

Table of Contents

Preface	xiii
Chapter 1. Airline Crew Pairing Optimization	1
Laurent ALFANDARI and Anass NAGIH	
1.1. Introduction.	1
1.2. Definition of the problem	2
1.2.1. Constructing subnetworks.	2
1.2.2. Pairing costs	4
1.2.3. Model.	4
1.2.4. Case without resource constraints	5
1.3. Solution approaches.	7
1.3.1. Decomposition principles	7
1.3.2. Column generation, master problem and subproblem	8
1.3.3. Branching methods for finding integer solutions	10
1.4. Solving the subproblem for column generation.	11
1.4.1. Mathematical formulation.	11
1.4.2. General principle of effective label generation	11
1.4.3. Case of one single resource: the bucket method	13
1.4.4. Case of many resources: reduction of the resource space	16
1.5. Conclusion	21
1.6. Bibliography	22
Chapter 2. The Task Allocation Problem	23
Moaiz BEN DHAOU and Didier FAYARD	
2.1. Presentation.	24
2.2. Definitions and modeling.	24
2.2.1. Definitions	24
2.2.2. The processors	25

2.2.3. Communications	25
2.2.4. Tasks	26
2.2.5. Allocation types	26
2.2.6. Allocation/scheduling	27
2.2.7. Modeling	28
2.3. Review of the main works	29
2.3.1. Polynomial cases	30
2.3.2. Approximability	33
2.3.3. Approximate solution	34
2.3.4. Exact solution	35
2.3.5. Independent tasks case	36
2.4. A little-studied model	38
2.4.1. Model	38
2.4.2. A heuristic based on graphs	39
2.5. Conclusion	43
2.6. Bibliography	43
Chapter 3. A Comparison of Some Valid Inequality Generation Methods for General 0–1 Problems	49
Pierre BONAMI and Michel MINOUX	
3.1. Introduction	49
3.2. Presentation of the various techniques tested	53
3.2.1. Exact separation with respect to a mixed relaxation	53
3.2.2. Approximate separation using a heuristic	55
3.2.3. Restriction + separation + relaxed lifting (RSRL)	55
3.2.4. Disjunctive programming and the <i>lift and project</i> procedure	59
3.2.5. Reformulation–linearization technique (RLT)	63
3.3. Computational results	67
3.3.1. Presentation of test problems	67
3.3.2. Presentation of the results	67
3.3.3. Discussion of the computational results	68
3.4. Bibliography	70
Chapter 4. Production Planning	73
Nadia BRAUNER, Gerd FINKE and Maurice QUEYRANNE	
4.1. Introduction	73
4.2. Hierarchical planning	74
4.3. Strategic planning and productive system design	75
4.3.1. Group technology	75
4.3.2. Locating equipment	77
4.4. Tactical planning and inventory management	77
4.4.1. A linear programming model for medium-term planning	78

4.4.2. Inventory management.	79
4.4.3. Wagner and Whitin model	80
4.4.4. The economic order quantity model (EOQ)	83
4.4.5. The EOQ model with joint replenishments.	88
4.5. Operations planning and scheduling	90
4.5.1. Tooling	91
4.5.2. Robotic cells.	97
4.6. Conclusion and perspectives.	104
4.7. Bibliography	105
Chapter 5. Operations Research and Goods Transportation	111
Teodor Gabriel CRAINIC and Frédéric SEMET	
5.1. Introduction.	111
5.2. Goods transport systems	113
5.3. Systems design.	115
5.3.1. Location with balancing requirements	115
5.3.2. Multiproduct production–distribution	118
5.3.3. <i>Hub</i> location.	119
5.4. Long-distance transport.	122
5.4.1. Service network design	122
5.4.2. Static formulations	123
5.4.3. Dynamic formulations	130
5.4.4. Fleet management	131
5.5. Vehicle routing problems	137
5.5.1. Definitions and complexity	138
5.5.2. Classical extensions	138
5.6. Exact models and methods for the VRP	139
5.6.1. Flow model with three indices	140
5.6.2. Flow model for the symmetric CVRP.	141
5.6.3. Set partitioning model	142
5.6.4. Branch-and-cut methods for the CVRP.	143
5.6.5. Column generation methods for the VRPTW	146
5.7. Heuristic methods for the VRP	147
5.7.1. Classical heuristics	147
5.7.2. Metaheuristics.	152
5.7.3. The VRP in practice	159
5.8. Conclusion	160
5.9. Appendix: metaheuristics	161
5.9.1. Tabu search	161
5.9.2. Evolutionary algorithms.	162
5.10. Bibliography	164

