Bond Graph Modeling In Simscape

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***Abstract*—**Modeling is a complex process realized through several levels of abstraction. Since each level has its own ontological primitives, a problem of model transformation from one level to another appears. In order to decrease discontinuities in a development process, this paper discusses a bond graph model library implemented in Simscape. Simscape is a software tool intended for modeling and simulation of physical systems in Simulink environment. Thanks to this library, it is possible to use physical network and bond graph approach in modeling, within the same model, on two different levels. In other words, for both structure and behavior description a unique notation is used. Besides the library of basic bond graph elements, an example of a model of a component used as interface between a bond graph and other Simscape domains is also given.

Application of Simscape bond graph library is illustrated through an example of a hydraulic system model. The model combines standard Simscape and bond graph blocks.

***Keywords*—**Bond graphs, Simscape, Object oriented modeling, Hydraulic system

I. Introduction

EVEN besides the adopted methodology, modeling is a creative process that is difficult to formalize. A lot of things depend on knowledge, experience and intuition of a modeler. Methodology provides a set of concepts, ontological primitives, which help in model description but don't say how a model is formed. Recommendations from experience, modeling heuristics on how to conduct a modeling process are usually given, however no general rule exists.

At the beginning of model forming, even informally, we need to adopt a conceptual framework in order to move easily through modeling space. Modeling is usually structured through three levels of abstraction (Fig. 1) [1], [2] where each level represents a different point of view of a system.

The modeling process is usually stared at the technical components level (TCL model). Subsystems/components and their mutual relations are identified in the system. For graphical representation of subsystems/components, more or less standard symbols that indicate their function are used.

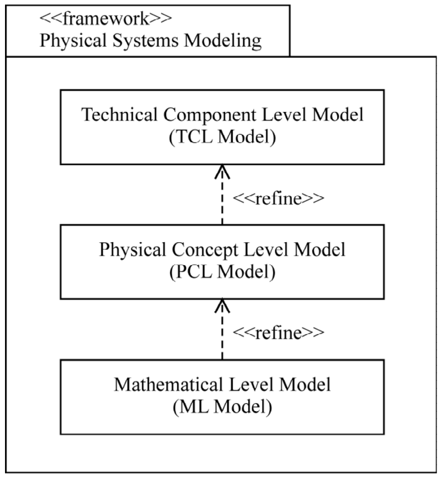

Fig. 1 Physical Systems Modeling Framework

Relations between the model elements are drawn following real relations that exist between the system components. This is how network representation of systems that describes system structure (function) is reached. Each nod from such network can be a component or a subsystem that can further be decomposed. A typical example of such a model is any hydraulic system diagram. The final model from this phase is defined by interface, as for the whole system so for each component individually, which should be realized by the models on next levels.

After completed structural decomposition, we move to describing behavior of the system, i.e. to physical concept level (PCL). Depending on purpose of the model and desired exactness, each component is attached by relevant physical processes and their mutual relations. In other words, we qualitatively describe behavior of the system. The process is not straightforward because different physical concepts can be attached to single component. The idea is to describe the system with physical terms (inertia, friction, leakage, resistance, capacitance, inductance, etc.), which are much closer to a domain expert, and to put the mathematical side of the problem into background. Here, we must take care about a contract that a component, through its interface, overtook in the previous modeling phase. This is the most important phase in modeling because it requires not only good knowledge of the system, but also ability and experience in deciding which processes to include in the model and which to leave out. For a

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