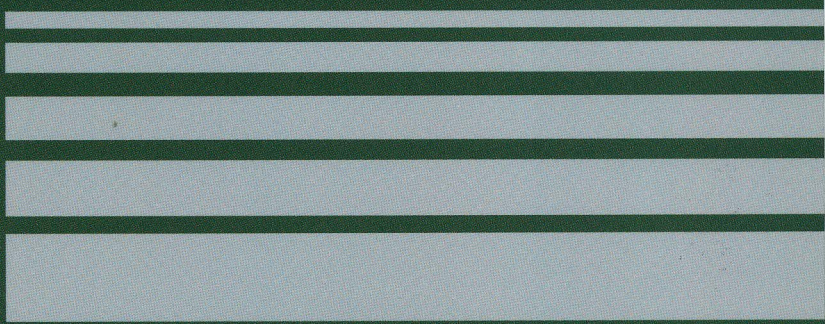
Progress in Systems
and Control Theory



Discrete Event Systems: Modeling and Control

S. Balemi P. Kozák R. Smedinga
Editors

Birkhäuser

S. Balemi, P. Kozák and R. Smedinga Editors
Discrete Event Systems: Modeling and Control

This book contains a collection of papers in the dynamically developing area of discrete event systems control. Research in this area is strongly motivated by applications in flexible manufacturing, communications, database management, traffic control. and concurrent and real-time software verification and design.

The papers were presented at the Joint Workshop on Discrete Event Systems (WODES'92) held in Prague, Czechoslovakia, on August 26-28, 1992. They reflect four directions of current research: models of real-time system behaviour, methods for decreasing computation and model complexity, unifying approaches to modeling, and new results in performance analysis and optimisation of discrete event systems.

The book presents recent results as well as several introductory papers on different subareas.

ISBN 978-3-0348-9916-1
9 783034 899161

Birkhäuser
Basel · Boston · Berlin

ISBN-13: 978-3-0348-9916-1

S. Balemi
P. Kozák
R. Smedinga
Editors

Discrete Event Systems: Modeling and Control

Proceedings of a Joint Workshop
held in Prague, August 1992

1993

Birkhäuser
Basel · Boston · Berlin

Silvano Balemi
Automatic Control Laboratory
Swiss Federal Institute of
Technology (ETH)
CH-8902 Zürich
Switzerland

Petr Kozák
Inst. of Information Theory
and Automation
Czechoslovak Academy of Sciences
Pod vodárenskou věží 4
182 08 Prague
Czech Republic

Rein Smedinga
Dept. of Computer Science
University of Groningen
P.O. Box 800
NL-9700 AV Groningen
The Netherlands

A CIP catalogue record for this book is available from the Library of Congress, Washington D.C., USA

Deutsche Bibliothek Cataloging-in-Publication Data

Discrete event systems: modeling and control ; proceedings of a joint workshop held in Prague, August 1992 / S. Balemi ... ed.
– Basel ; Boston ; Berlin : Birkhäuser, 1993
(Progress in systems and control theory ; Vol. 13)
ISBN-13: 978-3-0348-9916-1 e-ISBN-13: 978-3-0348-9120-2
DOI: 10.1007/978-3-0348-9120-2

NE: Balemi, Silvano [Hrsg.]; GT

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in other ways, and storage in data banks. For any kind of use permission of the copyright owner must be obtained.

© 1993 Birkhäuser Verlag, P.O. Box 133, CH-4010 Basel, Switzerland
Camera-ready copy prepared by the authors in LaTeX
Printed on acid-free paper produced from chlorine-free pulp
Softcover reprint of the hardcover 1st edition 1993

ISBN-13: 978-3-0348-9916-1

9 8 7 6 5 4 3 2 1

Contents

Preface VII

Logical Models

Augmented Language and Supervisory Control in Discrete Event Systems
T. Ushio 3

Input/Output Discrete Event Processes and System Modeling
S. Balemi 15

Supervisory Control and Formal Methods for Distributed Systems
K. İnan 29

An Overview of Results in Discrete Event Systems
Using a Trace Theory Based Setting
R. Smedinga 43

A Minimally Restrictive Policy for Deadlock Avoidance in a Class of FMS
Y. Brave and D. Bonvin 57

Similarity of Events in Discrete Event Systems
J. Pik 71

Control of Discrete Event Systems by means of the Boolean Differential Calculus
R. Scheuring and H. Wehlan 79

A Unifying Framework for Discrete Event System Control Theory
P. Kozák 95

Optimisation

Synchronized Continuous Flow Systems
G. J. Olsder 113

On a Generalized Asymptoticity Problem in Max Algebra
J. G. Braker and J. A. C. Resing 125

Conditions for Tracking Timing Perturbations in Timed Petri Nets with Monitors
K. J. Williams, J. A. Gannon, M. S. Andersland,
J. E. Lumpp, and T. L. Casavant 141

Extensions to the Theory of Optimal Control of Discrete Event Systems
R. Sengupta and S. Lafortune 153

THE WORKSHOP EXERCISE

The Workshop Exercise: An Introduction
..... 163

The Workshop Exercise Using a Trace Theory Based Setting
R. Smedinga 167

A Petri Nets-Based Approach to the Maze Problem Solving
F. Čapkovič 173

The Cat-and-Mouse Problem as a System of Boolean Equations
O. Kříž 181

Symbolic Supervisory Synthesis for the Workshop Exercise
G.J. Hoffmann and H. Wong-Toi 189

The Cat-and-Mouse Problem with Least Delays
P. Kozák 199

Supervisory Control with Variable Lookahead Policies: Illustrative Example
S. L. Chung, S. Lafortune and F. Lin 207

SELECTED BIBLIOGRAPHY 217

PREFACE

Research of discrete event systems is strongly motivated by applications in flexible manufacturing, in traffic control and in concurrent and real-time software verification and design, just to mention a few important areas. Discrete event system theory is a promising and dynamically developing area of both control theory and computer science.

Discrete event systems are systems with non-numerically-valued states, inputs, and outputs. The approaches to the modelling and control of these systems can be roughly divided into two groups. The first group is concerned with the automatic design of controllers from formal specifications of logical requirements. This research owes much to the pioneering work of P.J. Ramadge and W.M. Wonham at the beginning of the eighties. The second group deals with the analysis and optimization of system throughput, waiting time, and other performance measures for discrete event systems.

