
Preface

During the past decades scheduling has been among the most studied optimization problems and it is still an active area of research! Scheduling appears in many areas of science, engineering and industry and takes different forms depending on the restrictions and optimization criteria of the operating environments [8]. For instance, in optimization and computer science, scheduling has been defined as “the allocation of tasks to resources over time in order to achieve optimality in one or more objective criteria in an efficient way” and in production as “production schedule, i.e., the planning of the production or the sequence of operations according to which jobs pass through machines and is optimal with respect to certain optimization criteria.”

Although there is a standardized form of stating any scheduling problem, namely “efficient allocation of n jobs on m machines –which can process no more than one activity at a time– with the objective to optimize some objective function of the job completion times”, scheduling is in fact a family of problems. Indeed, several parameters intervene in the problem definition: (a) job characteristics (preemptive or not, precedence constraints, release dates, etc.); (b) resource environment (single *vs.* parallel machines, unrelated machines, identical or uniform machines, etc.); (c) optimization criteria (minimize total tardiness, the number of late jobs, makespan, flowtime, etc.; maximize resource utilization, etc.); and, (d) scheduling environment (static *vs.* dynamic, in the former the number of jobs to be considered and their ready times are available while in the later the number of jobs and their characteristics change over time).

Thus, different scheduling problems are identified in the literature (an early compendium of sequencing and scheduling problems is found in [1]; see [8] for an annotated bibliography). Among these scheduling problems we can mention Job Shop, Flow Shop, Sequencing problems, Identical Parallel Machine Scheduling, Timetabling and Multiprocessor scheduling.

On the other hand, scheduling problems have found their usefulness in a vast area of applications such as lot sizing [5], manufacturing [2] and production scheduling [10], to name a few.

Despite of large amount of research on scheduling, many researchers and practitioners from the academia and industry are devoting a considerable amount of efforts on the problem. This can be explained not only by the fact that most of the problems in the family of scheduling are computationally hard [6] and therefore there is still room for improvement in the resolution methods but also because manufacturing and production are continuously changing and introducing more and more demanding restrictions (e.g. Reconfigurable Manufacturing Systems have appeared as the next step in manufacturing, aiming the production of any quantity of highly customized products or novel scheduling problems arising from the field of environmentally conscious manufacturing); thus, “new” types of scheduling are arising. Moreover, the computational resources used for solving scheduling problems have significantly increased during the last years allowing to achieve more efficient solutions of large size scheduling problems.

This volume presents meta-heuristics approaches for scheduling problems arising in industrial and manufacturing applications. Nowadays, meta-heuristics have become a *de facto* approach to tackle in practice with the complexity of scheduling problems. Early work applied evolutionary computing methods to scheduling problems (see [3, 4, 9] and [29] for a review). The present volume is novel in many respects. First, the proposed approaches comprise a variety of meta-heuristics (Genetic Algorithms, Memetic Algorithms, Ant Colony Optimization, Particle Swarm Optimization, Tabu Search, Scatter Search, Variable Neighborhood Search). Second, in most cases, hybridization is approached as the most effective way to achieve state-of-the art results. Third, and most importantly, the scheduling problems arising in real life applications and real world data instances are solved using these meta-heuristics; these applications comprise reconfigurable manufacturing systems, lot sizing and scheduling in industry, railway scheduling and process, supply chain scheduling and scheduling problem arising in a real-world multi-commodity Oil-derivatives Pipeline. Finally, scheduling problems and meta-heuristics are presented in a comprehensive way making this volume an interesting contribution to the research on scheduling in industrial and manufacturing applications.

Chapters were selected after a careful review process by at least three reviewers on the basis of the originality, soundness and their contribution to both meta-heuristics and scheduling in industrial and manufacturing applications. Relevance of the proposed approaches was an important criterion for chapter selection, resulting in a volume where the reader will find comprehensive up-to-date surveys, novel meta-heuristic approaches and real life applications. The thirteen chapters of the volume are organized as follows.

In Chapter 1, *Zobolas et al.* present a survey on the main shop scheduling problems (flow shop, job shop, open shop, group shop and mixed shop) as well as their computational complexity. Thereafter, the most important exact, heuristic and meta-heuristic methods are presented and classified.

