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37A812 - KASSANDRA SCHMITT

This volume contains the proceedings of the 19th annual International Conference on Application and Theory of Petri Nets. The aim of the Petri net conference is to create a forum for the dissemination of the latest results in the application and theory of Petri nets. It always takes place in the last week of June. Typically there are 150 - 200 participants. About one third of these come from industry while the rest are from universities and research institutions. The conferences and a number of other activities are coordinated by a steering committee with the following members: G. Balbo (Italy), J. Billington (Australia), G. DeMichelis(Italy),C. Girault(France),K. Jensen (Denmark), S. Kumagai (Japan), T. Murata (USA), C. A. Petri (Germany; honorary member), W. Reisig (Germany), G.

Roucairol (France), G. Rozenberg (The Netherlands; chairman), M. Silva (Spain). The 19th conference has been organized for the rst time in Portugal, by the Department of Electrical Engineering of the Faculty of Sciences and Technology of the New University of Lisbon, together with the Center for Intelligent Robotics of UNINOVA. It takes place in Lisbon at the same time as EXPO'98, the last world exhibition of the 20th century.

Introduces theories and applications of timed Petri nets, focusing on their use in modeling of discrete event dynamic systems (DEDSs). Examines characteristics and performance of DEDSs, introduces fundamentals of Petri nets, and details analysis methods and application of deterministic timed transition Petri nets. Addresses firing policies, memory properties, and stochastic processes of timed Petri nets, and describes theory and application of high-level stochastic Petri nets and semi--Markovian SPN models. Annotation copyrighted by Book News, Inc., Portland, OR

One critical barrier leading to successful implementation of flexible manufacturing and related automated systems is the ever-increasing complexity of their modeling, analysis, simulation, and control. Research and development over the last three decades has provided new theory and graphical tools based on Petri nets and related concepts for the design of such systems. The purpose of this book is to introduce a set of Petri-net-based tools and methods to address a variety of problems associated with the design and implementation of flexible manufacturing systems (FMSs), with several implementation examples.There are three ways this book will directly benefit readers. First, the book will allow engineers and managers who are responsible for the design and implementation of modern manufacturing systems to evaluate Petri nets for applications in their work. Second, it will provide sufficient breadth and depth to allow development of Petri-net-based industrial applications. Third, it will allow the basic Petri net material to be taught to industrial practitioners, students, and academic researchers much more efficiently. This will foster further research and applications of Petri nets in aiding the successful implementation of advanced manufacturing systems.

Petri Net Synthesis for Discrete Event Control of Manufacturing Systems develops two essential resource-sharing concepts: parallel and sequential mutual exclusions and theoretical results in Petri synthesis. A parallel mutual exclusion (PME) is defined to model a resource shared by independent distributed processes, and a sequential mutual exclusion is a sequential composition of PMEs, modeling a resource shared by sequentially-related processes. A hybrid synthesis methodology for Petri net models and controllers is proposed using top-down, modular, and bottom-up design ideas and the mutual exclusion theory. An aggregate Petri net model is refined by replacing places and /or transitions with basic design modules which are mathematically and graphically described. Petri net design methods are presented for such buffers as automatic storage and retrieval systems. Using the proposed method synthesizes both Petri net structure and feasible initial markings, guaranteeing that resulting Petri nets have desirable system properties such as freedom from deadlock and cyclic behavior. A Petri net controller is extended to error recovery for automated manufacturing systems. The theory can guarantee that the desired system proper-

ties achieved by the original design will be preserved when the controller is augmented to deal with an error in the prescribed methods. Control code has been directly generated from Petri net definitions. The algorithm and implementation details are given for a flexible manufacturing system. Using the approach presented in Petri Net Synthesis for Discrete Event Control of Manufacturing Systems, engineers and research workers can develop their own discrete event control applications and experiments.

The world is full of events which cause, end or affect other events. The study of these events, from a system point of view, is very important. Such systems are called discrete event dynamic systems and are of a subject of immense interest in a variety of disciplines, which range from telecommunication systems and transport systems to manufacturing systems and beyond. There has always been an intense need to formulate methods for modelling and analysis of discrete event dynamic systems. Petri net is a method which is based on a well-founded mathematical theory and has a wide application. This book is a collection of recent advances in theoretical and practical applications of the Petri net method and can be useful for both academia and industry related practitioners.

High-level Petri nets are now widely used in both theoretical analysis and practical modelling of concurrent systems. The main reason for the success of this class of net models is that they make it possible to obtain much more succinct and manageable de scriptions than can be obtained by means of low-level Petri nets-while, on the other hand, they still offer a wide range of analysis methods and tools. The step from low-level nets to high-level nets can be compared to the step from assembly languages to modem programming languages with an elaborated type concept. In low-level nets there is only one kind of token and this means that the state of a place is described by an integer (and in many cases even by a boolean value). In high-level nets each token can carry complex information which, e. g. , may describe the entire state of a process or a data base. Today most practical applications of Petri nets use one of the different kinds of high-level nets. A considerable body of knowledge exists about high-level Petri nets this includes theoretical foundations, analysis methods and many applications. Unfortunately, the papers on high-level Petri nets have been scattered throughout various journals and collections. As a result, much of this knowledge is not readily available to people who may be interested in using high-level nets.

