Real Time Systems Lecture Notes Cm Krishna

A comprehensive introduction to interval logic and duration calculus for modelling, analysing and verifying real-time systems. The Duration Calculus (DC) represents a logical approach to formal design of real-time systems. In DC real numbers are used to model time and Boolean-valued (i.e. {0,1}-valued) functions over time to model states of real-time systems. The duration of a state in a time interval is the accumulated presence time of the state in the interval. DC extends interval logic to a calculus to specify and reason about properties of state durations. The text covers theory (completeness, decidability, undecidability, model-checking), results, as well as case studies (Deadline Driven Scheduler).
This reference book documents the scientific outcome of the DIMACS/SYCON Workshop on Verification and Control of Hybrid Systems, held at Rutgers University in New Brunswick, NJ, in October 1995. A hybrid system consists of digital devices that interact with analog environments. Computer science contributes expertise on the analog aspects of this emerging field of interdisciplinary research and design. The 48 revised full papers included were strictly refereed; they present the state of the art in this dynamic field with contributions by leading experts. Also available are the predecessor volumes published in the same series as LNCS 999 and LNCS 736.
Real-time systems need to react to certain input stimuli within given time bounds. For example, an airbag in a car has to unfold within 300 milliseconds in a crash. There are many embedded safety-critical applications and each requires real-time specification techniques. This text introduces three of these techniques, based on logic and automata: duration calculus, timed automata, and PLC-automata. The techniques are brought together to form a seamless design flow, from real-time requirements specified in the duration calculus; via designs specified by PLC-automata; and into source code for hardware platforms of embedded systems. The syntax, semantics, and proof methods of the specification techniques are introduced; their most important properties are established; and real-life examples illustrate their use. Detailed case studies and exercises conclude each chapter. Ideal for students of real-time systems or embedded systems, this text will also be of great interest to researchers and professionals in transportation and automation.
This book is concerned with Artificial Intelligence (AI) concepts and techniques as applied to industrial decision making, control and automation problems. The field of AI has been expanded enormously during the last years due to that solid theoretical and application results have accumulated. During the first stage of AI development most workers in the field were content with illustrations showing ideas at work on simple problems. Later, as the field matured, emphasis was turned to demonstrations that showed the capability of AI techniques to handle problems of practical value. Now, we arrived at the stage where researchers and practitioners are actually building AI systems that face real-world and industrial

problems. This volume provides a set of twenty four well-selected contributions that deal with the application of AI to such real-life and industrial problems. These contributions are grouped and presented in five parts as follows: Part 1: General Issues Part 2: Intelligent Systems Part 3: Neural Networks in Modelling, Control and Scheduling Part 4: System Diagnostics Part 5: Industrial Robotic, Manufacturing and Organizational Systems Part 1 involves four chapters providing background material and dealing with general issues such as the conceptual integration of qualitative and quantitative models, the treatment of timing problems at system integration, and the investigation of correct reasoning in interactive man-robot systems.

Real-Time Simulation Technologies: Principles, Methodologies, and Applications is an edited compilation of work that explores fundamental concepts and basic techniques of real-time simulation for complex and diverse systems across a broad spectrum. Useful for both new entrants and experienced experts in the field, this book integrates coverage of detailed theory, acclaimed methodological approaches, entrenched technologies, and high-value applications of real-time simulation—all from the unique perspectives of renowned international contributors. Because it offers an accurate and otherwise unattainable assessment of how a system will behave over a particular time frame, real-time simulation is increasingly critical to the optimization of dynamic processes and adaptive systems in a variety of enterprises. These range in scope from the maintenance of the national power grid, to space exploration, to the development of virtual reality programs and cyber-physical systems. This book outlines how, for these and other undertakings, engineers must assimilate real-time data with computational tools for rapid decision making under uncertainty. Clarifying the central concepts behind real-time simulation tools and techniques, this one-of-a-kind resource: Discusses the state of the art, important challenges, and high-impact developments in simulation technologies Provides a basis for the study of real-time simulation as a fundamental and foundational technology Helps readers develop and refine principles that are applicable across a wide variety of application domains As science moves toward more advanced technologies, unconventional design approaches, and unproven regions of the design space, simulation tools are increasingly critical to successful design and operation of technical systems in a growing number of application domains. This must-have resource presents detailed coverage of real-time simulation for system design, parallel and distributed simulations, industry tools, and a large set of applications.

