Contents

1 Exact, Heuristic and Meta-heuristic Algorithms for Solving Shop Scheduling Problems
G.I. Zobolas (Athens University of Economics and Business), C.D. Tarantilis (Athens University of Economics and Business), G. Ioannou (Athens University of Economics and Business) 1
1.1 Introduction 1
1.2 Production Scheduling Problems and their Classification 3
1.2.1 Single Machine Scheduling Problem 3
1.2.2 Parallel Machine Scheduling Problem 4
1.2.3 Major Shop Scheduling Problems 5
Flow Shop Scheduling Problem 5
Job Shop Scheduling Problem 6
Open Shop Scheduling Problem 7
Mixed Shop and Group Shop Scheduling Problems 7
1.2.4 Computational Complexity of Shop Scheduling Problems . 8
Complexity of the FSSP 8
Complexity of the JSSP 9
Complexity of the OSSP 9
1.2.5 Optimization of Production Scheduling Problems 10
1.3 Solution Methodologies for Shop Scheduling Problems 11
1.3.1 Exact Algorithms 11
1.3.2 Heuristic Algorithms 12
Constructive 12
Local Search 12
1.3.3 Meta-heuristic Algorithms 13
Definition 14
Classification of Meta-heuristic Methods 15
Meta-heuristic Algorithms used for Shop Scheduling Problems 15
Hybrid Methods 16

Adaptive Memory Programming - The Unified View 17
1.4 The Flow Shop Scheduling Problem 17
1.4.1 Heuristics for the FSSP 17
1.4.2 Meta-heuristics for the FSSP 19
1.5 The Job Shop Scheduling Problem 24
1.5.1 Heuristics for the JSSP 25
1.5.2 Meta-heuristics for the JSSP 26
1.6 The Open Shop Scheduling Problem 29
1.6.1 Heuristics for the OSSP 30
1.6.2 Meta-heuristics for the OSSP 30
References 31

2 Scatter Search Algorithms for Identical Parallel Machine Scheduling Problems
Manuel Iori (Università di Modena e Reggio Emilia), Silvano Martello (Università di Bologna) 41
2.1 Introduction 41
2.2 The problems 42
2.2.1 Identical Parallel Machine Scheduling Problem 42
2.2.2 Cardinality Constrained Parallel Machine Scheduling Problem 43
2.2.3 k_i-Partitioning Problem 44
2.3 Scatter Search 44
2.3.1 Scatter Search for $P||C_{max}$ 46
2.3.2 Scatter Search for $P|\# \leq k|C_{max}$ 48
2.3.3 Scatter Search for k_i-*PP* 49
2.4 Computational Results 49
2.4.1 Scatter Search vs simple heuristics and exact algorithms 49
2.4.2 Comparison of meta-heuristic algorithms for $P||C_{max}$ 52
2.4.3 Comparison among Scatter Search algorithms 54
2.4.4 Parameters Tuning 55
2.5 Conclusions 57
References 58

3 On the Effectiveness of Particle Swarm Optimization and Variable Neighborhood Descent for the Continuous Flow-Shop Scheduling Problem
Jens Czogalla (Helmut-Schmidt-University), Andreas Fink (Helmut-Schmidt-University) 61
3.1 Introduction 61
3.2 The Continuous Flow-Shop Scheduling Problem 62
3.2.1 How Iron Ore Becomes a Steel Plate 62
3.2.2 Formal Description 63
3.2.3 Literature Review 64
3.3 Particle Swarm Optimization 64

3.3.1 Standard Particle Swarm Optimization 64
3.3.2 Discrete Particle Swarm Optimization 66
3.3.3 Crossover Operators 69
3.4 Initial Swarm Population 70
3.5 Local Search 71
3.6 Computational Results 72
3.7 Conclusions 79
References 79

4 A Dynamical Ant Colony Optimization with Heuristics for Scheduling Jobs on a Single Machine with a Common Due Date
Zne-Jung Lee (Huafan University), Shih-Wei Lin (Huafan University) and Kuo-Ching Ying (Huafan University) 91
4.1 Introduction 91
4.2 Problem Formulation 93
4.3 Overview of Ant Colony Optimization 94
4.4 The Proposed Algorithm 95
4.5 Simulation Results 97
4.6 Conclusions 100
References 101

