

# **Lecture Notes in Statistics**

**117**

**Paul Glasserman   Karl Sigman  
David D. Yao (Editors)**

## **Stochastic Networks**

**Stability and Rare Events**



**Center for Applied Probability  
Columbia University**



**Springer**

# Stochastic Networks Stability And Rare Events

**Christiane Lemieux**



## **Stochastic Networks Stability And Rare Events:**

Stochastic Networks Paul Glasserman, Karl Sigman, David D. Yao, 2012-12-06 Two of the most exciting topics of current research in stochastic networks are the complementary subjects of stability and rare events roughly the former deals with the typical behavior of networks and the latter with significant atypical behavior Both are classical topics of interest since the early days of queueing theory that have experienced renewed interest motivated by new applications to emerging technologies For example new stability issues arise in the scheduling of multiple job classes in semiconductor manufacturing the so called re entrant lines and a prominent need for studying rare events is associated with the design of telecommunication systems using the new ATM asynchronous transfer mode technology so as to guarantee quality of service The objective of this volume is hence to present a sample by no means comprehensive of recent research problems methodologies and results in these two exciting and burgeoning areas The volume is organized in two parts with the first part focusing on stability and the second part on rare events But it is impossible to draw sharp boundaries in a healthy field and inevitably some articles touch on both issues and several develop links with other areas as well Part I is concerned with the issue of stability in queueing networks *Stochastic Networks* Paul Glasserman, Karl Sigman, David D Yao, 1996-07-30

**Introduction to Stochastic Networks** Richard Serfozo, 2012-12-06 In a stochastic network such as those in computer telecommunications and manufacturing discrete units move among a network of stations where they are processed or served Randomness may occur in the servicing and routing of units and there may be queueing for services This book describes several basic stochastic network processes beginning with Jackson networks and ending with spatial queueing systems in which units such as cellular phones move in a space or region where they are served The focus is on network processes that have tractable closed form expressions for the equilibrium probability distribution of the numbers of units at the stations These distributions yield network performance parameters such as expectations of throughputs delays costs and travel times The book is intended for graduate students and researchers in engineering science and mathematics interested in the basics of stochastic networks that have been developed over the last twenty years Assuming a graduate course in stochastic processes without measure theory the emphasis is on multi dimensional Markov processes There is also some self contained material on point processes involving real analysis The book also contains rather complete introductions to reversible Markov processes Palm probabilities for stationary systems Little laws for queueing systems and space time Poisson processes This material is used in describing reversible networks waiting times at stations travel times and space time flows in networks Richard Serfozo received the Ph D degree in Industrial Engineering and Management Sciences at Northwestern University in 1969 and is currently Professor of Industrial and Systems Engineering at Georgia Institute of Technology Prior to that he held positions in the Boeing Company Syracuse University and Bell Laboratories He has held **Fundamentals of Queueing Networks** Hong Chen, David D. Yao, 2013-04-17 The objective of this book is to collect in a single volume the

essentials of stochastic networks from the classical product form theory to the more recent developments such as diffusion and fluid limits stochastic comparisons stability control dynamic scheduling and optimization The selection of materials inevitably is a reflection upon our bias and preference but it is also driven to a large extent by our desire to provide a graduate level text that is well balanced in breadth and depth suitable for the classroom Given the wide ranging applications of stochastic networks in recent years from supply chains to telecommunications it is also our hope that the book will serve as a useful reference for researchers and students alike in these diverse fields The book consists of three parts The first part Chapters 1 through 4 covers continuous time Markov chain models including the classical Jackson and Kelly networks the notion of quasi reversible queues and stochastic comparisons The second part Chapters 5 through 10 focuses on Brownian models including limit theorems for generalized Jackson networks and multiclass feedforward networks an in depth examination of stability in a Kumar Seidman network and Brownian approximations for general multiclass networks with a mixture of priority and first in first out disciplines The third part Chapters 11 and 12 discusses scheduling in both queueing stochastic and fluid deterministic networks along with topics such as conservation laws polymatroid optimization and linear programming

*Control Techniques for Complex Networks* Sean Meyn, 2008 From foundations to state of the art the tools and philosophy you need to build network models

