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Using Simulation to Object-Oriented Order Picking System

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Abstract: Simulation is one of the most frequently used techniques for production system study and design. Simulation created by an object-oriented program has the advantages of hierarchical structures, inheritance, polymorphism and object re-use. This study uses eM-plant, the standard object-oriented software to model the order picking system. Order picking is an essential operation and the major cost constituent of the distribution center. This study attempts to provide the warehouse manager with order picking and operation; examines several storage assignment policies and several sensitivity analyses. The simulation experiment results can offer reference bases for warehouse administrator decision-making.

Key words: Simulation, assignment storage policy, order picking

INTRODUCTION

This study designs an efficient order picking system to reduce operating costs and improve customer service. Generally, improving order picking efficiency requires beginning from three concepts: (1) picking routing, determining the picker travel route and picking sequence of all items (2) storage assignment policy, namely developing a set of rules deciding where different items will be located in a warehouse and (3) order batching, a pre-operation conducted before the picking tour of an order.

This study discusses an order picking system involving multiple-pickers and wide aisles. The picking routing assumably adopts the return policy. This study develops a heuristic storage assignment policy which must simultaneously consider travel distance and congestion. This investigation aims to improve system efficiency via heuristic policy. This study uses a frequency-based assignment policy as a comparison under different order bating conditions to clarify the degree of improvement in heuristic policy. This study applies the simulation method to compare the efficiency of each storage policy.

Heuristic policy development involves analyzing open tandem queue networks with finite buffer. Exact queue analysis is generally complicated and time-consuming. This thesis therefore uses the approximation method proposed by Brandwajn and Jow (1988) to analyze the tandem queue network.

Rapid simulation software market expansion accounts thisopular type of tool. Various discrete-event simulation languages oriented to the manufacturing environment are used today. The eM-plant is the standard software for object-oriented, graphical and integrated modeling for simulating and visualizing business processes. The object-oriented simulation language operates by allowing the objects to pass messages. Each message represents a request to an object to perform certain functions.

This study creates an object-oriented simulation to implement a warehouse order picking system. The research objective is to provide information to the warehouse manager so that the manager more efficiently controls present warehouse situations and decision making. Furthermore, the simulation model can be web linked. The warehouse manager or all stores can search or input data to the simulation model through internet, as presented in Fig. 1.

In literature, several object-oriented methodologies and operations for the manufacturing can be found (King and Kim, 1995; Macreie and Paul, 1995). The selection of the object-oriented approach to design order picking system is mainly due to complex nature of problem (Usher, 1996).

A storage assignment policy or set of rules determining location of different items is still one of the most effective means of enhancing warehouse system performance and operational efficiency, in spite of software structure differences (Goetschalckx and Ratliff, 1990). Storage policy rules are based on demand, picking frequency, storage space, item characteristic, hazard, etc. Previous literature often refers to storage space and

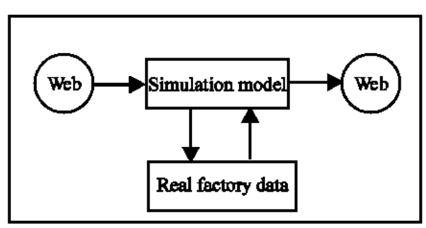

Fig. 1: Simulation in web application

picking frequency because they directly influence picking efficiency. Heskett (1963) first proposed the COI (cube-per-order index) for this reason. The COI assignment policy assigns items with a low storage space to picking frequency ratio to the location nearest the I/O point. Kallina and Lynn (1976) discussed some practical conclusions gathered from experience in applying the COI rule to assist in warehouse layout. Additionally, Caron *et al.* (1998) discussed correlation between the picks number in a tour and the differently skewed COI-based ABC curves yielded for traversal and return policies. In order to be more responsive to customers, many companies have adopted a postponement strategy (Van Hoek, 2001) leading to various value-adding activities that take place in the distribution center and which have to be scheduled and integrated in the order-picking process.

Storage policy literature is quite limited, whether for the COI rule or other rules. Schwarz *et al.* (1978) inspects automated warehouse system performance in other assignment rules through a specific storage policy that depends on item picking frequency. Gibson and Sharp (1992) and Gray *et al.* (1992) obtain a common result that locates high frequency close to the I/O point, enabling increased picking efficiency. However, they do not provide a definite assignment policy.

