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AN INVESTIGATION OF THE DISPATCHING AND EXPEDITING RULES IN BUFFER MANAGEMENT

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Abstract

Buffer Management is a proactive way of controlling the flow of materials on a shop floor. For shops using the Drum-Buffer-Rope (DBR) scheduling system, information on the effectiveness of non-constraint resources can be captured by monitoring the buffer status. Practitioners use this information to initiate improvement efforts and to decide to expedite when some of the inevitable disruptions are likely to undermine shop performance. This study attempts to investigate three areas in Buffer Management: dispatching rules, expediting rules, and variance reduction. The selected dispatching rules are First-Come-First-Served (FCFS), Shortest Processing Time (SPT) and Minimum Slack Time (MINSLK). Both static and dynamic expediting rules are compared. Reduction in the coefficient of variance for processing times from 100% to 50% corresponds to the process of quality improvement. Mean protective capacity of non-constraint resources is varied to represent different levels of loading on the shop. Inventory and due date measures are used to appraise shop performance. Simulation results indicate that the FCFS dispatching rule is the method of choice if due date performance is important. The shop using the SPT dispatching rule produces lower cycle times. The dynamic expediting rule is only preferred in the shop using FCFS and when mean protective capacity is low. The reduction in processing time variability renders a dramatically improved shop performance.

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Chapter 1
Introduction

1.1. Background

Time as a strategic source of competitive advantage has become more significant in today's changeable competitive markets (Stalk, 1988). To outperform the competition, world class companies build the distinctive capabilities of managing time into production, new product development and distribution.

The marketing function aims to capture information about customers' expectations (Lockamy and Cox, 1994). This information then needs to be translated to a form suitable for the production function. Only companies that can utilise their resources effectively will achieve fast response times to customer demands. Lead time is simply the total time required to deliver products to the customers and has been identified by many companies as a strategic measure of competitive advantage (Stalk, 1988; Carter *et al.*, 1995; Tersine and Hummingbird, 1995).

The production function critically determines a company's ability to compete on time-based dimensions. The link between actions and decisions at an operational level and competitive position must be explicit if a company is going to survive. However, the inherent variability in the shop floor makes this process non-trivial. A shop floor is characterised by two phenomena, namely dependent events and statistical fluctuations (Goldratt and Cox, 1992). Failure to accommodate these phenomena leads to poor performance, such as long lead time, long queues, broken setups, lost and defective parts, late deliveries and large work-in process inventories (Umble and Srikanth, 1990).

One way to simplify the complexity of operations is to use the Drum-Buffer-Rope (DBR) technique as a material control mechanism on the shop floor (Graves *et al.*, 1995). DBR is a novel way of managing the flow of materials on the shop floor by focusing on a few capacity constraints (Goldratt and Cox, 1992). The central premise of DBR is that the resource with the lowest capacity determines the production rate of the entire manufacturing line. Orders are scheduled according to the time availability of the constraint resource and listed in the master production schedule. A time buffer is maintained in front of the constraint resource to keep the constraint or "drum" working effectively. This buffer is required because of the variable processing times and unavoidable disruptions introduced by the upstream resources. The pace of the non-constraint resources is synchronized by controlling the input of materials to the gating operations. The "rope" regulates the order release rate to be the same as the consumption rate of the drum, so undesirable work in process (WIP) inventories do not build up. Parts are processed in a First Come First Served (FCFS) order by non-constraint resources. In this manner, DBR can achieve high due date performance of the orders and at the same time maintain the low WIP inventory (Umble and Srikanth, 1990).

The success of DBR depends on the method used to ensure that the constraint resource is never starved of work. The first task is to eliminate the worst case variability at the constraint. Thus, the constraint can effectively process the parts according to the drum schedule. The second step uses information in the buffer. Severe disruptions at the upstream resources may cause expected parts to be missing from the buffer. Workers can monitor the buffer status and from there determine the cause of those upstream disruptions that endanger the output rate of the production line. Expediting parts at the non-constraint resources is suggested if the missing part has passed the critical point in the buffer. The use of buffer status to improve the shop floor performance is called Buffer Management.

The main advantage of DBR is its ability to stabilise the amount of WIP in a production facility and to protect the critical resource, thereby providing stable lead times. A further advantage of applying DBR and Buffer Management is the ability to help decision makers characterise the key strategic factors, as a basis for planning an appropriate course of action for operations improvements on the shop floor. These efforts enable practitioners to focus on ongoing improvement and to increase profit, as a result of fast response time to customers' needs (Goldratt and Cox, 1992). Therefore, the method of DBR and Buffer Management simplifies and improves the manufacturing shop and also highlights many opportunities to improve the shop. The next section addresses these opportunities.

