The Vehicle Routing Problem Latest Advances And New Challenges Operations Researchcomputer Science Interfaces Series

This proceedings volume highlights the role and importance of Operational Research (OR) in the digital era and the underlying ICT challenges. The selected papers cover recent advances in all branches of operational research, mathematical modeling and decision making. It covers a wide range of key areas from digital economy, to supply chain management, and also finance. The book adopts an applied perspective that covers the contributions of OR in the broad field of business and economics linked with the discipline of computer science. The chapters are based on papers presented at the 6th International Symposium & 28th National Conference on Operational Research. Although the conference is organized by the Hellenic Operational Research Society (HELORS), the contributions in this book promotes international co-operation among researchers and practitioners working in the field.

This tutorial introduces readers to several variants of routing problems with profits. In these routing problems each node has a certain profit, and not all nodes need to be visited. Since the orienteering problem (OP) is by far the most frequently studied problem in this category of routing problems, the book mainly focuses on the OP. In turn, other problems are presented as variants of the OP, focusing on the similarities and differences. The goal of the OP is to determine a subset of nodes to visit and in which order, so that the total collected profit is maximized and a given time budget is not exceeded.The book provides a comprehensive review of variants of the OP, such as the team OP, the team OP with time windows, the profitable tour problem, and the prize-collecting travelling salesperson problem. In addition, it presents mathematical models and techniques for solving these OP variants and discusses their complexity. Several simple examples and benchmark instances, together with their best-known results, are also included. Finally, the book reviews the latest applications of these problems in the fields of logistics, tourism and others.

We are very pleased to present this LNCS volume, the proceedings of the 8th InternationalConferenceonParallelProblemSolvingfromNature(PPSNVIII). PPSN is one of the most respected and highly regarded conference series in evolutionary computation and natural computing/computation. This biennial eventwas?rstheldinDortmundin1990,andtheninBrussels(1992),Jerusalem (1994), Berlin (1996), Amsterdam (1998), Paris (2000), and Granada (2002). PPSN VIII continues to be the conference of choice by researchers all over the world who value its high quality. We received a record 358 paper submissions this year. After an extensive peer review process involving more than 1100 reviews, the programme c- mittee selected the top 119 papers for inclusion in this volume and, of course, for presentation at the conference. This represents an acceptance rate of 33%. Please note that review reports with scores only but no textual comments were not considered in the chairs' ranking decisions. The papers included in this volume cover a wide range of topics, from e- lutionary computation to swarm intelligence and from bio- inspired computing to real-world applications. They represent some of the latest and best research in evolutionary and natural computation. Following the PPSN tradition, all - persatPPSNVIII werepresentedasposters.Therewere7 sessions:eachsession consisting of around 17 papers. For each session, we covered as wide a range of topics as possible so that participants with di?erent interests would ?nd some relevant papers at every session.

Computer Science and Operations Research continue to have a synergistic relationship and this book - as a part of the Operations Research

and Computer Science Interface Series - sits squarely in the center of the confluence of these two technical research communities. The research presented in the volume is evidence of the expanding frontiers of these two intersecting disciplines and provides researchers and practitioners with new work in the areas of logic programming, stochastic optimization, heuristic search and post-solution analysis for integer programs. The chapter topics span the spectrum of application level. Some of the chapters are highly applied and others represent work in which the application potential is only beginning. In addition, each chapter contains expository material and reviews of the literature designed to enhance the participation of the reader in this expanding interface.

