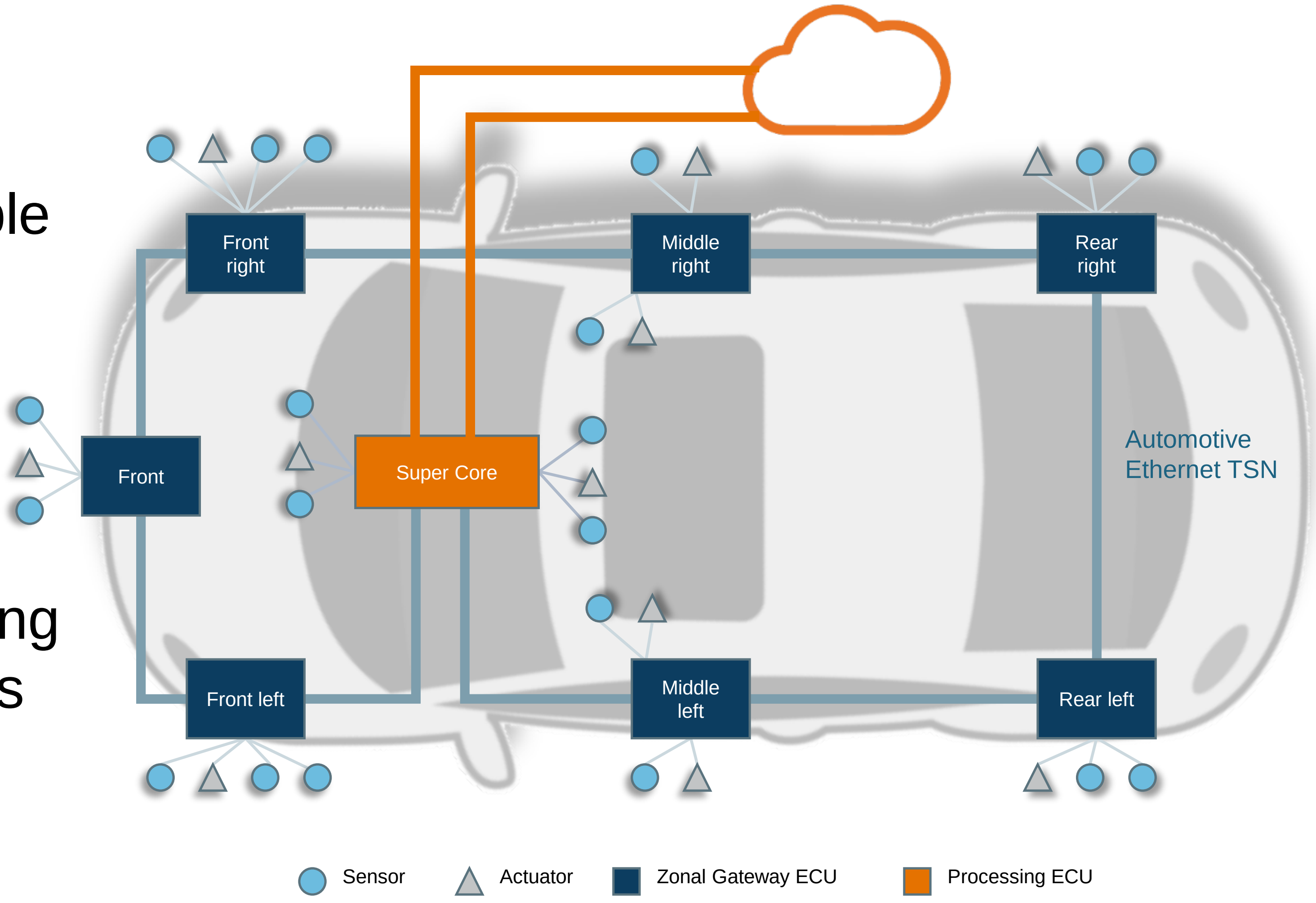
- Further consolidation of the processing units
- Processing blades provide scalable computational power
- Automotive Ethernet TSN backbone architecture reused
- Zonal architecture blends upcoming vehicle functions and technologies with savings in weight and cost



