In: Sequencing and Scheduling with Inaccurate Data Editors: Yuri N. Sotskov and Frank Werner,
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PREFACE

The usual assumption that the scheduling parameters (such as processing times, setup times, release dates or due dates) are exactly known before scheduling restricts practical aspects of scheduling theory since it is often not valid for real-world processes. These problem data may be given either as random variables, fuzzy numbers, or they may be uncertain. As a consequence, during the last decades, four different approaches for dealing with scheduling problems with inaccurate data have been developed.

In a stochastic approach, particular scheduling parameters (e.g. the processing times) are assumed to be random variables with known probability distributions. In a fuzzy approach, 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.

For problems with uncertain (e.g. interval) processing times, there basically exist two approaches, namely 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. In the former case, one determines a solution minimizing the largest cost over all possible scenarios. The min-max regret criterion is a less conservative criterion, where one determines a solution minimizing the largest deviation from the optimum over all possible scenarios. 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.

This book consists of four parts. Each of this part deals with one of the approaches mentioned above. It starts with a survey chapter and contains between two and three further chapters.

Part I deals with the stochastic approach and contains three chapters. In Chapter 1, Cai, Wu, Zhang and Zhou give an overview on scheduling with the stochastic approach. This chapter surveys the literature on scheduling problems with random data, e.g. processing times, due dates and patterns of machine breakdowns. Both problems with regular and non-regular optimization criteria are considered.

In Chapter 2, Vredeveld considers a combination of online and stochastic scheduling. For this combined model, known as stochastic online scheduling, 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. Various stochastic online scheduling policies are presented and their approximation guarantees are proved.

In Chapter 3, stochastic scheduling problems are considered 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 using a phase-type approximation for a non-exponential distribution.

Part II deals with the fuzzy approach. First, in Chapter 4, 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. In addition, also multi-objective fuzzy job shop scheduling problems are considered. Finally, a genetic algorithm is described.

Then, in Chapter 5, Masmoudi, Hans, Leus and Hait introduce uncertainty into multi-project rough-cut capacity planning, where fuzzy sets are used to model uncertainties. In particular, uncertain workloads are modelled as fuzzy numbers. A simulated annealing algorithm is presented to solve the underlying optimization problem. For the computational experiments, instances from a maintenance centre are used. It is also investigated how multi-objective optimization techniques can be applied.

Chapter 6 by 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. In addition, a fuzzy greedy algorithm is given to solve this scheduling problem.

Finally, in Chapter 7, Chen presents a fuzzy tailored nonlinear fluctuation smoothing rule for job dispatching in a semiconductor manufacturing factory. The effectiveness of the method presented is illustrated by a simulation study which confirms that slack diversification is indeed a good idea for improving the performance of a fluctuation smoothing rule.

Part III deals with the robust approach. In Chapter 8, Kasperski and Zielinski give an overview on minmax regret scheduling problems. For finding a solution, the robust approach is applied, 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.

In Chapter 9, Hazir and Dolgui deal with robust assembly line balancing. This chapter gives the state of the art in this direction and presents some new research perspectives. The discussion and analysis presented in this chapter may help to identify open problems and interesting research subjects with broad industrial applications.

Chapter 10 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.

In Chapter 11, Gören and Sabuncuoglu present a bi-criteria approach to scheduling in the face of uncertainty. They consider robustness and stability simultaneously. This chapter considers proactive scheduling 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 deals with the stability approach. In Chapter 12, Sotskov and Werner present a survey of sequencing and scheduling problems with uncertain data which can be solved by applying a stability method. This chapter delivers a comprehensive understanding of the stability method and the models which are appropriate for sequencing and scheduling under uncertainty. For different sequencing and scheduling problems, the authors discuss mathematical models, known results and the algorithms developed.

In Chapter 13, Sotskov and Egorova apply the stability method to the sequencing problem of minimizing total weighted flow time on a single machine under interval uncertainty. The applied stability method combines a stability analysis, a multi-stage decision framework and the solution concept of a minimal dominant set of job permutations. In their method, the authors use the optimality and stability boxes. Choosing a permutation with the largest stability (optimality) box may be used as a stopping rule at the off-line stage of scheduling.

Chapter 14 by Matsveichuk and Sotskov deals with the stability approach for a two-stage minimum-length scheduling problem with uncertain (interval) processing times. For the problem considered, a minimal dominant set of schedules is determined which can be represented by a dominance graph. Useful properties of such a digraph are established. It is shown how the dominance digraph may be used for constructing a minimal dominant set of schedules. At the off-line stage of scheduling, a minimal dominant set of schedules is constructed which enables a scheduler to make quickly a scheduling decision at the on-line stage whenever additional information on the realization of an uncertain processing time becomes available.

In Chapter 15, Nikulin deals with the accuracy and stability functions for the problem of minimizing a linear form on a set of substitutions. Such a problem is both considered in a single and multiple criteria framework. The author introduces appropriate measures of the quality of the optimal solution with respect to an uncertain environment. The results obtained are interpreted in terms of some well-known job sequencing models. This chapter establishes also a link between sensitivity analysis and robust optimization.

Finally, the editors would like to emphasize that there is no unique method that will fit all the different types of uncertainties arising in the real world, and probably this will also be not the case in the future. Thus, the particular approaches described in this book aim to complement but not to replace the other methods in sequencing and scheduling. Each of the approaches has its specific strengths and areas, where it can be particularly applied.

According to the intended structure of this book, the main authors have been invited to prepare a particular chapter for one specified part together with a selected author team. The editors thank all contributors for accepting our invitation and for the preparation of interesting chapters. We are also grateful to Nova Science Publishers for the pleasant cooperation during the preparation of this book.

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Yuri Sotskov
United Institute of Informatics Problems
National Academy of Sciences of Belarus
Surganova Str. 6
220012 Minsk
Belarus
Email: sotskov@newman.bas-net.by

Frank Werner
Faculty of Mathematics
Otto-von-Guericke University Magdeburg
PSF 4120
39016 Magdeburg
Germany
Email: frank.werner@ovgu.de
http://www.math.uni-magdeburg.de/∼werner