This book presents latest research results on problems and solutions in safety-critical system design. Logic, process algebra, and action/event models are applied to specification, modeling, analysis and verification of real-time and fault-tolerant systems.

Real-Time Systems Engineering and Applications is a well-structured collection of chapters pertaining to present and future developments in real-time systems engineering. After an overview of real-time processing, theoretical foundations

are presented. The book then introduces useful modeling concepts and tools. This is followed by concentration on the more practical aspects of real-time engineering with a thorough overview of the present state of the art, both in hardware and software, including related concepts in robotics. Examples are given of novel real-time applications which illustrate the present state of the art. The book concludes with a focus on future developments, giving direction for new research activities and an educational curriculum covering the subject. This book can be used as a source for academic and industrial researchers as well as a textbook for computing and engineering courses covering the topic of real-time systems engineering.

This book constitutes the refereed proceedings of 10 international workshops held in conjunction with the merged 1998 IPPS/SPDP symposia, held in Orlando, Florida, US in March/April 1998. The volume comprises 118 revised full papers presenting cutting-edge research or work in progress. In accordance with the workshops covered, the papers are organized in topical sections on reconfigurable architectures, run-time systems for parallel programming, biologically inspired solutions to parallel processing problems, randomized parallel computing, solving combinatorial optimization problems in parallel, PC based networks of workstations, fault-tolerant parallel and distributed systems, formal methods for parallel programming, embedded HPC systems and applications, and parallel and distributed real-time systems.

This volume is the proceedings of the Ninth International Conference on the Mathematical Foundations of Programming Semantics, held in New Orleans in April 1993. The focus of the conference series is the semantics of programming languages and the mathematics which supports the study of the semantics. The semantics is basically denotation. The mathematics may be classified as category theory, lattice theory, or logic. Recent conferences and workshops have increasingly emphasized applications of the semantics and mathematics. The study of the semantics develops with the mathematics and the mathematics is inspired by the applications in semantics. The volume presents current research in denotational semantics and applications of category theory, logic, and lattice theory to semantics.

Real-time and embedded systems are essential to our lives, from controlling car engines and regulating traffic lights to monitoring plane takeoffs and landings to providing up-to-the-minute stock quotes. Bringing together researchers from both academia and industry, the Handbook of Real-Time and Embedded Systems provides comprehensive covera

Safety-Critical Real-Time Systems brings together in one place important contributions and up-to-date research results in this fast moving area. Safety-Critical Real-Time Systems serves as an excellent reference, providing insight into some of the most challenging research issues in the field.

This book provides a comprehensive overview of both theoretical and pragmatic aspects of resource-allocation and scheduling in multiprocessor and multicore hard-real-time systems. The authors derive new, abstract models of real-time tasks that capture accurately the salient features of real application systems that are to be implemented on multiprocessor platforms, and identify rules for mapping application systems onto the most appropriate models. New run-time multiprocessor scheduling algorithms are presented, which are demonstrably better than those currently used, both in terms of run-time efficiency and tractability of off-line analysis. Readers will benefit from a new design and analysis framework for multiprocessor real-time

systems, which will translate into a significantly enhanced ability to provide formally verified, safety-critical real-time systems at a significantly lower cost.

This book constitutes the refereed proceedings of the International Workshop on Hybrid and Real-Time Systems, HART'97, held in Grenoble, France, in March 1997. The volume presents 18 revised full papers and 9 short presentations carefully selected during a highly competitive evaluation process; also included are full versions or abstracts of 7 invited papers or tutorials. Hybrid Systems consist of digital devices interacting with analog environments; thus the emerging area lies at the crossroads of computer science and control theory. This book focusses on mathematically sound methods for the rigorous and systematic design and analysis of hybrid systems and real-time systems.