Communication backbone

Vehicle Zonal Intelligent Power Distribution

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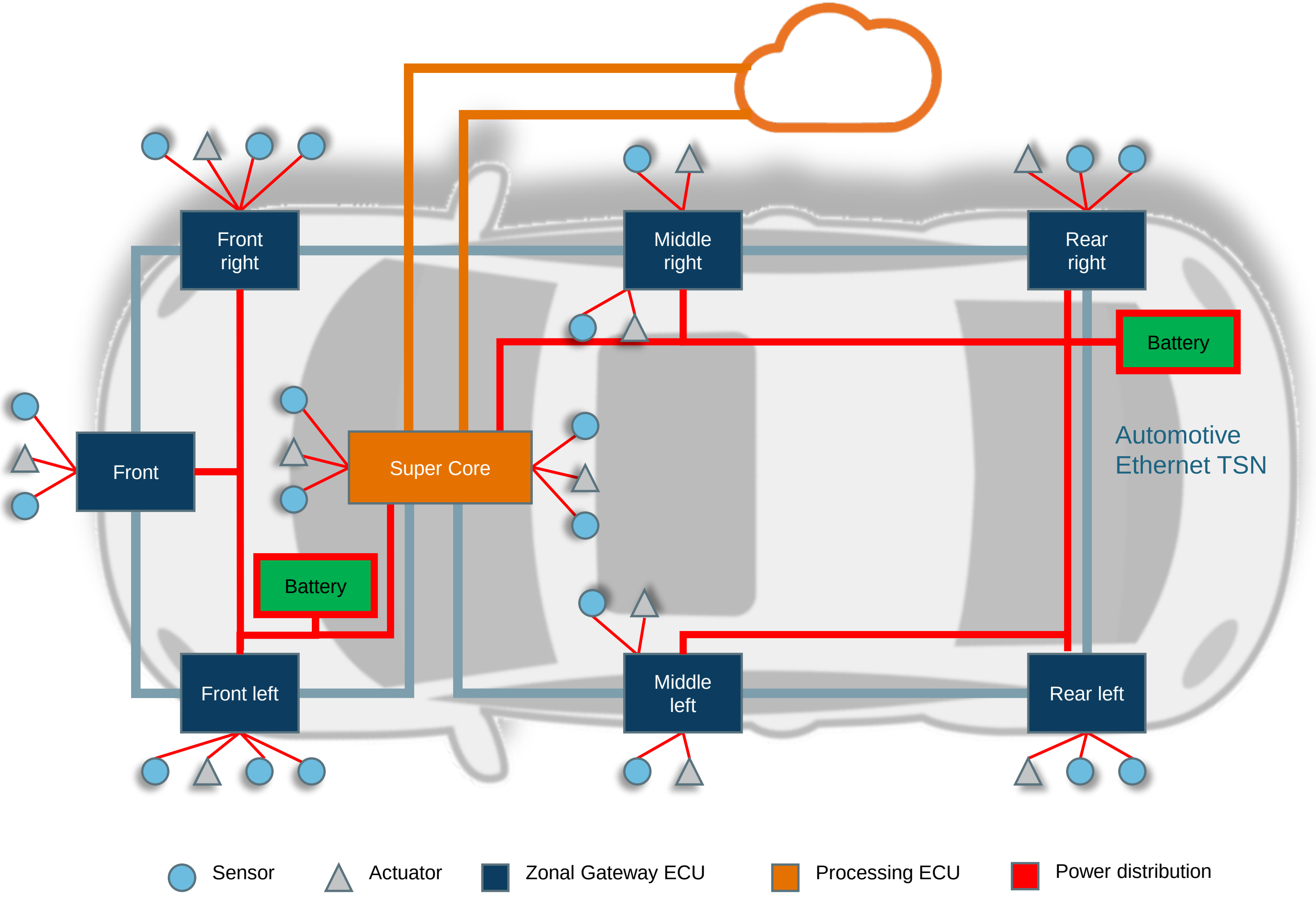
- Dual battery scenario with hierarchical power distribution
- Promoting the application of electronic switches and fuses
- Integration in zonal gateways allow for novel applications:
  - Virtualizing the central fuse box
  - Tailored fuse characteristics
  - Intelligent power management: load optimization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



