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DUE DATE SCHEDULING MODELS IN MAKE TO ORDER FIRMS

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ABSTRACT

Scheduling problems are NP – Hard combinatorial optimization problems, since many algorithms have been developed which offers new promising insights for solving resource allocation problems. Most of the literatures with lead time and pricing decisions focus only on simple models dealing with single machines in job shop areas. These models cannot be used to make day to day operational decisions in any other industrial applications. Such decisions are required for survival of the firms in a highly competitive market. In this paper, we address the various algorithms quoted in the literature for daily operational decisions that a make to order firm faces with respect to quoting due date to the customers to an order about to be placed.

KEYWORDS: Due Date, Make to Order, Make to Service, Scheduling

INTRODUCTION

Whether it is a make-to-order system or not, due date management is an issue for every production system. However, it is of more importance when the production is triggered by customer orders. For higher customer satisfaction, a production system would prefer quoting due dates for new orders as early as possible. However, it also desires to keep more slack for accepted orders so that it can retain necessary flexibility to meet these due dates in reality and to balance the opportunity cost of an early due date in the case of profit maximization. Due date scheduling (DDS) problems may be classified along several dimensions, such as the type of setting (offline/online), presence or absence of immediate or delayed quotation, type of the floor shop, objective function type, number of customer types, presence of service level constraints, etc. The typical company in the make-to-order firm has to supply a wide variety of products, usually in small quantities, ranging from a range of standard products to all orders requiring a customized product.

The arrival of customer enquiries is a stochastic process over time. Each order requires processing (transformation work) on a series of workstations. Jobs enter the production system and go to the first workstation in their routing sequence. They typically join a queue of other jobs waiting their turn for their processing work to be carried out. Once the work on a job at a workstation is completed, the job is transported to the next workstation in its routing sequence, where it again joins a queue of jobs awaiting processing. The manufacturing lead time is thus the sum of the set-up and processing times at each of the workstations in the job's routing sequence plus all of the time spent waiting in queues in front of the workstations. It is well known that in the produce-to-order sector an order can spend up to 90%of the total time in production waiting in front of or between workstations.

The literature on order acceptance and due-date setting is limited. It is reported by Stommel (1976) and Stalk G., Hout, T.M. (1992) that manufacturing lead times are often long and unreliable almost entirely due to the large proportion of time spent in the queues. An exact method for selecting a subset of orders that maximizes revenues for the static problem in which all order arrivals are known in advance is presented by Slot nick and Morton (1996), and Lewis and Slot nick (2002) have developed a dynamic programming approach for the multi-period case. A mixed-integer program for quantity and due-date quoting available to promise is presented by Chen et al. (2001). Hegedus and

Hopp (2001) consider order delay costs that measure the positive difference between the quoted due date and the requested due date of an order.

Order acceptance strategies based on scheduling methods are presented by Wester et al. (1992) and Akkan (1997). Wester et al. (1992) reported that the decision of whether or not to accept a new order depends on how much order tardiness it will introduce into the system. Akkan (1997) suggests accepting a new order if it can be included in the schedule such that it is completed by its due date, and without changing the schedule for already accepted orders. Ebben et al. (2005) developed a workload-based acceptance strategy in a job shop environment. Corti et al. (2006) propose a model supporting decision makers who have to verify the feasibility of customer requested due dates.

It adopts a capacity-driven approach to compare the capacity requested by both potential and already confirmed orders with the actual level of available capacity. Zorzini et al. (2008) investigate current practice supporting capacity and delivery lead-time management in the capital goods sector based on a sample of 15 Italian manufacturers and propose a model to formalize the decision process for setting due dates in selected cases. Another approach is order acceptance based on revenue management principles, e.g. Harris and Pinder (1995), Bertrand and van Ooijen (2000) and Geunes et al. (2006).

This paper presents the review of most promising models for quoting due dates to the customers in make to order forms. The next section discusses the three models that are applied in scheduling in a Make to order or Make to service firms.