This book considers large and challenging multistage decision problems, which can be solved in principle by dynamic programming (DP), but their exact solution is computationally intractable. We discuss solution methods that rely on approximations to produce suboptimal policies with adequate performance. These methods are collectively known by several essentially equivalent names: reinforcement learning, approximate dynamic programming, neuro-dynamic programming. They have been at the forefront of research for the last 25 years, and they underlie, among others, the recent impressive successes of self-learning in the context of games such as chess and Go. Our subject has benefited greatly from the interplay of ideas from optimal control and from artificial intelligence, as it relates to reinforcement learning and simulation-based neural network methods. One of the aims of the book is to explore the common boundary between these two fields and to form a bridge that is accessible by workers with background in either field. Another aim is to organize coherently the broad mosaic of methods that have proved successful in practice while having a solid theoretical and/or logical foundation. This may help researchers and practitioners to find their way through the maze of competing ideas that constitute the current state of the art. This book relates to several of our other books: Neuro-Dynamic Programming (Athena Scientific, 1996), Dynamic Programming and Optimal Control (4th edition, Athena Scientific, 2017), Abstract Dynamic Programming (2nd edition, Athena Scientific, 2018), and Nonlinear Programming (Athena Scientific, 2016). However, the mathematical style of this book is somewhat different. While we provide a rigorous, albeit short, mathematical account of the theory of finite and infinite horizon dynamic programming, and some fundamental approximation methods, we rely more on intuitive explanations and less on proof-based insights. Moreover, our mathematical requirements are quite modest: calculus, a minimal use of matrix-vector algebra, and elementary probability (mathematically complicated arguments involving laws of large numbers and stochastic convergence are bypassed in favor of intuitive explanations). The book illustrates the methodology with many examples and illustrations, and uses a gradual expository approach, which proceeds along four directions: (a) From exact DP to approximate DP: We first discuss exact DP algorithms, explain why they may be difficult to implement, and then use them as the basis for approximations. (b) From finite horizon to infinite horizon problems: We first discuss finite horizon exact and approximate DP methodologies, which are intuitive and mathematically simple, and then progress to infinite horizon problems. (c) From deterministic to stochastic models: We often discuss separately deterministic and stochastic problems, since deterministic problems are simpler and offer special advantages for some of our methods. (d) From model-based to model-free implementations: We first discuss model-based implementations, and then we identify schemes that can be appropriately modified to work with a simulator. The book is related and supplemented by the companion research monograph Rollout, Policy Iteration, and Distributed Reinforcement Learning (Athena Scientific, 2020), which focuses more closely on several topics related to rollout, approximate policy iteration, multiagent problems, discrete and Bayesian optimization, and distributed computation, which are either discussed in less detail or not covered at all in the present book. The author's website contains class notes, and a series of videolectures and slides from a 2021 course at ASU, which address a selection of topics from both books.

The classic vehicle routing problem considers the distribution of goods to geographically scattered customers from a central depot using a homogeneous fleet of vehicles with finite capacity. Each customer has a known demand and can be visited by exactly one vehicle. Each vehicle services the assigned customers in such a way that all customers are fully supplied and the total service does not exceed the vehicle capacity. In the split delivery vehicle routing problem, a customer can be visited by more than one vehicle, i.e., a customer demand can be split between various vehicles. Allowing split deliveries has been proven to potentially reduce the operational costs of the fleet. This study efficiently solves the split delivery vehicle routing problem using three new approaches. In the first approach, the problem is solved in two stages. During the first stage, an initial solution is found by means of a greedy approach that can produce high quality solutions comparable to those obtained with existing sophisticated approaches. The greedy approach is based on a novel concept called the route angle control measure that helps to produce spatially thin routes and avoids crossing routes. In the second stage, this constructive approach is extended to an iterative approach using adaptive memory concepts, and then a variable neighborhood descent process is added to improve the solution obtained. A new solution diversification scheme is presented in the second approach based on concentric rings centered at the depot that partitions the original problem. The resulting sub-problems are then solved using the greedy approach with route angle control measures. Different ring settings produce varied partitions and thus different solutions to the original problem are obtained and improved via a variable neighborhood descent. The third approach is a learning procedure based on a set or population of solutions. Those solutions are used to find attractive attributes and construct new solutions within a tabu search framework. As the search progresses, the existing population evolves, better solutions are included in it whereas bad solutions are removed from it. The initial set is constructed using the greedy approach with the route angle control measure whereas new solutions are created using an adaptation of the well known savings algorithm of Clarke and Wright (1964) and improved by means of an enhanced version of the variable neighborhood descent process. The proposed approaches are tested on benchmark instances and results are compared with existing implementations.

