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PROBABILITY, MARKOV CHAINS, QUEUES, AND SIMULATION

The Mathematical Basis of Performance Modeling

WILLIAM J. STEWART

Probability Markov Chains Queues And Simulation

Chao Zhang



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Probability, Markov Chains, Queues, and Simulation William J. Stewart, 2009-07-06 Probability Markov Chains Queues and Simulation provides a modern and authoritative treatment of the mathematical processes that underlie performance modeling. The detailed explanations of mathematical derivations and numerous illustrative examples make this textbook readily accessible to graduate and advanced undergraduate students taking courses in which stochastic processes play a fundamental role. The textbook is relevant to a wide variety of fields including computer science, engineering, operations research, statistics, and mathematics. The textbook looks at the fundamentals of probability theory from the basic concepts of set-based probability through probability distributions to bounds, limit theorems, and the laws of large numbers. Discrete and continuous time Markov chains are analyzed from a theoretical and computational point of view. Topics include the Chapman-Kolmogorov equations, irreducibility, the potential fundamental and reachability matrices, random walk problems, reversibility, renewal processes, and the numerical computation of stationary and transient distributions. The M/M/1 queue and its extensions to more general birth-death processes are analyzed in detail, as are queues with phase-type arrival and service processes. The M/G/1 and G/M/1 queues are solved using embedded Markov chains; the busy period, residual service time, and priority scheduling are treated. Open and closed queueing networks are analyzed. The final part of the book addresses the mathematical basis of simulation. Each chapter of the textbook concludes with an extensive set of exercises. An instructor's solution manual in which all exercises are completely worked out is also available to professors only. Numerous examples illuminate the mathematical theories. Carefully detailed explanations of mathematical derivations guarantee a valuable pedagogical approach. Each chapter concludes with an extensive set of exercises. **Markov Chains** Pierre

Bremaud, 2013-03-09 In this book, the author begins with the elementary theory of Markov chains and very progressively brings the reader to the more advanced topics. He gives a useful review of probability that makes the book self-contained and provides an appendix with detailed proofs of all the prerequisites from calculus, algebra, and number theory. A number of carefully chosen problems of varying difficulty are proposed at the close of each chapter, and the mathematics are slowly and carefully developed in order to make self-study easier. The author treats the classic topics of Markov chain theory both in discrete time and continuous time, as well as the connected topics such as finite Gibbs fields, nonhomogeneous Markov chains, discrete time regenerative processes, Monte Carlo simulation, simulated annealing, and queueing theory. The result is an up-to-date textbook on stochastic processes. Students and researchers in operations research and electrical engineering, as well as in physics and biology, will find it very accessible and relevant. **Markov Chains and Dependability Theory** Gerardo Rubino, Bruno Sericola, 2014-06-12 Dependability metrics are omnipresent in every engineering field, from simple ones through to more complex measures combining performance and dependability aspects of systems. This book presents the mathematical basis of the analysis of these metrics in the most used framework: Markov models describing both basic results

and specialised techniques The authors first present both discrete and continuous time Markov chains before focusing on dependability measures which necessitate the study of Markov chains on a subset of states representing different user satisfaction levels for the modelled system Topics covered include Markovian state lumping analysis of sojourns on subset of states of Markov chains analysis of most dependability metrics fundamentals of performability analysis and bounding and simulation techniques designed to evaluate dependability measures The book is of interest to graduate students and researchers in all areas of engineering where the concepts of lifetime repair duration availability reliability and risk are important

Markov Chains Bruno Sericola, 2013-08-05 Markov Chains Theory and Applications Markov chains are a fundamental class of stochastic processes They are widely used to solve problems in a large number of domains such as operational research computer science communication networks and manufacturing systems The success of Markov chains is mainly due to their simplicity of use the large number of available theoretical results and the quality of algorithms developed for the numerical evaluation of many metrics of interest The author presents the theory of both discrete time and continuous time homogeneous Markov chains He carefully examines the explosion phenomenon the Kolmogorov equations the convergence to equilibrium and the passage time distributions to a state and to a subset of states These results are applied to birth and death processes He then proposes a detailed study of the uniformization technique by means of Banach algebra This technique is used for the transient analysis of several queuing systems

