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## Modular Supervisory Control and Coordination of State Tree Structures

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Abstract:	Optimal nonblocking modular supervisory control of discrete-event systems is developed using state tree structures to manage state explosion. The total specification of the system to be controlled is decomposed into several sub-specifications, and a separate optimal (maximally permissive) nonblocking supervisor designed for each. Under an additional global nonblocking condition we directly obtain an optimal nonblocking modular state feedback control for the full system. If that condition fails, i.e. the modular controlled system is blocking, an additional coordinator is adjoined which renders the global controlled behavior both nonblocking and optimal.

# Nonblocking Supervisory Control Of State Tree Structures

**Chuan Ma**



## **Nonblocking Supervisory Control Of State Tree Structures:**

**Nonblocking Supervisory Control of State Tree Structures** Chuan Ma, W. Murray Wonham, 2009-09-02 This monograph proposes how to manage complexity by organizing the system as a State Tree Structure STS Based on STS which is an adaptation of statecharts to Supervisory Control Theory an efficient recursive symbolic algorithm is presented that can perform nonblocking supervisory control design in reasonable time and memory for complex systems Nonblocking Supervisory Control of State Tree Structures presents how this results in tractable and highly comprehensible controllers especially to users who are not specialists in Discrete Event Systems

**Nonblocking Supervisory Control of State Tree Structures [microform]** Chuan Ma, 2004 It is well known that the optimal nonblocking supervisory control problem is NP hard subject in particular to state space explosion that is exponential in the number of system components In this thesis we propose to manage complexity by organizing the system as a State Tree Structure STS STS are an adaptation of statecharts to Supervisory Control Theory SCT Based on STS we present an efficient recursive symbolic algorithm that can perform nonblocking supervisory control design in reasonable time and memory for systems of state size 1020 and higher The resulting controllers are tractable and highly comprehensible

Nonblocking Supervisory Control of State Tree Structures Chuan Ma, W. Murray Wonham, 2005-05-04 This monograph proposes how to manage complexity by organizing the system as a State Tree Structure STS Based on STS which is an adaptation of statecharts to Supervisory Control Theory an efficient recursive symbolic algorithm is presented that can perform nonblocking supervisory control design in reasonable time and memory for complex systems Nonblocking Supervisory Control of State Tree Structures presents how this results in tractable and highly comprehensible controllers especially to users who are not specialists in Discrete Event Systems

Supervisory Control of Discrete-Event Systems W. Murray Wonham, Kai Cai, 2018-08-17 This book shows how supervisory control theory SCT supports the formulation of various control problems of standard types like the synthesis of controlled dynamic invariants by state feedback and the resolution of such problems in terms of naturally definable control theoretic concepts and properties like reachability controllability and observability It exploits a simple abstract model of controlled discrete event systems DES that has proved to be tractable appealing to control specialists and expressive of a range of control theoretic ideas It allows readers to choose between automaton based and dually language based forms of SCT depending on whether their preference is for an internal structural or external behavioral description of the problem The monograph begins with two chapters on algebraic and linguistic preliminaries and the fundamental concepts and results of SCT are introduced To handle complexity caused by system scale architectural approaches the horizontal modularity of decentralized and distributed supervision and the vertical modularity of hierarchical supervision are introduced Supervisory control under partial observation and state based supervisory control are also addressed in the latter a vector DES model that exploits internal regularity of algebraic structure is proposed Finally SCT is generalized to deal with timed DES by incorporating

temporal features in addition to logical ones Researchers and graduate students working with the control of discrete event systems or who are interested in the development of supervisory control methods will find this book an invaluable aid in their studies The text will also be of assistance to researchers in manufacturing logistics communications and transportation areas which provide plentiful examples of the class of systems being discussed

