

Real-Time Scheduling

- Primary goal: ensure predictability
- Secondary goal: ensure predictability
- Typical metrics:
 - Guarantee miss ration = 0 (hard real-time)
 - Guarantee Probability(missed deadline) < X% (firm real-time)
 - Minimize miss ration / maximize completion ration (firm real-time)
 - Minimize overall tardiness; maximize overall usefulness (soft real-time)
- E.g., EDF (Earliest Deadline First, LLF (Least Laxity First), RMS (Rate-Monotonic Scheduling), DM (Deadline Monotonic Scheduling)
- Recall: Real-time is about enforcing predictability, and does not equal to fast computing!!!

Scheduling In Real Time Systems

Giorgio Buttazzo



Scheduling In Real Time Systems:

Scheduling in Real-Time Systems Francis Cottet, Joëlle Delacroix, Claude Kaiser, Zoubir Mammeri, 2002-11-22 Real time systems are used in a wide range of applications including command and control systems flight control telecommunication systems and online purchase payment Provides an accessible yet comprehensive treatment of real time computing and communications systems Outlines the basics of real time scheduling and scheduling policies designed for real time applications Each chapter contains examples and case studies along with test exercises and solutions Deadline

Scheduling for Real-Time Systems John A. Stankovic, Marco Spuri, Krithi Ramamritham, Giorgio Buttazzo, 1998-10-31 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 Multiprocessor Scheduling for Real-Time Systems Sanjoy Baruah, Marko Bertogna, Giorgio

Buttazzo,2015-01-02 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 **Real-Time Systems Design and Analysis** Phillip A.

Laplante,2004-04-26 The leading guide to real time systems design revised and updated This third edition of Phillip Laplante s bestselling practical guide to building real time systems maintains its predecessors unique holistic systems based approach devised to help engineers write problem solving software Dr Laplante incorporates a survey of related technologies and their histories complete with time saving practical tips hands on instructions C code and insights into decreasing ramp up times Real Time Systems Design and Analysis Third Edition is essential for students and practicing software engineers who want improved designs faster computation and ultimate cost savings Chapters discuss hardware considerations and software requirements software systems design the software production process performance estimation and optimization and engineering considerations This new edition has been revised to include Up to date information on object oriented technologies for real time including object oriented analysis design and languages such as Java C and C Coverage of significant developments in the field such as New life cycle methodologies and advanced programming practices for real time including Agile methodologies Analysis techniques for commercial real time operating system technology Hardware advances including field programmable gate arrays and memory technology Deeper coverage of Scheduling and rate monotonic theories Synchronization and communication techniques Software testing and metrics Real Time Systems Design and Analysis Third Edition remains an unmatched resource for students and practicing software engineers who want improved designs faster computation and ultimate cost savings Real-Time Systems Rajib Mall,2009-05 The presence and use of real time systems is becoming increasingly common Examples of such systems range from nuclear reactors to automotive controllers and also entertainment software such as games and graphics animation The growing importance of rea

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

Real-Time Systems Jane W. S. Liu, 2000 This text describes not only how but also why through insightful illustrative examples Real Time Systems is both a valuable reference for professionals and an advanced text for Computer Science and Computer Engineering students

BOOK JACKET Real-Time and Embedded Computing Systems and Applications Jing Chen, Seongsoo Hong, 2004-04-08 This volume contains the 37 papers presented at the 9th International Conference on Real Time and Embedded Computing Systems and Applications RTCSA 2003 RTCSA is an international conference organized for scientists and researchers from both academia and industry to hold intensive discussions on advancing technologies topics on real time systems embedded systems ubiquitous pervasive computing and related topics RTCSA 2003 was held at the Department of Electrical Engineering of National Cheng Kung University in Taiwan Paper submissions were well distributed over the various aspects of real time computing and embedded system technologies There were more than 100 participants from all over the world The papers including 28 regular papers and 9 short papers are grouped into the categories of scheduling networking and communication embedded systems pervasive ubiquitous computing systems and architectures resource management systems and databases performance analysis and tools and development The grouping is basically in accordance with the conference program Earlier versions of these papers were published in the conference proceedings However some papers in this volume have been modified or improved by the authors in various aspects based on comments and feedback received at the conference It is our sincere hope that researchers and developers will benefit from these papers We would like to thank all the authors of the papers for their contribution We thank the members of the program committee and the reviewers for their excellent work in evaluating the submissions We are also very grateful to all the members of the organizing committees for their help guidance and support

