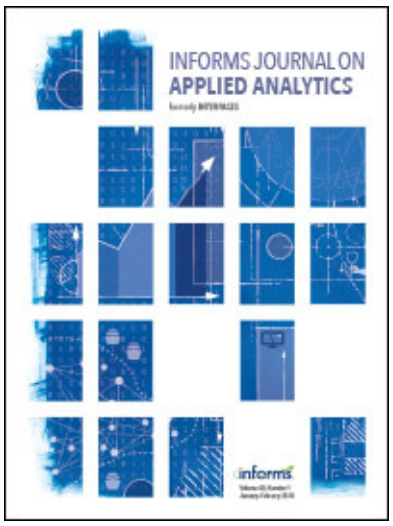

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Book Reviews

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Book Reviews

Benjamin Lev
School of Management, The University of Michigan–Dearborn, 4901 Evergreen Road,
Dearborn, Michigan 48128-1491, blev@umich.edu

The range of books reviewed is wide, covering theory and applications in operations research, statistics, management science, econometrics, mathematics, computers, and information systems (no software is reviewed). In addition, we include books in other fields that emphasize technical applications. Publishers who wish to have their books reviewed should send them to Professor Benjamin Lev. We list the books received; not all books received can be reviewed because space is limited. Those who would like to review books are urged to send me their names, addresses, and specific areas of expertise. We commission all reviews and do not accept unsolicited book reviews. Readers are encouraged to suggest books that might be reviewed or to ask publishers to send me copies of such books.

The authors or editors of the books reviewed in this issue are Ulrich Faigle, Walter Kern, and George Still; Matthew S. Goldberg and Anduin E. Touw; Rajendra P. Srivastava and Theodore J. Mock; Kishor S. Trivedi; and Wil van der Aalst and Kees van Hee.

FAIGLE, ULRICH, WALTER KERN, GEORGE STILL. 2002. *Algorithmic Principles of Mathematical Programming.* Kluwer Academic Publishers, Dordrecht, The Netherlands. 337 pp. $103.00.

Mathematical programming traditionally decomposes into three areas: discrete optimization, linear optimization, and nonlinear optimization. In *Algorithmic Principles of Mathematical Programming* Faigle, Kern, and Still cover all the main topics in the three areas and provide comprehensive introductions to algorithmic techniques in mathematical programming "with a strong emphasis on the central position of linear algebra both in the structural analysis and the computational procedures." This book is one of Kluwer's texts in the mathematical sciences at the graduate level. A number of comparable textbooks on mathematical programming are available. A distinguishing feature of this book is that the authors focus on the mathematical structure and principles in efficient algorithms. The book is compact and well organized, and the authors have carefully chosen powerful approaches and recent techniques for solving discrete and continuous optimization problems.

The authors have made the book as self-contained as possible by outlining vector space, linear system, and polyhedra in the first three chapters. In Chapter 1, they review the basic notations and facts from linear algebra and analysis that are used as tools in mathematical programming. In Chapter 2, the authors discuss fundamental computational techniques for linear systems, including Gaussian elimination, orthogonal project and least-square approximation, integer solution of linear equations, and linear inequalities. In Chapter 3, they consider polyhedra as geometrical objects with the goal of providing some geometric intuition for the algebraic results about linear inequality systems.

Chapter 4 concerns linear programs and the simplex method. After covering the general structure of linear programs within the framework of linear inequality systems, the authors illustrate all the important concepts and the classic simplex methods in linear programs concisely, including duality, primal-dual simplex methods, and sensitive analysis.

In Chapter 5, "Lagrangian duality," the authors move from linear to nonlinear optimization problems by extending the dual concepts they discussed for linear programming. They present Lagrangian relaxation and optimality conditions, which provide the fundamentals of some methods in integer programming and nonlinear programming.

In Chapter 6, Faigle, Kern, and Still discuss a primal-dual interior point algorithm (IPM) for linear programs, which is widely used in current IPM-based optimization software. They also discuss some related issues, including constructing basic solutions from an approximate solution, initialization, and upper and lower bounds for the number of iterations for linear programs.

