Chapter 6
A Meta-Model Based Approach to the Definition of the Analysis Results of Petri Net Models

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ABSTRACT

Multi-formalism modeling techniques enable the modeling and analysis of different aspects of a system. One of the main issues in the integration of multiple tools to support multi-formalisms is how to provide a common method to report the results of the analysis and how to interchange them between models, based on different formalisms, that often represent the system behavior at different granularity levels. In this chapter, the authors focus on the Petri Net formalism, and they present a preliminary work toward the definition of a common XML-based language for the specification of the results obtained from the analysis of Petri net models. The authors use a meta-model based approach, where first a structured set of meta-models representing the Petri net result concepts and their relationships are defined. Then, model transformation rules enable the mapping of meta-models to XML constructs.

INTRODUCTION

Multi-formalism modeling and solution techniques enable the modeling and analysis of different aspects of a complex system. Two main approaches have been followed for the design and implementation of modeling tools supporting such techniques. One approach consists in building an integrated modeling framework from scratch, that accommodates multiple modeling formalisms, multiple ways to combine models expressed in different formalisms and multiple solution methods (e.g., Sanders et al., 2003; Gribaudo et al., 2006; Vittorini et al., 2004; Barbierato et al., 2011; Iacono et al., 2012). The other approach is based on the integration of multiple tools, each one supporting a single modeling formalism and a set of solution techniques, in a common software environment. For example, in the Software Performance Engineering field (e.g., Smith &Williams, 2002; and many years of activities in the main workshops and conferences in the field, such as

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WOSP, ICPE, SIGMETRICS or SIGSOFT), most of the works that propose model-2-model (M2M) transformations from semi-formal specifications (e.g., UML, AADL) to performance/dependability formal models (Balsamo et al., 2004; Bernardi et al., 2012b) follow this second approach to provide a tool support for the application of their methods.

The multiple tool integration implies several issues to be tackled; in particular, concerning the results obtained from the model analysis, how to provide a common method for reporting them and how to enable tool interoperability such that the results obtained using one tool can be used as input parameters in another tool.

A common language to express the analysis results can be a solution to the aforementioned issues. In this paper, we focus on the Petri net formalism and we present a preliminary work toward the definition of a common XML-based language for the specification of the results obtained from the analysis of Petri net models.

Although the focus is on a single formalism, it should be observed that different *dialects* of Petri net exists, in the literature, which share common base concepts of the formalism as well as analysis techniques.

Moreover, some Petri net analysis techniques produce results that actually are models expressed in lower-level formalisms (e.g., state space-based techniques developed for Stochastic Petri Net boil down to the generation of Continuous Time Markov Chains). Then a language that supports the specification of such results also support the specification of such lower-level formalisms.

We follow the meta-model based approach described in (Hillah et al., 2009), where reference meta-models for untimed Petri Nets (PN) are defined first, then, using model-to-text transformation rules, the former are mapped to XML constructs (i.e., elements, attributes) which define the syntax of the ISO/IEC standard Petri Net Markup Language (PNML) (ISO/IEC15909-1, 2004; ISO/IEC15909-2, 2011).

As sketched in Figure 1, the *PNResults meta-models*, proposed in this paper, are related to the standard PN meta-models, since some PN concepts represented in the latter are refined in the former. In turn, the proposed XML language obtained by applying the transformation rules, namely *PNRESML*, enables to relate PNRESML documents - that specify the results from the analysis of a concrete Petri Net model -to the PNML documents describing the Petri net models used for the analysis.

The paper is organized as follows. The next Section introduces the meta-model based approach used to define PNML. The third Section describes the structured set of meta-models that represent the results of the analysis of a Petri net model and the mapping of the meta-models to PNRESML is presented. Finally, in the fourth and fifth Sections we discuss future work and draw conclusions.

BACKGROUND

The basic concepts of the Petri net formalism have been defined in (ISO/IEC15909-1, 2004) with meta-models, in terms of UML class diagrams. Figure 2 provides an overview of the Petri net meta-model packages and their *merge* relationships. Currently the standard covers untimed Petri nets, in particular Place/Transition nets (*PT-Net*), symmetric nets and high-level Petri nets (*HLPNG*).

Figure 3 shows the *PNML Core* and *PT-Net* meta-models, the part related to the graphical representation of a Petri Net has been omitted

Figure 1. Meta-model based approach