Model-Based Product Line Engineering

Variations on a Theme

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“The changing nature of products is disrupting value chains, forcing companies to rethink and retool nearly everything they do internally.”
Model-Based Systems Engineering

Design before you build

• Standard based graphical modelling
  – Common language
    • Improves understanding
    • Facilitates collaboration
    • Achieves stakeholder buy in
  – Problem abstraction, to see the ‘wood from the trees’

• Systems engineering process automation
  – Tools enable a more efficient systems engineering process
  – Tangible designs to review, finding problems earlier
  – Traceability from requirements through models to system
  – Enables Rapid Prototyping, Simulation & Trade Studies

• Reduces the total cost of systems engineering
  – Reduce learning curve & cost with an industry standard language
  – Capture system design IP to reduce risks & retain value
  – Optimized allocation to mechanical, electrical & software engineering
  – Design & build the right systems, right
System Product Line Engineering (PLE) Challenges

Product line explosion

- Increasing number of product families
- Increasing number of products in families
- Understanding product similarity
- Maximizing reuse
- Understanding product variations
- Deciding between options
- Development cycle time
- Commercial product needs
  - Customize existing capabilities to suit client requirements
  - Redeploy common systems & software to the Market
  - Time from requirements to cash
• Orthogonal Variability Modeling (OVM)

• The concept of ‘Variability’ Modelling in OVM
  - Variation Points
  - Variants
  - Variability Constraints

• Integrates variability modeling with systems modeling

• References:
  - Klaus Pohl, Günter Böckle, Frank van der Linden, Software Product Line Engineering – Foundations, Principles, and Techniques, 2005
Designing a single system platform rather than as creating a multitude of products

• MBSE + Modular Design + Variation
  – Common language improves
    • Communication
    • Collaboration
    • Stakeholder buy in
  – Architected modular design & reuse
  – System product lines designed up front

• Maximum commonality & minimal variation
  – Less duplicated effort with optimized reuse
  – Parallel working through ‘design by contract’
  – More commonality between designs and implementations
  – Managed product line complexity

OMG Systems Modeling Language
+ Orthogonal Variability Modeling
Variability Approaches

- Model Variability using inheritance
- Model Variability using OVM
  - Orthogonal Variability Modeling
Modeling Systems of Systems
Model-Based Systems Engineering
Disaster Relief Challenge….Provide Ice:

• **Goals and Objectives:** For the challenge, show how today’s tools can be used and integrated together to support planning, analysis, decision making, communications, and documentation and reporting while minimizing duplication of effort, or data entry. Refer to the listing of Goals and Objectives posted on the TVC page for a full listing of all Goals and Objectives to consider including as part of your demonstration.

• **Challenge:** It is summer time in Sin City, a dessert city located in a hot, dry climate zone experiencing temperatures ranging between 70 – 100 degrees Fahrenheit (20-35 C). A recent natural disaster has devastated the area within a 100 mile radius. An estimated 15000 people lost power due to the destruction, and need to find shelter. Most roads are impassible to the public so there is limited vehicle transportation and the electricity is out in most of the disaster area. As part of emergency response requirements, shelters must be set up within 24 hours from when the evacuations begin to help sustain those who need to relocate. As part of the initial emergency response, ice must be provided to sustain perishables such as medicine and foods, and to support first aid needs. Power and potable water are to be provided with the shelter solution.
Operational Concept for Disaster Relief

OV-1a [Disaster Relief High Level Operational Concept] High Level Operational Concept [OV-1a]

Disaster Relief High Level Operational Concept

- Government
- Victim
- Disaster Management
- Health Care Organization
- Press Office
- National Media
- Member of Public
- Rescue Unit

Relationships:
- Government helps Victim
- Victim requests Disasters Management
- Disaster Management coordinates Health Care Organization
- Health Care Organization coordinates Disaster Management
- Disaster Management coordinates Press Office
- Press Office informs National Media
- National Media informs Member of Public
- Member of Public assists Rescue Unit
- Rescue Unit assists Disaster Management
Operational Concept for Disaster Relief Internals

OV-1a [High Level Operational Concept] Ice Provision High Level Operational Concept [OV-1a]

- Provides Ice
- Provides Water
- Provides Shelter

- Food Storage and Distribution
- Potable Water Supply
- Shelter Coordination
- Ice Provision

