A Framework for Enhancing Responsiveness in Sales Order Processing System Using Web Services and Ubiquitous Computing Technologies

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Abstract. This study attempts to enhance the responsiveness of enterprises by adjusting the delivery dates taking into account of the production and delivery schedules in a supply chain. To enhance responsiveness, we suggest a due-date assignment method and re-negotiation process for a sales order processing system. The due-date assignment method is designed with the concept of categorized customers' priorities and the re-negotiation process is designed with the concept of the partial delivery and due-date delay allowances. Usually, the due-dates have been considered as customer-assigned exogenous parameters or fixed endogenous variables set by manufacturers. However, those are customary in some industries, e.g. semi-conductor manufacturing, that customers often request changes for their delivery dates after placing an order if something unexpected happens. From these observations, we also propose a new architecture of responsive sales order processing system based on Web Services and Ubiquitous Computing technologies for reliable real-time information.

Keywords: responsiveness; due-date assignment; web services technology; ubiquitous computing technology

1 Introduction

This study attempts to enhance the responsiveness of enterprises with regard to the production and delivery schedules in a supply chain. According to Christopher [1], the real competitions are not between companies, but rather they are between supply chains. Production cost and quality are not distinctive competencies; they might be necessary conditions for manufacturing firms to survive. Flexibility and

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responsiveness are becoming distinctive competencies in the age of limitless global competition.

The sales order processing is one of the most important business processes to enhance the responsiveness of a manufacturing firm [2] and due-dates have great influence on the performance of sales order processing. Therefore, well-structured and flexible due-date managements are expected in responsive sales order processing.

In academia, the due-dates have been considered as customer-assigned exogenous parameters or fixed endogenous variables determined by manufacturers. However, those are customary in some industries, e.g. semi-conductor, that customers often change their due-dates after placing an order by a re-negotiation process if something unexpected happens. From these observations, we propose architecture for responsive sales order processing system based on Web Services and Ubiquitous Computing technologies. And we also suggest due-date assignment methods for three categorized customers based on their priorities and a re-negotiation process.

The remainder of this paper is organized as follows. Section 2 reviews previous studies related on sales order processing. Section 3 presents problem descriptions, due-date assignment methods, and proposed architecture for responsive sales order processing system. In section 4, we describe due-date re-negotiation process. Finally, we give some concluding remarks in Section 5.

2 Literature Review

There have been a great number of articles on sales order processing over the decades. Works on due-date related studies can be categorized into due-date assignment problems and order acceptance/rejection problems.

The due-date assignment problems consider how to quote due-dates which minimize (or maximize) the due-date related objective function. Due-dates had been considered as customer-assigned exogenous parameters in early scheduling studies. Because of finite capacity and lead time management, due-dates were considered as manufacturer-determined endogenous variables. There were several common due-date assignment rules (e.g. CON, NOP, SLK, PPW, TWK, etc.) which are rule-based due-date assignment policies. Gordon *et al.* [3] presented a review on summarized common due-date assignment studies in single machine and parallel machines. Özdamar and Yazgaç [4] proposed efficient capacity and lead time management in Make-to-Order (MTO) companies using linear capacity planning model to minimize total backorder and overtime costs. ElHafsi [5] considered rush order and partial deliveries allowance. Welker and Vries [6] formalized the ordering process to achieve responsiveness.

Order acceptance/rejection problems focus on the question whether the received order request is beneficial or not to accept. Some studies dealt with rule-based order acceptance/rejection policies ([7], [8]). More recently, several studies focused on Available-to-Promise (ATP) problems ([9], [10], [11]) in Make-to-Stock (MTS) environments and Capable-to-Promise (CTP) problems ([12], [13], [14]) in MTO environments.

There are also several studies that considered multiple priority orders ([15], [16], [17]) and cost model for rush order acceptance [18] in order processing.

There have been considerable studies in the sales order processing problems. But these previous studies considered the due-dates as exogenous parameters or fixed endogenous variables. In this paper, the assigned due-dates with pre-contracted co-operative customers are considered as re-negotiable variables. In the following section, we suggest a framework for responsive sales order processing system using Web Services and Ubiquitous Computing technologies.

