Q u a s i m o d o

Quantitative System Properties in Model-Driven-Design of Embedded Systems

Quasimodo will develop theory, techniques and tool components for handling quantitative (e.g. real-time, hybrid and stochastic) constraints in model-driven development of real-time embedded systems.

At a Glance: Quasimodo

Quantitative System Properties in Model-Driven-Design of Embedded Systems

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Duration: *36 months*

Start: 2008.01.01

Total Cost: *2.696.000 €*

EC Contribution: 1.995.000€…

KEYWORDS: Quantities, non-functional properties, modelling, analysis, testing, code-generation, algorithms.

Main Objectives

Characteristic for embedded systems is that they have to meet a multitude of quantitative constraints. These constraints involve the resources that a system may use (computation resources, power consumption, memory usage, communication bandwidth, costs, etc.), assumptions about the environment in which it operates (arrival rates, hybrid behaviour), and requirements on the services that the system has to provide (timing constraints, QoS, availability, fault tolerance, etc.).

Quasimodo will focus on developing new techniques and tools for model-driven design, analysis, testing and code-generation for advanced embedded systems with complex quantitative constraints.

Existing Model-Driven Development (MDD) tools are rather limited in their handling of quantitative constraints. Hence MDD will not realise its full potential in the embedded systems area unless the ability to handle quantitative properties is drastically improved.

The objective of the Quasimodo project is to develop theory, techniques and tool components for handling quantitative (e.g. real-time, hybrid and stochastic) constraints in model-driven development of real-time embedded systems. More specifically, the project aims at:

1. Improving the modelling of diverse quantitative aspects of embedded systems.
2. Providing a wide range of powerful techniques for analysing models with quantitative information and for establishing abstraction relations between them.
3. Generating predictable code from quantitative models.
4. Improving the overall quality of testing by using suitable quantitative models as the basis for generating sound and correct test cases.
5. Applying the techniques to real-life case-studies and disseminating the results to industry.

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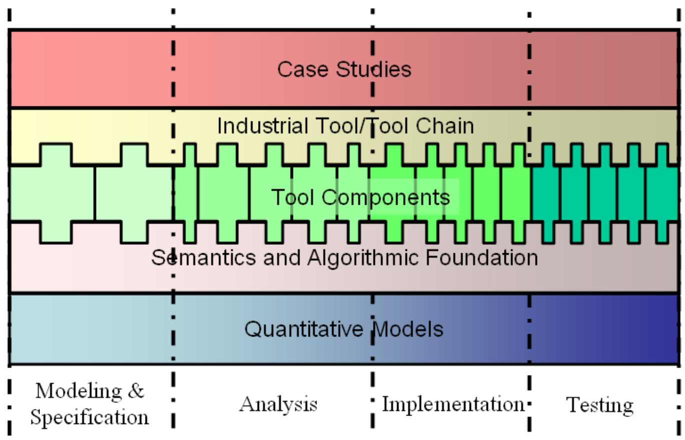
Technical Approach

To achieve its aims, Quasimodo will - as illustrated in the figure below - **cover all of the logical phases of a typical development trajectory** including Modelling and Specification, Analysis, Implementation and Testing. The Quasimodo project will start on the basis of previous theoretical and practical experience of the consortium members, in the areas of verification (real-time, cost-decorated, stochastic and hybrid systems), scheduling and controller synthesis (finite-state, real-time and cost-decorated systems), implementability (finite-state and real-time systems) and testing (finite-state, data-intense and realtime systems).



The principle aim of the project is to provide a coherent and scalable methodology with a supporting collections of tool components that can be used to design reliable embedded systems that meet their requirements in a controlled and resource-efficient way using a model-driven approach. This means that design decision, analysis, code-generation, testing, etc. are always based upon design models that reflect the relevant aspects of the systems. To focus on aspects such as performance, timeliness, and efficient resource-usage, which are central to embedded systems, the **models must provide quantitative information** such as information about timing, cost, data, stochastics and hybrid phenomena.

Algorithmic methods will be developed for analysis of functional correctness and performance issues. The analysis methods include data-structures for symbolic exploration of the behaviour of models, abstraction and compositionality principles for relating design models and help to control the size and complexity of the models, exploitation of approximate analysis techniques for partial analysis of very complex models and, orthogonally, optimal utilisation of the given computing platform on which the algorithms are implemented.

In the implementation step, **executable code running on given physical devices has to be provided**. The theoretical framework of the quantitative models assumes infinitely fast hardware, infinitely precise clocks, unbounded memory etc. In contrast real CPUs are subject to hard limitations in terms of frequency and memory-size. Thus, how to guarantee that properties established by a given model are also valid of its implementation is a major challenge.

Current industrial testing practise is often manual without effective automation and is consequently rather error prone and costly: it is estimated that 30-70% of the total development cost is related to testing. **Model-based testing is a novel approach to testing with high potential of improving cost and efficiency.** We intend to extend the model-based testing technology to the setting of quantitative models allowing generation, selection, execution and provision of coverage-measures to be made.

In order to demonstrate the usefulness of our techniques, we will **apply them to several complex industrial case studies**, and provide a collection of unique tool components to be use as plug-ins in industrial tools or tool chains.

Key Issues

One key issue is modelling of quantitative information in models with sound semantic basis. Typically these models are automata extended with notations for real-time, continuous, stochastic, and resource consumption. Another central problem is the development of efficient symbolic techniques, algorithms and data-structures for the (automated) analysis of quantitative models, and that can be implemented in tools for analysis, test and controller/code-generation.

Expected Impact

By enabling early and automated analysis, design, and test of embedded systems with quantitative constraints, the results of Quasimodo will increase the competitiveness of European embedded systems industry **and will help establish Europe as a leader in design of complex embedded systems**. This objective will be reached by both advancing the state-of-the-art of models, tools and methods for quantitative design, together with knowledge transfer to European industries.