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Improving the delivery efficiency of the customer order scheduling problem in a job shop

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ABSTRACT

The focus of this paper is customer order scheduling (COS) problem, where each order consists of a set of jobs that must be shipped as one batch at the same time. In COS each job is part of a customer order and the make-up of the jobs in the order are pre-specified. Most of the existing research deals with COS in a single machine or in a parallel machine shop for developing an optimal solution. COS is common in a normal job shop, and the more complex the shop, the more complex the scheduling. Most existing research has focused on trying to reduce the completion time of the batch. That is, the focus is only on the point in time the last job is finished, while ignoring the actual duration of the jobs within the same order. The longer it takes to complete all the jobs within an order the more it increases the stock of finished goods and the more it deteriorates the efficiency of the logistics and the supply chain management.

A new dispatching rule, referred to as Minimum Flow Time Variation (MFV), has been proposed for COS in a normal job shop, in order to reduce the total time it takes to complete all jobs within the same order. That is, the individual completion times of all jobs for the same customer order will be controlled in order to improve the shipping performance. In the simulation test and statistical analysis, the level of work in process (WIP) under the MFV rule in the finished goods warehouse is reduced by more than 70% compared to any other method. The MFV method will efficiently reduce the stock level of finished goods, and controls the waiting time required before they can be shipped. Depending on the environmental factors, the performance of our proposed method will become increasingly significant the more complex the system.

1. Introduction

In this research, we consider the scheduling of customer orders in a normal job shop. In customer order scheduling, each job is part of a customer order and the composition of the job in the order is pre-specified. Let's consider a manufacturing facility that produces different types of products. A customer can request a variety of products in a single order. After the entire order is produced, the products are shipped to the customer. Each order is a batch and each product is a job. The composition of a batch is specified by the order. Since 1990, many researches have been done on the issue of customer order scheduling (COS). Most of the existing researches deal with the problem of COS in a single machine or in a parallel machine shop to develop an optimal solution. Besides, most existing research has focused on trying to reduce the completion time of the batch. That is, the focus is only on the point in time the last job is finished, while ignoring the actual duration of the jobs within the same order. The longer it takes to complete all the jobs within an order the more it increases the stock of finished goods and the more it deteriorates the efficiency of the logistics and the supply chain management.

For time-based competition, on-time delivery is the most crucial performance factor. How to finish a product at the moment it is required is the modern concept, similar to the just-in-time (JIT) principle. In either concept, inventory should be erased if possible. There are three kinds of inventory in the production system, including materials/parts, work in process (WIP), and finished goods. The materials/parts inventory is controlled by purchasing management and material requirement planning (MRP). WIP is subject to the efficiency of the shop floor control, especially order releasing and scheduling. To reduce the inventory level of finished goods, jobs from the same order should be finished as close as possible at the same time since they will be shipped as a batch at the same time. Hence, in the present study we will try to model a new dispatching rule for COS in a normal job shop in order to minimize the completion time variability of all the jobs for the same order. That is, the individual completion times for all the jobs in the same customer order will be controlled in order to improve the shipping performance.

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The remainder of this paper is organized as follows. The relevant literature on the COS in a job shop is reviewed in the next section. Section 3 describes the methodology of the proposed dispatching rule. The simulation model and the data collected are presented in Section 4, while the statistical analysis and discussion are summarized in Section 5. Finally, in Section 6 we draw our conclusions and discuss some future works.

2. Customer order scheduling in job shop

The focus of this study is the case of customer order scheduling (COS), where each order consists of a set of jobs that must be shipped as one batch. The relatively new types of customer order scheduling cases are derived from several real-world applications. Let's consider a manufacturing facility which produces different types of products, and the customer can order any combination of product types. The composition of an order is specified by the purchased order. The company may not ship the order until all the products in the order are completed.

Yang (2005) provided three additional examples for the customer order scheduling case. First is the automobile repair shop. Each car has at least one broken part. A mechanic represents a machine. A car and each broken part can be considered as an order and a job, respectively. If a car has more than one broken part, then more than one mechanic may work simultaneously on the car. A car stays in the repair shop until all problems are fixed. The second application is the production of components for subsequent assembly. Let's consider an electronics manufacturing facility where computer monitors are produced. Generally, this is a multi-stage production process including several fabrication operations, and a final assembly operation. The fabrication operations create various components including printed circuit board, front and back cabinet covers, and color display tubes. The components are then combined into a batch, and that batch is the set of parts required to produce one type of monitor. The final assembly operation is not started until all required components are finished by the fabrication operations. The third example is the scheduling of a crane at a port. The importance of this case was noted by Peterkofsky and Daganzo (1990). They reported that a typical cargo ship spends 60% of its time in port, at a rate of about $1000 per hour. Each ship has several holds, and each hold requires either loading or unloading. A crane represents a machine, and a ship and a hold can be considered as an order and a job, respectively. A ship stays at berth until all work on the ship is completed. The objective is to minimize the total time that the ship spends in port.

In recent years, managing the efficiency of a supply chain has become an important topic for academic research and practical application in shop. How to deliver the products to a customer on time is an important task. Most customer orders must be delivered at a suitable time to the customer to allow them to carry on with their manufacturing process. Therefore, customer order scheduling is an important topic for improving customer satisfaction and providing a competitive advantage.

Unlike most of the classical scheduling literatures, COS is not only concerned with individual jobs. In this study we consider the entire customer order. In our review of the literature there were only a few studies that focused on the customer order scheduling problem (Table 1). Most of the studies focused on the single machine or parallel machine system and tried to find an optimal solution. Julien and Magazine (1990) assumed a job-dependent set-up time for two different types of jobs. They assumed a Dynamic Programming (DP) algorithm for the single machine problem when there are only two types of jobs and the batch processing order is fixed. The objective here is to minimize the total completion time of the orders. Coffman, Nozari, and Yannakakis (1989) considered the same problem as that of Julien and Magazine (1990) under the assumption that the batch processing order is not fixed. In addition, Baker (1988), Gupta, Ho, and van der Veen (1997) and Gerodimos, Glass, and Potts (2000) also focused on the single machine case.

Yang (2005) introduced the relatively new class of the case of COS for parallel machines. He proposed an optimal solution procedure for each of several problems with different types of objectives, job restrictions, and machine environments. Yang and Posner

Table 1
Analysis of COS related researches.

Authors	Shop's condition			Jobs' condition			Methodology			Performance indicators	
	Single machine	Parallel machine	Multiple machines	Job shop	Single process	Multiple process	Optimization	Heuristics	Flow-time oriented	Due-date oriented	Delivering oriented
Wang and Cheng (2007)			V		V		V		V		
Erel and Ghosh (2007)	V				V		V		V		
Yang and Posner (2005)		V					V	V	V		
Yang (2005)	V	V					V		V		V
Ahmadi et al. (2005)			V		V		V		V	V	
Gerodimos et al. (2000)	V				V		V		V		
Blocher et al. (1998)				V		V		V	V	V	
Blocher and Chhajed (1996)		V			V		V		V		
Gupta et al. (1997)	V				V		V		V		
Webster and Baker (1995)	V				V		V		V		
Peterkofsky and Daganzo (1990)		V			V		V		V		
Julien and Magazine (1990)	V				V		V		V		
Daganzo (1989)		V			V		V		V		
Coffman et al. (1989)	V				V		V		V		
Baker (1988)	V				V		V		V		
Santos and Magazine (1985)	V				V		V		V		
MFV[a]				**V**		**V**		**V**	**V**	**V**	**V**

[a] MFV is developed by this research.