3 Responsive Sales Order Processing

As mentioned above, most of the current sales order processing systems do not consider due-date re-negotiations. We can think of several reasons for such phenomenon. They may have come from:

- Contractual responsibility to meet due-dates
- Long response time for re-negotiation
- Unavailability of reliable real-time shop floor and inventory information

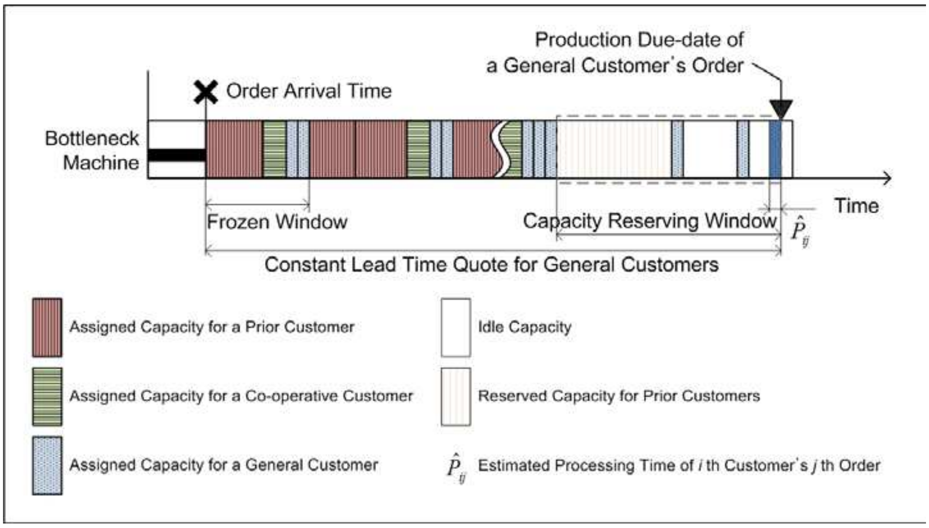
So, we are going to propose not only the method for re-negotiating due-dates between collaborating partners but also an information sharing framework for reliable real-time data based on Web Services and Ubiquitous Computing technologies, namely a manufacturing execution system (MES) based on Radio Frequency Identification technology.

In this study, we categorized customers into three types based on their priorities, namely the general, co-operative, and prior customers. General customers have low level profit contributions to the manufacturing firm, relatively small sized order quantity histories, and short term relations. Co-operative customers are different from general customers in the sense that their delivery due-dates are set with shorter buffer time, and they can make special contracts to allow for partial deliveries or due-date re-negotiations. Prior customers are such customers that have shown high level profit contributions and long term business relations. The prior customers have the privilege of asking for rush orders whose due-dates can only be set by preempting previous orders set by current production schedules.

3.1 Description of the Problems Considered

In this study, we assume the following:

1. Make-to-Order environment
2. A bottleneck machine
3. Pre-contracted co-operative customers who are willing to re-negotiate due-dates
4. A scheduling system
5. Web Services-based order management system
6. Reliable real-time shop floor and inventory monitoring system based on Ubiquitous Computing technology



- **Fig. 1.** Due-date Assignment for a General Customer's Order

We assumed a single machine case for conceptual descriptions. But, we can also think the single machine as a bottleneck machine or machine at differentiation point (i.e. decoupling point or customization point in postponement) in flow shop environment.