The present book contains selected papers presented at the Joint Workshop on Discrete Event Systems (WODES'92) held in Prague, Czechoslovakia, on August 26-28, 1992 and organized by the Institute of Information Theory and Automation of the Czechoslovak Academy of Sciences, Prague, Czechoslovakia, by the Automatic Control Laboratory of the Swiss Federal Institute of Technology (ETH), Zurich, Switzerland, and by the Department of Computing Science of the University of Groningen, Groningen, the Netherlands.

Thirty research papers of high quality were presented and discussed thoroughly by the participants from fourteen countries. Five invited survey lectures given by leading researchers covered main topics of the discrete event system area. Nine different solutions to a simple control problem, stated at the workshop announcement with the aim to stimulate comparison between different approaches, were presented during a special session.

The book reflects four main topics of current research: models of real-time system behaviour, methods for decreasing computational and model complexity, unifying approaches to modelling, and performance analysis of discrete event systems.

The contributions of all speakers and vivid discussions among the participants as well as the quiet summer days in historical Prague contributed to the success of the meeting. We thank the members of the Institute of Information Theory and Automation for their help, in particular Dr. Jiří Pik, Mrs. Marie Kolářová, and Mrs. Jarmila Zoltánová, without whom all this would not have been possible.

We hope that this book containing both recent results and survey papers will be useful as reference material and also as an introductory reading.

The editors

Selected Bibliography on Discrete Event System Control

The references listed below contain journal papers and books closely related to the modelling and control of discrete event systems. This bibliography, however, does not objectively represent the different research directions of the field. For instance, it does not contain references to stochastic systems, stochastic optimisation, operation research, and simulation. Only some references to perturbation analysis, scheduling, and min-max algebra are included. References to Petri nets are included only if they pertain to the latter topics. Nevertheless, the research area represented by the given references is the well-defined subarea of DES control at the logical level.

An extensive Petri nets bibliography collected by H. Plünnecke and W. Reisig has been published in *Advances in Petri Nets,* Lecture Notes in Computer Science No. 524, Springer Verlag, Berlin, 1991, pages 317–572. A "selected and annotated bibliography on perturbation analysis" by Y.C. Ho has appeared in *Discrete Event Systems: Models and Application,* Lecture Notes in Control and Information Sciences No. 103, Springer Verlag, Berlin, 1987, pages 217–224. Moreover, many interesting papers on DES control can be found in the proceedings of the IEEE Conference on Decision and Control, the American Control Conference, the IFAC World Congress, and the European Control Conference.

The items are alphabetically ordered according to the authors. A current version of a DES control BibTeX database including also conference papers, technical reports and other publications can be obtained via anonymous ftp from the server ifa.ethz.ch or via e-mail from the editors.

The editors

Aggarwal, S., Alonso, R. and Courcoubetis, C. (1987a). *Distributed Reachibility Analysis for Protocol Verification Environments*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 40–56. (IIASA Conference, Sopron, Hungary).

Aggarwal, S. and Gopinath, B. (1988). Special issue on tools for computer communication systems, *IEEE Trans. Software Eng.*, **14**(3): 277–404.

Aggarwal, S., Barbará, D. and Meth, K. (1987b). SPANNER: A tool for the specification, analysis, and evaluation of protocols, *IEEE Trans. Software Eng.*, **13**(12): 1218–1237.

Aggarwal, S., Barbará, D. and Meth, K. (1988). A software environment for the specification and analysis of problems of coordination and concurrency, *IEEE Trans. Software Eng.*, **14**(3): 280–290.

Akella, R. and Kumar, P. (1986). Optimal control of production rate in a failure prone manufacturing system, *IEEE Trans. Autom. Control*, **31**(2): 116–126.

Alur, R. and Dill, D. (1991). *The Theory of Timed Automata*, number 600 in *Lecture Notes in Computer Science Series*, Springer-Verlag, pp. 45–73. Proceedings of the REX workshop "Real Time: Theory in Practice".

Alur, R. and Henzinger, T. A. (1991). *Logics and Models of Real Time: A Survey*, number 600 in *Lecture Notes in Computer Science Series*, Springer-Verlag, pp. 74–106. Proceedings of the REX workshop "Real Time: Theory in Practice".

Anderson, D. (1988). Automated protocol implementation with RTAG, *IEEE Trans. Software Eng.*, **14**(3): 291–300.

Arbib, M. (1966). Automata theory and control theory – a rapprochement, *Automatica*, **3**: 161–189.

Arbib, M. and Manes, E. (1974). Foundations of system theory: Decomposable systems, *Automatica*, **10**: 285–302.

Arbib, M. and Ziegler, H. (1969). On the relevance of abstract algebra to control theory, *Automatica*, **5**: 589–606.

Archetti, F. and Sciomachen, A. (1987). *Representation, Analysis and Simulation of Manufacturing Systems by Petri Net Based Models*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 162–178. (IIASA Conference, Sopron, Hungary).

Aveyard, R. (1974). A boolean model for a class of discrete event systems, *IEEE Trans. Systems Man and Cybernetics*, **4**(3): 249–258.

Baccelli, F. and Makowski, A. (1989). Queueing models for systems with synchronization constraints, *Proc. of the IEEE*, **77**(1): 138–161.

Baccelli, F., Cohen, G. and Gaujal, B. (1991). Recursive equations and basic properties of timed petri nets, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(4): 415–439.

Baccelli, F., Cohen, G., Olsder, G. and Quadrat, J. (1992). *Synchronization and Linearity*, Wiley.

Badrinath, B. and Ramamritham, K. (1988). Synchronizing transactions on objects, *IEEE Trans. Computers*, **37**(5): 541–547.

Balemi, S., Hoffmann, G., Gyugyi, P., Wong-Toi, H. and Franklin, G. (1993). Supervisory control of a rapid thermal multiprocessor, *Joint issue Automatica and IEEE Trans. Autom. Control on* Meeting the Challenge of Computer Science in the Industrial Applications of Control. to appear.

Banaszak, Z. and Krogh, B. (1990). Deadlock avoidance in flexible manufacturing systems with concurrently competing process flows, *IEEE Trans. Robotics and Automation*.

Benveniste, A. and Berry, G. (1991a). Special section: Another look at real-time programming, *Proc. of the IEEE*.

Benveniste, A. and Berry, G. (1991b). The synchronous approach to reactive and real-time systems, *IEEE Trans. Autom. Control*, **9**(79): 1270–1282.

