Contents

Preface v

1 Introduction 1

1.1 Combinatorial optimization and integer programming 1

1.2 Complexity theory 3

1.3 Heuristic and relaxation methods 5

1.4 Generalized network design problems 7

2 The Generalized Minimum Spanning Tree Problem (GMSTP) 9

2.1 Definition and complexity of the GMSTP 10

2.2 An exact algorithm for the GMSTP 12

2.3 Mathematical models of the GMSTP 14

2.3.1 Formulations based on tree properties 14

2.3.2 Formulations based on arborescence properties 17

2.3.3 Flow based formulations 19

2.3.4 A model based on Steiner tree properties 23

2.3.5 Local-global formulation of the GMSTP 24

2.4 Approximation results for the GMSTP 28

2.4.1 Introduction 29

2.4.2 Positive results: the design of the approximation algorithms . . 30

2.4.3 A negative result for the GMSTP 32

2.4.4 An approximation algorithm for the GMSTP with bounded cluster size 34

2.5 Solving the GMSTP 41

2.5.1 A branch-and-cut algorithm for solving the GMSTP 42

2.5.2 A heuristic algorithm for solving the GMSTP 44

2.5.3 Rooting procedure for solving the GMSTP 46

2.5.4 Solving the GMSTP with Simulated Annealing 48

2.6 Notes 59

3 The Generalized Traveling Salesman Problem (GTSP) 60

3.1 Definition and complexity of the GTSP 61

3.2 An efficient transformation of the GTSP into the TSP 61

Bibliografische Informationen
http://d-nb.info/1018441379

digitalisiert durch DEUTSCHE NATIONAL BIBLIOTHEK

3.3 An exact algorithm for the Generalized Traveling Salesman Problem . 63
3.4 Integer programming formulations of the GTSP 65
3.4.1 Formulations based on the properties of Hamiltonian tours ... 65
3.4.2 Flow based formulations 66
3.4.3 A local-global formulation 69
3.5 Solving the Generalized Traveling Salesman Problem 71
3.5.1 Reinforcing ant colony system for solving the GTSP 72
3.5.2 Computational results 75
3.5.3 A hybrid heuristic approach for solving the GTSP 78
3.5.4 Computational results 88
3.6 The drilling problem 92
3.6.1 Stigmergy and autonomous robots 93
3.6.2 Sensitive robots 94
3.6.3 Sensitive robot metaheuristic for solving the drilling problem . 94
3.6.4 Numerical experiments 97
3.7 Notes 99

4 The Railway Traveling Salesman Problem (RTSP) 100

4.1 Definition of the RTSP 100
4.2 Preliminaries 101
4.3 Methods for solving the RTSP 103
4.3.1 The size reduction method through shortest paths 103
4.3.2 A cutting plane approach for the RTSP 111
4.3.3 Solving the RTSP via a transformation into the classical TSP . 114
4.3.4 An ant-based heuristic for solving the RTSP 119
4.4 Dynamic Railway Traveling Salesman Problem 121
4.4.1 Ant colony approach to the Dynamic RTSP 122
4.4.2 Implementation details and computational results 124
4.5 Notes 126

5 The Generalized Vehicle Routing Problem (GVRP) 128

5.1 Definition and complexity of the GVRP 129
5.2 An efficient transformation of the GVRP into a capacitated arc routing problem 130
5.3 Integer linear programming formulations of the GVRP 132
5.3.1 A general formulation 132
5.3.2 A node based formulation 135
5.3.3 Flow based formulations 137
5.4 A numerical example 139

5.5 Special cases of the proposed formulations 141
5.5.1 The Generalized multiple Traveling Salesman Problem 141
5.5.2 The Generalized Traveling Salesman Problem 143
5.5.3 The Clustered Generalized Vehicle Routing Problem 144
5.6 Solving the Generalized Vehicle Routing Problem 147
5.6.1 An improved hybrid algorithm for Solving the GVRP 147
5.6.2 An efficient memetic algorithm for solving the GVRP 154
5.6.3 Computational experiments 159
5.7 Notes 165
6 The Generalized Fixed-Charge Network Design Problem (GFCNDP) 167
6.1 Definition of the GFCNDP 168
6.2 Integer programming formulations of the GFCNDP 169
6.3 Solving the GFCNDP 173
6.4 Computational results 175
6.5 Notes 177
7 The Generalized Minimum Edge-Biconnected Network Problem (GMEBCNP) 178
7.1 Definition and complexity of the GMEBCNP 178
7.2 A mixed integer programming model of the GMEBCNP 179
7.3 Solving the GMEBCNP 181
7.3.1 Simple Node Optimization Neighborhood (SNON) 181
7.3.2 Node Re-Arrangement Neighborhood (NRAN) 182
7.3.3 Edge Augmentation Neighborhood 182
7.3.4 Node Exchange Neighborhood 183
7.3.5 Variable Neighborhood Descent 183
7.4 Computational results 185
7.5 Notes 185
Bibliography 188
Index 202