SCHEDULING MODELS

Mixed Integer Linear Programming Model (Stefansson, H., et al, 2009)

The first step is to use a deterministic MILP model to obtain a solution based on the forecasted demand without considering uncertainty. In the next step, the alternative demand scenarios are generated based on the historical forecast error distribution and the current forecast. The demand scenarios are used as input for a linear programming (LP) model which is used to test the robustness or feasibility of the MILP solution for each of the demand scenarios. In the third step, the overall results are evaluated and if the long-term production plan is feasible enough for many of the demand samples, depending on the robustness criteria, then the current plan is used; but if not, then the demand forecast is adjusted and the MILP model is solved again iteratively until the robustness criterion has been met. The algorithm can be summarized in the following steps:

Step 1: Generate a demand forecast.

Step 2: Run the deterministic MILP model to obtain a solution based on the forecasted demand without considering uncertainty.

Step 3: Generate alternative demand scenarios based on the historical error distribution and the current demand forecast.

Step 4: Run the LP model to test the feasibility of the solution obtained in Step 2 for each of the demand scenarios.

Step 5: If the solution from Step 2 is feasible enough for many of the demand samples (depending on the robustness criteria) then the solution has been found, else go to Step 6.

Step 6: Adjust the demand forecast according to results from Step 4 and go back to Step 2.

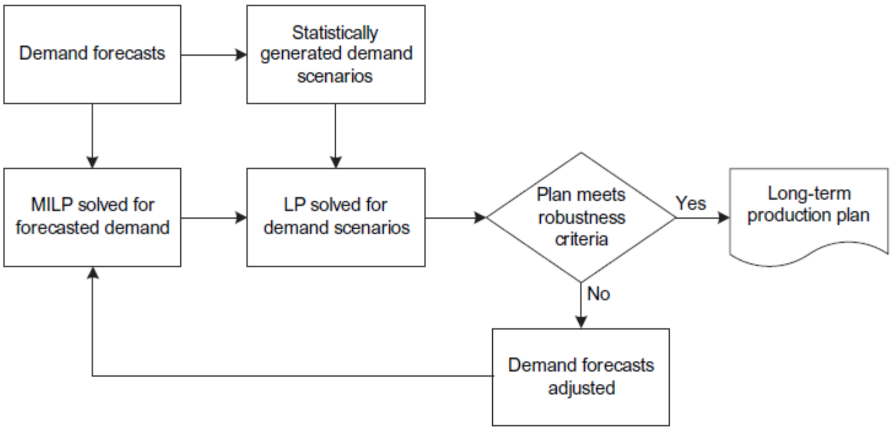

Figure 1: Mixed Integer Linear Programming Model

Bi-Objective Due-Date Setting Model (Sawik T, 2009)

In this section, integer programming formulations are proposed for bi-objective due-date setting over a rolling planning horizon (Figure 2). Two sets of integer programs are proposed: a weighted-sum program Due Date Setting, based on the scalarisation approach, and a hierarchy of two programs Order Arrival and Due Date, based on the lexicographic approach. The primary objective of the due-date setting problem is to maximize the customer service level that is to minimize the number of delayed orders O_{sum}, i.e. the orders for which the committed due dates are later than the customer requested dates. Minimization of the number of delayed orders may often lead to a large number of delayed products since a high customer service level can be achieved by setting later due dates for a small number of large-size customer orders.

Therefore, an alternative primary objective is to minimize the number of delayed products P_{sum}. Similarly, two alternative secondary objective functions are considered: minimization of the total delay Q_{sum} of all orders or minimization of the maximum delay Q_{max} among all orders, where order delay is defined as the positive difference between the committed and the requested due date. While the minimisation of Q_{sum} aims at reducing the total delay of all postponed customer orders, the minimisation of Q_{max} gives preference to a reduction in the maximum delay with respect to the requested due date of each individual order.