Vehicle Zonal EE Architecture

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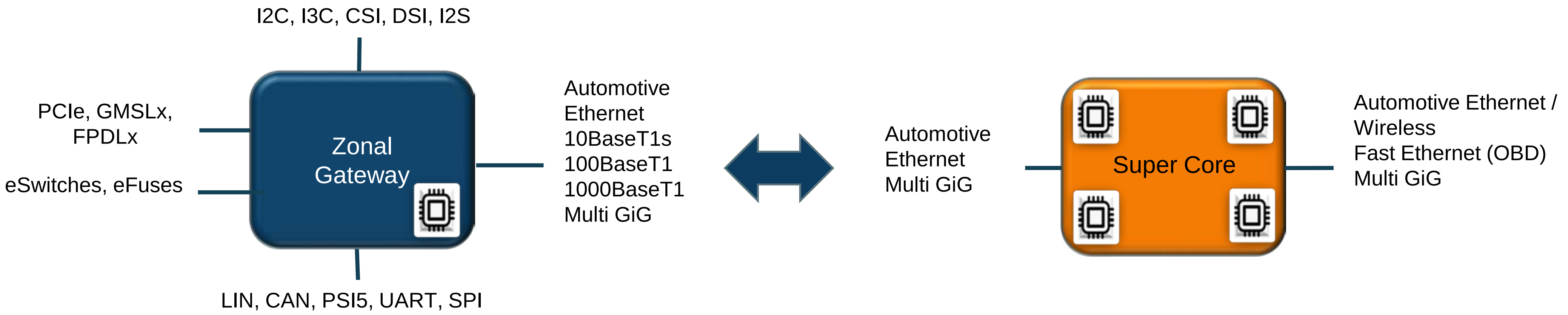