Global competition has made it necessary for manufacturers to introduce such advanced technologies as flexible and agile manufacturing, intelligent automation, and computer-integrated manufacturing. However, the application extent of these technologies varies from industry to industry and has met various degrees of success. One critical barrier leading to successful implementation of advanced manufacturing systems is the ever-increasing complexity in their modeling, analysis, simulation, and control. The purpose of this work is to introduce a set of Petri net-based tools and methods to address a variety of problems associated with the design and implementation of flexible manufacturing systems (FMSs). More specifically, this work proposes Petri nets as an integrated

tool for modeling, simulation, and control of flexible manufacturing systems (FMSs). The contributions of this work are multi-fold. First, it demonstrates a new application of PNs for simulation by evaluating the performance of pull and push diagrams in manufacturing systems. Second, it introduces a class of PNs, Augmented--timed Petri nets (ATPNs) in order to increase the power of PNs to simulate and control flexible systems with breakdowns. Third, it proposes a new class of PNs called Realtime Petri nets (RTPNs) for discrete event control of FMS s. The detailed comparison between RTPNs and traditional discrete event methods such as ladder logic diagrams is presented to answer the basic question 'Why is a PN better tool than ladder logic diagram?' and to justify the PN method. Also, a conversion procedure that automatically generates PN models from a given class of logic control specifications is presented. Finally, a methodology that uses PNs for the development of object-oriented control software is proposed. The present work extends the PN state-of-the-art in two ways. First, it offers a wide scope for engineers and managers who are responsible for the design and the implementation of modem manufacturing systems to evaluate Petri nets for applications in their work. Second, it further develops Petri net-based methods for discrete event control of manufacturing systems.
Modeling and control issues in automated manufacturing systems. Introduction to Markov processes and queueing theory. Petri net theory in manufacturing. Formal definitions, classification, and properties of ordinary petri nets. Analysis of petri nets. Timed, stochastic, and generalized stochastic petri nets. Performance analysis of automated manufacturing systems using petri nets. Petri net modeling and real-time controllers.

In the competitive business arena companies must continually strive to create new and better products faster, more efficiently, and more cost effectively than their competitors to gain and keep the competitive advantage. Computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM) are now the industry standa
Standard Petri nets have been used to model and analyze Flexible Manufacturing Systems. The timed Petri net, which can incorporate the time delay associated with manufacturing events, provides additional information about real time behavior of practical systems. The Timed Petri Net Simulation Tool, a highly interactive graphical tool, is applied to simulate the modeled flexible manufacturing systems. Timed Petri net models are experimented with. Machine utilization data and throughput are obtained. Analysis of the results shows that the system performance can be optimized by choosing proper parameters.

Petri Nets were introduced in the doctoral dissertation by K.A. Petri, titled "Kommunikation mit Automaten" and published in 1962 by University of Bonn. Petri Nets are graphical (the intuitive graphical modeling language) and mathematical (advanced formal analysis method) tool. The concurrence of performed actions is the natural phenomenon due to which Petri Nets are perceived as mathematical tool for modeling concurrent systems. The main idea of this theory was modified by many researchers according to their needs, owing to the unusual "flexibility" of this theory. The present monograph focuses on Petri Nets applications in two main areas: manu-

facturing (section 1) and computer science (section 2). These two areas have still huge influence on our lives and our world. The theory of Petri Nets is still developing: some directions of investigations are presented in section 3. And at the end there is section 4 including some infesting facts concerning application of Petri Nets in the public area: the analysis and control of public bicycle sharing systems. The monograph shows the results of research works performed with use of Petri Nets in science centers all over the world.

Driven by the request for increased productivity, flexibility, and competitiveness, modern civilization increasingly has created high-performance discrete event dynamic systems (DEDSs). These systems exhibit concurrent, sequential, competitive activities among their components. They are often complex and large in scale, and necessarily flexible and thus highly capital-intensive. Examples of systems are manufacturing systems, communication networks, traffic and logistic systems, and military command and control systems. Modeling and performance evaluation play a vital role in the design and operation of such high-performance DEDSs and thus have received widespread attention from researchers over the past two decades. One methodology resulting from this effort is based on timed Petri nets and related graphical and mathematical tools. The popularity that Petri nets have been gaining in modeling of DEDSs is due to their powerful representational ability of concurrency and synchronization; however these properties of DEDSs cannot be expressed easily in traditional formalisms developed for analysis of `classical' systems with sequential behaviors. This book introduces the theories and applications of timed Petri nets systematically. Moreover, it also presents many practical applications in addition to theoretical developments, together with the latest research results and industrial applications of timed Petri nets. Timed Petri Nets: Theory and Application is intended for use by researchers and practitioners in the area of Discrete Event Dynamic Systems.

