Introduction To Discrete Event Systems

Introduction To Discrete Event Systems Introduction to Discrete Event Systems Discrete Event Systems (DES) are dynamic systems characterized by the occurrence of events at discrete points in time, which cause changes in the system's state. These systems are fundamental in modeling, analyzing, and controlling complex processes across various industries, including manufacturing, transportation, telecommunications, and computer networks. Understanding the core principles of discrete event systems is essential for engineers, researchers, and practitioners aiming to optimize system performance, ensure reliability, and develop efficient control strategies. In this comprehensive guide, we will explore the concept of discrete event systems, their fundamental components, modeling techniques, analysis methods, and applications. Whether you are new to the field or seeking a detailed overview, this article aims to provide a clear, structured, and SEO-friendly introduction to DES. What Are Discrete Event Systems? Discrete Event Systems are systems where state changes occur at discrete moments due to the occurrence of specific events. Unlike continuous systems, which evolve smoothly over time, DES evolve through a sequence of instantaneous events. These events can be anything from a machine starting or stopping, a packet arriving at a network node, to a vehicle entering or leaving a traffic intersection. Key characteristics of discrete event systems include: - Event-driven dynamics: System changes are triggered by events rather than continuous inputs. - Discrete states: The system occupies a finite or countably infinite set of states. - Asynchronous operation: Events occur at unpredictable times, leading to asynchronous state transitions. - Model complexity: DES can model highly complex, non-linear, and stochastic processes. Understanding these features is crucial for effective modeling and control of such systems. Fundamental Components of Discrete Event Systems A typical discrete event system comprises several core components that work together to define its behavior: States States represent the different configurations or conditions the system can be in at any given time. For example, in a manufacturing system, states could include "idle," "processing," or "maintenance." 2 Events Events are occurrences that trigger state transitions. They are the fundamental drivers of system evolution. Examples include a machine completing a job, a sensor detecting an anomaly, or a customer arrival. Transitions Transitions are the rules or functions that define how the system moves from one state to another in response to events. Timing Timing considerations specify when events occur and how long the system stays in particular states before transitioning. These can be deterministic or stochastic. Modeling Discrete Event Systems Modeling is a critical step in analyzing and controlling DES. Several formal methods are available for representing discrete event systems, with the most prevalent being Finite State Machines, Petri Nets, and Discrete Event Simulation. Finite State Machines (FSMs) FSMs are mathematical models consisting of a finite set of states, input events, transition functions, and output functions. They are widely used for simple DES modeling due to their intuitive structure. Petri Nets Petri Nets are graphical and mathematical tools that model concurrent, asynchronous, and stochastic systems effectively. They consist of places, transitions, and tokens, providing a visual representation of system states and events. Discrete Event Simulation (DES) Simulation techniques allow for modeling complex systems where analytical solutions are difficult. Discrete event simulation involves simulating the occurrence of events over time to analyze system performance. Analysis of Discrete Event Systems Analyzing DES involves examining their behavior, performance, and robustness. Several techniques are employed: 3 Reachability Analysis: Determines which states can be reached from the initial state, helping to identify possible system configurations and deadlocks. Performance Evaluation: Assesses metrics such as throughput, delay, utilization, and reliability. Controllability and Supervisory Control: Designs controllers to ensure the system behaves within desired parameters, avoiding unsafe states. Stochastic Analysis: Incorporates randomness in events or transitions to evaluate probabilistic system behaviors. Control Strategies for Discrete Event Systems Controlling DES involves designing mechanisms to influence system behavior, ensuring safety, efficiency, and goal achievement. Common approaches include: Supervisory Control A supervisory controller observes system events and enables or disables certain actions to prevent undesirable states. This approach is widely used in manufacturing and automation. Discrete Event Control Algorithms Algorithms such as Petri Net-based controllers or finite state controllers are used to enforce specific behaviors, optimize throughput, or minimize delays. Decentralized Control In large-scale systems, control is distributed among multiple agents or controllers to improve scalability and robustness. Applications of Discrete Event Systems DES are applied in numerous domains due to their ability to model asynchronous, event- driven processes: Manufacturing Systems: Modeling assembly lines, robotic systems, and workflow management. Transportation and Traffic Control: Managing traffic signals, railway operations, and air traffic control systems. Computer Networks: Analyzing packet flows, network protocols, and resource allocation. Telecommunications: Modeling switching systems and communication protocols. Healthcare Systems: Scheduling patient treatments, managing hospital 4 workflows, and resource planning. The versatility of DES makes them indispensable for designing efficient, reliable, and safe systems across multiple industries. Challenges and Future Directions Despite their strengths, modeling and controlling discrete event systems pose challenges: - Complexity: Large systems can lead to state-space explosion, making analysis computationally intensive. - Uncertainty: Stochastic events and unpredictable behaviors complicate modeling. - Real-time requirements: Ensuring timely responses in control systems demands efficient algorithms. To address these challenges, ongoing research focuses on: - Developing scalable modeling techniques. - Integrating machine learning for adaptive control. - Combining DES with continuous system models for hybrid systems. - Enhancing simulation tools for better analysis. Conclusion Understanding the introduction to discrete event systems is fundamental for anyone involved in the design, analysis, or control of complex asynchronous systems. By capturing system behavior through states, events, and transitions, DES provide a powerful framework for modeling real-world processes. Their applications span numerous industries, making them essential tools for optimizing performance, ensuring safety, and facilitating innovation. As technology advances and systems become increasingly interconnected and dynamic, the importance of discrete event systems continues to grow. Mastery of their principles enables engineers and researchers to develop smarter, more resilient systems that meet the demands of modern society. Keywords for SEO: discrete event systems, DES, system modeling, system analysis, supervisory control, Petri Nets, finite state machines, discrete event simulation, system applications, system control strategies QuestionAnswer What are discrete event systems and how are they different from continuous systems? Discrete event systems