- Member of Public
- Support Services Coordinator

- Contacts
- Emergency Communications

- Coordinates
- Coordinates
- Coordinates

- Manages
- Informs

[Architectural Description] Enterprise [CV-1]

- Disaster Management
High Level View of the Enterprise

Phase 1
Project Setup

Phase 2
Assist Public

Provided Capabilities

[Architectural Description] Capabilities [CV-2]
Dictionary of Project Capabilities

CV-2 [Architectural Description] Capabilities [CV-2]

- Manage National Crises
  - Manage Terrorist Attacks
  - Manage Biological Outbreaks
  - Manage Environmental Incidents
  - Logistics
  - Communications
  - Medical
  - Security
  - Shelter
  - Food Provision
  - Temperate Storage
  - Cold Storage
  - Management
  - Provide Ice
Functional Decomposition of Capabilities

**CV-6 Manage National Crises - [CV-6]**

- «Capability» «block» Manage National Crises
  - «ActivityPartOfCapability» «activity» Manage Terrorist Attacks
  - «ActivityPartOfCapability» «activity» Manage Biological Outbreaks
  - «ActivityPartOfCapability» «activity» Manage Environmental Incidents

Manage National Crises - [OV-5a]
Functional Decomposition of Activities
Model-Based Product Line Engineering
Modeling Product Lines

Product Line Model
- Variability Model
- Base Model
  - MBSE
- Decision Set

Product Model
- Remaining (Unresolved) Variability Model
- Product Base Model
  - MBSE

Create Product Model
Variant Selector
Decision Set Editor
Evaluation of Architectures

- Disaster Variants
  - Environmental Variants
  - Disaster Type
    - Terrorist
      - Manage Terrorist Attacks
        - Performer: Explosive Containment
      - Architectural Description: Terrorist Response
    - Biological
      - Manage Biological Outbreaks
        - Performer: Outbreak Mitigation
      - Architectural Description: Biological Response
    - Environmental
      - Manage Environmental Incidents
        - Performer: Environment Response
      - Architectural Description: Environmental Response
Evaluation of Architectures
### Variability Disaster

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Evaluation of Architectures
Evaluation of Architectures

[Diagram showing various environmental variants and architectural descriptions related to disaster response context.]
Evaluation of Architectures

Nodes Deleted
Activities Deleted
Asset Based Modular Design
System Structure for Victim Support
System Structure for Victim Support
System Overview of an Ice Plant
System Overview of an Ice Plant
The History of Reuse


• ISO 26550 (December 2013)

• MBPLE (2014)

(Linda Northrop, SEI SSPL 2008-2012)
Model Asset Reuse

• The OMG Reusable Asset Specification (RAS)
  - Used for defining reusable assets, their interfaces, characteristics and supporting elements

• Three key dimensions describe reusable assets:
  - Granularity describes how many particular problems or solution alternatives a packaged asset addresses.
  - The visibility varies from black-box assets, whose internals cannot be seen and are not modifiable, to white box assets which are visible and modifiable.
  - The articulation describes the degree of completeness of the artifacts in providing the solution.

• Asset also include supporting documentation, requirements addressed, interfaces, etc.

• Provides a standards-based “model of models” approach instead of a “mega-model” approach.
Asset Reuse

Higher Level Models

Links via Assets

Lower Level Models
Asset Library View in other model
Distiller model complete system
Model-Based Product Line Engineering

- Integrated MBSE, Modular Design & Variability Modeling = Model-Based Product Line Engineering
Development Cost Reduction & Delivery Time Improvements

• SE (Non-Modelled Systems Engineering)
  – 59% of Projects Delivered on Time

• MBSE (Model Based Systems Engineering)
  – 62% of Projects Delivered on Time
  Compared to SE
  – 55% Reduction in Total Development Cost per Project

• MB-PLE (Model Based Product Line Engineering)
  – 75% of Projects Delivered on Time
  Compared to SE
  – 62% Reduction in Total Development Cost per Project

(EMF 2013 Independent Survey Results from 667 Systems engineering respondents)
These books are the foundation of the INCOSE Systems Product Line Engineering Handbook.
Questions and Answers

1. loop
1.1 Question
1.1.1 Answer
end loop

while open questions exist

{Speech Time}

You : Attendee
Me : Speaker

Question
Answer

Question
Answer
Questions and Answers

Thanks for your attention!

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