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Performance Modeling, Loss Networks, and Statistical Multiplexing

Ravi Mazumdar

***SYNTHESIS LECTURES ON
COMMUNICATION NETWORKS***

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Performance Modeling Loss Networks And Statistical Multiplexing Ravi Mazumdar

**Konstantinos Poularakis, Leandros
Tassiulas, T.V. Lakshman**



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Performance Modeling, Loss Networks, and Statistical Multiplexing Ravi Mazumdar, 2022-11-10 This monograph presents a concise mathematical approach for modeling and analyzing the performance of communication networks with the aim of understanding the phenomenon of statistical multiplexing The novelty of the monograph is the fresh approach and insights provided by a sample path methodology for queueing models that highlights the important ideas of Palm distributions associated with traffic models and their role in performance measures Also presented are recent ideas of large buffer and many sources asymptotics that play an important role in understanding statistical multiplexing In particular the important concept of effective bandwidths as mappings from queueing level phenomena to loss network models is clearly presented along with a detailed presentation of loss network models and accurate approximations for large networks Table of Contents Introduction to Traffic Models and Analysis Queues and Performance Analysis Loss Models for Networks Statistical Multiplexing

Performance Modeling, Stochastic Networks, and Statistical Multiplexing Ravi R. Mazumdar, 2013-06-01 This monograph presents a concise mathematical approach for modeling and analyzing the performance of communication networks with the aim of introducing an appropriate mathematical framework for modeling and analysis as well as understanding the phenomenon of statistical multiplexing The models techniques and results presented form the core of traffic engineering methods used to design control and allocate resources in communication networks The novelty of the monograph is the fresh approach and insights provided by a sample path methodology for queueing models that highlights the important ideas of Palm distributions associated with traffic models and their role in computing performance measures The monograph also covers stochastic network theory including Markovian networks Recent results on network utility optimization and connections to stochastic insensitivity are discussed Also presented are ideas of large buffer and many sources asymptotics that play an important role in understanding statistical multiplexing In particular the important concept of effective bandwidths as mappings from queueing level phenomena to loss network models is clearly presented along with a detailed discussion of accurate approximations for large networks Table of Contents Introduction to Traffic Models and Analysis Queues and Performance Analysis Loss Models for Networks Stochastic Networks and Insensitivity Statistical Multiplexing

Performance Modeling, Stochastic Networks, and Statistical Multiplexing, Second Edition Ravi R. Mazumdar, 2022-05-31 This monograph presents a concise mathematical approach for modeling and analyzing the performance of communication networks with the aim of introducing an appropriate mathematical framework for modeling and analysis as well as understanding the phenomenon of statistical multiplexing The models techniques and results presented form the core of traffic engineering methods used to design control and allocate resources in communication networks The novelty of the monograph is the fresh approach and insights provided by a sample path methodology for queueing models that highlights the important ideas of Palm distributions associated with traffic

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Performance Modeling of Communication Networks with Markov Chains Jeonghoon Mo, 2022-05-31 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

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Performance Modeling Markov Chain Modeling Developing Markov Chain Performance Models Advanced Markov Chain Models

Network Connectivity Chen Chen, Hanghang Tong, 2022-01-26 Networks naturally appear in many high impact domains ranging from social network analysis to disease dissemination studies to infrastructure system design Within network studies network connectivity plays an important role in a myriad of applications The diversity of application areas has spurred numerous connectivity measures each designed for some specific tasks Depending on the complexity of connectivity measures the computational cost of calculating the connectivity score can vary significantly Moreover the complexity of the connectivity would predominantly affect the hardness of connectivity optimization which is a fundamental problem for network connectivity studies This book presents a thorough study in network connectivity including its concepts computation and optimization Specifically a unified connectivity measure model will be introduced to unveil the commonality among existing connectivity measures For the connectivity computation aspect the authors introduce the connectivity

tracking problems and present several effective connectivity inference frameworks under different network settings Taking the connectivity optimization perspective the book analyzes the problem theoretically and introduces an approximation framework to effectively optimize the network connectivity Lastly the book discusses the new research frontiers and directions to explore for network connectivity studies This book is an accessible introduction to the study of connectivity in complex networks It is essential reading for advanced undergraduates Ph D students as well as researchers and practitioners who are interested in graph mining data mining and machine learning

