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Preface

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Preface

One of the primary goals of the 2005 INFORMS meeting tutorials is to address the evolving challenges faced by our community, especially with respect to the visibility and impact of our profession. Indeed, communicating the role of operations research and management science (OR/MS) to industrial and governmental organizations often remains quite difficult, even to those organizations that can benefit the most from OR/MS. After all, the vast majority of people who navigate to and from work, plan their weekly budget, and decide when and at what price to buy airplane tickets never know that they are (heuristically) solving complex OR/MS problems. While the loss of five minutes on the way to work or paying 5% over the cheapest-possible airfare is of little consequence, it is well-documented that decision processes worth millions of dollars, or even those determining the difference between life and death, can unquestionably benefit from OR/MS principles.

INFORMS tutorials sessions provide an opportunity to witness the application of OR/MS to new problem domains, investigate new theoretical investigations from first principles, understand the foundations and procedures of new methods, and participate in the ongoing implementation of our findings in the classroom and in practice. However, they currently lack a certain outreach ability: Those who are not familiar with OR/MS will likely not attend the annual meeting in the first place, and even those present must budget their resources between subdivision meetings, parallel sessions, and other service responsibilities. Moreover, those who are in fact able to attend the tutorials sessions often do not have a written artifact of the topic to which they can refer after the conference. It is therefore the goal of this book to remedy these shortcomings and widen the visibility of new research and applications in our field. Last year's Tutorial Chair, Dr. Harvey Greenberg, compiled a volume consisting of eight tutorial chapters that complement the tutorial sessions presented at the 2004 INFORMS meeting in Denver. He has continued his efforts by establishing a series of tutorial compilations to be published by INFORMS, of which this book represents the first volume.

Illya Hicks, Arie Koster, and Elif Kolotoğlu begin in Chapter 1 by examining the concepts of branch and tree decomposition techniques in the context of combinatorial optimization. Although branch and tree decompositions are not new concepts, their usefulness in the realm of optimization is something that has only recently blossomed in the literature. While a firm background in graph theory concepts is useful to appreciate the details of their work, the reward is an exciting new approach to solving certain discrete optimization problems from an implicit enumeration perspective that is fundamentally different from most ad-hoc algorithms designed for hard optimization problems. The success of researchers that apply branch and tree decomposition techniques to combinatorial optimization problems (including the traveling salesman problem, synchronous optical network design problems, and frequency assignment problems) are truly eye-opening.

Julia Higle presents an introduction to stochastic programming in Chapter 2. Stochastic programming is rapidly becoming a hot area of research as the necessity of incorporating uncertainty into optimization models, rather than relying on sample means as deterministic input, has become evident. Higle demonstrates this concept with a simple example, illustrating the shortcomings of utilizing mean estimates and sensitivity analysis in optimization problems. One can then begin to imagine the myriad applications that can benefit from stochastic programming problems, such as electricity markets, telecommunication network design, and air transportation problems, where demand and system operability are

rarely known with certainty. This discussion recaps theory and solution techniques for basic two-stage problems, in which a decision must be made at the present time, followed by the realization of some stochastic event (e.g., actual demands or component failures), after which a set of *recourse decisions* must be made. For those readers already familiar with the stochastic programming, the closing sections offer new insights into stochastic decomposition methods for uniting statistical methods with classical decomposition techniques and multistage optimization models that challenge the limits of modern computing ability.

Multistage optimization is not limited to stochastic programming scenarios. While perhaps the best-known example of multistage optimization lies in air transportation, another less-researched area lies in railroad optimization, as discussed in Chapter 3. These problems involve a unique set of challenges with very significant costs. Ravindra K. Ahuja, Claudio Cunha, and Güvenç Sahin provide six classes of rail optimization problems, each of which is a large-scale NP-hard optimization problem. The authors provide specific details regarding the sizes of these problems, and they discuss the actual financial benefit of employing their methods. In addition to its interesting application of mathematical modeling and very large-scale neighborhood-based heuristics, this chapter is an exemplar of the importance of OR/MS in contemporary applications and the need for OR/MS professionals to seek out such applications.

Chapter 4 continues the network optimization theme, but in the context of modern security challenges that are faced in designing critical network infrastructures. Gerald Brown, Matthew Carlyle, Javier Salmerón, and Kevin Wood provide a comprehensive review of network interdiction problems and contemporary methods for their solution. The problems contained within this chapter are for the most part Stackelberg games, wherein an enemy may decide to disrupt a portion of the network after which the protagonist must make some recourse decision to mitigate the attack. The authors make a convincing case by repeated examples and illustrations that enough data exists in the public domain to justify the assumption that enemies are capable of acting with full knowledge of a network's capabilities. The authors discuss cases ranging from securing subway systems to airport security to electric grids in order to demonstrate the usefulness of their models and algorithms.