Hard Real-Time Computing Systems Giorgio C Buttazzo, 2011-09-10 This updated edition offers an indispensable exposition on real time computing with particular emphasis on predictable scheduling algorithms It introduces the fundamental concepts of real time computing demonstrates the most significant results in the field and provides the essential

methodologies for designing predictable computing systems used to support time critical control applications Along with an in depth guide to the available approaches for the implementation and analysis of real time applications this revised edition contains a close examination of recent developments in real time systems including limited preemptive scheduling resource reservation techniques overload handling algorithms and adaptive scheduling techniques This volume serves as a fundamental advanced level textbook Each chapter provides basic concepts which are followed by algorithms illustrated with concrete examples figures and tables Exercises and solutions are provided to enhance self study making this an excellent reference for those interested in real time computing for designing and or developing predictable control applications

Resource Management in Real-time Systems and Networks C. Siva Ram Murthy,G. Manimaran,2001 This book introduces the concepts and state of the art research developments of resource management in real time systems and networks Real time systems and networks are of increasing importance in many applications including automated factories telecommunication systems defense systems and space systems This book introduces the concepts and state of the art research developments of resource management in real time systems and networks Unlike other texts in the field it covers the entire spectrum of issues in resource management including task scheduling in uniprocessor real time systems task scheduling fault tolerant task scheduling and resource reclaiming in multiprocessor real time systems conventional task scheduling and object based task scheduling in distributed real time systems message scheduling QoS routing dependable communication multicast communication and medium access protocols in real time networks It provides algorithmic treatments for all of the issues addressed highlighting the intuition behind each algorithm and giving examples The book also includes two chapters of case studies

Soft Real-Time Systems: Predictability vs. Efficiency Giorgio C Buttazzo,Giuseppe Lipari,Luca Abeni,Marco Caccamo,2006-07-02 Hard real time systems are very predictable but not sufficiently flexible to adapt to dynamic situations They are built under pessimistic assumptions to cope with worst case scenarios so they often waste resources Soft real time systems are built to reduce resource consumption tolerate overloads and adapt to system changes They are also more suited to novel applications of real time technology such as multimedia systems monitoring apparatuses telecommunication networks mobile robotics virtual reality and interactive computer games This unique monograph provides concrete methods for building flexible predictable soft real time systems in order to optimize resources and reduce costs It is an invaluable reference for developers as well as researchers and students in Computer Science

Hard Real-Time Computing Systems Giorgio Buttazzo,2010-12-01 Hard Real Time Computing Systems Predictable Scheduling Algorithms and Applications is a basic treatise on real time computing with particular emphasis on predictable scheduling algorithms It introduces the fundamental concepts of real time computing illustrates the most significant results in the field and provides the essential methodologies for designing predictable computing systems which can be used to support critical control applications This volume serves as a textbook for advanced level courses on the topic

Each chapter provides basic concepts which are followed by algorithms that are illustrated with concrete examples figures and tables Exercises are included with each chapter and solutions are given at the end of the book The book also provides an excellent reference for those interested in real time computing for designing and or developing predictable control applications

Embedded and Real Time System Development: A Software Engineering Perspective Mohammad Ayoub Khan, Saqib Saeed, Ashraf Darwish, Ajith Abraham, 2013-11-19 Nowadays embedded and real time systems contain complex software The complexity of embedded systems is increasing and the amount and variety of software in the embedded products are growing This creates a big challenge for embedded and real time software development processes and there is a need to develop separate metrics and benchmarks

Embedded and Real Time System Development A Software Engineering Perspective Concepts Methods and Principles presents practical as well as conceptual knowledge of the latest tools techniques and methodologies of embedded software engineering and real time systems Each chapter includes an in depth investigation regarding the actual or potential role of software engineering tools in the context of the embedded system and real time system The book presents state of the art and future perspectives with industry experts researchers and academicians sharing ideas and experiences including surrounding frontier technologies breakthroughs innovative solutions and applications The book is organized into four parts Embedded Software Development Process Design Patterns and Development Methodology Modelling Framework and Performance Analysis Power Management and Deployment with altogether 12 chapters The book is aiming at i undergraduate students and postgraduate students conducting research in the areas of embedded software engineering and real time systems ii researchers at universities and other institutions working in these fields and iii practitioners in the R D departments of embedded system It can be used as an advanced reference for a course taught at the postgraduate level in embedded software engineering and real time systems

Feedback-based Task Scheduling in Real-time Systems Suzhen Lin, 2005 Real time computing is an enabling technology for many current and next generation applications One of the key components of real time systems is the scheduling of tasks the objective of which is to meet task deadlines predictably Traditional real time task scheduling paradigms perform well in static or dynamic systems in which the workload can be accurately modeled Unfortunately in many complex applications unpredictable dynamic factors exist due to which precise workload characterization is difficult In recent years feedback control techniques have been successfully applied to address the issue of unpredictable workload in computing systems In this dissertation we develop feedback based algorithms and analysis for some important dynamic scheduling problems in real time systems First we address the problem of selective herbicide spraying in precision farming application The goal is to achieve low weed miss ratio and high CPU utilization We carry out system identification vehicle modeling and controller design In our design the requested CPU utilization is fed back and the vehicle speed is controlled The system model is verified and performance evaluation is carried out through simulation studies The second problem is task scheduling based on m k firm deadline

