Storage Assignment Problem for Automated Warehouse in Manufacturing Systems*

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***Abstract*—This study addresses the storage assignment problem in an automated warehouse of the manufacturing system. The storage assignment problem is a part of warehouse operations and is particularly concerned with grouping and allocation of the products in the warehouse. In this study we focus on the part supply of the warehouse operation in the manufacturing system, which is responsible to supply parts or raw material to the processing machine in the production line. In a modern high-tech manufacturing system, part-supply warehouse is located in same building with a production line supplying parts with the automated material handling system (AMHS) such as automated guided vehicles (AGVs) or autonomous mobile robots (AMRs). Unlike the warehouse operations dealt in the context of e-commerce or supply chain management, the demands of the parts is relatively predictable and centralized-logistics control with AMHS is possible. In this study, we demonstrates that the part grouping and allocation of the parts in the warehouse plays the critical roles in the overall performance of the warehouse operations in the manufacturing systems. In addition, this on-going study shares the industry needs of the automated warehouse operation studies and propose valuable topics in this area to academic communities.**

***Index Terms*—Manufacturing system, Automated warehouse, Storage assignment problem**

I. Extended Abstract

A warehouse is a system that stores products or raw materials before distribution. As the size of the e-commerce or manufacturing system in which the warehouse system is primarily used grows, the warehouse system must store a larger amount of products and materials and finish work on a tighter schedule. For this reason, a new type of warehouse was required. As of 2007, more than 80% of warehouse systems are traditional picker-to-parts systems, where operators pick up and deliver products directly. The major drawback of the picker-to-parts system is the unproductive picker walking when picking up and delivering materials one after another [1]. In addition, inefficiency can occur due to personal factors such as physical and mental factors [2]. To address this inefficiency, a parts-to-picker system has been proposed in which materials in the warehouse move directly to the place where the order processing operator is located. Among the parts-to-picker systems, the robotic mobile fulfillment system(RMFS), in which robots deliver mobile shelves to order processing sites, was first proposed in 1989 and introduced to the market in 2003. A representative example is the KIVA system introduced by Amazon Robotics in 2008. This system was successfully applied to the field, reducing logistics costs by 20% and transportation time to 1/6.

The composition of the warehouse system based on RMFS is shown in Fig. 1. The operator in the receiving area receives the material that has arrived from the outside and delivers them to the storage area. The material is stored on the shelf, and the automated guided vehicle(AGV) system carries these shelves. AGV carries shelves to the kitting area and the material is packed and moved to the production line.

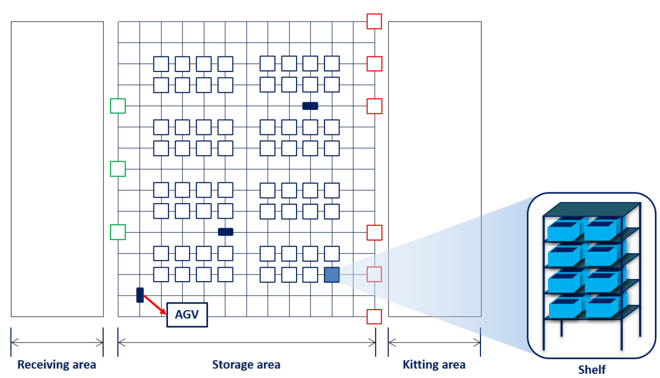

Fig. 1. Composition of an warehouse system

The target system of this study is the RMFS-based automated warehouse of the manufacturing system. The manufacturing system generates a production plan based on given firm orders and demand forecasts. Once the production plan is determined, the demand for materials required by the warehouse and the production schedule for the machines at the production line are generated. According to the production plan, the material is sent to the production line from the

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warehouse, and the products are delivered to the customer after the production is completed following the production schedule.

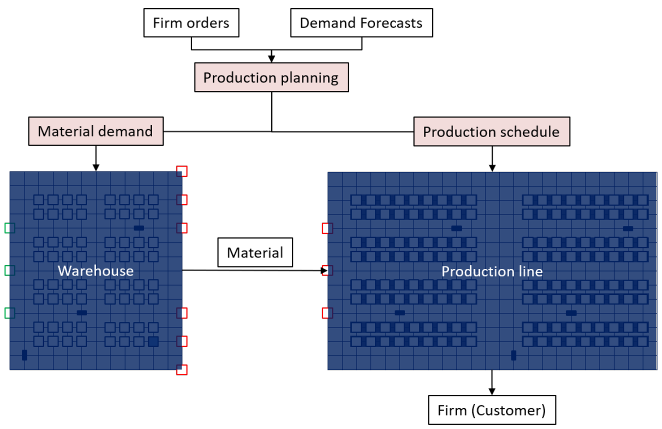

Fig. 2. Manufacturing system

In this study, we address the storage assignment problem in the warehouse reflecting the characteristics of the manufacturing system. There are many differences between warehouses for E-commerce and manufacturing systems. Previous studies generally target E-commerce warehouses and there has been no storage assignment problem study reflecting these characteristics of the manufacturing system. The warehouse of E-commerce stores finished products. The type and quantity of products include in each order are small and the order occurs completely randomly [1]. Accordingly, decision-making in E-commerce warehouses has to proceed dynamically. On the other hand, raw material is stored in the warehouse of the manufacturing system. The type and number of materials requested are larger than those of E-commerce, and the production schedule can be used when making decisions in the manufacturing system. Therefore, decision-making can proceed statically.

The storage assignment problem is shown in Fig. 3. The storage assignment problem can be largely divided into two decision-makings: the first is the storage composition decision and the second is the storage location assignment decision. In this study, we focus on the storage composition decision under the assumption that all shelves exist in the same location. Information about the request and the inventory in the receiving area is used as input data. Request information contains which type and how much of material is ordered. Inventory information contains the quantity and types of materials in the receiving area. Based on these input data, the storage state is determined by solving the storage assignment problem. The decision-making determines which materials are stored on which shelves and how much.

The objective of the storage assignment problem covered in this study is to minimize the number of shelves used to process orders. Inadequate storage assignment increase shelf usage, thereby increasing the required number of AGVs and increasing the total kitting time. Since this phenomenon causes inefficiency in the overall warehouse system, the objective of this study is to minimize the number of shelves used.

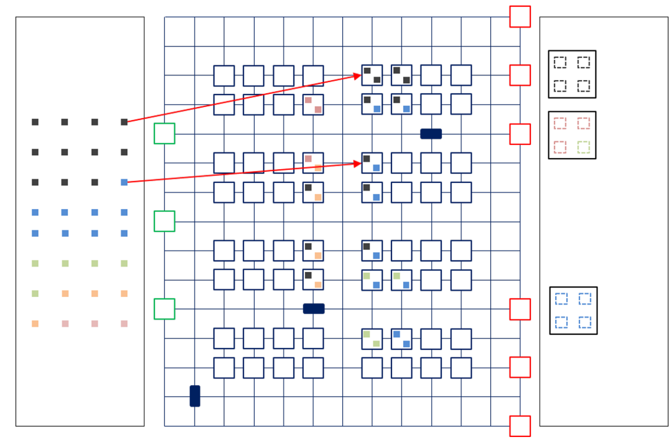

Fig. 3. Storage assignment problem

We demonstrate preliminary experiments in various mix rate cases. We show how the number of shelves, product mix, and inventory pattern impacts the overall performance of the operations with various simulation studies. We eventually provides the insights of the warehouse supply operations with AMHS in manufacturing system and possible directions for the future research.

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