Critical networks and business processes can often be disrupted accidentally due to randomness in demands. In particular, the effectiveness of many supply chain applications depends very strongly on the quality of the forecast demands. In Chapter 5, Joseph Geunes, Yasemin Merzifonluoğlu, H. Edwin Romeijn, and Kevin Taaffe consider the impact of demand uncertainty for the case in which a supplier must select certain groups of demands (e.g., products) that they will try to satisfy. This chapter incorporates key concepts in discrete optimization and revenue management with traditional supply chain optimization research, and demonstrates another vital class of problems in which multiple stages of decisions must be addressed in an integrated fashion.

Revenue management is examined in Chapter 6 in more detail by Garrett van Ryzin and Kalyan T. Talluri. The depth and breadth of the field of revenue management is due in part to its successful application in a number of different industries, and to its importance as a subcomponent of other research fields (such as the study described in §5). This chapter examines methods for controlling capacity on a single resource (such as airline tickets) by various types of control strategies, such as levying booking limits or reserving capacity for classes of consumers. Based on these fundamentals, the authors then develop some of the basic theory and applications for revenue management in a self-contained manner.

While the first part of this book has focused almost entirely on quantitative methods for decision making, a large body of research exists in the field of decision analysis that merges quantitative research with decision making in practical settings. James Matheson makes this connection in Chapter 7 with an entertaining discussion on engineering the decision-making process. This chapter is not only valuable to the growing body of Decision Analysis Society members within INFORMS, but also to OR/MS researchers whose models include human

decision-making entities. Some of the most resonant contributions of Matheson's work are his description the decision hierarchy, accompanied by examples and illustrations of this structure, and a summary set of 10 commandments for decision analysis.

J. Neil Bearden and Amnon Rapoport approach human decision making in Chapter 8 from the rare perspective of behavioral psychologists with an expertise in optimization. They investigate several optimal stopping and triage-assignment problems, which are certainly interesting optimization problems in their own right. In addition to providing optimal solution techniques for these problems, Bearden and Rapoport have conducted a long series of behavioral experiments to judge how humans actually make decisions, and what sort of suboptimal behaviors humans exhibit in these problems. This study is of primary importance to the OR/MS community because while systems are often designed with the "rational" decision maker in mind, the findings presented in Chapter 8 demonstrate that humans tend to exhibit common suboptimal traits that should be anticipated in the design of human-in-the-loop systems. This chapter thus affords unique insights and opportunities to conduct new and more realistic game theory studies by better understanding specific characteristics of suboptimal human behavior.

The last two chapters of this volume discuss the implementation of these new ideas and classical concepts in the OR/MS classroom and in open-source computing environments. In Chapter 9, James Cochran provides a detailed discussion of active learning methods that are proven to enhance the understanding and retention of OR/MS material in the classroom. This chapter provides a unique contribution to the INFORMS audience for several reasons. One is that Cochran's message is not only valuable to academics within INFORMS, but to anyone in a leadership position responsible for communicating OR/MS principles. A second important and unique aspect of this chapter is that the discussion is geared toward the quantitative classroom, unlike many general-purpose teaching tips that do not necessarily translate to engineering classrooms. Finally, this chapter provides concrete examples of how active learning can be injected into the classroom, along with pointers to free software available to ease the transition.

The final chapter examines one facet of the Computational Infrastructure for Operations Research (COIN-OR) project, which is a collection of open-source optimization libraries that become stable and effective over time through repeated use and improvement by the optimization community. Chapter 10 contains a tutorial written by John Forrest and Robin Lougee-Heimer on how to use the COIN branch-and-cut (CBC) solver. (This chapter is perhaps a tutorial in the most literal sense, in that it provides specific source code on how to implement these algorithms.) While many OR/MS researchers have a vital interest in CBC in particular, this chapter also serves as a gateway to the many other libraries in the COIN-OR project.

These chapters accomplish more than recapping classical OR/MS methods; they provide an accessible discussion of evolving issues in theory, methodology, applications, and implementation. While each of these topics is very obviously distinct in their respective problem domains, they share the common thread that they are all of substantial importance, are new and emerging topics (some truly in their infancy), and are open to new ideas from the INFORMS community to further their development and impact.

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