“D.6.5.6 - New version of the System Dynamics tool”

“WP 6.5: Cloud computing service for simulation based project management”

“WP6 - Modelling and simulation services”

MODRIO (11004)

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Executive summary

System dynamics is a mathematical modelling technique for understanding how complex systems, such as socio-economic, financial, and climatic, behave over time. System dynamics models are structured from elementary units and relations between them. The causal loops formed in the model structure typically induce the principal behavioural properties of the model.

In the WP6 of the Modrio project, the Simantics System Dynamics modelling and simulation tool is developed, in order to support business cases in WP8. This document presents the new features added to Simantics System Dynamics (e.g., XMILE support) since the previous milestone.

Summary

1. Introduction

System dynamics is a methodology to understand the behaviour of dynamic complex systems of different domains based on modelling and simulation. The modelled systems can be, e.g., socio-economic, financial, climatic, or physical, just to name a few. System dynamics models consist of only a few basic types of variables which are used to construct stock and flow diagrams with feedback loops and delays.

As the deliverable D6.5.6, a new version of the Simantics and OpenModelica based system dynamics tool, Simantics System Dynamics [1], is developed. The tool development is directed to support business cases in WP8. The version update includes not only support for a new open model interchange format, but also several internal improvements and critical bug fixes.

The tool is used in the Modrio project (WP 8.9) to develop an interactive game based on a complex workforce management model. The tool also has a small but steadily growing international user base (based on the activity in the support forum [2]).

The software is open source under EPL (Eclipse Public License [3]), and it can be downloaded at the tool homepage [1] or the Simulation Store [4]. Online documentation for the tool is available under the Simantics wiki [5], and several tutorial videos and screen captures are provided in the home page [1].

2. XMILE support

The main new feature in this version of Simantics System Dynamics is support for the XMILE model interchange format. This chapter provides a brief description of the XMILE file format and the extent to which it is currently supported. Full report of the implementation work is provided as attachment [a], and will be made publicly as a part of the tool documentation at a later date.

2.1. XMILE file format

XMILE is an XML-based file format designed to facilitate system dynamics model interchange between different tool vendors. An XMILE document provides a complete description of a system dynamics model that includes basically everything from the model contents (e.g. stocks, flows) to what the model looks like (diagram representation of the model) and how it is operated (interface controls, macros, special parameters). However, in order to provide support for this file format, a tool vendor only has to implement support for a small subset of these features (basically model structure and simulation parameters). The more advanced features are optional and can be toggled on and off in the document header. A simple example of an XMILE document is provided below.

```
<?xml version="1.0" encoding="utf -8">
<xmile version="1.0" xmlns=" http://docs.oasis-open.org/xmile/ns/XMILE/v1.0">
  <header>
    <vendor>Simantics </vendor>
    <product version="1.9.0">System Dynamics</product>
  </header>
<model>
  <variables>
    <stock name="material">
      <eqn>1000</eqn>
      <outflow material_draining</outflow>
    </stock>
    <flow name="material_draining">
      <eqn>material / draining_time</eqn>
    </flow >
    <aux name="draining_time">
      <eqn>10</eqn>
    </aux>
    </variables>
  </model >
</xmile>
```

2.2. Support in Simantics System Dynamics

The current version of Simantics System Dynamics is able to import and export models in the XMILE file format. Most of the basic functionality required by the specification, and several more advanced features are supported. More specifically, Simantics System Dynamics meets the base level conformance defined in the specification apart from support for model behaviours and models split into multiple files. Some features that are technically supported also have some specific limitations. One such feature is the library of mathematical functions required by XMILE, which is not completely implemented because some of the functions in the library have side-effects that are problematic to support in the Modelica-based Simantics System Dynamics. We also have not implemented a translator between general Modelica-code (which the user of Simantics System Dynamics is able to write) and the macro language defined in the XMILE specification. In practice this means that XMILE import and export work completely automatically only for models that rely entirely on the library of functions defined in the XMILE specification, and even then if the more esoteric functions are not used. It should still be noted that with manual work, the user is able to fix any issues created by the automatic import and export functionalities. More detailed descriptions of these (and other unmentioned) issues is again provided in appendix [a].

Even though the XMILE support is currently limited, it works in practice for virtually every publicly available XMILE 1.0 model. When the specification is eventually more widely adopted and more models become available, our support will also be improved.

3. Other new features

This chapter provides a brief overview on the other recent improvements in Simantics System Dynamics.

3.1. Internal solver and other improvements

The internal solver introduced in the previous release has seen some significant improvements. The library of mathematical functions it supports is significantly expanded; it now contains basically everything found in java.lang.Math, as well as random number generation with several different distributions. Vector-matrix operations and if-then-else have also been fixed, which means that all our example models can finally be simulated with the internal solver as well as recent versions of OpenModelica.

In addition to the internal solver, there have also been other more general bux fixes and improvements to make the tool more stable and easy to use. The API that provides integration with Simupedia [6] (used to create web-interfaces for models) has also seen some updates.

3.2. New deployments

We also updated our build process to produce different packages of the tool to better meet the varying needs of different users. There are now 8 different builds with 3 varying aspects, which are machine architecture (32- or 64-bit) and the inclusion or exclusion of Java Runtime Environment and OpenModelica. These changes reduce the package size significantly, which helps people with data caps or slow internet connections, and it also allows more advanced users to choose which version of OpenModelica and Java Runtime Environment they want to install and use. It should be noted that because the most basic version of the tool does not include OpenModelica, some more advanced operations, such as playback experiments and sensitivity analysis, are not available unless the user installs it separately.

4. References

[1] Simantics System Dynamics home page, online: http://sysdyn.simantics.org

[2] Simantics System Dynamics forum, online: https://www.simantics.org/sysdyn-forum

[3] Eclipse Public License, online: https://www.eclipse.org/legal/epl-v10.html

[4] Simulation Store, online: https://www.simulationstore.com/sysdyn

[5] Simantics System Dynamics documentation, online: https://www.simantics.org/end_user_wiki/index.php/Simantics_System_Dynamics

[6] Simupedia, online: http://www.simupedia.com/

5. Attachments

[a] XMILE support in Simantics System Dynamics.pdf