Benveniste, A. and Guernic, P. L. (1990). Hybrid dynamical systems theory and the SIGNAL language, *IEEE Trans. Autom. Control*, **35**(5): 535–546.

Benveniste, A., Le Guernic, P. and Jacquemot, C. (1991). Synchronous programming with events and relations: the SIGNAL language and its semantics, *Science of Computer and Programming*, **16**: 103–149.

Berthelot, G. and Terrat, R. (1982). Petri nets theory for the correctness of protocols, *IEEE Trans. Communications*, **30**(12): 2497–2505.

Bhattacharya, P. and Ephremides, A. (1989). Optimal scheduling with strict deadlines, *IEEE Trans. Autom. Control*, **34**(7): 721–728.

Bochmann, D. and Posthoff, C. (1981). *Binäre Dynamische Systeme*, R. Oldenbourg Verlag München Wien.

Bochmann, G. (1985). Finite state description of communication protocols, *Computer Networks and ISDN Systems*, **2**: 361–372.

Bochmann, G., Cerny, E., Gagné, M., Jarda, C., Léveillé, A., Lacaille, C., Maksud, M., Raghunathan, K. and Sarikaya, B. (1982). Experience with formal specifications using and extended state transition model, *IEEE Trans. Communications*, **30**(12): 2506–2511.

Boel, R. and Schuppen, J. v. (1989). Distributed routing for load balancing, *Proc. of the IEEE*, **77**(1): 210–221.

Boukas, E. and Haurie, A. (1990). Manufacturing flow control and preventive maintenance: A stochastic control approach, *IEEE Trans. Autom. Control*, **35**(9): 1024–1031.

Brand, D. and Zafiropulo, P. (1983). On communicating finite-state machines, *J. ACM*, **30**(2): 323–342.

Brand, K. and Kopainsky, J. (1988). Principles and engineering of process control with Petri nets, *IEEE Trans. Autom. Control*, **33**(2): 138–149.

Brandt, R., Garg, V., Kumar, R., Lin, F., Marcus, S. and Wonham, W. (1990). Formulas for calculating supremal controllable and normal sublanguages, *System and Control Letters*, **15**(2): 111–117.

Brave, Y. and Heymann, M. (1990). Stabilization of discrete-event processes, *Int. J. Control*, **51**(5): 1101–1117.

Brave, Y. and Heymann, M. (1992). Optimal attraction in discrete event processes, *Information Sciences*.

Brookes, S., Hoare, C. and Roscoe, A. (1984). A theory of communicating sequential processes, *J. ACM*, **31**(3): 560–599.

Brooks, C., Cieslak, R. and Varaiya, P. (1990). A method for specifying, implementing and verifying media access control protocols, *IEEE Control System Magazine*, **10**(4): 87–94.

Browne, M., Clarke, E. and Grumberg, O. (1989). Reasoning about networks with many identical finite state processes, *Information and Computation*, **81**: 13–31.

Burns, A. and Wellings, A. (1990). *Real-Time Systems and their Programming Languages*, Addison-Wesley.

Buzacott, J. (1982). "Optimal" operating rules for automated manufacturing systems, *IEEE Trans. Autom. Control*, **27**(1): 80–86.

Cao, X. (1985). Convergence of parameter sensitivity estimates in a stochastic experiment, *IEEE Trans. Autom. Control*, **30**(9): 845–853.

Cao, X. (1989a). The predictability of discrete event systems, *IEEE Trans. Autom. Control*, **34**(11): 1168–1171.

Cao, X. (1989b). The static property of perturbed multiclass closed queuing network and decomposition, *IEEE Trans. Autom. Control*, **34**(2): 246–249.

Cao, X. and Ho, Y. (1987). Sensitivity analysis and optimization of throughput in a production line with blocking, *IEEE Trans. Autom. Control*, **32**(11): 959–967.

Cao, X.-R. and Ho, Y.-C. (1990). Models of discrete event systems, *IEEE Control System Magazine*, **10**(4): 69–76.

Cao, X.-R. and Ma, D.-J. (1991). Event rates and aggregation in hierarchical systems, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(3): 271–288.

Cassandras, C. (1990). Toward a control theory for discrete event systems, *IEEE Control System Magazine*, **10**(4): 66–68.

Cassandras, C. and Strickland, S. (1989a). Observable augmented systems for sensitivity analysis of Markov and semi-Markov processes, *IEEE Trans. Autom. Control*, **34**(10): 1026–1037.

Cassandras, C. and Strickland, S. (1989b). On line sensitivity analysis of Markov chains, *IEEE Trans. Autom. Control*, **34**(1): 76–86.

Cassandras, C. and Strickland, S. (1989c). Sample path properties of timed discrete event systems, *Proc. of the IEEE*, **77**(1): 59–71.

Chase, C. and Ramadge, P. (1992). On real-time scheduling policies for flexible manufacturing systems, *IEEE Trans. Autom. Control*, **37**(4): 491–496.

Chen, E. and Lafortune, S. (1991a). Dealing with blocking in supervisory control of discrete event systems, *IEEE Trans. Autom. Control*, **36**(6): 724–735.

Chen, E. and Lafortune, S. (1991b). On nonconflicting languages that arise in supervisory control of discrete event systems, *System and Control Letters*, **17**: 105–113.

Cho, H. and Marcus, S. (1989a). On supremal languages of classes of sublanguages that arise in supervisor synthesis problems with partial observation, *Mathematics of Control, Signals and Systems*, **2**(2): 47–69.

Cho, H. and Marcus, S. (1989b). Supremal and maximal sublanguages arising in supervisor synthesis problems with partial observations, *Math. Systems Theory*, **22**: 177–211.

Chong, E. and Ramadge, P. (1991). Convergence of infinitesimal optimizationn algorithms using infinitesimal perturbation analysis estimates, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(4): 339–372.

Choueka, Y. (1974). Theories of automata on ω-tapes: A simplified approach, *Journal of Computer and System Sciences*, **8**: 117–141.

Cieslak, R. and Varaiya, P. (1990). Undecidability results for deterministic communicating sequential processes, *IEEE Trans. Autom. Control*, **35**(9): 1032–1039.

Cieslak, R. and Varaiya, P. (1991). Simulating finitely recursive processes, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(4): 373–392.

Cieslak, R., Desclaux, C., Fawaz, A. and Varaiya, P. (1988). Supervisory control of discrete-event processes with partial observations, *IEEE Trans. Autom. Control*, **33**(3): 249–260.