Smart Delivery Systems: Solving Complex Vehicle Routing Problems examines both exact and approximate methods for delivering optimal solutions to rich vehicle routing problems, showing both the advantages and disadvantages of each approach. It shows how to apply machine learning and advanced data analysis techniques to improve routing systems, familiarizing readers with the concepts and technologies used in successfully implemented delivery systems. The book explains both the latest theoretical and practical advances in intelligent delivery and scheduling systems and presents practical applications for designing new algorithms for real-life scenarios. Emphasizes both sequential and parallel algorithms Uniquely combines methods and algorithms, real-life applications, and parallel computing Includes recommendations on how to choose between different methods for solving applications Provides learning aids, end of chapter references, bibliography, worked examples and exercises

With application to subscription bus routing.

Comprehensively teaches the fundamentals of supply chain theory This book presents the methodology and foundations of supply chain management and also demonstrates how recent developments build upon classic models. The authors focus on strategic, tactical, and operational aspects of supply chain management and cover a broad range of topics from forecasting, inventory management, and facility location to transportation, process flexibility, and auctions. Key mathematical models for optimizing the design, operation, and evaluation of supply chains are presented as well as models currently emerging from the research frontier.

Fundamentals of Supply Chain Theory, Second Edition contains new chapters on transportation (traveling salesman and vehicle routing problems), integrated supply chain models, and applications of supply chain theory. New sections have also been added throughout, on topics including machine learning models for forecasting, conic optimization for facility location, a multi-supplier model for supply uncertainty, and a game-theoretic analysis of auctions. The second edition also contains case studies for each chapter that illustrate the real-world implementation of the models presented. This edition also contains nearly 200 new homework problems, over 60 new worked examples, and over 140 new illustrative figures. Plentiful teaching supplements are available, including an Instructor's Manual and PowerPoint slides, as well as MATLAB programming assignments that require students to code algorithms in an effort to provide a deeper understanding of the material. Ideal as a textbook for upper-undergraduate and graduate-level courses in supply chain management in engineering and business schools, Fundamentals of Supply Chain Theory, Second Edition will also appeal to anyone interested in quantitative approaches for studying supply chains.

This book presents recent work that analyzes general issues of green transportation. The contributed chapters consider environmental objectives in transportation, including topics such as battery swap stations for electric vehicles, efficient home healthcare routing, waste collection, and various vehicle routing problems. The content will be valuable for researchers and postgraduate students in computer science, operations research, and urban planning.

In the field of combinatorial optimization problems, the Vehicle Routing Problem (VRP) is one of the most challenging. Defined more than 40 years ago, the problem involves designing the optimal set of routes for fleets of vehicles for the purpose of serving a given set of customers. Interest in VRP is motivated by its practical relevance as well as its considerable difficulty. The Vehicle Routing Problem covers both exact and heuristic methods developed for the VRP and some of its main variants, emphasizing the practical issues common to VRP. The book is composed of three parts containing contributions from well-known experts. The first part covers basic VRP, known more commonly as capacitated VRP. The second part covers three main variants of VRP: with time windows, backhauls, and pickup and delivery. The third part covers issues arising in real-world VRP applications and includes both case studies and references to software packages.

This dissertation examines the Split Delivery Vehicle Routing Problem (SDVRP), a relaxed version of classical capacitated vehicle routing problem (CVRP) in which the demand of any client can be split among the vehicles that visit it. We study both scenarios of the SDVRP in this dissertation. For the SDVRP with a fixed number of the vehicles, we provide a Two-Stage algorithm. This approach is a cutting-plane based exact method called Two-Stage algorithm in which the SDVRP is decomposed into two stages of clustering and routing. At the first stage, an assignment problem is solved to obtain some clusters that cover all demand points and get the lower bound for the whole problem; at the second stage, the minimal travel distance of each cluster is calculated as a traditional Traveling Salesman Problem (TSP), and the upper bound is obtained. Adding the information obtained from the second stage as new cuts into the first stage, we solve the first one again. This procedure stops when there are no new cuts to be created from the second stage. Several valid inequalities have been developed for the first stage to increase the computational speed. A

valid inequality is developed to completely solve the problem caused by the index of vehicles. Another strong valid inequality is created to provide a valid distance lower bound for each set of demand points. This algorithm can significantly outperform other exact approaches for the SDVRP in the literature. If the number of the vehicles in the SDVRP is a variable, we present a column generation based branch and price algorithm. First, a restricted master problem (RMP) is presented, which is composed of a finite set of feasible routes. Solving the linear relaxation of the RMP, values of dual variables are thus obtained and passed to the sub-problem, the pricing problem, to generate a new column to enter the base of the RMP and solve the new RMP again. This procedure repeats until the objective function value of the pricing problem is greater than or equal to zero (for minimum problem). In order to get the integer feasible (optimal) solution, a branch and bound algorithm is then performed. Since after branching, it is not guaranteed that the possible favorable column will appear in the master problem. Therefore, the column generation is performed again in each node after branching. The computational results indicate this approach is promising in solving the SDVRP in which the number of the vehicles is not fixed.

