Computers & Operations Research 40 (2013) 1758–1765

Contents lists available at SciVerse ScienceDirect

Computers & Operations Research

journal homepage: www.elsevier.com/locate/caor

# Scheduling with compressible and stochastic release dates

Jian Zhang [a], Wensheng Yang [b], Yiliu Tu [a,*]

[a] Department of Mechanical and Manufacturing Engineering, University of Calgary, 2500 University Drive NW, Calgary, Alberta, Canada T2N 1N4
[b] Management Science & Engineering, Nanjing University of Science & Technology, 200 Xiaolingwei Street, Nanjing, Jiangsu 210094, China

ARTICLE INFO

Available online 20 January 2013

*Keywords:*
Single-machine scheduling
Compressible and stochastic release dates
Due-date guarantee

ABSTRACT

In this work we study a one-machine scheduling problem which is featured by: (a) the release date of each job is compressible and stochastic, (b) each job has to be delivered before its due date (deadline) and (c) the manufacturer can expedite the production through overtime at an extra cost. The objective function of the scheduling problem is to minimize the total cost which includes the compressing cost and the overtime production cost. We propose a heuristic algorithm in which the stochastic problem is converted to the deterministic problem by a release-time "converting policy". We coin a concept of a job's late-release-impact factor (LRIF) and we propose a LRIF based converting policy. We compare the LRIF based converting policy with the ones used in practice, and the numerical test shows that the LRIF based converting policy can obtain the schedule with the lowest actual total cost.
© 2013 Elsevier Ltd. All rights reserved.

## 1. Introduction

Nowadays, increasing uncertainties in customer demand drives manufacturing firms to undertake appropriate management strategies in their production planning. One-of-a-kind production (OKP) is one such strategy that allows local firms to provide highly customized products, and at the same time to meet the customers' due-date requirements. Comparing to mass customization, OKP is featured as a "once" successful approach on the product development and production according to specific customer requirements, i.e., no prototype or specimen will be made [1]. Thus, OKP manufacturers usually outsource the production of some particular components, which are not kept in inventory and are only ordered when they are specifically required. This outsourcing can be to a supplier or a member company, which can provide just-in-time (JIT) deliveries. However, if the supplier does not have JIT capability, the component has to be ordered according to the lead time [2]. In this work, we study the scheduling problem that when a manufacturer orders components from its suppliers, the manufacturer faces multiple lead-time options under different prices, and for each lead-time option, instead of a deterministic lead time, the suppliers of the components only promises the delivery within a time interval. The following examples illustrate this problem setting.

Example 1 A manufacturer orders components from one supplier, who offers orders with different priority options at different prices, e.g., regular order, rush order and super rush order.

Example 2 The manufacturer has multiple substitutable component suppliers in different locations, e.g., local, domestic and offshore. The suppliers offer different prices, while the promised lead times are different because of the differences in distance.

Example 3 When the manufacturer makes orders from its supplier(s), there are multiple transport modes, e.g., by air, by rail and by road, each of which incurs a different transport cost.

In the three examples above, it is usually hard to guarantee an exact date when the order can be delivered, and instead the manufacturer only expects a time interval. Because the delivery of the component constraints the release of each job within the manufacturer, we hereafter use the term "compressible and stochastic release dates" to refer to the optional lead-time intervals offered by the component supplier.

In this work, we study the manufacturer which can expedite the production by expediting, i.e., overtime, under an overtime cost when the manufacturer's regular production capacity is not enough. It has been proved that in the make-to-order industry, expediting by overtime production is a common practice to guarantee the due-date delivery [3].

We summarize the problem studied in this work as the single-machine scheduling problem with compressible and stochastic release dates, due-date guarantee and costly expediting. The target of the manufacturer is to minimize the total cost which

* Corresponding author. Tel.: +1 403 220 4142; fax: +1 403 282 8406.
*E-mail addresses:* jiazhang@ucalgary.ca (J. Zhang), wensheng_yang@mail.njust.edu.cn (W. Yang), paultu@ucalgary.ca (Y. Tu).

0305-0548/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.cor.2013.01.011

includes the total cost for compressing the release dates and the total cost for expediting.

Our sections are organized as follows. In Section 2, a review of relevant literature is conducted. In Section 3, we describe the problem with notations. As a foundation for developing the heuristic for the scheduling problem with compressible and stochastic release date, in Section 4, we first study the problem with the setting that the release dates are compressible and deterministic. Then in Section 5, we solve the stochastic problem by converting the stochastic problem to the deterministic problem. Finally, a summary of conclusion is presented in Section 6.

## 2. Literature review

This work relates to the literature on the scheduling of jobs with release-date and due-date constraints. There is now a substantial literature that studies the scheduling problem with the jobs constrained by the fixed and deterministic release dates, and a detailed survey of the works on this problem setting can be found in [4]. Here we focus on the literature with the concerns of compressible and stochastic release dates.