This volume contains papers from the North American Process Algebra Workshop, held in Stony Brook, New York, 28 August 1992. This was the first in a proposed series of workshops, intended to increase awareness of process algebras in the United States and Canada, and to promote their use and development. The workshop was held simultaneously with CONCUR 92, the annual conference on concurrency theories. It provided an important forum for the discussion and exchange of ideas, and allowed recent developments in the application of algebraic techniques to concurrency theory to be presented. The resulting volume provides a good cross-section of current research work in Canada, USA and Europe. Among the specific topics covered are: real-time calculi and expansion theorems; modal logics in timed process algebra; process communication environment; a process calculus with incomparable priorities; exception handling in process algebra; bisimulations on observation structures; computing ready simulations efficiently; analysis of value-passing CCS agents with infinite sorts; an extension of the testing method for processes passing infinite values; constructive semantics; a causality-based semantics for CCS. NAPAW 92 provides an comprehensive overview of this important, up-and-coming area of computer science. It will provide essential reading for both postgraduate students and researchers in industry and academia.

This book presents the revised versions of nine invited lectures presented by leading researchers at the fourth edition of the International School on Formal Methods for the Design of Computer, Communication, and Software Systems, SFT 2004, held in Bertinoro, Italy, September 2004. SFM 2004 is devoted to real-time systems. The lectures presented cover formal models and languages for the specification, modeling, analysis, and verification of time-critical systems, the expressiveness of such models and languages, as well as supporting tools and related applications in different domains. The book offers a unique and comprehensive state-of-the-art survey on real-time systems. Researchers and advanced students will appreciate the book as a valuable source of reference and a systematic guide to the use of formal methods for the specification, analysis, and verification of real-time systems.

This title is devoted to presenting some of the most importantconcepts and techniques for describing real-time systems andanalyzing their behavior in order to enable the designer to achieveguarantees of temporal correctness. Topics addressed include mathematical models of real-timesystems and associated formal verification techniques such as modelchecking, probabilistic modeling and verification, programming anddescription languages, and validation approaches based on testing.With contributions from authors who are experts in their respectivefields, this will provide the reader with the state of the art informal verification of real-time systems and an overview ofavailable software tools.

This book grew out of a NATO Advanced Study Institute summer school that was held in Antalya, TUrkey from 26 May to 6 June 1997. The purpose of the summer school was to expose recent advances in the formal verification of systems composed of both logical and continuous time components. The course was structured in two parts. The first part covered theorem-proving, system automaton models, logics, tools, and

complexity of verification. The second part covered modeling and verification of hybrid systems, i. e. , systems composed of a discrete event part and a continuous time part that interact with each other in novel ways. Along with advances in microelectronics, methods to design and build logical systems have grown progressively complex. One way to tackle the problem of ensuring the error-free operation of digital or hybrid systems is through the use of formal techniques. The exercise of comparing the formal specification of a logical system namely, what it is supposed to do to its formal operational description-what it actually does!-in an automated or semi-automated manner is called verification. Verification can be performed in an after-the-fact manner, meaning that after a system is already designed, its specification and operational description are regenerated or modified, if necessary, to match the verification tool at hand and the consistency check is carried out.

Because almost all technical systems are more or less interfaced with software these days, attacks against computer systems can cause considerable economic and physical damage. For this reason, understanding the dependability of such systems, as well as the improvement of cyber security and its development process, are amongst the most challenging and crucial issues in current computer science research. This book contains the lectures from the NATO Advanced Study Institute (ASI) Summer School entitled Engineering Dependable Software Systems, held in Marktoberdorf, Germany, in July and August 2012. This two week course for young computer scientists and mathematicians working in the field of formal software and systems was designed to give an in-depth presentation of state-of-the-art topics in the field, as well as promoting international contacts and collaboration and the teaming up of leading researchers and young scientists. The 12 lectures delivered at the school and presented here cover subjects including: model-based testing, formal modeling and verification, deductively verified software, model checking, performance analysis, integrating risk analysis, embedded systems and model checking, among others. The book will be of interest to all those whose work involves the development of large-scale, reliable and secure software systems.

