

Probability Markov Chains Queues And Simulation The Mathematical Basis Of Performance Modeling By William J Stewart 2009 07 26

Markov chains are central to the understanding of random processes. This is not only because they pervade the applications of random processes, but also because one can calculate explicitly many quantities of interest. This textbook, aimed at advanced undergraduate or MSc students with some background in basic probability theory, focuses on Markov chains and quickly develops a coherent and rigorous theory whilst showing also how actually to apply it. Both discrete-time and continuous-time chains are studied. A distinguishing feature is an introduction to more advanced topics such as martingales and potentials in the established context of Markov chains. There are applications to simulation, economics, optimal control, genetics, queues and many other topics, and exercises and examples drawn both from theory and practice. It will therefore be an ideal text either for elementary courses on random processes or those that are more oriented towards applications. Intersecting two large research areas - numerical analysis and applied probability/queueing theory - this book is a self-contained introduction to the numerical solution of structured Markov chains, which have a wide applicability in queueing theory and stochastic modeling and include M/G/1 and GI/M/1-type Markov chain, quasi-birth-death processes, non-skip free queues and tree-like stochastic processes. Written for applied probabilists and numerical analysts, but accessible to engineers and scientists alike, the treatment of computer systems performances, it provides a systematic treatment of the theory and algorithms for important families of structured Markov chains and a thorough overview of the current literature. The book, consisting of nine Chapters, is presented in three parts. Part 1 covers a basic description of the fundamental concepts related to Markov chains, a systematic treatment of the structure matrix tools, including finite Toeplitz matrices, displacement operators, FFT, and the infinite block Toeplitz matrices, their relationship with matrix power series and the fundamental problems of solving matrix equations and computing canonical factorizations. Part 2 deals with the description and analysis of structure Markov chains and includes M/G/1, quasi-birth-death processes, non-skip-free queues and tree-like processes. Part 3 covers solution algorithms where new convergence and applicability results are proved. Each chapter ends with bibliographic notes for further reading, and the bookends with an appendix collecting the main general concepts and results used in the book, a list of the main annotations and algorithms used in the book, and an extensive index.

Stochastic processes are mathematical models of random phenomena that evolve according to prescribed dynamics. Processes commonly used in applications are Markov chains in discrete and continuous time, renewal and regenerative processes, Poisson processes, and Brownian motion. This volume gives an in-depth description of the structure and basic properties of these stochastic processes. A main focus is on equilibrium distributions, strong laws of large numbers, and ordinary and functional central limit theorems for cost and performance parameters. Although these results differ for various processes, they have a common trait of being limit theorems for processes with regenerative increments. Extensive examples and exercises show how to formulate stochastic models of systems as functions of a system's data and dynamics, and how to represent and analyze cost and performance measures. Topics include stochastic networks, spatial and space-time Poisson processes, queueing, reversible processes, simulation, Brownian approximations, and varied Markovian models. The technical level of the volume is between that of introductory texts that focus on highlights of applied stochastic processes, and advanced texts that focus on theoretical aspects of processes.

Great advances have been made in recent years in the field of computational probability. In particular, the state of the art - as it relates to queueing systems, stochastic Petri-nets and systems dealing with reliability - has benefited significantly from these advances. The objective of this book is to make these topics accessible to researchers, graduate students, and practitioners. Great care was taken to make the exposition as clear as possible. Every line in the book has been evaluated, and changes have been made whenever it was felt that the initial exposition was not clear enough for the intended readership. The work of major research scholars in this field comprises the individual chapters of Computational Probability. The first chapter describes, in nonmathematical terms, the challenges in computational probability. Chapter 2 describes the methodologies available for obtaining the transition matrices for Markov chains, with particular emphasis on stochastic Petri-nets. Chapter 3 discusses how to find transient probabilities and transient rewards for these Markov chains. The next two chapters indicate how to find steady-state probabilities for Markov chains with a finite number of states. Both direct and iterative methods are described in Chapter 4. Details of these methods are given in Chapter 5. Chapters 6 and 7 deal with infinite-state Markov chains, which occur frequently in queueing, because there are times one does not want to set a bound for all queues. Chapter 8 deals with transforms, in particular Laplace transforms. The work of Ward Whitt and his collaborators, who have recently developed a number of numerical methods for Laplace transform inversions, is emphasized in this chapter. Finally, if one wants to optimize a system, one way to do the optimization is through Markov decision making, described in Chapter 9. Markov modeling has found applications in many areas, three of which are described in detail: Chapter 10 analyzes discrete-time queues. Chapter 11 describes networks of queues, and Chapter 12 deals with reliability theory.

