Optimizing the service level of regular criteria for the stochastic flexible job shop scheduling problem

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Mots-clés : *Flexible Job Shop, Stochastic processing times, Service level, Tabu search*

1 Introduction

The Stochastic Flexible Job-shop Scheduling Problem (SFJSP) is an extension of the FJSP, in which a set of jobs have to be processed on a set of flexible machines, and each job requires a number of consecutive operations (routing) before being completed. Finding a solution to this problem means determining both an assignment of operations to machines and a sequence of the operations on the machines while respecting the routing of every job.

The SFJSP has been considerably less studied than its deterministic version. In the FJSP, all problem parameters are supposed to be known, and set-up times between operations are negligible or included in the processing times. In the SFJSP considered in this work, processing times are considered stochastic and characterized by independent random variables following known finite probability distributions. Under random processing times and for a given threshold T, the probability that the makespan is lower than or equal to T is maximized. To solve the SFJSP with *makespan service level*, a solution approach, based on tabu search (inspired by the work of [1]) and a Monte Carlo sampling-based approximation dedicated to considering random processing times, is introduced in our previous work [2].

In this abstract, we extend the notion of service level to other regular criteria. We also apply a new approach to deal with random processing times in the FJSP, by operating directly with the probability distributions of processing times and exploiting several bounds of the probability distribution associated with the considered optimization criterion [3].

2 Service level on regular criteria

In our previous study [2], we considered the maximization of the probability that the makespan C_{max} is lower than or equal to a given threshold T, as an optimization criterion under uncertainty. This probability, denoted by $\alpha(S,T)$, is known as the *makespan service level* associated with sequence S and threshold T :

$$\alpha(S,T) = \mathbb{P}(C_{max}(S) \leq T). \tag{1}$$

Most of the articles in the scheduling literature focus on the minimization of the makespan, which usually does not meet real-life requirements. In this sense, we extend the notion of service level to other more industrially relevant optimization criteria such as :

$$\max \mathbb{P}(T_{max} = 0), \tag{2}$$

$$\max \mathbb{P}\Big(\sum_j w_j C_j \leq T\Big), \tag{3}$$

$$\max \sum_j w_j \Big(\mathbb{P}(C_j \leq d_j) \Big), \tag{4}$$

where C_j is the completion time of job j, d_j, resp. w_j, denotes the due date, resp. weight, of job j, and $T_{max} = \max_j(0, C_j - d_j)$.

Objective (2), which maximizes the probability that the maximum tardiness T_{max} is equal to zero, is equivalent to the makespan service level (see (1)) when all due dates d_j are equal, i.e. $d_j = T$, $\forall j \in \mathcal{J}$. This is equivalent to adding a virtual operation after the end of the last operation of each job j with a processing time of $T - d_j$ in the general case. Objective (3) maximizes the probability that the weighted sum of the completion times does not exceed the threshold T. Compared to Objective (3), Objective (4) is normalized, and the weight w_j makes more sense as it values the importance of satisfying the due date of job j.

3 Dealing with uncertainties

To deal with random processing times in the SFJSP, we adopt in [2] a crude Monte Carlo sampling performed prior to the optimization. This approach presents a number of issues related to the sample size guaranteeing an accurate service level and the computational cost induced by a large sample size. Instead of explicitly operating with the multi-dimensional samples of the resulting joint probability distribution, we implicitly evaluate the service level based on the probability distributions of random processing times. Existing upper and lower bounds of the makespan distribution [3] are applied and extended to other scheduling criteria to accelerate the evaluation of moves within the tabu search framework presented in [2].

4 Conclusions

This abstract focuses on the stochastic flexible job shop scheduling problem under random processing times. In addition to the makespan, an extension of the notion of service level discussed in [2] to other regular criteria is presented. A new strategy to handle the uncertainty in the SFJSP is also introduced. The results of computational experiments will be provided and analyzed in the conference.

Références

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