Contents

Preface 15

Chapter 1. The Complexity of Single Machine Scheduling Problems under Scenario-based Uncertainty 23
Mohamed Ali ALOULOU and Federico DELLA CROCE

1.1. Introduction 23
1.2. Problem *MinMax*(1|*prec*|$f_{\max}$, θ) 25
1.2.1. Uncertainty on due dates 25
1.2.2. Uncertainty on processing times and due dates 27
1.3. Problem *MinMax*(1||$\sum w_j C_j, w_j$) 28
1.4. Problem *MinMax*(1||$\sum U_j, \theta$) 29
1.4.1. Uncertainty on due dates 29
1.4.2. Uncertainty on processing times 29
1.5. Bibliography 35

Chapter 2. Approximation of Multi-criteria Min and Max *TSP*(1, 2) 37
Eric ANGEL, Evripidis BAMPIS, Laurent GOURVÈS and Jérôme MONNOT

2.1. Introduction 37
2.1.1. The traveling salesman problem 37
2.1.2. Multi-criteria optimization 38
2.1.3. Organization of the chapter 39
2.2. Overview 39
2.3. The bicriteria *TSP*(1, 2) 40
2.3.1. Simple examples of the non-approximability 42
2.3.2. A local search heuristic for the bicriteria *TSP*(1, 2) 43
2.3.3. A nearest neighbor heuristic for the bicriteria *TSP*(1, 2) 48
2.3.4. On the bicriteria Max *TSP*(1, 2) 52

2.4. *k*-criteria *TSP*(1, 2) 55
2.4.1. Non-approximability related to the number of generated solutions 56
2.4.2. A nearest neighbor heuristic for the *k*-criteria *TSP*(1, 2) 60
2.5. Conclusion 67
2.6. Bibliography 68

Chapter 3. Online Models for Set-covering: The Flaw of Greediness 71
Giorgio AUSIELLO, Aristotelis GIANNAKOS and Vangelis Th. PASCHOS

3.1. Introduction 71
3.2. Description of the main results and related work 73
3.3. The price of ignorance 76
3.4. Competitiveness of `TAKE-ALL` and `TAKE-AT-RANDOM` 77
3.4.1. `TAKE-ALL` algorithm 77
3.4.2. `TAKE-AT-RANDOM` algorithm 78
3.5. The nasty flaw of greediness 79
3.6. The power of look-ahead 82
3.7. The maximum budget saving problem 88
3.8. Discussion 91
3.9. Bibliography 91

Chapter 4. Comparison of Expressiveness for Timed Automata and Time Petri Nets 93
Béatrice BÉRARD, Franck CASSEZ, Serge HADDAD, Didier LIME and Olivier-Henri ROUX

4.1. Introduction 93
4.2. Time Petri nets and timed automata 95
4.2.1. Timed transition systems and equivalence relations 96
4.2.2. Time Petri nets 98
4.2.3. Timed automata 101
4.2.4. Expressiveness and equivalence problems 103
4.3. Comparison of semantics *I*, *A* and *PA* 104
4.3.1. A first comparison between the different semantics of TPNs 104
4.3.2. A second comparison for standard bounded TPN 107
4.4. Strict ordering results 111
4.5. Equivalence with respect to timed language acceptance 113
4.5.1. Encoding atomic constraints 113
4.5.2. Resetting clocks 115
4.5.3. The complete construction 116
4.5.4. $\Delta(\mathcal{A})$ and $\mathcal{A}$ accept the same timed language 117
4.5.5. Consequences of the previous results 121

4.6. Bisimulation of TA by TPNs 122
4.6.1. Regions of a timed automaton 122
4.6.2. From bisimulation to uniform bisimulation 124
4.6.3. A characterization of bisimilarity 128
4.6.4. Proof of necessity 129
4.6.5. First construction 131
4.6.6. Second construction 137
4.6.7. Complexity results 141
4.7. Conclusion 142
4.8. Bibliography 143

