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Principles of Model Checking Model Checking, second edition **25 Years of Model Checking** *Handbook of Model Checking* **Model Checking, second edition** **Systems and Software Verification** *Model Checking Quantum Systems* **Symbolic Model Checking** **Principles of the Spin Model Checker** **Handbook of Model Checking** *Model Checking Software* *Formal Methods and Software Engineering* **Computer Aided Verification** **Computer Aided Verification Model Checking** **Software Tools for Practical Software Verification** Model Checking **Software Modeling and Verification** **Using UML Statecharts** **Abstraction Refinement for Large Scale Model Checking** *Model Checking Software* Model Checking and Artificial Intelligence Verification of Reactive Systems **Model Checking Software** **VMCAI 2004** **Computer Aided Verification** *Model Checking Software* Formal Methods for Performance Evaluation Verifying Cyber-Physical Systems The Spin Model Checker *Principles of Cyber-Physical Systems* **Real-time Systems** *Stochastic Model Checking* **Temporal Logics in Computer Science** **Decision Procedures** *Symposium 25 Years of Model Checking* Logic in Computer Science *Model Checking Software* Reactive Systems **Model-Checking Based Data Retrieval** Modeling and Verification of Parallel Processes

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This book presents revised versions of selected papers from the 6th Workshop on Model Checking and Artificial Intelligence, MoChArt 2010, held in Atlanta, GA, USA in July 2010, as well as papers contributed subsequent to the workshop. The 7 papers presented were carefully reviewed and selected for inclusion in this book. In addition, the book also contains an extended abstract of the invited talk held at the workshop. The topics covered by these papers are general search algorithms, application of AI techniques to automated program verification, multiagent systems and epistemic logic, abstraction, epistemic model checking, and theory of model checking. This book constitutes the refereed proceedings of the 5th International Conference on Verification, Model Checking, and Abstract Interpretation, VMCAI 2004, held in Venice, Italy in January 2004. The 22 revised full papers presented together with 4 invited contributions were carefully reviewed and selected from 68 submissions. The papers are organized in topical sections on security, formal methods, model checking, software checking, liveness and completeness, and miscellaneous. As systems being developed by industry and government grow larger and more complex, the need for superior specification and verification approaches and tools becomes increasingly vital. The developer and customer must have complete confidence that the design produced is correct, and that it meets forma development and verification standards. In this text, UML expert author Dr. Doron Drusinsky compiles all the latest information on the application of UML (Universal Modeling Language) statecharts, temporal logic, automata, and other advanced tools for run-time monitoring and verification. This is the first book that deals specifically with UML verification techniques. This important information is introduced within the context of real-life examples and solutions, particularly focusing on national defense applications. A practical text, as opposed to a high-level theoretical one, it emphasizes getting the system developer up-to-speed on using the tools necessary for daily practice. A practical, tutorial-style text (other books on this topic discuss the tools and formalisms only theoretically) Includes an unclassified case study example from the U.S. Missile Defense project This book constitutes the refereed proceedings of the 10th International SPIN workshop on Model Checking of Software, SPIN 2003, held in Portland, OR, USA in May 2003 as an ICSE 2003 satellite workshop. The 14 revised full papers and 3 revised tool papers presented were carefully reviewed and selected from 30 submissions. The book presents state-of-the-art results on the analysis and verification of distributed software systems using the SPIN model checker as one of the most powerful and widely applied

