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Lectures on Formal Methods and Performance Analysis

First EEF/Euro Summer School
on Trends in Computer Science
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Revised Lectures



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Foreword

Traditionally, models and methods for the analysis of the functional correctness of reactive systems, and those for the analysis of their performance (and dependability) aspects, have been studied by different research communities. This has resulted in the development of successful, but distinct and largely unrelated modeling and analysis techniques for both domains. In many modern systems, however, the difference between their functional features and their performance properties has become blurred, as relevant functionalities become inextricably linked to performance aspects, e.g. isochronous data transfer for live video transmission.

During the last decade, this trend has motivated an increased interest in combining insights and results from the field of *formal methods* – traditionally focused on functionality – with techniques for *performance modeling and analysis*. Prominent examples of this cross-fertilization are extensions of process algebra and Petri nets that allow for the automatic generation of performance models, the use of formal proof techniques to assess the correctness of randomized algorithms, and extensions of model checking techniques to analyze performance requirements automatically. We believe that these developments mark the beginning of a new paradigm for the modeling and analysis of systems in which qualitative and quantitative aspects are studied from an integrated perspective. We are convinced that the further work towards the realization of this goal will be a growing source of inspiration and progress for both communities.

The aim of the EEF summerschool on *Formal Methods and Performance Analysis* (FMPA) was to report on the state-of-the-art research and tool development for the integrated modeling and analysis of functional and performance aspects of reactive systems. To provide the necessary background it also included lectures on basic models and techniques of both performance evaluation and formal methods for reactive systems. The lectures were given by internationally recognized experts from the formal methods and performance analysis communities. These invited lecturers were: Christel Baier (*Model checking probabilistic and Markovian models*), Gianfranco Balbo (*Petri nets and stochastic Petri nets*), Ed Brinksma (*Process algebra*), Christos Cassandras (*Discrete event simulation*), Gianfranco Ciardo (*Structured and distributed analysis*), Reinhard German (*Non-Markovian analysis*), Boudewijn Haverkort (*Markov chain models and analysis*), Holger Hermanns (*Markovian process algebra*), Ulrich Herzog (*Formal methods for performance analysis*), Jane Hillston (*Compositional and decompositional analysis*), Joost-Pieter Katoen (*Non-Markovian process algebra*), William Sanders (*Stochastic activity networks and their analysis*), Roberto Segala (*Verification of probabilistic distributed algorithms*) and Pierre Wolper (*Model checking*).

This LNCS volume contains a series of articles by lecturers at the summerschool, which survey most of the topics covered at the school, as well as some

additional, related material. We believe that this volume will be of considerable interest to researchers from both the formal methods and performance analysis communities, and that it should prove an excellent starting point for those who wish to get acquainted with the research at the crossroads of these fields.

FMPA was organized as the first school on Trends in Computer Science by the European Educational Forum (established in 1996), a European research training initiative focusing on basic research in Computer Science and its applications. EEF has partner organizations from 7 countries (Denmark, The Netherlands, Finland, United Kingdom, Italy, Germany, France) which together involve 34 universities. The primary aim of the EEF is the training of Ph.D. students and young researchers. The training activities include workshops, schools, highly focused conferences, as well as conferences that provide a forum for a variety of topics of current interest. For more information, see the EEF web page: <http://www.tucs.abo.fi/EEF/>.

FMPA was held at Hotel Val Monte in Berg en Dal, a beautiful village close to Nijmegen. The school was very well attended with 80 participants from all over the world, with 36 attendees who were sponsored through the High-Level Scientific Conference Programme of the European Commission. Other sponsors were the Dutch National Graduate School IPA (Institute for Programming research and Algorithmics), the Netherlands Organization for Scientific Research (NWO), the Royal Dutch Academy of Sciences (KNAW), and the Center for Tele-Informatics and Information Technology (CTIT).

We would like to thank all lecturers for their excellent lectures and their high-level contributions to these lecture notes. We thank Jos Baeten, Tijn Borghuis, and Grzegorz Rozenberg for inviting us to organize FMPA as part of the EEF summerschool series and for their assistance in maintaining the proper contacts with the EC and Springer-Verlag. On the local level, we thank Pedro D'Argenio and in particular Joke Lammerink for their assistance with the organization of the school.

May 2001

Ed Brinksma, Holger Hermanns, Joost-Pieter Katoen

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