Chapter 5. A "Maximum Node Clustering" Problem 145
Giuliana CARELLO, Federico DELLA CROCE, Andrea GROSSO and Marco LOCATELLI

5.1. Introduction 149
5.2. Approximation algorithm for the general problem 147
5.3. The tree case 150
5.3.1. Dynamic programming 150
5.3.2. A fully polynomial time approximation scheme 155
5.4. Exponential algorithms for special cases 156
5.5. Bibliography 159

Chapter 6. The Patrolling Problem: Theoretical and Experimental Results .. 161
Yann CHEVALEYRE

6.1. Introduction 161
6.2. The patrolling task 162
6.3. Previous work 164
6.4. The cyclic strategies 165
6.4.1. Patrolling with a single-agent 165
6.4.2. Extending to multi-agent case 167
6.4.3. Optimality of cyclic strategies 168
6.5. Partition-based strategies 169
6.6. Experiments 171
6.7. Conclusion 172
6.8. Bibliography 174

Chapter 7. Restricted Classes of Utility Functions for Simple Negotiation Schemes: Sufficiency, Necessity and Maximality 175
Yann CHEVALEYRE, Ulle ENDRISS and Nicolas MAUDET

7.1. Introduction 175
7.2. Myopic negotiation over indivisible resources 177
7.2.1. Negotiation problems and deals 178

7.2.2. Negotiating with money 179
7.2.3. Negotiating without money 180
7.3. Convergence for restricted classes of utility functions 180
7.4. Modular utility functions and variants 182
7.5. Sufficient classes of utility functions 184
7.5.1. Framework with money 184
7.5.2. Framework without money 185
7.6. Necessity issues 185
7.6.1. Modularity is not necessary 186
7.6.2. There is no sufficient and necessary class 186
7.6.3. Evaluating conditions on profiles of utility functions is intractable 187
7.7. Maximal classes of utility functions 191
7.7.1. Framework with money 192
7.7.2. Framework without money 196
7.8. Conclusion 198
7.9. Bibliography 199

Chapter 8. Worst-case Complexity of Exact Algorithms for NP-hard Problems 203
Federico DELLA CROCE, Bruno ESCOFFIER, Marcin KAMIŃSKI and Vangelis Th. PASCHOS

8.1. MAX-CUT 204
8.1.1. Extending a partial partition of vertices 206
8.1.2. An algorithm for graphs with bounded maximum degree 209
8.1.3. An algorithm for general graphs 210
8.2. Pruning the search tree by dominance conditions: the case of MAXCUT-3 211
8.2.1. Dominance conditions 212
8.2.2. The worst-case upper-time bound for MAX-CUT-3 214
8.3. A more careful analysis for pruning: the case of MIN 3-DOMINATING SET 226
8.3.1. Analysis 227
8.3.2. Counting 228
8.3.3. Case n°1 228
8.3.4. Case n°2 232
8.3.5. Case n°3 234
8.3.6. Complexity analysis 237
8.4. Bibliography 239

Chapter 9. The Online Track Assignment Problem 241
Marc DEMANGE, Gabriele DI STEFANO and Benjamin LEROY-BEAULIEU

9.1. Introduction 241
9.1.1. Related works 242
9.1.2. Results 243
9.2. Definitions and notations 243
9.3. Bounds for the permutation graph in a left-to-right model 245
9.4. Bounds for overlap graphs 249
9.5. Bounds for permutation graphs in a more general model 252
9.6. Conclusion 256
9.7. Bibliography 256

Chapter 10. Complexity and Approximation Results for the Min Weighted Node Coloring Problem 259
Marc DEMANGE, Bruno ESCOFFIER, Jérôme MONNOT, Vangelis Th. PASCHOS and Dominique DE WERRA