The Vehicle Routing Problem: Latest Advances and New ChallengesSpringer Science & Business Media

This book is composed by the papers accepted for presentation and discussion at The 2019 International Conference on Information Technology & Systems (ICITS'20), held at the Universidad Distrital Francisco José de Caldas, in Bogotá, Colombia, on 5th to 7th February 2020. ICIST is a global forum for researchers and practitioners to present and discuss recent findings and innovations, current trends, professional experiences and challenges of modern information technology and systems research, together with their technological development and applications. The main topics covered are: information and knowledge management; organizational models and information systems; software and systems modelling; software systems, architectures, applications and tools; multimedia systems and applications; computer networks, mobility and pervasive systems; intelligent and decision support systems; big data analytics and applications; human–computer interaction; ethics, computers & security; health informatics; information technologies in education.

In a unified and carefully developed presentation, this book systematically examines recent developments in VRP. The book focuses on a portfolio of significant technical advances that have evolved over the past few years for modeling and solving vehicle routing problems and VRP variations. Reflecting the most recent scholarship, this book is written by one of the top research scholars in Vehicle Routing and is one of the most important books in VRP to be published in recent times.

Vehicle routing problems, among the most studied in combinatorial optimization, arise in many practical contexts (freight distribution and collection, transportation, garbage collection, newspaper delivery, etc.). Operations researchers have made significant developments in the algorithms for their solution, and÷Vehicle Routing: Problems, Methods, and Applications, Second Edition÷reflects these advances. The text of the new edition is either completely new or significantly revised and provides extensive and complete state-of-the-art coverage of vehicle routing by those who have done most of the innovative research in the area; it emphasizes methodology related to specific classes of vehicle routing problems and, since vehicle routing is used as a

benchmark for all new solution techniques, contains a complete overview of current solutions to combinatorial optimization problems. It also includes several chapters on important and emerging applications, such as disaster relief and green vehicle routing.÷

Arc Routing: Theory, Solutions and Applications is about arc traversal and the wide variety of arc routing problems, which has had its foundations in the modern graph theory work of Leonhard Euler. Arc routing methods and computation has become a fundamental optimization concept in operations research and has numerous applications in transportation, telecommunications, manufacturing, the Internet, and many other areas of modern life. The book draws from a variety of sources including the traveling salesman problem (TSP) and graph theory, which are used and studied by operations research, engineers, computer scientists, and mathematicians. In the last ten years or so, there has been extensive coverage of arc routing problems in the research literature, especially from a graph theory perspective; however, the field has not had the benefit of a uniform, systematic treatment. With this book, there is now a single volume that focuses on state-of-the-art exposition of arc routing problems, that explores its graph theoretical foundations, and that presents a number of solution methodologies in a variety of application settings. Moshe Dror has succeeded in working with an elite group of ARC routing scholars to develop the highest quality treatment of the current state-of-the-art in arc routing.

This book is dedicated to metaheuristics as applied to vehicle routing problems. Several implementations are given as illustrative examples, along with applications to several typical vehicle routing problems. As a first step, a general presentation intends to make the reader more familiar with the related field of logistics and combinatorial optimization. This preamble is completed with a description of significant heuristic methods classically used to provide feasible solutions quickly, and local improvement moves widely used to search for enhanced solutions. The overview of these fundamentals allows appreciating the core of the work devoted to an analysis of metaheuristic methods for vehicle routing problems. Those methods are exposed according to their feature of working either on a sequence of single solutions, or on a set of solutions, or even by hybridizing metaheuristic approaches with others kind of methods.

