Compositional Variant Management and its Application in Embedded Software Development

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Dr. Markus Kees, Ford Forschungszentrum Aachen GmbH
Achim Seibertz, PROSTEP IMP GmbH
**Facts**
- Established in October 2005
- 8 offices in Germany

**Specialization**
“Solution provider for integrated processes, methods and technologies for the development of mechatronic products”

**Projects**
- > 20 successful customer projects in the automotive industry
- 3 successfully finalized research projects
- 1 active research project
- 3 ProSTEP iViP Association projects
Challenges of Variant Management

Complexity Driver
- Increase of Product Variants (Market Segmentation)
- Increase of Variant Product Functions
- Increase of Variant Engineering Data

Current Situation
- Variants are specified and managed in decentralized, discipline-specific Data Management Systems and Development Tools
- Decentralized & Tool specific Systems of Rules are used for Configuration

Goal
- Development of a pervasive Variant Modeling & Management Methodology
- Support of the entire Product Creation Process
- Compatible with existing and established Specification Methods
Product Variants correlates with Variants in the Engineering Data along the Development Process

...very, very, very simplified representation
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...very, very, very simplified representation
E/E- Engineering Data are stored in different, non-pervasive IT-Systems

Goal: Achieve Traceability & Process-Support by System Integration

Goal: Reduce Development Effort and increase Quality by Tool-Integration

...very, very, very simplified representation
Variant specification in a PDM-System (Example: Siemens PLM Teamcenter)

Specification of Variant Positions

Specification of the corresponding Conditions

Configuration of an Instance
Variant Specification in Requirements Management Systems (Example: IBM Rational DOORS)

Assignments to Configuration are expressed by Attributes

150% Specification

Configuration by means of Filtering for „T“

100% Specification
The Idea of compositional Variant Management in the PDP

Variant Data and Structures along the PDP

Transformation into a generic Variants Representation

Unified Representation of different Variant Information

Composition of the different Variants Models by means of the overlaying Product Variants model

Analysis of Sub- and Total-Model (e.g. Consistence)
Methodology of Compositional Variant Management (Example: E/E-Development)

1. Rule Based Specification of Product Variants by Feature-Models

2. Definition of the Functional Architecture & Structure incl. Variants

3. Linking (Product Variants with Function Variants)

4. Linking (Function Variants with Engineering Data)

5. Derive Configuration of Engineering Data from configured Product Model
   - Analysis

Engineering Data (Example E/E)
- Requirements
- Architecture
- Implementation
- Test
• With feature models complex variant product families and data can be described in a user friendly graphical manner.
• Furthermore the benefit of feature models is the transformability into propositional logic, which can be analyzed to check for consistence, dead features, etc.
Methodology of Compositional Variant Management (Example: E/E-Development)

1. Rule Based Specification of Product Variants by Feature-Models
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5. Derive Configuration of Engineering Data from configured Product Model
   • Analysis

Engineering Data (Example E/E)
• Requirements
• Architecture
• Implementation
• Test
Application @

Research & Advanced Engineering - Europe

Compositional Variant Management in Model Based Embedded Software Development
<table>
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<tr>
<th>Process data</th>
<th>Requirements</th>
<th>SW Architecture</th>
<th>Modeling &amp; Code Generation</th>
<th>Verification &amp; Validation</th>
<th>Documentation</th>
<th>Calibration</th>
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<tbody>
<tr>
<td>Development System</td>
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<td>Matlab/Simulink</td>
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- The tool chain of model based Software and function development has been enhanced since 1995 (Series Code Generation in 1999, formal Verification in 2004)
- Dependency of requirements and fulfillment of these had been ensured through a thorough process integration
- All process files have been managed with the eASEE.edm
System landscape: Potential Future scenario

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<td>Embedded-Validator &amp; Tester</td>
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</tr>
</tbody>
</table>

Documentation Generated

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Linking of engineering data of any kind.
Methodology of Compositional Variant Management - Variant Management at FFA

1. Offline variant management tool with metadata exchange to backbone and link to development tool
2. Representation and configuration of feature model, model configuration, and parameters
Methodology of Compositional Variant Management - Simulink Integration

Development System

• System descriptions
• VM-Data
• Global data lists

XML

Data Dictionary

• Active/selected system descriptions
• VM-Data

Data Management System

eASEE Engineering Data Backbone

Meta data exchange
File exchange

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Development 2010

**Development System**
- eASEE.rqm
- Matlab/Simulink
- Embedded-Validator & Tester
- CalDesk
- AUTOSAR Architecture Tools
- TargetLink
- RCP/HIL

**Data Management System**
- eASEE.sdm
- eASEE.edm
- eASEE.tdm
- eASEE.cdm

**Generated Documentation**
- eASEE.sdm
- eASEE.edm
- eASEE.tdm
- eASEE.cdm

**eASEE Engineering Data Backbone**

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Open challenges and Future Vision

- Integration pilots of RQM and SDM
- Methodical integration of VM GUI into eASEE landscape
- Graphical specification & representation of all variant information analogue to Feature Modelling
- Rule based configuration
- Completion of future target TDM and CDM
- Full traceability of all objects transparent to the user
- Analysis capabilities of variant data
Outlook
The Idea of compositional Variant Management in the PDP & its realization

- Transformation into a generic Variants Representation
- Unified Representation of different Variant Information
- Composition of the different Variants Models by means of the overlaying Product Variants model
- Analysis of Sub- and Total-Model (e.g. Consistence)
Product line and variant specification using feature modeling

Domain specific import or input of variant development artifacts

Compositional linkage of product variants and development artifacts

Rule based configuration to compose consistent product- and development data

Attribute based optimization of product lines
Thanks for your attention!

Dr. Markus Kees  
Hybrid Vehicle Technologies / Electronics & Control  
Alternative Powertrains  
Ford Research & Advanced Engineering Europe  
e-mail: mkees@ford.com

Achim Seibertz  
Head of Methods & Technology  
PROSTEP IMP GmbH  
e-mail: achim.seibertz@prostep.com