Chapter 10
Model-Based Analysis and Engineering of Automotive Architectures with EAST-ADL

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ABSTRACT

Modern cars have turned into complex high-technology products, subject to strict safety and timing requirements, in a short time span. This evolution has translated into development processes that are not as efficient, flexible, and agile as they could or should be. Model-based design offers many potential solutions to this problem. This chapter presents the main aspects and capabilities of a rich model-based design framework, founded on EAST-ADL, and developed during the MAENAD project. EAST-ADL is an architecture description language specific to the automotive domain and complemented by a methodology compliant with the ISO26262 standard. The language and the methodology set the stage for a high-level of automation and integration of advanced analyses and optimization capabilities to effectively improve development processes of modern cars.

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INTRODUCTION

Commercial automobiles have become complex high-technology products in a relatively short time span. Different factors contribute to this complexity. One of them is the increasing number of vehicle functionalities supported by software, electronics and mechatronic technologies; a trend that does not seem to slow down. The involvement of carmakers in the development of these functionalities differs from one vehicle domain to the other (chassis, body, powertrain), ranging from black box integration to white-box developments. Another factor is the way in which car manufacturers have evolved from their historical mechanical and manufacturing background to the intricate organizations that develop the automobile products of today. The advent of the electrical vehicle makes this last two factors even more evident, not only because of the "untraditional" technologies that carmakers need to master, but also because the arrival of new stakeholders, actors and interests around the electrical vehicle mean that the traditional scope of the automobile has changed.

Generally, this evolution has translated into development processes that are not as efficient, flexible and agile as they could or should be (Chale, Gaudre & Tucci-Piergiovanni, 2012). The need to master these different complexity-inducing factors and improve the efficiency of product development, plus the arrival of the ISO 26262 standard (which besides from safety-related aspects, also raises issues concerning development processes of automotive systems, currently under-formalized) have motivated the adoption of model-based system engineering. Model-based system engineering advocates the use of models, conforming to a common semantic meta-model, all along the system development process. The meta-model specifies a common unambiguous semantics formalizing system engineering terminology and then providing a common language for system descriptions, i.e. models. Models, produced along the development process, provide system descriptions at different abstraction levels. Abstraction levels help human reasoning and analysis capabilities allowing system specifications to be refined and incrementally validated as long as the comprehension of the system increases. The meta-model approach is also attractive for system development as meta-models and their related models can be easily extended to support an open ended evolution of domain specific concepts.

But model-based system engineering is not only about meta-models, with their possibility to provide unambiguous system descriptions at different abstraction levels. Indeed, models, when formalized through a meta-model, provide the sufficient level of precision to be computer-interpreted. This feature allows providing a computer assisted system engineering process that formalizes and automates system design activities.

Thanks to these capabilities, the adoption of model-based design has several benefits including an improvement of quality, through a more rigorous and costless traceability between requirements, design, analysis and testing. While the benefits of model-based design are widely understood, there is no COTS solution today providing a full-fledged model-based environment for automotive systems. The first problem is that many commercial solutions use proprietary meta-models that scarcely fit automotive design needs. Moreover, ideally, the meta-model should be shared in the entire automotive domain, and then proprietary languages should be avoided opting instead for standard languages. UML extensions as SysML, could be an option, but SysML, per se, does not support many concepts of vital importance for the automotive domain, as for instance, concepts for safety analysis, timing analysis and variability. To support these concepts UML needs to be specialized through specific profiles. Even though some efforts have been spent in that direction in literature – e.g. for safety (Cancila, Terrier, Belmonte, Dubois, Espinoza, Gerard, & Cuccuru, 2009), for timing (OMG MARTE, 2011) – we did not reach the stage in which these efforts are unified and integrated in SyML.