Primarily an introduction to the theory of stochastic processes at the undergraduate or beginning graduate level, the primary objective of this book is to initiate students in the art of stochastic modelling. However it is motivated by significant applications and progressively brings the student to the borders of contemporary research. Examples are from a wide range of domains, including operations research and electrical engineering. Researchers and students in these areas as well as in physics, biology and the social sciences will find this book of interest.

Markov processes are processes that have limited memory. In particular, their dependence on the past is only through the previous state. They are used to model the behavior of many systems including communications systems, transportation networks, image segmentation and analysis, biological systems and DNA sequence analysis, random atomic motion and diffusion in physics, social mobility, population studies, epidemiology, animal and insect migration, queueing systems, resource management, dams, financial engineering, actuarial science, and decision systems. Covering a wide range of areas of application of Markov processes, this second edition is revised to highlight the most important aspects as well as the most recent trends and applications of Markov processes. The author spent over 16 years in the industry before returning to academia, and he has applied many of the principles covered in this book in multiple research projects. Therefore, this is an applications-oriented book that also includes enough theory to provide a solid ground in the subject for the reader. Presents both the theory and applications of the different aspects of Markov processes Includes numerous solved examples as well as detailed diagrams that make it easier to understand the principle being presented Discusses different applications of hidden Markov models, such as DNA sequence analysis and speech analysis.

We will occasionally footnote a portion of text with a **, to indicate Notes on the that this portion can be initially bypassed. The reasons for bypassing a Text portion of the text include: the subject is a special topic that will not be referenced later, the material can be skipped on first reading, or the level of mathematics is higher than the rest of the text. In cases where a topic is self-contained, we opt to collect the material into an appendix that can be read by students at their leisure. The material in the text cannot be fully assimilated until one makes it Notes on "their own" by applying the material to specific problems. Self-discovery Problems is the best teacher and although they are no substitute for an inquiring mind, problems that explore the subject from different viewpoints can often help the student to think about the material in a uniquely personal way. With this in mind, we have made problems an integral part of this work and have attempted to make them interesting as well as informative.

Continuous-Time Markov Chains and Applications Models, Algorithms and Applications
Introduction to Probability
Continuous-Time Markov Chains
An Applications-Oriented Approach
Optimal Design of Queueing Systems
Basics of Applied Stochastic Processes
Computational Probability
Markov Processes for Stochastic Modeling
Introduction to Probability Models

The First Comprehensive Book on the Subject Focusing on the underlying structure of a system, Optimal Design of Queueing Systems explores how to set the parameters of a queueing system, such as arrival and service rates, before putting it into operation. It considers various objectives, comparing individually optimal (Nash equilibrium), socially optimal, class optimal, and facility optimal flow allocations. After an introduction to basic design models, the book covers the optimal arrival rate model for a single-facility, single-class queue as well as dynamic algorithms for finding individually or socially optimal arrival rates and prices. It then examines several special cases of multiclass queues, presents models in which the service rate is a decision variable, and extends models and techniques to multifacility queueing systems. Focusing on networks of queues, the final chapters emphasize the qualitative properties of optimal solutions. Written by a long-time, recognized researcher on models for the optimal design and control of queues and networks of queues, this book frames the issues in the general setting of a queueing system. It shows how design models can control flow to achieve a variety of objectives.