Chapters 7 through 9 concern integer programming and combinatorial optimization. In Chapter 7, the authors discuss network flows by presenting typical problems and basic algorithms, including shortest paths, maximum flow and minimum cost flows. In Chapter 8, they discuss the complexity of optimization problems and algorithmic efficiency, providing particular insight into discrete optimization. Beginning with the basic concepts, they explore the running

times of algorithms and the complexity of problems, giving many examples. In Chapter 9, they present three methods for integer programming. After formulating three typical problems with integer-linear-program models, they focus on cutting plane and Lagrangian relaxation methods and the branch-and-bound method and related strategies. They end the chapter with dualizing binary constraints, which can be transferred to a special case of semidefinite program. Unlike most other chapters, this chapter does not include clear algorithmic steps for the methods presented.

The last part, Chapters 10 through 12, makes up two-fifths of the book and is devoted to nonlinear programming. In Chapter 10, the authors start by introducing the concepts of convex set and convex functions and then deal with convex optimization problems and quadratic programming. In the last two sections, they turn to the ellipsoid method and its applications, including linear programming, separation and optimization, and convex optimization. In Chapter 11, the authors address unconstrained optimization and discuss decent methods, conjugate methods, Gauss-Newton, and quasi-new methods. The chapter ends with an introduction of subgradient methods for nondifferentiable functions. In Chapter 12, they cover first and second optimality conditions and the main algorithms for constrained nonlinear optimization, including feasible-direction-based primal methods, penalty and barrier methods, sequential quadratic programming, and interior-point methods. The authors conclude the chapter by introducing semi-infinite and semidefinite programs, which have received increasing attention in recent years.

After covering the important concepts and methods in each chapter, the authors provide some carefully chosen exercises or examples to help readers to understand the text, though they give very few numerical examples. They also present concise proofs for most of the theorems and lemmas they discuss in the book.

In teaching a graduate course on nonlinear optimization for engineering and science students, I used Faigle, Kern, and Still's book as one of the main reference books for the course. The comments from students, which I agree with, include the following: "I like the fact that the algorithms are given in a clear, concise way in a bold box" and "It would be better if more numerical examples were provided to illustrate important algorithms and concepts." As an instructor, I like the rigorous treatment of most concepts and theorems, and I take the book along as a handbook during teaching. One of my concerns is that the discussions of some topics are insufficient. For example, without a normal equation or an augmented system in interior-point methods, the algorithm IPM given on p. 115 is inefficient in practice. Furthermore, in future editions, I would like to see additional material covering approximate algorithms and truth-region methods.

In summary, this is a very good textbook that is suitable for advanced undergraduate or graduate level courses on the principles of mathematical programming within the areas of applied mathematics, operations research, and computer sciences. The book will also interest practitioners and academics in mathematical programming, operations research, and industrial engineering.

Guoqing Zhang
Department of Industrial and Manufacturing Systems Engineering, University of Windsor, Windsor, Ontario, Canada N9B 3P4, gzhang@uwindsor.ca

Goldberg, Matthew S., Anduin E. Touw. 2003. *Statistical Methods for Learning Curves and Cost Analysis*. INFORMS, Linthicum, MD. 186 pp. $30.00.

Goldberg and Touw give a thoughtful, thorough, and welcome discussion of the application of current statistical methods to parameter-estimation problems of interest to cost analysts. They focus on estimation problems related to cost progress (learning), the widely observed decrease in unit production costs as more and more units are produced in a given plant. They treat an approximation to the Crawford model of the phenomenon. In its exact form, that model specifies the cost of the Qth unit produced as $T_1 Q^b$, where T_1 and b are constant parameters.

Goldberg and Touw consider six estimation methods for the two parameters of the Crawford model: lot-midpoint nonlinear least squares (NLS), lot-midpoint iteration, minimum percentage error (MPE), maximum likelihood estimation (MLE), iteratively reweighted least squares (IRLS), and maximum quasi-likelihood. NLS is nonlinear least squares estimation of the model's two parameters. Lot-midpoint iteration is a heuristic method of treating the NLS minimization problem by constructing a sequence of linear models whose parameters are obtained by linear least-squares estimation. MLE is the familiar estimation method; MPE is a certain psuedolikelihood estimator that maximizes a truncated likelihood function. IRLS is discussed in the literature; Goldberg and Touw refer to Seber and Wild (1989, pp. 88–89). Descriptions of maximum quasi-likelihood also are available; Goldberg and Touw cite McCullagh and Nelder (1989, Chapter 9). While lot-midpoint NLS and lot-midpoint iteration are specific to cost progress work, the other models are generally applicable.

Cost analysts and estimators will certainly appreciate Goldberg and Touw's illuminating discussions of serial correlation of observation errors and of statistical dependences among items in work-breakdown structures. Their detailed examples of calculations of

the statistics of estimating errors and of means for coping with serially correlated observation errors are particularly helpful.