5 Deterministic Search Algorithm for Sequencing and Scheduling
Seamus M. McGovern (U.S. DOT National Transportation Systems Center) Surendra M. Gupta (Northeastern University) 105
5.1 Introduction 105
5.2 Literature Review 107
5.3 Formulating The Reverse Production Scheduling Problem 108
5.4 Modeling The Problem As A Multiprocessor Scheduling Problem And Proof As Unary NP-Complete 110
5.5 H-K Heuristic 112
5.5.1 Heuristic Search Background 112
5.5.2 Heuristic Motivation and Introduction 112
5.5.3 The H-K Process and DLBP Application 114
5.6 Electronic Product Instance 118
5.7 Numerical Analysis 119
5.8 Future Research 121
5.9 Conclusions 122
References 122

6 Sequential and Parallel Variable Neighborhood Search Algorithms for Job Shop Scheduling
Mehmet E. Aydin (University of Bedfordshire) Mehmet Sevkli (Fatih University) 125
6.1 Introduction 125

6.2 Variable Neighborhood Search 127
6.3 Parallelization of VNS 128
6.4 VNS Algorithms for Job Shop Scheduling 133
6.4.1 Job shop scheduling problems 133
6.4.2 Problem representation 133
6.4.3 Neighborhood Structure 134
6.4.4 VNS algorithms for JSS 134
6.5 Experimental Study 135
6.5.1 Experimentation with VNS algorithms 136
6.5.2 Parallel VNS algorithms 137
6.5.3 Related works 141
6.6 Conclusions 142
References 143

7 Solving Scheduling Problems by Evolutionary Algorithms for Graph Coloring Problem
Pawel B. Myszkowski (Wroclaw University of Technology) 145
7.1 Introduction 145
7.2 Graph Coloring Problem (GCP): definition and notations 146
7.3 Applications of Graph Coloring Problem 147
7.3.1 University timetabling: Examination Timetabling and Course Timetabling 147
7.3.2 Job-shop Scheduling Problem 148
7.3.3 Multiprocessor Scheduling Tasks Problem 148
7.4 GRACOM: Evolutionary Algorithm applied to Graph Coloring Problem 149
7.4.1 Coding of solution and a partial fitness function (*pff*) 150
7.4.2 A measure of population diversity 152
7.4.3 Genetic operators 153
Iteration Build Solution (IBIS) 153
Best Color Crossover (BCX) 156
7.5 Experiments and results 158
7.5.1 Genetic operators 158
7.5.2 Population size 159
7.5.3 Individual selection method 161
7.6 Tests of GRACOM efficiency 161
7.6.1 Scheduling experiments 163
7.7 Conclusions and future work 165
References 165

8 Heuristics and meta-heuristics for lot sizing and scheduling in the soft drinks industry: a comparison study
D. Ferreira (Universidade Federal de Sao Carlos), P.M. França (Universidade Estadual Paulista) A. Kimms (University of Duisburg-Essen), R. Morabito (Universidade Federal de Sao Carlos), S. Rangel

(Universidade Estadual Paulista), C.F.M. Toledo (Universidade Federal de Lavras) 169
8.1 Introduction 169
8.1.1 Soft Drinks Plant 170
8.1.2 Literature Review 173
8.2 Evolutionary Approaches 178
8.2.1 The MA structure 178
8.2.2 The multi-population structure 181
8.2.3 Individual representation 182
8.2.4 Decoding and evaluation 185
8.2.5 Crossover and mutation 187
8.2.6 Local search algorithm 189
8.3 The Decomposition and Relaxation Approach 191
8.3.1 Model development 191
8.3.2 Relax and fix strategies 196
8.3.3 The relaxation approach 198
8.4 Computational Tests 199
8.4.1 Generation of instances 200
8.4.2 Computational results 202
8.5 Final Remarks and Conclusions 206
References 207

9 Hybrid Heuristic Approaches for Scheduling in Reconfigurable Manufacturing Systems
Ricardo Galán (Agua y Estructuras, S.A. (Ayesa)) 211
9.1 Introduction 211
9.2 Scope of the Research 213
9.3 Formation of Product Families for RMS 213
9.3.1 Identification of Product Attributes 213
9.3.2 Review and Selection of Grouping Methods 214
9.3.3 Development of the Methodology 215
Formation of Matrices 215
Clustering Methodology for RMS 223
Application of the ALC Algorithm 224
9.4 Selection and Scheduling of Product Families for RMS 226
9.4.1 Selection of Parameters 227
9.4.2 Methodology to Estimate Costs 227
Identification of Parameters 228
Cost Sensitivity 231
9.4.3 Mathematical Model 234
9.5 Production Planning with Heuristics 237
9.5.1 Heuristics to Solve the RMS Problem 239
Variant of the Nearest Neighbor Heuristic 239
Ant Colony Optimization 240
9.5.2 Hybrid Approaches to Solve the RMS Problem 243