Cohen, G., Dubois, D., Quadrat, J. and Viot, M. (1985). A linear-system-theoretic view of discrete-event processes and its use for performance evaluation in manufacturing, *IEEE Trans. Autom. Control*, **30**(3): 210–220.

Cohen, G., Moller, P., Quadrat, J. and Viot, M. (1989). Algebraic tools for the performance evaluation of discrete event systems, *Proc. of the IEEE*, **77**(1): 39–58.

Collective (1987). Challenges to control: A collective view, *IEEE Trans. Autom. Control*, **32**(4): 275–285.

Concepcion, A. and Zeigler, B. (1988). DEVS formalism: A formalism for hierarchical model development, *IEEE Trans. Software Eng.*, **14**(2): 228–241.

Cuninghame-Green, R. (1989). Discrete events and max-algebra, *CWI Quarterly*, **2**(3): 257–258.

David, R. and Alla, H. (1992). *Petri Nets & Grafcet: Tools for modelling discrete event systems*, Prentice Hall.

Dayhoff, J. and Atherton, R. (1987). A model for wafer fabrication dynamics in integrated circuit manufacturing, *IEEE Trans. Systems Man and Cybernetics*, **17**(1): 91–100.

Delchamps, D. (1990). Stabilizing a linear system with quantized state feedback, *IEEE Trans. Autom. Control*, **35**(8): 916–924.

Denardo, E. (1982). *Dynamic Programming: Models and Applications*, Prentice-Hall Inc., Englewood Cliffs.

Denham, M. (1988). *A Petri Net Approach to the Control of Discrete-Event Systems*, Vol. 47 of Denham and Laub (1988), pp. 191–214.

Denham, M. and Laub, A. (eds) (1988). *Advanced Computing Concepts and Techniques in Control Engineering*, Vol. 47 of *Computer and Systems Sciences*, Springer Verlag.

DeNicola, R. (1987). Extensional equivalences for transition systems, *Acta Informatica*, **24**: 211–237.

Desrochers, A. (1990). *Modeling and Control of Automated Manufacturing Systems*, IEEE Computer Society Press, Washington, DC.

Diaz, M. (1982). Modeling and analysis of communication protocols using Petri net based models, *Computer Networks and ISDN Systems*, **6**: 439–441.

Dill, D. (1989). *Trace Theory for Automatic Hierarchical Verification of Speed-Independent Circuits*, ACM Distinguished Dissertations, The MIT Press, Cambridge, Massachussetts.

Du, Y. and Wang, S. (1988). Control of discrete-event systems with minimal switchings, *Int. J. Control*, **48**(3): 981–991.

Du, Y. and Wang, S. (1989). Translation of output constraint into event constraint in the control of discrete event systems, *Int. J. Control*, **50**(6): 2635–2644.

Ephremides, A. and Verdú, S. (1989). Control and optimization methods in communication network problems, *IEEE Trans. Autom. Control*, **34**(9): 930–942.

Ezzine, J. and Haddad, A. (1989). Error bounds in the averaging of hybrid systems, *IEEE Trans. Autom. Control*, **34**(11): 1188–1191.

Fendick, K. and Whitt, W. (1989). Measurements and approximations to describe the offered traffic and predict the average workload in a single-server queue, *Proc. of the IEEE*, **77**(1): 171–194.

Gershwin, S. (1987). *A Hierarchical Framework for Discrete Event Scheduling in Manufacturing Systems*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 197–216. (IIASA Conference, Sopron, Hungary).

Gershwin, S. (1989). Hierarchical flow control: A framework for scheduling and planning discrete events in manufacturing systems, *Proc. of the IEEE*, **77**(1): 195–209.

Glasserman, P. and Gong, W. (1990). Smoothed perturbation analysis for a class of discrete-event systems, *IEEE Trans. Autom. Control*, **35**(11): 1218–1230.

Glasserman, P. and Yao, D. (1991). Algebraic structure of some stochastic discrete event systems, with applications, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(1): 7–36.

Glynn, P. (1989). A GSMP formalism for discrete event systems, *Proc. of the IEEE*, **77**(1): 14–23.

Golaszewski, C. and Ramadge, P. (1988). *Supervisory Control of Discrete Event Processes with Arbitrary Controls*, Vol. 47 of Denham and Laub (1988), pp. 459–469.

Golaszewski, C. and Ramadge, P. (1989). The complexity of some reachability problems for a system on a finite group, *System and Control Letters*, **12**: 431–435.

Gong, W. and Cassandras, C. (1991). Perturbation analysis of a multiclass queueing system with admission control, *IEEE Trans. Autom. Control*, **36**(6): 707–723.

Gong, W. and Ho, Y. (1987). Smoothed perturbation analysis of discrete event dynamic systems, *IEEE Trans. Autom. Control*, **32**(11): 858–866.

Habermann, A. (1969). Prevention of systems deadlocks, *Communications of the ACM*, **12**(7): 373–385.

Harel, D. (1987). Statecharts: A visual formalism for complex system, *Science of Computer Programming*, **8**(3): 231–274.

Harel, D. (1992). Biting the silver bullet: Toward a brighter future for software development, *IEEECM*, **25**(1): 8–20.

Hatono, I., Yamagata, K. and Tamura, H. (1991). Modeling and on-line scheduling of flexible manufacturing systems using stochastic Petri nets, *IEEE Trans. Software Eng.*, **17**(2): 126–132.

Hennessy, M. and Milner, R. (1985). Algebraic laws for nondeterminism and concurrency, *J. ACM*, **32**(1): 137–161.

Heymann, M. (1990). Concurrency and discrete event control, *IEEE Control System Magazine*, **10**(4): 103–112.

Hillion, H. and Proth, J. (1989). Performance evaluation of job-shop systems using timed event-graphs, *IEEE Trans. Autom. Control*, **34**(1): 3–9.

Ho, Y. (1985). On the perturbation analysis of discrete-event dynamic systems, *Journal of Optimization Theory and Applications*, **46**(4): 535–545.

Ho, Y. (1987a). Performance evaluation and perturbation analysis of discrete event dynamic systems, *IEEE Trans. Autom. Control*, **32**(7): 563–572.

Ho, Y. (1987b). *A Selected and Annotated Bibliography on Perturbation Analysis*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 217–224. (IIASA Conference, Sopron, Hungary).

Ho, Y. (1989a). Dynamics of discrete event systems, *Proc. of the IEEE*, **77**(1): 3–6. Introduction.