**Scheduling and Reconfiguration of Real-Time Systems** Xi Wang,ZhiWu Li,2023-11-15 This book presents a methodology for the real time scheduling problems of real time systems RTS from the viewpoint of control theory Generally any system can be viewed as an RTS if it performs real time application functions and behaves correctly depending on given logical activities and satisfying specified deadlines for the activities This monograph provides broad views and detailed introductions to supervisory control theory SCT and its application in real time scheduling and reconfiguration Based on three popular SCT modelling frameworks discrete event system DES timed DES TDES and state tree structures STS the authors provide RTS modelling frameworks thereafter SCT is used to find their safe execution sequences As the main contribution we use untimed DES events to represent the execution and preemption of each individual RTS task This modelling formalism brings the possibilities to model the preemptions of tasks executions Furthermore in somecases priorities cannot be assigned to real time tasks In order to solve this problem a matrix based priority free conditional preemption PFCP relation is provided which generalizes fixed priority FP RTS scheduling As a natural extension a generalized modular modelling framework is presented to model the task parameters instead of the global real time task The modular models are taken to be generic entities which also considers the exact execution time of real time tasks STS are undoubtedly recognized as a computationally efficient SCT framework which manages the state explosion problem significantly Hence building on the untimed modular RTS models a novel STS based RTS modeling framework is formulated by assigning dynamic priorities as specified optimality criteria which can be utilized to model sporadic RTS processing both sporadic and multi period periodic tasks providing a small set of the safe execution sequences which rank at the top

**Formal Methods in Manufacturing Systems: Recent Advances** Li, Zhiwu,2013-05-31 Evolving technologies in mass production have led to the development of advanced techniques in the field of manufacturing These technologies can quickly and effectively respond to various market changes necessitating processes that focus on small batches of multiple products rather than large single product lines Formal Methods in Manufacturing Systems Recent Advances explores this shifting paradigm through an investigation of contemporary manufacturing techniques and formal methodologies that strive to solve a variety of issues arising from a market environment that increasingly favors flexible systems over traditional ones This book will be of particular use to industrial engineers and students of the field who require a detailed understanding of current trends and developments in manufacturing tools This book is part of the Advances in Civil and Industrial Engineering series collection

*Coordination Control of Distributed Systems* Jan H. van Schuppen,Tiziano Villa,2014-09-25 This book describes how control of distributed systems can be

advanced by an integration of control communication and computation The global control objectives are met by judicious combinations of local and nonlocal observations taking advantage of various forms of communication exchanges between distributed controllers Control architectures are considered according to increasing degrees of cooperation of local controllers fully distributed or decentralized control control with communication between controllers coordination control and multilevel control The book covers also topics bridging computer science communication and control like communication for control of networks average consensus for distributed systems and modeling and verification of discrete and of hybrid systems Examples and case studies are introduced in the first part of the text and developed throughout the book They include control of underwater vehicles automated guided vehicles on a container terminal control of a printer as a complex machine and control of an electric power system The book is composed of short essays each within eight pages including suggestions and references for further research and reading By reading the essays collected in the book Coordination Control of Distributed Systems graduate students and post docs will be introduced to the research frontiers in control of decentralized and of distributed systems Control theorists and practitioners with backgrounds in electrical mechanical civil and aerospace engineering will find in the book information and inspiration to transfer to their fields of interest the state of art in coordination control

*Formal Aspects of Component Software* Farhad Arbab, Sung-Shik Jongmans, 2020-02-12 This book constitutes the thoroughly revised selected papers from the 16th International Conference on Formal Aspects of Component Software FACS 2019 held in Amsterdam The Netherlands in October 2019 The 9 full papers presented together with 9 full papers and 3 short papers as well as 2 other papers were carefully reviewed and selected from 27 submissions FACS 2019 is concerned with how formal methods can be used to make component based and service oriented software development succeed Formal methods have provided a foundation for component based software by successfully addressing challenging issues such as mathematical models for components composition and adaptation or rigorous approaches to verification deployment testing and certification

**Complex Systems** Georgi M. Dimirovski, 2016-05-19 This book gives a wide ranging description of the many facets of complex dynamic networks and systems within an infrastructure provided by integrated control and supervision envisioning design experimental exploration and implementation The theoretical contributions and the case studies presented can reach control goals beyond those of stabilization and output regulation or even of adaptive control Reporting on work of the Control of Complex Systems COSY research program Complex Systems follows from and expands upon an earlier collection Control of Complex Systems by introducing novel theoretical techniques for hard to control networks and systems The major common feature of all the superficially diverse contributions encompassed by this book is that of spotting and exploiting possible areas of mutual reinforcement between control computing and communications These help readers to achieve not only robust stable plant system operation but also properties such as collective adaptivity integrity and survivability at the same time retaining desired performance quality