Provides an introduction to basic structures of probability with a view towards applications in information technology A First Course in Probability and Markov Chains presents an introduction to the basic elements in probability and stochastic inprobability, including combinatorics, probability measures, probability distributions, conditional probability, inclusion-exclusion formulas, random variables, dispersion indexes, independent random variables, weak and strong laws of large numbers and central limit theorem. In the second part of the book, Focus is given to Discrete-Time Discrete Markov Chains, which is addressed together with an introduction to Poisson processes and continuous Time Discrete Markov Chains. This book also looks at making use of measure theory notations that unify all the presentation, in particular avoiding the separate treatment of continuous and discrete distributions. A First Course in Probability and Markov Chains: Presents the basic elements of probability. Explores elementary probability with combinatorics, uniformprobability, the inclusion-exclusion principle, independence and convergence of random variables. Features applications of Law of Large Numbers, Introduces Bernoulli and Poisson processes as well as discrete-time continuous time Markov Chains with discrete states. Includes illustrations and examples throughout, along with solutions to problems featured in this book. The authors present a unified and comprehensive overview of probability and Markov Chains aimed at educating engineers working with probability and statistics as well as advanced undergraduate students in sciences and engineering with a basic background in mathematical analysis and linear algebra.

*Critically acclaimed text for computer performance analysis--now in its second edition The Second Edition of this now-classic text provides a current and thorough treatment of queueing systems, queueing networks, continuous and discrete-time Markov chains, and simulation. Thoroughly updated with new content, as well as new problems and worked examples, the text offers readers both the theory and practical guidance needed to conduct performance and reliability evaluations of computer, communication, and manufacturing systems. Starting with basic probability theory, the text sets the foundation for the more complicated topics of queueing networks and Markov chains, using applications and examples to illustrate key points. Designed to engage the reader and build practical performance analysis skills, the text features a wealth of problems that mirror actual industry challenges. New features of the Second Edition include: * Chapter examining simulation methods and applications * Performance analysis applications for wireless, Internet, J2EE, and Kanban systems * Latest material on non-Markovian and fluid stochastic Petri nets, as well as solution techniques for Markov regenerative processes * Updated discussions of new and popular performance analysis tools, including ns-2 and OPNET * New and current real-world examples, including DiffServ routers in the Internet and cellular mobile networks With the rapidly growing complexity of computer and communication systems, the need for this text, which expertly mixes theory and practice, is tremendous. Graduate and advanced undergraduate students in computer science will find the extensive use of examples and problems to be vital in mastering both the basics and the fine points of the field, while industry professionals will find the text essential for developing systems that comply with industry standards and regulations.*

"This book is a highly recommendable survey of mathematical tools and results in applied probability with special emphasis on queueing theory....The second edition at hand is a thoroughly updated and considerably expended version of the first edition.... This book and the way the various topics are balanced are a welcome addition to the literature. It is an indispensable source of information for both advanced graduate students and researchers."

--MATHEMATICAL REVIEWS

This book gives a systematic treatment of singularly perturbed systems that naturally arise in control and optimization, queueing networks, manufacturing systems, and financial engineering. It presents results on asymptotic expansions of solutions of Komogorov forward and backward equations, properties of functional occupation measures, exponential upper bounds, and functional limit results for Markov chains with weak and strong interactions. To bridge the gap between theory and applications, a large portion of the book is devoted to applications in controlled dynamic systems, production planning, and numerical methods for controlled Markovian systems with large-scale and complex structures in the real-world problems. This second edition has been updated throughout and includes two new chapters on asymptotic expansions of solutions for backward equations and hybrid LQG problems. The chapters on analytic and probabilistic properties of two-time-scale Markov chains have been almost completely rewritten and the notation has been streamlined and simplified. This book is written for applied mathematicians, engineers, operations researchers, and applied scientists. Selected material from the book can also be used for a one semester advanced graduate-level course in applied probability and stochastic processes.