constraints in real time systems The proposed solution feeds back the current dynamic failure rate DFR and adjusts the task s QoS based on DFR on line We also propose a novel fairness metric to evaluate the fairness in QoS among tasks achieved by the scheduler The simulation results show that the QoS of tasks can be improved significantly while keeping the DFR below a certain threshold The third problem is combined task scheduling with fault tolerance in real time systems In our model the rate monotonic scheduling algorithm and deferrable server algorithm are used to schedule periodic and aperiodic tasks respectively By using feedback control technique we adjust the capacity of the deferrable servers based on the failure rate of the periodic tasks The performances of the systems are evaluated through simulation studies The last problem is task scheduling in distributed real time systems We propose a double loop scheme to keep the deadline miss ratio close to the set point and maximize the CPU utilization and analyze the stability of the system in Z domain We also propose a global scheduling method to achieve load balancing by using a suitable load index The performances of the systems are evaluated through simulation studies The feedback based solutions proposed in this dissertation are based on the principle of controlling the trade off between deadline miss ratio and resource utilization This idea can be adapted not only to other scheduling problems in real time systems but also to scheduling problems in non real time systems

Deadline

Scheduling for Real-Time Systems John A. Stankovic,Marco Spuri,Krithi Ramamritham,2011-05-01

Real-Time

Systems and Embedded Software: Techniques, Challenges, and Applications Sudharsan Vaidhun bhaskar Dr. Shubhi Gupta,2025-01-18 In an era dominated by technology real time systems and embedded software have become the backbone of countless critical applications from aerospace and automotive systems to industrial automation and healthcare devices These systems demand precision reliability and performance often operating under stringent time constraints where even a millisecond can make the difference between success and failure Real Time Systems and Embedded Software Techniques Challenges and Applications is designed to serve as a definitive resource for professionals researchers and students eager to explore the complexities of designing and implementing these systems The book addresses both foundational principles and advanced methodologies providing readers with the knowledge needed to navigate this dynamic and challenging domain This book covers Core concepts and architectures of real time systems Techniques for designing and analyzing time critical embedded software Challenges in resource constrained environments and strategies to overcome them Applications across industries including automotive telecommunications and IoT Emerging trends such as edge computing AI integration and cybersecurity in real time systems By combining theoretical insights with practical examples this book aims to bridge the gap between academia and industry Each chapter is designed to offer actionable knowledge that can be applied directly to real world projects whether you re optimizing a real time operating system or developing embedded solutions for cutting edge applications The field of real time systems and embedded software continues to evolve at a rapid pace driven by advances in hardware software and connectivity This book not only provides a thorough understanding of current best practices but also

prepares readers to anticipate and adapt to future developments Authors *Operating System (A Practical App)* Rajiv Chopra, 2009 For the Students of B E B Tech M E M Tech Operating Systems A Practical Approach which covers the syllabi of B Tech B E CSE IT M Tech M E CSE IT BCA MCA of many universities of India like Delhi University GGSIPU Delhi UPTU Lucknow WBUT RGPV MDU etc **Real-Time Systems, Architecture, Scheduling, and Application** Seyed Morteza Babamir, 2012-04-11 This book is a rich text for introducing diverse aspects of real time systems including architecture specification and verification scheduling and real world applications It is useful for advanced graduate students and researchers in a wide range of disciplines impacted by embedded computing and software Since the book covers the most recent advances in real time systems and communications networks it serves as a vehicle for technology transition within the real time systems community of systems architects designers technologists and system analysts Real time applications are used in daily operations such as engine and break mechanisms in cars traffic light and air traffic control and heart beat and blood pressure monitoring This book includes 15 chapters arranged in 4 sections Architecture chapters 1 4 Specification and Verification chapters 5 6 Scheduling chapters 7 9 and Real word applications chapters 10 15 **Scheduling in Real-time Systems to Ensure Graceful Degradation** Wei-Kuan Shih, 1992 *Active, Real-Time, and Temporal Database Systems* Sten F. Andler, Jörgen Hansson, 1999-02-24 This book constitutes the thoroughly refereed post workshop proceedings of the Second International Workshop on Active Real Time and Temporal Database Systems ARTDB 97 held in Como Italy in September 1997 The nine revised full papers presented were carefully reviewed and selected from a total of 17 submissions Also included are an introductory survey chapter and three invited papers written by prominent researchers in the field as well as two summaries of the panel discussions held at the workshop The papers are devoted to the issue of building database systems supporting reactive behaviour while enforcing timeliness and predictability

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 Exfoliative toxin from Staph. aureus. Fever, red raised blistering skin, peeling skin. Culture baby's nose and ... CASE
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