IEEE International Conference on Mechatronics (ICM2019), Ilmenau, Germany, March 2019

Integrated Automotive Requirements Engineering With a SysML-Based Domain-Specific Language

Ralph Maschotta, Alexander Wichmann, Armin Zimmermann
Systems and Software Engineering, Technische Universität Ilmenau
Ilmenau, Germany
ralph.maschotta / alexander.wichmann / armin.zimmermann@tu-ilmenau.de

Kristina Gruber
BMW Group
Munich, Germany
kristina.gruber@bmw.de

***Abstract*—The rising overall complexity of modern cars as a special case of mechatronic systems leads to an increasing number of functions implemented by electric and electronic (E/E-) systems. Well-known design problems of complex modular systems arise out of this. To achieve high-quality standards along the whole product life cycle, modern systems and software engineering methods and techniques are necessary. Model-based approaches are widely used in the automotive domain, based on different types of models used in development phases at different abstraction levels. The Unified Modeling Language and the Systems Modeling Language are general-propose modeling languages that are widely used in the automotive domain. However, there are several domain-specific languages that support the automotive domain more specifically. A domain-specific SysML profile for functional and nonfunctional requirements in automotive technical systems has been proposed in our previous work. This paper describes our model-driven approach to specify domain-specific languages and corresponding domain-specific tools. The specifications are based on UML extensions using profiles only, which is a lightweight approach compared to other proposals. This allows the reuse and extension of existing UML or SysML models. A domain-specific graphical editor is presented in this paper based on the specified extensions. The resulting graphical editor is used to model an automotive technical system as an example.**

***Index Terms*—Automotive system design, integrated mechatronic design, model analysis, model queries, UML, SysML, validation, model-driven engineering, Eclipse Sirius**

I. Introduction

The overall complexity of modern cars is significantly increased over the last decades and will continue to do so in the foreseeable future. Thus, the number of functions implemented by electric and electronic (E/E-) systems is increasing as well, which leads to well-known design problems in complex modular systems. To achieve high-quality standards and fulfill required standards like functional safety [1] along the whole product life cycle, methods and techniques from concepts like Automotive SPICE [2] are beneficial. Systems and software engineering processes include systems and software requirements analysis and -design, where different requirements and model elements have to be defined. Automotive SPICE defines concepts such as bidirectional traceability, steps to ensure consistency, and building relations between different engineering artifacts like relations between requirement and elements of the system. Model-driven systems engineering approaches are used for their implementation.

Various types of models are used in automotive development phases at different abstraction levels [3], [4]. The industrial standard Unified Modeling Language (UML) [5] originally introduced for software is a general-propose modeling language that is widely used now. The meta-model of the UML can be extended (heavyweight extension), or a profile can be created (lightweight extension) to enable the UML-based approach for the automotive system design. The Systems Modeling Language (SysML) [6] is a general-purpose modeling language for systems engineering to support the specification of several aspects of complex systems and is an example of a UML profile. It is designed to be used with a wide range of system applications. However, the current state of the language does not cover all aspects of representation, description, and manipulation of requirements for automotive systems in the area of integrated car development. One of the common problems in complex systems engineering is characteristic in automotive companies with separate designer groups being responsible for E/E elements, mechanical design, and functional or safety aspects. This leads to conflicts and unforeseen reiterations in the design, as the effect of decisions in one group may influence other parts without being noticed.

Another widespread approach to building models for the automotive domain is the specification of custom domain-specific language using special metamodeling languages like Eclipse Ecore [7], [8]. Depending on the involved engineering disciplines (e.g. hardware-, mechanical, or software engineering), different domain-specific models are used, which can be defined in various ways [9]–[14].

A domain-specific SysML profile for functional and non-functional requirements in automotive technical systems has been proposed in our previous work [15]. This SysML profile supports engineers in modeling requirements of automotive technical systems including their relationships. Its main idea is the integration of aspects both from the mechanical / architectural as well as the E/E sides of the automotive system design. It is extended to capture essential information for the development tasks of automotive systems in [16]. Based on the model, the paper introduced formal queries on the model to support several traceability aspects. Systems designers can thus be warned about potential design conflicts or unknown dependencies. Moreover, these model queries enable a model analysis to improve design model quality and to reduce side