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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. Queueing analysis is a vital tool used in the evaluation of system performance. Applications of queueing analysis cover a wide spectrum from bank automated teller machines to transportation and communications data networks. Fully revised, this second edition of a popular book contains the significant addition of a new chapter on Flow & Congestion Control and a section on Network Calculus among other new sections that have been added to remaining chapters. An introductory text, Queueing Modelling Fundamentals focuses on queueing modelling techniques and applications of data networks, examining the underlying principles of isolated queueing systems. This book introduces the complex queueing theory in simple language/proofs to enable the reader to quickly pick up an overview to queueing theory without utilizing the diverse necessary mathematical tools. It incorporates a rich set of worked examples on its applications to communication networks. Features include: Fully revised and updated edition with significant new chapter on Flow and Congestion Control as-well-as a new section on Network Calculus A comprehensive text which highlights both the theoretical models and their applications through a rich set of worked examples, examples of applications to data networks and performance curves Provides an insight into the underlying queuing principles and features step-by-step derivation of queueing results Written by experienced Professors in the field Queueing Modelling Fundamentals is an introductory text for undergraduate or entry-level post-graduate students who are taking courses on network performance analysis as well as those practicing network administrators who want to understand the essentials of network operations. The detailed step-by-step derivation of queueing results also makes it an excellent text for professional engineers. A general switching cost model is formulated, and the problem of characterizing the optimal policy for a certain class of systems possessing such a cost structure is addressed. The class of systems studied can be described in terms of a pair of state descriptors which render the underlying probabilistic structure Markovian. The state descriptor consists of a one-dimensional variable, called exogenous, which is subject to explicit control by the decision-maker, and a vector of variables, called endogenous, which are only implicitly controlled by the decision-maker. The variable server M/M/c queueing system is an example. In such a system the exogenous variable is the number of servers employed (bounded above by c), and the endogenous variable is the number of customers in the system. The cost structure consists of two components: a variable cost of the system being in a particular state, assumed to be proportional to the length of time spent in that state, and a switching cost incurred instantaneously whenever the value of the exogenous variable is changed. A framework is developed for the analysis of systems where the length of time between review points is a random variable dependent on the state of the system. A characterization of the optimal control policy is given. The M/M/c queueing system is considered in detail and some attention is also given to the GI/M/c queueing system. The literature on equilibrium behavior of customers and servers in queuing systems is rich. However, there is no comprehensive survey of this field. Moreover, what has been published lacks continuity and leaves many issues uncovered. One of the main goals of this book is to review the existing literature under one cover. Other goals are to edit the known results in a unified manner, classify them and identify where and how they relate to each other, and fill in some gaps with new results. In some areas we explicitly mention open problems. We hope that this survey will motivate further research and enable researchers to identify important open problems. The models described in this book have numerous applications. Many examples can be found in the cited papers, but we have chosen not to include applications in the book. Many of the ideas described in this book are special cases of general principles in Economics and Game Theory. We often cite references that contain more general treatment of a subject, but we do not go into the details. we have highlighted the results For each topic covered in the book, that, in our opinion, are the most important. We also present a brief discussion of related results. The content of each chapter is briefly de scribed below. Chapter 1 is an introduction. It contains basic definitions, models and solution concepts which will be used frequently throughout the book. This book constitutes the refereed post-conference proceedings of the 25th International Conference on Distributed and Computer and Communication Networks, DCCN 2022, held in Moscow, Russia, in September 26–29, 2022. The 31 revised full papers and 2 revised short papers were carefully reviewed and selected from 130 submissions. The papers cover the following topics: computer and communication networks; analytical modeling of distributed systems; and distributed systems applications. Queueing systems and networks are being applied to many areas of technology today, including telecommunications, computers, satellite systems, and traffic processes. This timely book, written by 26 of the most respected and influential researchers in the field, provides an overview of fundamental queueing systems and networks as applied to these technologies. Frontiers in Queueing: Models and Applications in Science and Engineering was written with more of an engineering slant than its predecessor, Advances in Queueing: Theory, Methods, and Open Problems. The earlier book was primarily concerned with methods, and was more theoretically oriented. This new volume, meant to be a sequel to the first book, was written by scientists and queueing theorists whose expertise is in technology and engineering, allowing readers to answer questions regarding the technicalities of related methods from the earlier book. Each chapter in the book surveys the classes of queueing models and networks, or the applied methods in queueing, and is followed by a discussion of open problems and future research directions. The discussion of these future trends is especially important to novice researchers, students, and even their advisors, as it provides the perspectives of eminent scientists in each area, thus showing where research efforts should be focused. Frontiers in Queueing: Models and Applications