Ho, Y. and Cao, X. (1985). Perturbation analysis and optimization of queueing networks, *Journal of Optimization Theory and Applications*, **40**: 559–582.

Ho, Y. and Cao, X. (1991). *Perturbation Analysis of Discrete Event Dynamic Systems*, Kluwer Academic Publishers.

Ho, Y. and Cassandras, C. (1983). A new approach to the analysis of discrete event dynamic systems, *Automatica*, **19**: 149–167.

Ho, Y. and Li, S. (1988). Extensions of infinitesimal perturbation analysis, *IEEE Trans. Autom. Control*, **33**(5): 427–438.

Ho, Y. C. (1989b). Special issue on the dynamics of discrete event systems, *Proc. of the IEEE.*

Hoare, C. (1978). Communicating sequential processes, *Communications of the ACM*, **21**(8): 666–677.

Hoare, C. (1985). *Communicating Sequential Processes*, International Series in Computer Science, Prentice-Hall International, Englewood Cliffs, NJ.

Holloway, L. and Krogh, B. (1990). Synthesis of feedback control logic for a class of controlled Petri nets, *IEEE Trans. Autom. Control*, **35**(5): 514–523.

Hopcroft, J. E. and Ullman, J. D. (1969). *Formal Languages and their Relation to Automata*, Addison-Wesley Series in Computer Science, Addison-Wesley.

Hopcroft, J. E. and Ullman, J. D. (1979). *Introduction to Automata Theory, Languages and Computation*, Addison-Wesley Series in Computer Science, Addison-Wesley.

Houben, G., Dietz, J. and van Hee, K. (1987). *The SMARTIE Framework for Modelling Discrete Dynamic Systems*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 179–196. (IIASA Conference, Sopron, Hungary).

Hyung, L. and Lee, K. (1991). Finding the shortest path in railroad systems using the super-network, *Int. J. Systems Science*, **22**(7): 1307–1314.

Ichikawa, A. and Hiraishi, K. (1987). *Analysis and Control of Discrete Event Systems Represented by Petri Nets*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 115–134. (IIASA Conference, Sopron, Hungary).

İnan, K. (1992). An algebraic approach to supervisory control, *Mathematics of Control, Signals and Systems*, **2**(5): 151–164.

Inan, K. and Varaiya, P. (1987). *Finitely Recursive Processes*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 1–18. (IIASA Conference, Sopron, Hungary).

Inan, K. and Varaiya, P. (1988). Finitely recursive process models for discrete event systems, *IEEE Trans. Autom. Control*, **33**(7): 626–639.

Inan, K. and Varaiya, P. (1989). Algebras of discrete event models, *Proc. of the IEEE*, **77**(1): 24–38.

Javor, A. (1975). An approach to the modelling of uncertainties in the simulation of quasideterministic discrete event systems., *Problems of Control and Information Theory*, **4**(3): 219–229.

Kahn, G. (ed.) (1987). *Functional Programming Languages and Computer Architecture*, Vol. 274 of *Lecture Notes in Computer Science*, Springer Verlag, Berlin.

Kamath, M. and Sanders, J. (1991). Modeling operator/workstation interference in asynchronous automatic assembly systems, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(1): 93–124.

Kavi, K., Buckles, B. and Bhat, U. (1987). Isomorphisms between Petri nets and dataflow graphs, *IEEE Trans. Software Eng.*, **13**(10): 1127–1134.

Kim, K.-H. and Hwang, C.-S. (1990). Research trends and the theory of distributed simulation, *Korea Information Science Society Review*, **8**(1): 56–63.

Kodama, S. and Kumagai, S. (1985). Discrete event system-net model approach, *Journal of the Society of Instrument and Control Engineers*, **24**(7): 623–632.

Kouikoglou, V. and Phillis, Y. (1991). An exact discrete-event model and control policies for production linies with buffers, *IEEE Trans. Autom. Control*, **36**(5): 515–527.

Kozák, P. (1992a). Discrete events and general systems theory, *Int. J. Systems Science*, **23**(9): 1403–1422.

Kozák, P. (1992b). On feedback controllers, *Int. J. Systems Science*, **23**(9): 1423–1431.

Kramer, J., Magee, J. and Sloman, M. (1984). A software architecture for distributed computer control systems, *Automatica*, **20**(1): 93–102.

Kramer, J., Magee, J. and Sloman, M. (1988). *An Overview of Distributed System Construction Using CONIC*, Vol. 47 of Denham and Laub (1988), pp. 237–255.

Krogh, B. and Feng, D. (1989). Dynamic generation of subgoals for autonomous mobile robots using local feedback information, *IEEE Trans. Autom. Control*, **34**(5): 483–493.

Kuipers, B. (1989). Qualitative reasoning: Modelling and simulation with incomplete knowledge, *Automatica*, **25**(4): 571–585.

Kumar, R., Garg, V. and Marcus, S. (1991). On controllability and normality of discrete event dynamical systems, *System and Control Letters*, **17**: 157–168.

Kurshan, R. (1987). *Reducibility in Analysis of Coordination*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 19–39. (IIASA Conference, Sopron, Hungary).

Lafortune, S. (1988). Modeling and analysis of transaction execution in database systems, *IEEE Trans. Autom. Control*, **33**(5): 439–447.

Lafortune, S. and Chen, E. (1990). The infimal closed controllable superlanguage and its application in supervisory control, *IEEE Trans. Autom. Control*, **35**(4): 398–405.

Lafortune, S. and Lin, F. (1991). On tolerable and desirable behavior in supervisory control of discrete event systems, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(1): 61–92.

Lafortune, S. and Wong, E. (1986). A state transition model for distributed query processing, *ACM Trans. Database Systems*, **11**(3): 294–322.

Lafortune, S. and Yoo, H. (1990). Some results on Petri net languages, *IEEE Trans. Autom. Control*, **35**(4): 482–485.

Larsen, F. and Evans, F. (1988). *Structural Design of Decentralized Control Systems*, Vol. 47 of Denham and Laub (1988), pp. 257–288.

L'Ecuyer, P. and Haurie, A. (1988). Discrete event dynamic programming with simultaneous events, *Mathematics of Operations Research*, **13**(1): 152–163.

Lee, K.-H. and Favrel, J. (1985). Hierarchical reduction method for analysis and decomposition of Petri nets, *IEEE Trans. Systems Man and Cybernetics*, **15**(2): 272–280.