### **Performance Guarantees in Communication Networks**

Cheng-Shang Chang, 2012-12-06 Providing performance guarantees is one of the most important issues for future telecommunication networks This book describes theoretical developments in performance guarantees for telecommunication networks from the last decade Written for the benefit of graduate students and scientists interested in telecommunications network performance this book consists of two parts The first introduces the recently developed filtering theory for providing deterministic hard guarantees such as bounded delay and queue length The filtering theory is developed under the min plus algebra where one replaces the usual addition with the min operator and the usual multiplication with the addition operator As in the classical linear system theory the filtering theory treats an arrival process or a departure process as a signal and a network element as a system Network elements including traffic regulators and servers can be modelled as linear filters under the min plus algebra and they can be joined by concatenation filter bank summation and feedback to form a composite network element The problem of providing deterministic guarantees is equivalent to finding the impulse response of composite network elements This section contains material on s r calculus Filtering theory for deterministic traffic regulation service guarantees and networks with variable length packets Traffic specification Networks with multiple inputs and outputs Constrained traffic regulation The second part of the book addresses stochastic soft guarantees focusing mainly on tail distributions of queue lengths and packet loss probabilities and contains material on s q r q calculus and q envelope rates The large deviation principle The theory of effective bandwidth The mathematical theory for stochastic guarantees is the theory of effective bandwidth Based on the large deviation principle the theory of effective bandwidth

provides approximations for the bandwidths required to meet stochastic guarantees for both short range dependent inputs and long range dependent inputs

**System Performance Evaluation** Erol Gelenbe, 2000-03-24 Throughout successive generations of information technology the importance of the performance evaluation of software computer architectures and computer networks endures For example the performance issues of transaction processing systems and redundant arrays of independent disks replace the virtual memory and input output problems of the 70s ATM performance issues supercede those associated with electronic telephony of the 70s As performance issues evolve with the technologies so must our approach to evaluation In System Performance Evaluation Methodologies and Applications top academic and industrial experts review the major issues now faced in this arena In a series of structured focused chapters they present the state of the art in performance methodologies and applications They address developments in analytical modeling and its interaction with detailed analysis of measurement data They also discuss performance evaluation methodologies for large scale software systems in general and in the context of critical applications such as nuclear reactor control and air transportation systems With its particular emphasis on network performance for wireless networks the Internet and ATM networking System Performance Evaluation becomes the ideal vehicle for professionals in computer architecture networking and software engineering to stay up to date and proficient in this essential aspect of information technology

**Queueing Networks**

Richard J. Boucherie, Nico M. van Dijk, 2010-11-25 This handbook aims to highlight fundamental methodological and computational aspects of networks of queues to provide insights and to unify results that can be applied in a more general manner The handbook is organized into five parts Part 1 considers exact analytical results such as of product form type Topics include characterization of product forms by physical balance concepts and simple traffic flow equations classes of service and queue disciplines that allow a product form a unified description of product forms for discrete time queueing networks insights for insensitivity and aggregation and decomposition results that allow sub networks to be aggregated into single nodes to reduce computational burden Part 2 looks at monotonicity and comparison results such as for computational simplification by either of two approaches stochastic monotonicity and ordering results based on the ordering of the process generators and comparison results and explicit error bounds based on an underlying Markov reward structure leading to ordering of expectations of performance measures Part 3 presents diffusion and fluid results It specifically looks at the fluid regime and the diffusion regime Both of these are illustrated through fluid limits for the analysis of system stability diffusion approximations for multi server systems and a system fed by Gaussian traffic Part 4 illustrates computational and approximate results through the classical MVA mean value analysis and QNA queueing network analyzer for computing mean and variance of performance measures such as queue lengths and sojourn times numerical approximation of response time distributions and approximate decomposition results for large open queueing networks span Part 5 enlightens selected applications as span loss networks originating from circuit switched telecommunications applications capacity sharing

originating from packet switching in data networks and a hospital application that is of growing present day interest spanThe book shows that spanthe intertwined progress of theory and practicespan will remain to be most intriguing and will continue to be the basis of further developments in queueing networks

### **Monte Carlo and Quasi-Monte Carlo Sampling**

Christiane Lemieux,2009-04-03 Quasi Monte Carlo methods have become an increasingly popular alternative to Monte Carlo methods over the last two decades Their successful implementation on practical problems especially in finance has motivated the development of several new research areas within this field to which practitioners and researchers from various disciplines currently contribute This book presents essential tools for using quasi Monte Carlo sampling in practice The first part of the book focuses on issues related to Monte Carlo methods uniform and non uniform random number generation variance reduction techniques but the material is presented to prepare the readers for the next step which is to replace the random sampling inherent to Monte Carlo by quasi random sampling The second part of the book deals with this next step Several aspects of quasi Monte Carlo methods are covered including constructions randomizations the use of ANOVA decompositions and the concept of effective dimension The third part of the book is devoted to applications in finance and more advanced statistical tools like Markov chain Monte Carlo and sequential Monte Carlo with a discussion of their quasi Monte Carlo counterpart The prerequisites for reading this book are a basic knowledge of statistics and enough mathematical maturity to follow through the various techniques used throughout the book This text is aimed at graduate students in statistics management science operations research engineering and applied mathematics It should also be useful to practitioners who want to learn more about Monte Carlo and quasi Monte Carlo methods and researchers interested in an up to date guide to these methods