(DES) are dynamic systems where state changes occur at discrete points in time due to events, unlike continuous systems where changes happen continuously over time. DES are typically modeled using automata, Petri nets, or state machines, focusing on event-driven behavior. Why is the study of discrete event systems important in modern engineering? Discrete event systems are vital for modeling and controlling complex systems like manufacturing processes, communication networks, and transportation systems, where the timing and sequence of events are critical for efficiency and reliability. 5 What are common mathematical models used to represent discrete event systems? Common models include finite automata, Petri nets, timed automata, and max-plus algebra models, which help analyze system behavior, concurrency, synchronization, and performance. How does control theory apply to discrete event systems? Control theory for DES involves designing controllers that ensure desired system performance by enabling or disabling events, managing resource allocation, and preventing unsafe or undesirable states. What are some typical applications of discrete event systems? Applications include manufacturing systems, traffic control, communication networks, robotic systems, and healthcare processes, where event sequencing and timing are crucial. What are the main challenges in analyzing discrete event systems? Challenges include state explosion problems, modeling complex interactions, ensuring system reliability, and designing controllers that handle nondeterminism and concurrency efficiently. How do simulation tools assist in the study of discrete event systems? Simulation tools enable researchers and engineers to model, analyze, and test DES behavior under various scenarios, facilitating better understanding, validation, and optimization of system performance. What is the future outlook for research in discrete event systems? Future research focuses on integrating DES with cyber- physical systems, developing scalable algorithms for large-scale systems, and applying machine learning techniques for adaptive control and decision-making. Introduction to Discrete Event Systems: An Investigative Overview Discrete Event Systems (DES) represent a fundamental area within systems theory and control engineering, characterized by the occurrence of instantaneous events at discrete points in time. These systems are prevalent across a multitude of domains, including manufacturing, communication networks, transportation, and automated control processes. This article aims to provide a comprehensive, investigative overview of discrete event systems, exploring their theoretical foundations, modeling approaches, analysis techniques, and practical applications. --- Understanding Discrete Event Systems At its core, a Discrete Event System is a dynamic system where state changes occur only at discrete moments, triggered by the occurrence of specific events. Unlike continuous systems, which evolve smoothly over time according to differential equations, DES evolve through a sequence of events that induce state transitions. This discrete nature allows for the modeling of systems where changes happen instantaneously, such as a machine starting or stopping, a packet arriving in a network, or a train arriving at a station. Key Characteristics of Discrete Event Systems: - Event-Driven Dynamics: System evolution is driven solely by events rather than continuous processes. - State Transitions: Changes in Introduction To Discrete Event Systems 6 system states are triggered by events, often following predefined rules. - Asynchronous Operation: Events occur asynchronously, making the timing and sequencing critical for analysis. - Hybrid System Compatibility: DES often interface with continuous systems, forming hybrid models. Understanding these core features is essential for developing effective models and analysis techniques for DES. --- Historical Context and Theoretical Foundations The formal study of discrete event systems emerged prominently during the 1970s and 1980s, primarily driven by the need to model and control complex manufacturing and communication systems. Pioneering work by Cassandras, Ramadge, and others laid the groundwork for modern DES theory, integrating automata theory, formal languages, and control theory. Foundational Concepts: - Automata Theory: Many DES are modeled as finite automata, where states represent system configurations and transitions correspond to events. - Formal Languages: The sequences of events (strings) are analyzed within formal language frameworks to understand system behavior. - Petri Nets: A graphical and mathematical tool that models concurrent, asynchronous, and nondeterministic system behaviors. - Supervisory Control Theory: Developed notably by Ramadge and Wonham, this theory addresses how to control DES to achieve desired behaviors while respecting system constraints. This theoretical backbone provides the tools necessary to analyze, verify, and control discrete event systems rigorously. --- Modeling Discrete Event Systems Modeling is a critical step in understanding and analyzing DES. The choice of model influences the ability to verify system properties and design controllers. Finite Automata and State Transition Models Finite automata (FA) are perhaps the most common modeling formalism for DES. An FA consists of: - A finite set of states - An initial state - A set of events (input alphabet) - Transition functions mapping states and events to subsequent states Advantages: - Simplicity and well-understood theoretical properties - Suitable for systems with finite states and event sets Limitations: - Less effective for systems with infinite or very large state spaces - Difficult to model concurrency Petri Nets Petri nets extend finite automata with the ability to model concurrent, synchronized, and resource-sharing behaviors. They are composed of: - Places (representing conditions or resources) - Transitions (events) - Tokens (markings indicating state) Advantages: - Natural representation of concurrency and synchronization -