in Science and Engineering also includes applications to vital areas of engineering and technology, specifically, telecommunications, computers and computer networks, satellite systems, traffic processes, and more applied methods such as simulation, statistics, and numerical methods. All researchers, from students to advanced professionals, can benefit from the sound advice and perspective of the contributors represented in this book. As is well known, Pontryagin's maximum principle and Bellman's dynamic programming are the two principal and most commonly used approaches in solving stochastic optimal control problems. * An interesting phenomenon one can observe from the literature is that these two approaches have been developed separately and independently. Since both methods are used to investigate the same problems, a natural question one will ask is the fol lowing: (Q) What is the relationship betwccn the maximum principlc and dy namic programming in stochastic optimal controls? There did exist some researches (prior to the 1980s) on the relationship between these two. Nevertheless, the results usually werestated in heuristic terms and proved under rather restrictive assumptions, which were not satisfied in most cases. In the statement of a Pontryagin-type maximum principle there is an adjoint equation, which is an ordinary differential equation (ODE) in the (finite-dimensional) deterministic case and a stochastic differential equation (SDE) in the stochastic case. The system consisting of the adjoint equa tion, the original state equation, and the maximum condition is referred to as an (extended) Hamiltonian system. On the other hand, in Bellman's dynamic programming, there is a partial differential equation (PDE), of first order in the (finite-dimensional) deterministic case and of second or der in the stochastic case. This is known as a Hamilton-Jacobi-Bellman (HJB) equation. 5th Werner Kern Award for Productivity Research 2005 Kanban control systems bear a great potential to significantly improve operations. A company may reap the full benefits of kanban control only after determining an optimal or near-optimal system configuration. To do that, methods are needed to evaluate the performance and operating costs of individual system configurations. We propose an innovative construction-kit approach that enables us to build stochastic analytical models of a large class of single- and multi-product kanban systems. The presented construction-kit approach may be extended and augmented in various directions. "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 One of the first books in the timely and important area of heavy traffic analysis of controlled and uncontrolled stochastics networks, by one of the leading authors in the field. The general theory is developed, with possibly state dependent parameters, and specialized to many different cases of practical interest. This book is dedicated to Jinhua Cao on the occasion of his 80th birthday. Jinhua Cao is one of the most famous reliability theorists. His main contributions include: published over 100 influential scientific papers; published an interesting reliability book in Chinese in 1986, which has greatly influenced the reliability of education, academic research and engineering applications in China; initiated and organized Reliability Professional Society of China (the first part of Operations Research Society of China) since 1981. The high admiration that Professor Cao enjoys in the reliability community all over the world was witnessed by the enthusiastic response of each contributor in this book. The contributors are leading researchers with diverse research perspectives. The research areas of the book iclude a broad range of topics related to reliability models, queueing theory, manufacturing systems, supply chain finance, risk management, Markov decision processes, blockchain and so forth. The book consists of a brief Preface describing the main achievements of Professor Cao; followed by congratulations from Professors Way Kuo and Wei Wayne Li, and by Operations Research Society of China, and Reliability Professional Society of China; and further followed by 25 articles roughly grouped together. Most of the articles are written in a style understandable to a wide audience. This book is useful to anyone interested in recent developments in reliability, network security, system safety, and their stochastic modeling and analysis. This fundamental exposition of queueing theory, written by leading researchers, answers the need for a mathematically sound reference work on the subject and has become the standard reference. The thoroughly revised second edition contains a substantial number of exercises and their solutions, which makes the book suitable as a textbook. 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. This book constitutes the proceedings of the 18th International Conference on Information Technologies and Mathematical Modelling, ITMM 2019, named after A.F. Terpugov, held in Saratov, Russia, in June 2019. The 25 full papers presented in this volume were carefully reviewed and selected from 72 submissions. The conference covers various aspects of information technologies, focusing on queueing theory, stochastic processes, Markov processes, renewal theory, network performance equation and network protocols. The service systems, such as data centers and healthcare systems, are usually of large scale which makes the system more sensitive to environments and more vulnerable to interruptions. It is thus important to better design the system and develop optimal scheduling policies that will help to minimize the cost in random environments and prevent interruptions. On the other hand, the control of jump diffusions has attracted much attention due to its vast applicability to stochastic networks, mathematical finance, telecommunications, etc. The primary goal of this dissertation is to study the stability and optimal scheduling of large-scale stochastic networks in random environments and address control problems of jump diffusions. I study multiclass many-server queues for which the arrival, service, and abandonment rates are all modulated by a common finite-state Markov process in the "averaged" Halfin-Whitt regime. I establish a functional central limit theorem for the diffusion-scaled queueing process and show that the limiting process is a controlled diffusion. I address the infinite-horizon discounted and long-run average (ergodic) optimal control problems and establish asymptotic optimality. The ergodic properties of a class of Markov-modulated general birth-death processes under