This dissertation examines the Split Delivery Vehicle Routing Problem (SDVRP), a relaxed version of classical capacitated vehicle routing problem (CVRP) in which the demand of any client can be split among the vehicles that visit it. We study both scenarios of the SDVRP in this dissertation. For the SDVRP with a fixed number of the vehicles, we provide a Two-Stage algorithm. This approach is a cutting-plane based exact method called Two-Stage algorithm in which the SDVRP is decomposed into two stages of clustering and routing. At the first stage, an assignment problem is solved to obtain some clusters that cover all demand points and get the lower bound for the whole problem; at the second stage, the minimal travel distance of each cluster is calculated as a traditional Traveling Salesman Problem (TSP), and the upper bound is obtained. Adding the information obtained from the second stage as new cuts into the first stage, we solve the first one again. This procedure stops when there are no new cuts to be created from the second stage. Several valid inequalities have been developed for the first stage to increase the computational speed. A

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Ten years after coming into force of the Stockholm Convention on Persistent Organic Pollutants (POPs), a wide range of organic chemicals (industrial formulations, plant protection products, pharmaceuticals and personal care products, etc.) still poses the highest priority environmental hazard. The broadening of knowledge of organic pollutants (OPs) environmental fate and effects, as well as the decontamination techniques, is accompanied by an increase in significance of certain pollution sources (e.g. sewage sludge and dredged sediments application, textile industry), associated with a potential generation of new dangers for humans and natural ecosystems. The present book addresses these aspects, especially in the light of Organic Pollutants risk assessment as well as the practical application of novel analytical methods and techniques for removing OPs from the environment. Providing analytical and environmental update, this contribution can be particularly valuable for engineers and environmental scientists.

This book discusses all the major nature-inspired algorithms with a focus on their application in the context of solving navigation and routing problems. It also reviews the approximation methods and recent nature-inspired approaches for practical navigation, and compares these methods with traditional algorithms to validate the approach for the case studies discussed. Further, it examines the design of alternative solutions using nature-inspired techniques, and explores the challenges of navigation and routing problems and nature-inspired metaheuristic approaches.

TEODOR GABRIEL CRAINIC, DIRECTOR The Centre for Research on Transportation (C.R.T.) was founded in 1971 by the Universite de Montreal. From 1988 on, it is jointly managed by the Universite de Montreal and its affiliated schools, the Ecole des Hautes Etudes Commerciales and Ecole Poly technique. Professors, students and researchers from many institutions in the Montreal area join forces at the C.R.T. to analyze transportation, logistics and telecommunication systems from a multidisciplinary perspective. The C.R.T. pursues three major, complementary objectives: training of high-level specialists; the advancement of knowledge and technology; the transfer of technology towards industry and the public sector. Its main field of expertise is the develop ment of quantitative and computer-based models and methods for the analysis of urban, regional and intercity transportation networks, as well as telecommunication systems. This applies to the study of passenger and commodity flows, as well as to the socioeconomic aspects of transportation: policy, regulation, economics. The twenty-fifth anniversary of the C.R.T. offered the opportunity to evaluate past accomplishments and to identify future trends and challenges. Five colloquia were thus organized on major research and application themes that also reflected our main research areas. They gathered together

internationally renowned researchers who linked recent scientific and technological advances to modeling and methodological challenges waiting to be tackled, particularly concerning new problems and applica tions, and the increasingly widespread use of new technologies.

The symposium Operations Research 2007 was held from September 5-7, 2007 at the Saarland University in Saarbru ?cken. This international conference is at the same time the annual meeting of the German - erations Research Society (GOR). The transition in Germany (and many other countries in Europe) from a production orientation to a service society combined with a continuous demographic change generated a need for intensi?ed Op- ations Research activities in this area. On that account this conference has been devoted to the role of Operations Research in the service industry. The links to Operations Research are manifold and include many di?erent topics which are particularly emphasized in scienti?c sections of OR 2007. More than 420 participants from 30 countries made this event very international and successful. The program consisted of three p- nary,elevensemi-plenaryandmorethan300contributedpresentations, which had been organized in 18 sections. During the conference, the GOR Dissertation and Diploma Prizes were awarded. We congratulate all winners, especially Professor Wolfgang Domschke from the Da- stadt University of Technology, on receiving the GOR Scienti?c Prize Award.

