

# Design of Heterogeneous Multiprocessor Systems for Real-Time Applications

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## First year report to ARTES

### 1. Introduction and Objectives

The final goal of this research is to develop a design environment which supports the specification, verification, analysis, and synthesis of heterogeneous hardware/software systems for real-time applications. One of the important features of such a design environment is that it starts from specifications at a high level of abstraction and supports the designer from the early phases of the design. The input specification only describes the overall functionality of the designed system and includes the imposed constraints (timing, power consumption, cost, etc.). Starting from such a system specification, the design environment supports the automatic or interactive exploration of a large design space which leads to high performance and cost effective solutions. At the same time, early detection of design errors and the use of synthesis tools which take into consideration timing constraints, drastically reduces the number of functional and timing errors detected in later design phases and, thus, avoids expensive revisions of the design.

The following issues have been identified in the project proposal as being of particular interest: system modelling and specification, performance estimation and scheduling, design space exploration.

The project has been defined and conducted in close cooperation with Ericsson Radio Systems in Kista (department for Radio and Systems Technology). At the suggestion of our industrial partners we have adopted a "GSM Base-Station Transceiver", as a case study.

### 2. Achievements up till Now

#### 1. System specification.

In order to manage large specifications in an efficient manner and to support system level reuse, an object-oriented methodology based on UML has been investigated with special emphasis on simulation in the context of real-time constraints and on reusability aspects. The model of a GSM Base-Station Transceiver has been elaborated. This work has been of great interest for the industrial partners. It also led to interesting conclusions concerning the suitability of UML and the underlying methodology, for specification of embedded applications. Last but not least it was an opportunity for the PhD student involved in the project to study a large and complex application in the telecom area.

## 2. Performance estimation & scheduling

One important input we got from our industrial partners is that performance estimation and scheduling (as part of the system design process) based on deterministic worst case execution times is not a realistic approach for their application area. Therefore, we propose a probabilistic approach to system design which has to be applied gradually to the main phases of the design process: allocation, mapping, scheduling.

Currently, our research is focused on analytical performance estimation of mono-processor task schedules, where the task execution times are known only probabilistically. We intend to extend this to multi-processor task schedules in the near future.

Task scheduling of stochastic tasks raises additional challenges compared to classical worst-case execution time task models. We address the problem under as general assumptions as possible. As an underlying mathematical model for the analysis, we use stochastic processes, in particular, generalized semi-Markov chains. We developed an algorithm to derive the stochastic process out of the initial task specification. The stochastic process - a DAG - is constructed in a memory and time efficient way. This is extremely important, because of the complexity of the problem, and several techniques have been applied in order to achieve a performance which allows the analysis of large systems.

## **3. Industrial Cooperation**

The main industrial partner which participates actively in the project is Ericsson Radio Systems in Kista.

The industrial partners participate in the case studies and evaluations of results. Regular meetings have been held to discuss the project activities, disseminate produced results, and get their feedback. This will be continued for the rest of the project.

## **4. Mobility Activities**

The PhD student working on the project, Sorin Manolache, made a six-week visit to Ericsson Radio Systems at Kista, in autumn 2000. The visit has led to a better understanding of the industrial codesign process and the need for tools for the earlier design activities. A design case has also been identified as a result of the visit.

## **5. Publications**

R. Jigorea, S. Manolache, P. Eles, Z. Peng, "Modelling and Simulation of Heterogeneous Embedded Systems with UML", The 1999 Conference of the Scandinavian Simulation Society, SIMS99, Linköping, Sweden, 1999.

R. Jigorea, S. Manolache, P. Eles, Z. Peng, "Modeling of Real-Time Embedded Systems in an Object-Oriented Design Environment with UML", 3rd IEEE International Symposium on Object-oriented Real-Time Distributed Computing (ISORC 2000), Newport Beach, California, March 2000.

S. Manolache, P. Eles, Z. Peng, "Efficient Performance Analysis of Stochastic Task Schedules", Technical report, Department of Computer and Information Science, Linköping University (Submitted for Publication at an International Conference).

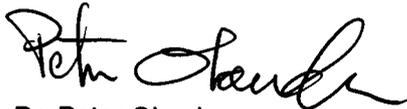
To whom it may concern:

A statement from the industry contact for the project Design of Heterogeneous Multiprocessor Systems for Real-Time Applications

In the autumn of 2000 Sorin Manolache spent six weeks at the department for Radio and Systems Technology at Ericsson Radio Systems in Kista. During this time he worked in a project aimed at future base-station platforms. His previous studies into the modelling of the GSM standard allowed him to take active part in the work and he made significant contributions to the Ericsson project. We were very satisfied with his performance.

While here Sorin presented his current work on system analysis based on probabilistic models to the department members. His approach was deemed novel and interesting. Ericsson has at several occasions during 1999 and 2000 given further feedback to the ARTES project at ESLAB during face-to-face meeting where plans and progress have been reviewed.

Yours sincerely,



Dr. Peter Olanders  
Director  
Radio and Systems Technology  
Generic Technologies  
Ericsson Radio Systems AB