fast regime switching are studied. I show the ergodic properties of the properly scaled joint Markov process with a parameter that is taken large. Under very weak hypotheses, it is shown that if the averaged process is exponentially ergodic for large values of the parameter, then the same applies to the original joint Markov process. The ergodic control problem for a class of controlled jump diffusions driven by a compound Poisson process is studied. I provide a full characterizations of optimality via the Hamilton--Jacobi--Bellman (HJB) equation, for which the regularity of solutions under mild hypotheses is established. In addition, I show that optimal stationary Markov controls are a.s. pathwise optimal. I show that one can fix a stable control outside a compact set and obtain near-optimal solutions by solving the HJB on a sufficiently large bounded domain. The optimal scheduling problems for multiclass many-server queues in an alternating renewal random environment in the Halfin-Whitt regime are studied. Assuming that the downtimes are asymptotically negligible and only the service processes are affected, I show that the limits of the diffusion-scaled state processes are controlled jump diffusions driven by a compound Poisson jump process. I establish the asymptotic optimality of the infinite-horizon discounted and ergodic problems for the queueing dynamics. This is the first book completely devoted to controlled queueing systems. The book gathers the newest results of the theory of Markov decision processes related to queueing models and demonstrates their applications to main types of control in queueing systems, including control of arrivals, control of service mechanism, and control of service discipline. Emphasis is placed on conditions providing further "good" structural properties of Markov optimal strategies such as monotonicity, threshold or hysteretic character, and priority. Each chapter is followed by exercises, most of which allow the reader to complete technical fragments of proofs. The text assumes the reader is familiar with standard courses of analysis, probability theory, and queueing theory. Controlled queueing processes have been studied by several authors. The common model is a one-station queueing system at which customers arrive at a steady rate. The important feature is that management can vary the capacity of the service station according to the queue size, and thus, by increasing or decreasing the service intensity, control the queue size. The present paper describes the problem of determining the optimal control policy. Intervals are considered of service intensity values (not discrete sets). The arrival of customers at the service station is assumed to be a homogeneous Poisson process with a known arrival intensity. The service time is assumed to be exponentially distributed, with an intensity which can be changed and controlled. The cost structure of the system is discussed. There are three main cost components. The orientation (or set-up) cost of changing the service intensity; the service cost; and the queueing cost. The policy of optimal control is derived with an infinite horizon, which minimizes the expected total discounted future costs. This is carried out by setting and solving the proper Dynamic Programming functional equations. A path-breaking account of Markov decision processes-theory and computation This book's clear presentation of theory, numerous chapter-end problems, and development of a unified method for the computation of optimal policies in both discrete and continuous time make it an excellent course text for graduate students and advanced undergraduates. Its comprehensive coverage of important recent advances in stochastic dynamic programming makes it a valuable working resource for operations research professionals, management scientists, engineers, and others. Stochastic Dynamic Programming and the Control of Queueing Systems presents the theory of optimization under the finite horizon, infinite horizon discounted, and average cost criteria. It then shows how optimal rules of operation (policies) for each criterion may be numerically determined. A great wealth of examples from the application area of the control of queueing systems is presented. Nine numerical programs for the computation of optimal policies are fully explicated. The Pascal source code for the programs is available for viewing and downloading on the Wiley Web site at www.wiley.com/products/subject/mathematics. The site contains a link to the author's own Web site and is also a place where readers may discuss developments on the programs or other aspects of the material. The source files are also available via ftp at ftp://ftp.wiley.com/public/sci_tech_med/stochastic Stochastic Dynamic Programming and the Control of Queueing Systems features: * Path-breaking advances in Markov decision process techniques, brought together for the first time in book form * A theorem/proof format (proofs may be omitted without loss of continuity) * Development of a unified method for the computation of optimal rules of system operation * Numerous examples drawn mainly from the control of queueing systems * Detailed discussions of nine numerical programs * Helpful chapter-end problems * Appendices with complete treatment of background material A graduate text on theory and methods using applied probability techniques for scheduling service, manufacturing, and information networks. We treat the 'approximately' optimal control problem for tandem queueing or production networks (with local feedback allowed) under heavy traffic. The buffers (scaled with traffic) are finite. The controls allow various inputs, connecting links and the processors to be shut down or opened, in order to manage the system. The service and arrival rates, as well as the routing probabilities can also be controlled, and the system statistics can depend on the system state (scaled buffer occupancies). The associated costs involve holding costs, costs for shutting off/on the links or processors and the opportunity cost for lost production. It is shown that the (scaled) controlled system converges weakly (in an appropriate sense) to a controlled limit 'reflected' diffusion. In the rescaled time, the actions of the controllers lead to multiple 'simultaneous' impulses in the limit problem. Thus we have a non-standard limit control problem, and the usual methods of weak convergence for systems under heavy traffic must be modified. Since the optical or nearly optimal controls for the physical process are usually not possible to get, it is of considerable interest to know whether an optimal or