Iori and Martello in Chapter 2 address the identical parallel machine scheduling problem and some generalizations arising from real world situations. The authors survey the current state of the art for the most performing meta-heuristic algorithms, with special emphasis on Scatter Search.

In Chapter 3, *Czogalla and Fink* study the effectiveness of Particle Swarm Optimization (PSO) and Variable Neighborhood Descent for the Continuous Flow-Shop Scheduling Problem. The authors examine the use of different crossover operators in PSO and hybridization with variable neighborhood descent. The results of their study stress the importance of local search in increasing the performance of PSO procedures.

Lee et al. in the fourth chapter present an ACO approach for Scheduling Jobs on a Single Machine with a Common Due Date. The authors consider the version of Dynamic ACO in which the parameter of heuristic information is dynamically adjusted. Moreover, hybridization with other heuristics is implemented and evaluated.

In the fifth chapter *McGovern and Gupta* present the use of the Hunter-Killer (H-K) general purpose heuristic for solving new complex scheduling problems arising from the field of environmentally conscious manufacturing, the goal of which is to determine a product's part removal schedule. A scheduling application of the H-K heuristic is demonstrated using an electronic product case study.

Aydin and Sevcli in the sixth chapter report sequential and parallel Variable Neighborhood Search algorithms for Job Shop Scheduling problems. Starting from the observation that VNS could sometimes take long time to reach good solutions, especially when tackling large size instances of Job Shop Scheduling, the authors propose the parallelization of VNS in order to speed up computations. A number of variable neighborhood search algorithms are examined for the problem and then four different parallelization policies are presented and their performance evaluated.

In the seventh chapter *Myszkowski* uses Graph Coloring problem for modelling several scheduling problems. The author presents a new evolutionary approach to the Graph Coloring Problem, which is then applied for solving timetabling, scheduling, multiprocessor scheduling task and other assignment problems.

Ferreira et al. in the eighth chapter presents a comparison study for heuristics and meta-heuristics for lot sizing and scheduling in the soft drinks industry. The study concentrates on two-level production planning problem where, on each level, a lot sizing and scheduling problem with parallel machines, capacity constraints and sequence-dependent setup costs and times must be solved. The comparison study is accomplished for two different approaches, namely, an evolutionary technique comprising both a GA and its MA version, and a decomposition and relaxation approach.

Galan in the ninth chapter proposes hybrid heuristic approaches for scheduling problems arising in reconfigurable manufacturing systems. Besides

a specific heuristic for the problem, both Tabu Search and Ant Colony Optimization have been implemented and experimentally evaluated.

Tormos et al. in the tenth chapter introduce a Genetic Algorithm for Railway Scheduling Problems. Their work is motivated by the need to solve very complex real-world problems such as timetabling in a large railway system. The authors have used real instances obtained from the Spanish Manager of Railway Infrastructure to experimentally evaluate the performance of the proposed GA.

In the eleventh chapter, *Banerjee et al.*, address a natural stigmergic computational technique, namely Bee Colony Optimization, for process scheduling arising in a milk production center, in which process scheduling, supply chain network etc. are crucial. The scheduling problem is considered in its multi-objective form and the concept of Pareto Dominance has been introduced in the form of Pareto Bee Colony Optimization. A performance simulation and comparison has been accomplished for the proposed algorithms.

García Sánchez et al. in Chapter twelve present an approach that combines simulation and Tabu Search for solving scheduling problem arising in a real-world multi-commodity Oil-derivatives Pipeline. In the proposed approach, the simulation enables an accurate assessment of particular schedules, while the Tabu Search guides the search in order to reach satisfactory schedules. The authors have applied the proposed methodology to a particular subsystem of the pipeline Spanish network.

In the last Chapter, *Abraham et al.* propose several swarm intelligence based meta-heuristics for scheduling work-flow applications in distributed data-intensive computing environments. A Variable Neighborhood Particle Swarm Optimization (VNPSO) algorithm is proposed and the performance is compared with a multi-start particle swarm optimization algorithm and multi-start genetic algorithm. Experiment results illustrate the algorithm performance and its feasibility and effectiveness for scheduling work-flow applications.

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