Goldberg and Touw develop many statistical properties of the estimation methods analytically. Doing this completely for all of them would be a daunting task, and, wisely, the authors use simulations to complete their study. The extensive set of simulation experiments reported in Chapter 5 is particularly helpful. I was glad to see that Goldberg and Touw report errors in a quantity representative of the things cost analysts actually wish to infer, specifically, the predicted costs of certain units. (They report errors in the model's two parameters, too, but those parameters are only intermediate quantities, not usually the things practitioners actually produce.)

The authors find that MPE is biased, and sensitive to outliers. They find that lot-midpoint iteration, while theoretically unsatisfactory, performs unexpectedly well. They recommend IRLS and NLS as estimating methods of choice.

I was puzzled to see Goldberg and Touw devote so much attention, in a book emphasizing modern statistical methods, to an approximate Crawford model developed to cope with the limited computational support of an earlier era. Nevertheless, they use their chosen model very effectively to illustrate the modern statistical methods.

One problem of approximations of the kind they use, however, is the difficulty of making wholly consistent treatments. In dealing with this problem Goldberg and Touw have only indifferent success. On p. 6 they say, "The learning curve is most often specified so that the cost of unit Q—the marginal cost—is a power function of Q." This identification of marginal cost at Q with the cost of unit Q contradicts their statement on p. 34, that "simply evaluating the marginal cost curve at the argument 1.0 is inexact because only the integral under the marginal cost curve is meaningful." When arguing on pp. 32 and 33 that the Crawford and Wright models are equivalent "under the assumption of zero non-recurring costs, and using the continuous approximation," Goldberg and Touw use an approximation for the average cost of the first Q units produced (their Equation 2.6) that is not consistent with the approximation they use elsewhere for lot average cost (their Equations 1.6 and 2.16)

These are, however, matters of detail. They do not detract from the book's impressive achievements in showing how modern statistical methods can be applied to tasks faced by cost analysts and estimators. Practitioners will find Goldberg and Touw's book enlightening conceptually and regularly useful in their daily work.

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David Lee

Logistics Management Institute, 2000 Corporate Ridge Road, McLean, Virginia 22102-7805, dlee@lmi.org

Srivastava, Rajendra P., Theodore J. Mock, eds. 2002. *Belief Functions in Business Decisions* (*Studies in Fuzziness and Soft Computing*). Springer-Verlag, New York. 334 pp. $90.00.

In *Belief Functions in Business Decisions*, Srivastava and Mock compile research papers by authors from around the world. The book covers three basic areas of current research.

The first area is the foundations of belief functions, and it consists of three chapters. In the first chapter, "Introduction to belief functions," Srivastava and Mock discuss the belief-function concept and the need for the belief-function methodology in performing audits. In the second chapter, "Decision making in a context where uncertainty is represented by belief functions," Smets describes the background and notation for the development of belief-function models, including ones based on the transferable belief model and the upper and lower probabilities model. Within the context of these models, he shows how to make decisions. In the last chapter of this section, "Empirical models for the Dempster-Shafer theory," Klopotek and Wierzchon provide three interpretations for belief functions, the marginally correct approximation, the qualitative model, and the quantitative model.

The second area the book covers is applications of belief functions to business systems and auditing applications. In the first chapter of this section, "The descriptive ability of models of audit risk," Monroe and Ng investigate the degree of consistency between auditors' intuitive assessments of audit risk and audit risk values generated by various models, including the belief-function model. Particularly interesting is that they can demonstrate that inconsistencies occur with the use of all models except the belief-function model. The second chapter, "The effectiveness and efficiency of belief-based audit procedures," is by Jung and Fink. Using simulation results, they show that the belief-based audit approach is the best, although not the most efficient, method for conducting financial audits. Generally, they assert that beliefs better represent the uncertainties found in audit evidence. In the third chapter, "Auditors' evaluations of uncertain audit evidence: belief functions versus probabilities," Harris, Srivastava, and Plumlee describe an empirical study that shows that auditors express their evaluations about the strength, uncertainty, and ignorance of evidence in ways that

are consistent with belief functions but inconsistent with Bayesian probability. In the final chapter in this section, "Conflict, consistency and consonance in belief functions: Coherence and integrity of belief systems," Gillett discusses conflict and nonspecific evidence in the belief-function formalism. He provides a means for assessing and resolving conflict, including retraction and addition of evidence.