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 practitionersOCO secrets."

As a consequence of the wide distribution of software and software infrastructure, information security and safety depend on the quality and excellent understanding of its functioning. Only if this functionality is guaranteed as safe, customer and information are protected against adversarial attacks and malfunction. A vast proportion of

information exchange is dominated by computer systems. Due to the fact that technical systems are more or less interfaced with software systems, most information exchange is closely related to software and computer systems. Information safety and security of software systems depend on the quality and excellent understanding of its functioning. The last few years have shown a renewed interest in formally specifying and verifying software and its role in engineering methods. Within the last decade, interactive program verifiers have been applied to control software and other critical applications. Software model checking has made strides into industrial applications and a number of research tools for bug detection have been built using automatic program-verification technology. Such solutions are high-level programming methods which provide strategies to ensure information security in complex software systems by automatically verified correctness. Based on the specific needs in applications of software technology, models and formal methods must serve the needs and the quality of advanced software engineering methods. This book provides an in-depth presentation of state-of-the-art topics on how to meet such challenges covering both theoretical foundations and industrial practice.

With emphasis on flexible resource management in networked and embedded real-time control systems operating in dynamic environments with uncertainty, this book is devoted to the integration of control with computing and communication. It covers the authors' recent and original research results within a unified framework of feedback scheduling. This useful reference also includes rich example problems, case studies, and extensive references to the literature.

Written by the members of the IFIP Working Group 2.3 (Programming Methodology) this text constitutes an exciting reference on the front-line of research activity in programming methodology. The range of subjects reflects the current interests of the members, and will offer insightful and controversial opinions on modern programming methods and practice. The material is arranged in thematic sections, each one introduced by a problem which epitomizes the spirit of that topic. The exemplary problem will encourage vigorous discussion and will form the basis for an introduction/tutorial for its section.

Models that include a notion of time are ubiquitous in disciplines such as the natural sciences, engineering, philosophy, and linguistics, but in computing the abstractions provided by the traditional models are problematic and the discipline has spawned many novel models. This book is a systematic thorough presentation of the results of several decades of research on developing, analyzing, and applying time models to computing and engineering. After an opening motivation introducing the topics, structure and goals, the authors introduce the notions of formalism and model in general terms along with some of their fundamental classification criteria. In doing so they present the fundamentals of propositional and predicate logic, and essential issues that arise when modeling time across all types of system. Part I is a summary of the models that are traditional in engineering and the natural sciences, including fundamental computer science: dynamical systems and control theory; hardware design; and software algorithmic and complexity analysis. Part II covers advanced and specialized formalisms dealing with time modeling in heterogeneous software-intensive systems: formalisms that share finite state machines as common “ancestors”; Petri nets in many variants; notations based on mathematical logic, such as temporal logic;

process algebras; and “dual-language approaches” combining two notations with different characteristics to model and verify complex systems, e.g., model-checking frameworks. Finally, the book concludes with summarizing remarks and hints towards future developments and open challenges. The presentation uses a rigorous, yet not overly technical, style, appropriate for readers with heterogeneous backgrounds, and each chapter is supplemented with detailed bibliographic remarks and carefully chosen exercises of varying difficulty and scope. The book is aimed at graduate students and researchers in computer science, while researchers and practitioners in other scientific and engineering disciplines interested in time modeling with a computational flavor will also find the book of value, and the comparative and conceptual approach makes this a valuable introduction for non-experts. The authors assume a basic knowledge of calculus, probability theory, algorithms, and programming, while a more advanced knowledge of automata, formal languages, and mathematical logic is useful.