Formal analysis methods like Introduction To Discrete Event Systems 7 reachability and liveness Limitations: - Increased complexity in large systems - Less intuitive for purely sequential systems Hybrid Models and Extensions Some systems require hybrid models that combine discrete and continuous dynamics, such as hybrid automata or timed Petri nets. These models are vital when modeling real- world systems with both rapid discrete events and slower continuous processes. --- Analysis Techniques for Discrete Event Systems Analyzing DES involves verifying properties like reachability, controllability, observability, and stability. Several techniques and tools have been developed to facilitate this process. Reachability Analysis Determines whether a particular state or set of states can be reached from an initial configuration. Critical for verifying safety and liveness properties. Controllability and Supervisory Control The supervisory control theory aims to synthesize controllers that restrict the system’s behavior to desired specifications. Key concepts include: - Controllability: Ensuring that the supervisor can prevent undesirable events - Nonblockingness: Guaranteeing that the system can always reach a marked (goal) state The Ramadge-Wonham framework formalizes these ideas, enabling systematic controller design. Observability and State Estimation In many systems, not all events or states are observable. Techniques like observer design and state estimation are employed to infer system states from partial information, essential for feedback control. Performance and Verification Tools Tools such as model checkers, simulation environments, and formal verification techniques are used to validate system properties against specifications. --- Applications of Discrete Event Systems The versatility of DES modeling and analysis methods has led to their widespread application across diverse fields. Introduction To Discrete Event Systems 8 Manufacturing and Production Systems In manufacturing, DES are used to model assembly lines, robotic work cells, and supply chains, enabling optimization of throughput, resource allocation, and fault diagnosis. Communication Networks and Protocols Modeling packet flow, network protocols, and traffic management benefits from DES approaches, ensuring reliable data transmission and congestion control. Transportation and Traffic Control Traffic signal control, railway operations, and air traffic management utilize DES models to improve safety, efficiency, and scheduling. Automated and Cyber-Physical Systems From autonomous vehicles to smart grids, DES underpin the design of complex, interconnected systems requiring precise control and coordination. --- Current Challenges and Future Directions Despite significant advancements, the study and application of discrete event systems continue to confront challenges: - Scalability: Managing the state explosion problem in large systems - Uncertainty and Nondeterminism: Incorporating stochastic elements - Integration with Continuous Dynamics: Developing seamless hybrid models - Real-Time Control: Ensuring timely responses in dynamic environments - Data-Driven Modeling: Leveraging machine learning and big data for system identification Emerging research focuses on integrating DES with artificial intelligence, enhancing autonomous decision- making, and developing more robust, scalable analysis tools. --- Conclusion Introduction to discrete event systems reveals a rich and evolving field that combines theoretical rigor with practical relevance. From foundational automata theory to modern hybrid models, DES offer a powerful framework for modeling, analyzing, and controlling systems characterized by discrete, asynchronous events. As technological systems grow increasingly complex and interconnected, the importance of DES in ensuring efficiency, safety, and reliability will only expand. Continued research and development in modeling techniques, analysis methods, and application domains promise to keep discrete event systems at the forefront of systems engineering and control theory for years to come. discrete event systems, automation, control theory, state machines, system modeling, event-driven systems, supervisory control, formal methods, Petri nets, system simulation

