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# Model-Based Testing of Reactive Systems

Advanced Lectures

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# Preface

*Testing* is the primary hardware and software verification technique used by industry today. Usually, it is ad hoc, error prone, and very expensive. In recent years, however, many attempts have been made to develop more sophisticated, formal testing methods. But a comprehensive account of the area of formal testing is missing. The goal of this seminar volume is to provide an in-depth exposure of this emerging area, especially to make it easily accessible to new researchers in this field.

Since testing describes the methodology used to obtain better systems, it is widely used in many scientific and industrial sectors dealing with system development. As such, a book on testing is hardly ever a comprehensive overview on the whole domain of testing, but a selection of important approaches and application domains. In this volume, we focus on testing methods for *reactive systems*. By reactive systems, we understand software and hardware systems with a (usually) non-terminating behavior that interact through visible events, such as Web servers, communication protocols, operating systems, smart cards, processors, etc.

Furthermore, in most chapters of this book, we follow the so-called *model-based* approach. The underlying assumption in the model-based approach is the existence of a precise formal model of the system being developed. This model can be used for studying the system to be. Especially in the testing phase of product development, it can be used to generate *complete test suites* to show *conformance* of the model and the actual implementation, or, just to derive “interesting” *test cases* to check the developed system.

The 19 chapters of the book are grouped into six parts. In the first part, we present the approaches for *testing for finite-state machines*, also called *Mealy machines*. The second part, called *testing of labeled transition systems*, gives an overview of the testing theory due to Hennessy and De Nicola together with its extensions to I/O, timed, and probabilistic systems. In Part III, we focus on methodology, algorithms, and techniques for *model-based test case generation*.

The methods illustrated in the first three parts of the book led to the development of test tools and have been applied in many case studies showing their advantages and drawbacks. Several tools and case studies are presented in Part IV.

While test case generation can be considered the heart of testing, the testing process as a whole is more complicated. The test cases have to be executed on the system under test. In several application domains, test suites are used to show conformance to a standard. For this, test cases have to be interchanged among developers. Furthermore, testing should be included in the overall development process. In Part V, called *Standardized Test Notation and Execution Architecture* we cover recent developments.

The last part of the book introduces two extensions of the typical testing approach. It describes methods for the continuous testing effort, also at a later run-time of the system. Furthermore, it recalls essentials of model checking, a different powerful technique to get “better” systems, on the one hand to separate model checking and testing, on the other hand to show possible combination leading to approaches like *black box checking* or *adaptive model checking*. We meaningfully term this last part *Beyond Testing*.

The volume is the outcome of a research seminar that was held in Schloss Dagstuhl in January 2004 and that took place as part of the so-called GI/Research Seminar series. Thirty three young researchers participated in the seminar; each of them prepared a presentation based on one or several recent articles, reshaping the material in form with special emphasis on motivation, examples, and also exercises.

Thanks are due to the International Conference and Research Center of Dagstuhl and the “Gesellschaft für Informatik (GI)” for the support it provided. Further funding was provided by the Research Training Network GAMES financed by the European Commission under the Fifth Framework Programme. We also would like to thank the authors of the tutorial papers as well as their reviewers for their efforts. Last but not least, we would like to thank Britta Liebscher and Springer for substantial help in technical and editorial matters.

The editors hope that this book will help many readers to enter the domain of model-based testing, either to apply the so-far-developed techniques to enhance their product under development, or to improve the current testing techniques to make them even more efficient and effective.

Munich, Uppsala, Enschede, Zurich, January 2005

Manfred Broy  
 Bengt Jonsson  
 Joost-Pieter Katoen  
 Martin Leucker  
 Alexander Pretschner

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