### **Stochastic Network Optimization with Application to Communication and Queueing Systems**

Michael Neely,2022-05-31 This text presents a modern theory of analysis control and optimization for dynamic networks Mathematical techniques of Lyapunov drift and Lyapunov optimization are developed and shown to enable constrained optimization of time averages in general stochastic systems The focus is on communication and queueing systems including wireless networks with time varying channels mobility and randomly arriving traffic A simple drift plus penalty framework is used to optimize time averages such as throughput throughput utility power and distortion Explicit performance delay tradeoffs are provided to illustrate the cost of approaching optimality This theory is also applicable to problems in operations research and economics where energy efficient and profit maximizing decisions must be made without knowing the future Topics in the text include the following Queue stability theory Backpressure max weight and virtual queue methods Primal dual methods for non convex stochastic utility maximization Universal scheduling theory for arbitrary sample paths Approximate and randomized scheduling theory Optimization of renewal systems and Markov decision systems Detailed examples and numerous problem set questions are provided to reinforce the main concepts Table of Contents Introduction Introduction to Queues Dynamic Scheduling Example Optimizing Time Averages Optimizing Functions

of Time Averages Approximate Scheduling Optimization of Renewal Systems Conclusions Rare Event Simulation using Monte Carlo Methods Gerardo Rubino, Bruno Tuffin, 2009-03-18 In a probabilistic model a rare event is an event with a very small probability of occurrence The forecasting of rare events is a formidable task but is important in many areas For instance a catastrophic failure in a transport system or in a nuclear power plant the failure of an information processing system in a bank or in the communication network of a group of banks leading to financial losses Being able to evaluate the probability of rare events is therefore a critical issue Monte Carlo Methods the simulation of corresponding models are used to analyze rare events This book sets out to present the mathematical tools available for the efficient simulation of rare events Importance sampling and splitting are presented along with an exposition of how to apply these tools to a variety of fields ranging from performance and dependability evaluation of complex systems typically in computer science or in telecommunications to chemical reaction analysis in biology or particle transport in physics Graduate students researchers and practitioners who wish to learn and apply rare event simulation techniques will find this book beneficial **Advances in Applied Probability**, 2007 Monte Carlo and Quasi-Monte Carlo Methods 1996 Harald Niederreiter, Peter Hellekalek, Gerhard Larcher, Peter Zinterhof, 2012-12-06 Monte Carlo methods are numerical methods based on random sampling and quasi Monte Carlo methods are their deterministic versions This volume contains the refereed proceedings of the Second International Conference on Monte Carlo and Quasi Monte Carlo Methods in Scientific Computing which was held at the University of Salzburg Austria from July 9 12 1996 The conference was a forum for recent progress in the theory and the applications of these methods The topics covered in this volume range from theoretical issues in Monte Carlo and simulation methods low discrepancy point sets and sequences lattice rules and pseudorandom number generation to applications such as numerical integration numerical linear algebra integral equations binary search global optimization computational physics mathematical finance and computer graphics These proceedings will be of interest to graduate students and researchers in Monte Carlo and quasi Monte Carlo methods to numerical analysts and to practitioners of simulation methods *Models and Algorithms for Biomolecules and Molecular Networks* Bhaskar DasGupta, Jie Liang, 2016-01-07 By providing expositions to modeling principles theories computational solutions and open problems this reference presents a full scope on relevant biological phenomena modeling frameworks technical challenges and algorithms Up to date developments of structures of biomolecules systems biology advanced models and algorithms Sampling techniques for estimating evolutionary rates and generating molecular structures Accurate computation of probability landscape of stochastic networks solving discrete chemical master equations End of chapter exercises *Applied Probability and Queues* Soeren Asmussen, 2008-01-08 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** *Queue Structures and Algorithms* Richard Johnson,2025-05-31 Queue Structures and Algorithms Queue Structures and Algorithms offers a comprehensive exploration of queues a foundational concept in computer science and systems engineering The book guides readers from fundamental abstract definitions and operational guarantees of queues through the mathematical underpinnings of queue behaviors to nuanced analyses of algorithmic complexity and real world use cases Clear and rigorous treatment of both classical and modern queue variants including circular bounded persistent and generalized FIFO structures equips practitioners and researchers alike with a deep understanding of these essential data structures The text moves seamlessly from theory into practical implementation addressing challenges such as memory modeling concurrency controls high performance tuning and fault tolerant design Rich discussions around advanced topics such as priority queues and heaps lock free and wait free queues distributed messaging patterns and queueing networks ensure that the book caters to the needs of software engineers distributed system architects and algorithm designers working at the forefront of technology Case studies featuring Kafka RabbitMQ and SQS provide insight into state of the art production systems while coverage of auditing compliance and security concerns ensures that reliability and robustness remain central themes throughout Finally the book embraces the future of queue technologies by surveying emerging areas like adaptive queue management integration with persistent and non volatile memory trustless environments powered by blockchain and even nascent quantum and bio inspired approaches With detailed modeling techniques grounded in queueing theory insights into stochastic methods and an eye toward open research challenges Queue Structures and Algorithms is a definitive forward looking resource for anyone seeking mastery over the design and application of modern queue systems

