RT-176: Verification and Validation (V&V) of System Behavior Specifications

Sponsor: DASD(SE)

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www.sercuarc.org
Presentation Agenda

• Research Motivation & Objectives
• Technical Accomplishments
• Future Work
Motivation

- Model-based methods tools and approaches on their own do not guarantee success

- The model may adhere to notational specifications while the design itself may be incomplete, ambiguous, inefficient, or contain unwanted system behaviors

- This research developed methods and tools to steer and shape 
  *behavioral design*
  
  — to meet requirements (verification)
  — to meet expectations (validation)
Prevailing Problem:

- Incompleteness
  - Only a subset of possible behaviors are included with actors and interactions drawn on the same diagram

MP Value Proposition:

- Scope-completeness
  - Generates full set of possible event traces (use case extensions) exhaustively up to a user-defined limit on iterations

Source: https://www.uml-diagrams.org/google-sign-on.uml-activity-diagram-example.html
Prevailing Problem:
• Ambiguity
  — Behavior models that describe general activities but are unclear about who is doing each activity, or are otherwise unclear about activities performed

MP Value Proposition:
• Separation of concerns
  — Behaviors are separated by actor, and interactions between actors are separately layered on as constraints
  — Modeling in MP enables discussion and clarification of the behavior logic

Source: https://www.uml-diagrams.org/google-sign-on.uml-activity-diagram-example.html
**Prevailing Problem:**

- Inefficiency
  - When people continue to do work that an automated computing device could do faster and with fewer errors

**MP Value Proposition:**

- Efficient task allocation
  - Humans focus on using their experience, creativity, and pattern detection skills to inspect and evaluate, and use automated tools to compute, generate, and search

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**Motivation**

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**Behavior Rules**

- Actor 1
- Actor 2
- ... (Actor n)

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**Interaction Rules**

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**Scenario alternative variants**

1. 2. 3. 4. ... x
Prevailing Problem:

- Unwanted behaviors
  — Built systems that may meet requirements, but also permit extra undesired behaviors

MP Value Proposition:

- Behavior pruning
  — Enforces the necessary model structure for exposing and purging unwanted behaviors in the design before they emerge in the actual system

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Research Objectives

• Demonstrate use of the UAV behavior models for early V&V analysis of requirements
  — using MP to expose positive and negative system behaviors permitted by the design

• Formalize patterns of common design flaws or other model properties
  — Catalog of anti-patterns catalog
Presentation Agenda

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Organization of the Technical Report

Appendix A: List of Publications and Invited Talks

Appendix B: References Cited

Appendix C: Collaborator Courses that Integrate or Contribute Research Results

Appendix D: Monterey Phoenix Overview

Appendix E: Catalog of Reusable Architecture Patterns

Appendix F: Instructions for Downloading MP Models

Appendix G: Model Based V&V (MCSE MPT) Demonstration

https://sercuarc.org/project/?id=35&project=Verification+and+Validation+%28V+%26+V%29+of+System+Behavior+Specifications
Run button

https://firebird.nps.edu

Scope of execution

Trace window

Number of traces

All traces

Console window

Code window
Non-Combat Operations Scenario 1
Non-Combat Operations Scenario 1
Phase 3 Alternative Emergent Behaviors

Far left: Baseline scenario; vessel located and payload on target.

Middle left: Vessel located but payload missed target.

Middle right: AV needs to return before vessel is located.

Far right: Vessel not found but AV drops payload.

AV_Temp.mp, debugging model for Av7f_phase3.mp developed by D. Shifflett 8/21/2018
Requirements Discovery

• What should happen if the payload just misses the target (trace 3)?
  —Could the payload still be retrieved by target vessel? What would help?

• What should happen if the AV has to return before locating/reaching the vessel (trace 4)?
  —Could the payload be dropped at max range with a means for vessel retrieval?

• What should happen if the AV drops the payload prematurely, enroute to the vessel (trace 6)?
  —Though unintended by the modeler, does trace 6 contain an idea for handling out of range vessels or AVs experiencing a return to base condition?

All of these operational “what ifs” were exposed through MP modeling of the provided baseline scenario.
MP modeling of SysML behavior diagrams can help to expose requirements that may otherwise not be considered until later in the lifecycle.
## Architecture Model Anti-Patterns
(Examples in Four Languages)

<table>
<thead>
<tr>
<th>No.</th>
<th>DM2 / UPDM</th>
<th>UPIA</th>
<th>SDL</th>
<th>LML</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.1.1</td>
<td>Activities with no child and no parent</td>
<td>Operational tasks with no child and no parent</td>
<td>Functions with no child and no parent</td>
<td>Actions with no child and no parent</td>
</tr>
<tr>
<td>H.2.4</td>
<td>Requirements with more than one parent</td>
<td>Requirements with more than one parent</td>
<td>Requirements with more than one parent</td>
<td>Requirements with more than one parent</td>
</tr>
<tr>
<td>H.5.1</td>
<td>Performers having itself as a child</td>
<td>Capability roles having itself as a child</td>
<td>Components having itself as a child</td>
<td>Assets having itself as a child</td>
</tr>
<tr>
<td>FPA.1.1</td>
<td>Activities that are not performed by any performer</td>
<td>Operational tasks that are not performed by any capability role</td>
<td>Functions that are not performed by any component</td>
<td>Actions that are not performed by any asset</td>
</tr>
<tr>
<td>FL.3.1</td>
<td>Activities that do not produce or consume any resources</td>
<td>Operational tasks that do not produce or consume any information elements</td>
<td>Functions that do not produce or consume any items</td>
<td>Actions that do not generate or receive any input/outputs</td>
</tr>
<tr>
<td>PL.6.1</td>
<td>Performers that exchange some resource, but are not connected to any common connectors</td>
<td>Capability Roles that exchange some information element, but are not connected to any common links</td>
<td>Components that exchange some item, but are not connected to any common links</td>
<td>Assets that exchange some Input/output, but are not connected by any common conduits</td>
</tr>
<tr>
<td>T.2.1</td>
<td>Activities that do not trace to any requirement</td>
<td>Operational Tasks that do not trace to any requirement</td>
<td>Functions that are not based on any requirement</td>
<td>Actions that do not satisfy/verify/trace to any requirement</td>
</tr>
<tr>
<td>S.5.1</td>
<td>Performers that interact with each other through exchange of resources, but are not subject to a common standard</td>
<td>Capability roles that interact with each other through exchange of information elements, but are not specified by a common standard-labeled requirement</td>
<td>Components that interact with each other through exchange of items, but are not specified by a common standard-labeled requirement</td>
<td>Assets that interact with each other through exchange of input/outputs, but satisfy no common standardizing requirement</td>
</tr>
</tbody>
</table>

Technical report contains a total of 46 anti-patterns
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Future Work

• Further test the Monterey Phoenix approach on MBSE pilot projects
• Formalize the types and definitions of emergent behavior for use in risk analysis
• Train model developers how to verify and validate SysML models from other tools using MP
• Generate SysML sequence, activity, and state transition views from MP models
• Develop a graphical gateway to MP (enable code generation from diagrams)
RT-176 Interim Report and Models:  
https://sercuarc.org/project/?id=35&project=Verification+and+Validation%28V%26V%29+of+System+Behavior+Specifications  

Monterey Phoenix and Related Work:  
https://wiki.nps.edu/display/mp  
https://firebird.nps.edu  

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