Applications in the individual chapters are drawn from the general implementation of model based diagnosis and systems engineering in medical technology in communication and in power and airport networks the creation of biologically inspired control brains and safety critical human machine systems process industrial uses biped robots large space structures and unmanned aerial vehicles and precision servomechanisms and other advanced technologies Complex Systems provides researchers from engineering applied mathematics and computer science backgrounds with innovative theoretical and practical insights into the state of the art of complex networks and systems research It employs physical implementations and extensive computer simulations Graduate students specializing in complex systems research will also learn much from this collection pp

**Supervisor Localization** Kai Cai, W. Murray Wonham, 2015-06-23 This monograph presents a systematic top down approach to distributed control synthesis of discrete event systems DES The approach is called supervisor localization its essence is the allocation of external supervisory control action to individual component agents as their internal control strategies The procedure is first synthesize a monolithic supervisor to achieve globally optimal and nonblocking controlled behavior then decompose the monolithic supervisor into local controllers one for each agent The collective behavior of the resulting local controllers is identical to that achieved by the monolithic supervisor The basic localization theory is first presented in the Ramadge Wonham language based supervisory control framework then demonstrated with distributed control examples of multi robot formations manufacturing systems and distributed algorithms An architectural approach is adopted to apply localization to large scale DES this yields a heterarchical localization procedure which is also demonstrated with benchmark examples Moreover a state based framework state tree structures is exploited for efficient computation of localization Finally localization is extended to timed DES which addresses distributed control synthesis with temporal specifications The authors TCT software and sourcecode will help the reader to reproduce the results demonstrated in the examples Academic researchers and graduate students interested in discrete event and distributed systems and control will find this book an instructive resource It will also be useful for researchers in manufacturing supply chain and logistics and practitioners in related industries

**Abstract State Machines, Alloy, B, VDM, and Z** John Derrick, John Fitzgerald, Stefania Gnesi, Sarfraz Khurshid, Michael Leuschel, Steve Reeves, Elvinia Riccobene, 2012-06-26 This book constitutes the proceedings of the Third International Conference on Abstract State Machines B VDM and Z which took place in Pisa Italy in June 2012 The 20 full papers presented together with 2 invited talks and 13 short papers were carefully reviewed and selected from 59 submissions The ABZ conference series is dedicated to the cross fertilization of five related state based and machine based formal methods Abstract State Machines ASM Alloy B VDM and Z They share a common conceptual foundation and are widely used in both academia and industry for the design and analysis of hardware and software systems The main goal of this conference series is to contribute to the integration of these formal methods clarifying their commonalities and differences to better understand how to combine different approaches for

accomplishing the various tasks in modeling experimental validation and mathematical verification of reliable high quality hardware software systems      *Modeling, Control and Implementation of Smart Structures* B. Bandyopadhyay,T.C. Manjunath,M. Umapathy,2007-04-22 This book presents an overview over smart structures its concepts its active involvement in the vibration control their applications and the extensive research work done      **Formal Methods for Industrial Critical Systems** Kim Guldstrand Larsen,Tim Willemse,2019-08-23 This book constitutes the proceedings of the 24th International Conference on Formal Methods for Industrial Critical Systems FMICS 2019 held in Amsterdam The Netherlands in August 2019 The 9 regular papers presented in this volume were carefully reviewed and selected from 15 submissions The conference also featured invited talks by Jaco van de Pol Aarhus University and Twente University jointly with CONCUR and Holger Hermanns Universit t des Saarlandes and a special session on commercial formal methods in industry The aim of the FMICS conference series is to provide a forum for researchers who are interested in the development and application of formal methods in industry In particular FMICS brings together scientists and engineers who are active in the area of formal methods and interested in exchanging their experiences in the industrial usage of these methods The FMICS conference series also strives to promote research and development for the improvement of formal methods and tools for industrial applications      Industrial Internet of Things Sabina Jeschke,Christian Brecher,Houbing Song,Danda B. Rawat,2016-10-12 This book develops the core system science needed to enable the development of a complex industrial internet of things manufacturing cyber physical systems IIoT M CPS Gathering contributions from leading experts in the field with years of experience in advancing manufacturing it fosters a research community committed to advancing research and education in IIoT M CPS and to translating applicable science and technology into engineering practice Presenting the current state of IIoT and the concept of cybermanufacturing this book is at the nexus of research advances from the engineering and computer and information science domains Readers will acquire the core system science needed to transform to cybermanufacturing that spans the full spectrum from ideation to physical realization      **Formal Methods in Manufacturing** Javier Campos,Carla Seatzu,Xiaolan Xie,2018-09-03 Illustrated with real life manufacturing examples Formal Methods in Manufacturing provides state of the art solutions to common problems in manufacturing systems Assuming some knowledge of discrete event systems theory the book first delivers a detailed introduction to the most important formalisms used for the modeling analysis and control of manufacturing systems including Petri nets automata and max plus algebra explaining the advantages of each formal method It then employs the different formalisms to solve specific problems taken from today s industrial world such as modeling and simulation supervisory control including deadlock prevention in a distributed and or decentralized environment performance evaluation including scheduling and optimization fault diagnosis and diagnosability analysis and reconfiguration Containing chapters written by leading experts in their respective fields Formal Methods in Manufacturing helps researchers and application engineers handle fundamental