Numerical Methods for Solving Discrete Event Systems Winfried Grassmann, Javad Tavakoli, 2022-11-05 This graduate textbook provides an alternative to discrete event simulation It describes how to formulate discrete event systems how to convert them into Markov chains and how to calculate their transient and equilibrium probabilities The most appropriate methods for finding these probabilities are described in some detail and templates for efficient algorithms are provided These algorithms can be executed on any laptop even in cases where the Markov chain has hundreds of thousands of states This book features the probabilistic interpretation of Gaussian elimination a concept that unifies many of the topics covered such as embedded Markov chains and matrix analytic methods The material provided should aid practitioners significantly to solve their problems This book also provides an interesting approach to teaching courses of stochastic processes

Matrix and Analytical Methods for Performance Analysis of Telecommunication Systems Valeriy Naumov, Yuliya Gaidamaka, Natalia Yarkina, Konstantin

Samouylov, 2022-02-15 This introductory textbook is designed for a one semester course on the use of the matrix and analytical methods for the performance analysis of telecommunication systems It provides an introduction to the modelling and analysis of telecommunication systems for a broad interdisciplinary audience of students in mathematics and applied disciplines such as computer science electronics engineering and operations research

Queueing Theory 1, 2021-03-05 The aim of this book is to reflect the current cutting edge thinking and established practices in the investigation of queueing systems and networks This first volume includes ten chapters written by experts well known in their areas The book studies

the analysis of queues with interdependent arrival and service times characteristics of fluid queues modifications of retrial queueing systems and finite source retrial queues with random breakdowns repairs and customers collisions Some recent tendencies in the asymptotic analysis include the average and diffusion approximation of Markov queueing systems and networks the diffusion and Gaussian limits of multi channel queueing networks with rather general input flow and the analysis of two time scale nonhomogenous Markov chains using the large deviations principle The book also analyzes transient behavior of infinite server queueing models with a mixed arrival process the strong stability of queueing systems and networks and applications of fast simulation methods for solving high dimension combinatorial problems *Managerial Approaches Toward Queuing Systems and Simulations* Hernandez-Gonzalez, Salvador, Hernandez Ripalda, Manuel Dario, 2018-02-02 To promote fast and accessible service many organizations and businesses utilize technological or structured systems to create efficient waiting times and receptions *Managerial Approaches Toward Queuing Systems and Simulations* provides emerging research on the various aspects of line management structures and organizations While highlighting the components of queue control such as attention capacity quantitative analysis and serial systems this book will teach readers about the factors of queue systems that promote effective and efficient line areas and waiting times This book is an important resource for managers engineers and researchers interested in the elements and stages of queueing management

Perturbed Semi-Markov Type Processes II Dmitrii Silvestrov, 2022-03-21 This book is the second volume of a two volume monograph devoted to the study of limit and ergodic theorems for regularly and singularly perturbed Markov chains semi Markov processes and multi alternating regenerative processes with semi Markov modulation The second volume presents a complete classification of ergodic theorems for alternating regenerative processes including more than twenty five such theorems The text addresses new asymptotic recurrent algorithms of phase space reduction for multi alternating regenerative processes modulating by regularly and singularly perturbed finite semi Markov processes It also features a new study of super long long and short time ergodic theorems for these processes The book also contains a comprehensive bibliography of major works in the field It provides an effective reference for both graduate students as well as theoretical and applied researchers studying stochastic processes and their applications Markov Chain Aggregation for Agent-Based Models Sven Banisch, 2015-12-21 This self contained text develops a Markov chain approach that makes the rigorous analysis of a class of microscopic models that specify the dynamics of complex systems at the individual level possible It presents a general framework of aggregation in agent based and related computational models one which makes use of lumpability and information theory in order to link the micro and macro levels of observation The starting point is a microscopic Markov chain description of the dynamical process in complete correspondence with the dynamical behavior of the agent based model ABM which is obtained by considering the set of all possible agent configurations as the state space of a huge Markov chain An explicit formal representation of a resulting micro chain including microscopic transition rates is

derived for a class of models by using the random mapping representation of a Markov process The type of probability distribution used to implement the stochastic part of the model which defines the updating rule and governs the dynamics at a Markovian level plays a crucial part in the analysis of voter like models used in population genetics evolutionary game theory and social dynamics The book demonstrates that the problem of aggregation in ABMs and the lumpability conditions in particular can be embedded into a more general framework that employs information theory in order to identify different levels and relevant scales in complex dynamical systems