10.1. Introduction 259
10.2. General results 262
10.2.1. Structural properties 262
10.2.2. Approximation results 264
10.2.2.1. General graphs 264
10.2.2.2. k-colorable graphs 266
10.2.2.3. When list coloring is easy 268
10.3. Weighted node coloring in triangle-free planar graphs 270
10.4. Weighted node coloring in bipartite graphs 273
10.4.1. Hardness results 273
10.4.2. P_5-free bipartite graphs 278
10.5. Split graphs 280
10.5.1. Complexity result 280
10.5.2. Approximation result 281
10.6. Cographs 284
10.7. Interval graphs 285
10.8. Bibliography 286

Chapter 11. Weighted Edge Coloring 291
Marc DEMANGE, Bruno ESCOFFIER, Giorgio LUCARELLI, Ioannis MILIS, Jérôme MONNOT, Vangelis Th. PASCHOS and Dominique DE WERRA

11.1. Introduction 291
11.2. Related problems 293
11.3. Preliminaries and notation 294
11.4. Complexity and (in) approximability 295

11.5. Graphs of $\Delta = 2$ 296
11.6. A 2-approximation algorithm for general graphs 298
11.7. Bipartite graphs 299
11.7.1. A $\frac{2\Delta-1}{3}$-approximation algorithm 299
11.7.2. A $\frac{7}{6}$-approximation algorithm for $\Delta = 3$ 301
11.7.3. An approximation algorithm for $\Delta \leq 7$ 307
11.8. Trees 310
11.8.1. Feasible *k*-Coloring and bounded degree trees 310
11.8.2. Stars of chains 312
11.9. Conclusions 315
11.10. Bibliography 315

Chapter 12. An Extensive Comparison of 0-1 Linear Programs for the Daily Satellite Mission Planning 319
Virginie GABREL

12.1. Introduction 319
12.2. Different formulations for the daily satellite mission planning problem 320
12.2.1. The daily satellite mission planning problem 320
12.2.2. The "natural" model 320
12.2.3. The flow formulation 321
12.3. Models comparison 324
12.3.1. About the stable set polytope 324
12.3.2. Stable set polytope and daily mission planning problem formulations 325
12.4. Experiments and results 326
12.5. Conclusion 327
12.6. Bibliography 328

Chapter 13. Dantzig-Wolfe Decomposition for Linearly Constrained Stable Set Problem 329
Virginie GABREL

13.1. Introduction 329
13.2. The Dantzig-Wolfe decomposition in 0-1 linear programming 330
13.3. The stable set problem with additional linear constraints 333
13.4. Dantzig-Wolfe decomposition on stable set constraints: strengthening the LP-relaxation 334
13.4.1. Gap between LP-relaxations of master and initial problems 334
13.4.2. The case of co-comparability graph 335
13.4.3. A decomposition scheme for general graphs 337

13.5. Conclusion 337
13.6. Bibliography 338

Chapter 14. Algorithmic Games 339
Aristotelis GIANNAKOS, Vangelis Th. PASCHOS and Olivier POTTIÉ

14.1. Preliminaries 340
14.1.1. Basic notions on games 340
14.1.2. Complexity classes mentioned throughout the chapter 343
14.2. Nash equilibria 345
14.3. Mixed extension of a game and Nash equilibria 347
14.4. Algorithmic problems 348
14.4.1. Games of succinct description 349
14.4.2. Results related to the computational complexity of a mixed equilibrium 349
14.4.3. Counting the number of equilibria in a mixed strategies game 355
14.5. Potential games 355
14.5.1. Definitions 356
14.5.2. Properties 356
14.6. Congestion games 360
14.6.1. Rosenthal's model 360
14.6.2. Complexity of congestion games (Rosenthal's model) 363
14.6.3. Other models 364
14.7. Final note 368
14.8. Bibliography 368

Chapter 15. Flows! 373
Michel KOSKAS and Cécile MURAT

15.1. Introduction 373
15.2. Definitions and notations 374
15.3. Presentation of radix trees 375
15.3.1. Database management 377
15.3.2. Image pattern recognition 379
15.3.3. Automatic translation 380
15.4. Shortest path problem 380
15.4.1. Finding paths in $G[t]$ 382
15.4.2. Complexity 385
15.5. The Flow problem 388
15.5.1. The Ford-Fulkerson algorithm 388
15.6. Conclusion 390
15.7. Bibliography 391