Introduction to Discrete Event SystemsDiscrete Event SystemsDiscrete Event SystemsDiscrete-event System SimulationSynthesis and Control of Discrete Event SystemsDiscrete Event Systems: Modeling and ControlDiscrete Event Systems: Modeling and ControlCyber Security for Discrete Event SystemsControl of Discrete-Event SystemsControl of Discrete-Event SystemsStochastic Discrete Event SystemsSupervisory Control of Discrete-Event SystemsDiscrete Event Systems: Modeling and ControlModeling Discrete-Event Systems with GPenSIMDiscrete Event Systems 2004 (WODES'04)2016 13th International Workshop on Discrete Event Systems (WODES)Autonomous and cooperative control of networked discrete-event systemsModeling and Simulation of Discrete Event Systems2016 13th International Workshop on Discrete Event Systems (WODES)Discrete-event System Simulation Christos G. Cassandras Christos G. Cassandras R. Boel Jerry Banks Benoît Caillaud S. Balemi S. Balemi Raphael Fritz Carla Seatzu Carla Seatzu Armin Zimmermann W. Murray Wonham S. Balemi Reggie Davidrajuh Janan Zaytoon Christos G. Cassandras Markus Zgorzelski Byoung Kyu Choi Christos G. Cassandras Jerry Banks