Chapter 6. Optimization Models for Transportation Systems Planning . . .	177
Teodor Gabriel CRAINIC and Michael FLORIAN	
6.1. Introduction.	177
6.2. Spatial interaction models	178
6.3. Traffic assignment models and methods.	181
6.3.1. System optimization and user optimization models.	182
6.3.2. Algorithms for traffic assignment for the user optimization model.	184
6.3.3. The user problem as variational inequality	189
6.4. Transit route choice models	193
6.5. Strategic planning of multimodal systems.	197
6.5.1. Demand.	199
6.5.2. Mode choice	200
6.5.3. Representing transport supply and assigning demand	200
6.6. Conclusion	204
6.7. Bibliography	204
Chapter 7. A Model for the Design of a Minimum-cost Telecommunications Network	209
Marc DEMANGE, Cécile MURAT, Vangelis Th. PASCHOS and Sophie TOULOUSE	
7.1. Introduction.	209
7.2. Minimum cost network construction	210
7.2.1. The difficulties of solving jointly or globally	210
7.2.2. Why tackle the global problem?	212
7.2.3. How to circumvent these difficulties	212
7.3. Mathematical model, general context	213
7.3.1. Hypotheses.	213
7.3.2. The original problem.	214
7.3.3. Solution principle	214
7.4. Proposed algorithm	216
7.4.1. A bit of sensitivity in an NP-hard world	217
7.4.2. The initial solution	217
7.4.3. Step-by-step exploration.	217
7.5. Critical points	220
7.5.1. Parametric difficulties	220
7.5.2. Realities not taken into account	221
7.5.3. Complexity in size of the problem	221
7.6. Conclusion	223
7.7. Bibliography	223

Chapter 8. Parallel Combinatorial Optimization	225
Van-Dat CUNG, Bertrand LE CUN and Catherine ROUCAIROL	
8.1. Impact of parallelism in combinatorial optimization.	225
8.2. Parallel metaheuristics	226
8.2.1. Notion of walks	227
8.2.2. Classification of parallel metaheuristics	228
8.2.3. An illustrative example: scatter search for the quadratic assignment or QAP	230
8.3. Parallelizing tree exploration in exact methods	235
8.3.1. Return to two <i>success stories</i>	235
8.3.2. B&X model and data structures	237
8.3.3. Different levels of parallelism	238
8.3.4. Critical tree and anomalies	239
8.3.5. Parallel algorithms and granularity	240
8.3.6. The BOB++ library.	241
8.3.7. B&X on grids of machines	243
8.4. Conclusion	247
8.5. Bibliography	248
 Chapter 9. Network Design Problems: Fundamental Methods	 253
Alain Quilliot	
9.1. Introduction.	253
9.2. The main mathematical and algorithmic tools for network design	258
9.2.1. Decomposition in linear programming and polyhedra	258
9.2.2. Flows and multiflows	265
9.2.3. Queuing network	272
9.2.4. Game theory models	273
9.3. Models and problems	275
9.3.1. Location problems	275
9.3.2. Steiner trees and variants	275
9.4. The STEINER-EXTENDED problem	280
9.5. Conclusion	281
9.6 Bibliography	281
 Chapter 10. Network Design Problems: Models and Applications	 291
Alain Quilliot	
10.1. Introduction	291
10.2. Models and location problems	293

10.2.1. Locating the network access device	294
10.2.2. Locating machines and activities at the core of a production space	296
10.3. Routing models for telecommunications	298
10.3.1. Numerical tests	299
10.4. The design or dimensioning problem in telecommunications.	301
10.4.1. Numerical tests	302
10.5. Coupled flows and multiflows for transport and production	306
10.5.1. Analysis of the COUPLED-FLOW-MULTIFLOW (CFM) problem	310
10.6. A mixed network pricing model	314
10.7. Conclusion	319
10.8. Bibliography	319
Chapter 11. Multicriteria Task Allocation to Heterogenous Processors with Capacity and Mutual Exclusion Constraints.	327
Bernard ROY and Roman SLOWINSKI	
11.1. Introduction and formulation of the problem	328
11.1.1. Example a: organizing non-compulsory lesson choices by students	329
11.1.2. Example b: temporal activity programming	330
11.1.3. Example c: task scheduling on machines	330
11.2. Modeling the set of feasible assignments	331
11.3. The concept of a blocking configuration and analysis of the unblocking means	334
11.3.1. A reminder of a few results from flow theory	334
11.3.2. Analysis of the minimum cut revealed by labeling a maximum flow on N	334
11.3.3. The concept of blocking configuration	336
11.3.4. Unblocking actions	341
11.4. The multicriteria assignment problem	346
11.4.1. Definition of the criteria family	346
11.4.2. Satisfactory compromise selection strategy.	347
11.5. Exploring a set of feasible non-dominated assignments in the plane $g_2 \times g_3$	348
11.5.1. The bicriteria assignment problem with mutual exclusion constraints.	348
11.5.2. Finding supported solutions of problem P	351
11.5.3. Matrix representation of problem P	352
11.5.4. Finding unsupported solutions of problem P	353

11.6. Numerical example	357
11.6.1. Example with a blocking configuration present	357
11.6.2. Example without a blocking configuration	360
11.7. Conclusion	363
11.8. Bibliography	364
General Bibliography	365
List of Authors	401
Index	405
Summary of Other Volumes in the Series	409