Chapter 16. The Complexity of the Exact Weighted Independent Set Problem 393
Martin MILANIČ and Jérôme MONNOT

16.1. Introduction 393
16.2. Preliminary observations 397
16.3. Hardness results 399
16.3.1. Bipartite graphs 400
16.3.2. A more general hardness result 403
16.4. Polynomial results 405
16.4.1. Dynamic programming solutions 406
16.4.1.1. mK_2-free graphs 406
16.4.1.2. Interval graphs 407
16.4.1.3. k-thin graphs 408
16.4.1.4. Circle graphs 409
16.4.1.5. Chordal graphs 410
16.4.1.6. AT-free graphs 413
16.4.1.7. Distance-hereditary graphs 415
16.4.1.8. Graphs of treewidth at most k 417
16.4.1.9. Graphs of clique-width at most k 422
16.4.2. Modular decomposition 424
16.5. Conclusion 428
16.6. Bibliography 429

Chapter 17. The Labeled Perfect Matching in Bipartite Graphs: Complexity and (in)Approximability 433
Jérôme MONNOT

17.1. Introduction 433
17.2. The 2-regular bipartite case 436
17.3. Some inapproximation results 438
17.4. The complete bipartite case 446
17.5. Bibliography 452

Chapter 18. Complexity and Approximation Results for Bounded-size Paths Packing Problems 455
Jérôme MONNOT and Sophie TOULOUSE

18.1. Introduction 455
18.1.1. Bounded-size paths packing problems 455
18.1.2. Complexity and approximability status 457
18.1.3. Theoretical framework, notations and organization 458
18.2. Complexity of $\mathbf{P}_k$PARTITION and related problems in bipartite graphs 460

18.2.1. Negative results from the *k*-dimensional matching problem 460
18.2.1.1. *k*-dimensional matching problem 460
18.2.1.2. Transforming an instance of *k*DM into an instance of $\mathbf{P}_k$PACKING 460
18.2.1.3. Analyzing the obtained instance of $\mathbf{P}_k$ PACKING 462
18.2.1.4. **NP**-completeness and **APX**-hardness 463
18.2.2. Positive results from the maximum independent set problem ... 466
18.3. Approximating MAXW$\mathbf{P}_3$PACKING and MIN3-PATHPARTITION 466
18.3.1. MAXW$\mathbf{P}_3$PACKING in graphs of maximum degree 3 467
18.3.2. MAXW$\mathbf{P}_3$PACKING in bipartite graphs of maximum degree 3 470
18.3.3. MIN3-PATHPARTITION in general graphs 473
18.4. Standard and differential approximation of $\mathbf{P}_k$P 475
18.4.1. Differential approximation of $\mathbf{P}_k$P from the traveling salesman problem 475
18.4.2. Approximating $\mathbf{P}_4$P by means of optimal matchings 478
18.4.2.1. Description of the algorithm 478
18.4.2.2. General $\mathbf{P}_4$P within the standard framework 479
18.4.2.3. General $\mathbf{P}_4$P within the differential framework 482
18.4.2.4. Bi-valued metric $\mathbf{P}_4$P with weights 1 and 2 within the standard framework 483
18.4.2.5. Bi-valued metric $\mathbf{P}_4$P with weights *a* and *b* in the differential framework 486
18.5. Conclusion 491
18.6. Bibliography 492

Chapter 19. An Upper Bound for the Integer Quadratic Multi-knapsack Problem 495
Dominique QUADRI, Eric SOUTIF, Pierre TOLLA

19.1. Introduction 495
19.2. The algorithm of Djerdjour *et al.* 497
19.3. Improving the upper bound 498
19.4. An efficient heuristic to calculate a feasible solution 500
19.5. Computational results 500
19.6. Conclusion 503
19.7. Bibliography 503

List of Authors 507

Index 511