Reuse of Physical System Models by means of Semantic Knowledge Representation: A Case Study applied to Modelica

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Abstract

The emerged knowledge from a system's study shall be persistent and shared to increase the possibilities of improvement and apply it to other similar systems or situations. It is possible to design models that show the real conditions of the represented system by describing it conceptually, in a universal and normalized language that any domain expert could understand.

This paper presents the design and development of a solution to store and reuse physical system models (PSM) by indexing and retrieving their content and metadata. To do so, a mapping between the representation modelling language, Modelica, and a semantic-based representation schema, Relationship-RSHP, is defined as Modelica2RSHP (M2R). The use of Modelica, as a highly used language within the industry domain for modelling physical systems and the RSHP schema and used for years in systems engineering for knowledge management, enhances the strategy to map Modelica physical system models to RSHP as a direct link to perform simple transformations and to provide the basis to define and compare complex transformations. More specifically, the goal of the M2R approach is to establish the needed interconnection between the PSM domain and the knowledge field, by importing PSM, as electrical circuits designed under Modelica language into system repositories where their semantic information is kept for their persistency.

In order to design the interconnection between Modelica language and RSHP model, there have been specified the regular tree grammars that can be used for a transformation between both Modelica and RSHP grammars. The M2R has been implemented using the .NET framework. For that, it was required to build the Java JModelica sources to parse Modelica v3.2 and to extract the Java libraries dependencies to generate a script that transform the required Java libraries into .NET DLLs interpreted in .NET through the IKVM, an implementation of Java interpreter for .NET framework.

The M2R tool is also designed to be added in the knowledge management tool knowledgeMANAGER (kM), which supports the RSHP model to represent the information. The use of kM makes it possible to index and retrieve physical systems models, enabling the possibility to find similar PSM to a given query, with the capability to retrieve the model information and the similarity percentage with the query.

To prove the capabilities of M2R, a case study has been conducted to compare text vs. concept based information retrieval processes. A dataset of 25 electrical circuits and a set of 30 queries have been designed to extract precision and recall metrics assessing that the presented approach improves the retrieval of Modelica artifacts.

The results of the study show that by using M2R, a Modelica designed model could be reused by the proper mechanisms to represent the elements and relationships within the electrical circuit, to store such elements into a repository, to define a retrieval algorithm that would allow the identification of PSM by content and to retrieve the model according to different queries. For instance, a user should be able to express the next query based on natural language text: *Electrical circuits that contain a sine voltage source directly connected to an operational amplifier by a 20kΩ resistor*. In current Modelica environments, those tasks are hard to accomplish since they were not designed for these purposes. Advanced regular expressions could be a solution, but an approach taking advantage of describing elements and relationships can really improve the retrieval of Modelica artifacts, enhancing the reusability factor of existing PSM.

The main conclusion is that it is possible to state that a domain specific technology such as RSHP for knowledge representation can help the management of physical system artifacts, modelled in Modelica language, as knowledge assets. This gives the possibility to share and reuse physical system models by selecting a collection of them, from a wide physical system type's application as Modelica allows, in a standard format of representation, enhancing a methodology to reuse PSM, traceability actions or quality analysis of the models.

Keywords: Information Representation, Physical System Models, Modelica Language, Model Reuse, Knowledge Reuse