Finally, the third area of the book consists of applications of belief functions to operations management, finance, and economics. In the first chapter, "Evaluating mergers and acquisitions: A belief function approach," Srivastava and Datta outline a conceptual framework for acquisition and merger decisions using the belief-function framework. They show how to use expert knowledge of relevant factors to incorporate uncertainty in the evidence. Decision makers are introduced to evidential networks to organize all relevant features of the model and to perform belief updating and revision. Jirousek, Vejnarova, and Gemela wrote the second chapter, "Possibilistic belief network constructed by operations of composition and its application to financial analysis." They define a possibilistic belief network and support it by using simple examples. They use this modeling approach to construct a detailed example of the apparatus necessary for a financial analysis of engineering enterprises. McBurnley and Parsons wrote the third chapter, "Using belief functions to forecast demand for mobile satellite services." They apply Smets' transferable belief model for demand forecasting in a new and expensive telecommunication service. In their model, forecasting must be performed in an area where potential customers are not familiar with the products and services. They claim "that belief functions have a considerable potential for application in highly-uncertain business domains, such as in the forecasting of demand for new products and services." The fourth chapter in this section is "Modeling financial portfolios using belief functions." The authors, Shenoy and Shenoy, justify and apply the theory of belief functions in financial portfolio management. They show how to model portfolio changes as information accumulates about factors that influence individual stocks or portfolios. In the final chapter, "Futures hedging under prospect utility and Knightian uncertainty," Lien demonstrates how Knightian uncertainty is related to belief functions, using a futures hedging decision under Knightian uncertainty.

This addition to the belief-function literature is a complete and thoroughly updated collection of results. The authors provide readers who are proficient in mathematics and business modeling with the theoretical background needed to understand their papers. All are well written, illustrated, with examples, and thoroughly annotated and referenced. The book should prove useful to people developing expert systems, particularly in such areas as auditing.

Gary M. Johnson
14154 Round Hill Road, King George, Virginia

TRIVEDI, KISHOR S. 2002. *Probability and Statistics with Reliability, Queuing and Computer Science Applications*, 2nd ed. John Wiley and Sons, New York. 830 pp. $89.95.

In the second edition of *Probability and Statistics with Reliability, Queuing and Computer Science Applications,* Kishor S. Trivedi provides a comprehensive introduction to probability, stochastic processes, and statistics for students of computer science, electrical and computer engineering, and applied mathematics. In this updated edition of the popular classic (blue book), he relates fundamental concepts in probability and statistics to computer science and engineering. He uses Markov chains and other statistical tools to illustrate processes in the performance and reliability of computer systems and networks. As a textbook, the book is intended for a two-semester course for seniors and first-year graduate students. The practical examples in every chapter, which cover a wide range of applications, including computer systems, computer networking, telecommunications, wireless systems, and software reliability, make this book an excellent resource for practitioners as well. The examples are current and are very helpful in exposing the mathematical concepts.

In Chapters 1 to 5, Trivedi provides an introduction to probability theory, which could be used as the core material for a one-semester introductory course on applied probability theory. A major strength of this introductory section of the book is the use of examples and problems as motivation for the probability concepts. Each chapter also includes sections on the application of the probability concepts to performance and reliability analysis.

Chapter 1, "Introduction," concerns the concepts of sample spaces, events and event algebra, probability axioms, combinatorial problems, Bayes rule, and Bernoulli trials. On the application side, the author introduces reliability analysis using block diagrams and fault trees, methods of inclusion exclusion, sum of disjoint products, factoring, and the reliability analysis of multistate systems.

In Chapter 2, "Discrete random variables," the author covers the functions and distributions for discrete random variables. In Chapter 3, "Continuous random variables," he covers the functions and distributions for continuous random variables. In addition to the exponential distribution, he presents such other continuous distributions as the Pareto, log-logistic, and defective distributions that are used in reliability theory.

In Chapter 4, "Expectation," Trivedi covers moments, transform methods, and inequalities and limit theorems. On the application side, he discusses computation of mean time to failure for systems with different types of redundancy schemes. In Chapter 5, "Conditional distribution and expectation," he considers mixture distributions, conditional expectation, and random sums. In discussing applications, he introduces the concept of imperfect fault coverage and its impact on system reliability.

Chapters 6 to 9 are devoted to stochastic processes and their applications, and they could be used as the core material for a one-semester second course on system modeling.