Lee-Kwang, H., Favrel, J. and Oh, G.-R. (1987). Hierarchical decomposition of Petri net languages, *IEEE Trans. Systems Man and Cybernetics*, **17**(5): 877–878.

Lee, T. and Lai, M.-Y. (1988). A relational algebraic approach to protocol verification, *IEEE Trans. Software Eng.*, **14**(2): 184–193.

Leeming, A. (1981). A comparison of some discrete event simulation languages, *Simuletter*, **12**(1–4): 9–16.

Leung, Y.-T. and Suri, R. (1990). Performance evaluation of discrete manufacturing systems, *IEEE Control System Magazine*, **10**(4): 77–86.

Levi, S.-T. and Agrawala, A. (1990). *Real-Time System Design*, McGraw-Hill, New York.

Levis, A. (1984). Information processing and decision-making organizations: A mathematical description, *Large Scale Systems*, **7**: 151–163.

Li, Y. and Wonham, W. (1988). On supervisory control of real-time discrete event systems, *Information Sciences*, **46**(3): 159–183.

Lin, F. (1991). Control of large scale discrete event systems: Task allocation and coordination, *System and Control Letters*, **17**: 169–175.

Lin, F. and Wonham, W. (1988a). Decentralized supervisory control of discrete-event systems, *Information Sciences*, **44**(3): 199–224.

Lin, F. and Wonham, W. (1988b). On observability of discrete-event systems, *Information Sciences*, **44**(3): 173–198.

Lin, F. and Wonham, W. (1990). Decentralized control and coordination of discrete-event systems with partial observation, *IEEE Trans. Autom. Control*, **35**(12): 1330–1337.

Lin, F., Vaz, A. and Wonham, W. (1988). Supervisor specification and synthesis for discrete event systems, *Int. J. Control*, **48**(1): 321–332.

Lingarkar, R., Liu, L., Elbestavwi, M. and Sinha, N. (1990). Knowledge-based adaptive computer control in manufacturing systems: A case study, *IEEE Trans. Systems Man and Cybernetics*, **20**(3): 606–618.

Looney, C. and Alfize, A. (1987). Logical controls via boolean rule matrix transformations, *IEEE Trans. Systems Man and Cybernetics*, **17**(6): 1077–1082.

Lynch, N. and Tuttle, M. (1989). An introduction to input/output automata, *CWI Quarterly*, **2**(3): 219–246.

Magott, J. (1984). Performance evaluation of concurrent systems using Petri nets, *Information Processing Letters*, **18**(1): 7–13.

Maimon, O. and Tadmor, G. (1988). Model-mased low-level control in flexible manufacturing systems, *Robotics & Computer-Integrated Manufacturing*, **4**(3/4): 423–428.

Maler, O., Manna, Z. and Pnueli, A. (1991). *From Timed to Hybrid Systems*, number 600 in *Lecture Notes in Computer Science Series*, Springer-Verlag, pp. 447–484. Proceedings of the REX workshop "Real Time: Theory in Practice".

Manna, Z. and Pnueli, A. (1992). *The temporal logic of reactive and concurrent systems*, Springer-Verlag.

McIntyre, M. (1987). Some direct interconnections between formal language theory and discrete-time linear system theory, *IEEE Trans. Circuits and Systems*, **34**(9): 1102–1107.

Merlin, P. and Bochmann, G. (1983). On the construction of submodule specifications and communication protocols, *ACM Trans. Programming Languages and Systems*, **5**(1): 1–25.

Milner, R. (1980). *A Calculus of Communicating Systems*, Vol. 92 of *LNCS*, Springer-Verlag, New York.

Milner, R. (1989). *Communication and Concurrency*, Prentice Hall, New York.

Mowshowitz, A. (1968). Entropy and the complexity of graphs, *Bulletin Math. Biophys.*, **30**: 175–204.

Muhanna, W. (1991). Composite programs: Hierarchical construction, circularity, and deadlocks, *IEEE Trans. Software Eng.*, **17**(4): 320–333.

Murata, T. (1977a). Petri nets, marked graphs, and circuit-system theory, *IEEE Trans. Circuits and Systems*.

Murata, T. (1977b). State equations, controllability, and maximal matchings of Petri nets, *IEEE Trans. Autom. Control*, **22**(3): 412–416.

Murata, T. (1980). Synthesis of decision-free concurrent systems for prescribed resources and performance, *IEEE Trans. Software Eng.*, **6**(6): 525–530.

Murata, T. (1989). Petri nets: Properties, analysis, and applications, *Proc. of the IEEE*, **77**(4): 541–580.

Naylor, A. and Volz, R. (1987). Design of integrated manufacturing system control software, *IEEE Trans. Systems Man and Cybernetics*, **17**(6): 881–897.

Olderog, E.-R. (1991). *Nets, Terms and Formulas*, Vol. 23 of *Cambridge Tracts in Theoretical Computer Science*, Cambridge University Press.

Olsder, G. (1991). Eigenvalues of dynamic max-min systems, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(2): 177–207.

Olsder, G. and de Vries, R. (1987). *On an Analogy of Minimal Realizations in Conventional and Discrete-Event Dynamic Systems*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 149–161. (IIASA Conference, Sopron, Hungary).

Olsder, G., Resing, J., de Vries, R., Keane, M. and Hooghiemstra, G. (1990). Discrete event systems with stochastic processing times, *IEEE Trans. Autom. Control*, **35**(3): 299–302.

Oommen, B. and Hansen, E. (1984). The asymptotic optimality of discretized linear reward-inaction learning automata, *IEEE Trans. Systems Man and Cybernetics*, **14**(3): 542–545.

Ostroff, J. (1988). *Temporal Logic and Extended State Machines in Discrete Event Systems*, Vol. 47 of Denham and Laub (1988), pp. 215–236.

Ostroff, J. (1989). *Temporal Logic for Real-Time Systems*, RSP, Research Studies Press / Wiley. Taunton, UK.

Ostroff, J. (1990). A logic for real-time discrete event processes, *IEEE Control System Magazine*, **10**(4): 95–102.

Ostroff, J. and Wonham, W. (1990). A framework for real-time discrete event control, *IEEE Trans. Autom. Control*, **35**(4): 386–397.

Özsu, M., Wong, K. and Koon, T. (1988). System modeling and analysis using Petri nets, *Syst. Anal. Model. Simul.*, **5**(1): 3–25.

Özveren, C. and Willsky, A. (1990). Observability of discrete event systems, *IEEE Trans. Autom. Control*, **35**(7): 797–806.