nearly optimal control for the limit process is also nearly optimal for the physical system with heavy traffic. This is shown to be true, under reasonable conditions. Although the limit control problem is non-standard and there is little available theory concerning it, acceptable numerical procedures are available. Keywords: Numerical methods for stochastic control. Control and Dynamic Systems: Advances in Theory and Applications, Volume 36 reviews advances in theory and applications of large scale control and dynamic systems. Contributors focus on production control and the determination of optimal production rates, along with active control systems, uncertainty in control system design, and methods for analyzing multistage commodity markets. This volume is organized into eight chapters and begins with an introduction to multiobjective decision-tree analysis and its significance in applied situations, with two substantive examples. It then shifts to important techniques for the determination of robust economic policies, methods used in the analysis of multistage commodity markets, and a computationally effective algorithm for the determination of the optimal production rate. This book also describes many highly effective techniques for near optimal and robust model truncation. Robust adaptive identification and control algorithms for disturbances and unmodeled system dynamics are given consideration. The final chapter provides examples of the applied significance of the techniques presented in this book, including such large scale systems areas as aerospace, defense, chemical, environmental, and infrastructural industries. This book will be of interest to students and researchers in engineering and computer science. Four problem areas were studied. These are: (1) controlled heavy traffic queueing systems, (2) queueing systems with due dates, (3) backward-forward stochastic differential equations, and (4) Ginzburg-Landau equations and evolving interfaces. In areas (1) and (2), diffusion approximations were obtained for queues in heavy traffic. In (3), connections were established between quasi-linear partial differential equations and diffusion processes constructed via a new class of stochastic differential equations. Finally, (4) provides a study of the partial differential equation characterizing vortices in superconducting material in three dimensions. This book presents state-of-the-art solution methods and applications of stochastic optimal control. It is a collection of extended papers discussed at the traditional Liverpool workshop on controlled stochastic processes with participants from both the east and the west. New problems are formulated, and progresses of ongoing research are reported. Topics covered in this book include theoretical results and numerical methods for Markov and semi-Markov decision processes, optimal stopping of Markov processes, stochastic games, problems with partial information, optimal filtering, robust control, Q-learning, and self-organizing algorithms. Real-life case studies and applications, e.g., queueing systems, forest management, control of water resources, marketing science, and healthcare, are presented. Scientific researchers and postgraduate students interested in stochastic optimal control,- as well as practitioners will find this book appealing and a valuable reference. The report describes models for single-server queueing systems with Poisson arrivals and general service-time distribution which are controlled by turning the server on-and-off. The objective is an operating policy which minimizes (maximizes) expected discounted cost (reward) over an infinite horizon. Four distinct models of intermittent service systems are considered. The cost structure for these models includes fixed costs for starting-up and shutting-down the service facility, a server operating cost per unit time and either a holding cost for waiting customers or a reward for serving customers. Two of the models are based on different assumptions concerning the holding cost function. The two remaining models include provisions for balking (an arriving customer chooses not to join the queue) and reneging (customers leaving the queue without being served). For each of the models, there exists an optimal policy characterized by a pair of critical numbers (N, M): turn the server on whenever the number of customers equals (or exceeds) M and turn the server off whenever the number of customers is less than or equal to N. Algorithms for computing the optimal critical numbers are described. (Author). This is a graduate level textbook that covers the fundamental topics in queuing theory. The book has a broad coverage of methods to calculate important probabilities, and gives attention to proving the general theorems. It includes many recent topics, such as server-vacation models, diffusion approximations and optimal operating policies, and more about bulk-arrival and bull-service models than other general texts. * Current, clear and comprehensive coverage * A wealth of interesting and relevant examples and exercises to reinforce concepts * Reference lists provided after each chapter for further investigation One of the first books in the timely and important area of heavy traffic analysis of controlled and uncontrolled stochastics networks, by one of the leading authors in the field. The general theory is developed, with possibly state dependent parameters, and specialized to many different cases of practical interest. We study fluid queues from the perspective of dynamical systems. Following an approach outlined in [Bro] and [BGG99], the dynamics are described with stochastic differential equations driven by Poisson arrival processes. One advantage of this approach is that it allows us to employ techniques from optimal stochastic control to solve queueing problems. We make connections between these subjects explicit through concrete applications in traffic shaping, admission control, and dynamic round-robin scheduling. In the process, we will develop a new stochastic differential equation model for fluid circular buffers and well as synchronization primitives like the binary semaphore. We consider stability and consistency concerns associated with numerically approximating optimal controls when a closed form solution is unavailable. Finally, we introduce a concept of conditional optimal control which when paired with a classical traffic modeling approach, allows us to develop queueing controls for fluid queues which are driven by traffic with general statistics and are optimal in a restricted sense.

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