Advanced Data Mining and Applications Quan Z. Sheng, Gill Dobbie, Jing Jiang, Xuyun Zhang, Wei Emma Zhang, Yannis Manolopoulos, Jia Wu, Wathiq Mansoor, Congbo Ma, 2024-12-12 This six volume set LNAI 15387 15392 constitutes the refereed proceedings of the 20th International Conference on Advanced Data Mining and Applications ADMA 2024 held in Sydney New South Wales Australia during December 3 5 2024 The 159 full papers presented here were carefully reviewed and selected from 422 submissions These papers have been organized under the following topical sections across the different volumes Part I Applications Data mining Part II Data mining foundations and algorithms Federated learning Knowledge graph Part III Graph mining Spatial data mining Part IV Health informatics Part V Multi modal Natural language processing Part VI Recommendation systems Security and privacy issues

Aligning Business Processes and Information Systems Robert Heinrich, 2014-07-10 Business processes and information systems mutually affect each other in non trivial ways Frequently processes are designed without taking the systems impact into account and vice versa Missing alignment at design time results in quality problems at run time Robert Heinrich gives examples from research and practice for an integrated design of process and system quality A quality reference model characterizes process quality and a process notation is extended to operationalize the model Simulation is a powerful means to predict the mutual quality impact to compare design alternatives and to verify them against requirements The author describes two simulation approaches and discusses interesting insights on their application in practice

Advances in Communication Networking Thomas Bauschert, 2013-08-28 This book constitutes the refereed proceedings of the 19th EUNICE IFIP WG 6.2.6.6 workshop on Advances in Communication Networking EUNICE 2013 held in Chemnitz Germany in August 2013 The 23 oral papers demonstrated together with 9 poster presentations were carefully reviewed and selected from 40 submissions The papers are organized in topical sections on network modeling and design traffic analysis network and traffic management services over mobile networks monitoring and measurement security concepts application of ICT in smart grid and smart home environments data dissemination in ad hoc and sensor networks and services and applications

Formal Methods for Dynamical Systems Marco Bernardo, Erik de Vink, Alessandra Di Pierro, Herbert Wiklicky, 2013-06-12 This book presents 5 tutorial lectures given by leading researchers at the 13th edition of the International School on Formal Methods for the Design of Computer Communication and Software Systems SFM 2013 held in Bertinoro Italy in June 2013 SFM 2013 was devoted to dynamical systems and covered several topics including chaotic dynamics information theory

systems biology hybrid systems quantum computing and automata based models and model checking **Intelligent**

Transportation Systems Syed Faraz Hasan, Nazmul Siddique, Shyam Chakraborty, 2017-09-09 This new edition continues to focus on the nuts and bolts of wireless network access for devices on board vehicles. It has been updated to reflect on the most recent trends in the broad domain of Intelligent Transport Systems. It covers 802.11ac, a recent standard that is very useful in context where a large amount of information is to be sent in a limited time window. The new edition includes a thorough revision of the Vehicular Communication Issues and Standards chapter with new citations and a new subsection on security. The new edition also cites numerous fresh research works to give readers an updated overview of the field. An update on the time delay incurred by applications that always run in the background (Skype etc.) is also covered. The Future Directions and Research Ideas chapter is also largely re-written. An entirely new chapter on D2D communication, keeping in view the vehicular context, has been added in this edition. This volume will be a useful addition to the libraries for both the students of wireless communication and those studying applied probability.