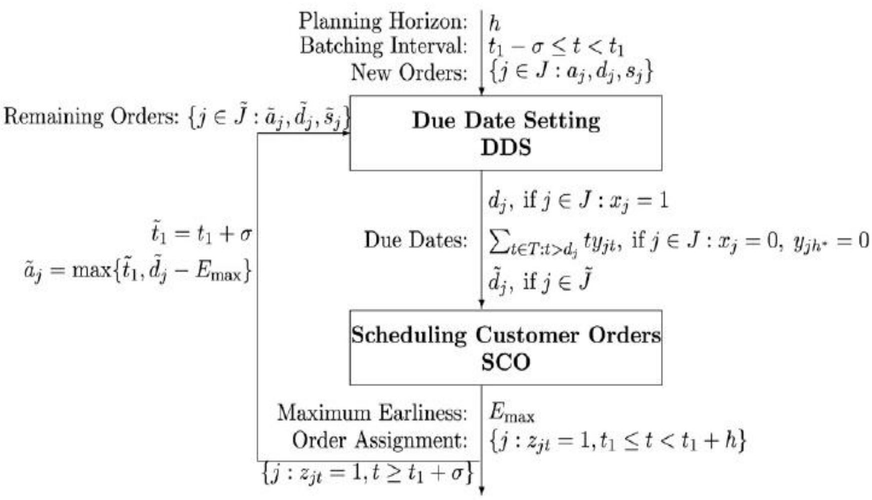

Figure 2: A Weighted-Sum Program Due Date Setting Approach

Then Due Date Setting approach can be replaced by the two integer programs Order Arrival (OA) and Due Date (DD) to be solved sequentially by using Lexicographic approach (Figure 3).

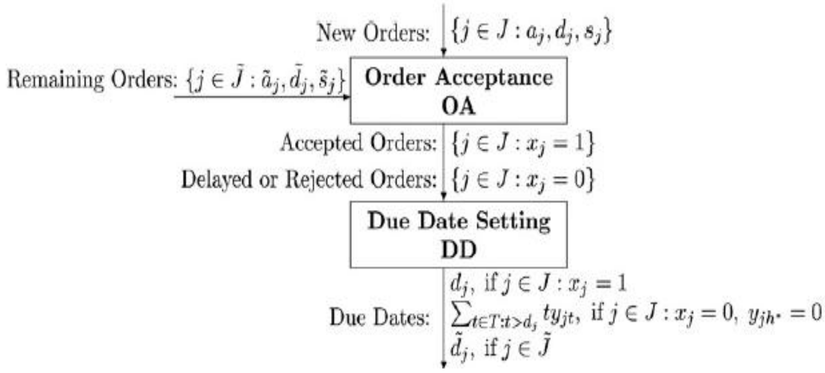

Figure 3: Lexicographic Approach - A Hierarchy of Two Programs Order Arrival and Due Date Production Control and Scheduling Model (Eivazy. H et al, 2009)

Complexity increases when the system produces both make-to-stock (MTS) and make-to-order (MTO) products in order to improve the production system utilization. The proposed model encompasses two major modules: release module and dispatching module. The release module deals with two issues: prioritizing the MTS and MTO products in the job pool and determining when and which products can be released into the shop floor. The only considered issue of dispatching module is to prioritize the MTS and MTO products in the queue of each workstation whenever a machine becomes idle. The major role of this module is to release products from the job pool into the fab at the right time and in appropriate amount in order to achieve the production management objectives. Figure 4 illustrates the steps of the release module in detail. Briefly, the steps of the release module are (1) prioritizing the products in the job pool and (2) examining the release conditions and release possibility. The release module performs these two steps concurrently and continuously in the course of time. At first, the release module prioritizes the releasing products in the job pool and determines the sequence of them. Then, it examines all release conditions. If a release condition is actualized, it forms a set of products in the job pool that are eligible for release, called feasible set. Finally, it examines the release possibility of each product in order of its priority in the feasible set. The examining process continues until none of the products in the feasible set can be released.