**Knowledge Management, Organizational Intelligence And Learning, And Complexity - Volume III** L. Douglas Kiel,2009-08-25 Knowledge Management Organizational Intelligence and Learning and Complexity is the component of Encyclopedia of Technology Information and Systems Management Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias The Theme on Knowledge Management Organizational Intelligence and Learning and Complexity in the Encyclopedia of Technology Information and Systems Management Resources provides the latest scientific insights into the evolution of complexity in both the natural and social realms Emerging perspectives from the fields of knowledge management computer based simulation and the organizational sciences are presented as tools for understanding and supporting this evolving complexity and the earth s life support systems These three volumes are aimed at the following a wide spectrum of audiences from the merely curious to those seeking in depth knowledge University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs

**Stochastic Networks and Queues** Philippe Robert,2013-04-17 Queues and stochastic networks are analyzed in this



book with purely probabilistic methods The purpose of these lectures is to show that general results from Markov processes martingales or ergodic theory can be used directly to study the corresponding stochastic processes Recent developments have shown that instead of having ad hoc methods a better understanding of fundamental results on stochastic processes is crucial to study the complex behavior of stochastic networks In this book various aspects of these stochastic models are investigated in depth in an elementary way Existence of equilibrium characterization of stationary regimes transient behaviors rare events hitting times and critical regimes etc A simple presentation of stationary point processes and Palm measures is given Scaling methods and functional limit theorems are a major theme of this book In particular a complete chapter is devoted to fluid limits of Markov processes     *Markov Processes and Related Fields* ,2001     *Networked and Event-Triggered Control Approaches in Cyber-Physical Systems* Jinhui Zhang,Yuanqing Xia,Zhongqi Sun,Duanduan Chen,2022-01-28 The insertion of communication networks in feedback control loops complicates analysis and synthesis of Cyber Physical Systems CPSs and network induced uncertainties may degrade system control performances Thus this book researches networked delay compensation and event triggered control approaches for a series of CPSs subject to network induced uncertainties The authors begin with an introduction to the concepts and challenges of CPSs followed by an overview of networked control approaches and event triggered control strategies in CPSs Then networked delay compensation and event triggered control approaches are proposed for CPSs with network communication delay data dropout signal quantization and event triggered communication More specifically networked delay compensation approaches are proposed for linear nonlinear networked controlled plant with time varying and random network communication delays and data dropouts To reduce computational burden and network communication loads in CPSs event triggered control self triggered control co design of event triggered control and quantized control techniques and event triggered disturbance rejection control approaches are also presented This book is an essential text for researchers and engineers interested in cybersecurity networked control and CPS It would also prove useful for graduate students in the fields of science engineering and computer science

## Reviewing **Stochastic Networks Stability And Rare Events**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is really astonishing. Within the pages of "**Stochastic Networks Stability And Rare Events**," an enthralling opus penned by a very acclaimed wordsmith, readers set about an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve into the book's central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

<https://archive.kdd.org/data/detail/Documents/stress%20for%20success%20a%20holistic%20approach%20to%20stress%20and%20its%20management.pdf>

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### **Stochastic Networks Stability And Rare Events Introduction**

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