MADES: Embedded Systems Engineering Approach in the Avionics Domain

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Abstract. This article introduces the MADES Project [1]. MADES is developing new model-driven technologies to improve current practices in the development of embedded systems for the avionics and surveillance embedded systems industries, in particular taking advantage of MARTE [3], the OMG UML profile dedicated to Modelling and Analysis of Real time and Embedded Systems. The project is applying a holistic approach in building new tools and technologies that support design, validation, simulation, and code generation, while providing better support for component reuse. The tools and technologies developed within MADES are driven by requirements from industrial users in the Avionics and Defence domains and will undergo extensive validation through use in the development of new applications for avionics and radar surveillance.

Keywords: Advanced Model Driven Architecture, Embedded Systems Design, MARTE

1 Introduction

As the systems that employ embedded software become more complex, they tend to contain more errors, and it becomes more relevant to provide tools to aid the developers to overcome design, verification and validation difficulties. The MADES project will extend existing modelling languages and profiles to develop languages and dedicated tools that are focused on real-time systems for building avionics and surveillance applications. The project research and development will lead to new model-based verification and simulation methods, along with new model-based code generation methods and tools that will address both conventional programming languages and hardware description languages, as well as mappings to virtual platform technology that will enable richer and more flexible configuration of architectures and applications.

The MADES tools will provide developers with the ability to more easily reuse existing software components, ensure consistency of complex systems, and exploit advanced hardware platforms. The MADES tools and technologies will be integrated into a single framework providing a seamless environment for modelling, validation, and code generation of avionic and surveillance solutions.

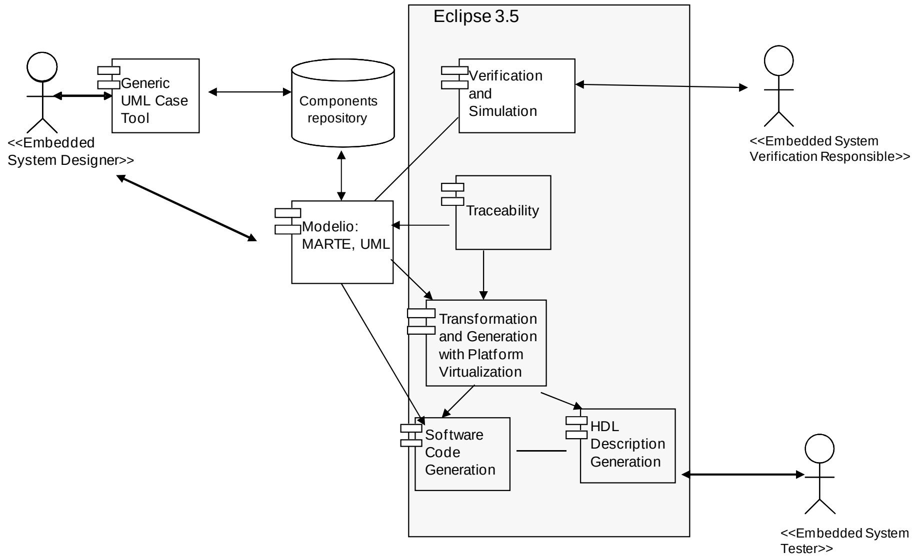

Fig. 1. MADES Architecture

The structure of the article is as follows. Section 2 gives a short overview of Research and Development Innovation in the project. Section 3 presents an overview of the industrial relevance of the project. Finally, section 4 concludes the paper.

2 Research & Development Innovation

MADES advances in Model Driven Engineering for embedded systems development will be based on extensions to the MARTE [3] Profile that will support improved verification, simulation and code generation. An industry leading modelling tool Modelio [6] from Softeam will be updated to provide specific support for new MADES modelling annotations allowing more advanced simulations and new transformations for improved analysis. A component repository enabling greater component reuse will contain the full knowledge gathered about components during each development phase, including information about component constraints for assembly. Automated formal verification techniques will be developed to efficiently check system properties, including temporal ones, by exploiting domain knowledge that will accelerate the verification process. A formal framework to combine models of both the system being developed and its physical environment will be defined to create a simulation environment through which valuable insight into system behaviour can be gained before deployment. New transformations and code generators will enable developers to virtualise complex hardware platforms while providing rich traceability support linked to the MADES verification and simulation technologies.