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

This book is an introduction to Markov chain modeling with applications to communication networks. It begins with a general introduction to performance modeling in Chapter 1 where we introduce different performance models. We then introduce basic ideas of Markov chain modeling: Markov property, discrete time Markov chain (DTMC) and continuous time Markov chain (CTMC). We also discuss how to find the steady state distributions from these Markov chains and how they can be used to compute the system performance metric. The solution methodologies include a balance equation technique, limiting probability technique, and the uniformization. We try to minimize the theoretical aspects of the Markov chain so that the book is easily accessible to readers without deep mathematical backgrounds. We then introduce how to develop a Markov chain model with simple applications: a forwarding system, a cellular system blocking, slotted ALOHA, Wi-Fi model, and multichannel based LAN model. The examples cover CTMC, DTMC, birth-death process and non birth-death process. We then introduce more difficult examples in Chapter 4, which are related to wireless LAN networks: the Bianchi model and Multi-Channel MAC model with fixed duration. These models are more advanced than those introduced in Chapter 3 because they require more advanced concepts such as renewal-reward theorem and the queueing network model. We introduce these concepts in the appendix as needed so that readers can follow them without difficulty. We hope that this textbook will be helpful to students, researchers, and network practitioners who want to understand and use mathematical modeling techniques. Table of Contents: Performance Modeling / Markov Chain Modeling / Developing Markov Chain Performance Models /

Advanced Markov Chain Models

Probability and Statistics with Reliability, Queueing, and Computer Science Applications

Probability Theory and Applications

Markov Processes and Applications

Essentials of Stochastic Processes

Markov Chains

The Mathematical Basis of Performance Modeling

Probability, Markov Chains, Queues

Performance, Asymptotics, and Optimization

A Course in Queueing Theory

Stochastic Networks

Stochastic Networks

A number of applied problems, Markov chains can be used to help model how plants grow, chemicals react, and atoms diffuse--and applications are increasingly being found in such areas as engineering, computer science, economics, and education. To apply the techniques to real problems, however, it is necessary to understand how Markov chains can be solved numerically. In this book, the first to offer a systematic and detailed treatment of the numerical solution of Markov chains, William Stewart provides scientists on many levels with the power to put this theory to use in the actual world, where it has applications in areas as diverse as engineering, economics, and education. His efforts make for essential reading in a rapidly growing field. Here Stewart explores all aspects of numerically computing solutions of Markov chains, especially when the state is huge. He provides extensive background to both discrete-time and continuous-time Markov chains and examines many different numerical computing methods--direct, single-and multi-vector iterative, and projection methods. More specifically, he considers recursive methods often used when the structure of the Markov chain is upper Hessenberg, iterative aggregation/disaggregation methods that are particularly appropriate when it is NCD (nearly completely decomposable), and reduced schemes for cases in which the chain is periodic. There are chapters on methods for computing transient solutions, on stochastic automata networks, and, finally, on currently available software. Throughout Stewart draws on numerous examples and comparisons among the methods he so thoroughly explains.

This book concerns continuous-time controlled Markov chains, also known as continuous-time Markov decision processes. They form a class of stochastic control problems in which a single decision-maker wishes to optimize a given objective function. This book is also concerned with Markov games, where two decision-makers (or players) try to optimize their own objective function. Both decision-making processes appear in a large number of applications in economics, operations research, engineering, and computer science, among other areas. An extensive, self-contained, up-to-date analysis of basic optimality criteria (such as discounted and average reward), and advanced optimality criteria (e.g., bias, overtaking, sensitive discount, and Blackwell optimality) is presented. A particular emphasis is made on the application of the results herein: algorithmic and computational issues are discussed, and applications to population models and epidemic processes are shown. This book is addressed to students and researchers in the fields of stochastic control and stochastic games. Moreover, it could be of interest also to undergraduate and beginning graduate students because the reader is not supposed to have a high mathematical background: a working knowledge of calculus, linear algebra, probability, and continuous-time Markov chains should suffice to understand the contents of the book. Contents:IntroductionControlled Markov ChainsBasic Optimality CriteriaPolicy Iteration and Approximation TheoremsOvertaking, Bias, and Variance OptimalitySensitive Discounted OptimalityBlackwell OptimalityConstrained Controlled Markov ChainsApplicationsZero-Sum Markov GamesBias and Overtaking Equilibria for Markov Games Readership: Graduate students and researchers in the fields of stochastic control and stochastic analysis. Keywords:Markov Decision Processes;Continuous-Time Controlled Markov Chains;Stochastic Dynamic Programming;Stochastic GamesKey Features:This book presents a reader-friendly, extensive, self-contained, and up-to-date analysis of advanced optimality criteria for continuous-time controlled Markov chains and Markov games. Most of the material herein is quite recent (it has been published in high-impact journals during the last five years) and it appears in book form for the first time.This book introduces approximation theorems which, in particular, allow the reader to obtain numerical approximations of the solution to several control problems of practical interest. To the best of our knowledge, this is the first time that such computational issues are studied for denumerable state continuous-time controlled Markov chains. Hence, the book has an adequate balance between, on the one hand, theoretical results and, on the other hand, applications and computational issuesThe books that analyze continuous-time controlled Markov chains usually restrict themselves to the case of bounded transition and reward rates, which can be reduced to discrete-time models by using the uniformization technique. In our case, however, the transition and the reward rates might be unbounded, and so the uniformization technique cannot be used. By the way, let us mention that in models of practical interest the transition and the reward rates are, typically, unbounded.Theorem: "The book contains a large number of recent research results on

