Contents

Part I Preliminaries

1 Introduction 3

2 The Knapsack Problem and Straightforward Optimization Methods . 7
2.1 The Reference Problem 7
2.2 An Additional Greedy Approach 10
2.3 Solving the Knapsack Problem by Enumeration 11
2.4 Branch and Bound 15
2.5 Summary 25

3 Search Heuristics 31
3.1 Search Heuristics Based on Repeated Solution Construction 33
3.1.1 Randomized Search by Solution Construction 34
3.1.2 Memory-based Search by Solution Construction 37
3.2 Search Heuristics Based on Repeated Solution Modification 43
3.2.1 Allowing Deteriorations only in Dead-ends 47
3.2.2 Allowing Deteriorations at any Time 51
3.3 Search Heuristics Based on Repeated Solution Recombination 56

Part II Metaheuristics

4 Metaheuristics in General 67
4.1 Intensification and Diversification 68
4.2 Algorithmic View 71
4.3 Defining the Term "Metaheuristic" 72
4.4 Summary 72

5 Metaheuristics Based on Solution Construction 75
5.1 Greedy Randomized Adaptive Search Procedure 75
5.1.1 Main Components of Greedy Randomized Adaptive Search Procedures 76

Bibliografische Informationen
http://d-nb.info/1000034682

digitalisiert durch DEUTSCHE NATIONAL BIBLIOTHEK

5.1.2 Algorithmic View 80
5.1.3 Problem Related Aspects 81
5.1.4 Intensification / Diversification 81
5.2 Ant Colony Optimization 82
5.2.1 Application to Optimization Problems 84
5.2.2 Main Components of Ant Colony Optimization 87
5.2.3 Algorithmic View 89
5.2.4 Problem Related Aspects 90
5.2.5 Intensification / Diversification 92

6 Metaheuristics Based on Solution Modification 95
6.1 Local Search as a Common Principle 95
6.1.1 The Link Between Solution Modification and Local Search . 95
6.1.2 Solution Processing Schemes 96
6.1.3 Problem Related Aspects 98
6.1.4 Creating the Initial Solution 99
6.1.5 Simple Improvement-based Local Search 99
6.2 Tabu Search 101
6.2.1 Main Components of Tabu Search 102
6.2.2 Algorithmic View 102
6.2.3 The Tabu List 103
6.2.4 Problem Related Aspects 105
6.2.5 Intensification / Diversification 107
6.3 Threshold Accepting 109
6.3.1 Main Components of Threshold Accepting 109
6.3.2 Algorithmic View 110
6.3.3 Problem Related Aspects 110
6.3.4 Intensification / Diversification 111
6.4 Simulated Annealing 112
6.4.1 Homogenous vs. Inhomogenous Simulated Annealing 114
6.4.2 Annealing Schedules 115
6.4.3 Main Components of Simulated Annealing 116
6.4.4 Algorithmic View 117
6.4.5 Problem Related Aspects 117
6.4.6 Intensification / Diversification 119

7 Metaheuristics Based on Solution Recombination 121
7.1 Genetic Algorithm 121
7.1.1 Main Components of Genetic Algorithms 123
7.1.2 Algorithmic View 123
7.1.3 Problem Related Aspects 126
7.1.4 Description of the Components of a Genetic Algorithm 127
7.1.5 Infeasibility 133
7.1.6 Intensification / Diversification 134
7.2 Scatter Search 135

7.2.1 Main Components of Scatter Search 135
7.2.2 Algorithmic View 137
7.2.3 Intensification / Diversification 143

8 Summarizing Remarks on Metaheuristics 145
8.1 Systematization Approaches 145
8.1.1 Systematization by Basic Principle 145
8.1.2 Alternative Taxonomies 146
8.2 Further Metaheuristics 151
8.2.1 Variable Neighborhood Search 152
8.2.2 Guided Local Search 153
8.2.3 Evolution Strategies 154
8.2.4 Particle Swarm Optimization 154

Part III Applications

9 Metaheuristics in Machine Scheduling 159
9.1 Introduction 159
9.1.1 Machine Scheduling in the Job Shop Case 159
9.1.2 Common Optimization Objectives 161
9.1.3 The Reference Problem 163
9.1.4 Types of Schedules 166
9.1.5 Mathematical Formulation 168
9.1.6 Problem Difficulty 168
9.2 Common Ways of Representing Solutions 169
9.2.1 The Sequence-based Representation 170
9.2.2 The Graph-based Representation 170
9.3 Constructive Heuristics 179
9.3.1 List Scheduling Algorithms 179
9.3.2 Insertion Algorithms 184
9.3.3 Bottleneck Based Scheduling 185
9.4 Metaheuristic Approaches Based on Solution Modification 186
9.4.1 *Neighborhood Concepts in Job Shop Scheduling* 186
9.4.2 Tabu Search Approaches 189
9.4.3 Simulated Annealing Approaches 198
9.5 Metaheuristic Approaches Based on Solution Construction 208
9.5.1 Solution Construction in Job Shop Scheduling 208
9.5.2 ACO Approaches 208
9.6 Metaheuristic Approaches Based on Solution Recombination 221
9.6.1 Genetic Algorithms 221

10 Metaheuristics in Vehicle Routing 237
10.1 Introduction 237
10.1.1 The Reference Problem 239
10.1.2 Common Optimization Objectives 242
10.2 Solution Representation 242

10.3 Constructive Heuristics 243
10.3.1 Savings Algorithm 244
10.4 Metaheuristic Approaches Based on Solution Construction 250
10.4.1 Greedy Randomized Adaptive Search Procedure 250
10.5 Metaheuristic Approaches Based on Solution Modification 266
10.5.1 Classic Neighborhood Concepts in Vehicle Routing 266
10.5.2 Tabu Search 270
10.6 Metaheuristic Approaches Based on Solution Recombination 281
10.6.1 Genetic Algorithm 281

11 Summary 291
11.1 Metaheuristics from a General Point of View 291
11.2 Guideline for Application Development 293
11.3 Comparison of Tabu Search for JSSP and VRP 296
11.4 Outlook 297
11.4.1 Further Developments and Trends in Heuristic Optimization 297
11.4.2 (Meta)heuristics in Industrial Practice 299

References 301