systems. This book is devoted to the study of the semantics and assuring the efficient execution of database query languages, where the database contains semistructured and time-varying information. The primary focus of the work presented is the definition of an effective graph-based approach to the formalization of query languages for semistructured and temporal information; as a result, query execution can be reduced to searching the database for subgraphs that are similar to the given query graph and thus can be supported through bisimulation. By integrating and refining graph-based methods and bisimulation, the author develops a powerful and flexible paradigm. The second research challenge solved is that of efficient implementation by modeling graphical queries as formulas in modal logic and interpreting database instance graphs as Kripke transition systems. This book constitutes the refereed proceedings of the 8th International SPIN Workshop held in Toronto, Canada, in May 2001. The SPIN model checker is one of the most powerful and popular systems for the analysis and verification of distributed and concurrent systems. The 13 revised full papers presented together with one invited survey paper and three invited industrial experience reports were carefully reviewed and selected from 26 submissions. Besides foundational issues of program analysis and formal verification, the papers focus on tools for model checking and practical applications in a variety of fields. An expanded and updated edition of a comprehensive presentation of the theory and practice of model checking, a technology that automates the analysis of complex systems. Model checking is a verification technology that provides an algorithmic means of determining whether an abstract model—representing, for example, a hardware or software design—satisfies a formal specification expressed as a temporal logic formula. If the specification is not satisfied, the method identifies a counterexample execution that shows the source of the problem. Today, many major hardware and software companies use model checking in practice, for verification of VLSI circuits, communication protocols, software device drivers, real-time embedded systems, and security algorithms. This book offers a comprehensive presentation of the theory and practice of model checking, covering the foundations of the key algorithms in depth. The field of model checking has grown dramatically since the publication of the first edition in 1999, and this second edition reflects the advances in the field. Reorganized, expanded, and updated, the new edition retains the focus on the foundations of temporal logic model while offering new chapters that cover topics that did not exist in 1999: propositional satisfiability, SAT-based model checking, counterexample-guided abstraction refinement, and software model checking. The book serves as an introduction to the field suitable for classroom use and as an essential guide for researchers. This book constitutes the refereed proceedings of the 16th International Conference on Computer Aided Verification, CAV 2004, held in Boston, MA, USA, in July 2004. The 32 revised full research papers and 16 tool papers were carefully reviewed and selected from 144 submissions. The papers cover all current issues in

computer aided verification and model checking, ranging from foundational and methodological issues to the evaluation of major tools and systems. This book presents a set of 11 papers accompanying the lectures of leading researchers given at the 7th edition of the International School on Formal Methods for the Design of Computer, Communication and Software Systems, SFM 2007, held in Bertinoro, Italy in May/June 2007. SFM 2007 was devoted to formal techniques for performance evaluation and covered several aspects of the field. Formal methods is the term used to describe the specification and verification of software and software systems using mathematical logic. Various methodologies have been developed and incorporated into software tools. An important subclass is distributed systems. There are many books that look at particular methodologies for such systems, e.g. CSP, process algebra. This book offers a more balanced introduction for graduate students that describes the various approaches, their strengths and weaknesses, and when they are best used. Milner's CCS and its operational semantics are introduced, together with notions of behavioural equivalence based on bisimulation techniques and with variants of Hennessy-Milner modal logics. Later in the book, the presented theories are extended to take timing issues into account. The book has arisen from various courses taught in Iceland and Denmark and is designed to give students a broad introduction to the area, with exercises throughout. A comprehensive, modern and technically precise exposition of the theory and main applications of temporal logics in computer science. The LASER school is intended for professionals from the industry (engineers and managers) as well as university researchers, including PhD students. Participants learn about the most important software technology advances from the pioneers in the field. The school's focus is applied, although theory is welcome to establish solid foundations. The format of the school favors extensive interaction between participants and speakers. LASER 2011 is devoted to software verification tools. There have been great advances in the field of software verification in recent years. Today verification tools are being increasingly used not only by researchers, but by programming practitioners. The summer school will focus on several of the most prominent and practical of such tools from different areas of software verification (such as formal proofs, testing and model checking). During the school the participants will not only learn the principles behind the tools, but also get hands-on experience, trying the tools on real programs. This book constitutes the refereed proceedings of the 15th International SPIN workshop on Model Checking Software, SPIN 2008, held in Los Angeles, CA, USA, in August 2008. The 17 revised full papers presented together with 1 tool paper and 4 invited talks were carefully reviewed and selected from 41 submissions. The main focus of the workshop series is software systems, including models and programs. The papers cover theoretical and algorithmic foundations as well as tools for software model checking and foster interactions and exchanges of ideas with related areas in software engineering, such as static analysis, dynamic

