HOW TO DESIGN PRODUCT LINES BY MEANS OF MBSE

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• Short Introduction to Orthogonal Variability Modeling (OVM)
  – Approaches for Variant Modeling with OMG SysML
  – Model Elements of OVM

• How to construct a Product Line Model in SysML
  – Vs. „normal Generalizations“/Redefinitions (helpful, but not here)

• Example to make decisions and generate a Product Model
  – Check Consistency (using automatic Verification), e.g. missing Traceability

• Extending OVM
  – Example Parametric Variability

• External vs. Internal Variability
  – Optimizing Product Line Model and Variability Model

• Q&A
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SHORT INTRODUCTION TO OVM
THE PROBLEM

Systems modelling language **SysML:** There are **no** elements explicitly depicting product variability.

However, since a while, most systems belong to **product lines with many variants:**

1 variant

> $10^{23}$ variants
VARIANT MODELING IN SYSML

Several approaches exist to extend SysML:

- **VAMOS method** by Tim Weilkiens uses the profile mechanism of SysML to extend the language with a concept for variant modeling
  - Variability model and system model are not separate (not orthogonal)

- **Feature models** (feature trees) and the Orthogonal Variability Modelling Language OVM (*) depict only the variability of product lines
  - Variability model is linked to a separate 150% system model

- The concepts of **OVM** are defined in ISO 26550:2015

✓ Orthogonality of OVM facilitates model verification
✓ OVM is aligned to a standard
ORTHOGONAL VARIABILITY MODELING LANGUAGE (OVM)

Mandatory variation point VP

Variations V

Optional variation point VP

Optional variability dependency

Alternative variability dependency

(Source: K. Lauenroth, Vom Projekt zum Produkt durch Produktlinien und Variantenmanagement, 2010)
HOW TO CONSTRUCT A PRODUCT LINE MODEL IN SYSML
In SysML, there are means to express similarities and for reuse:
- Generalization
- Type and Usage for
  - Blocks, Parts and Ports
  - Activities
  - State Machines
  - Interactions
  - Etc.

Overloading a model from 100% product to a 150% product line is possible:
- Diagrams as filtered views can separate the distinct product perspectives
- Example: More than just one roof in the car chassis
EXAMPLE TO MAKE DECISIONS AND GENERATE A PRODUCT MODEL
• Instead of copying similar elements between different product models, the similarities exist only once in one model.

• Specific elements for a product must be marked as variable
  – Linked with an OVM Artifact Dependency to a variable element
  – Decisions on the variability can be then traced to the linked modeling elements
    • If I want a low-budget elevator, I get a wooden box as the car
• OVM DecisionSets contain
  – explicitly included
  – explicitly excluded
  – (Variability Parameter Values)

• Implicit Decisions can be calculated
  – Using Variability Dependencies
    • Requires/excludes

• DecisionSets can be
  – Complete
  – Incomplete
  – Consistent
  – Inconsistent
    • Only here a product model cannot be generated
• All explicitly excluded Variants can be pruned out
  – Including all artifacts linked to them

• All implicitly excluded Variants can be calculated and pruned out
  – Also including all artifacts linked to them

• Model element pruning needs to retain model consistency
  – Contained objects
  – Object links
  – Etc.
PARAMETRIC VARIABILITY AS OVM EXTENSION
• Some selections are simple

• But what if we have too many options to select?
Solution:

• Extend OVM to use parameters

• This makes modeling of the Product Line Model much easier

• Parameters can be linked to meta model properties
  – Here: Multiplicity

PARAMETRIC VARIABILITY AS OVM EXTENSION
5 EXTERNAL VERSUS INTERNAL VARIABILITY
EXTERNAL VERSUS INTERNAL VARIABILITY

Design targets for product lines:

• Maximize external variability to maximize sales
• Minimize internal variability to minimize development efforts:
  – Increase usage of standard parts
  – Make sure that an external variation point is connected to only one internal variation point
  – …

Appropriate models and tools are needed for design for variability
EXTERNAL VERSUS INTERNAL VARIABILITY

OVM-based product line models support very well product line designers:

• Distinction between external and internal variation points

• Standard parts can be masked such that the designer can focus on variability issues

• Indicators like reuse factors can be calculated

• Number of internal VPs related to one external VP can be determined

• …
QUESTIONS AND ANSWERS

1. loop
2. while open questions exist
3. {Speech Time}
4. You: Attendee
5. Me: Speaker
6. end loop
7. Question
8. Answer

Description

Thanks for your attention!