A number of works can be found researching the scheduling with compressible release date. Cheng and Shakhlevich [5] studied the single-machine scheduling of unit-time jobs with controllable release dates, and they developed an algorithm of polynomial complexity to find the integer Pareto optimal points which minimize the makespan and the total compression cost. Later, Janiak [6] generalized the condition of unit-time jobs. Several works can be found studying the case where both the jobs' release dates and processing times are compressible, i.e. [7–11]. For more particular case, Shakhlevich and Strusevich [10] also consider the controllable processing speed of the server in their work. We can find some papers in the literature using the term “resource dependent release date” to refer to the release date which can be compressed under a certain cost. Choi et al. [12] and Li et al. [13] studied the single-machine scheduling problem with resource dependent release dates to minimize total resource consumption. They do not include the makespan in the objective function, but constrain the makespan or the total job completion time to be under a given limit. In all the papers mentioned above, the authors do not consider the due-date constraint of each job. Seldom papers study the scheduling problem with the concerns of both compressible release dates and due dates. Janiak [14] and Ventura et al. [15] both studied single-machine scheduling problem with common due date and resource-dependent release dates. According to our best knowledge, there is no research so far studying the general scheduling problem with jobs constrained by compressible release dates and different due dates.

For the literature relating to the scheduling with stochastic release dates, we only find [16] in which the author assumes the release date of each job follows an arbitrary joint distribution, but he only study the case where the target is to minimize the sum of weighted job completion times. The works in the literature of scholastic scheduling mainly study the case where the processing time of each job is random, e.g. [17], or the case where the scheduling is online and the scheduler expects an arrival stream of new jobs, e.g. [18].

For the literature on due-date-guaranteed scheduling with production expediting, Bratley et al. [19] first studied the scheduling problem in which the due date of each job is a constraint. They develop an algorithm which find the optimal schedule which minimize the elapsed time if feasible solution exists. A number of papers can be found which include expediting such as [20–23], but none of the papers considers the constraints of the jobs' release dates.

## 3. Problem description and notations

In this section, we describe our problem settings with notation. For clarity, we summarize the notation used in this paper in Table 1.

Without loss of generality, we suppose that the manufacturer's production periods are managed in days, and Day $t : t \in \mathbb{N}$ is the $t$th day after the current day. We study a manufacturer which has $J$ jobs to be scheduled, each of which is indexed by $j : j \in \{1,2,\ldots,J\}$.

We treat the manufacturer as a one-machine production system. A job's workload is described by the processing time required by the job. We use $p_j$ to denote Job $j$'s processing time which indicates how many hours are required for the manufacturer to process Job $j$. A job can be processed under the manufacturer's regular hours or overtime hours in each working day. We assume that if a job is processed in the manufacturer's regular hours, no cost is incurred; otherwise, if a job is processed in the manufacturer's overtime hours, an overtime cost $z$ will be incurred for each overtime hour. We assume that within the manufacturer, the maximum number of regular hours in each working day, namely the manufacturer's daily regular production capacity, is fixed at a positive integer $H$, and the number of overtime working hours in each day is not constrained. This setting is common in practice when a manufacturer employs a number of fulltime workers with fixed base monthly payment

**Table 1**
Notation.

| Symbol | Explanation |
|---|---|
| $t$ | Day $t$ is the $t$th day after the current day |
| $J$ | The total number of the jobs to be scheduled |
| $j$ | A job's index such that $j \in \{1,2,\ldots,J\}$ |
| $p_j$ | The processing time of Job $j$ |
| $H$ | The manufacturer's daily regular production capacity, i.e., the maximum number of regular hours in each working day |
| $v_j$ | The overtime hours used for processing Job $j$ |
| $z$ | The cost incurred for a unit overtime hour |
| $r_j$ | The release date of Job $j$ |
| $\xi_j$ | The compressing fee for Job $j$, i.e., the cost incurred for compressing the release date of a unit workload (processing time) of Job $j$ |
| $\xi_j(r_j)$ | Job $j$'s compressing fee function when the release date of Job $j$ is deterministic |
| $r_j^{LB}$ | The earliest possible release date of Job $j$ |
| $f_j^R(r\|\xi_j)$ | The probability mass function (pmf) of Job $j$'s release date under compressing fee $\xi_j$ when the release date of Job $j$ is stochastic |
| $F_j^R(r\|\xi_j)$ | The cumulative distribution function (cdf) of Job $j$'s release date under compressing fee $\xi_j$ when the release date of Job $j$ is stochastic |
| $d_j$ | The guaranteed due date (deadline) of Job $j$ |
| $s_j$ | Job $j$'s start time |
| $c_j$ | Job $j$'s completion time |
| $S$ | The schedule of all the jobs. In the deterministic case $S=(\vec{r},\vec{s},\vec{v})$ while in the stochastic case $S=(\vec{\xi},\vec{s},\vec{v})$. $\vec{r}$, $\vec{\xi}$, $\vec{s}$ and $\vec{v}$ indicate the release dates, the compressing fees, the staring times and the overtime workloads of all the jobs, respectively |
| $r_j^*(\xi_j)$ | The converted release date of Job $j$ under converting fee $\xi_j$ when the release date is stochastic. $*$ can be substituted with $O$, $P$, $N$ or $L$ to denote the converted release date under different converting policy |
| $L_j(S)$ | Job $j$'s LRIF of when the job Schedule is $S$ |
| $L'_j(S)$ | The surrogate measure of Job $j$'s LRIF |

Download English Version:

https://daneshyari.com/en/article/475781

Download Persian Version:

https://daneshyari.com/article/475781

Daneshyari.com