Advances in Multi-Channel Resource

Allocation Bo Ji,Xiaojun Lin,Ness B. Shroff,2022-05-31 The last decade has seen an unprecedented growth in the demand for wireless services These services are fueled by applications that often require not only high data rates but also very low latency to function as desired However as wireless networks grow and support increasingly large numbers of users these control algorithms must also incur only low complexity in order to be implemented in practice Therefore there is a pressing need to develop wireless control algorithms that can achieve both high throughput and low delay but with low complexity operations While these three performance metrics i e throughput delay and complexity are widely acknowledged as being among the most important for modern wireless networks existing approaches often have had to sacrifice a subset of them in order to optimize the others leading to wireless resource allocation algorithms that either suffer poor performance or are difficult to implement In contrast the recent results presented in this book demonstrate that by cleverly taking advantage of multiple physical or virtual channels one can develop new low complexity algorithms that attain both provably high throughput and provably low delay The book covers both the intra cell and network wide settings In each case after the pitfalls of existing approaches are examined new systematic methodologies are provided to develop algorithms that perform provably well in all three dimensions

Modeling and Optimization in Software-Defined Networks Konstantinos

Poularakis,Leandros Tassiulas,T.V. Lakshman,2022-06-01 This book provides a quick reference and insights into modeling and optimization of software defined networks SDNs It covers various algorithms and approaches that have been developed for optimizations related to the control plane the considerable research related to data plane optimization and topics that have significant potential for research and advances to the state of the art in SDN Over the past ten years network programmability has transitioned from research concepts to more mainstream technology through the advent of technologies amenable to programmability such as service chaining virtual network functions and programmability of the data plane However the rapid development in SDN technologies has been the key driver behind its evolution The logically centralized abstraction of network states enabled by SDN facilitates programmability and use of sophisticated optimization and control algorithms for enhancing network performance policy management and security Furthermore the centralized aggregation of network telemetry facilitates use of data driven machine learning based methods To fully unleash the power of this new SDN paradigm though various architectural design deployment and operations questions need to be addressed Associated with

these are various modeling resource allocation and optimization opportunities The book covers these opportunities and associated challenges which represent a call to arms for the SDN community to develop new modeling and optimization methods that will complement or improve on the current norms

Scheduling and Congestion Control for Wireless and Processing Networks Libin Jiang, Jean Walrand, 2022-06-01 In this book we consider the problem of achieving the maximum throughput and utility in a class of networks with resource sharing constraints This is a classical problem of great importance In the context of wireless networks we first propose a fully distributed scheduling algorithm that achieves the maximum throughput Inspired by CSMA Carrier Sense Multiple Access which is widely deployed in today's wireless networks our algorithm is simple asynchronous and easy to implement Second using a novel maximal entropy technique we combine the CSMA scheduling algorithm with congestion control to approach the maximum utility Also we further show that CSMA scheduling is a modular MAC layer algorithm that can work with other protocols in the transport layer and network layer Third for wireless networks where packet collisions are unavoidable we establish a general analytical model and extend the above algorithms to that case Stochastic Processing Networks SPNs model manufacturing communication and service systems In manufacturing networks for example tasks require parts and resources to produce other parts SPNs are more general than queueing networks and pose novel challenges to throughput optimum scheduling We propose a deficit maximum weight DMW algorithm to achieve throughput optimality and maximize the net utility of the production in SPNs

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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

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Conclusions Communication Networks Jean Walrand, Shyam Parekh, 2022-05-31 This book results from many years of teaching an upper division course on communication networks in the EECS department at the University of California Berkeley. It is motivated by the perceived need for an easily accessible textbook that puts emphasis on the core concepts behind current and next generation networks. After an overview of how today's Internet works and a discussion of the main principles behind its architecture, we discuss the key ideas behind Ethernet, WiFi networks, routing, internetworking, and TCP. To make the book as self-contained as possible, brief discussions of probability and Markov chain concepts are included in the appendices. This is followed by a brief discussion of mathematical models that provide insight into the operations of network protocols. Next, the main ideas behind the new generation of wireless networks based on LTE and the notion of QoS are presented. A concise discussion of the physical layer technologies underlying various networks is also included. Finally, a sampling of topics is presented that may have significant influence on the future evolution of networks, including overlay networks like content delivery and peer-to-peer networks, sensor networks, distributed algorithms, Byzantine agreement, source compression, SDN and NFV, and Internet of Things.

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