Model-based Manufacturing Engineering System SysML to Simulation Analysis Model

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ABSTRACT

The objective of this project is to enable the construction of manufacturing system simulation models using model based engineering principles. This capability will result in:
- Better and more reliable sharing of system specifications between stakeholders.
- Faster, better, cheaper integration and use of analysis tools.

SysML – Systems Modeling Language
Profiling Mechanism to create a Domain Specific Language (DSL)

ATL – A Model Transformation Language

Arena Simulation Model for Analysis
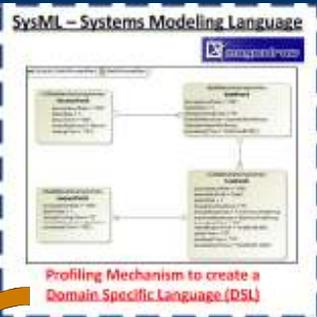
**DSL + Model Transformation = 10x reduction in simulation development time and effort**

This project is currently implemented for Rockwell Collins electronic assembly system.

Solution Approach

The essence of our approach involves the following steps:

1. Using SysML, we create a "domain specific language", or DSL, for modeling the electronics systems assembly processes used by Rockwell Collins (RC); this DSL provides the syntax and semantics for describing a bill of materials (BOM), the resources used in the manufacturing process, and the process plan for each part in the BOM.

2. Using a model transformation language (ATL in the ECLIPSE domain), we develop a script that will parse an instance model developed using the DSL, and create an Microsoft Access™ database containing the corresponding Arena simulation model.

3. The model is read by Arena from the Access database, and executed.

Methodology
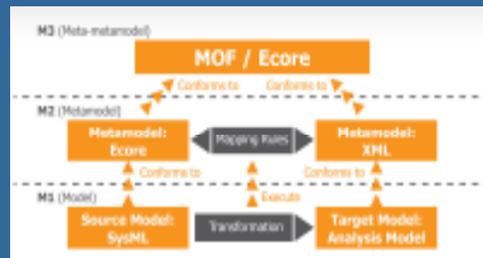
SysML has been developed in the context of OMG's -layered meta-modeling architecture, called the Meta-Object Facility (MOF), The three layers of models/abstractions in this application are:

- M1 - user models.
- M2 - meta-models, and
- M3 - meta-meta-models.

where M1 is the least abstract and M3 is the most.

Domain Specific Language
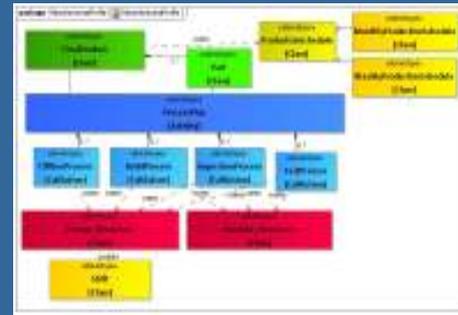
Using the *Profiling Mechanism* in SysML, a domain specific language is articulated using stereotypes. Each stereotype can have multiple attributes.

Model-based Manufacturing System

Bill of Material (BOM)

Block Definition Diagrams (bdd) are used to represent the bill of material in the manufacturing assembly system.
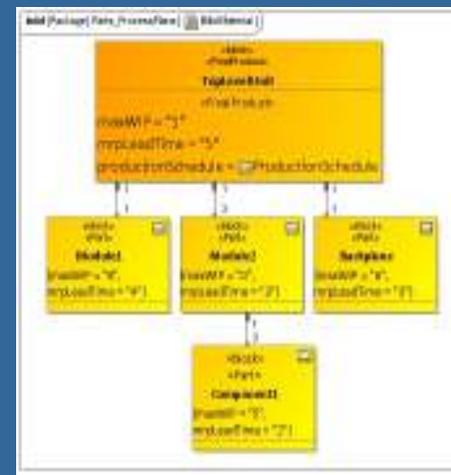
Components and sub-components relationships are depicted here using composition relationships with multiplicity to show the number of sub-components needed in the next component.

Process Plans

Activity Diagrams (act) are used to represent the process plans for each part in the BOM.
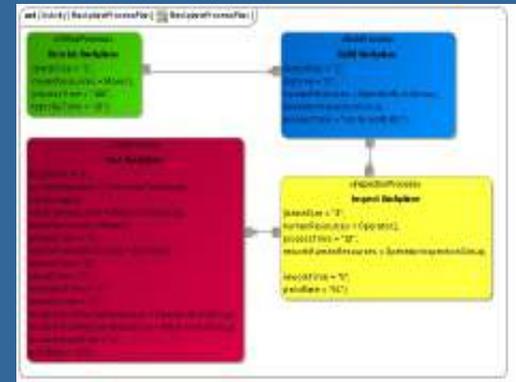
This example shows a process plan for one of the manufacturing parts which consists of four manufacturing activities.

Transformation

Atlas transformation language (ATL) is employed to construct a transformation script that will automatically translate the SysML model into an analysis model in Arena®.

Potential Benefits

Potential benefits are attained in:
- Order of magnitude reduction in the time, cost and effort required to develop manufacturing system simulations.
- Formal specification of manufacturing systems in SysML that supports early feedback to product and manufacturing systems designs.

Other opportunities:
- This approach can be extended to other domains, such as supply chains, humanitarian logistics systems, and health care systems, by defining an appropriate DSL and transformation
- This approach can be extended to other analysis tools as well, such as optimization, queuing networks, financial models, etc.