Özveren, C. and Willsky, A. (1991). Output stabilizability of discrete event dynamic systems, *IEEE Trans. Autom. Control*, **36**(8): 925–935.

Özveren, C. and Willsky, A. (1992a). Aggregation and multi-level control in discrete event systems, *Automatica*, **28**(3): 565–578.

Özveren, C. and Willsky, A. (1992b). Invertibility of discrete event dynamic systems, *Mathematics of Control, Signals and Systems*, **5**(4): 365–390.

Özveren, C., Willsky, A. and Antsaklis, P. (1991). Stability and stabilizality of discrete event dynamic systems, *J. ACM*, **38**(3): 730–752.

Passino, K. and Antsaklis, P. (1991). Event rates and aggregation in hierarchical systems, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(3): 271–288.

Perdu, D. and Levis, A. (1991). A Petri net model for evaluation of expert systems in organizations, *Automatica*, **27**(2): 225–237.

Perkins, J. and Kumar, P. (1989). Stable, distributed, real-time scheduling of flexible manufacturing/assembly/disassembly systems, *IEEE Trans. Autom. Control*, **34**(2): 139–148.

Peterson, J. (1977). Petri nets, *ACM Computing Surveys*, **9**(3): 223–252.

Peterson, J. (1981). *Petri Net Theory and the Modelling of Systems*, Prentice-Hall, Englewood Cliffs.

Pnueli, A. (1986). *Applications of Temporal Logic to the Specification and Verification of Reactive Systems: A Survey and Current Trends*, number 224 in *Lecture Notes in Computer Science Series*, Springer-Verlag, pp. 510–584.

Ramadge, P. (1987). *Supervisory Control of Discrete Event Systems: A Survey and Some New Results*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 69–80. (IIASA Conference, Sopron, Hungary).

Ramadge, P. (1988). *The Complexity of Some Basic Control Problems for Discrete Event Systems*, Vol. 47 of Denham and Laub (1988), pp. 171–190.

Ramadge, P. (1989). Some tractable supervisory control problems for discrete-event systems modeled by Büchi automata, *IEEE Trans. Autom. Control*, **34**(1): 10–19.

Ramadge, P. (1990). On the periodicity of symbolic observations of piecewise smooth discrete-time systems, *IEEE Trans. Autom. Control*, **35**(7): 807–813.

Ramadge, P. and Wonham, W. (1987a). Modular feedback logic for discrete event systems, *SIAM J. Control Optim.*, **25**(5): 1202–1218.

Ramadge, P. and Wonham, W. (1987b). Supervisory control of a class of discrete event processes, *SIAM J. Control Optim.*, **25**(1): 206–230.

Ramadge, P. and Wonham, W. (1989). The control of discrete event systems, *Proc. of the IEEE*, **77**(1): 81–98.

Rea, K. and Johnston, R. (1987). Automated analysis of discrete communication behavior, *IEEE Trans. Software Eng.*, **13**(10): 1115–1126.

Reisig, W. (1985). *Petri Nets. An Introduction*, Vol. 4 of *Monographs on Theoretical Computer Science*, Springer-Verlag.

Righter, R. and Walrand, J. (1989). Distributed simulation of discrete event systems, *Proc. of the IEEE*, **77**(1): 99–113.

Riordon, J. (1969a). An adaptive automaton controller for discrete-time Markov processes, *Automatica*, **5**: 721–730.

Riordon, J. (1969b). Optimal feedback characteristics from stochastic automaton models, *IEEE Trans. Autom. Control*, **14**: 89–92.

Rosenberger, F., Molnar, C., Chaney, T. and Fang, T. (1988). II-modules: Internally clocked delay-insensitive modules, *IEEE Trans. Computers*, **37**(9): 1005–1018.

Roszkowska, E. and Banaszak, Z. (1991). *Problems of Deadlock Handling in Pipeline Processes*, Computer and Information Sciences VI, Elsevier Science Publisher.

Rudie, K. and Wonham, W. (1990). The infimal prefix-closed and observable superlanguage of a given language, *System and Control Letters*, **15**(5): 361–371.

Rudie, K. and Wonham, W. (1992). Think globally, act locally: Decentralized supervisory control, *IEEE Trans. Autom. Control*, **37**(11): 1692–1708.

Sabnani, K. (1988). An algorithmic technique for protocol verification, *IEEE Trans. Communications*, **36**(8): 924–931.

Sajkowski, M. (1987). *Protocol Verification Using Discrete-Event Models*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 100–114. (IIASA Conference, Sopron, Hungary).

Schumacher, J. (1989). Discrete events: Perspectives from system theory, *CWI Quarterly*, **2**(2): 131–146.

Schwartz, R. and Melliar-Smith, P. (1982). From state machines to temporal logic: Specification methods for protocol standards, *IEEE Trans. Communications*, **30**(12): 2486–2496.

Seiche, W. (1991). Control synthesis based on a graph-theoretical Petri net analysis, *Int. J. of Microelectronics and Reliability*, **31**(4): 563–575.

Sengupta, R. and Lafortune, S. (1991). A graph-theoretical optimal control problem for terminating discrete event processes, *Discrete Event Dynamic Systems: Theory and Applications*, **2**(1): 139–172.

Shanthikumar, J. and Yao, D. (1989). Second order stochastic properties of queueing systems, *Proc. of the IEEE*, **77**(1): 162–170.

Sharifnia, A., Caramanis, M. and Gershwin, S. (1991). Dynamic setup scheduling and flow control in manufacturing systems, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(2): 149–175.

Shreve, S. and Bertsekas, D. (1979). Universally measurable policies in dynamic programming, *Mathematics of Operations Research*, **4**(1): 15–30.

Smedinga, R. (1987). *Using Trace Theory to Model Discrete Events*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. 81–99. (IIASA Conference, Sopron, Hungary).

Smedinga, R. (1993). Locked discrete event systems: how to model and how to unlock, *Discrete Event Dynamic Systems: Theory and Applications*.

Sparaggis, P. and Cassandras, C. (1991). Monotocity properties of cost functions in queueing networks, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(3): 315–327.

Sreenivas, R. and Krogh, B. (1991). On condition/event systems with discrete state realizations, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(2): 209–235.

Sreenivas, R. and Krogh, B. (1992). On Petri nets models of infinite state supervisors, *IEEE Trans. Autom. Control*, **37**(2): 274–277.