Zonal Gateway ECU

- 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

Zonal Gateway ECU Design Approach

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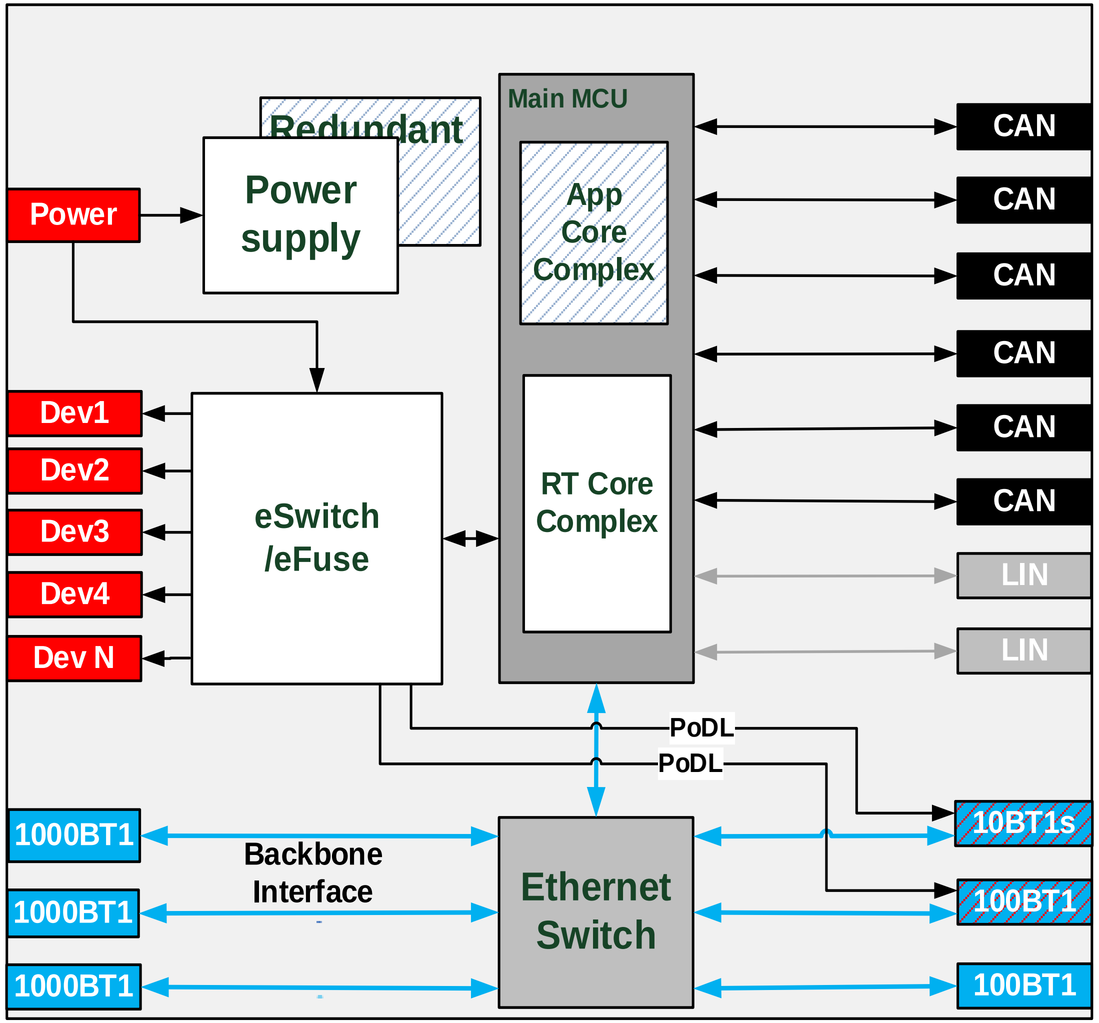

PoDL - Power over Data Line

- 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

Case Study Setup – Optimized EE Architecture

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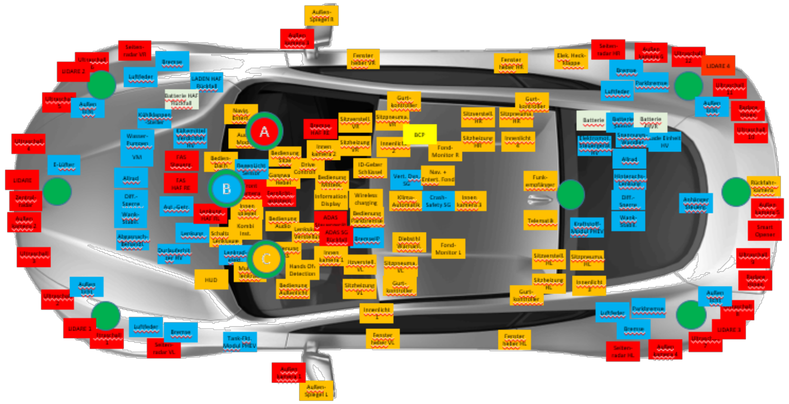
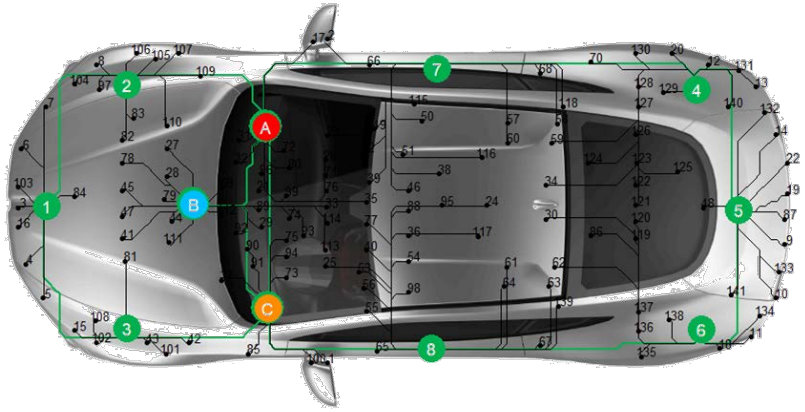
- Estimate the wiring harness of different zonal architectures
- Qualify the trade-off between savings in harness and expenses on zonal ECUs
- Therefore an environment was set up to
  - map the ECUs on the layout of the vehicle
  - automatically generate a wiring harness from the positions of the ECUs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



