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Travel time estimation and order batching in a 2-block warehouse

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Abstract

Order batching problem (OBP) is the problem of determining the number of orders to be picked together in one picking tour. Although various objectives may arise in practice, minimizing the average throughput time of a random order is a common concern. In this paper, we consider the OBP for a 2-block rectangular warehouse with the assumptions that orders arrive according to a Poisson process and the method used for routing the order-pickers is the well-known S-shape heuristic. We first elaborate on the first and second moment of the order-picker's travel time. Then we use these moments to estimate the average throughput time of a random order. This enables us to estimate the optimal picking batch size. Results from simulation show that the method provides a high accuracy level. Furthermore, the method is rather simple and can be easily applied in practice.

Keywords: Logistics; Warehousing; Order picking; Order batching

1. Introduction

Order picking, the process of retrieving items from their storage (or buffer) locations to fill customer orders, is known as the most time consuming and laborious component of the warehousing activities (Tompkins et al., 2003). Recent trends in distribution, logistics, and manufacturing have increased the importance of order picking. In distribution logistics few-but-large quantity orders are being replaced by many-but-small orders, which have to be processed in very tight time windows. In manufacturing, there is a move to smaller lot-sizes, point-of-use delivery, and cycle time reductions. These changes make rapid

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and flexible order picking a crucial issue for many warehouse-related companies to remain competitive in today's environment. The order picking operation is therefore a strong candidate for productivity improvement studies.

There are four essential factors that greatly influence the performance and efficiency of the order picking operation. They are: (a) layout of the warehouse, (b) the routing and sorting policy, (c) the storage strategy and (d) the batching method (Petersen, 1997). In the literature, the routing and layout problem already received much attention. Roodbergen and De Koster (2001a) show that the optimal routing policy for a warehouse with multiple cross aisles can be found by using dynamic programming. Roodbergen (2001) presents a model for determining the optimal layout (i.e., number of pick and cross aisles) with respect to minimizing the throughput time for a warehouse where products are randomly stored. The influences of storage strategies on the average travel distance are investigated in Caron et al. (1998) and Petersen and Schmenner (1999). However, the batching problem, especially for the case of warehouses with multiple cross aisles, has not been considered thoroughly.

The order batching problem (OBP) concerns the decision of how to group orders and then to assign them to order-pickers. Nowadays online retailing companies that focus on specialized product types (such as books, computers or CDs etc.) often receive orders with only one or few order lines (or stock keeping units—SKUs). If the order-picker starts a tour for every order, the capacity may even be insufficient to serve all orders. If the order-picker waits to have a sufficiently large number of orders, the average time in system of the orders may be longer than desired. Clearly, we can increase the efficiency of the order picking process in such environments by serving a group of orders instead of individual orders. The critical issue is, therefore, to determine how many orders the order-picker should serve in a tour to minimize the average throughput time of a random order.

In the literature, there are several articles discussed the OBP. However, the nature of the OBP in these publications is not always the same. Many of them focus on the OBP in single-aisle automatic storage and retrieval systems (e.g. Elsayed and Lee, 1996; Elsayed et al., 1993; Hwang et al., 1988) while some others concentrate on batching methods in multiple-aisle manual-picking systems (e.g., Gibson and Sharp, 1992; De Koster et al., 1999; Gademann et al., 2001). These publications focus on one of the following objective functions: (a) minimizing the average travel distance to pick an order and thereby throughput time, (b) minimizing the maximum lead-time of any of the batches, (c) minimizing the total earliness and tardiness penalties of order retrievals. In this research, we are interested in manual-pick order picking systems, and minimizing the average throughput time of a random order. This objective is well-known and most commonly used in the order picking literature (Gibson and Sharp, 1992; Rosenwein, 1996; Caron et al., 1998; Chew and Tang, 1999; Roodbergen and De Koster, 2001a,b and many others). We now briefly mention the most recent and/or closely related publications.

Rosenwein (1996) proposes an order batching heuristic in a single-block (i.e., no middle cross aisle) warehouse. The main idea of this heuristic is assigning orders, one by one, to a picking tour until either the tour capacity constraint is encountered or the list of unassigned orders is empty. The first order in a batch, the *seed* order, is chosen randomly among unassigned orders. Further orders are added, one by one, to the batch according to one of two additional order selection rules. The first rule selects the order based on the order's center of gravity, while the other chooses the order that minimizes the number of additional aisle to be visited.

De Koster et al. (1999) perform a comparative study for order batching heuristics in multiple-aisle picker-to-parts (i.e., pickers travel to storage locations to pick the requested items) warehouses. They consider two groups of heuristics: *Seed* algorithms and the somewhat more complex (and CPU time consuming) *Time Savings* algorithms. The performance of the algorithms is evaluated using two different routing strategies: the S-shape and the largest-gap strategy. The heuristics are compared for travel time, number of batches formed and also for the applicability in practice. They conclude that: (a) even simple order batching methods lead to significant improvement compared to the first-come, first-serve batching rule, (b) the Seed