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# Sequencing Picking, Packaging Operations for Stockpile Retrieval Warehousing System

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## ABSTRACT

**An extensive review on warehouse operation planning problems is presented. The problems are classified according to the basic warehouse functions, i.e., receiving, storage, order picking, and shipping. The literature in each category is summarized with an emphasis on the characteristics of various decision support models and solution algorithms. The purpose is to provide a bridge between academic researchers and warehouse practitioners, explaining what planning models and methods are currently available for warehouse operations, and what are the future research opportunities.**

## INTRODUCTION

Warehouses are an essential component of any supply chain. Their major roles include: buffering the material flow along the supply chain to accommodate variability caused by factors such as product seasonality and/or batching in production and transportation; consolidation of products from various suppliers for combined delivery to customers; and value-added-processing such as kitting, pricing, labeling, and product customization.

Market competition requires continuous improvement in the design and operation of production-distribution networks, which in turn requires higher performance from warehouses. The adoption of new management philosophies such as Just-In-Time (JIT) or lean production also brings new challenges for warehouse systems, including tighter inventory control, shorter response time, and a greater product variety. On the other hand, the widespread implementation of new information technologies (IT), such as bar coding, radio frequency communications (RF), and warehouse management systems (WMS), provides new opportunities to improve warehouse operations. These opportunities include, but are not limited to: real-time control of warehouse operation, easy communication with the other parts of the supply chain, and high levels of automation.

A number of warehouse operation decision support models have been proposed in the literature, but there remains considerable difficulty in applying these models to guide warehouse operations. The objective of this paper is to classify and summarize the prior research results, and to identify research opportunities for the future. The intended outcome is both a guide to practitioners on the analytical methodologies and tools available to support better warehouse operation planning, and a roadmap for academic researchers to future research opportunities.

This paper presents a comprehensive review of the state-of-the-art in research on warehouse operation planning. We first present a unifying framework to classify the research on different but related warehouse problems. Within this framework, historical progress and major results are summarized with an emphasis on how the research on these problems evolved and the relationships between various problems. Future research directions are identified and discussed. The scope of this paper is restricted to warehouse operation-planning methods. There are a lot of related results on performance evaluation, which we believe deserve a separate discussion since it is a key issue in warehouse design and operation that provides the basis for intelligent decision-making. The companion paper (Gu et al., 2005) provides a detailed discussion on this topic together with warehouse design, computational systems, and case studies. Readers may also refer to Rowe horst et al. (2000) for a recent survey on the overall warehouse design and operation problems.

### Section snippets

### Framework

The basic requirements in warehouse operations are to receive Stock Keeping Units (SKUs) from suppliers, store the SKUs, receive orders from customers, retrieve SKUs and assemble them for shipment, and ship the completed orders to

customers. There are many issues involved in designing and operating a warehouse to meet these requirements. Resources, such as space, labor, and equipment, need to be allocated among the different warehouse functions, and each function needs to be carefully

**Receiving and shipping**
Goods arrive to a warehouse in a carrier and are unloaded at the receiving docks. Later they are loaded into a carrier and leave the warehouse through the shipping docks. For cross-docking warehouses, received goods are sent directly from the receiving docks to the shipping docks. For traditional warehouses that hold inventory, received goods are put away into storage and later picked and shipped through shipping docks. In this case, the receiving and shipping operations are more complex to

**Storage**
Storage is a major warehouse function. Three fundamental decisions shape the storage function, i.e., how much inventory should be kept in the warehouse for an SKU; how frequently and at what time should the inventory for an SKU be replenished; and where should the SKU be stored in the warehouse and distributed and moved among the different storage areas. The first two questions lead to the lot sizing and staggering problems, respectively, which belong to the traditional inventory control area

**Order picking**
Different order picking methods can be employed in a warehouse, for example, single-order picking, batching and sort-while-pick, batching and sort-after-pick, single-order picking with zoning, and batching with zoning (Yoon and Sharp, 1996). Each order picking method consists of some or all of the following basic steps: batching, routing and sequencing, and sorting.

## CONCLUSIONS AND DISCUSSIONS

The distribution of the research results among the various warehouse operational problems is shown in Fig. 1, where the numbers in parentheses represent the number of papers addressing the corresponding problem. It is clear that the past research has focused strongly on storage and order picking. This is not surprising since these are the two warehouse functions that have the largest impact on the overall warehouse operational performance including storage capacity, space utilization, and order

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