Lecture Notes in Real-Time Intelligent SystemsSpringer

Forthe29thtime,SOFSEM(SOFtwareSEMinar)washeld.Havingtransformed over the years from a local event to a fully international conference, the c- temporary SOFSEM is a mix of a winter school and a conference striving for multidisciplinarity in computer science, accompaniedby workshops dedicated to a narrow ?eld (this year multimedia and softcomputing) and a student forum. This volume constitutes the proceedings of SOFSEM 2002 held in Milovy, Czech Republic, November 22–29, 2002. This year, 23 papers were submitted from 11 countries. The selection of the 11 best papers accepted by the Program Committee was based on their contribution to the state of the art, technical soundness, clarity of presentation, and relevance of bibliography. The Steering Committee supported by the Advisory Board recommended 12 invited talks focusedonthefollowingkeytopicareas:distributedandparallelsystems,system design and testing, databases and information systems, and fundamentals. SOFSEM is the result of considerable e?ort by a number of people. It is our pleasure to record our thanks to the Advisory Board for its support, to the Steering Committee for its general guidance, and to the Organizing Committee for making SOFSEM 2002 happen. It has been an honor for us to work with the members of the Program Committee and other referees who devoted a lot of e?ort to reviewing the submitted papers.

The vast majority of control systems built today are embedded; that is, they rely on built-in, special-purpose digital computers to close their feedback loops. Embedded systems are common in aircraft, factories, chemical processing plants, and even in cars–a single high-end automobile may contain over eighty different computers. The design of embedded controllers and of the intricate, automated communication networks that support them raises many new questions—practical, as well as theoretical—about network protocols, compatibility of operating systems, and ways to maximize the effectiveness of the embedded hardware. This handbook, the first of its kind, provides engineers, computer scientists, mathematicians, and students a broad, comprehensive source of information and technology to address many questions and aspects of embedded and networked control. Separated into six main sections—Fundamentals, Hardware, Software, Theory, Networking, and Applications—this work unifies into a single reference many scattered articles, websites, and specification sheets. Also included are case studies, experiments, and examples that give a multifaceted view of the subject, encompassing computation and communication considerations.

This book constitutes the thoroughly refereed post-proceedings of the Fifth International School and Symposium on Advanced Distributed Systems, ISSADS 2005, held in Guadalajara, Mexico in January 2005. The 50 revised full papers presented were carefully reviewed and selected from over 100 submissions. The papers are organized in topical sections on database systems, distributed and parallel algorithms, real-time distributed systems, cooperative information systems, fault tolerance, information retrieval, modeling and simulation, wireless networks and mobile computing, artificial life and multi agent systems.

Intelligent computing refers greatly to artificial intelligence with the aim at making computer to act as a human. This newly developed area of real-time intelligent computing integrates the aspect of dynamic environments with the human intelligence. This book presents a comprehensive practical and easy to read account which describes current state-of-the art in designing and implementing real-time intelligent computing to robotics, alert systems, IoT, remote access control, multi-agent systems, networking, mobile smart systems, crowd sourcing, broadband systems, cloud computing, streaming data and many other applications areas. The solutions discussed in this book will encourage the researchers and IT professional to put the methods into their practice.

This book presents the proceedings of the 10th International Conference on Fundamentals of Computation Theory, FCT '95, held in Dresden, Germany in August 1995. The volume contains five invited lectures and 32 revised papers carefully selected for presentation at FCT '95. A broad spectrum of theoretical computer science is covered; among topics addressed are algorithms and data structures, automata and formal languages, categories and types, computability and complexity, computational logics, computational geometry, systems specification, learning theory, parallelism and concurrency, rewriting and high-level replacement systems, and semantics.

The Engineering of Complex Real-Time Computer Control Systems brings together in one place important contributions and up-to-date research results in this important area. The Engineering of Complex Real-Time Computer Control Systems serves as an excellent reference, providing insight into some of the most important research issues in the field.

This book constitutes the refereed proceedings of the joint International Conferences Formal Modeling and Analysis of Timed Systems, FORMATS 2004, and Formal Techniques in Real-Time and Fault-Tolerant Systems, FTRTFT 2004, held in Grenoble, France, in September 2004. The 24 revised full papers presented together with abstracts of 2 invited talks were carefully reviewed and selected from 70 submissions. Among the topics addressed are formal verification, voting systems, formal specification, dependable automation systems, model checking, timed automata, real-time testing, fault-tolerance protocols, fail-safe fault tolerance, real-time scheduling, satisfiability checking, symbolic model checking, stochastic hybrid systems, timed Petri nets, and event recording automata.