IMCs and Markov games and puts them in perspective. It is written in a very conscious manner, contains detailed proofs of all main results, as well as extensive bibliographic remarks. The book is a very valuable piece of work for researchers on continuous-time CMCs and Markov games. Zentralblatt MATH

"This well-written book is clear and accessible treatment of the theory of discrete and continuous-time Markov chains, with an emphasis towards applications. The mathematical treatment is precise and rigorous without superfluous details, and the results are immediately illustrated in illuminating examples. This book will be extremely useful to anybody teaching a course on Markov processes." Jean-Fran çois Le Gall, Professor at Universit é de Paris-Orsay, France. Markov processes is the class of stochastic processes whose past and future are conditionally independent, given their present state. They constitute important models in many applied fields. After an introduction to the Monte Carlo method, this book describes discrete time Markov chains, the Poisson process and continuous time Markov chains. It also presents numerous applications including Markov Chain Monte Carlo, Simulated Annealing, Hidden Markov Models, Annotation and Alignment of Genomic sequences, Control and Filtering, Phylogenetic tree reconstruction and Queueing networks. The last chapter is an introduction to stochastic calculus and mathematical finance. Features include: The Monte Carlo method, discrete time Markov chains, the Poisson process and continuous time jump Markov processes. An introduction to diffusion processes, mathematical finance and stochastic calculus. Applications of Markov processes to various fields, ranging from mathematical biology, to financial engineering and computer science. Numerous exercises and problems with solutions to most of them

Continuous time parameter Markov chains have been useful for modeling various random phenomena occurring in queueing theory, genetics, demography, epidemiology, and competing populations. This is the first book about those aspects of the theory of continuous time Markov chains which are useful in applications to such areas. It studies continuous time Markov chains through the transition function and corresponding q-matrix, rather than sample paths. An extensive discussion of birth and death processes, including the Sietliens moment problem, and the Karlin-McGregor method of solution of the birth and death processes and multidimensional population processes is included, and there is an extensive bibliography. Virtually all of this material is appearing in book form for the first time.

This text is designed for an introductory probability course at the university level for sophomores, juniors, and seniors in mathematics, physical and social sciences, engineering, and computer science. It presents a thorough treatment of ideas and techniques necessary for a firm understanding of the subject. The text is also recommended for use in discrete probability courses. The material is organized so that the discrete and continuous probability discussions are presented in a separate, but parallel, manner. This organization does not emphasize an overly rigorous or formal view of probability and therefore offers some strong pedagogical value. Hence, the discrete discussions can sometimes serve to motivate the more abstract continuous probability discussions. Features: Key ideas are developed in a somewhat leisurely style, providing a variety of interesting applications to probability and showing some nonintuitive ideas. Over 600 exercises provide the opportunity for practicing skills and developing a sound understanding of ideas. Numerous historical comments deal with the development of discrete probability. The text includes many computer programs that illustrate the algorithms or the methods of computation for important problems. The book is a beautiful introduction to probability theory at the beginning level. The book contains a lot of examples and an easy development of theory without any sacrifice of rigor, keeping the abstraction to a minimal level. It is indeed a valuable addition to the study of probability theory. --Zentralblatt MATH