Hybrid Approach of Nearest Neighbor Variant and Tabu Search . . . 244
Hybrid Approach of ACS with Local Search . . . 247
9.6 Conclusions . . . 250
References . . . 251

10 A Genetic Algorithm for Railway Scheduling Problems
P. Tormos, A. Lova, F. Barber, L. Ingolotti, M. Abril, M.A. Salido . . . 255
10.1 Introduction . . . 255
10.2 The Train Timetabling Problem (TTP) . . . 256
10.2.1 Notation . . . 257
10.2.2 Feasibility of a Solution - Set of Constraints . . . 258
10.2.3 Optimality of a Solution - Objective function . . . 264
10.3 Solving Process: A Genetic Algorithm Approach . . . 264
10.3.1 Basic Scheme of the GA . . . 265
10.3.2 Definition of Individuals: Solution Encoding . . . 266
10.3.3 Fitness Computation . . . 267
10.3.4 Initial Population . . . 268
10.3.5 Crossover . . . 269
10.3.6 Mutation . . . 270
10.3.7 Selection . . . 271
10.3.8 Decodification Process . . . 271
10.4 Solving Real Cases with GA . . . 272
10.4.1 Results . . . 273
10.5 Conclusions . . . 275
References . . . 275

11 Modelling Process and Supply Chain Scheduling Using Hybrid Meta-heuristics
Soumya Banerjee (Birla Institute of Technology), G.S.Dangayach (Malviya National Institute of Technology), S.K.Mukherjee (Birla Institute of Technology), P.K. Mohanti (University of New Brunswick) . 277
11.1 Introduction and Background . . . 277
11.2 Related Works on Meta-heuristics . . . 279
11.3 Motivation and Importance Behind the Model . . . 281
Concept of Hybrid Meta Heuristics for the Proposed Model . . . 281
11.4 Bee Colony Optimization . . . 283
Mathematical Model of Foraging for Honey Bees . . . 283
11.5 Multi-Objective Optimization and Standard Bee Colony Optimization Algorithm . . . 285
11.5.1 Waggle Dance –Computational Interpretations . . . 286
11.5.2 Forage and Combining Rough Set . . . 286
11.5.3 Process Scheduling and Optimization under Uncertainty . 287
11.5.4 Rough Set . . . 288

11.6 Case Study of Milk Food Product Processing and Production 289
11.6.1 The Proposed PBC Optimization Algorithm 291
11.7 Implementation of PBCO as Multi Objective Optimization 294
11.7.1 Experimental Evaluation 295
11.7.2 Process Betterment through PBCO - A Comparative Study 295
11.8 Conclusions and Future Work 298
References 298

12 Combining Simulation and Tabu Search for Oil-derivatives Pipeline Scheduling
Álvaro García-Sánchez (Universidad Politécnica de Madrid), Luis Miguel Arreche (Universidad Politécnica de Madrid), Miguel Ortega-Mier(Universidad Politécnica de Madrid) 301
12.1 Introduction 301
12.2 Literature review 303
12.3 Problem Statement and Modelling Approach 304
12.3.1 Pipeline system characteristics 304
12.3.2 Problem Definition and Schedule Representation 304
12.3.3 Objective 306
12.3.4 Modelling Approach 306
12.4 The Pipeline Simulator 307
12.5 Tabu Search 309
12.5.1 General Outline 310
12.5.2 Types of Movements 311
12.5.3 Stage selection 315
12.5.4 Tabu Lists and Aspiration Criterion 316
12.5.5 Diversification list 317
12.5.6 Terminating criterion 317
12.5.7 Worsening Limits 318
12.6 Case Study. Computational results 318
12.7 Conclusions and Future Work 323
References 324

13 Particle Swarm Scheduling for Work-Flow Applications in Distributed Computing Environments
Ajith Abraham, Hongbo Liu, Mingyan Zhao 327
13.1 Introduction 327
13.2 Problem formulation 328
13.3 Particle Swarm Heuristics for FDSP 332
13.3.1 Canonical Model 332
13.3.2 Variable Neighborhood Particle Swarm Optimization Algorithm (VNPSO) 335
13.4 Experiment Results and Algorithm Performance Demonstration .. 338
13.5 Conclusions 339

13.6 Acknowledgements 341
References 341

Index 343