Preface to the First Edition

There are several books on queueing theory available for students as well as researchers. At the low end of mathematical sophistication, some provide useable formulas in a recipe fashion. At the high end there are research monographs on specific topics and books with emphasis on theoretical analysis. In between there are a few textbooks with one common feature. All of them require an adequate background knowledge on probability and Markov processes that can be acquired normally with a semester-length graduate course. Consequently, most of those who deal with the modeling and analysis of queueing systems either do not take a course on the subject because they have to spend an extra semester, or take a course on queueing systems without the necessary background and learn only how to use the results. This book is addressed to remedy this situation by providing a one semester foundational introduction to the theory necessary for modeling and analysis of systems while developing the essential Markov process concepts and techniques with queueing processes as examples.

Some of the key features of the book also distinguish it from others. Its introductory chapter includes a historical perspective on the growth of queueing theory in the last 100 years. With emphasis on modeling and analysis it deals with topics such as identification of models, collection of data, and tests for stationarity and independence of observations. It provides a rigorous treatment of basic models commonly used in applications with appropriate references for advanced topics. It gives a comprehensive discussion of statistical inference techniques useable in the modeling of queueing systems and an introduction to decision problems in their management. The book also includes a chapter, written by computer scientists, on the use of computational tools and simulation in solving queueing theory problems.

The book can be used as a text for first year graduate students in the applied science areas such as computer science, operations research, and industrial and/or systems engineering, and allied fields such as manufacturing and communication engineering. It can also serve as a text for upper level undergraduate students in mathematics, statistics, and engineering who have a reasonable background in calculus and basic probability theory. It is the product of the author's experience in teaching queueing theory for 40 years at various levels with or without the necessary background in stochastic processes.

The mathematical background assumed for the coverage of topics is a two or three semester course in calculus, some exposure to transforms and matrices, and an introductory course in probability and statistics, all at the undergraduate level. No familiarity with measure theoretic terminology is assumed. An appendix on mathematical results provides some of the essential theorems for reference.

The book does not advocate any specific software in the numerical analysis of queueing problems. The one chapter on the modeling and analysis using computational tools employs matrix laboratory (MATLAB) for the purpose and we believe students can benefit more by using mathematical software such as MATLAB and Mathematica rather than system specific software because of their limited scope.

For this author writing this book has been a retirement project. He is indebted to Southern Methodist University and the Institute for the Study of Earth and Man for providing necessary resources and facilities even after his retirement. He acknowledges his gratitude to Professors Krishna Kavi and Robert Akl of the University of North Texas for contributing a chapter on numerical analysis of queueing systems in which the author's expertise does not go very far. Special acknowledgment of indebtedness is also made of the reviewers' comments that have helped in improving the organization and contents of the book. The author also wishes to thank Professor N. Balakrishnan for recommending this book for inclusion in the Statistics for Industry and Technology Series of Birkhauser. Thanks are due to Professor Junfang Yu of the Department of Engineering Management, Information and Systems of Southern Methodist University for using the prepublication copy of the book in his class and pointing out some of the typographical errors in it. Thanks are also due to Ms. Sheila Crain of the Department of Statistical Science, for setting the manuscript in LaTex with care and perseverance.

The author's wife Girija, son Girish, and daughter Gouri, have supported and encouraged him throughout his academic career. They deserve all the credit for his success.

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Dallas, Texas
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Preface to the Second Edition

After the publication of the first edition of this book, like most authors in the academic world, the author felt that some improvements could have been made in it. So with this revised edition, the author has taken the opportunity to make changes, which hopefully, will increase the usefulness of the book. One major change is the inclusion of additional topics with the help of contributing guest authors to broaden the scope of methodology of analysis and the applicability of queueing models.

This edition includes all topics covered in the first edition with one major rearrangement. The short chapter on renewal models has been absorbed in two other chapters, the theoretical portion in Chapter 3 covering basic concepts in stochastic processes, and the modeling portion in Chapter 6 along with extended Markov models.

Another change made in the narrative of topics covered in the first edition is to warn the reader when an analysis or derivation requires a mathematical background beyond what is stated in the preface to the first edition. Under those circumstances it is suggested that, the reader may skip such analyses or derivations without sacrificing the understanding of the subject.

Professor Srinivas R. Chakravarthy, a contributing guest author, has contributed a chapter on the matrix-analytic method as an alternative method of analysis of queueing systems. The matrix-analytic method was introduced by Professor Marcel Neuts in the 1970s and he expanded its scope along with his associates including the author of this chapter, in the 1980s. Since then its reach in the analysis of queueing systems has grown far and wide. At this time it would not be an exaggeration to say that the majority of new research being done in the application of queueing theory uses this method.

In order to broaden the appeal of the book to applied scientists, a chapter on queueing theory applications in the analysis of manufacturing systems and another on applications in the computer and communication systems have been included. The first is a new chapter authored by Professor Andrew Junfang Yu. The second chapter, authored by Professor Krishna M. Kavi, is an expanded version of a chapter which also included simulation in the first edition. In

this edition simulation of queueing systems gets a separate chapter by itself. Among all the application areas of queueing theory at this time, computer and communication systems, and manufacturing systems stand out because of their breadth and usefulness. For this reason these two chapters have been included as areas of application of queueing theory in this edition.

Most of the statements made in the preface to the first edition of the book stand true for this edition as well. A few additional acknowledgments are also in order. The author is grateful to the three contributing authors for adding their expertise in three different areas. The author is indebted to Southern Methodist University and the Institute for the Study of Earth and Man for their continuing support for his retirement projects. Some of the changes in the earlier material have come about in response to comments made by the reviewers of the first edition. The author wishes to thank them. He also wishes to thank the editors of Birkhauser/Springer, and the Statistics for Industry and Technology series editor Professor N. Balakrishnan for initiating and supporting this revision. Thanks are due to Ms. Sheila Crain for assisting in the preparation of the manuscript with skill and patience.

The author is indebted to his wife Girija, for supporting him in this project. Professor N. U. Prabhu of Cornell University introduced the author to queueing theory in the early 1960s while they were at the University of Western Australia. This book, therefore, is dedicated to Professor Prabhu in recognition of the role he has played in the scholastic career of the author.

Instructors may request a guide to the solutions of exercises via the Springer website at http://www.springer.com/gp/book/9780817684204

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