principles and deal with typical quality goals in the design and operation of manufacturing systems Timed State Tree Structures Ali Saadatpoor, **H-infinity Control and Estimation of State-multiplicative Linear Systems** Eli

Gershon, Uri Shaked, Isaac Yaesh, 2005-06-24 Multiplicative noise appears in systems where the process or measurement noise levels depend on the system state vector Such systems are relevant for example in radar measurements where larger ranges involve higher noise level This monograph embodies a comprehensive survey of the relevant literature with basic problems being formulated and solved by applying various techniques including game theory linear matrix inequalities and Lyapunov parameter dependent functions Topics covered include convex  $H_2$  and  $H_\infty$  norms analysis of systems with multiplicative noise state feedback control and state estimation of systems with multiplicative noise dynamic and static output feedback of stochastic bilinear systems tracking controllers for stochastic bilinear systems utilizing preview information Various examples which demonstrate the applicability of the theory to practical control engineering problems are considered two such examples are taken from the aerospace and guidance control areas **Robot Motion and Control**

**2007** Krzysztof R. Kozłowski, 2009-06-10 Robot Motion Control 2007 presents very recent results in robot motion and control Forty one short papers have been chosen from those presented at the sixth International Workshop on Robot Motion and Control held in Poland in June 2007 The authors of these papers have been carefully selected and represent leading institutions in this field **Formal Methods for Industrial Critical Systems** Gwen Salaün, Bernhard Schätz, 2011-09-19

This book constitutes the proceedings of the 16th International Workshop on Formal Methods for Industrial Critical Systems FMICS 2011 held in Trento Italy in August 2011 The 16 papers presented together with 2 invited talks were carefully reviewed and selected from 39 submissions The aim of the FMICS workshop series is to provide a forum for researchers who are interested in the development and application of formal methods in industry It also strives to promote research and development for the improvement of formal methods and tools for industrial applications **H-infinity Control for**

**Nonlinear Descriptor Systems** He-Sheng Wang, Chee-Fai Yung, Fan-Ren Chang, 2006-01-18 The authors present a study of the  $H_\infty$  control problem and related topics for descriptor systems described by a set of nonlinear differential algebraic equations They derive necessary and sufficient conditions for the existence of a controller solving the standard nonlinear  $H_\infty$  control problem considering both state and output feedback One such condition for the output feedback control problem to be solvable is obtained in terms of Hamilton Jacobi inequalities and a weak coupling condition a parameterization of output feedback controllers solving the problem is also provided All of these results are then specialized to the linear case The derivation of state space formulae for all controllers solving the standard  $H_\infty$  control problem for descriptor systems is proposed Among other important topics covered are balanced realization reduced order controller design and mixed  $H_2$   $H_\infty$  control  $H_\infty$  Control for Nonlinear Descriptor Systems provides a comprehensive introduction and easy access to advanced topics



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