PERFORMANCE ANALYSIS OF COMMUNICATIONS NETWORKS AND SYSTEMS

PIET VAN MIEGHEM, CAMBRIDGE UNIVERSITY PRESS 2006, ISBN-13: 978-0-521-85515-0, HARDCOVER, 530 PAGES

REVIEWER: Z. PAPIR

The monograph *Performance Analysis of Communications Networks and Systems* by Piet Van Mieghem, Professor of Delft University of Technology (Netherlands), can be recommended for graduate students and researchers working in the area of networking performance analysis.

The book consists of three parts. Part I, "Probability Theory," is a very specific probability theory refresher. It is specific in that its two first chapters reveal a classical approach, while the three succeeding chapters summarize, in an interesting manner, problems related to correlated random variables (with a focus on their computer generation), inequalities governing random variables, and, last but not least, limit laws for sums of independent random variables.

Part II, "Stochastic Processes," deals in an ascending way with a classical theory of stochastic processes. The tour starts with the Poisson process that next is generalized to renewal processes. Then we are presented with both discrete- and continuous-time Markov chains, together with their performance applications. Part II ends with a general queuing theory and some queuing models (basic ones as well as more advanced).

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Part III, "Physics of Networks," should attract the attention of any networking performance analyst who wants to stay up to date on a relatively new field of research investigating network evolution from a complex systems point of view. Leonard Kleinrock — we all remember what he has done in networking performance analysis — said during his invited talk at IEEE INFOCOM 2006 (Barcelona, Spain) that a complex system approach (integrating methodologies offered by biology, physics, sociology, etc.) would be a breakthrough in worldwide network investigation. So you cannot miss Part III of this book; however, frankly speaking, you must get acquainted with some selected issues touched on by the author in the first two parts.

The book includes a lot of solved exercises and supplementary problems well suited for self-work, as well as an exhaustive bibliography.

In Chapter 2, "Random Variables," the author introduces concepts and basic theorems related to both probability and set theory. Then the author presents discrete and continuous random variables with some focus on the logarithm of the probability generation function. The chapter ends with a discussion of several random variables and their independence and correlation. Chapter 3, "Basic Distributions," presents the Bernoulli, geometric, Poisson, uniform, and exponential distributions. The chapter closes discussing some atypical extras such as sums of random variables, minimum or maximum of a set of random variables, and order statistics. The author did not forget nontrivial distributions (like the Gumpel, Cauchy, Weibull, and Pareto ones) that have recently gained a lot of attention.

The content of Chapter 4, "Correlation," is the first convincing proof that van Mieghem's book departs far from what other similarly titled books offer. The chapter deals with generation of correlated random variables that is extremely useful in simulation experiments. The discussion starts with generation of correlated Gaussian random variables and then is generalized to arbitrary ones. Three cases (uniform, exponential, and lognormal variates) are presented in detail. Chapter 5, "Inequalities," is an interesting survey of inequalities met when dealing with random variables. Almost everybody knows Markov and Chebyshev inequalities, and maybe the Chernoff bound as well. Unless you have heard about Jensen and Gauss inequalities or a relationship between a generating function and large deviations, this is another good reason to get more familiar with van Mieghem's book.

Chapter 6, "Limit Laws," cannot be missed as solution of different problems simplifies considerably when approaching limits is allowed. After quotation of some basic results of series summability, the author escapes directly toward convergence of a random variable sequence, and then presents the weak and strong law of large numbers, the law of iterated algorithm, and the central limit theorem. The chapter closes with some discussion of limit properties of the maximum and minimum of a set of random variables.

Part II, "Stochastic Processes," starts smoothly with the Poisson process in Chapter 7. Do not expect a novel approach in this chapter; maybe you will get your satisfaction when reading a section devoted to modeling stochastic processes from measurements. For unknown reasons the author skipped a spatial Poisson pro-

