Trends of Future E/E-Architectures

How new Architectures change the Automotive Industry

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Future Mobility
Electrified, Automated and Connected

electrified
- plug-in
- eScooter
- range
- fun-to-drive
- battery
- charging infrastructure

automated
- highway-pilot
- redundancy
- valet parking
- sensors
- electric steering

connected
- eCall
- cloud
- services
- car2car
- fleet management
- augmented reality

- costs
- hybrid
- e-motor
- power electronics
- legislation
- emergency braking
- driver assistance
- autopilot
- electronic horizon
- smartphone integration
Trends of Future E/E-Architectures
Challenges and Bottlenecks

**Functional Complexity**
Wide diversity of cross-domain functionalities need to be handled and distributed

**Flexibility**
Future E/E systems need to allow swift introduction of new innovations & SW sharing

**Scalability**
Many segments, markets and technologies leading to complex, and expensive variant handling

**External Communication**
Leads to higher data traffic and significant security risks

**Communication Bandwidth**
Inter-domain and cross-domain communication bandwidths not sufficient for future data traffic

**Computing Power**
Serial computing in embedded systems is hitting the technological limits
Trends of Future E/E-Architectures

BOSCH view on E/E-Roadmap

Vehicle Centralized E/E Architecture
domain independent
central vehicle brain(s)

(Cross) Domain Centralized E/E Architecture
increasing cross domain functions

Distributed E/E Architecture

Vehicle Fusion
Domain independent
“(Central) Vehicle Control Computer” with potential “Zone ECUs”

Domain Fusion
Domain overlapping
“Cross Domain Control Units” / “Cross Domain Computer”

Domain Centralization
Domain specific
“Domain Control Units” / “Domain Computer”

Integration

Functional Integration
Each function has its ECU
(“Function Specific Control Units”)

Modular

Increasing number of vehicle functions in the cloud

Vehicle Cloud Computing

Performance ECUs e.g. (Cross-)Domain Control Unit, (Cross-)Domain Computer, Vehicle Control Computer

typ. state of the art automotive ECUs (function specific)
Optional ECUs (e.g. Central Gateway)
Domain independent Zone ECUs
Domain specific Zone ECUs (e.g. todays Door ECU)

Sensors/Actuators
ECU = Electronic Control Unit

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Increasing Market Share of Vehicle Fusion EE Architectures

- Suppliers need to adapt their product portfolio for vehicle fusion architectures (Integration Platform Vehicle Computers, Zone ECUs, Application-SW, MW, ...)

- Increasing number of major OEMs envisage introduction of vehicle centralized E/E-architectures until ~2025

- (Cross-) Domain centralized E/E-architectures still considered as mainstream 2021

- ≤2018 ≤2019 ~2020 ~2025 ~2030
  "Model 3"  "Model 3"

  "Model 3"

  "Model 3"

  "Model 3"

  "Model 3"

*: initial assignment; Target Architecture is TBD and may differ from associated picture

-SOP for E/E architectures
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High Complexity Meets Automotive Safety And Reliability

**Embedded ECU**

1st SOP: 2019  
DMIPS: 1.500  
RAM: 6 MB  
µC  

**Vehicle Computer**

Supporting ARM and x86

1st SOP: 2019  
DMIPS: 3.000  
RAM: 16 MB  
µC  

**AI Computer**

Supporting ARM and x86

1st SOP: 2019  
DMIPS: 14.000-34.000  
RAM*: 512 MB-3GB  
µC  
µP  

**Cloud Comp.**

SOP: 2025  
DMIPS: 500.000  
TOPS: >300  
µC  
µP  
HW acceleration  

<table>
<thead>
<tr>
<th>Integration Platforms</th>
<th>Performance Platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1st SOP: 2019</td>
<td>1st SOP: 2020</td>
</tr>
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<td>DMIPS: 3.000</td>
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<td>DASy 1.0 enhanced</td>
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<td>PT ECU</td>
<td>Head Unit</td>
</tr>
<tr>
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</tr>
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<td>1st SOP: 2019</td>
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<td>DMIPS: 14.000-34.000</td>
<td>DMIPS: 260.000</td>
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<td>Adaptive Posix OS</td>
<td>AI</td>
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</tbody>
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* ROM: Extension by eMMC possible
Trends of Future E/E-Architectures
Vehicle RunTime Environment: Software enabling Vehicle Computers

VC building blocks
- Data / Service Provider
- App1
- App2
- App3
- API
- VRTE
  - Continuous update
- HW
  - 3-4years Lifecycle

