Industrial Applications of Combinatorial Optimization

Applied Optimization

Volume 16

Series Editors:

Panos M. Pardalos
University of Florida, U.S.A.

Donald Hearn
University of Florida, U.S.A.

The titles published in this series are listed at the end of this volume.

Industrial Applications of Combinatorial Optimization

Edited by

Gang Yu

Department of Management Science & Information Systems,
and the Center for Management of Operations and Logistics,
University of Texas at Austin,
Austin, Texas, U.S.A.

SPRINGER-SCIENCE+BUSINESS MEDIA, B.V.

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 978-1-4419-4797-0 ISBN 978-1-4757-2876-7 (eBook)
DOI 10.1007/978-1-4757-2876-7

Printed on acid-free paper

CONTENTS

PREFACE

Industries rely more and more on advanced technology. Accelerated computer evolution makes large-scale computation practical. Many enterprises are beginning to benefit from more efficient allocation of resources and more effective planning, scheduling, manufacturing, and distribution by adopting state-of-the-art decision support systems. Academics increasingly emphasize application-driven research. All these forces have moved optimization from a pure classroom and textbook terminology to an accepted tool in today's business world.

This book chronicles and describes applications of combinatorial optimization in industry. A wide range of applications is included:

- manpower planning
- production planning
- job sequencing and scheduling
- manufacturing layout design
- facility planning
- vehicle scheduling and routing
- retail seasonal planning
- space shuttle scheduling, and
- telecommunication network design.

The applications covered in this book comprise a representative set of industry sectors including electronics, airlines, manufacturing, tobacco, retail, telecommunication, defense, and livestock. These examples should encourage operations researchers and applied mathematicians by pointing out how the importance and practicality of optimization is starting to be realized by the management of various organizations and how some pioneering developments in this field are beginning to bear fruit.

Since the birth nearly three decades ago of complexity theory which classified a majority of combinatorial optimization problems as NP-complete–a class of intractable problems–researchers and practitioners have never given up their efforts in exploring ways to tackle large-scale, complex, real-world combinatorial problems. Significant progress has been made in the areas of polyhedral theory and bound generations. More importantly, various effective heuristics such as simulated annealing, tabu search, GRASP, genetic algorithms, neural networks, etc. have been developed. These novel approaches, together with rapidly increasing computational speed, enable researchers and practitioners to solve real-world combinatorial optimization problem to an acceptable degree. This book demonstrates the results of such endeavors.

To put the future into perspective, however, not enough emphasis is placed on the integration and timeliness of systems used to support planning and operational tasks. Supply chain management promoting enterprise-wide optimization is a big step in this direction. Integrated, real-time decision support systems based on optimization technology promise of a whole new level of advancements. Real-time management and operations control poses its own challenges, because of the large scale of operations, the complexities in balancing resource utilization and regulatory concerns, the dynamic industrial operational environment, and the desire to provide high-quality, reliable, and consistent service to customers. The key to attaining smooth operational control, capturing a stable and profitable share of the competitive market, and meeting customers' rising demands and expectations is the deployment of advanced decision support systems which efficiently manage scarce and valuable resources.

Currently, most industries store data and develop systems through fragmented architecture. The systems don't communicate seamlessly with each other. Complete real-time data are lacking. Multiple data instances reside in different systems, leading to pitfalls in data integrity and synchronization. Graphical user interfaces don't have the same look and feel across the systems. Lastly, many managers still rely on computer printouts and manually- generated charts to plan and make daily operational decisions.

More important, even though some companies deploy isolated decision support information technology systems, these systems generate sub-optimal, localized, and uncoordinated solutions. For example, the system for generating production planning traditionally does not take into account the difficulty in compiling corresponding staffing assignments. The systems for generating production schedules and inventory policies tend to disregard the complexity of their consequent distribution issues. The system for manpower planning doesn't consider training scheduling and training resource use. The systems for planning de-

cisions don't offer robust solutions needed for speedy recovery when there are disruptions. In all, this lack of integration among decision support systems leads to inferior responsiveness to change and imposes costs throughout the enterprise.

In addition to integration of systems, timeliness is another critical metric of decision effectiveness overlooked by many companies. Few companies have implemented or are even in the process of implementing real-time decision support technology to control daily operations. There is no doubt that the quality of a solution is important to revenue, cost, performance, and customer satisfaction. But the window of opportunity is extremely narrow for deploying the needed resources to implement real-time decisions. Decision support system solutions must be generated quickly to avoid complications associated with environment changes, resource availability modifications, and the introduction of new problems.

