Challenges towards New Software Platform for Automated Driving and High Computational ECU’s

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Who am I?

Project General Manager @TOYOTA (E/E Architecture Development Div.)
Engaged in In-House Development of Chassis Control Systems (ESC, 4WS)
2 Times assigned to Toyota Motor Europe (Electronics Systems for European Vehicles)
Responsible for Basic Software development for All Toyota Vehicles.
Engaged in AUTOSAR activities and served as a Steering Committee Member from TOYOTA
Developed AUTOSAR based BSW into All Toyota Vehicles

Currently on second assignment from TOYOTA to IAI Corporation.
Assistant Director at IAI, developing software for industrial robots.
Today’s Agenda

• TOYOTA E/E Architecture Evolution and Software Platform (BSW)
• Technical Trends and Next Generation E/E Architecture
• Challenges towards New Systems (CASE) Development
• Summary
E/E Architecture evolved in order to meet
- Complex System Requirement
- Development effort reduction

Connected ECU’s utilize Common Software Platform (Basic Software)
Proprietary Specification → Standard Specification
Proprietary Software → Standard Software

Common understanding of Spec.(Functions)
Common usage of Implementations

Split & Share of Responsibility between OEM, Tier1, Tier2
TOYOTA standard BSW with full AUTOSAR compliance

Support TNGA (TOYOTA New Global Architecture) requirement

More than 82 ECU, 27 Tier-1 Projects (including in-house development)

Business model for efficient Software development
   (BSW: Global BSW Vender, Application: OEM)
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Technical Trends: Development Process

Modular approach creates Many Variants

System / Software become too Large (Cross Domain Functionality)

Tier-1 Development Process need to be Agile (streamlined product line strategy)

OEM has to cope with
1) “large variant set” (including smaller vehicle)
2) “systems’ engineering” for global optimization
3) short sprint release “repeatedly”

Potential measure on E/E Architecture
1) Open System (on demand)
2) Centralization
3) Frequent Update (OTA)
E/E Architecture Evolution

Layered LAN

Central Gateway + Domain LAN

Computing Platform

Computing Platform++

Simple LAN

P2P LAN

Online cloud

Offline cloud

Added value

Commodity

E/E Architecture may need

- Central ECU
- Brain ECU

Functions could be distributed to Zone ECU

- Adaptive AUTOSAR
- Classic AUTOSAR
- Non-AUTOSAR

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Future E/E Architecture: Central & Zone Concept

Central & Zone Concept is recognized as ultimate goal of Physical E/E Architecture

<table>
<thead>
<tr>
<th>Impact image on change</th>
<th>Current Architecture (Domain based)</th>
<th>Next Gen. (Central and Zone)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Goal: Cost down by ECU integration</td>
<td>Goal: Easy software plugin</td>
</tr>
<tr>
<td></td>
<td>No space</td>
<td>Goal: Localize physical changes</td>
</tr>
<tr>
<td></td>
<td>Heavy weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Few vehicle coverage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less extendibility</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Power</th>
<th>① Dedicated, additional wire and route required</th>
<th>① Minimized wire under Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>② Dedicated, additional wire and route required</td>
<td>② Minimized wire under Zone</td>
</tr>
<tr>
<td></td>
<td>③ Negotiation effort on network design</td>
<td>③ Localized change (i.e. comm. matrix)</td>
</tr>
<tr>
<td>Network</td>
<td>④ Redesign on additional ECU</td>
<td>④ Spared space for additional ECU</td>
</tr>
<tr>
<td>Mounting</td>
<td>⑤ Software changes on distributed ECUs</td>
<td>⑤ Software change only on Central ECU</td>
</tr>
<tr>
<td>Logical</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Open question:
- how to migrate toward Central & Zone Architecture
- Timelines for Introduction
A Possible Migration Scenario

- Speed (Time to market)
- Development
- Deployment
- Cost
- Hardware consolidation
- Flexibility
- Localize OTA change

**Autonomous**

**Car Share**

**MaaS service**

**EV** (Regulation in various countries)

**Connected**

**Central Gateway + Domain**

**Brains overlay**

**Brains + Domain Master**

**Offline cloud**

Introduction of New Applications may become a Driving Force
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Application Driver for Future E/E Architecture: CASE

Size / Complexity

Connected

Vehicle as a part of IoT

Autonomous

Lv3, Lv4, ...

Electrification

Shared

Infotainment
Body
ADAS
Powertrain / Chassis

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OEM
Vehicle as a part of IoT

Source: Morgan Stanley Research.chargedevs.com

Source: chargedevs.com

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TOYOTA
Let’s have a brief look at the actual development status
Highway Automated Driving System
It seems to be working well....
How to Validate/Verify the System ... Globaly

142 Billion Km (on road test) Necessary for Full AutoDriving

May take 2700 years (Avr Spd 60Km/h)

Total Road Extension (Global) \( \approx 36 \) Million km (Calculated from 2013 World Factbook)

Comprehensive Validation is Necessary

Test Cases should cover all the Roads Globally

=> Condensed/Compressed Validation Method Necessary
Utilizing Virtual Environment for Verification Coverage

Verifying "Recognition"
- Backlight
- Road-surface reflection

Verifying "Planning/Control"

Simulation is effective for matrix-style verification (Automatic, Re-usable, Rare scene)

Utilize to develop algorithm for Planning/Control performance

Accumulated Data and Simulation is the key for Verification coverage
Driving Scene in Backlight

<table>
<thead>
<tr>
<th>Time</th>
<th>Vehicle Speed</th>
<th>Vehicle Location</th>
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</thead>
<tbody>
<tr>
<td>24.942</td>
<td>89.805 km/h</td>
<td>X₀: 390.769</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y₀: -275.540</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Z₀: -5.805</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Station: 599.762 m</td>
</tr>
</tbody>
</table>
Utilizing Virtual Environment for Verification Coverage

Verifying "Recognition"
- Backlight
- Road-surface reflection

Utilizing computer graphics images

Verifying "Planning/Control"
- Simulation is effective for matrix-style verification (Automatic, Re-usable, Rare scene)

e.g. Merging on highway (Ariake IC) Result from MILS evaluation

Successfully merged in front
Successfully merged in behind

Utilize to develop algorithm for Planning/Control performance

Accumulated Data and Simulation is the key for Verification coverage
Enabling Technologies for CASE Systems Development

Research

Pre-development

Development & Series Production

Virtual Environment (PC base)

Mass Production ECU

Scaling Computational Power

Application → Functionality Checked

Application → Real-Time, Performance Checked

Application → Deployment ready

Same Functionality between different Computing Platforms

e.g. Deep learning server

e.g. Voice recognition

e.g. trunk server

Optimize

getting closer

Hardware update

backend

onboard

Central Unit
Enabling Technologies for CASE Systems Development

Key software (for OEM) may be executed on adaptive PF. Scalable software (extended features) are located at central ECU.

Split & Share of Responsibility between OEM, Tier1, Tier2

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Summary

- E/E Architecture May Evolve to Central & Zone Concept
- Migration from Domain LAN Architecture may be enabled by Adapting CASE Systems into the Architecture
- Verification & Validation of CASE System only possible with utilization of Virtual Technology
- Software Platform (Adaptive AUTOSAR) must support same functionality between Virtual Environment to Mass Production ECU’s
- Work Split & Share between OEM, Tier1, Tier2 essential for the success of Future Software Platform and E/E Architecture
Thank you very much for your attention!