Sahni and Gonzalez (1976) show that the storage assignment problem is NP-complete, resulting in heuristic storage policy development. The frequency-based policy is a part of heuristic storage policies. Items are assigned storage locations according to their item picking frequency in the frequency-based storage policy. High frequency items are generally located closest to the I/O point. Riccardo *et al.* (2007) present a new integrated approach to support the decision making process in optimising a picker to part, forward-reserve, less than unit load order picking system. So this study explains several definite storage assignment policies that depend on item picking frequency (Jarvis and Mcdowell, 1991; Riccardo *et al.*, 2007).

WAREHOUSE DESCRIPTION AND ASSUMPTIONS

Consider a warehouse with three characteristics, wide-aisle, multi-pickers and limited aisle space. The order picking routing includes return strategy, one-way and L-pick tour and installed Computer Assisted Picking System (CAPS). A picker obtains order data from the host computer in the I/O point, the host computer transfers this data to a light-module and the picker then depends on the light-module to choose items under the return strategy. Light-modules in this warehouse are positioned at aisle entrances (called aisle-light-modules) and also on all racks within the aisles (called rack-light-modules). Aisle-light-modules indicate that the picker might have to pick something needed within an aisle, while rack-light-modules indicate the right place for picking required items. The picker should therefore only pick from aisles with a shining aisle-light module. The picker ignores the aisle without a shining aisle-light and moves to the next aisle. The picker wanting to enter an aisle already containing another picker waits in the buffer (waiting location) located between the upstream aisle and the target aisle until the other picker leaves; this situation is known as blocking. Buffer space is finite, so the picker can wait in the upstream aisle when the buffer is full. Therefore the blocking probability represents picking system efficiency. This is also a key point discussed in this study.

Assuming manual material handling, the picker uses a Rider Pallet Truck with infinite capacity. This study assumes that order arrival rate follows the Poisson distribution. The picker immediately culls the items required by the order upon order arrival at the warehouse I/O point. Therefore labor resources are assumed infinite. The travel time (service time) of an order within an aisle follows Exponential distribution and its average length is determined by the picking route and amount of items requiring picking within an aisle. An order picking system from the above resembles a tandem queue network with a finite buffer, with each aisle resembling a service and each picker taking an order indicating a customer.

This study analyzes total travel time of an order for individual frequency-based storage assignment using the above picking system and then measures picking system efficiency based on total travel time.

STORAGE ASSIGNMENT POLICIES APPLICATION

Most storage policies must consider two factors, namely required storage space and item picking frequency. Storage assignment sequence is assumably based on item picking frequency and storage space is ignored. The thesis named it a frequency-based assignment policy given this assumption. Items in this policy are assigned to storage based only on picking frequency and high frequency items are located close to the I/O point.

Petersen and Schmenner (1999) propose four variations of frequency-based storage policy in an order picking operation. Meanwhile, this study designs a Heuristic assignment policy and uses it to compare the Diagonal, With-aisle and Across-aisle of the frequency-based storage policy in the order picking system. The different frequency-based storage policy generates a dissimilar assignment sequence and also influences system travel time. This study objective discusses congestion for particular frequency-based assignment policies and investigates their cause and result. Thus the following process is used:

Step 1: Calculate the picking frequency for each item.
Step 2: According to frequency, we sort items from small to large.
Step 3: Determine the level of priority sequence given a particular storage policy, i.e., Heuristic or With-aisle storage policy.
Step 4: Assign each item to using various storage policies.
Step 5: Calculate the mean travel time and analyze the congestion situation for each particular storage policy.
Step 6: Use the simulation method examining and extending simulation effect.

THE ORDER PICKING FRAMEWORK

Relevant product information such as demand rate from each store is collected since product properties differ. The warehouse database also provides the present warehouse situation such as storage amount and inventory to the storage assignment method. The method produces several policies afterward. We input each policy to the simulation model and calculate policy performance. The warehouse manager makes decisions according to performance and implements the decision in a real warehouse, as presented in Fig. 2.

