FOUNDATIONS OF REAL-TIME COMPUTING
Formal Specifications and Methods

edited by

André M. van Tilborg
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Foundations Of Real Time Computing Formal Specifications And Methods

R.J. Linn,M.Ü. Uyar

Foundations Of Real Time Computing Formal Specifications And Methods:

   Foundations of Real-Time Computing: Scheduling and Resource Management André M. van Tilborg,Gary M. Koob,2012-12-06 This volume contains a selection of papers that focus on the state of the art in real time scheduling and resource management Preliminary versions of these papers were presented at a workshop on the foundations of real time computing sponsored by the Office of Naval Research in October 1990 in Washington D C A companion volume by the title Foundations of Real Time Computing Fonnal Specifications and Methods complements this book by addressing many of the most advanced approaches currently being investigated in the arena of formal specification and verification of real time systems Together these two texts provide a comprehensive snapshot of current insights into the process of designing and building real time computing systems on a scientific basis Many of the papers in this book take care to define the notion of real time system precisely because it is often easy to misunderstand what is meant by that term Different communities of researchers variously use the term real time to refer to either very fast computing or immediate on line data acquisition or deadline driven computing This text is concerned with the very difficult problems of scheduling tasks and resource management in computer systems whose performance is inextricably fused with the achievement of deadlines Such systems have been enabled for a rapidly increasing set of diverse end uses by the unremitting advances in computing power per constant dollar cost and per constant unit volume of space End use applications of deadline driven real time computers span a spectrum that includes transportation systems robotics and manufacturing aerospace and defense industrial process control and telecommunications   *Foundations of Real-Time Computing: Formal Specifications and Methods* André M. van Tilborg,Gary M. Koob,2013-09-14 This volume contains a selection of papers that focus on the state of the art in formal specification and verification of real time computing systems Preliminary versions of these papers were presented at a workshop on the foundations of real time computing sponsored by the Office of Naval Research in October 1990 in Washington D C A companion volume by the title Foundations of Real Time Computing Scheduling and Resource Management complements this hook by addressing many of the recently devised techniques and approaches for scheduling tasks and managing resources in real time systems Together these two texts provide a comprehensive snapshot of current insights into the process of designing and building real time computing systems on a scientific basis The notion of real time system has alternative interpretations not all of which are intended usages in this collection of papers Different communities of researchers variously use the term real time to refer to either very fast computing or immediate on line data acquisition or deadline driven computing This text is concerned with the formal specification and verification of computer software and systems whose correct performance is dependent on carefully orchestrated interactions with time e g meeting deadlines and synchronizing with clocks Such systems have been enabled for a rapidly increasing set of diverse end uses by the unremitting advances in computing power per constant dollar cost and per constant unit volume of space End use applications of real

time computers span a spectrum that includes transportation systems robotics and manufacturing aerospace and defense industrial process control and telecommunications   **Foundations of Real-Time Computing: Formal Specifications and Methods** André M. van Tilborg,Gary M. Koob,1991 This volume contains a selection of papers that focus on the state of the art in formal specification and verification of real time computing systems Preliminary versions of these papers were presented at a workshop on the foundations of real time computing sponsored by the Office of Naval Research in October 1990 in Washington D C A companion volume by the title Foundations of Real Time Computing Scheduling and Resource Management complements this hook by addressing many of the recently devised techniques and approaches for scheduling tasks and managing resources in real time systems Together these two texts provide a comprehensive snapshot of current insights into the process of designing and building real time computing systems on a scientific basis The notion of real time system has alternative interpretations not all of which are intended usages in this collection of papers Different communities of researchers variously use the term real time to refer to either very fast computing or immediate on line data acquisition or deadline driven computing This text is concerned with the formal specification and verification of computer software and systems whose correct performance is dependent on carefully orchestrated interactions with time e g meeting deadlines and synchronizing with clocks Such systems have been enabled for a rapidly increasing set of diverse end uses by the unremitting advances in computing power per constant dollar cost and per constant unit volume of space End use applications of real time computers span a spectrum that includes transportation systems robotics and manufacturing aerospace and defense industrial process control and telecommunications   **Formal Techniques in Real-Time and Fault-Tolerant Systems** Jan Vytopil,2012-12-06 Formal Techniques in Real Time and Fault Tolerant Systems focuses on the state of the art in formal specification development and verification of fault tolerant computing systems The term fault tolerance refers to a system having properties which enable it to deliver its specified function despite certain faults of its subsystem Fault tolerance is achieved by adding extra hardware and or software which corrects the effects of faults In this sense a system can be called fault tolerant if it can be proved that the resulting extended system under some model of reliability meets the reliability requirements The main theme of Formal Techniques in Real Time and Fault Tolerant Systems can be formulated as follows how do the specification development and verification of conventional and fault tolerant systems differ How do the notations methodology and tools used in design and development of fault tolerant and conventional systems differ Formal Techniques in Real Time and Fault Tolerant Systems is divided into two parts The chapters in Part One set the stage for what follows by defining the basic notions and practices of the field of design and specification of fault tolerant systems The chapters in Part Two represent the how to section containing examples of the use of formal methods in specification and development of fault tolerant systems The book serves as an excellent reference for researchers in both academia and industry and may be used as a text for advanced courses on the subject   **Formal Methods and Hybrid Real-Time Systems** Cliff B. Jones,Zhiming