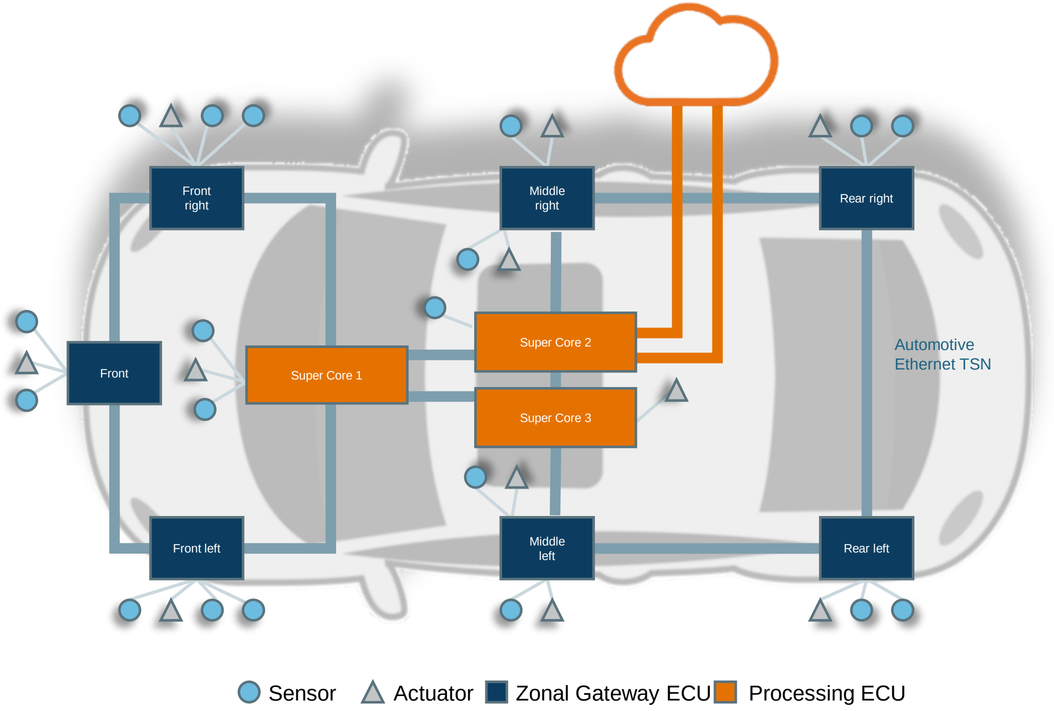
Spatial mapping of the ECUs onto the layout of the vehicle