Masterarbeit aus dem Jahr 2011 im Fachbereich BWL - Beschaffung, Produktion, Logistik, Note: Sehr gut, Karl-Franzens-Universitat Graz (Produktion und Logistik), Sprache: Deutsch, Abstract: Der Hauptbestandteil dieser Arbeit ist das Testen verschiedener lokaler Suchoperatoren fur eine Erweiterung des gutbekannten Vehicle Routing Problems. Diese erst vor kurzem eingefuhrte Erweiterung wurde notwendig um ein Routenplanungsproblem zu losen, das daraus bestand, Getranke und Tabakwaren in dichtbesiedelten Groystadten in Brasilien auszuliefern. Es wurde nun versucht herauszunden, welche der VRPTW Operatoren geeignet sind, um das Vehicle Routing Problem with Time Windows and Multiple Deliverymen (VRPTWMD) moglichst gut zu losen. Insgesamt wurden vier Operatoren implementiert, wobei Relocate und Ejection Chains auf die Routenminimierung abzielen und Cross bzw. 2-opt entsprechend die gefahrene Distanz verringern sollten. Um die Operatoren zu testen, wurden die benotigten Startlosungen mit der von Solomon entwickelten I1 Einfugeheuristik generiert. Die Erkenntnisse aus den Tests wurden schieylich dazu verwendet, eine best performance Variante zu entwickeln, welche anhand der Solomon Instanzen R101 bis R112 getestet wurde. Die Ergebnisse der Tests benden sich am Ende der Arbeit. The Vehicle Routing Problem with time windows is a well studied problem in literature. The extension to Vehicle Routing Problem with Time Windows and Multiple Deliverymen (VRPTWMD) has been proposed to solve a delivery problem of commodities, like beverages and tobacco in highly populated areas in Brazil. This rather new problem structure in the VRPTW context, is the main subject of the work. In this thesis, the aim is to nd out, which operators used for VRP are most suitable for the VRPTWMS. Relocate and Ejection Chain operators were tested for truck and deliverymen reduction, Cross and 2-opt were implemented to reduce distance. The Solomon I1 insertion heuristic was used to obtain starting solutions,

Increasing customer needs, the globalization of markets and the evolution of e-commerce add to the complexity of logistic

processes. In today's business, it is well understood that an effective management of logistic processes is impossible without the use of computer-based tools and quantitative methods. This book presents in a systematic way quantitative approaches to distribution logistics and supply chain management. The main orientation of the book is towards practical problem solving, and numerous case studies and practical applications are presented. The topics covered include: supply chain management, revers logistics, e-commerce, facility location and network planning, vehicle routing, warehousing, inventory control.

In a context of global competition, the optimization of logistics systems is inescapable. Logistics Systems: Design and Optimization falls within this perspective and presents twelve chapters that well illustrate the variety and the complexity of logistics activities. Each chapter is written by recognized researchers who have been commissioned to survey a specific topic or emerging area of logistics. The first chapter, by Riopel, Langevin, and Campbell, develops a framework for the entire book. It classifies logistics decisions and highlights the relevant linkages to logistics decisions. The intricacy of these linkages demonstrates how thoroughly the decisions are interrelated and underscores the complexity of managing logistics activities. Each of the chapters focus on quantitative methods for the design and optimization of logistics systems.

Solving Transport Problems establishes fundamental points and good practice in resolving matters regarding green transportation. This is to prompt further research in conveyance issues by providing readers with new knowledge and grounds for integrated models and solution methods. Focusing on green transportation, this book covers various sub-topics and thus consists of diverse content. Traditionally, academia and transport practitioners have mainly concentrated on efficient fleet management to achieve economic benefits and better-quality service. More recently, due to growing public environmental concerns and the industry understanding of the issue, the academic community has started to address environmental issues. The studies of green transportation compiled in this book have identified certain areas of interest, such as references, viewpoints, algorithms and ideas. Solving Transport Problems is for researchers, environmental decision-makers and other concerned parties, to start discussion on developing optimized technology and alternative fuel-based integrated models for environmentally cleaner transport systems.