Communication networks underpin our modern world, and provide fascinating and challenging examples of large-scale stochastic systems. Randomness arises in communication systems at many levels: for example, the initiation and termination times of calls in a telephone network, or the statistical structure of the arrival streams of packets at routers in the Internet. How can routing, flow control and connection acceptance algorithms be designed to work well in uncertain and random environments? This compact introduction illustrates how stochastic models can be used to shed light on important issues in the design and control of communication networks. It will appeal to readers with a mathematical background wishing to understand this important area of application, and to those with an engineering background who want to grasp the underlying mathematical theory. Each chapter ends with exercises and suggestions for further reading.

Provides methods of analysis for the interaction between Markov chains of finite states and matrix theory will also be highlighted. Some classical iterative methods for solving linear systems will be introduced for finding the stationary distribution of a Markov chain. The chapter then covers the basic theories and algorithms for hidden Markov models (HMMs) and Markov decision processes (MDPs). Chapter 2 discusses the applications of continuous time Markov chains to model queueing systems and discrete time Markov chain for computing the PageRank, the ranking of websites on the Internet. Chapter 3 studies Markovian models for manufacturing and re-manufacturing systems and presents closed form solutions and fast numerical algorithms for solving the captured systems. In Chapter 4, the authors present a simple hidden Markov model (HMM) with fast numerical algorithms for estimating the model parameters. An application of the HMM for customer classification is also presented. Chapter 5 discusses Markov decision processes for customer lifetime values. Customer Lifetime Values (CLV) is an important concept and quantity in marketing management. The authors present an approach based on Markov decision processes for the calculation of CLV using real data. Chapter 6 considers higher-order Markov chain models, particularly a class of parsimonious higher-order Markov chain models. Efficient estimation methods for model parameters based on linear programming are presented. Contemporary research results on applications to demand predictions, inventory control and financial risk measurement are also presented. In Chapter 7, a class of parsimonious multivariate Markov models is introduced. Again, efficient estimation methods based on linear programming are presented. Applications to demand predictions, inventory control policy and modeling credit ratings data are discussed. Finally, Chapter 8 re-visits hidden Markov models, and the authors present a new class of hidden Markov models with efficient algorithms for estimating the model parameters. Applications to modeling interest rates, credit ratings and default data are discussed. This book is aimed at senior undergraduate students, postgraduate students, professionals, practitioners, and researchers in applied

mathematics, computational science, operational research, management science and finance, who are interested in the formulation and computation of queueing networks, Markov chain models and related topics. Readers are expected to have some basic knowledge of probability theory, Markov processes and matrix theory.

General Irreducible Markov Chains and Non-Negative Operators

Gibbs Fields, Monte Carlo Simulation, and Queues

Probability, Stochastic Processes, and Queueing Theory

Performance Modeling of Communication Networks with Markov Chains

Selected Topics on Continuous-Time Controlled Markov Chains and Markov Games

Fundamentals of Queueing Networks

A First Course in Probability and Markov Chains

Markov chains are a fundamental class of stochastic processes.They are widely used to solve problems in a large number of domainsuch as operational research, computer science, communicationnetworks and manufacturing systems. The success of Markov chains ismainly due to their simplicity of use, the large number ofavailable theoretical results and the quality of algorithmsdeveloped for the numerical evaluation of many metrics ofinterest. The author presents the theory of both discrete-time andcontinuous-time homogeneous Markov chains. He carefully examinesthe explosion phenomenon, the Kolmogorov equations, the convergenceto equilibrium and the passage time distributions to a state and to subset of states. These results are applied to birth-and-deathprocesses. He then proposes a detailed study of the uniformizationtechnique by means of Banach algebra. This technique is used for the transient analysis of several queueing systems. Contents 1. Discrete-Time Markov Chains 2. Continuous-Time Markov Chains 3. Birth-And-Death Processes 4. Uniformization 5. Queues After the Authors Bruno Sericola is a Senior Research Scientist at Inria Rennes- Bretagne Atlantique in France. His main research activityis in performance evaluation of computer and communication systems,dependability analysis of fault-tolerant systems and stochasticmodels.

