Metaheuristics: Computer Decision-Making

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Metaheuristics: Computer Decision-Making

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Preface

Combinatorial optimization is the process of finding the best, or optimal, solution for problems with a discrete set of feasible solutions. Applications arise in numerous settings involving operations management and logistics, such as routing, scheduling, packing, inventory and production management, location, logic, and assignment of resources. The economic impact of combinatorial optimization is profound, affecting sectors as diverse as transportation (airlines, trucking, rail, and shipping), forestry, manufacturing, logistics, aerospace, energy (electrical power, petroleum, and natural gas), telecommunications, biotechnology, financial services, and agriculture.

While much progress has been made in finding exact (provably optimal) solutions to some combinatorial optimization problems, using techniques such as dynamic programming, cutting planes, and branch and cut methods, many hard combinatorial problems are still not solved exactly and require good heuristic methods. Moreover, reaching "optimal solutions" is in many cases meaningless, as in practice we are often dealing with models that are rough simplifications of reality. The aim of heuristic methods for combinatorial optimization is to quickly produce good-quality solutions, without necessarily providing any guarantee of solution quality. Metaheuristics are high level procedures that coordinate simple heuristics, such as local search, to find solutions that are of better quality than those found by the simple heuristics alone. Modern metaheuristics include simulated annealing, genetic algorithms, tabu search, GRASP, scatter search, ant colony optimization, variable neighborhood search, and their hybrids. In many practical problems they have proved to be effective and efficient approaches, being flexible to accommodate variations in problem structure and in the objectives considered for the evaluation of solutions. For all these reasons, metaheuristics have probably been one of the most stimulating research topics in optimization for the last two decades.

Metaheuristics: Computer Decision-Making grew out of the *4th Metaheuristics International Conference* (MIC2001), held in Porto, Portugal, on July 16–20, 2001, and chaired by Jorge Pinho de Sousa. Kluwer Academic Publishers published three books developed from previous editions of the Metaheuristic In-

ternational Conference (MIC'95 [1] held in Breckenridge, United States, in 1995; MIC'97 [2] held in Sophia-Antipolis, France, in 1997; and MIC'99 [3] held in Angra dos Reis, Brazil, in 1999). Though this book is not a conference proceedings, it does characterize the type of research presented at MIC2001.

Metaheuristics: Computer Decision-Making exemplifies how much the field has matured in the last few years. The volume has 33 papers, covering a broad range of metaheuristics and related topics, as well as applications. Metaheuristics and related topics include:

- genetic algorithms: Chapters 6, 9, 10, 13, 14, 17, 20, 21, and 24;
- tabu search: Chapters 15, 18, 27, 28, and 31;
- greedy randomized adaptive search procedures (GRASP): Chapters 26, 28, 30, and 31;
- local search: Chapters 19, 25, 27, and 32;
- path-relinking: Chapters 1, 28, and 30;
- ant colony systems: Chapters 5, 22, and 33;
- memetic algorithms: Chapters 4 and 29;
- variable neighborhood search: Chapters 7 and 23;
- simulated annealing: Chapters 16 and 21;
- neural networks: Chapters 8 and 20;
- population reinforcement optimization based exploration (PROBE): Chapter 2;
- Lagrangian heuristics: Chapter 3;
- scatter search: Chapter 13; and
- constraint programming: Chapter 25.

Applications and problems types include:

- assignment and partitioning problems:
  - generalized assignment: Chapter 1,
  - quadratic assignment: Chapter 12,
  - linear assignment: Chapter 22,

[1] I.H. Osman and J.P. Kelly (eds.), *Meta-heuristics: Theory and Applications*, Kluwer, 1996.
[2] S. Voss, S. Martello, I.H. Osman, and C. Roucairol (eds.), *Meta-heuristics: Advances and Trends in Local Search Paradigms for Optimization*, Kluwer, 1999.
[3] C.C. Ribeiro and P. Hansen (eds.), *Essays and Surveys in Metaheuristics*, Kluwer, 2002.

  - number partitioning: Chapter 4,
  - multi-constraint knapsack: Chapter 2, and
  - linear ordering: Chapter 3;
- scheduling:
  - nurse rostering: Chapter 7,
  - school timetabling: Chapters 8 and 31,
  - discrete-continuous scheduling: Chapter 18, and
  - discrete-lot sizing and scheduling: Chapter 27;
- tree and graph problems:
  - Steiner problem in graphs: Chapter 28,
  - communication network design: Chapter 29,
  - capacitated minimum spanning tree: Chapter 30,
  - k-cardinality tree: Chapter 23,
  - graph drawing: Chapter 19, and
  - graph coloring: Chapter 15;
- statistics:
  - least squares estimation: Chapter 6, and
  - generalized vector-valued regression: Chapter 20;
- cutting problems:
  - strip packing with guillotine patterns: Chapter 24, and
  - cutting stock: Chapter 32;
- mathematical programming:
  - multiobjective optimization: Chapter 10,
  - integer programming: Chapter 26, and
  - minimax problem: Chapter 17;
- vehicle routing: Chapters 5 and 33;
- single source capacitated location: Chapter 9;
- industrial applications:
  - power systems: Chapter 21,
  - petroleum reservoir optimization: Chapter 13, and
  - classification from biological databases: Chapter 16; and

- heuristic search software framework: Chapter 11.

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Florham Park and Porto, April 2003

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To our children:

Alec, Sasha, Pedro, and Mariana.