

Preface to Second Edition

We have a habit in writing articles published in scientific journals to make the work as finished as possible, to cover up all the tracks, to not worry about the blind alleys or describe how we had the wrong idea first, and so on. So there isn't any place to publish, in a dignified manner, what we actually did in order to get to do the work.

Richard P. Feynman, Nobel Lecture, 1965.

When the first edition of this book first appeared, there were few books that covered Linear Algebraic Queueing Theory (LAQT), all at a higher level. At that time I made the claim that this would become the approach of choice. Now, some 15 years later, the claim has largely been realized, particularly in problems concerning semi-Markov processes and system reliability. The prediction that because transient phenomena could now be expressed in a computationally manageable form, this subject would also become more important, seems to be slowly coming true as well. Many research papers have been published, resulting in several books containing collections of these papers, mostly on computational methods, as in for instance, [STEWART95], [CHAK-ALFA97]i, and [LATOUCHE-TAYLOR00]. The monograph by Latouche and Ramaswami (leaders in the field) [LATOUCHE-RAM99] covers the subject well, but at a higher level. (Their title, *Introduction to Matrix Analytic Methods ...* could be modified to *Introduction to Advanced Matrix Analytic Methods ...*[†].) Yet no new book at the intermediate level has emerged that takes a linear algebraic approach. That is, when possible, theorems are proven by matrix algebraic manipulation, rather than using explicit properties of matrices or probabilistic arguments. Therefore, an updated version of the original is needed.

This second edition, in addition to making many corrections and improvements, is larger by a third than the first edition. The increase in size reflects the growing recognition of the importance of processes that generate unboundedly large variances or long-range autocorrelation, as seen in CPU times, file sizes, telecommunications traffic, finance, and insurance claims. Thus an extensive amount of material has been added to Chapter 3 describing a broad set of ME functions. In particular there is an entire section on power-tail (PT), or Pareto distributions (they form a proper subset of the heavy-tailed distributions), including a section showing how they can be represented by ME distributions within the Markovian structure, even though they have infinite moments. They are then used in Chapters 4 and 5 to study queues with

[†]A definition of *elementary*, or *introductory* is: “that which the author understands.” *Advanced* means: “that which the author is not sure about,” whereas *intermediate* is: “that which the author figured out while writing the book.”

PT service times, and to see how PT renewal processes affect system times.

A new Chapter 8 has been added that covers Semi-Markov processes (SMP), an important topic that is used extensively in queueing models of performance from system reliability to telecommunications systems to performance of computer clusters to inventory problems in operations research. We first give a formal mathematical description of the properties of SMPs and the related Markov Renewal Processes (MRP). Several detailed examples are then presented, each with a different state-space construction. We then look at some *ON-OFF* models used in modeling telecommunications traffic.

The old Chapter 8 is now Chapter 9, and includes a new section on how to deal with networks of nonexponential servers.

Acknowledgments

When I decided to write a second edition in 2000 I realized that the original text, written in DITROFF, would have to be translated to L^AT_EX. Lucky for me that my friend, Dr. Michael Greiner, willingly took on the task of writing the translator and overseeing its execution by Michael Schneider. Without their efforts I might still be doing the translation by hand. I must thank my friends at Technical University of Munich, Prof. Eike Jessen and Dr. Manfred Jobmann, for their longtime support and encouragement from the time I spent my sabbatical year at TUM in 1994. Manfred has carefully read the original and now the final version and has found more errata than I can afford to pay at \$1 per error. Don Costello invited me to give a series of lectures and then encouraged me to write the second edition with expanded coverage of heavy-tailed distributions. Thanks to former Dean Amir Fagri and the School of Engineering at UCONN, and my department chair, Reda Ammar, for providing funding and a sabbatical so I could work on the book and hire Justin Besiglio and Robert Sheahan to produce many of the figures herein. In the last two years, Robert and Feng Zhang have generated the rest of the graphs and helped with the formatting of the book. I don't know how I can show proper appreciation of their extraordinary efforts. Thanks to my former students, Jisung Woo, Steve Thompson, Marwan Sleiman, Sarah Tasneem, Cindy Siriwong, Gehan Verasinghe and the many students who have taken my LAQT course but whose names have slipped from my grasp, for sharing in the proofreading. Special thanks to my former students and present collaborators, Hans-Peter Schwefel, Pierre Fiorini, Ahmed Mohamed, and Imad Antonios for their invaluable input. Prof. Søren Asmussen provided valuable suggestions on making tighter definitions, in particular on defining *heavy-tailed* distributions and their subsets. I also want to thank Peter Köhl for spending so much time editing the entire book, as well as other suggestions for improving the text. Any errors that remain are mine alone. My thanks to Springer-Verlag for their offer to publish the book, and thanks most of all to my wife, Sue, for persevering through it all.



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