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Formal Methods for the Design of Real-Time Systems

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Preface

A large class of computing systems can be specified and verified by abstracting away from the temporal aspects of their behavior. In *real-time systems*, instead, time issues become essential. Their correctness depends not only on which actions they can perform, but also on the action execution time. Due to their importance and design challenges, real-time systems have attracted the attention of a considerable number of computer scientists and engineers from various research areas.

This volume collects a set of papers accompanying the lectures of the fourth edition of the *International School on Formal Methods for the Design of Computer, Communication and Software Systems (SFM)*. The school addressed the use of formal methods in computer science as a prominent approach to the rigorous design of computer, communication and software systems. The main aim of the SFM series is to offer a good spectrum of current research in foundations as well as applications of formal methods, which can be of help for graduate students and young researchers who intend to approach the field.

SFM-04:RT was devoted to real-time systems. It covered formal models and languages for the specification, modeling, analysis, and verification of these time-critical systems, the expressiveness of such models and languages, as well as supporting tools and related applications in different domains.

The opening paper by Rajeev Alur and Parthasarathy Madhusudan provides a survey of the theoretical results concerning decision problems of reachability, language inclusion, and language equivalence for timed automata. The survey is concluded with a discussion of some open problems. Elmar Bihler and Walter Vogler's paper presents timed extensions of Petri nets with continuous and discrete time and a natural testing-based faster-than relation for comparing asynchronous systems. Several applications of the theory are also presented. Jos C.M. Baeten and Michel A. Reniers present the theory and application of classical process algebras extended with different notions of time and time passing and compare their expressiveness via embeddings and conservative extensions. The PAR communication protocol is considered as a case study. The expressiveness of existing timed process algebras that deal with temporal aspects by following very different interpretations is also the main theme of Diletta R. Cacciagrano and Flavio Corradini's paper. In addition, they compare the expressiveness of urgent, lazy and maximal progress tests. Mario Bravetti presents a theory of probabilistic timed systems where durations are expressed by generally distributed random variables. The theory supports the specification of both real-time and stochastic time during the design and analysis of concurrent systems. Bran Selic, instead, provides an overview of the foundations of the runtime semantics underlying the Unified Modeling Language (UML) as defined in revision 2.0 of the official OMG standard.

After these contributions on formal timed models, timed languages and their expressiveness, the volume includes the description of three significant tools supporting the specification, modeling, analysis and verification of real-time systems. Gerd Behrmann, Alexandre David and Kim G. Larsen's tutorial paper on the tool Uppaal provides an introduction to the implementation of timed automata in the tool, the user interface, and the usage of the tool. Reference examples and modeling patterns are also presented. Marius Bozga, Susanne Graf, Ileana Ober, Iulian Ober, and Joseph Sifak present an overview on the IF toolset, which is an environment for the modeling and validation of heterogeneous real-time systems. The toolset is built upon a rich formalism, the IF notation, allowing structured automata-based system representations. A case study concerning the Ariane-5 Flight Program is presented. Finally, Joost-Pieter Katoen, Henrik Bohnenkamp, Ric Klaren, and Holger Hermanns survey the language Modest, a modeling and description language for stochastic and timed systems, and its accompanying tool environment MOTOR. The modeling and analysis with this tool of a device-absence-detecting protocol in plug-and-play networks is reported in the paper.

We believe that this book offers a quite comprehensive view of what has been done and what is going on worldwide at present in the field of real-time models and languages for the specification, analysis, and verification of time-critical systems. We wish to thank all the lecturers and all the participants for a lively and fruitful school. We also wish to thank the whole staff of the University Residential Center of Bertinoro (Italy) for the organizational and administrative support, as well as the sponsors of the school – AICA and ONRG – for making it possible through the provision of grants to some of the participants.

September 2004 Marco Bernardo and Flavio Corradini

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