analysis, and testing. The first book introducing computer aided verification techniques for quantum systems with quantum computing and communication hardware. This book collects the research work of leading-edge researchers and practitioners in the areas of analysis, synthesis, design and implementation of real-time systems with applications in various industrial fields. Their works are grouped into six parts, together encompassing twenty chapters. Each part is devoted to a mainstream subject, the chapters therein developing one of the major aspects of real-time system theory, modeling, design, and practical applications. Starting with a general approach in the area of formalization of real-time systems, and setting the foundations for a general systemic theory of those systems, the book covers everything from building modeling frameworks for various types of real-time systems, to verification, and synthesis. Other parts of the book deal with subjects related to tools and applications of these systems. A special part is dedicated to languages used for their modeling and design. The applications presented in the book reveal precious insights into practitioners' secrets. This book constitutes the refereed proceedings of the 20th International Symposium on Model Checking Software, SPIN 2013, held in Stony Brook, NY, USA, in July 2013. The 18 regular papers, 2 tool demonstration papers, and 2 invited papers were carefully reviewed and selected from 40 submissions. The traditional focus of SPIN has been on explicit-state model checking techniques, as implemented in SPIN and other related tools. While such techniques are still of key interest to the workshop, its scope has broadened over recent years to include techniques for the verification and formal testing of software systems in general. This is the first introductory textbook on Spin, the only requirement is a background in programming. Spin models are written in the Promela language which is easily learned by students and programmers. Spin is easy to install and use. The Spin model checker is not only a widely used professional tool but it is also a superb tool for teaching important concepts of computer science such as verification, concurrency and nondeterminism. The book introduces Spin-based software that the author has developed for teaching. Complete programs demonstrate each construct and concept and these programs are available on a companion website. Recent years have seen the development of powerful tools for verifying hardware and software systems, as companies worldwide realise the need for improved means of validating their products. There is increasing demand for training in basic methods in formal reasoning so that students can gain proficiency in logic-based verification methods. The second edition of this successful textbook addresses both those requirements, by continuing to provide a clear introduction to formal reasoning which is both relevant to the needs of modern computer science and rigorous enough for practical application. Improvements to the first edition have been made throughout, with extra and expanded sections on SAT solvers, existential/universal second-order logic, micro-models, programming by contract and total correctness. The coverage of model-checking has been

substantially updated. Further exercises have been added. Internet support for the book includes worked solutions for all exercises for teachers, and model solutions to some exercises for students. A comprehensive introduction to the foundations of model checking, a fully automated technique for finding flaws in hardware and software; with extensive examples and both practical and theoretical exercises. Our growing dependence on increasingly complex computer and software systems necessitates the development of formalisms, techniques, and tools for assessing functional properties of these systems. One such technique that has emerged in the last twenty years is model checking, which systematically (and automatically) checks whether a model of a given system satisfies a desired property such as deadlock freedom, invariants, and request-response properties. This automated technique for verification and debugging has developed into a mature and widely used approach with many applications. Principles of Model Checking offers a comprehensive introduction to model checking that is not only a text suitable for classroom use but also a valuable reference for researchers and practitioners in the field. The book begins with the basic principles for modeling concurrent and communicating systems, introduces different classes of properties (including safety and liveness), presents the notion of fairness, and provides automata-based algorithms for these properties. It introduces the temporal logics LTL and CTL, compares them, and covers algorithms for verifying these logics, discussing real-time systems as well as systems subject to random phenomena. Separate chapters treat such efficiency-improving techniques as abstraction and symbolic manipulation. The book includes an extensive set of examples (most of which run through several chapters) and a complete set of basic results accompanied by detailed proofs. Each chapter concludes with a summary, bibliographic notes, and an extensive list of exercises of both practical and theoretical nature. This book summarizes recent research on abstraction techniques for model checking large digital system. Considering the size of today's digital systems and the capacity of state-of-the-art verification algorithms, abstraction is the only viable solution for the successful application of model checking techniques to industrial-scale designs. The suite of algorithms presented here represents significant improvement over prior art; some have already been adopted by the EDA companies in their commercial/in-house verification tools. This volume contains the proceedings of the conference on Computer Aided Verification (CAV 2002), held in Copenhagen, Denmark on July 27-31, 2002. CAV 2002 was the 14th in a series of conferences dedicated to the advancement of the theory and practice of computer-assisted formal analysis methods for software and hardware systems. The conference covers the spectrum from theoretical results to concrete applications, with an emphasis on practical verification tools, including algorithms and techniques needed for their implementation. The conference has traditionally drawn contributions from researchers as well as practitioners in both academia and industry. This year we