Chapter 6, "Stochastic processes," concerns stochastic processes: classification of stochastic processes, Bernoulli process, Poisson process, and renewal processes. He discusses applications of availability analysis and a renewal model of program behavior.

In Chapter 7, "Discrete-time Markov chains," Trivedi introduces discrete-time Markov chains and then covers the following topics: computation of n-step transition probabilities, state classification and limiting probabilities, distributions of times between state changes, Markov modulated Bernoulli processes, irreducible finite chains with aperiodic states, and discrete-time birth-death processes. He treats software performance and reliability analysis separately in a section on finite Markov chains with absorbing states, and he devotes a section to $M/G/1$ queueing systems. Application examples include multiprocessor memory interference, software reliability, software performance, performance of cache memories, and performance of paging systems.

In Chapter 8, "Continuous-time Markov chains," he introduces continuous Markov chains and then covers: birth-death process and models, non-birth-death processes, and Markov chains with absorbing states. He also discusses solution techniques for transient and steady-state behavior of continuous-time Markov chains and automated generation of continuous-time Markov chains with generalized stochastic Petri nets (SPNs) and stochastic reward nets. He introduces and uses Markov reward models throughout this chapter. He also discusses availability modeling and performability modeling, nonhomogeneous Markov chains, and semi-Markov models.

In Chapter 9, "Networks of queues," Trivedi discusses queueing networks: open and closed queueing networks, general service distributions and multiple job types, and non-product-form queueing networks. He devotes a section to computing response-time distributions for open networks and closed networks.

In Chapter 10, "Statistical inference," the author covers parameter estimation and hypothesis testing, and in Chapter 11, "Regression and analysis of variance," he covers: least-squares curve fitting, coefficients of determination, confidence intervals in linear regression, trend detection and slope estimation, correlation analysis, nonlinear regression, and analysis of variance. The applications described include statistics of reliability and availability, detection of software aging, and estimation with dependent samples.

The book ends with four appendices: a bibliography sorted by theory and applications; properties of various discrete and continuous distributions; statistical tables of distribution functions; and properties and tables of Laplace transforms.

This edition features an entirely new section on SPNs as well as new sections on system-availability modeling, wireless-system modeling, numerical solution techniques for Markov chains, software-reliability modeling, and other subjects. Trivedi has made extensive revisions to take new developments in solution techniques and applications into account and to bring the book totally up to date. A major strength of this book is the large number of application examples that are good abstractions of real-world problems, that serve to motivate and illustrate complex theoretical concepts. The book includes more than 200 worked examples and independent-study exercises for each section. A solution manual is available from the publisher.

The textbooks that can be compared with Trivedi's book are Jain's (1991), Ross's (2002), and Tobias and Trindade's (1995). Jain concentrates only on performance modeling and does not treat reliability, availability, and performability modeling. Ross offers a fine treatment of probability concepts and models, however, Ross focuses only on probabilistic models for computer science. Tobias and Trindade (1995) consider only reliabililty analysis using a statistical perspective; in particular, they do not cover Markov chain methods and do not do any performance analysis.

I highly recommended this book for academics for use as a textbook and for researchers and professionals in the field as a useful reference.

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Veena B. Mendiratta
Bell Labs, Lucent Technologies, 1960 Lucent Lane, Naperville, Illinois 60566

Van der Aalst, Wil, Kees van Hee. 2002. *Workflow Management: Models, Methods, and Systems*. The MIT Press, Cambridge, MA. 368 pp. $40.00.

The authors' purpose in *Workflow Management: Models, Methods, and Systems* is to describe the management of business processes in contexts in which people use generic software products to handle the information logistics of the processes. These generic software products, also called Work-Flow Management Systems (WFMSs), support and enhance business processes by ensuring that the right information is moved to the right persons and computer applications at the right time and in the right format. One should not be confused by the term *work flow*. The authors use it as a synonym for business processes. The term is meaningful because it helps readers to distinguish WFMSs from other kinds of business process software products, for example those that are useful only for representing, redesigning, analyzing, and simulating processes. WFMSs do not perform any of the tasks of a business process; rather they rely on other application software for the execution of process tasks. The authors suggest that the availability of WFMSs gives people an opportunity to change the traditional procedures used to design and implement business processes. Generally, the logic of a traditional procedure is to first organize a process before computerizing it. The authors argue that WFMSs enable process engineers to follow a new approach. They propose that engineers could first design business processes in an abstract manner without considering the specifics of the implementation. Thereafter, the process engineer would design the information systems and the organization concurrently. This separation of the design phases implies that the designer would have the option of allocating process tasks either to persons or to information systems. The WFMS hence serves as the link that enables the creation of the work flows and the implementation of the abstract work-process design. The authors have done an excellent job of presenting an innovative and potentially valuable approach and its underlining theory, framework, and tools in a clear and understandable manner.