Wiring the ECUs in a zonal architecture and estimating the harness length

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



Zonal EE Architecture Leads to Significant Savings

Service-Oriented-Architecture in Zonal Settings

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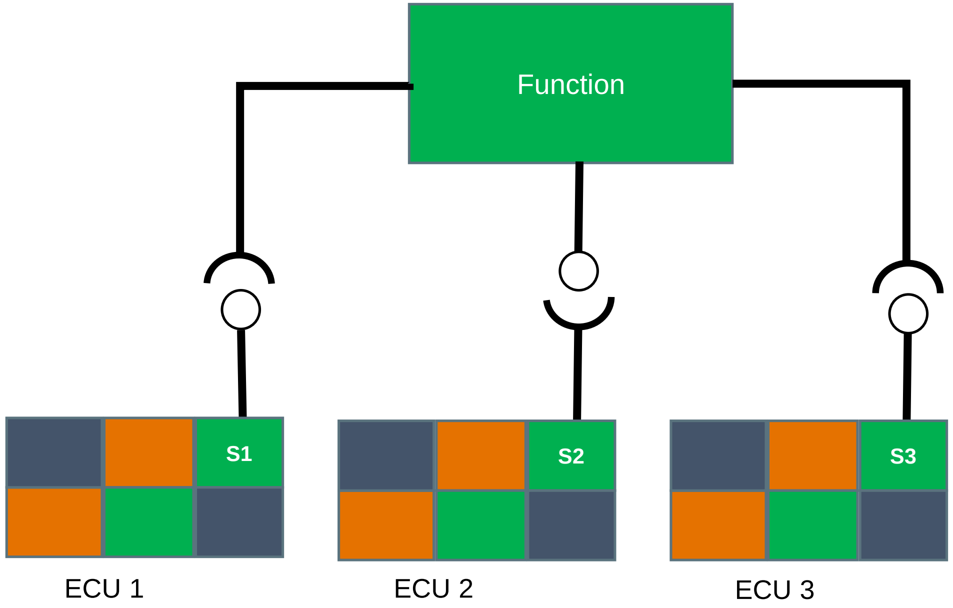
- Disruption in EE topology impacts the software ecosystem
  - Functions no longer associated by ECU, but by domain
  - A single function is constituted by services, provided by different ECUs
  - Several SW suppliers delivering services to the same ECU
  - Business logic of functions moved to a central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



Functions are broken down into services,
Services run on different ECUs,
ECUs are interconnected via Automotive Ethernet TSN.

Applying the Advantages of SOA

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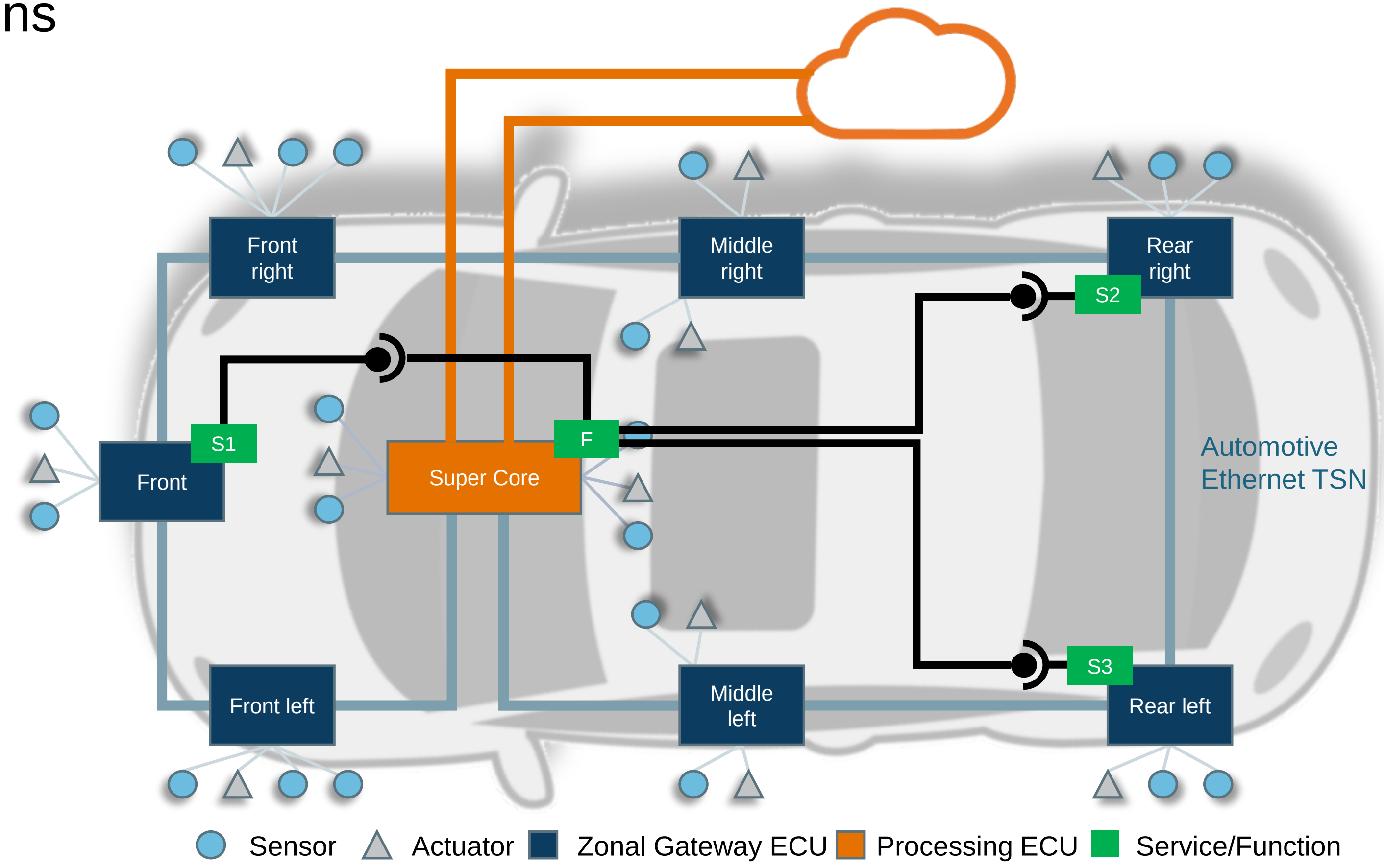
- Abstract from physical to logical connections
- Services availability throughout the IP-based network
- Well-established experience from other industries are applicable
- Legacy communication mechanisms will remain
  - Mission critical ECUs (e.g. ESP) using signal-based communication
  - Services can 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