received 94 regular paper submissions out of which 35 were selected. Each submission received an average of 4 referee reviews. In addition, the CAV program contained 11 tool presentations selected from 16 submissions. For each tool presentation, a demo was given at the conference. The large number of tool submissions and presentations testified to the liveliness of the field and its applied flavor.

A foundational text that offers a rigorous introduction to the principles of design, specification, modeling, and analysis of cyber-physical systems. A cyber-physical system consists of a collection of computing devices communicating with one another and interacting with the physical world via sensors and actuators in a feedback loop. Increasingly, such systems are everywhere, from smart buildings to medical devices to automobiles. This textbook offers a rigorous and comprehensive introduction to the principles of design, specification, modeling, and analysis of cyber-physical systems. The book draws on a diverse set of subdisciplines, including model-based design, concurrency theory, distributed algorithms, formal methods of specification and verification, control theory, real-time systems, and hybrid systems, explaining the core ideas from each that are relevant to system design and analysis. The book explains how formal models provide mathematical abstractions to manage the complexity of a system design. It covers both synchronous and asynchronous models for concurrent computation, continuous-time models for dynamical systems, and hybrid systems for integrating discrete and continuous evolution. The role of correctness requirements in the design of reliable systems is illustrated with a range of specification formalisms and the associated techniques for formal verification. The topics include safety and liveness requirements, temporal logic, model checking, deductive verification, stability analysis of linear systems, and real-time scheduling algorithms. Principles of modeling, specification, and analysis are illustrated by constructing solutions to representative design problems from distributed algorithms, network protocols, control design, and robotics. This book provides the rapidly expanding field of cyber-physical systems with a long-needed foundational text by an established authority. It is suitable for classroom use or as a reference for professionals.

Model checking is a computer-assisted method for the analysis of dynamical systems that can be modeled by state-transition systems. Drawing from research traditions in mathematical logic, programming languages, hardware design, and theoretical computer science, model checking is now widely used for the verification of hardware and software in industry. The editors and authors of this handbook are among the world's leading researchers in this domain, and the 32 contributed chapters present a thorough view of the origin, theory, and application of model checking. In particular, the editors classify the advances in this domain and the chapters of the handbook in terms of two recurrent themes that have driven much of the research agenda: the algorithmic challenge, that is, designing model-checking algorithms that scale to real-life problems; and the modeling challenge, that is, extending the formalism beyond Kripke structures and temporal