This book gathers a selection of peer-reviewed papers presented at the International Conference on Operations Research (OR 2018), which was held at the Free University of Brussels, Belgium on September 12 - 14, 2018, and was jointly organized by the German Operations Research Society (GOR) and the Belgian Operational Research Society (ORBEL). 575 scientists, practitioners and students from mathematics, computer science, business/economics and related fields attended the conference and presented more than 400 papers in parallel topic streams, as well as special award sessions. The respective papers discuss classical mathematical optimization, statistics and simulation techniques. These are complemented by computer science methods, and by tools for processing data, designing and implementing information systems. The book also examines recent advances in information technology, which allow big data volumes to be processed and enable real-time predictive and prescriptive business analytics to drive decisions and actions. Lastly, it includes problems modeled and treated while taking into account uncertainty, risk management, behavioral issues, etc.

Column Generation is an insightful overview of the state of the art in integer programming column generation and its many applications. The volume begins with "A Primer in Column Generation" which outlines the theory and ideas necessary to solve large-scale practical problems, illustrated with a variety of examples. Other chapters follow this introduction on "Shortest Path Problems with Resource Constraints," "Vehicle Routing Problem with Time Window," "Branch-and-Price Heuristics," "Cutting Stock Problems," each dealing with methodological aspects of the field. Three chapters deal with transportation applications: "Large-scale Models in the Airline Industry," "Robust Inventory Ship Routing by Column Generation," and "Ship Scheduling with Recurring Visits and Visit Separation Requirements." Production is the focus of another three chapters: "Combining Column Generation and Lagrangian Relaxation," "Dantzig-Wolfe Decomposition for Job Shop Scheduling," and "Applying Column Generation to Machine Scheduling." The final chapter by François Vanderbeck, "Implementing Mixed Integer Column Generation," reviews how to set-up the Dantzig-Wolfe reformulation, adapt standard MIP techniques to the column generation context (branching, preprocessing, primal heuristics), and deal with specific column generation issues (initialization, stabilization, column management strategies).
The vehicle routing problem (VRP) is one of the most famous combinatorial optimization problems. In simple terms, the goal is to determine a set of routes with overall minimum cost that can satisfy several geographical scattered - mands. A ?eet of vehicles located in one or more depots is available to ful?ll the requests. A large number of variants exist, adding di?erent constraints to the original de?nition. Some examples are related to the number of depots, the ordering for visiting the customers or to time windows specifying a desirable period to arrive to a given location. The original version of this problem was proposed by Dantzig and Ramser in 1959 [1]. In their seminal paper, the authors address the calculation of a set of optimal routes for a ?eet of gasoline delivery trucks. Since then, the VRP has attractedtheattentionofalargenumberofresearchers.Aconsiderablepartofits success is a consequence of its practical interest, as it resembles many real-world problems faced everyday by distribution and transportation companies, just to mention a few applications areas. In this context, the development of e?cient optimization techniques is crucial. They are able to provide new and enhanced solutionstologisticoperations,andmaythereforeleadtoasubstantialreduction in costs for companies. Additionally, and from a research oriented perspective, the VRP is a challenging NP-hard problem providing excellent benchmarks to access the e?ciency of new global optimization algorithms.
This book describes the main classical combinatorial problems that can be encountered when designing a logistics network or driving a supply chain. It shows how these problems can be tackled by metaheuristics, both separately and using an integrated approach. A huge number of techniques, from the simplest to the most advanced ones, are given for helping the reader to implement efficient solutions that meet its needs. A lot of books have been written about

metaheuristics (methods for solving hard optimization problems) and supply chain management (the field in which we find a huge number of combinatorial optimization problems) in the last decades. So, the main reason of this book is to describe how these methods can be implemented for this class of problems.

Vehicle routing problems, among the most studied in combinatorial optimization, arise in many practical contexts (freight distribution and collection, transportation, garbage collection, newspaper delivery, etc.). Operations researchers have made significant developments in the algorithms for their solution, and Vehicle Routing: Problems, Methods, and Applications, Second Edition reflects these advances. The text of the new edition is either completely new or significantly revised and provides extensive and complete state-of-the-art coverage of vehicle routing by those who have done most of the innovative research in the area; it emphasizes methodology related to specific classes of vehicle routing problems and, since vehicle routing is used as a benchmark for all new solution techniques, contains a complete overview of current solutions to combinatorial optimization problems. It also includes several chapters on important and emerging applications, such as disaster relief and green vehicle routing.