Combination of Zonal Architecture and SOA Proliferate Functionalities

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

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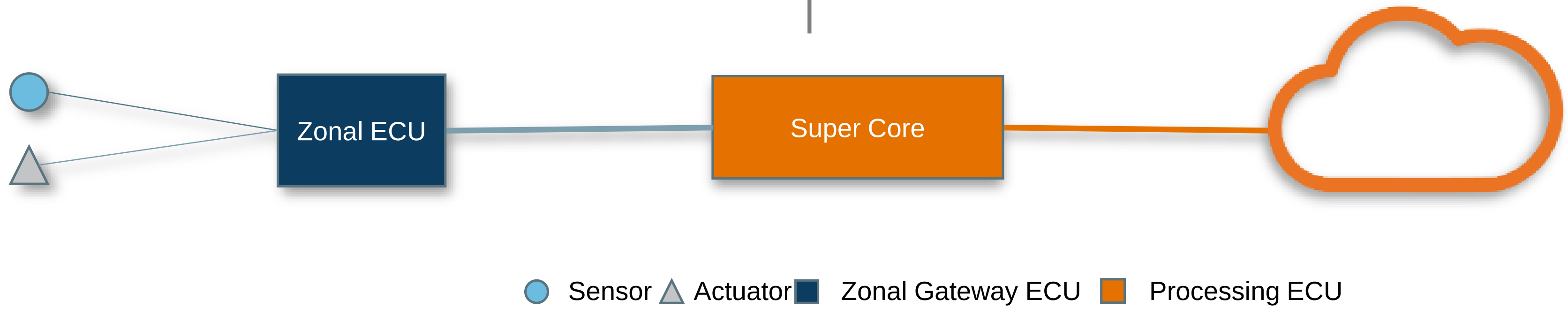
- The data processing shall happen in real-time with low latency
- Sensors create data which can be processed either
  - next to the sensor (smart sensor),
  - in a zonal ECU with appropriate computational power,
  - in a central compute node such as Super Core or
  - off-board in Edge or Cloud computing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