logic. The book will be valuable for researchers and graduate students engaged with the development of formal methods and verification tools. This Festschrift volume, published in celebration of the 25th Anniversary of Model Checking, features papers based on talks at the symposium "25 Years of Model Checking", 25MC, which was part of the 18th International Conference on Computer Aided Verification. This volume contains the proceedings of the conference on Computer Aided Verification (CAV 2003) held in Boulder, Colorado, on July 8–12, 2003. CAV 2003 was the 15th in a series of conferences dedicated to the advancement of the theory and practice of computer-assisted formal analysis methods for hardware and software systems. The conference covers the spectrum from theoretical results to applications, with emphasis on practical verification tools, including algorithms and techniques needed for their implementation. The conference has traditionally drawn contributions from researchers as well as practitioners in both academia and industry. The program of the conference consisted of 32 regular papers, selected from 87 submissions. In addition, the CAV program featured 9 tool presentations and demonstrations selected from 15 submissions. Each submission received an average of 5 referee reviews. The large number of tool submissions and presentations testifies to the liveliness of the field and to its applied flavor. The CAV 2003 program included a tutorial day with three invited tutorials by Ken McMillan (Cadence) on SAT-Based Methods for Unbounded Model Checking, Doron Peled (Warwick) on Algorithmic Testing Methods, and Willem Visser (NASA) on Model Checking Programs with Java PathFinder. The conference also included two invited talks by Amitabh Srivastava (Microsoft) and Michael Gordon (Cambridge). Five workshops were associated with CAV 2003: – ACL2 2003: 4th International Workshop on the ACL2 Theorem Prover and Its Applications. – BMC 2003: 1st International Workshop on Bounded Model Checking. – PDMC 2003: 2nd International Workshop on Parallel and Distributed Model Checking. – RV 2003: 3rd Workshop on Runtime Verification. – SoftMC 2003: 2nd Workshop on Software Model Checking. A decision procedure is an algorithm that, given a decision problem, terminates with a correct yes/no answer. Here, the authors focus on theories that are expressive enough to model real problems, but are still decidable. Specifically, the book concentrates on decision procedures for first-order theories that are commonly used in automated verification and reasoning, theorem-proving, compiler optimization and operations research. The techniques described in the book draw from fields such as graph theory and logic, and are routinely used in industry. The authors introduce the basic terminology of satisfiability modulo theories and then, in separate chapters, study decision procedures for each of the following theories: propositional logic; equalities and uninterpreted functions; linear arithmetic; bit vectors; arrays; pointer logic; and quantified formulas. The SPIN workshop series brings together researchers and practitioners interested in explicit state model checking technology as it is applied

to the verification of software systems. Since 1995, when the SPIN workshop series was instigated, SPIN workshops have been held on an annual basis at Montreal (1995), New Brunswick (1996), Enschede (1997), Paris (1998), Trento (1999), Toulouse (1999), Stanford (2000), and Toronto (2001). While the first SPIN workshop was a stand-alone event, later workshops have been organized as more or less closely related events with larger conferences, in particular with CAV (1996), TACAS (1997), FORTE/PSTV (1998), FLOC (1999), World Congress on Formal Methods (1999), FMOODS (2000), and ICSE (2001). This year, SPIN 2002 was held as a satellite event of ETAPS 2002, the European Joint Conferences on Theory and Practice of Software. The co-location of SPIN workshops with conferences has proven to be very successful and has helped to disseminate SPIN model checking technology to wider audiences. Since 1999, the proceedings of the SPIN workshops have appeared in Springer-Verlag's "Lecture Notes in Computer Science" series. The history of successful SPIN workshops is evidence for the maturing of model checking technology, not only in the hardware domain, but increasingly also in the software area. While in earlier years algorithms and tool development around the SPIN model checker were the focus of this workshop series, the scope has recently widened to include more general approaches to software model checking. Current research in this area concentrates not so much on completely verifying system models, but rather on analyzing source code in order to discover software faults. This volume contains the proceedings of the 17th International SPIN Workshop on Model Checking Software (SPIN 2010). The workshop was organized by and held at the University of Twente, The Netherlands, on 27–29 September 2010. The workshop was co-located with the 5th International Conference on Graph Transformation (ICGT 2010) and several of its satellite workshops, and with the joint PDMC and HiBi workshops, on Parallel and Distributed Methods for Verification and on High-performance computational systems Biology. The SPIN workshop is a forum for practitioners and researchers interested in state-space analysis of software-intensive systems. This is applicable in particular to concurrent and asynchronous systems, including protocols. The name of the workshop reflects the SPIN model checking tool by Gerard J. Holzmann, which won the ACM System Software Award 2001, and is probably the most widely used industrial-strength model checker around. The focus of the workshop is on theoretical advances and extensions, algorithmic improvements, and empirical evaluation studies of (mainly) state-based model checking techniques, as implemented in the SPIN model checker and other tools. The workshop encourages interaction and exchange of ideas with all related areas in software engineering. To this end, we co-located SPIN 2010 with the graph transformation, and high-performance analysis communities. This year, we received 33 submissions, divided between 29 regular and 4 tool papers. Each paper was rigorously reviewed by at least four reviewers, and judged on its quality and its