Liu,Jim Woodcock,2007-09-04 This Festschrift volume is published to honour both Dines Bj rner and Zhou Chaochen on the occasion of their 70th birthdays The volume includes 25 refereed papers by leading researchers current and former colleagues who congregated at a celebratory symposium held in Macao China in the course of the International Colloquium on Theoretical Aspects of Computing ICTAC 2007 The papers cover a broad spectrum of subjects **Real-Time Database Systems** Azer Bestavros,Kwei-Jay Lin,Sang Hyuk Son,2012-12-06 Despite the growing interest in Real Time Database Systems there is no single book that acts as a reference to academics professionals and practitioners who wish to understand the issues involved in the design and development of RTDBS Real Time Database Systems Issues and Applications fulfills this need This book presents the spectrum of issues that may arise in various real time database applications the available solutions and technologies that may be used to address these issues and the open problems that need to be tackled in the future With rapid advances in this area several concepts have been proposed without a widely accepted consensus on their definitions and implications To address this need the first chapter is an introduction to the key RTDBS concepts and definitions which is followed by a survey of the state of the art in RTDBS research and practice The remainder of the book consists of four sections models and paradigms applications and benchmarks scheduling and concurrency control and experimental systems The chapters in each section are contributed by experts in the respective areas Real Time Database Systems Issues and Applications is primarily intended for practicing engineers and researchers working in the growing area of real time database systems For practitioners the book will provide a much needed bridge for technology transfer and continued education For researchers this book will provide a comprehensive reference for well established results This book can also be used in a senior or graduate level course on real time systems real time database systems and database systems or closely related courses Hard Real-Time Computing Systems Giorgio C Buttazzo,2007-08-19 Real time computing plays a crucial role in our society since an increasing num ber of complex systems rely in part or completely on processor control Ex amples of applications that require real time computing include nuclear power plants railway switching systems automotive electronics air traffic control telecommunications robotics and military systems In spite of this large application domain most of the current real time systems are still designed and implemented using low level programming and empirical techniques without the support of a scientific methodology This approach results in a lack of reliability which in critical applications may cause serious environmental damage or even loss of life This book is a basic treatise on real time computing with particular emphasis on predictable scheduling algorithms The main objectives of the book are to introduce the basic concepts of real time computing illustrate the most sig nificant results in the field and provide the basic methodologies for designing predictable computing systems useful in supporting critical control applica tions The book is written for instructional use and is organized to enable readers without a strong knowledge of the subject matter to quickly grasp the material Technical concepts are clearly defined at the beginning of each chapter and algorithm descriptions are reinforced

through concrete examples illustrations and tables **Real-Time Database Systems** Kam-Yiu Lam,Tei-Wei Kuo,2006-04-18 In recent years tremendous research has been devoted to the design of database systems for real time applications called real time database systems RTDBS where transactions are associated with deadlines on their completion times and some of the data objects in the database are associated with temporal constraints on their validity Examples of important applications of RTDBS include stock trading systems navigation systems and computer integrated manufacturing Different transaction scheduling algorithms and concurrency control protocols have been proposed to satisfy transaction timing data temporal constraints Other design issues important to the performance of a RTDBS are buffer management index accesses and I O scheduling Real Time Database Systems Architecture and Techniques summarizes important research results in this area and serves as an excellent reference for practitioners researchers and educators of real time systems and database systems