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a substantial portion of this book is a revised version of discrete event systems modeling and performance analysis 1993 which was written by the first author and received the 1999 harold chestnut prize awarded by the international federation of automatic control ifac for best control engineering textbook this new expanded book is a comprehensive introduction to the field of discrete event systems emphasizing breadth of coverage and accessibility of the material to readers with different backgrounds its key feature is the emphasis placed on a unified modeling framework that transcends specific application areas and allows linking of the following topics in a coherent manner language and automata theory supervisory control petri net theory max algebra markov chains and queueing theory discrete event simulation perturbation analysis and concurrent estimation techniques introduction to discrete event systems will be of interest to advanced level students in a variety of disciplines where the study of discrete event systems is relevant control communications computer engineering computer science manufacturing engineering operations research and industrial engineering discrete event systems analysis and control is the proceedings of wodes2000 the 5th workshop on discrete event systems held in ghent belgium on august 21 23 2000 this book provides a survey of the current state of the art in the field of modeling analysis and control synthesis of discrete event systems lecture notes for a mini course on sensitivity analysis for performance evaluation of timed discrete event systems and 48 carefully selected papers covering all areas of discrete event theory and the most important applications domains topics include automata theory and supervisory control 12 petri net based models for discrete event systems and their control synthesis 11 max and timed automata models 9 applications papers related to scheduling failure detection and implementation of supervisory controllers 7 formal description of plcs 6 and finally stochastic models of discrete event systems 3

offers comprehensive coverage of discrete event simulation emphasizing and describing the procedures used in operations research methodology generation and testing of random numbers collection and analysis of input data verification of simulation models and analysis of output data

the first motivation of synthesis and control of discrete event systems is to inform the reader of recent developments and current trends in system synthesis this is a field of active research aiming to supply efficient techniques for developing safe systems in various areas covering control of embedded and manufacturing systems distributed implementation of systems and protocols and hardware circuits in all areas considerations about distribution and care for an efficient implementation of the synthesised systems play an increasing role justified by better applicability to problems encountered in the design of practical systems the second motivation of the book which is a selection of presentations given at two workshops on synthesis of controllers and on synthesis of concurrent systems is to incite the research community to establish stronger links between two subjects that could be better related as several presentations do show the selected papers are research papers ranging from theory to practice with automata products of automata and petri nets playing a prominent role all areas mentioned above as areas of application of system synthesis are covered by some of the selected papers

research of discrete event systems is strongly motivated by applications in flex ible 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 re search 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 op timization 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 au gust 26 28 1992 and organized by the institute of information theory and au tomation 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 research of discrete event systems is strongly motivated by applications in flex ible 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 re search 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 op timization 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 au gust 26 28 1992 and organized by the institute of information theory and au tomation 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

cyber physical systems are a crucial part of modern automation applications these systems are widespread across the production industry and critical infrastructures where a high degree of security reliability and availability is required this work investigates possible defense mechanisms against attacks on cyber physical systems modeled by networked discrete event systems based on a threat assessment attack prevention attack detection and localization and attack recovery methods are proposed the cyber attacks under consideration are stealthy attacks that actively hide their influence and are not detectable by conventional anomaly detection schemes the attack prevention is based on a controller encryption scheme exploiting the use of homomorphic encryption the attack detection and localization are realized by introducing unexpected behavior into the transmitted signals and analyzing the timing behavior the attack recovery reconfigures the controller based on the information gained from the attack localization and monte carlo tree search

control of discrete event systems provides a survey of the most important topics in the discrete event systems theory with particular focus on finite state automata petri nets and max plus algebra coverage ranges from introductory material on the basic notions and definitions of discrete event systems to more recent results special attention is given to results on supervisory control state estimation and fault diagnosis of both centralized and distributed decentralized systems developed in the framework of the distributed supervisory control of large plants disc project later parts of the text are devoted to the study of congested systems though fluidization an over approximation allowing a much more efficient study of observation and control problems of timed petri nets finally the max plus algebraic approach to the analysis and control of choice free systems is also considered control of discrete event systems provides an introduction to discrete event systems for readers that are not familiar with this class of systems but also provides an introduction to research problems and open issues of current interest to readers already familiar with them most of the material in this book has been presented during a ph d school held in cagliari italy in june 2011

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stochastic discrete event systems sdes capture the randomness in choices due to activity delays and the probabilities of decisions this book delivers a comprehensive overview on modeling with a quantitative evaluation of sdes it presents an abstract model class for sdes as a pivotal unifying result and details important model classes the book also includes nontrivial examples to explain real world applications of sdes

