Quantitative Analysis of Service-Oriented Architectures

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ABSTRACT

In this article we address the integration of functional models with non-functional models in the context of service-oriented enterprise architecture. Starting from the observation that current approaches to model-driven development have a strong focus on functionality, we argue the necessity of including non-functional aspects as early as possible in the service design process. We distinguish two modelling spaces, the design space and the analysis space, which can be integrated by means of model transformations. Quantitative results obtained in the analysis space, using special-purpose analysis techniques, can be related back to the design models by means of a reverse transformation. This provides a framework for incorporating non-functional analysis into methodological support for e-service development. While, for detailed design models, performance analysis is more or less covered by existing techniques, there is still a gap at the architectural overview level. Therefore, we propose an approach for performance analysis of layered, service-oriented architecture models, which consists of two phases: a “top-down” propagation of workload parameters, and a “bottom-up” propagation of performance or cost measures. By means of an example, we demonstrate the application of the approach and show that a seamless integration with detailed performance analysis methods (e.g., queueing analysis) can be achieved.

Keywords: enterprise architecture; model-driven architecture; performance analysis; service-oriented architecture

INTRODUCTION

Current approaches to model-driven development of applications and services, including OMG’s model driven architecture (MDA), have a strong focus on functional properties. Non-functional aspects, such as security, cost, and quality of service (e.g., performance and reliability), are often added as an afterthought. A drawback of this approach is that, once a design has been produced, performance problems can seldom be fixed by adding functions and generally the solution lies in redesign. Therefore, it is particularly important here that problems are detected early in the design cycle and become an integral part of the design process. This is where the main value of model-driven (non-functional) analysis lies, which, as we will argue, starts at the level of global architectural (computation-independent) models and propagates through all MDA model layers to detailed system specifica-
Architectures describe components, their relations, and underlying design principles of a system (IEEE, 2000). Constructing architectures may help to, among others, increase the insight and overview required to successfully align the business and ICT. Architectural descriptions may be used to relate detailed design models to each other (of applications and services, but also of, e.g., business processes or the technical infrastructure). The combination of design models, together with the relations specified by the architectural description, prescribes the realisation of a system.

While existing techniques for performance analysis mainly address quantitative properties of detailed design models, the quantitative aspects of architectural models have hardly received any attention in literature. Nevertheless, quantitative properties are also important at this architectural level. In the first place, because the quantitative properties of the detailed designs influence each other: for example, business processes impose performance requirements on the applications and technical infrastructure, while the performance characteristics of systems influence the quantitative behaviour of business processes. Moreover, the availability of global performance and cost estimates in the early architectural design stage can provide invaluable support for system design decisions and prevent the need for expensive redesigns at later stages.

Based on the above observations, we present in this paper our view on how models of functional and non-functional aspects, as well as the analysis of these models, can be considered in an integrated way, through all the MDA layers of models. We show the role of architectural models and how model transformations can be used to link the different types of design and analysis models. In this context, we propose an approach for the quantification and performance analysis of architectural models. This approach is based on the propagation of quantitative input parameters and of calculated performance measures through a layered, service-oriented architectural model. It complements existing detailed performance analysis techniques (e.g., queueing analysis) which can be ‘plugged in’ to provide the performance results for the model elements.

Through an example, we also show how the analysis of non-functional aspects (in particular performance) influences the design process, thus corroborating the common claim that non-functional aspects should be integrated in the development process in an early stage.

The remainder of this paper is organised as follows. In the second section, we put forward our view on the role of model transformations, analysis and integration in the context of MDA, which form the background of our research. The third section summarises the ArchiMate language, which is used to express models at the architectural level. The fourth section presents a short review of related work in two areas related to the topics that we discuss: performance analysis of architectural models and design model to analysis model transformations. In the fifth section, we present our approach for performance analysis of architectural models, which is illustrated by means of an example. Finally, in the sixth section, we draw our conclusions and give some pointers to future work.

Model Transformations, Analysis and Integration

In this section we present our view on model integration, with a focus on the specification and analysis of non-functional aspects, and the role that model transformations play in this. Similar to Skene & Emmerich (2003a, 2003b), we distinguish between models in a design space and in an analysis space, and define transformations between these spaces. However, we explicitly include the whole MDA stack, as well as the integration of heterogeneous design models by means of an integration model at the architectural level. Before we explain our two central ideas — the role of model transformations and analysis and model integration — in more detail, we first summarise the MDA philosophy.
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