Diffusion Approximations for Double-ended Queues with Reneging in Heavy Traffic

Xin Liu

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Abstract: We study a double-ended queue consisting of two classes of customers. Whenever there is a pair of customers from both classes, they are matched and leave the system. The matching is instantaneous following first-come-first-match principle. If a customer cannot be matched immediately, he/she will stay in a queue. We also assume customers are impatient with generally distributed patience times. Under suitable heavy traffic conditions, we establish simple linear asymptotic relationships between the diffusion-scaled queue length process and the diffusion-scaled offered waiting time processes, and show that the diffusion-scaled queue-length process converges weakly to a diffusion process that admits a unique stationary distribution.
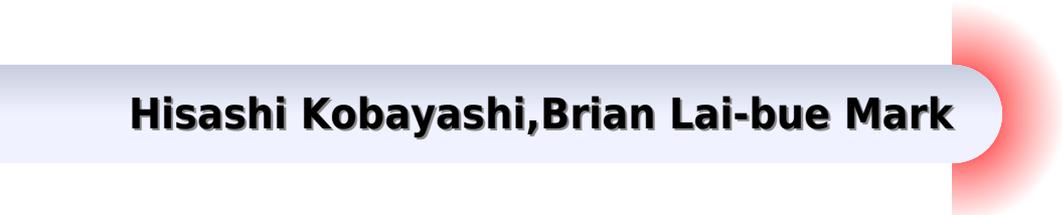
1. Introduction

Consider a simple matching system which consists of two classes of customers. Whenever there is a pair of customers from both classes, they are matched and leave the system immediately. The matching follows first-come-first-match principle. If a customer from one class cannot be matched immediately, he/she will stay in a queue and wait for the upcoming arrivals from the other class. Thus there cannot be non-zero numbers of customers from both classes simultaneously in the system. Customers are assumed to be impatient and they can leave the system without being matched. Such system forms a double-ended queueing system, which is schematically shown in Figure 1. We assume that the arrival processes are independent renewal processes, and the patience times for customers of each class are identically independently distributed (i.i.d.) with a general distribution. Under a suitable heavy traffic condition and a mild condition on patience-time distributions, we establish simple asymptotic linear relationships between the diffusion-scaled queue length process and the diffusion-scaled offered waiting time processes, and show that the diffusion-scaled queue length process converges weakly to a diffusion process. Finally, the unique stationary distribution of the diffusion limit is derived. Diffusion approximations for double-ended queues with renewal arrivals and exponential patience times are studied in [24], and our current work extends the heavy traffic diffusion approximation result in [24] to a setting with generally distributed patience times.

Double-ended queues have been studied for many applications, including taxi-service systems, financial markets, assembly systems, perishable inventory systems, and organ transplant

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Diffusion Approximations And Bounds For Queues

Hisashi Kobayashi,Brian Lai-bue Mark

Diffusion Approximations And Bounds For Queues:

   Mathematical Principles of the Internet, Volume 1 Nirdosh Bhatnagar,2018-11-20 This two volume set on Mathematical Principles of the Internet provides a comprehensive overview of the mathematical principles of Internet engineering The books do not aim to provide all of the mathematical foundations upon which the Internet is based Instead they cover a partial panorama and the key principles Volume 1 explores Internet engineering while the supporting mathematics is covered in Volume 2 The chapters on mathematics complement those on the engineering episodes and an effort has been made to make this work succinct yet self contained Elements of information theory algebraic coding theory cryptography Internet traffic dynamics and control of Internet congestion and queueing theory are discussed In addition stochastic networks graph theoretic algorithms application of game theory to the Internet Internet economics data mining and knowledge discovery and quantum computation communication and cryptography are also discussed In order to study the structure and function of the Internet only a basic knowledge of number theory abstract algebra matrices and determinants graph theory geometry analysis optimization theory probability theory and stochastic processes is required These mathematical disciplines are defined and developed in the books to the extent that is needed to develop and justify their application to Internet engineering   *Network Traffic Engineering* Andrea Baiocchi,2020-09-01 A comprehensive guide to the concepts and applications of queuing theory and traffic theory Network Traffic Engineering Models and Applications provides an advanced level queuing theory guide for students with a strong mathematical background who are interested in analytic modeling and performance assessment of communication networks The text begins with the basics of queueing theory before moving on to more advanced levels The topics covered in the book are derived from the most cutting edge research project development teaching activity and discussions on the subject They include applications of queuing and traffic theory in LTE networks Wi Fi networks Ad hoc networks Automated vehicles Congestion control on the Internet The distinguished author seeks to show how insight into practical and real world problems can be gained by means of quantitative modeling Perfect for graduate students of computer engineering computer science telecommunication engineering and electrical engineering Network Traffic Engineering offers a supremely practical approach to a rapidly developing field of study and industry   **System Modeling and Analysis** Hisashi Kobayashi,Brian Lai-bue Mark,2009 Kobayashi and Mark present the most up to date analytical models simulation techniques and computational algorithms useful for performance evaluation of complex systems including computer systems communication networks transportation systems and manufacturing systems Broader in scope than other texts this book provides more in depth coverage of topics such as computational algorithms and approximations It appeals to students with a background or interest in a wide range of areas including systems analysis or telecommunication networks Publisher s website   Stochastic Models in Queueing Theory Jyotiprasad Medhi,2002-11-06 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 *Approximations for the Transient Behavior of Some Queues* Thoddi Kotiah (C. T.),1976 <u>Comparison Methods for Queues and Other Stochastic Models</u> Dietrich Stoyan,1983 Studies stochastic models of queueing reliability inventory and sequencing in which random influences are considered One stochastic mode rl is approximated by another that is simpler in structure or about which simpler assumptions can be made After general results on comparison properties of random variables and stochastic processes are given the properties are illustrated by application to various queueing models and questions in experimental design renewal and reliability theory PERT networks and branching processes <u>Queueing Systems: Theory</u> Leonard Kleinrock,1974 Queueing systems Some important random processes Elementary queueing theory Birth death queueing systems in equilibrium Markovian queues in equilibrium Intermediate queueing theory The queue M G I The Queue G M m The method of collective marks Advanced material The queue G G I Appendices Glossary A queueing theory primer Bounds inequalities and approximations Priority queueing Computer time sharing and multiacces systems Computer communication networks analysis and design Computer communication networks measurement flow control and ARPANET traps Glossary v 2 Computer applications ISBN 0 471 49111 X **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 theanalysis 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 spanPart 5 enlightens selected applications as spanloss 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   *Queueing Systems, Volume 2* Leonard Kleinrock,1976 Queueing Systems Volume 1 Theory Leonard Kleinrock This book presents and develops methods from queueing theory in sufficient depth so that students and professionals may apply these methods to many modern engineering problems as well as conduct creative research in the field It provides a long needed alternative both to highly mathematical texts and to those which are simplistic or limited in approach Written in mathematical language it avoids the theorem proof technique instead it guides the reader through a step by step intuitively motivated yet precise development leading to a natural discovery of results Queueing Systems Volume I covers material ranging from a refresher on transform and probability theory through the treatment of advanced queueing systems It is divided into four sections 1 preliminaries 2 elementary queueing theory 3 intermediate queueing theory and 4 advanced material Important features of Queueing Systems Volume 1 Theory include techniques of duality collective marks queueing networks complete appendix on z transforms and Laplace transforms an entire appendix on probability theory providing the notation and main results needed throughout the text definition and use of a new and convenient graphical notation for describing the arrival and departure of customers to a queueing system a Venn diagram classification of many common stochastic processes 1975 0 471 49110 1 417 pp Fundamentals of Queueing Theory Second Edition Donald Gross and Carl M Harris This graduated meticulous look at queueing fundamentals developed from the authors lecture notes presents all aspects of the methodology including Simple Markovian birth death queueing models advanced Markovian models networks series and cyclic queues models with general arrival or service patterns bounds approximations and numerical techniques and simulation in a style suitable to courses of study of widely varying depth and duration This Second Edition features new expansions and abridgements which enhance pedagogical use new material on numerical solution techniques for both steady state and transient solutions changes in simulation language and new results in statistical analysis and more Complete with a solutions manual here is a comprehensive rigorous introduction to the basics of the discipline 1985 0 471 89067 7 640 pp

  A Compensation Approach for Queueing Problems I. J. B. F. Adan,1994   **AT & T Bell Laboratories Technical Journal** ,1984   Bulk Queues M. L. Chaudhry,James G. C. Templeton,1986   *Stochastic Analysis of Computer and Communication Systems* Hideaki Takagi,1990 Analytical techniques for evaluating the performance of computer and communication systems have evolved hand in hand with the progress in these systems since the late 1960 s and an enormous amount of knowledge has been accumulated in this interplay of applied mathematics and computer science This book includes nineteen lengthy surveys of the state of the art of performance evaluation techniques and an extensive bibliography

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