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

research of discrete event systems is strongly motivated by applications in flex ible 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 re search 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 op timization 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 au gust 26 28 1992 and organized by the institute of information theory and au tomation 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

modeling discrete event systems with gpensim describes the design and applications of general purpose petri net simulator gpensim which is a software tool for modeling simulation and performance analysis of discrete event systems the brief explains the principles of modelling discrete event systems as well as the design and applications of gpensim it is based on the author s lectures that were given on modeling simulation and performance analysis of discrete event systems the brief uses gpensim to enable the efficient modeling of complex and large scale discrete event systems gpensim which is based on matlab is designed to allow easy integration of petri net models with a vast number of toolboxes that are available on the matlab the book offers an approach for developing models that can interact with the external environment this will help readers to solve problems in industrial diverse fields these problems include airport capacity evaluation for aviation authorities finding bottlenecks in supply chains scheduling drilling operations in the oil and gas industry and optimal scheduling of jobs in grid computing this brief is of interest to researchers working on the modeling simulation and performance evaluation of discrete event systems as it shows them the design and applications of an efficient modeling package since the book also explains the basic principles of modeling discrete event systems in a step by step manner it is also of interest to final year undergraduate and postgraduate students

approx 484 pages

this thesis considers networked discrete event systems the overall system is a network of subsystems each of which includes a technical process modelled by an i o automaton together with a controller and a network unit these subsystems are interconnected by physical couplings and digital communication links an important characteristic of the networked discreteevent systems is the partial autonomy of the subsystems which is reflected by the fact that each subsystem solves its local tasks individually cooperation among the subsystems becomes necessary if physical couplings or control specifications have to be resolved by two or more subsystems in order to satisfy the local tasks hence the subsystems participate in satisfying cooperative tasks by adapting their behaviours while using the communication network without a coordinator in these situations the following question arises when and what information has to be exchanged by the subsystems and what should the structure of the communication network look like as a main result of this thesis it is proved that the subsystems in the networked discrete event system determine deadlock free execution orders of cooperative tasks with distributed model information by using the communication network and solving their local tasks the applicability of the cooperative control solution is demonstrated by means of a collaborative process at the handling system hans markus zgorzelski received his bachelor in electrical engineering and information science from the ruhr universität bochum in 2011 and he received his masters in electrical engineering and information science from the ruhr universität bochum in 2014 from 2014 to 2020 he was a scientific co worker at the institute of automation and computer control where he obtained his phd his research was focused on networked discrete event systems

computer modeling and simulation m s allows engineers to study and analyze complex systems discrete event system des m s is used in modern management industrial engineering computer science and the military as computer speeds and memory capacity increase so des m s tools become more powerful and more widely used in solving real life problems based on over 20 years of evolution within a classroom environment as well as on decades long experience in developing simulation based solutions for high tech industries modeling and simulation of discrete event systems is the only book on des m s in which all the major des modeling formalisms activity based process oriented state based and event based are covered in a unified manner a well defined procedure for building a formal model in the form of event graph acd or state graph diverse types of modeling templates and examples that can be used as building blocks for a complex real life model a systematic easy to follow procedure combined with sample c codes for developing simulators in various modeling formalisms simple tutorials as well as sample model files for using popular off the shelf simulators such as sigma ace and arena up to date research results as well as research issues and directions in des m s modeling and simulation of discrete event systems is an ideal textbook for undergraduate and graduate students of simulation industrial engineering and computer science as well as for simulation practitioners and researchers

for junior and senior level simulation courses in engineering business or computer science discrete event system simulation examines the principles of modeling and analysis that translate to all software tools rather than a particular software tool this language independent text explains the basic aspects of the technology including the proper collection and analysis of data the use of analytic techniques verification and validation of models and designing simulation experiments it offers an up to date treatment of simulation of manufacturing and material handling systems computer systems and computer networks students and instructors will find a variety of resources including simulation source code for download additional exercises and solutions web links and errata at the associated website dmnicol web engr illinois edu bcnn index html

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