This book presents the refereed proceedings of the Second International Workshop on Tools and Algorithms for the Construction and Analysis of Systems, TACAS '96, held in Passau, Germany in March 1996. The book presents 19 revised full papers selected from a total of 47 submissions together with 11 tool presentations and 3 invited papers. The collection of papers addresses all current aspects of the design and analysis of

distributed systems; the volume is organized in topical sections on tools, model checking and testing, security, models and methods, case studies, and logic and programs.

This book constitutes the thoroughly refereed post-proceedings of the Third International Conference on Formal Modeling and Analysis of Timed Systems, FORMATS 2005, held in Uppsala, Sweden in September 2005 in conjunction with ARTIST2 summer school on Component Modelling, Testing and Verification, and Static analysis of embedded systems. The 19 revised full papers presented together with the abstracts of 3 invited talks were carefully selected from 43 submissions. The papers cover work on semantics and modeling of timed systems, formalisms for modeling and verification including timed automata, hybrid automata, and timed petri nets, games for verification and synthesis, model-checking, case studies and issues related to implementation, security and performance analysis.

This book constitutes the refereed proceedings of the Fifth International AMAST Workshop on Formal Methods for Real-Time and Probabilistic Systems, ARTS '99, held in Bamberg, Germany in May 1999. The 17 revised full papers presented together with three invited contributions were carefully reviewed and selected from 33 submissions. The papers are organized in topical sections on verification of probabilistic systems, model checking for probabilistic systems, semantics of probabilistic process calculi, semantics of real-time processes, real-time compilation, stochastic process algebra, and modeling and verification of real-time systems.

Cyber-physical systems closely combine and coordinate subsystems consisting of both computational and physical elements. Such systems have become indispensable in the fields of aerospace, automotive and the automation industries, as well as in consumer appliances. Safety, security and reliability are all essential elements of the trustworthiness of these modern cyber-physical systems. Protecting the data within such systems from external attack (security) and protecting the environment from any potential malfunction or misuse of these systems (safety) are subjects traditionally considered separately, but a closer look reveals that techniques for the construction and analysis of the software-based systems used in both security and safety are not necessarily fundamentally different. This book presents papers from the 2016 Marktoberdorf summer school on software engineering, held in Marktoberdorf, Germany, in August 2016. As its title – Dependable Software Systems Engineering – suggests, the lectures at this summer school explored various aspects of the engineering of more dependable software systems, and the 10 lectures included here cover subjects from programming languages and formal analysis tools to verification, validation and assurance. The book will be of interest to all those whose work involves the development and testing of more reliable and secure software systems.

This book constitutes the refereed proceedings of the 6th International Symposium on Formal Techniques in Real-Time and Fault-Tolerant Systems, FTRTFT 2000, held in Pune, India in September 2000. The 21 revised full papers presented together with three invited contributions were carefully reviewed and selected from numerous submissions. The papers are organized in topical sections on model checking, fault tolerance, scheduling, validation, verification, logic and automata.

This volume contains the proceedings of FTRTFT 2002, the International S- posium on Formal Techniques in Real-Time and Fault-Tolerant Systems, held at the University of Oldenburg, Germany, 9–12 September 2002. This sym- sium was the seventh in a series of FTRTFT symposia devoted to problems and solutions in safe system design. The previous symposia took place in Warwick 1990, Nijmegen 1992, Lub ? eck 1994, Uppsala 1996, Lyngby 1998, and Pune 2000. Proceedings of these symposia were published as volumes 331, 571, 863, 1135, 1486, and 1926 in the LNCS series by Springer-Verlag. This year the sym- sium was co-sponsored by IFIP Working Group 2.2 on Formal Description of Programming Concepts. The

symposium presented advances in the development and use of formal techniques in the design of real-time, hybrid, fault-tolerant embedded systems, covering all stages from requirements analysis to hardware and/or software - plementation. Particular emphasis was placed on UML-based development of real-time systems. Through invited presentations, links between the dependable systems and formal methods research communities were strengthened. With the increasing use of such formal techniques in industrial settings, the conference aimed at stimulating cross-fertilization between challenges in industrial usages of formal methods and advanced research.