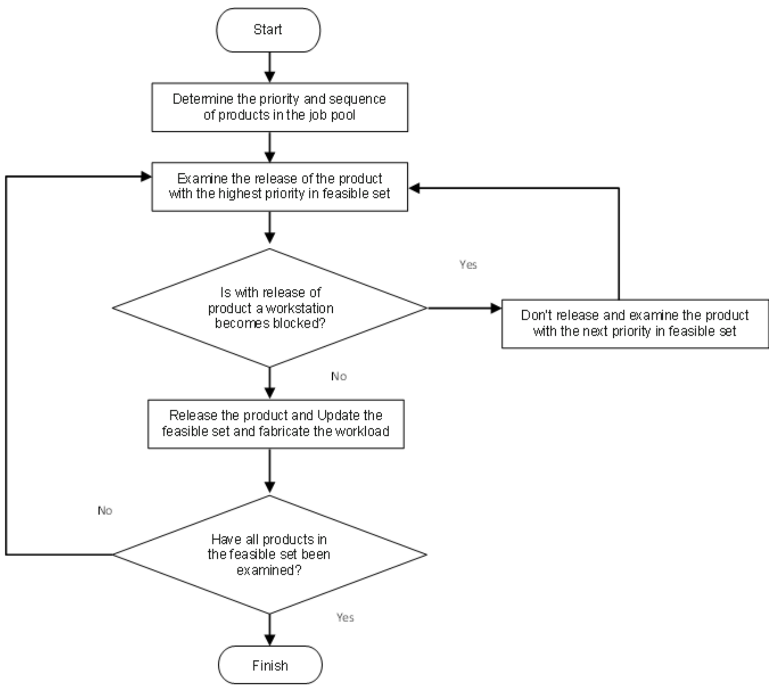

Figure 4: Steps in Release Module

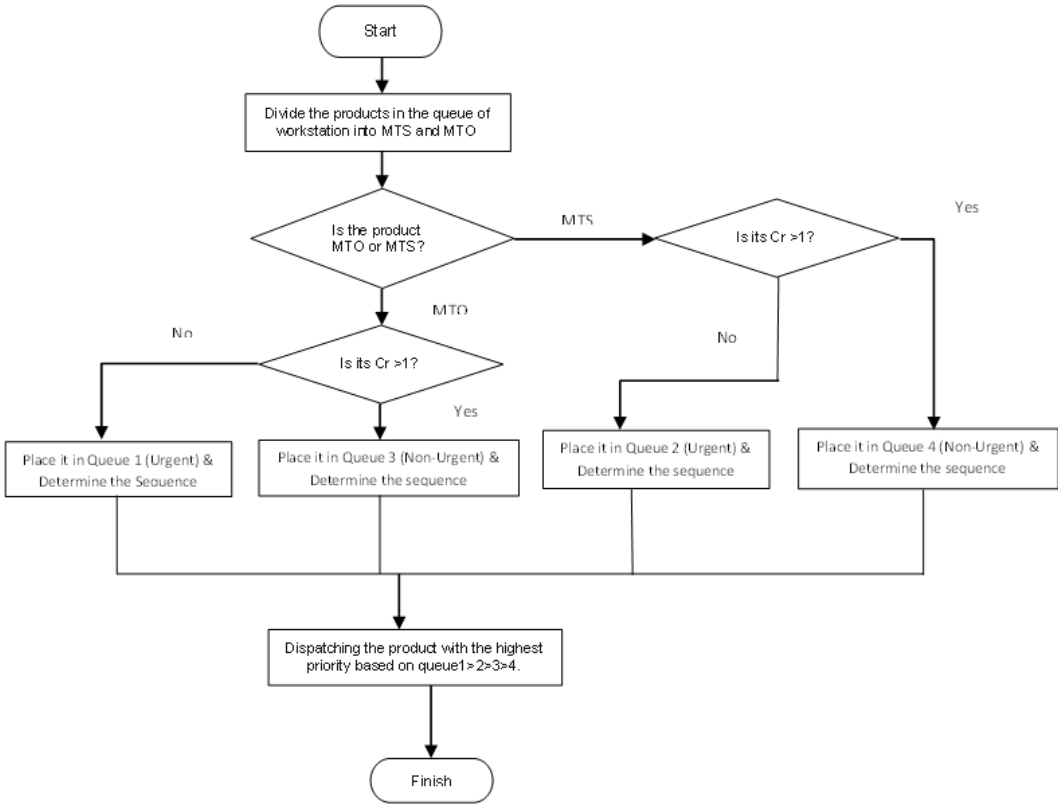

Figure 5: Steps in Dispatch Module

The prioritizing and sequencing the products in the queue of each workstation is the only decision that should be made in the dispatching module. Here it tries to create a balanced production line by imposing WIP balancing in each layer and between two adjacent layers of MTS products. The different steps of the proposed dispatch module are depicted in Figure 5. The critical ratio is computed using the below stated formula:

$$\text{Critical Ratio (Cr)} = \frac{\text{Due Date of Part} - \text{time}}{\text{Expected Remaining Processing and Waiting Time}}$$

CONCLUSIONS

This paper provided a new insight into what can be today's starting points in scheduling models research. We hope that this paper inspire more researchers in the area of automated planning and scheduling to analyze these three models and develop algorithms for new research issues.

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