A Review of Algorithms for Order Batching Problem in Distribution Center

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Abstract—Order batching is pivotal for the efficiency of order picking operations so that researches on this problem are prevalent. The aim of this paper is to analyze and summarize the range and idea of order batching by giving an overview of the different solution approaches which have been suggested in the literature, and at last indicate tendency of future research of order batching.

Keywords—order batching; manual picking; algorithms; time window; performance

I. INTRODUCTION

Recent tendency shows that the demand of customer has been changing from large amount and small variety orders to small amount and large variety orders, and no matter when orders arrive they should be picked and delivered correctly and timely. This requires companies and enterprises who want to gain advantages to establish more efficient and flexible order picking system in competitive market. Order picking is the most important activity in distribution center and its costs may account for 50%-65% of overall operating costs for warehouse. The efficiency of this activity will directly affect customer service level. Despite several attempts to make this procedure become automatic order picking still requires a lot of manual work in practice, so that most literatures concentrate on manual picking system. Manual picking system can be distinguished into two kinds: picker-to-parts system and parts-to-picker system. With respect to system of first kind, managers face three planning problems on operative level, they are storage location, order batching and picker routing problem. Among these problems order batching is proved to be critical as good batch method contributes greatly to the productivity as well as flexibility via reducing the time needed to process customer orders.

II. OVERVIEW OF ALGORITHMS IN ORDER BATCHING PROBLEM

Order batching problem is known to be NP-hard problem. Though some of researches are based on optimization approaches, the results are limited in small scale situation. Thus using heuristic algorithm to deal with order batching is almost become common sense.

A. Classical Algorithms

The classical algorithms include priority rule-based algorithm, seed algorithm and saving algorithm. In priority rule-based algorithm, customer orders are assigned successively to batches in accordance with priorities assigned previously. First-Come-First-Server (FCFS) rule probably the most straightforward one where priority is assigned as customer order come in. Seed algorithm is introduced by Elsayed [1] in 1981, it generate batches sequentially in two phases. An initial order (seed) is chosen for a batch in selection phase, afterwards unsigned customer orders are added to the seed according to an order-congruency rule in matching phase. The methods related to selection of seed order and order-congruency rule is considered by To & Tseng et al. [2, 3]. Saving algorithm is based on the algorithm introduced by Clarke and Wright [4] in 1964 which has been applied in several ways for order batching problem. Savings are computed which can be obtained in terms of tour length reduction by assigning the items of customer orders to one batch instead of collecting them separately. In the improved version of Elsayed and Unal [5] which is known as C&W(ii) savings are recalculated each time a new assignment of customer orders to batches has been made. Classical algorithms illustrate general methods for the study of batching issue and indicate a path for subsequent researchers. These algorithms are still active in recent studies.

B. Data Mining Approach

Hwang et al. [6] consider order batching problem as a clustering problem, they bring two feature vectors to determine picking locations for each order. Three similarity measures are defined correspondingly. Their study offers a new sight of this the problem. Lee and Du [7] introduce three formulas to calculate similarity factor based on cluster analysis, they also establish cluster model for Order batching problem in which batching results are calculated through a heuristic algorithm similar to saving algorithm. After that routing length of picker is taken into account according to the batching result. For in the whole batching procedure walking distance is not involved so that the algorithm is highly simplified. Chen et al. [8] bring Association Rule (AS) into order batching. It sets foundation for the method raised by Chen and Wu [9] which combines data mining and integer programing. In this method, at first similarities of customer orders are determined by means of an association rule. For each pair of orders an order correlation measure is obtained. 0-1 integer programing approach is then used to cluster customer orders into batches. Hsieh and Huang [10] develop two new heuristics called K-means batching.
Another population-based algorithm which is prevalent in dealing with order batching problem is Genetic Algorithm (GA) introduced by Holland in 1975. GA iteratively generates a large number of possible solutions. Each of the solution is defined as an individual that could transfer their genes to next generations through mutation and crossover. This means the solution with better gene has more probability to survive. Hsu et al. [17] propose a solution to order batching problem with GA which each solution is represented by a string of integers which groups each customer order into a particular batch. The fitness of a solution is calculated by the length of tour between the longest in population and current solution. Koch and Wäschser [18] develop a mixed algorithm with GA and LS, the result shows this method predominate the benchmark algorithm in Hsu’s. Tsai et al. [19] come up with a batching model which considers both travel distance and due date. GA is used to solve the order batching and picker routing problem at the same time. Based on the study of Hsu, Wan et al. [20] consider the effect of seed order selection on optimization result. Wang [21] develop multi-objective model of order batching in order picking procedure, which considers picking rout, picking times and lead time. They solve the model with FCFS, GA and Improved Niche Genetic Algorithm (INGA) respectively.

F. Time Window Approach

Unlike the static order batching problem, a more real case is that orders arrive randomly during the time of processing previous orders. And before new order arrives the information is not available. The study under this circumstance calls dynamic order batching or on-line batching. In dynamic batching time window approach is widely used which can be carried out in two different ways, namely variable time window and fixed time window. In variable time window batching it is usually assumed that the capacity of the picking device is defined in the number of customer orders, and pickers proceed after certain amount of orders arrive. In fixed time window batching all customers orders arriving during a particular time interval are assigned to batches. Chew and Tang [22] present a travel time model of a single block order picking warehouse with variable time window batching. They design a queuing network with two queues. In the first one, customer orders arrive according to a Poisson-process and batches are generated by means of the FCFS rule. If a particular number of customer orders is in the first queue, these orders are assigned to a batch and are moved to the second queue. Le-Duc et al. [23] carry out a similar investigation of random customer order for a two block layout warehouse. A corresponding model of fixed time window is presented by Van Nieuenhuyse and De Koster [24]. Henn [25] tries to modify method in static order batching to dynamic order batching. In his model orders from customers arrive at different time point and three types of decision point are defined. At each decision point, orders which have not been assigned are considered as static. That means dynamic batching is divided into many static batching problem. For every batch decision is made whether start immediately or postpone for future possible combination. Ma and Wen [26] bring the idea of postponed manufacturing to picking process in warehouse, and propose a dynamic time window strategy based on
IV. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

A. Conclusions

This paper reviews the order batching problem at the angle of heuristics. Some of researchers attempt to apply heuristics which have been successfully adopted in other areas including data mining, neural network, artificial intelligence and so on. However, the published result of numerical experiment is based on distinct configurations such as dimension and size of the warehouse, quantity and scale of customer orders, capacity of picking devices, selection of routing strategies and so on. As a result, it seems impossible to draw a general conclusion like whether one heuristic is better than another. In spite of this, exploring faster algorithm is usually worth-while. When retrospect the history of order batching problem, focus has changed from desire to promote productivity and control the costs to accelerate respond and raise customer service level. This change react the fact that new requirements are continuously arising for any entities in supply chain. For order batching problem, it makes researchers consider more about the circumstances in real world. Like considering due date batching problem, dynamic batching and so on, future research may offer more details in literatures.

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REFERENCES


