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USING OPERATIONAL APPROACHES TO PREDICT THE PERFORMANCE OF LARGE-SCALE SHUTTLE-VEHICLE-TYPE MINI-LOAD AS/RS SYSTEMS

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ABSTRACT

As ever more automated storage and retrieval systems (AS/RSs) are in frequent use in dynamic logistics environments around the world, using various operational approaches to evaluate AS/RS performance becomes a more complex challenge for logistics managers. In this paper, simulation models are developed considering the approaches of both operational priorities and storage location allocation. The aims are to visualize the dynamic operation processes easily and provide rapid performance evaluation of shuttle-vehicle-type mini-load AS/RSs in a dynamic logistics environment. The simulation results show that performance indicators such as the average total flow time for storage and retrieval operations under different operational-priority rules are applicable to methods for enhancing customer satisfaction by shortening the lead time from merchandise ordering to customer delivery.

1 INTRODUCTION

Shuttle-vehicle-type mini-load automated storage and retrieval systems (SVM-AS/RSs) allow for rapid storage and retrieval, thereby enhancing the buffering function of flexible storage and sorting operations. Careful design and control of operations including storage location allocation approaches (SLAAs) and operational priorities (OPs) can result in considerable improvements in SVM-AS/RS performance.
An example of a SVM-AS/RS is shown in Figure 1. The systems considered in the present study comprise (i) lightweight shuttle vehicles installed at each storage level, (ii) storage and retrieval lifters, (iii) layer conveyors connecting the lifters and shuttle vehicles, and (iv) incoming and outgoing aisle conveyors.
The SLAA used in the present study represents how items are assigned to storage locations. SVM-AS/RSs use two main SLAAs, namely randomized storage location assignment (RSLA) and closest-to-outgoing-layer-conveyors storage (COLCS). Generally, RSLA has the best space utilization, and COLCS has the shortest expected flow time for retrieval operations. Two general OP strategies are considered in

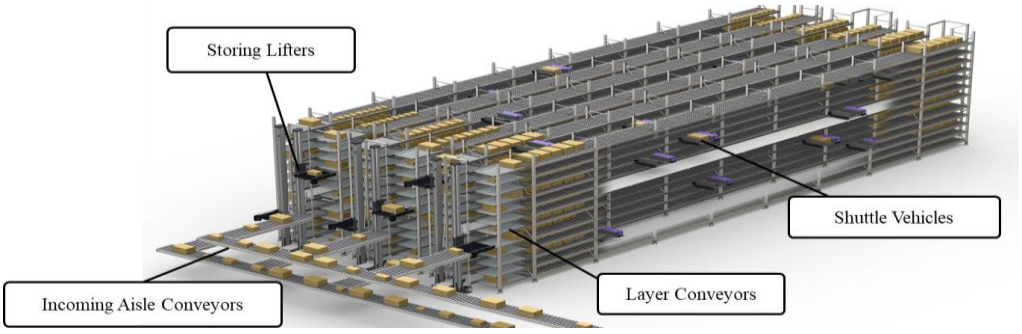

Figure 1: Example of a SVM-AS/RS.

the present study. In storage-operations first, incoming mini-loads are given preferential treatment over outgoing mini-loads. Consequently, retrieval operations are started only once when the incoming operations are finished. By contrast, in alternate operation (AO), operations can alternate cyclically between retrieval and storage.

2 CASE STUDY

Simulations have traditionally been used as a decision-making tool for logistics operations to ensure that continuous operations are maintained (Takakuwa 1994; Gaku and Takakuwa 2018). The following two sets of appropriate SVM-AS/RS specifications are considered to guarantee at least 500 racks:

Type A: 2 banks, 50 bays, 5 levels = 500 racks;
Type B: 2 banks, 45 bays, 6 levels = 540 racks.

When storage or retrieval operations experience congestion, both OPs and SLAAs must be considered. Based on (Gaku and Takakuwa 2018), the present study aims to provide rapid performance evaluation of SVM-AS/RSs in a dynamic logistics environment considering both OPs and SLAAs. Figure 2 shows the 95% confidence interval on the average total flow time for storage and retrieval operations considering two general OP strategies and two different SLAAs. Note that AO with RSLA gives the shortest expected flow time for storage and retrieval operations.

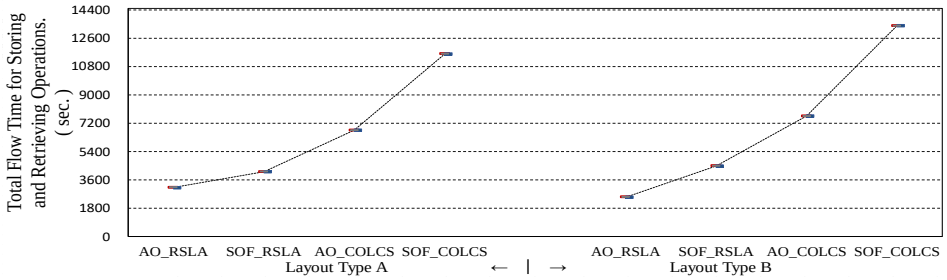

Figure 2: 95% confidence interval on the average total flow time for storing and retrieving operations.

3 CONCLUSION

It is demonstrated how simulation experiments can be performed to examine the dynamic performance of different layouts, taking both OPs and SLAAs into consideration. When storage and retrieval operations experience congestion, AO with RSLA gives the shortest expected flow time for storage and retrieval operations.

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