Quantitative Finance Maria Cristina Mariani, Ionut Florescu, 2019-11-08 Presents a multitude of topics relevant to the quantitative finance community by combining the best of the theory with the usefulness of applications. Written by accomplished teachers and researchers in the field, this book presents quantitative finance theory through applications to specific practical problems and comes with accompanying coding techniques in R and MATLAB and some generic pseudo algorithms to modern finance. It also offers over 300 examples and exercises that are appropriate for the beginning student as well as the practitioner in the field. The Quantitative Finance book is divided into four parts. Part One begins by providing readers with the theoretical backdrop needed from probability and stochastic processes. We also present some useful finance concepts used throughout the book. In part two of the book, we present the classical Black-Scholes-Merton model in a uniquely accessible and understandable way. Implied volatility as well as local volatility surfaces are also discussed. Next, solutions to Partial Differential Equations (PDE), wavelets, and Fourier transforms are presented. Several methodologies for pricing options, namely tree methods, finite difference method, and Monte Carlo simulation methods, are also discussed. We conclude this part with a discussion on stochastic differential equations (SDEs). In the third part of this book, several new and advanced models from current literature, such as general Lévy processes, nonlinear PDEs for stochastic volatility models in a transaction fee market, PDEs in a jump diffusion with stochastic volatility models, and factor and copulas models, are discussed. In part four of the book, we conclude with a solid presentation of the typical topics in fixed income securities and derivatives. We discuss models for pricing bonds, marketable securities, credit default swaps (CDS), and securitizations. Classroom tested over a three-year period with the input of students and experienced practitioners, it emphasizes the volatility of financial analyses and interpretations. Weaves theory with application throughout the book. Utilizes R and MATLAB software programs. Presents pseudo algorithms for readers who do not have access to any particular programming system. Supplemented with extensive author-maintained web

site that includes helpful teaching hints data sets software programs and additional content Quantitative Finance is an ideal textbook for upper undergraduate and beginning graduate students in statistics financial engineering quantitative finance and mathematical finance programs It will also appeal to practitioners in the same fields **Intelligent Transport**

Systems Syed Faraz Hasan, Nazmul Siddique, Shyam Chakraborty, 2012-07-25 Focusing on the nuts and bolts of wireless network access for computers on board vehicles this volume shows how in car computerization now does much more than merely act as a glorified map reader Wireless communication is transforming road travel in ways previously undreamt of allowing vehicles to talk to a wider network and monitor road conditions potential delays and traffic congestion all automatically Toll payments can be made without opening the driver's window on a cold day while vehicles might themselves take active steps to avoid collisions It is the connection between on board computers and wireless access points ubiquitous in most cities now that is a key area of research Moving vehicles transfer their communications to new points as they progress and this causes delays known as handover latency In this book new stochastic models are developed to map the disruption when connecting to 802.11 WLAN points It details the application of stochastic tools to analyzing communication networks as well as previous literature on handover latency and relevant mathematical modeling Finally it presents a scheme for monitoring traffic congestion using WLAN connectivity This volume will be a useful addition to the libraries both of wireless communication students and those studying probability theory **Developments in Reliability Engineering** Mangey

Ram, 2024-08-09 Modern systems have become increasingly complex to design and build while the demand for reliability and cost effective enhancement continues Robust international competition has further intensified the need for all designers managers practitioners scientists and engineers to ensure a level of reliability of their products and processes before release at the lowest cost Developments in Reliability Engineering equips its audience with the necessary information to keep up with the latest original research and state of the art advances in reliability engineering The volume offers an excursus from historical theories and methods to the present world practical utility of these concepts with worked out examples Guides readers through reliability topics from an historical perspective to new research results advancements and latest developments Draws on the authors experience of reliability analysis in a range of industries and disciplines showing the need for reliability from the product design stage right through to aftercare Provides methods throughout making this title a good source of actionable information **Optimization and Business Improvement Studies in Upstream Oil and Gas**

Industry Sanjib Chowdhury, 2016-08-03 Delves into the core and functional areas in the upstream oil and gas industry covering a wide range of operations and processes Oil and gas exploration and production E and future production is expected to come from increasingly difficult reserves deeper horizon low quality crude All these are making E P activities even more challenging in terms of operations technology cost and risk Therefore it is necessary to use scarce resources judiciously and optimize strategies cost and capital and improve business performance in all spheres of E P business

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Distributed Computer and Communication Networks Vladimir M. Vishnevskiy, Konstantin E. Samouylov, Dmitry V. Kozyrev, 2019-12-17 This book constitutes the refereed proceedings of the 22nd International Conference on Distributed and Computer and Communication Networks DCCN 2019 held in Moscow Russia in September 2019 The 44 full papers and 2 short papers were carefully reviewed and selected from 174 submissions The papers cover the following topics Computer and Communication Networks Analytical Modeling of Distributed Systems and Distributed Systems Applications

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