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Book Review

Performance Analysis of Communications Networks and Systems. Piet Van Mieghem, Cambridge University Press, 2006

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In recent years graph-based methods have been heavily utilized to explore certain aspects of complex systems, particularly those of biological, sociological or technological origin. This topological approach has revealed that complex networks representing quite disparate systems can have common non-trivial features, like the small-world property, or scale-free distribution of the node degrees (number of edges/links incident to a node). Thus a study of a particular complex network can have relevance in any general study of complex systems. In this spirit the book being reviewed, which is primarily aimed at an applied mathematics and engineering readership, has the potential of also being useful to an audience of physicists.

This book consists of three parts. The first two parts, which cover probability theory and stochastic processes respectively, review the basic concepts in probability theory and Poisson process, renewal theory, discrete and continuous Markov chains, their applications, branching processes, and general queueing theory and models thereof. The two parts are self-contained, almost a book in itself, and in terms of the material covered, very reminiscent of Ross' *Introduction to Probability Model*s (Academic Press, VII$^{\text{th}}$ edition). While not covering Brownian processes, van Mieghem's book has more comprehensive chapters on queueing theory and models, as well as expanded and very well written chapters summarizing the limit laws and inequalities in probability theory.

What I found remarkable about these introductory chapters is the author's succinct style, covering a great number of concepts in about three hundred pages (of which about fifty is spent on queueing models), and at the same time retaining the mathematical rigor and, importantly, the clarity of exposition. This makes the book an excellent reference to many important concepts in stochastic theory. In this regard I can highly recommend it.

While very pleased with the introductory chapters, I was somewhat disappointed with the third part on the Physics of Networks. Probably, a more appropriate title for this part would be the Mathematics of Communication Networks. The subject of networks is approached from the communication system theory perspective, motivated by some practical problems in real-time communication systems, and not the point of view of physics. The book's title is a good descriptor of what this part covers. It is indeed tailored for those interested in solving real network engineering problems analytically, in particular those involving real-time internet communications, such as real-time video, interactive games, internet telephony, and so forth. But, it is exactly the potential that this book has in providing a unique perspective on the physics of complex networks, particularly in terms of its parsimonious style and clear mathematical exposition, that makes me want the book to delve deeper into some of the topics. Some of the concepts prominently covered in the book, such as the shortest path problem, connectivity and robustness, can be related to the physical problems of connectivity, information transfer and dynamic stability, but it is really left to the reader to fill in the blanks. Other interesting physical topics, e.g. synchronization, are left out completely. I also think that a physicist interested in complex networks will find much of the jargon used in the book somewhat alien. While some of the terms frequently used in the book are simple translations, like the *hop count*, which is the telecommunication jargon for the topological node-to-node distance, other terms are rather specific to this problem and harder to relate to general complex network terminology. For example, the *multicast gain*, $g_N(m)$, prominently used and defined as the average number of hops (links) in the shortest path tree rooted at a source and ending at m randomly chosen distinct destinations. Many aspects of this graph-based metric were studied in the book. For example, one of the sections states and discusses the Chuang-Sirbu law, an empirical power-law observed for the Internet ($g_N(m) \approx m^{0.8}$) that I have not encountered before. Another interesting metric featured in the book is the *flooding time*, which is the minimum time needed to inform all nodes in the network. And these are only some of the examples of the metrics not commonly encountered in the mainstream physics literature on complex networks, but which might prove useful to it or to some other areas in statistical physics.

In summary, the book contains in its introductory parts, as well as in its appendices (Stochastic Matrices and Algebraic Graph Theory) a lot of valuable and clearly explained material for a reader interested in the physics of complex networks. The same reader, a physicist, might also find the book too specialized to be of general value. Not to discourage anyone who has a chance to explore this book, many new concepts and graph based measures of performance might offer a fresh perspective and new ideas. While hoping for more of a physical perspective on complex networks, I certainly don't regret spending some time on this book.

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