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cess; if included, this topic would perfectly fit the author's approach of scanning nontrivial issues. Next, Chapter 8, "Renewal Theory," Chapter 9, "Discrete-Time Markov Chains," and Chapter 10, "Continuous-Time Markov Chains," are well written basic summaries. Chapter 11, "Applications of Markov Chains," provides analysis of some interesting cases such as a random walk, a birth and death process, the slotted Aloha, and a Markov model of the Web including ranking of Web pages. Chapter 12, "Branching Processes," delivers a rigorously written introduction to the branching process (a population of items produces offspring that in turn replicates itself) that can be observed in biology, nuclear physics, electronics, and, last but not least, in packet transmission networks. Packetized transmission of information means queuing, so at the very end of Part II we enter Chapter 13, "Queuing Theory." Queuing theory is presented from a rather general point of view: arrival/service/service processes, both Lindley's and Benes approaches to service phenomena, The PASTA property, and the great Little's law. In my opinion it is a pity that the author omitted such an important queuing apparatus as arrival/service curves together with their concatenation, envelopes, and possibly traffic regulators. Chapter 14, "Queuing Models," provides an analysis of the easiest queuing models. The author rightly complains that most interesting queuing problems need tailor-made solutions. Nevertheless, two exact solvable models are presented that played a key role in the development of asynchronous transfer mode (N-D/D/1 and AMS-queue).

If you prefer fresh approaches and results within the area of probabilistic modeling of packet networks at the inevitable danger being haunted by rigorous mathematical derivations, you must refer to van Mieghem's book.

Part III, "Physics of Networks," consists of four chapters. Chapter 15, "General Characteristics of Graphs," deals with tools describing both growth and evolution of graphs representing the Internet interconnection structure. The interested reader can get acquainted with problems such as a degree of a graph node, graph connectivity and robustness, graph metrics, and a hop count in sparse graphs. Considerations included in this chapter create a starting point for the successive chapters. The shortest path problem is presented in Chapter 16. In fact, the shortest path problem is a generalization of a hop count issue with a link weight structure imposed. The author starts with some simple graph models with exponential weighting. More sophisticated results assume that link weights can be treated as random variables as their values are uncertain. Chapter 17, "The Efficiency of Multicast," provides an analysis of multicast gain as compared to unicast transmission. The transmission goes on over many destinations uniformly distributed along some shortest path in a network. Both assumptions are realistic in large graphs. To quote van Mieghem, "the analysis ... may be valuable to derive a business model for multicast." Chapter 18, "The Hopcount to an Anycast Group," deals with an interesting option provided by IPv6 being the anycast address. The anycast address is a unicast address with a set of interfaces specified. The advantage is that a group of interfaces at different locations is treated as one single address. IPv6 makes it possible to route packets from their source to the closest anycast member, resulting in an anycast gain. In this chapter a probability density function of the number of hops to the nearest member of the anycast group is determined in order to get some insight into anycast efficiency.

The book is closed with three appendices: "Stochastic Matrices," "Algebraic Graph Theory," and "Solutions of Problems."

In summary, if you prefer fresh approaches and results within the area of probabilistic modeling of packet networks at the inevitable danger being haunted by rigorous mathematical derivations, you must refer to van Mieghem's book.

COMPUTER NETWORKING AND THE INTERNET (FIFTH EDITION)

FRED HALSALL, PEARSON EDUCATION LIMITED, 2005, HARDCOVER, 802 PAGES, ISBN 0-321-26358-8

REVIEWER: ROBERT WOJCIK

Fred Halsall, in *Computer Networking and the Internet*, has managed to present the overall idea of the global network and describe single components with adequate attention according to their importance. This book aims to cover all aspects of functioning of the Internet, ranging from the transmission of bits, through frames and packets, up to the application layer. The author himself says "the book has been written primarily as a course textbook for both university and college students studying courses relating to the technical issues associ-

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ated with computer networking based on the Internet, its protocols and applications," and that is all true. As an academic textbook this position is simply excellent. Easy-to-understand language, enriched with a great number of figures, diagrams and tables, helps in memorization and better assimilation of the topic. Moreover, each chapter in the book ends with a set of questions and tasks related to respective sections of a given chapter. It is extremely useful in order to check if one has understood covered topics entirely.

The book is organized into 10 chapters, each of which opens with an overview of the presented contents and ends with a unique visual summary followed by exercises corresponding to each presented topic. Furthermore, the reader will find five additional sections (Appendices), a supplementary bibliography for enhancing knowledge on each chapter, as well as alphabetical content and acronym indices.

Chapter 1 introduces the reader to the basics of data communications and networking. Issues concerning various transmission types, quality of service parameters, currently used transmission media, and the way in which signals are represented in them are briefly presented. Additionally, the IP stack is briefly introduced.

This book is a valuable source of information for undergraduate or graduate students with technical experience and interest in computer networking in general.

The next four chapters describe different types of networks as well as their place and importance in the global network. In Chapter 2 the telephone network is presented. The focus is put on the transmission systems, mainly on access networks, ranging from analog subscriber lines with public switced telephone network (PSTN) modems to digital subscriber lines (DSL) and ISDN, but also on core systems such as plesiochronous digital hierarchy (PDH) and synchronous digital hierarchy (SDH).

