Chapter 14
Model–Based System Design Using SysML:
The Role of the Evaluation Diagram

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ABSTRACT

Model-based system design is served by a single, multi-layered model supporting all design activities, in different levels of detail. SysML is a modeling language, endorsed by OMG, for system engineering, which aims at defining such models for system design. It provides discrete diagrams to describe system structure and components, to explore allocation policies crucial for system design, and to identify design requirements. In this chapter, SysML is used for the model-based design of enterprise information system architecture, supporting a systemic view of such systems, where software and hardware entities are treated as system components composed to create the system architecture. SysML extensions to facilitate the effective description of non-functional requirements, especially quantitative ones, and their verification are presented. The integration of evaluation parameters and results into a discrete SysML diagram enhances the requirement verification process, while the visualization of evaluation data helps system engineers to explore design decisions and properly adjust system design. Based on the proposed extensions, a SysML profile is developed. The experience obtained when applying the profile for renovating the architecture of a large-scale enterprise information system is also briefly discussed to explore the potential of the proposed extensions.

INTRODUCTION

Model-based engineering (MBE) is about elevating models to a central and governing role in the engineering process for the specification, design, integration, validation, and operation of a system (Estefan, 2008). Model-based system design is supported by a number of methodologies (Estefan, 2008; Balmelli et al., 2006) and is effectively accommodated by Systems Modeling Language (SysML) (SysML, 2010). SysML, endorsed by OMG and INCOSE, facilitates the description of a broad range of systems and systems-of-systems in a hierarchical fashion, while it is fully supported by most UML modeling tools. It enables the description of allocation policies and provides a discrete diagram for requirements specification. To describe specific system domains, a SysML profile should be specified, using standard UML extension mechanisms, as stereotypes and constraints (OMG, 2007a).

Model-based design of information systems is explored by methodologies such as the ones presented in Nolan et al. (2008), ISO (2009), Izukura et al. (2011), and Nikolaidou et al. (2009). UML and recently SysML are adopted in all of them as the system modeling language. As indicated in most of them, when building large-scale information systems, software engineering is usually focused, while the combination of software and hardware and the way it might affect overall system performance is often neglected. Software architecture design decisions are influenced by network infrastructure design, while non-functional requirements, as performance requirements, can usually be satisfied by effective allocation of software components to hardware. In practice, both software and network infrastructure architecture should be designed in parallel to efficiently explore their interrelations and ensure non-functional requirement satisfaction.

In the following, a systemic view of enterprise information system (EIS) architecture design is explored, utilizing SysML as the system modeling language. Such an approach treats both software and hardware entities as system components interacting to achieve the desired functionality under specific performance and availability conditions.

SysML requirement diagram and corresponding entities should be severely extended to effectively support the description of non-functional design requirements, especially the quantitative ones, such as performance. Furthermore, their verification must be performed using quantitative methods, for example, simulation. While there is a wide number of efforts to simulate SysML models using external simulators, such as the ones described in Paredis et al. (2010), McGinnis & Ustun (2009), and Wang & Dagli (2008), one should consider the integration of evaluation results into SysML system models to enhance the verification of non-functional requirements by the system designer and the exploration of alternative design solutions.

To enable the analytical description and verification of non-functional requirements and the validation of related system design decisions, we propose to include a discrete diagram, called evaluation diagram, to serve system evaluation activity and manage evaluation results and requirement verification. Proposed architecture scenarios are evaluated (Kacem et al., 2006), as discrete evaluation scenarios are included in the evaluation diagram, and related design decisions may be properly adjusted by the system designer. Using the proposed extensions, a SysML profile for EIS architecture design was implemented as a plugin to the MagicDraw modeling tool (NoMagic, 2013) focusing performance requirement description and verification.

To explain the proposed concepts and discuss the benefits of applying them in model-based system design, a case study on renovating the architecture of a large-scale enterprise information system is also briefly presented as an example. Experience obtained may be applied in other domains as well.

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