significance and relevance for SPIN. We accepted 13 regular papers, and 2 tool papers for presentation and for publication in this volume. This book is a solid foundation of the most important formalisms used for specification and verification of reactive systems. In particular, the text presents all important results on μ -calculus, w -automata, and temporal logics, shows the relationships between these formalisms and describes state-of-the-art verification procedures for them. It also discusses advantages and disadvantages of these formalisms, and shows up their strengths and weaknesses. Most results are given with detailed proofs, so that the presentation is almost self-contained. Includes all definitions without relying on other material Proves all theorems in detail Presents detailed algorithms in pseudo-code for verification as well as translations to other formalisms The SPIN Model Checker is used for both teaching software verification techniques, and for validating large scale applications. The growing number of users has created a need for a more comprehensive user guide and a standard reference manual that describes the most recent version of the tool. This book fills that need. SPIN is used in over 40 countries. The official SPIN web site, spinroot.com receives between 2500 and 3000 hits per day. It has been estimated that up to three-quarters of the \$400 billion spent annually to hire programmers in the United States is ultimately spent on debugging Formal methods have made significant progress in recent years with successful stories from Microsoft (SLAM project), Intel (i7 processor verification) and NICTA/OK-Lab (formal verification of an OS kernel). The main focus of formal engineering methods lies in how formal methods can be effectively integrated into mainstream software engineering. Various advanced theories, techniques and tools have been proposed, developed and applied in the specification, design and verification of software or in the construction of software. The challenge now is how to integrate them into engineering development processes to effectively deal with large-scale and complex computer systems for their correct and efficient construction and maintenance. This requires us to improve the state of the art by researching effective approaches and techniques for integration of formal methods into industrial engineering practice, including new and emerging practice. This series, International Conferences on Formal Engineering Methods, brings together those interested in the application of formal engineering methods to computer systems. This volume contains the papers presented at ICFEM 2010, the 12th International Conference on Formal Engineering Methods, held November 17–19, in Shanghai, China, in conjunction with the Third International Symposium on Unifying Theories of Programming (UTP 2010). The Program Committee received 114 submissions from 29 countries and regions. Each paper was reviewed by at least three program committee members. This book constitutes the refereed proceedings of the 8th International SPIN Workshop held in Toronto, Canada, in May 2001. The SPIN model checker is one of the most powerful and popular systems for the analysis and verification of distributed and concurrent systems. The 13 revised full papers presented

together with one invited survey paper and three invited industrial experience reports were carefully reviewed and selected from 26 submissions. Besides foundational issues of program analysis and formal verification, the papers focus on tools for model checking and practical applications in a variety of fields. Model checking is a powerful approach for the formal verification of software. It automatically provides complete proofs of correctness, or explains, via counter-examples, why a system is not correct. Here, the author provides a well written and basic introduction to the new technique. The first part describes in simple terms the theoretical basis of model checking: transition systems as a formal model of systems, temporal logic as a formal language for behavioral properties, and model-checking algorithms. The second part explains how to write rich and structured temporal logic specifications in practice, while the third part surveys some of the major model checkers available. A graduate-level textbook that presents a unified mathematical framework for modeling and analyzing cyber-physical systems, with a strong focus on verification. Verification aims to establish whether a system meets a set of requirements. For such cyber-physical systems as driverless cars, autonomous spacecraft, and air-traffic management systems, verification is key to building safe systems with high levels of assurance. This graduate-level textbook presents a unified mathematical framework for modeling and analyzing cyber-physical systems, with a strong focus on verification. It distills the ideas and algorithms that have emerged from more than three decades of research and have led to the creation of industrial-scale modeling and verification techniques for cyber-physical systems. Formal verification means having a mathematical model of a system, a language for specifying desired properties of the system in a concise, comprehensible and unambiguous way, and a method of proof to verify that the specified properties are satisfied. When the method of proof is carried out substantially by machine, we speak of automatic verification. Symbolic Model Checking deals with methods of automatic verification as applied to computer hardware. The practical motivation for study in this area is the high and increasing cost of correcting design errors in VLSI technologies. There is a growing demand for design methodologies that can yield correct designs on the first fabrication run. Moreover, design errors that are discovered before fabrication can also be quite costly, in terms of engineering effort required to correct the error, and the resulting impact on development schedules. Aside from pure cost considerations, there is also a need on the theoretical side to provide a sound mathematical basis for the design of computer systems, especially in areas that have received little theoretical attention. Daily life relies more and more on safety critical systems, e.g. in areas such as power plant control, traffic management, flight control, and many more. MOVEP is a school devoted to the broad subject of modeling and verifying software and hardware systems. This volume contains tutorials and annotated bibliographies covering the main subjects addressed at MOVEP 2000. The four tutorials deal with Model Checking, Theorem Proving,