Presents the theory of general irreducible Markov chains and its connection to the Perron-Frobenius theory of nonnegative operators.

This new edition of Markov Chains: Models, Algorithms and Applications has been completely reformatted as a text, complete with end-of-chapter exercises, a new focus on management science, new applications of the models, and new examples with applications in financial risk management and modeling of financial data. This book consists of eight chapters. Chapter 1 gives a brief introduction to the classical theory on both discrete and continuous time Markov chains. Chapter 2 discusses the applications of continuous time Markov chains to model queueing systems and discrete time Markov chain for computing the PageRank, the ranking of websites on the Internet. Chapter 3 studies Markovian models for manufacturing and re-manufacturing systems and presents closed form solutions and fast numerical algorithms for solving the captured systems. In Chapter 4, the authors present a simple hidden Markov model (HMM) with fast numerical algorithms for estimating the model parameters. An application of the HMM for customer classification is also presented. Chapter 5 discusses Markov decision processes for customer lifetime values. Customer Lifetime Values (CLV) is an important concept and quantity in marketing management. The authors present an approach based on Markov decision processes for the calculation of CLV using real data. Chapter 6 considers higher-order Markov chain models, particularly a class of parsimonious higher-order Markov chain models. Efficient estimation methods for model parameters based on linear programming are presented. Contemporary research results on applications to demand predictions, inventory control and financial risk measurement are also presented. In Chapter 7, a class of parsimonious multivariate Markov models is introduced. Again, efficient estimation methods based on linear programming are presented. Applications to demand predictions, inventory control policy and modeling credit ratings data are discussed. Finally, Chapter 8 re-visits hidden Markov models, and the authors present a new class of hidden Markov models with efficient algorithms for estimating the model parameters. Applications to modeling interest rates, credit ratings and default data are discussed. This book is aimed at senior undergraduate students, postgraduate students, professionals, practitioners, and researchers in applied

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Gibbs Fields, Monte Carlo Simulation, and Queues

Probability, Stochastic Processes, and Queueing Theory

Performance Modeling of Communication Networks with Markov Chains

Selected Topics on Continuous-Time Controlled Markov Chains and Markov Games

Fundamentals of Queueing Networks

A First Course in Probability and Markov Chains

Markov chains are a fundamental class of stochastic processes.They are widely used to solve problems in a large number of domainsuch as operational research, computer science, communicationnetworks and manufacturing systems. The success of Markov chains ismainly due to their simplicity of use, the large number ofavailable theoretical results and the quality of algorithmsdeveloped for the numerical evaluation of many metrics ofinterest. The author presents the theory of both discrete-time andcontinuous-time homogeneous Markov chains. He carefully examinesthe explosion phenomenon, the Kolmogorov equations, the convergenceto equilibrium and the passage time distributions to a state and to subset of states. These results are applied to birth-and-deathprocesses. He then proposes a detailed study of the uniformizationtechnique by means of Banach algebra. This technique is used for the transient analysis of several queueing systems. Contents 1. Discrete-Time Markov Chains 2. Continuous-Time Markov Chains 3. Birth-And-Death Processes 4. Uniformization 5. Queues After the Authors Bruno Sericola is a Senior Research Scientist at Inria Rennes- Bretagne Atlantique in France. His main research activityis in performance evaluation of computer and communication systems,dependability analysis of fault-tolerant systems and stochasticmodels.

Presents the theory of general irreducible Markov chains and its connection to the Perron-Frobenius theory of nonnegative operators.