VC SW Domain Structure

Classic Applications
- Well Defined Safety
- RTE
- Defined QM

SOA Applications & Services
- Flexible Safety
- ARA
- Defined QM

APIs
- Well Defined Safety
- RTE
- Flexible Safety
- ARA
- Defined QM

Linux Platform

Application

V2X

Continuous update

Base VC configuration

Special type

Hypervisor
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Hardware Acceleration for Central Gateways

ETAS Data Engine

- “Any to any” interface, non-blocking bridging with low latency (< 2 µs) and low jitter (< 1 µs), high bandwidth (> 20 Gb/s)
- Operates on OSI-Layer 2-4 (incl. TCP, UDP, CAN TP, FlexRay TP, 1722)
- Offloads the CPU and reduces the interrupt load
- Supports typical automotive interfaces: CAN-FD, FlexRay, Ethernet, PCIe
- Configurable, flexible and extendable by dedicated software and hardware functionalities
Trends of Future E/E-Architectures

Energy consumption depending on E/E-Architecture

- Growing functionality w/ higher computing & communication performance drives the electrical power demand (up to 4 kW)
- Tightening CO₂-emission (ICE) regulations and range requirements (BEV) limit the overall power consumption
- Future E/E-architectures have to become more energy efficient (e.g. HW/SW co-design, local HW-accelerators, …)

In city cycle, 1 kW Powernet-Load increases CO₂-Emission by >30 g/km (cf. Japan. Citycycle JC08)

Assumptions acc. Premises vector 2.0:
CompactClass-G5.1, DI/TC 1.0L, 3zyl, 90kW, Efficiency_BRM = 0.85
vehicle weight (Veh+EM+Bat) = 1490 kg, cross section = 2.13 m², cw = 0.248, rolling radius = 306.5 mm, roll friction = 0.008
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Security: Holistic Approach

1. Individual ECU
   - ECU software and data integrity protection

2. In-Vehicle Networking
   - Integrity protection of critical in-vehicle signals and messages

3. EE Architecture
   - Protected and separated domains by E/E architecture and gateways

4. Connected Vehicle
   - Vehicle firewall and security standards for external interfaces

5. Intrusion Detection System
   - Monitors data communications and logs abnormal events

Cyber Security Backend

- Event Logs
- Security Update
- Intrusion Detection System (IDS)
- Firewall
  - IDS
  - IPS

Intrusion Detection System (IDS)

- Monitors data communications and logs abnormal events
- Intrusion Detection System
  - Monitors data communications and logs abnormal events

Connected Vehicle

- Vehicle firewall and security standards for external interfaces

EE Architecture

- Protected and separated domains by E/E architecture and gateways

In-Vehicle Networking

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Individual ECU

- ECU software and data integrity protection
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Multi purpose camera

- Safe perception through an algorithmic multi-path approach
- Large field of view for detection of crossing vulnerable road users
- High angular resolution with increased range at the center
- Artificial intelligence for robust perception and behavior prediction

**FEATURES**
- Bosch system-on-chip for ultra-high performance algorithms (flow, classifiers, disparity) with low power consumption and low thermal dissipation
- Reliable full scene understanding for increased safety using algorithmic multi-path approach
- Semantic segmentation based on deep learning and optical flow for model-free video processing
- Optical path optimization for advanced driver assistance systems

Front radar sensor plus

- Impresses with improved precision, wider range and opening angles
- Scalable construction kit
- Immune to adverse weather conditions
- High performance with advanced Bosch chirp sequence modulation scheme

**FEATURES**
- NCAP (AEB City, AEB Inter-Urban, AEB Vulnerable Road Users)
- Improved comfort for Adaptive cruise control (ACC) up to 210 km/h
- Partially automated driving (supports traffic jam assist / pilot, highway assist)
- Multi-object tracking
- Handles complex traffic situations
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Summary

- Automated, Connected, Electrified & Shared (ACES) drive ...
  - ... the tremendous growth of cross domain functions and system characteristics like functional safety, cyber security and energy management and hence system complexity
  - ... the functional centralization and introduction of vehicle integration platforms and zone controllers

- In future, vehicle functions can / will be re-allocated to vehicle computers according to changed requirements and constitute the separation of SW from HW

- New architectures require high computational power and communication bandwidth but need simultaneously high power efficiency leading to the use of HWA for selected applications

- Higher AD level (> SAE L3) need large numbers of number of sensors with technological diversity

Vehicles become the internet devices with the most complex software and highest computational power
Thank you!

The Revolution of Automotive Architectures has started

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