Petri nets provide useful concepts and tools for studying the structure and control of concurrent systems. They have been used in the modeling of a wide variety of systems from computers to sociotechnical systems. This report discusses the use of Petri nets in the modeling and analysis of flexible manufacturing systems (FMS). Net concepts relevant to the manufacturing systems are introduced and qualitative properties such as the existence or absence of deadlock, safeness, and boundedness are discussed using the method of invariants. The modeling and analysis techniques are illustrated by means of simple manufacturing systems and the concepts of coloured Petri nets and their usefulness in the modeling of FMS is considered.

Over the past two decades, research in the theory of Petri nets and the development of graphical tools has yielded a powerful methodology. The contributions in Petri Nets in Flexible and Agile Automation present theoretical development of Petri nets as well as in industrial applications to areas such as discrete- event control design, scheduling, performance evaluation and deadlock avoidance. These contributions also include comparative studies of Petri nets and other approaches. A primary theme of this book is to provide a unified approach to the applications of Petri nets in flexible and agile automation and, in that regard, a common notation and terminology is used. The book also allows read-

ers to evaluate the benefits and applicability of state-of-the-art Petri net methods and apply CAD tools to problems of interest. Petri Nets in Flexible and Agile Automation is not only an essential reference for researchers, it is also a very useful tool for engineers, analysts and managers who are responsible for the design, implementation and operation of the next generation of manufacturing systems.

Petri nets are widely used in modeling, analysis, and control of discrete event systems arising from manufacturing, transportation, computer and communication networks, and web service systems. However, Petri net models for practical systems can be very large, making it difficult to apply such models to real-life problems. System Modeling and Control with Resource-Oriented Petri Nets introduces a new resource-oriented Petri net (ROPN) model that was developed by the authors. Not only does it successfully reduce model size, but it also offers improvements that facilitate effective modeling, analysis, and control of automated and reconfigurable manufacturing systems. Presenting the latest research in this novel approach, this cutting-edge volume provides proven theories and methodologies for implementing cost and time-saving improvements to contemporary manufacturing systems. It provides effective tools for deadlock avoidance—deadlock-free routing and deadlock-free scheduling. The authors supply simple and complex industrial manufacturing system examples to illustrate time-tested concepts, theories, and approaches for solving real-life application problems. Written in a clear and concise manner, the text covers applications to automated and reconfigurable manufacturing systems, automated guided vehicle (AGV) systems, semiconductor manufacturing systems, and flexible assembly systems. Explaining complex concepts in a manner that is easy to understand, the authors provide the understanding and tools needed for more effective modeling, analysis, performance evaluation, control, and scheduling of engineering processes that will lead to more flexible and efficient manufacturing systems.
"This book addresses the development of reconfigurable embedded control systems and describes various problems in this important research area, which include static and dynamic (manual or automatic) reconfigurations, multi-agent architectures, modeling and verification, component-based approaches, architecture description languages, distributed reconfigurable architectures, real-time and low power scheduling, execution models, and the implementation of such systems"--

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. Contain-

ing 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.

Petri nets have evolved into a powerful tool for the modeling, analysis and design of asynchronous, concurrent systems. This thesis presents the modeling and analysis of a flexible manufacturing system (FMS) cell using Petri nets. In order to improve the productivity of such systems, the building of mathematical models is a crucial step. In this thesis, the theory and application of Petri nets are presented with emphasis on their application to the modeling and analysis of practical automated manufacturing systems. The theory of Petri nets includes their basic notation and properties. In order to illustrate how a Petri net with desirable properties can be modeled, this thesis describes the detailed modeling process for an FMS cell. During the process, top-down refinement, system decomposition, and modular composition ideas are used to achieve the hierarchy and preservation of important system properties. These properties include liveness, boundedness, and reversibility. This thesis also presents two illustrations showing the method adopted to model any manufacturing systems using ordinary Petri nets. The first example deals with a typical resource sharing problem and the second the modeling of Fanuc Machining Center at New Jersey Institute of Technology. Furthermore, this thesis presents the analysis of a timed Petri net for cycle time, system throughput and equipment utilization. The timed (deterministic) Petri net is first converted into an equivalent timed marked graph. Then the standard procedure to find the cycle time for marked graphs is applied. Secondly, stochastic Petri net is analyzed using SPNP software package for obtaining the system throughput and equipment utilization. This thesis is of significance in the sense that it provides industrial engineers and academic researchers with a comprehensive real-life example of applying Petri net theory to modeling and analysis of FMS cells. This will help them develop their own applications.

Using formal methods for the specification and verification of hardware and software systems is becoming increasingly important as systems increase in size and complexity. The aim of the book is to illustrate progress in formal methods based on Petri net formalisms. It presents both practical and theoretical foundations for the use of Petri nets in complex system engineering tasks. In doing so it bridges the gap between Petri nets and the systems modeling and implementation process. It contains a collection of examples arising from different fields, such as flexible manufacturing, telecommunication and workflow management systems.