In particular, concerning verification, MADES will build on current model-checking technology like explicit state-space exploration (SPIN, Bogor) and SAT-based verification (NuSMV, Alloy, Zot [7]) to provide decision procedures more specifically tailored to the project domain. By by exploiting domain abstractions and model fragments, the designers will be allowed to state properties in a way close to their domains that hides the formal notations (e.g., temporal logic) manipulated internally by the verification engine.

Concerning the simulation environment for physical systems, MADES intends to integrate state of the art industrial simulation tools like Matlab/Simulink or Modelica/Dymola/OpenModelica in the project formal framework supporting suitable subsets of UML/MARTE. This will allow for a smooth composition of software and physical models in a unified description permitting a closed-loop analysis of the system under development in its environment before the development process is started.

An enabling technology that underpins the framework is model transformation, which is the particular focus of the University of York [11], [12], [14],[15]. York will provide support for designing and implementing various kinds of model transformations – e.g., model-to-model transformations, model-to-text transformations – for a number of reasons. The transformations will support the verification tasks mentioned earlier, by allowing platform models (e.g., in subsets of UML/MARTE) to be mapped to verification technology, such as Zot or Alloy. The transformations will also support implementation, via code generation to industry-relevant target languages. Novel transformation constructs will be defined that allow transformations to so-called *virtual platforms* [5] that support compile-time virtualization. This will allow more flexible, more configurable applications to be developed while still supporting the principles of Model-Driven Engineering.

3 Industrial Relevance

The tools and technologies developed within MADES are driven by requirements from industrial users in the Avionics and Defence domains and will undergo extensive validation through use in the development of commercial applications for avionics and radar surveillance. Key criteria that will be measured during the industrial evaluations include:

Retargeting effort – effort required to migrate an application from one processor architecture to another: this will be dramatically reduced as a consequence of the analysis being carried out on abstract but precise and formalized models;

Reusability – number of software components that can be taken from one application development project to another: this will be fostered by the ability, provided by the developed tools, to state explicitly the assumptions of the various components concerning their interaction with other components and the environment;

Verification – number of errors corrected earlier in the development process through new model verification methods: this will come as a benefit of the precise semantics assigned to the UML/MARTE models and of analysis carried out on such models by means of the developed model-checking tools.

The project expects to deliver improvements in each of these areas, which will benefit industrial organizations throughout Europe by providing increased productivity, lower development costs, shorter development cycles and more reliable embedded system applications.

4 Conclusion

This paper presents the approach foreseen by the MADES Project and its focus on the needs for increased help demanded by the embedded system design industry. It outlines the Research and Innovation conceived by the project and its industrial relevance to improve current practices in the development of embedded systems, with special emphasis on avionics and surveillance systems.

The project is in an early beginning stage, however the challenges addressed by the project and planned impact are of great importance and are building on the expertise gained in the following European projects:

– MARTES [8]- Model-based Approach to Real-Time Embedded Systems development.
– SERIOUS [9]- Software Evolution, Refactoring, Improvement of Operational & Usable Systems
– JEOPARD [10] - Java Environment for Parallel Realtime Development
– MODELPLEX [11]- MODELling solution for comPLEX software systems
– MODELWARE [12]- MODELing solution for softWARE system
– INESS [13]- INtegrated European Signalling System
– SSEI [14]- Software Systems Engineering Initiative
– LSCITS [15]- Large-Scale Complex IT Systems
– MEDEIA[16]- Model-Driven Embedded Systems Design Environment for the Industrial Automation Sector
– MOMOCS [17] - MOdel driven MOdernisation of Complex Systems

To conclude the paper we would like to outline the expected impact:

- Significantly increased productivity of embedded system development by providing dedicated modelling tools, automated validation, transformation and generation.
- The project intends to improve competitiveness of European companies that rely on the design and integration of embedded systems in their products by

reducing design costs and time to market creating tools and methodologies specifically targeted to them.

- The project will develop and promote open models and standard will be easily usable by European SMEs that are already offering innovative product and services for embedded system design. The project will produce the MADES Approach guide to help and lead in this direction.
- MADES researches should reinforce European scientific and technological leadership in the design of complex embedded systems

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