The book is divided into seven chapters. In the first, the authors introduce a reference framework that helps to define the contexts in which WFMSs are used, helps people to model and analyze processes, and helps them to describe the functionality, features, and architecture of WFMSs. They define such concepts as business processes, resources, tasks, task selection, synchronization, process categories, and organizational structures, and they describe the historical evolution of the use of information systems for business processes.

In Chapter 2, the authors consider a vital tool for modeling and analyzing work flows—Petri nets. A Petri net is a formal approach for representing and analyzing processes. Carl Adam Petri devised the method in 1962, and it consists of representing processes graphically in terms of *places*, represented as circles, and *transitions*, represented as rectangles. Unlike other schematic methods, Petri nets have a strong mathematical basis. One can make strong statements about processes based on the mathematical attributes of their Petri nets. The authors give several examples that should help readers to understand work-flow concepts and the basic elements of Petri nets and equip them with the skills they need to map work flows into Petri nets.

Wil van der Aalst and Kees van Hee focus on the management of work flows in Chapter 3. They begin by describing resources, which are the components of WFMSs that execute work. They also define classes of resources and allocation principles, which link process definitions to resource classifications, and they also introduce various types of entities and entity relationships. They end the chapter by discussing the concepts of bottlenecks and process performance indicators.

In Chapter 4, the authors build on the previous three chapters by dealing with the analysis of work flows. They differentiate between the qualitative analysis of processes, which tests or validates the logical correctness of processes, and quantitative process analysis, which evaluates the performance attributes of a process, such as completion time, utilization capacity, and level of service. Under the qualitative analysis segment, the authors introduce the classic Petri net and the derivation of formal reachability graphs from Petri nets. They also illustrate flawed processes and take the reader through structural analysis steps. They illustrate basic mathematical attributes of work flows and give examples of sound and safe work flows. The authors close the chapter by discussing performance-analysis methods. Simulation is the primary approach the authors cover, apparently reasoning that WFMSs predominantly use this technique and not Markovian analysis or queueing theory. The chapter ends with a very brief exposé of Little's law for capacity calculation and planning.

In Chapter 5, the authors explore the functions and the architecture of work-flow systems, building the chapter around the Workflow Management Coalition's (WFMC's) reference model, the so-called work-flow reference model. According to this model, one could describe every WFMS using six components. First, the core of the work-flow system is the work-flow enactment service. This component ensures that the right information is processed in the right order and by the appropriate resources. To achieve its purposes, the work-flow enactment service depends on its process definition component to define processes. It also depends on its work-flow client applications to present work items to employees and

set processing rules. The work-flow enactment service is also assisted in its tasks by the invoked applications component and several work-flow client engines. All WFMSs are administered through the administration and monitoring tool component. The authors briefly describe the features of a few work-flow systems and the challenges of interfacing systems, of choosing the required technical infrastructure, and of selecting WFMSs. Chapter 6 seems to be a primer for those who intend to develop WFMSs, covering such issues as rapid application development and interactive, process-oriented system development. In Chapter 7, the authors describe the Sagitta case study, in which the Dutch Customs Service implemented WFMSs to enhance its process. They describe the essential steps involved in a real-life design and implementation of a WFMS in an organization. In the appendices of the book, the authors appropriately separate the more detailed and formal mathematical attributes of Petri nets and the modeling of WFMSs using the Uniform Modeling Language (UML) from the more managerial presentation of the book. The chapter exercises and the fully explained solutions to the exercises enhance the book's usefulness and understandability.

Most aspects of the book recommend it for the novice as well as for the business-process engineer who is interested in learning a new approach to enabling business processes. The book would be useful for both academics and management professionals. Some chapters may be difficult for readers who have no access to a WFMS. Readers will need an above-average foundation in analytical reasoning to understand the work-flow analysis section and the formal mathematical attributes of Petri nets.

Adenekan Dedeke
Department of Information Systems and Operations Management, Suffolk University, Boston, Massachusetts 02108

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