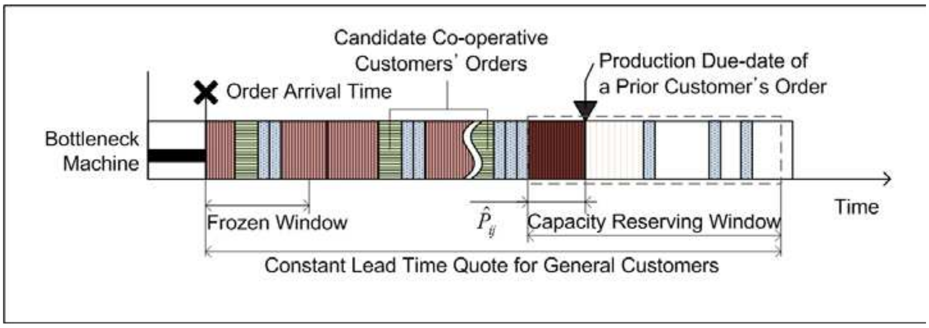
3.2 Due-date Assignment Methods

3.2.1 Due-date Assignment for General Customers' Orders

The general customers' orders are quoted constant lead time with proper buffers as shown in Figure 1. The production due-date of the order is assigned at the end of the capacity reserving window. If there is not enough idle capacity in the capacity reserving window to accept the general customer's order, the order will be delayed or rejected.

3.2.2 Due-date Assignment for Prior Customers' Orders

The due-date of a prior customer's order is assigned as shown in Figure 2. The scheduling system estimates the most favorable production completion time (i.e. the production due-date of the order) for the prior customer's orders considering current production plans and capacities. In case of a rush order, where the prior customer demands shorter lead time than the time set by the above procedure for prior customers' regular orders, then we need to find some co-operative customer who will re-negotiate their assigned due-dates which have been set already. Depending on whether we can find a co-operative customer who will concede, the prior customer' order may or may not be accepted.



- **Fig. 2.** Due-date Assignment for a Prior Customer's Order

3.2.3 Due-date Assignment for Co-operative Customers' Orders

Co-operative customers' orders are treated as general customers' one. But their orders are processed in advance among the general orders in the capacity reserving window as shown in Figure 3. In compensation for their cooperativeness, co-operative customers' orders are quoted shorter lead times and lager order quantities than general customers' lead times and order quantities.

3.3 Proposed Architecture for Responsive Sales Order Processing System

Our work proposes architecture for a responsive sales order processing system based on the Web Services and Ubiquitous Computing technologies as shown in Figure 4. The proposed system obtains reliable real-time shop floor status data through an MES based on RFID technology. This framework is important because the proposed flexible sales order processing system depends so much on reliable up-to-date information. The responsive sales order processing system is linked with enterprise resource planning (ERP), supplier relationship management (SRM), customer relationship management (CRM), and ubiquitous shop floor and inventory monitoring systems of the manufacturing firm. And responsive sales order processing