    Real-Time Systems Hermann Kopetz,2006-04-18 7 6 Performance Comparison ET versus TT 164 7 7 The Physical Layer 166 Points to Remember 168 Bibliographic Notes 169 Review Questions and Problems 170 Chapter 8 The Time Triggered Protocols 171 Overview 171 8 1 Introduction to Time Triggered Protocols 172 8 2 Overview of the TTP C Protocol Layers 175 8 3 TheBasic CNI 178 Internal Operation of TTP C 181 8 4 8 5 TTP A for Field Bus Applications 185 Points to Remember 188 Bibliographic Notes 190 Review Questions and Problems 190 Chapter 9 Input Output 193 Overview 193 9 1 The Dual Role of Time 194 9 2 Agreement Protocol 196 9 3 Sampling and Polling 198 9 4 Interrupts 201 9 5 Sensors and Actuators 203 9 6 Physical Installation 207 Points to Remember 208 Bibliographic Notes 209 Review Questions and Problems 209 Chapter 10 Real Time Operating Systems 211 Overview 211 10 1 Task Management 212 10 2 Interprocess Communication 216 10 3 Time Management 218 10 4 Error Detection 219 10 5 A Case Study ERCOS 221 Points to Remember 223 Bibliographic Notes 224 Review Questions and Problems 224 Chapter 11 Real Time Scheduling 227 Overview 227 11 1 The Scheduling Problem 228 11 2 The Adversary Argument 229 11 3 Dynamic Scheduling 231 x TABLE OF CONTENTS 11 4 Static Scheduling 237 Points to Remember 240 Bibliographic Notes 242 Review Questions and Problems 242 Chapter 12 Validation 245 Overview 245 12 1 Building aConvincing Safety Case 246 12 2 Formal Methods 248 12 3 Testing **Event-Triggered and Time-Triggered Control Paradigms** Roman Obermaisser,2006-01-27 Event Triggered and Time Triggered Control Paradigms presents a valuable survey about existing architectures for safety critical applications and discusses the issues that must be considered when moving from a federated to an integrated architecture The book focuses on one key topic the amalgamation of the event triggered and the time triggered control paradigm into a coherent integrated architecture The architecture provides for the integration of independent distributed application subsystems by introducing multi criticality nodes and virtual networks of known temporal properties The feasibility and the tangible advantages of this new architecture are demonstrated with practical examples taken from the automotive industry Event Triggered and Time Triggered Control Paradigms offers significant insights into the architecture and design of integrated embedded systems both at the conceptual

and at the practical level   *Real-Time Database and Information Systems: Research Advances* Azer Bestavros,Victor Fay-Wolfe,2012-12-06 Real time systems are defined as those for which correctness depends not only on the logical properties of the produced results but also on the temporal properties of these results In a database real time means that in addition to typical logical consistency constraints such as a constraint on a data item s value there are constraints on when transactions execute and on the freshness of the data transactions access The challenges and tradeoffs faced by the designers of real time database systems are quite different from those faced by the designers of general purpose database systems To achieve the fundamental requirements of timeliness and predictability not only do conventional methods for scheduling and transaction management have to be redesigned but also new concepts that have not been considered in conventional database systems or in real time systems need to be added Real Time Database and Information Systems Research Advances is devoted to new techniques for scheduling of transactions concurrency management transaction logging database languages and new distributed database architectures Real Time Database and Information Systems Research Advances is primarily intended for practicing engineers and researchers working in the growing area of real time database and information retrieval systems For practitioners the book will provide a much needed bridge for technology transfer and continued education For researchers the book will provide a comprehensive reference for well established results The book can also be used in a senior or graduate level course on real time systems real time database systems and database systems or closely related courses   **Deadline Scheduling for Real-Time Systems** John A. Stankovic,Marco Spuri,Krithi Ramamritham,Giorgio C Buttazzo,2012-12-06 Many real time systems rely on static scheduling algorithms This includes cyclic scheduling rate monotonic scheduling and fixed schedules created by off line scheduling techniques such as dynamic programming heuristic search and simulated annealing However for many real time systems static scheduling algorithms are quite restrictive and inflexible For example highly automated agile manufacturing command control and communications and distributed real time multimedia applications all operate over long lifetimes and in highly non deterministic environments Dynamic real time scheduling algorithms are more appropriate for these systems and are used in such systems Many of these algorithms are based on earliest deadline first EDF policies There exists a wealth of literature on EDF based scheduling with many extensions to deal with sophisticated issues such as precedence constraints resource requirements system overload multi processors and distributed systems Deadline Scheduling for Real Time Systems EDF and Related Algorithms aims at collecting a significant body of knowledge on EDF scheduling for real time systems but it does not try to be all inclusive the literature is too extensive The book primarily presents the algorithms and associated analysis but guidelines rules and implementation considerations are also discussed especially for the more complicated situations where mathematical analysis is difficult In general it is very difficult to codify and taxonomize scheduling knowledge because there are many performance metrics task characteristics and system configurations Also adding to the complexity is the fact that a

variety of algorithms have been designed for different combinations of these considerations In spite of the recent advances there are still gaps in the solution space and there is a need to integrate the available solutions For example a list of issues to consider includes preemptive versus non preemptive tasks uni processors versus multi processors using EDF at dispatch time versus EDF based planning precedence constraints among tasks resource constraints periodic versus aperiodic versus sporadic tasks scheduling during overload fault tolerance requirements and providing guarantees and levels of guarantees meeting quality of service requirements Deadline Scheduling for Real Time Systems EDF and Related Algorithms should be of interest to researchers real time system designers and instructors and students either as a focussed course on deadline based scheduling for real time systems or more likely as part of a more general course on real time computing The book serves as an invaluable reference in this fast moving field   Design Methods for Reactive Systems Roel Wieringa,2003 This book provides a framework for software design that shows where the techniques and approaches of design methods for software systems fit in It discusses three methods in detail and demonstrates how to pick techniques from each of them It also shows how to follow problem solving steps that focus on the design problem rather than on the method