Inresponsetothecallforpapers,39submissionswerereceived.Eachsubm- sion was reviewed by four program committee members assisted by additional referees. At the end of the reviewing process, the program committee accepted 17 papers for presentation at the symposium.

This tutorial volume originates from the 4th Advanced Course on Petri Nets, ACPN 2003, held in Eichsttt, Germany in September 2003. In addition to lectures given at ACPN 2003, additional chapters have been commissioned to give a well-balanced presentation of the state of the art in the area. This book will be useful as both a reference for those working in the area as well as a study book for the reader who is interested in an up-to-date overview of research and development in concurrent and distributed systems; of course, readers specifically interested in theoretical or applicational aspects of Petri nets will appreciate the book as well.

A large class of computing systems can be speci?ed and veri?ed by abstracting away from the temporal aspects of their behavior. Inreal-timesystems,instead, time issues become essential. Their correctness depends not only on which - tions they can perform, but also on the action execution time. Due to their importance and design challenges, real-time systems have attracted the att- tion 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 theInternational School on Formal Methods for the Design of C- puter,Communication andSoftware Systems (SFM). The school addressed the use of formal methods in computer science as a prominent approach to the r- orous design of computer, communication and software systems. The main aim of the SFM series is to o?er 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 ?eld. SFM-04:RT was devoted to real-time systems. It covered formal models and languagesforthespeci?cation,modeling,analysis,andveri?cationoftheseti- critical systems, the expressiveness of such models and languages, as well as supporting tools and related applications in di?erent domains.

Our understanding of real-time systems is rapidly approaching a level of maturity which calls for a consolidation of our present knowledge and experience. Particularly effective in influencing our understanding has been the conjoining of universal algebra with the theory and practice of real-time system development. This interplay between algebraic methodology and software technology (AMAST) for real-time systems is the theme for this text. Each chapter, derived from papers presented at the all-invitation 1st AMAST International Workshop on Real-Time Systems (Iowa, 1993), is written by leaders in their field. The chapters form an intriguing mix of modeling, specification, verification, and implementation of “real” real-time systems. They cover untimed and timed systems, sequential, concurrent and embedded real-time processes, integrated models using state machines, temporal logic and algebraic data models, real-time CSP, verification tools, system design using temporal logic, symbolic checking of discrete time models, iterative symbolic approximation in timing verification and verification of audio protocols, timed full LOTOS and timed LOTOS extensions, LOTOS specification of telephone services and flight warning computers, and performance analysis. Contents:Real-Time System = Discrete System + Clock VariablesReal-Time CSPVisual Tools for Verifying Real-Time SystemsDesigning Supervisors for Real-Time SystemsReal-Time Symbolic Model

Checking for Discrete Time ModelsVerification of an Audio Control ProtocolApproximations for Verifying Timing PropertiesA Timed Full LOTOS with Time/Action Tree SemanticsA Timed LOTOS ExtensionStatus-Oriented Telephone Service SpecificationExperimenting with LOTOS in the Aerospace IndustryPerformance Analysis and True Concurrency SemanticsState Machines, Temporal Logic and Algebraic Data ModelsAn Experiment in Developing Real-Time Systems Using Mec Readership: Computer scientists and software engineers. keywords:System, Time;Temporal Logic;Real Time System;Verification;Model Checking;Symbolic Model Checking;Control Protocol;Timing Properties;Performance Analysis;LOTOS;LOTOS Extension;State Machine;Visual Tools;Supervisory Tools;MEC System “… an interesting combination of papers devoted to the formal specification and verification of real-time systems. The diversity of approaches and the treatment of the subject from various angles work very much in its favour … recommend the book to anyone interested in the formal description of real-time systems' behavior.” Control Engineering Practice