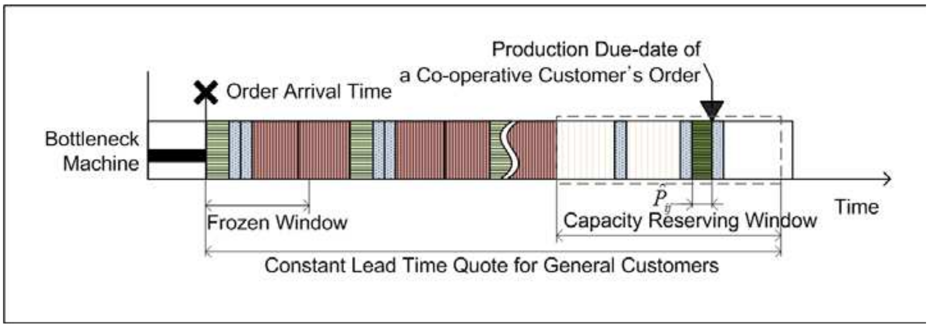


Fig. 3. Due-date Assignment for a Co-operative Customer's Order

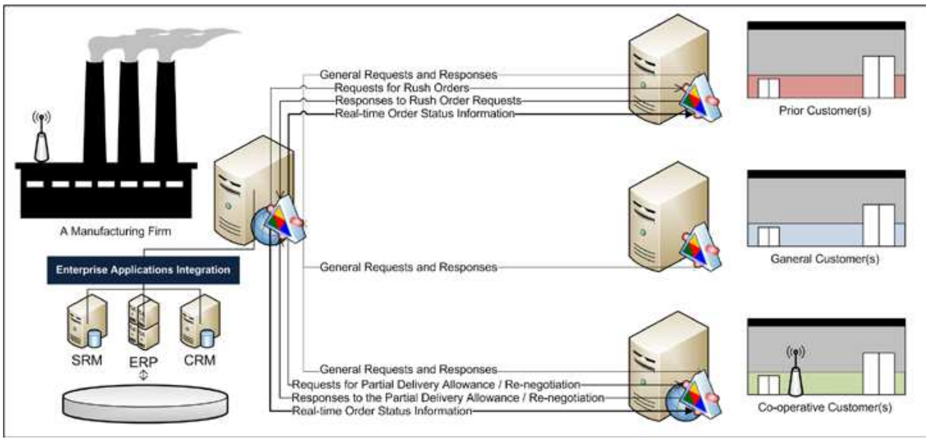


Fig. 4. Proposed Responsive Sales Order Processing System

system is connected with the customers' order management systems through Web Services.

It is assumed that there is a scheduling system to schedule production plans. The responsive sales order processing system requests to the scheduling system the following information in regular order processing stages:

- Estimated producing time of each customer's order
- Estimated production completion time of each prior customer's order
- Reserved capacity status

If a prior customer requests a rush order to the manufacturing firm, the responsive sales order processing system requests to the scheduling system ([19], [20], [21]) the following additional information:

- Capability checks
- Partial delivery and due-date re-negotiation suggestions
- Analysis on the responses from the co-operative customers

Generally, if additional requests are required, customers request to a manufacturing firm through phone, fax, or e-mail. If Web Services technology is adapted in order management systems, order requests and negotiations are automated by XML documents and Web Services. These Web Services technology reduces response time related with the sales order processing and increase the connectivity between a manufacturing firm and customers.

Ubiquitous Computing technology is being shaped up and implementation cases are being reported continually. By adopting this technology in sales order processing, visibility in a supply chain can be improved through the acquisition of reliable real-time information.

4 Re-negotiation Process

The manufacturing firm can respond to a rush order request of a prior customer by the following two stages.

1. Checking capabilities
   a. CTP check with scheduled production plans
   b. CTP check with alternative delivery channels
2. Re-negotiating with co-operative customers
   a. Build suggestions of partial delivery and due-date re-negotiation to the candidate co-operative customers
   b. Analyze the responses from the co-operative customers
   c. Build a rush order acceptance, modified offer or rejection message

In a rush order case, the responsive sales order processing system queries the co-operative customers to allow partial deliveries and due-date re-negotiation through the order management system. The requests will be processed by Web Services-based order management systems of the co-operative customers. If the request is in the predefined allowance level, the order management system responses to the manufacturing firm automatically. Co-operative customers' managers can intermediate the re-negotiation process if necessary.

Because ubiquitous shop floor and inventory monitoring system makes possible the acquisition of reliable real-time shop floor and inventory information, the manufacturing firm and co-operative customers can response quickly and viably. The manufacturing firm can provide real-time order status information (e.g. production, shipping, and delivering status, etc.) to the co-operative customers who have allowed the partial deliveries or due-date re-negotiations. This real-time information ensures minimization of uncertainties to the co-operative customers.

5 Conclusions

A partial due-date re-negotiation concept has been proposed by enhancing the connectivity and visibility of the supply chain using Web Services and Ubiquitous Computing technologies with co-operative customers. The proposed re-negotiation method could help the sales offices of manufacturing firms respond to prior customers' requests flexibly. Rush orders from prior customers, which was not possible previously, can be acceptable by the slacks gained by re-negotiations of co-operative customers' assigned orders. The whole sales order processing system can be automated under the framework proposed thanks to the Web Service and Ubiquitous Computing technologies.

We assumed that the vendors of the manufacturer have enough capacity and flexible enough to adapt to the requested change due to re-negotiation. This assumption may not be acceptable in some cases and vendors' flexibilities may also have to be considered to make this system viable.

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