Proceedings of the 2014 Winter Simulation Conference
A. Tolk, S. Y. Diallo, I. O. Ryzhov, L. Yilmaz, S. Buckley, and J. A. Miller, eds.

ORDER BATCHING IN A BUCKET BRIGADES ORDER PICKING SYSTEM WITH CONSIDERATION OF PICKER BLOCKING

Soondo Hong[1], Andrew L. Johnson[2], and Brett A. Peters[3]

[1]Department of Industrial Engineering
Pusan National University,
Pusan, 609-735, Korea

[2]Department of Industrial and Systems Engineering
Texas A&M University
College Station, TX 77843, USA

[3]Department of Industrial and Manufacturing Engineering
University of Wisconsin - Milwaukee
Milwaukee, WI 53201, USA

ABSTRACT

A bucket brigade strategy allows workloads in warehouses to be distributed with a minimal level of managerial planning and oversight. However, the variability and uncertainty of the pick locations within a particular order or batch often results in picker blocking and subsequent losses in productivity. This study formulates an order batching model for robust blocking control of dynamic bucket brigade OPSs. The Indexed Batching Model for Bucket brigades (IBMB) is composed of indexed batching constraints, bucket brigade picker blocking constraints, and release-time updating constraints. We show that the model minimizes the total retrieval time and improves picker utilization as much as ten percent across diverse and practical order picking situations.

1 INTRODUCTION

Order picking refers to the process of retrieving items from storage locations to fulfill customer orders. Tompkins, Bozer, & Tanchoco (2003) report that Order Picking Systems (OPSs) on average consume 55 percent of a retailer Distribution Center (DC)'s operational cost. This cost will likely be higher for an OPS under pressure to absorb demand variability from market fluctuation (Hong, Johnson, & Peters, 2012) and to resolve skill discrepancy from frequent workforce changes (Bartholdi & Eisenstein, 1996a). A bucket brigade strategy is useful for order picking both in warehouses and many types of manufacturing processes. Its characteristics of high throughput and a self-balancing property allow workloads to be distributed with a minimal level of managerial planning and oversight. To our knowledge, the relationship between the dynamic zone update and the blocking mitigation has not yet been proven.

2 APPROACH

We divide the picking area into "zones" in which a picker picks a batch (or order). Unlike other types of zone picking, the boundaries between zones are continuously updated to maintain high utilization of the pickers and to minimize the work in process (WIP). During this dynamic zone updating, bucket brigade order picking can potentially suffer from two operational drawbacks: picker blocking and hand-off delays. Since pick requirements are random over pick locations, pickers most often encounter blocking when the

978-1-4799-7486-3/14/$31.00 ©2014 IEEE

downstream picker is busy (Bartholdi & Eisenstein, 1996a). We note that picker blocking in bucket brigade order picking has received little attention in the literature, although some researchers (Bartholdi & Eisenstein, 1996a, 1996b; Bartholdi, Eisenstein, & Foley, 2001) have identified several operational rules or conditions that lead to reasonable overall operational performance in diverse settings.

Our model dynamically quantifies the blocking expected and efficiently mitigates picker blocking in bucket brigade order picking via adaptively changing the release sequence of the orders (or batches) and the batch formations. We call the indexed batching mechanism that we identify to manage the issues of blocking an Indexed Batching Model for Bucket brigades (IBMB). The model dynamically finds the best sequence and batch formation to arrange the variability and uncertainty of the pick locations within a particular order or batch. The IBMB Mixed Integer Programming formulation consists of indexed batching constraints, bucket brigade picker blocking constraints, and release-time updating constraints that help to minimize the total travel time including load/unload time, pick time, walk time, and time blocked.

3 EXPERIMENTAL RESULTS

Simulation analysis validates the quality of the operational policies provided by using IBMB. IBMB minimizes total retrieval time and improves picker utilization across diverse and practical order picking situations. Table 1 summarizes the results of varying the operational scenario and the batch size. Our batching strategy constrains each batch to be less than or equal to the capacity of the cart or picking support vehicle, *i.e.*, a constant number of items and each batch packed as tightly as possible. Typically, the expected number of picks per batch should be very close to the cart size, because the batches are packed optimally. In a standard picking situation, we find that IBMB reduces 64.4~91.1% of picker blocking with, on average, 0.18~0.64 seconds of computational time per cycle (*i.e.*, 5 batches) and that utilization improves by 2.14~6.98%. Specifically, the time blocked is 0.97~1.38% versus FCFS values of 4.75~5.05%. Hand-off delay shows minor increases or decreases.

Table 1. Experimental results from varying batch sizes and batching strategies

Scenarios	Batch	Utilization (%)			Time blocked (%)			Hand-off delay (%)			Run time
	Size	FCFS	IBMB	Diff (%)	FCFS	IBMB	Diff (%)	FCFS	IBMB	Diff (%)	(seconds)
Standard	20	89.95	93.98	4.48	5.05	0.97	80.82	5.00	5.05	-1.05	0.31
	40	91.92	95.42	3.81	4.75	1.39	70.79	3.32	3.19	4.03	0.64
Capability	20	91.31	94.02	2.97	3.20	0.28	91.11	5.49	5.69	-3.76	0.18
	40	93.94	95.95	2.14	2.43	0.48	80.37	3.63	3.57	1.62	0.28
Fast-walk	20	87.01	92.23	6.00	6.75	1.23	81.75	6.24	6.54	-4.80	0.28
	40	91.06	94.47	3.74	5.11	1.82	64.40	3.82	3.71	2.90	0.43
Small-OPS	20	84.67	90.59	6.98	7.94	1.57	80.28	7.38	7.85	-6.29	0.24
	40	90.03	93.41	3.75	5.89	2.03	65.50	4.08	4.56	-11.85	0.39

REFERENCES

Bartholdi, J. J., & Eisenstein, D. D. (1996a). Bucket brigades: a self-organizing order-picking system for a warehouse. In. School of Industrial and Systems Engineering, Georgia Tech, USA.

Bartholdi, J. J., & Eisenstein, D. D. (1996b). A production line that balances itself. *OPERATIONS RESEARCH, 44*, 21-34.

Bartholdi, J. J., Eisenstein, D. D., & Foley, R. D. (2001). Performance of bucket brigades when work is stochastic. *OPERATIONS RESEARCH, 49*, 710-719.

Hong, S., Johnson, A. L., & Peters, B. A. (2012). Large-scale order batching in parallel-aisle picking systems. *IIE Transactions, 44*, 88-106.

Tompkins, J. A., Bozer, Y. A., & Tanchoco, J. M. A. (2003). *Facilities Planning* (3rd ed.). Hoboken, NJ: J. Wiley.