Stankovic, J. A. and Ramamritham, K. (eds) (1988). *Tutorial: Hard Real-Time Systems*, IEEE Computer Society Press, Washington, D.C.

Subrahmanian, E. and Canon, R. (1981). A generator program for models of discrete-event systems, *Simulation*, **36**(3): 93–101.

Sunshine, C. (1982). Special issue on protocol specification, testing, and verification, *IEEE Trans. Communications*.

Suri, R. (1989). Perturbation analysis: The state of the art and research issues explained via the G/G/1 queue, *Proc. of the IEEE*, **77**(1): 114–137.

Suzuki, T., Shatz, S. and Murata, T. (1990). A protocol modeling and verification approach based on a specification language and Petri nets, *IEEE Trans. Software Eng.*, **16**(5): 523–536.

Tabak, D. and Levis, A. (1985). Petri net representation of decision models, *IEEE Trans. Systems Man and Cybernetics*, **15**(6): 812–818.

Tadmor, G. and Maimon, O. (1989). Control of large discrete event systems: Constructive algorithms, *IEEE Trans. Autom. Control*, **34**(11): 1164–1168.

Thistle, J. and Wonham, W. (1986). Control problems in a temporal logic framework, *Int. J. Control*, **44**(4): 943–976.

Tsitsiklis, J. (1989). On the control of discrete event dynamical systems, *Mathematics of Control, Signals and Systems*, **2**(2): 95–107.

Ushio, T. (1989a). Controllability and control-invariance in discrete-event systems, *Int. J. Control*, **50**(4): 1507–1515.

Ushio, T. (1989b). Controllable languages and predicates in discrete-event systems, *Transactions of the Institute of Electronics, Information and Communication Engineers A*, **J72A**(12): 2048–2051.

Ushio, T. (1989c). Modular feedbacks of discrete event systems with arbitrary control patterns, *Transactions of the Institute of Electronics, Information and Communication Engineers A*, **J72A**(6): 938–944.

Ushio, T. (1990a). Feedback logic for discrete event systems with arbitrary control patterns, *Int. J. Control*, **52**(1): 159–174.

Ushio, T. (1990b). Fixpoint characterization of controllability in discrete event systems with nondeterministic supervisors, *Transactions of the Institute of Electronics, Information and Communication Engineers A*, **J73A**(3): 642–644.

Ushio, T. (1990c). Maximally permissive feedback and modular control synthesis in Petri nets with external input places, *IEEE Trans. Autom. Control*, **35**(7): 844–848.

Ushio, T. (1990d). Modular feedbacks of discrete event systems with arbitrary control patterns, *Electronics and Communications in Japan, Part 3 (Fundamental Electronic Science)*, **73**(4): 99–106.

Van Breusegem, V., Campion, G. and Bastin, G. (1991). Traffic modelling and state feedback control for metro rail lines based on linear discrete-event state-space models, *IEEE Trans. Autom. Control*, **36**(7): 770–784.

Van de Snepscheut, J. (1985). *Trace Theory and VLSI Design*, Vol. 200 of *LNCS*, Springer-Verlag, New York.

Van der Rhee, F., Van Nauta Lemke, H. and Dukman, J. (1990). Knowledge based fuzzy control of systems, *IEEE Trans. Autom. Control*, **35**(2): 148–155.

Varaiya, P. (1987). *Preface*, Vol. 103 of Varaiya and Kurzhanski (1987), pp. iv–vii. (IIASA Conference, Sopron, Hungary).

Varaiya, P. and Kurzhanski, H. (eds) (1987). *Discrete Event Systems: Models and Application*, Vol. 103 of *Lecture Notes in Control and Information Sciences*, Springer Verlag, Berlin, Germany. (IIASA Conference, Sopron, Hungary).

Varaiya, P., Walrand, J. and Buyukkoc, C. (1985). Extensions of the multiarmed bandit problem: The discounted case, *IEEE Trans. Autom. Control*, **30**(5): 426–439.

Vaz, A. and Wonham, W. (1986). On supervisor reduction in discrete event systems, *Int. J. Control*, **44**(2): 475–491.

Wang, Z.-Q., Song, W.-Z. and Feng, C.-B. (1991). Full-state perturbation ananlysis of discrete event dynamic systems, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(3): 249–270.

Wardi, Y. and Hu, J. (1991). Strong consistency of infinitesimal perturbation analysis for tandem queueing networks, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(1): 37–60.

Wardi, Y., Gong, W.-B., Cassandras, C. and Kallmes, M. (1991). Smoothed perturbation analysis for a class of piecewise constant sample performance functions, *Discrete Event Dynamic Systems: Theory and Applications*, **1**(4): 393–414.

Whitney, D. (1969). State space models of remote manipulation tasks, *IEEE Trans. Autom. Control*, **14**(6): 617–623.

Willson, R. and Krogh, B. (1990). Petri net tools for the specification and analysis of discrete controllers, *IEEE Trans. Software Eng.*, **16**(1): 39–50.

Wirth, N. (1977). Toward a discipline of real-time programming, *Communications of the ACM*, **20**(8): 577–583.

Wolper, P. (1983). Temporal logic can be more expressive, *Information and Control*, **56**: 72–99.

Wonham, W. (1987). Some remarks on control and computer science, *IEEE Control System Magazine*, **7**(2): 9–10.

Wonham, W. (1988). *A Control Theory for Discrete Event Systems*, Vol. 47 of Denham and Laub (1988), pp. 129–169.

Wonham, W. and Ramadge, P. (1987). On the supremal controllable sublanguage of a given language, *SIAM J. Control Optim.*, **25**(3): 637–659.

Wonham, W. and Ramadge, P. (1988). Modular supervisory control of discrete event systems, *Mathematics of Control, Signals and Systems*, **1**: 13–30.

Yu, Y. and Gouda, M. (1982). Deadlock detection for a class of communicating finite state machines, *IEEE Trans. Communications*, **30**(12): 2512–2516.

Zeigler, B. (1989). DEVS representation of dynamical systems: Event-based intelligent control, *Proc. of the IEEE*, **77**(1): 72–80.

Zhong, H. and Wonham, W. (1990). On the consistency of hierarchical supervision in discrete-event systems, *IEEE Trans. Autom. Control*, **35**(10): 1125–1134.

Zuberek, W. (1986). Inhibitor D-timed Petri nets and performance analysis of communication protocols, *INFOR Journal*, **24**(3): 231–249.