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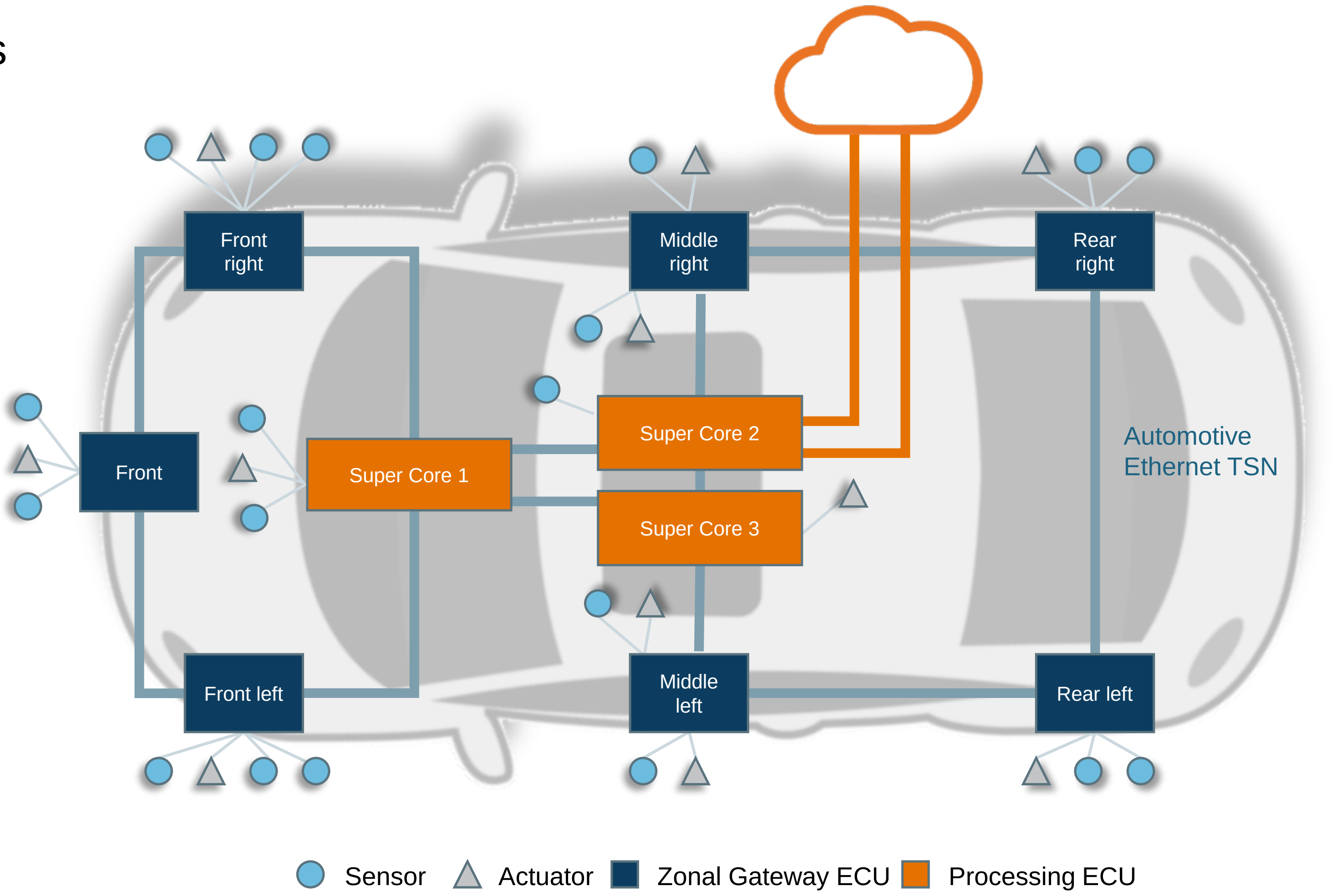
- Automotive Ethernet TSN network approach is the common rail for the zonal architecture
  - 1 to n zones
  - High bandwidth and real-time communication
  - Reliability and fail operational
- Zonal ring approach with is fully scalable:
  - Entry to luxury segment
  - Automated driving Level 1 to Level 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

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