Modeling Tool Support for SysML

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LieberLieber

- Austrian company
- 20+ engineers
- Influencing member of OMG
- Products and solutions for model-based software and systems development
- Preferred partner of SparxSystems Central Europe
Software is the glue for Industry 4.0!

- Digital/Model-Based Systems Engineering

- Interconnection of Different Systems
  - IT Systems
  - Production Systems
  - Sensors, Actuators
  - ...

- Handling of Variants and Variability
Systems Engineering Standards

- **OMG SysML**
  - Model-based specification of an Industry 4.0 production chain
  - Product state definitions

- **OMG Requirements Interchange Format (ReqIF)**
  - Universal data format for the exchange of development and production data

- **OMG Data Distribution Service (DDS)**
  - Cross-platform data communication

- **Feature Model-Based Variant Management**
  - Definition of product lines and specific product variants

- **OMG Query/View/Transformation (QVT)**
  - Model Transformation standard – including a graphical syntax
Industry 4.0 – Our Vision

Production Model (Structure & Behavior)

Primary Producer

Industry 4.0 Systems Engineer

SysML

ReqIF

DDS

Suppliers

Customer

Variant definition

Product

Final Producer
What is SysML?

- SysML stands for *Systems Modeling Language* and is a standardized graphical language for definition and description of technical systems of all kind.

- SysML is based on the software modeling language UML (Unified Modeling Language) and reuses many things of it, but also extends them in several parts.

- With SysML:
  - the structures (the architecture)
  - the behavior
  - the requirements

  of a system can be described and related to each other in a formal way.
SysML Diagram Types

Structural Diagrams
- Package Diagram
- Block definition diagram
- Internal block diagram
- Parametric diagram

Behavior diagrams
- Use case diagram
- Activity diagram
- State diagram
- Sequence diagram

Other diagrams
- Requirement diagram
SysML tool support

- SysML is defined as an UML-Extension (Profile)

- Supported by Sparx Enterprise Architect

- ...but
  - Weak modeling assistance
  - No validation rules
Lieber Systems Engineer

- Modeling Assistance for Systems Engineering
- Support for Functional Safety Aspects
- Extensions to differentiate Hardware and Software Components
- Support for Control Chain Architecture Methodology
- Model Validation
Modeling Industry 4.0 with SysML

Production Chain

Behavior
### Model Validation Results

<table>
<thead>
<tr>
<th>Rule ID</th>
<th>Rule Name</th>
<th>Checked Elements</th>
<th>Wrong Elements</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>SystemsEng...</td>
<td>Two connected ports must have identical property types.</td>
<td>32</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>A SysML port must be connected to another SysML port.</td>
<td>49</td>
<td>5</td>
<td>98.9%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>The direction for flow ports must be set in the tagged value direction.</td>
<td>49</td>
<td>20</td>
<td>59.18%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Two ports have the same classifier or a port has name and classifier of the opposite port sub-type</td>
<td>49</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Two SysML-Ports are connected by using a connector with Stereotype «timFlow».</td>
<td>49</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>All Port elements have at least one «satisfy» dependency connection to a Requirement element.</td>
<td>49</td>
<td>49</td>
<td>0%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Every port must have a specified property type.</td>
<td>49</td>
<td>3</td>
<td>93.33%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Every SysML-Port needs the stereotype «flowPort» (SysML 1.2) or «FlowPort» (SysML 1.3)</td>
<td>49</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>All Property/Port and Port elements must have at least one «satisfy» dependency connection to a...</td>
<td>19</td>
<td>19</td>
<td>0%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>No empty description for elements of type Port/Property and Port.</td>
<td>68</td>
<td>68</td>
<td>0%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Diagrams (except the component allocation view) can only use elements defined in the actual abs...</td>
<td>9</td>
<td>2</td>
<td>77.78%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Only Diagrams are allowed in «view» packages.</td>
<td>6</td>
<td>1</td>
<td>83.33%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Every requirement element must have at least one «satisfy» connection to a property/part or port...</td>
<td>5</td>
<td>1</td>
<td>80%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Allowed connections between elements are «timFlow», «satisfy», «derivaReq», «referenceOf»,...</td>
<td>105</td>
<td>1</td>
<td>99.05%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>Ports that are connected with a «referenceOf» Dependency must have the same name, type and...</td>
<td>8</td>
<td>3</td>
<td>68.75%</td>
</tr>
<tr>
<td>SystemsEng...</td>
<td>No empty names for model elements.</td>
<td>95</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Autosar-6</td>
<td>No Parameter Port on an AUTOSAR Application component is allowed.</td>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Autosar-3</td>
<td>The tag Category must be set on all «AUTOSAR Data Type» elements.</td>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Autosar-2</td>
<td>Every element must have a description.</td>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Autosar-1</td>
<td>A element name must not contain space characters.</td>
<td>0</td>
<td>0</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Model Quality Metric:** 72.86%
Conclusion and Outlook (1/2)

- LieberLieber provides improved modeling support for SysML

- SysML is useful for Industry 4.0 production chain definitions (structure and behavior)

- From SysML models code or other data (e.g. AutomationML) can be generated to drive Industry 4.0 realizations
Conclusion and Outlook (2/2)

- We collaborate with **Christian Doppler Laboratory** to realize model transformation tools based on the **OMG QVT** standard for graphical transformation rules and Enterprise Architect

http://www.sysml4industry.org