

Industrial Applications of Combinatorial Optimization

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Industrial Applications of Combinatorial Optimization

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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.

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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.

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