Book review

Sequencing and Scheduling with Inaccurate Data

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Often the problem data of a scheduling instance such as the processing times, the setup times, the release dates or the due dates are not exactly known before a particular solution algorithm is applied. This observation may substantially restrict practical aspects of scheduling theory. Within the last 40 years, several approaches have been developed for scheduling problems with inaccurate data depending on whether the data are given as random numbers, fuzzy numbers or whether they are uncertain (which means that they can take values from a given interval). This edited book considers the four major approaches for dealing with such problems: a stochastic approach, a fuzzy approach, a robust approach and a stability approach. It consists of 432 pages with 15 chapters on specific subjects in a particular area, each of them written by leading experts in the corresponding field. Each of the four parts is devoted to one of these approaches and contains first a survey chapter on this subject as well as a between two and three further chapters presenting some recent research results. Each chapter finishes with a detailed list of references, many of them from the last 10 years.

Part I (Chapters 1 - 3, about 70 pages) deals with the stochastic approach, where particular scheduling parameters are assumed to be random variables with known probability distributions. In the survey chapter, Cai, Wu, Zhang and Zhou give an overview on recent results for the stochastic approach, where problems with random data both for regular and non-regular optimization criteria are considered. Then Vredeveld deals with stochastic online scheduling, which is a combination of online and stochastic scheduling. Here it is assumed that the scheduler has no knowledge of future jobs to arrive and when a job arrives, the data of this job is only known via random variables. Several stochastic online scheduling policies are presented and approximation issues are discussed. In another chapter, Urgo considers stochastic scheduling problems with general distributions of the activity durations. The method presented estimates the distribution of the makespan of an activity network by means of the time to absorb a continuous Markov chain.

Part II (Chapters 4 - 7, about 85 pages) deals with the fuzzy approach, where the job processing times or other numerical data are given as fuzzy numbers. Fuzzy scheduling techniques either fuzzify directly existing scheduling rules or solve a mathematical programming problem to determine an optimal schedule. First, Sakawa considers job shop scheduling problems with fuzzy processing times and fuzzy due dates. Using the agreement index of fuzzy due dates and completion times, the fuzzy job shop problems are formulated in terms of maximizing the minimum agreement index. Multi-objective fuzzy job shop scheduling problems are also considered. Masmoudi, Hans, Leus and Hait introduce uncertainty into multi-project rough-cut capacity planning, where fuzzy sets are used to model uncertainties. A simulated annealing algorithm is presented to solve the underlying optimization problem. Then Masmoudi and Hait considers fuzzy modelling and a solution technique for the resource-constrained project scheduling problem. Inspired by the fuzzy/possibilistic approach, a technique is presented which keeps uncertainty at all steps of the modelling and solution procedure. Finally, Chen presents a fuzzy tailored non-linear fluctuation smoothing rule for job dispatching in a semiconductor manufacturing factory. The effectiveness of the method presented is illustrated by a simulation study.

For problems with uncertain processing times, there basically exist two approaches: a robust approach and a stability approach. In the robust approach, a solution is chosen using a particular robust criterion (e.g. the min-max criterion or the min-max regret criterion). The strategy of the stability approach consists in separating the structural input data (e.g. precedence and capacity constraints) from the numerical input data. This approach is based on a stability analysis, a multi-stage scheduling decision framework and the solution concept of a minimal dominant set. Each of the remaining parts deals with one of the above two approaches.

Part III (Chapters 8 - 11, about 125 pages) deals with the robust approach. First, Kasperski and Zielinski give an overview on minmax regret scheduling problems. The robust approach is applied for finding a solution, where the uncertainty is modelled by specifying a scenario set. The objective is to find a schedule with the best worst case performance over all possible scenarios. The major focus of this chapter is on the complexity of several minmax regret scheduling problems and some known algorithms for their solution. Then Hazir and Dolgui deal with robust assembly line balancing. Their chapter gives the state of the art in this area and presents some new research perspectives. Another chapter written by Ivanov, Sokolov, Solovyeva and Potryasev presents a dynamic analysis of supply chain robustness and adaptation using attainable sets and positional optimization as control theoretic tools. The authors demonstrate that attainable sets can be used to obtain estimations of the performance attainability and to consider perturbations in continuous time as constrained functions, while positional optimization can be used for the adaptation of supply chain schedules. Finally, Gören and Sabuncuoglu present a bi-criteria approach to scheduling in the face of uncertainty. They consider robustness and stability simultaneously. Proactive scheduling is considered in a single machine environment with random processing times, where the total expected flow time and the total variance of the job completion times are used as measures. Algorithms for finding the set of Pareto-optimal schedules as well as a fixed number of nearly Pareto-optimal schedules are presented.

Part IV (Chapters 12 - 15, about 145 pages) deals with the stability approach. Sotskov and Werner present a survey on the use of the stability methods for treating scheduling problems with interval data. This chapter delivers a comprehensive explanation of the stability method and related models. The focus is on results obtained by the authors during the last 25 years. The authors discuss mathematical models, known results and they present also some algorithms recently developed. They consider general shop, two-machine and single machine scheduling problems. In another chapter, Sotskov and Egorova apply the stability method to the problem of minimizing total weighted flow time on a single machine under interval uncertainty. In their approach, the authors use optimality and stability boxes. Matsveichuk and Sotskov apply the stability approach to a two-machine scheduling problem with uncertain processing times and minimization of the makespan. A minimal dominant set of schedules is determined and represented by a dominance graph. Some properties of the dominance graph are given. In the last chapter, Nikulin deals with accuracy and stability functions for the problem of minimizing a linear form on a set of substitutions, where problems both in a single and a multiple criteria framework are considered. Appropriate measures of the quality of the optimal solution with respect to an uncertain environment are introduced. The results obtained are interpreted in terms of job sequencing models, and also a link between sensitivity analysis and robust optimization is discussed.

The book provides the reader a comprehensive and up-to-date introduction into some current research subjects in the area of scheduling with inaccurate data. It can be recommended for advanced graduate or Ph.D. students students, researchers and practitioners dealing with uncertain scheduling problems. The book can also serve as a useful reference tool and can be a stimulation for further research in this interesting and growing subject.