AUTOSAR Architecture
Modeling of Multi-core
Electric Powertrain Controller

Dr. Sakthivel Manikandan Sundharam / Software Architect

Delphi Technologies
Bio: Sakthivel Manikandan Sundharam

True! Bit longer name - Shortly “Sakthi”

- Software Architect – Powertrain Electrification & Electronics
- 15+ Years of Automotive Embedded System Experience
- Ph.D. in Timing Aware Model-Based Design to Automotive Embedded Systems, University of Luxembourg, Luxembourg
- Masters in Embedded Systems, College of Engineering Chennai, India
- Work revolves around software architectural topics incorporating timing, memory, and safety constraints of automotive software.
Delphi Technologies - Powertrain Electrification Product Portfolio

1. Delphi Technologies - Powertrain Electrification Product Portfolio
2. HV Inverter System Context
3. Pitfalls in Legacy Approach of SW Architecture Modeling
4. Evaluation of Journey
   - Requirements to Architecture
   - Architecture authoring
   - Interfaces / Data dictionary
5. Lessons learnt and Best practices
Delphi Technologies - Powertrain Electrification Product Portfolio

Low cost, high density, rugged with various levels of integration available

- Single Inverter
- Inverter w/ DC/DC (CIDD)
- 48V Inverter for BSG
- 48V DC/DC Converter
- Supervisory Controller (Hybrid Control Unit)
- DC/DC Converters
- 3-in-1 Inverter
- Battery Pack Controller
- On-board Battery Chargers
- High Voltage Box
- 48V DC/DC
- Hybrid Control Software
Delphi Technologies Inverter – The Next Generation

<table>
<thead>
<tr>
<th>Inverter with conventional Power Module</th>
<th>Delphi Technologies Inverter with viper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravimetric power density (kVA/Kg)</td>
<td>Gravimetric power density (kVA/Kg)</td>
</tr>
<tr>
<td>16.1</td>
<td>20.6</td>
</tr>
<tr>
<td>25% higher</td>
<td></td>
</tr>
<tr>
<td>Volume (L)</td>
<td>Volume (L)</td>
</tr>
<tr>
<td>10.7</td>
<td>7.6</td>
</tr>
<tr>
<td>30% smaller</td>
<td></td>
</tr>
<tr>
<td>Mass (Kg)</td>
<td>Mass (Kg)</td>
</tr>
<tr>
<td>14.5</td>
<td>8.4</td>
</tr>
<tr>
<td>40% lighter</td>
<td></td>
</tr>
<tr>
<td>Efficiency Improvement (MPG)</td>
<td>Efficiency Improvement (MPG)</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

- Next gen Viper enables extra high voltage 800V bus inverters
- Flexibility to move from Si to SiC power switch to enable higher efficiency & lower cost
- Advanced capacitor enables up to 70% reduction in component volume & weight

Conventional
Many, many wire-bonds

Delphi Inverter next generation

Delphi Technologies
HV Inverter - System View

3 Core micro – Infineon AURIX 2G
Mixed ASIL : QM to ASILD

Multicore Electric Powertrain Controller
Pitfalls in Legacy Approach and Best Practices Evaluated

(a) Dearth of tool support for fine-grained modeling of AUTOSAR-based architecture design
(b) Lack of support for proof-of-concept study of what-if scenarios, performance analysis
(c) Gaps in requirements traceability

(a) AUTOSAR and Simulink System Composer toolboxes for AUTOSAR-based systems engineering
(b) Proof-of-concept studies, performance and viewpoint analysis of various stakeholders
(c) Bidirectional traceability
Static Software Architecture Tooling Twins

MLSL’s AUTOSAR Blockset + System Composer

Legacy SysML

Interface definition and Data Dictionary
Publishing Architecture Modeling onto Requirements Database

approach provides a lean way to publish the design to requirements database.

Also for existing requirements, it provides an option to link them.
Requirements to Architecture Linking

Tracking of requirements back and forth between modeling and requirements database to verify fulfillment of requirements.
Bi-directional Traceability - Forward

Requirements to Architecture Traceability
Bi-directional Traceability - Backward

Architecture to Requirements Traceability
Architecture to Requirements – Seamless Approach

- Whenever model updated due to maturity of the project, refresh option updates the same model onto requirements database
- Reversely, requirement attributes changed on the requirements database can easily be pushed back to SW architecture
arxml Import from BSW Tools (f.e Vector BSW-stack Tools)
Generation of SW Architecture Documents

Automated Scripts
Lessons Learnt and Best Practices

**AUTOSAR SW Architecture Authoring**
- Modeling of AUTOSAR-based system architecture using AUTOSAR blockset together with System composer toolbox in recent releases of Matlab/Simulink.
- Creating fine-grained AUTOSAR architecture models using Simulink System Composer data dictionary support.

**Requirements to SW architecture mapping**
- Employing seamless approach to establish bidirectional traceability between modeling environment and the requirements database. Tracking of requirements back and forth between both the environments to verify fulfillment of requirements.
- To publish requirements and design on to requirements database. Also, the approach updates both requirements and design whenever adapted for changes due to technical discussions in a more efficient way.

**Architectural simulation and SAD**
- Import and export of ARXMLs between architectural modeling environment to Basic software (BSW) configuration and development tool-chain to reduce ambiguity on architectural considerations and development time.
- Early model-based performance and trade-off analysis of non-functional requirements using custom-defined profiles (e.g. employing Matlab/Simulink and System Composer toolboxes).
AUTOSAR Architecture
Modeling of Multi-core
Electric Powertrain Controller

Dr Sakthivel Manikandan Sundharam /
Software Architect

Delphi Technologies

Q & A

30 June 2020