Chapter 3 concentrates on LAN. Here, we can find detailed information on the lowest layers of the ISO/OSI model, a description of the Ethernet/IEEE802.3 network, the carrier sense multiple access/collision ddetection (CSMA/CD) scheme, and, finally, LAN interconnection technologies with a distinction between hubs, switches, and bridges.

Chapter 4 relates to wireless networks. After presenting a radio interface and basic transmission methods, the differences between wired and wireless networks are described and necessary modifications introduced. The chapter ends with a description of cellular networks architectures: Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS), and Universal Mobile Telecommunications System (UMTS).

Chapter 5 is devoted to entertainment networks, especially cable and satellite television. The general process of signal transmission in these networks is presented, and Internet access methods are described.

Chapter 6 is the longest and probably the most important in the book. It deals with the Internet Protocol. First, the IPv4 datagram structure and current IP addressing issues are presented. Next, routing algorithms are described, including distance vector and link state shortest path first. Then the most significant protocols and methods concerning the IP stack are presented. These include Address Resolution Protocol (ARP) and Reverse ARP, Dynamic Host Configuration Protocol (DHCP), Internet Control Message Protocol (ICMP), Internet Group Management Protocol (IGMP) and, once again, routing related protocols: Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP). At the en IPv6 is introduced, followed by IPv4/IPv6 interoperability possibilities and problems.

In Chapter 7 the transport protocols are described. TCP, UDP, RTP, RTCP and wireless TCP are presented; however, the main focus is put on the most important protocol, TCP. The header format and issues such as connection establishment and termination, segmentation, and error and flow control procedures are extensively presented. Moreover, most of the rou-

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tines are accompanied by detailed diagrams, which make the topics easily understandable.

Chapter 8 covers common Internet applications, and their usage and significance. These are in order of appearance: the Domain Name System (DNS), email, FTP, Trivial FTP (TFTP), Simple Network Management Protocol (SNMP), and general aspects of Internet telephony.

Chapter 9 presents the World Wide Web environment. In the overview the general concept of Web browsing is presented. Then uniform resource locators (URLs) and HyperText Transfer Protocol (HTTP) are described. The rest of the chapter contains detailed description of HTML, brief presentations of Java and Javascript languages, audio and video streaming in the Internet, and the Wireless Application Protocol (WAP).

The last chapter, Chapter 10, focuses on security issues. First, the basic techniques of data encryption and authentication are presented. Then some concrete methods commonly used to achieve email privacy, Web security, and general network protection are presented.

This book has five appendices. Appendix A presents how multimedia (pictures, sound, and video) is represented in digital form. It also deals with compression methods and commonly used schemes (e.g., Huffman encoding). Appendices B and C are devoted to error detection and correction methods, respectively. Error detection mechanisms cover parity check, block sum check, and cyclic redundancy check (CRC), while error correction mechanisms concern block codes and convolutional codes. Appendix D is an addition to Chapter 4, and presents the propagation of electromagnetic waves in free space and radio transmission basics. The last and shortest appendix, Appendix E, introduces ATM as a backbone network technology.

Concluding, this book is a valuable source of information for undergraduate or graduate students with technical experience and interest in computer networking in general. In my opinion the one thing this book lacks is a thorough presentation of the layered OSI/ISO network model. Of course, all parts of this model are described in various chapters of the book, but it might be useful to introduce them first. The first edition of this book was published in 1985. Since then many new chapters have arisen and some have been updated. However, in certain parts of the book the reader may come across some obsolete information. Fortunately, they are quite insignificant to the understanding of the presented topics. In the author's defence, both mentioned flaws are of marginal importance, and do not disrupt the overall positive impression. Therefore, I have no doubts that this book is worth recommendation.

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"Wikipedia is an online community devoted… to a higher good. It is also no more immune to human nature than any other utopian project… Senators and congressmen have been caught tampering with their entries; the (full) House of Representatives has been banned … several times."

New Yorker: Annals of Information

A	National Public Radio
B	Enemy
C	When
D	Yacht
E	Oust
F	Rube
G	Knight
H	Eave
I	Rashomon
J	Ashen
K	Navajo
L	Nash
M	Ague
N	Light emitting diode
O	Smashup
P	Oath
Q	Fiber to the premises
R	Ions
S	Nepenthe
T	Federal Trade Commission
U	One
V	Russian roulette
W	Magnet
X	Aunt
Y	Tweet
Z	Internet service provider
a	Ohm
b	Neon