This new edition of Markov Chains: Models, Algorithms and Applications has been completely reformatted as a text, complete with end-of-chapter exercises, a new focus on management science, new applications of the models, and new examples with applications in financial risk management and modeling of financial data. This book consists of eight chapters. Chapter 1 gives a brief introduction to the classical theory on both discrete and continuous time Markov chains. Chapter 2 discusses the applications of continuous time Markov chains to model queueing systems and discrete time Markov chain for computing the PageRank, the ranking of websites on the Internet. Chapter 3 studies Markovian models for manufacturing and re-manufacturing systems and presents closed form solutions and fast numerical algorithms for solving the captured systems. In Chapter 4, the authors present a simple hidden Markov model (HMM) with fast numerical algorithms for estimating the model parameters. An application of the HMM for customer classification is also presented. Chapter 5 discusses Markov decision processes for customer lifetime values. Customer Lifetime Values (CLV) is an important concept and quantity in marketing management. The authors present an approach based on Markov decision processes for the calculation of CLV using real data. Chapter 6 considers higher-order Markov chain models, particularly a class of parsimonious higher-order Markov chain models. Efficient estimation methods for model parameters based on linear programming are presented. Contemporary research results on applications to demand predictions, inventory control and financial risk measurement are also presented. In Chapter 7, a class of parsimonious multivariate Markov models is introduced. Again, efficient estimation methods based on linear programming are presented. Applications to demand predictions, inventory control policy and modeling credit ratings data are discussed. Finally, Chapter 8 re-visits hidden Markov models, and the authors present a new class of hidden Markov models with efficient algorithms for estimating the model parameters. Applications to modeling interest rates, credit ratings and default data are discussed. This book is aimed at senior undergraduate students, postgraduate students, professionals, practitioners, and researchers in applied

followed by discussions of stochastic processes, including Markov chains and Poisson processes. The remaining chapters cover queuing, reliability theory, Brownian motion, and simulation. Many examples are worked out throughout the text, along with exercises to be solved by students. This book will be particularly useful to those interested in learning how probability theory can be applied to the study of phenomena in fields such as engineering, computer science, management science, the physical and social sciences, and operations research. Ideally, this text would be used in a one-year course in probability models, or a one-semester course in introductory probability theory or a course in elementary stochastic processes. New to this Edition: 65% new chapter material including coverage of finite capacity queues, insurance risk models and Markov chains Contains compulsory material for new Exam 3 of the Society of Actuaries containing several sections in the new exams Updated data, and a list of commonly used notations and equations, a robust ancillary package, including a ISM, SSM, and test bank Includes SPSS PASW Moleler and SAS JMP software packages which are widely used in the field Hallmark features: Superior writing style Excellent exercises and examples covering the wide breadth of coverage of probability topics Real-world applications in engineering, science, business and economics

New up-to-date edition of this influential classic on Markov chains in general state spaces. Proofs are rigorous and concise, the range of applications is broad and knowledgeable, and key ideas are accessible to practitioners with limited mathematical background. New commentary by Sean Meyn, including updated references, reflects developments since 1996.

An accessible introduction to probability, stochastic processes, and statistics for computer science and engineering applications Second edition now also available in Paperback. This updated and revised edition of the popular classic first edition relates fundamental concepts in probability and statistics to the computer sciences and engineering. The author uses Markov chains and other statistical tools to illustrate processes in reliability of computer systems and networks, fault tolerance, and performance. This edition features an entirely new section on stochastic Petri nets—as well as new sections on system availability modeling, wireless system modeling, numerical solution techniques for Markov chains, and software reliability modeling, among other subjects. Extensive revisions take new developments in solution techniques and applications into account and bring this work totally up to date. It includes more than 200 worked examples and self-study exercises for each section. Probability and Statistics with Reliability, Queuing and Computer Science Applications, Second Edition offers a comprehensive introduction to probability, stochastic processes, and statistics for students of computer science, electrical and computer engineering, and applied mathematics. Its wealth of practical examples and up-to-date information makes it an excellent resource for practitioners as well. An Instructor's Manual presenting detailed solutions to all the problems in the book is available from the Wiley editorial department.

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[Queuing Theory in Action](#)

[Queuing Networks and Markov Chains](#)

[Markov Chains and Stochastic Stability](#)

[Markov Chains: Models, Algorithms and Applications](#)

[Numerical Methods for Structured Markov Chains](#)