The rewards from applying integrated, real-time decision systems can be high. Several issues need to be noted.

- The integrated decision support framework must accommodate a wide range of scenarios and components.
- The focus needs to be on solution efficiency in order to achieve real-time advantages.
- The decision support system must provide for resource locking for multiple users responsible for the same set of resources.
- The system must be able to offer multiple solutions, allowing users to make choices in handling soft issues that are difficult to embed in the optimization model.
- There must be the capability to explore "what-ifs" which will facilitate interaction among decision makers and anticipate future problems.
- The new system must interface with information technology systems being phased out, with network communication, and with data integrity.
- The system's design and the graphic display must assist in user learning and acceptance.

It is my hope that these issues will be adequately addressed in future research and development. I am also looking forward to seeing future volumes of a similar theme that cover success stories on optimization applications in industry.

Gang Yu
The University of Texas at Austin
Austin, Texas, USA

ACKNOWLEDGMENTS

Those who contributed to this book deserve my highest respect and appreciation. Without their quality submissions, dedicated effort in making revisions, and patience while waiting for the birth of the book, publication of this volume would have been impossible. I owe a great deal to the anonymous referees who gave the reviewing tasks high priority and returned their reports faster than most of the journals I have submitted to. Working with the editor, John Martindale, whose positive attitude and accommodating manner relieved the pressure from my shoulder, has been a very pleasant process. My appreciation also goes to Caryn Cluiss, Jian Yang, and Xiaowei Wang who helped me with the tedious and time-consuming process of editing, formatting, and proofreading.

Having assumed too many responsibilities during the time this book was to be compiled, the completion was stretched beyond the targeted completion date. I am fortunate to have had my family's complete support and understanding, and I am especially indebted to my wife, Xiaomei Song. This book will leave a memorable mark on my life, since it began with the birth of my son and ended with the birth of my daughter.

Gang Yu
Editor
January 1998

CONTRIBUTORS

Michael F. Argüello
Center for Management of Operations and Logistics
The University of Texas at Austin
and CALEB Technologies Corp.

Dawei Bai
Department of Civil Engineering and Operations Research
Princeton University

Jonathan F. Bard
Department of Mechanical Engineering
The University of Texas at Austin

George A. Bohoris
School of Industrial Management
University of Pireaus
Pireaus, Greece

Shaukat A. Brah
Department of Decision Sciences
National University of Singapore
Singapore

Soo Y. Chang
Department of Industrial Engineering
Pohang University of Science and Technology
Kkyungbook, South Korea

Rahul Dé
Department of Business, Public Administration, and Economics
Bowie State University

Geon Cho
Department of Business Administration
Chonnan National University
Kwang Ju, Korea

Andreas Drexl
Institut für Betriebswirtschaftslehre
Christian-Albrechts-Universität zu Kiel
Kiel, Germany

Moshe Dror
Management Information Systems Department
University of Arizona

Stacy Dugan
CALEB Technologies Corp.

Fred Glover
The University of Colorado at Boulder

John L. Hunsucker
Department of Industrial Engineering
University of Houston

Hark-Chin Hwang
Department of Industrial Engineering
Pohang University of Science and Technology
Kkyungbook, South Korea

Alf Kimms
Institut für Betriebswirtschaftslehre
Christian-Albrechts-Universität zu Kiel
Kiel, Germany

Janny M. Y. Leung
Management Information Systems Department
University of Arizona

John Mulvey
Department of Civil Engineering and Operations Research
Princeton University

Katta G. Murty
University of Michigan

Miles G. Nicholls
School of Information Systems
Swinburne University of Technology
Victoria, Australia

George G. Polak
Department of Management Science and Information Systems
Wright State University

Edward C. Sewell
Department of Mathematics and Statistics
Southern Illinois University

Dong X. Shaw
School of Industrial Engineering
Purdue University

Stephen A. Smith
Santa Clara University

Yuri N. Sotskov
Institute of Engineering Cybernetics
Minsk, Belarus

J. C. Tan
Department of Systems
University of Pennsylvania

Vyacheslav S. Tanaev
Institute of Engineering Cybernetics
Minsk, Belarus

Michael T. Tapia
Department of Management Science and Information Systems
The University of Texas at Austin

Jane M. Thomas
Leicestershire, United Kingdom

Frank Werner
Otto-von-Guericke Universität Magdeburg
Facultät für Mathematik
Magdeburg, Germany

Gang Yu
Department of Management Science and Information Systems
and Center for Management of Operations and Logistics
The University of Texas at Austin