     Fault-Tolerant Real-Time Systems Stefan Poledna,2007-11-23 Real time computer systems are very often subject to dependability requirements because of their application areas Fly by wire airplane control systems control of power plants industrial process control systems and others are required to continue their function despite faults Fault tolerance and real time requirements thus constitute a kind of natural combination in process control applications Systematic fault tolerance is based on redundancy which is used to mask failures of individual components The problem of replica determinism is thereby to ensure that replicated components show consistent behavior in the absence of faults It might seem trivial that given an identical sequence of inputs replicated computer systems will produce consistent outputs Unfortunately this is not the case The problem of replica non determinism and the presentation of its possible solutions is the subject of Fault Tolerant Real Time Systems The Problem of Replica Determinism The field of automotive electronics is an important application area of fault tolerant real time systems Systems like anti lock braking engine control active suspension or vehicle dynamics control have demanding real time and fault tolerance requirements These requirements have to be met even in the presence of very limited resources since cost is extremely important Because of its interesting properties Fault Tolerant Real Time Systems gives an introduction to the application area of automotive electronics The requirements of automotive electronics are a topic of discussion in the remainder of this work and are used as a benchmark to evaluate solutions to the problem of replica determinism   Protocol Specification, Testing and Verification, XII R.J. Linn,M.Ü. Uyar,2016-09-20 For more than a decade researchers and engineers have been addressing the problem of the application of formal description techniques to protocol specification implementation testing and verification This book identifies the many successes that have been achieved within the industrial framework and the difficulties encountered in applying theoretical methods to practical situations Issues

discussed include testing and certification verification validation environments and automated tools formal specifications protocol conversion implementation specification languages and models Consideration is also given to the concerns surrounding education available to students and the need to upgrade and develop this through sponsorship of a study of an appropriate curriculum at both undergraduate and graduate levels It is hoped this publication will stimulate such support and inspire further research in this important arena   Responsive Computer Systems: Steps Toward Fault-Tolerant Real-Time Systems Donald Fussell,Miroslaw Malek,2012-12-06 Responsive Computer Systems Steps Towards Fault Tolerant Real Time Systems provides an extensive treatment of the most important issues in the design of modern Responsive Computer Systems It lays the groundwork for a more comprehensive model that allows critical design issues to be treated in ways that more traditional disciplines of computer research have inhibited It breaks important ground in the development of a fruitful modern perspective on computer systems as they are currently developing and as they may be expected to develop over the next decade Audience An interesting and important road map to some of the most important emerging issues in computing suitable as a secondary text for graduate level courses on responsive computer systems and as a reference for industrial practitioners   **The Testability of Distributed Real-Time Systems** Werner Schütz,2007-07-23 BY H KOPETZ A real time computer system must provide the intended service in two di mensions the functional value dimension and the temporal dimension The verification of a real time system implementation is thus necessarily more com plex than the verification of a non real time system which has to be checked in the value dimension only Since the formal verification techniques of temporal properties have not yet matured to the point where these techniques can be used in practical system development systematic design and testing are the only alternatives for the development of dependable real time systems At present up to and more than fifty percent of the development eff ort of complex real time computer systems is spent on testing The test activities are thus a significant cost element in any real time system project The attack on this cost element has to proceed from two fronts the design for testability and the development of a systematic test methodology supported by an appropriate tool set This book covers both of these topics   **Real-Time Systems Engineering and Applications** Michael Schiebe,Saskia Pferrer,2007-08-28 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 **Imprecise and Approximate Computation** Swaminathan Natarajan,2007-08-26 Real time systems are now used in a wide variety of applications Conventionally they were configured at design to perform a given set of tasks and could not readily adapt to dynamic situations The concept of imprecise and approximate computation has emerged as a promising approach to providing scheduling flexibility and enhanced dependability in dynamic real time systems The concept can be utilized in a wide variety of applications including signal processing machine vision databases networking etc For those who wish to build dynamic real time systems which must deal safely with resource unavailability while continuing to operate leading to situations where computations may not be carried through to completion the techniques of imprecise and approximate computation facilitate the generation of partial results that may enable the system to operate safely and avert catastrophe Audience Of special interest to researchers May be used as a supplementary text in courses on real time systems Constructing Predictable Real Time Systems Alexander D. Stoyenko,2012-12-06

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