EXAMPLE COMPUTATION AND SIMULATION

The example includes five aisles with six storage locations in the warehouse. The warehouse I/O point is located in its lower left portion. The order picking system is based on the earlier mentioned description. Aisle serial numbers are assigned from left to right. The warehouse shape is an irregular polygon, therefore aisle buffers are not equivalent. However, waiting location capacity situated at the entrance of aisle 1 is very large because the system avoids order loss. This study exhibits data relating to this warehouse, as follows:

No. of aisles (K)	= 5
Amount of racks within aisles (S)	= 6
Rack length (H_s)	= 2.5 m
Rack width (W_s)	= 1.5 m
Aisle width (W_a)	= 3.5 m
Average velocity of truck (v)	= 0.8 m sec^{-1}
Time of picking an item (t)	= 10 sec
Order arrival rate (λ)	= 0.4 order min^{-1}
Maximum queue capacity of aisles 1~5	= 50 3 3 2 2

RESULT OF FREQUENCY-BASED ASSIGNMENT POLICY

This study uses approximation to obtain various situation probability through service rate and then uses the process to calculate mean travel time and average number of pickers in the system (Table 1).

The approximation process uses eM-plant to solve the complicated simultaneous equation model.

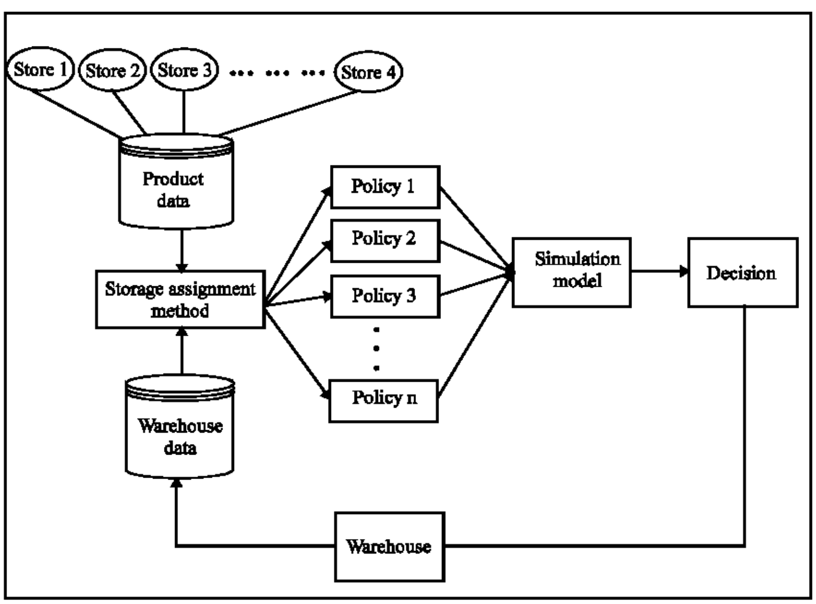

Fig. 2: The procedure of order picking system

Table 1: Average number of picker and mean travel time for frequency-based storage policies

Assignment policies	Average No. of pickers (L)	Mean travel time (T)	Over across-aisle (%)
Diagonal	3.3801	8.4503	8.9
Across-Aisle	3.1051	7.7628	-
Within-Aisle	3.4186	8.5465	10.1
Random	3.2852	8.2129	5.8

Optimal storage policy from Table 1 is obviously Across-aisle for all storage policies. Other storage policies in terms of mean travel time (Diagonal, With-Aisle and Random) are 8.9, 10.1 and 5.8% over Across-aisle policy. Travel distance using the Random storage policy is surprisingly longer than for any other storage policy, but performance using the random storage policy is better than with the Diagonal and Within-aisle storage policies. This study previously located high frequency items in the rack next to the I/O point, reducing travel distance in the order picking system. However, the order-picking route is the return strategy and is one way in this example. If the frequency-based assignment policy remains invariable, it may generate extreme workload in aisle 1. Travel distance reduces in the present example, but blocking probability increases substantially. Consequently, the system anticipates reducing travel time and thus must improve two critical factors together, as follows:

- Balance the workload of each aisle
- Reduce travel distance for all orders

CONCLUSIONS

Simulation is extensively applied in each field. This study implements an order picking system to the simulation model. Consequently, some information is obtained by the simulation model. The warehouse manager may analyze this information and find the best policy.

Object-oriented programming is a proven powerful technique, but a systematic design method should be used to implement reliable software, particularly in simulation model development. Unfortunately, the sphere falls beyond the scope of this study.

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