1.2. Problem Statement

Under DBR, the methods managers use to load a shop is based on a relationship between resource capacity and queue time. Delivery promises are given according to the constraint's schedule. To protect the constraint from starving, due to inevitable processing disruptions at non-constraint resources, a buffer of work, measured in time, can be placed in front of the capacity constraint. If one of the upstream resources breaks down, its spare capacity, termed protective capacity can be used to rebuild the constraint's buffer, once it has been repaired.

Materials or parts are released to the shop to arrive at the constraint resource a buffer time before they are due to be processed. Materials move through the non-constraint resources in FCFS order. A resource is authorised to work as soon as possible with the earliest part that has arrived. Instead of FCFS, there is no requirement for sophisticated priority dispatching rule used to choose the part from a queue, since the WIP inventory is only allowed to build up in front of the constraint resource (Gardiner *et al.*, 1993). However, in the situation when the material release control is steady and the protective capacities vary, managers may need alternative priority dispatching rule in order to increase due date performance such as minimizing lateness and thereby lead time. Therefore, the opinion that it is sufficient to merely use simple dispatching rules with DBR needs to be verified.

Buffer Management regularly evaluates the ability of non-constraint resources to process parts through to the buffer. Buffer status data is used to ensure the performance of the drum, as well as maintaining timely product deliveries. Buffer Management reacts to expedite the missing part at the non-constraint resources only when it has passed a half time buffer (Schragenheim and Ronen, 1991). This half time buffer is called the critical point because a late part after this point potentially endangers the master schedule. This expediting rule refers to the static checking point at the time buffer, after Goldratt and Fox (1986). As an alternative, Hurley (1996) proposes a more proactive approach to determine an action to expedite a missing part, using a dynamic checking point. An expediting action is taken if the remaining production time needed by a part to arrive at the buffer is less than the time remaining of a part to arrive at the critical point. This delta time indicates a need of expediting to give priority for a late part processing through upstream resources, enabling it to arrive when it is needed by the constraint. Since the protective capacities of the non-constraint resources vary, it is important to know the effect of the different expediting rules on the shop performance. A comparison test would also indicate the effectiveness of different expediting rules.

If an action to expedite a part is taken, the primary dispatching rule is temporarily ignored. However, expediting should not be used to "cover up" problems in the process or at the expense of increased WIP inventory. Process improvements, such as reducing variance, help to ensure timely product deliveries. Hence there is a need to examine the effect of reducing variance on shop performance. Thus improvement efforts can be carried out to reduce variability of processing time, as well as the possibility to reduce WIP inventory. More stable processing times lead to reduced protective capacity and buffer sizes.

In summary, three problems in DBR and Buffer Management have been identified. First, the benefit of simple dispatching rules such as FCFS is under question. The second problem is the comparison of static checking point and dynamic checking point to determine an action for expediting. The last problem is to evaluate the importance of quality improvement in Buffer Management, such as reducing processing time variance. Implementing this quality improvement can reduce the frequency of expediting. Thus Buffer Management should fully protect the constraint schedule and guide quality improvement efforts, that have a positive impact on the organisational performance along time-based dimensions.

1.3. Outline of the Study

Considering the objectives of the study, three research questions can be identified that guide the application of simulation to provide the appropriate answers. The questions are stated as follows:

1. Can it be shown statistically that the effect of the FCFS dispatching rule under DBR on shop performance is superior to other selected dispatching rules, given various levels of mean protective capacities?
2. Is the effectiveness of dynamic checking point superior to the static checking point for determining when to expedite?

3. Does the reduction of variance on the processing times of the upstream resources positively impact shop performance?

1.4. Importance of the Study

The findings can be used to generate new knowledge about the strategy used to effectively implement DBR and Buffer Management. The interpretation of the results also provides some implications for the practice of DBR and Buffer Management. Little is known of the effect of dispatching rules, expediting rules, and variance reduction under DBR environments. The need for this extension to Buffer Management research has been identified by Hurley (1996).

Research results will assist managers in conducting ongoing improvement. Managers will know where improvement can be used to cut current lead times without having a detrimental effect on organisational performance. For instance, the efforts of expediting can be reduced through implementing variance reduction program. In addition, managers will know how to determine the operating policies their shops use to counteract fluctuations in protective capacity, such what dispatching and expediting rules should be used.

1.5. Organisation of the Study

This introductory chapter has outlined the background, the problem, the purpose and the significance of this study.

Chapter two presents the theoretical frameworks of this study. It contains an outline of the fundamental concepts of DBR and Buffer Management, previous research on DBR, and a critique of current research and a summary.

Chapter three describes the methodology of this study, including model formulation. Model formulation incorporates dispatching rules, expediting rules and variance reduction. Chapter four discusses the simulation results and analysis. Chapter five provides some recommendations for future study. Finally, Chapter six presents a summary of significant findings and conclusions.