Composition and Abstraction Techniques, and Timed Systems. Three research papers give detailed views of High-Level Message Sequence Charts, Industrial Applications of Model Checking, and the use of Formal Methods in Security. Finally, four annotated bibliographies give an overview of Infinite State Space Systems, Testing Transition Systems, Fault-Model-Driven Test Derivation, and Mobile Processes. Model checking is a computer-assisted method for the analysis of dynamical systems that can be modeled by state-transition systems. Drawing from research traditions in mathematical logic, programming languages, hardware design, and theoretical computer science, model checking is now widely used for the verification of hardware and software in industry. The editors and authors of this handbook are among the world's leading researchers in this domain, and the 32 contributed chapters present a thorough view of the origin, theory, and application of model checking. In particular, the editors classify the advances in this domain and the chapters of the handbook in terms of two recurrent themes that have driven much of the research agenda: the algorithmic challenge, that is, designing model-checking algorithms that scale to real-life problems; and the modeling challenge, that is, extending the formalism beyond Kripke structures and temporal logic. The book will be valuable for researchers and graduate students engaged with the development of formal methods and verification tools. An expanded and updated edition of a comprehensive presentation of the theory and practice of model checking, a technology that automates the analysis of complex systems. Model checking is a verification technology that provides an algorithmic means of determining whether an abstract model—representing, for example, a hardware or software design—satisfies a formal specification expressed as a temporal logic formula. If the specification is not satisfied, the method identifies a counterexample execution that shows the source of the problem. Today, many major hardware and software companies use model checking in practice, for verification of VLSI circuits, communication protocols, software device drivers, real-time embedded systems, and security algorithms. This book offers a comprehensive presentation of the theory and practice of model checking, covering the foundations of the key algorithms in depth. The field of model checking has grown dramatically since the publication of the first edition in 1999, and this second edition reflects the advances in the field. Reorganized, expanded, and updated, the new edition retains the focus on the foundations of temporal logic model while offering new chapters that cover topics that did not exist in 1999: propositional satisfiability, SAT-based model checking, counterexample-guided abstraction refinement, and software model checking. The book serves as an introduction to the field suitable for classroom use and as an essential guide for researchers. The use of stochastic models in computer science is wide spread, for instance in performance modeling, analysis of randomized algorithms and communication protocols which form the structure of the Internet. Stochastic model checking is an important field in stochastic analysis. It has rapidly gained popularity, due to its

powerful and systematic methods to model and analyze stochastic systems. This book presents 7 tutorial lectures given by leading scientists at the ROCKS Autumn School on Stochastic Model Checking, held in Vahrn, Italy, in October 2012. The 7 chapters of this tutorial went through two rounds of reviewing and improvement and are summarizing the state-of-the-art in the field, centered around the three areas of stochastic models, abstraction techniques and stochastic model checking.

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