https://doi.org/10.48009/2_iis_2006_69-72

SYSTEM FOR ORDER ALLOCATION AMONG WAREHOUSES

Steffen Hett, University of Cologne, steffen.hett@web.de
Steve Davis, Clemson University, davis@clemson.edu

ABSTRACT

Increasing emphasis on supply chain management and growing competition in electronic commerce encourages companies to streamline order fulfillment through information systems. Many companies use more than one warehouse so they can benefit from an order-allocation system that assigns customer orders to warehouses. This paper outlines issues that must be considered in designing such a system, recommends a design approach, and indicates how the new system may be integrated with a legacy system.

Keywords: Information Systems, Order Fulfillment, Supply Chain Management

INTRODUCTION

Increasing emphasis on supply chain management and growing competition in electronic commerce encourages companies to streamline order fulfillment through information systems. Companies using more than one warehouse need an order-allocation system that assigns customer orders to warehouses.

Although some ERP systems have simple techniques for this allocation, they may not be satisfactory. For example, they may simply assign the order to the warehouse having the highest inventory level. For many companies such simple schemes are unsatisfactory because they fail to consider many important factors. Little has been published about how such a decision should be made and about how such a system should be designed. Therefore this paper investigates a new approach based on the multiple criteria decision making method.

THE ORDER ALLOCATION PROBLEM

It is easy to understand the order allocation problem by considering an example. Suppose there is one customer in New York and two warehouses, one in New York City and one in Atlanta. Both warehouses can fulfill the order, but which one should? A simple system might direct the order to Atlanta because it has a greater quantity in stock. However, shipping from Atlanta will take longer and will be more expensive. Thus the customer satisfaction will be less than if the order were fulfilled by the New York warehouse.

This example shows multiple considerations should influence the allocation decision. In this case geographical considerations are important in addition to the stock quantity. Any good solution to order allocation must consider multiple conditions and constraints, but current systems generally do not. Companies having their own warehouse(s) and distribution system usually allocate orders with a static customer assignment system. That means each customer is permanently assigned to a distribution center that is responsible for the customer's region. These distribution centers themselves are assigned to one specific warehouse. Companies owning warehouse(s) but not owning a distribution system depend on using carriers like UPS or FedEx to fulfill their deliveries. These carriers may employ dynamic allocation based upon the cheapest delivery price, but they generally do not account for issues inside the company they support.

Until the order allocation modules of ERP systems and carriers are improved, companies should consider using separate software for this purpose.

Few researchers have investigated dynamic allocation of orders employing multiple criteria. For example, Xu explored only a simple scheme that attempted to minimize outbound transportation costs [7]. Researchers have paid more attention to optimizing location of warehouses [1] and optimizing assignment of customers to warehouses [4] rather than dynamic allocation of orders.

Researchers have employed multiple criteria approaches to other problems having some concepts in common with order allocation. For example, Yahya and Kingsman [3] solved the problem of a government sponsored entrepreneur development program that allocates funds on criteria such as vendor ability, buyer needs, how the funds may aid the vendors to improve their business performance in the future, and how the funds will affects the development of the industry sector. They developed a model combining goal programming with pre-emptive priority ranking of goal constraints with a linear programming model. However, building a system based on such a model is a complex undertaking. Likewise complex are most other published approaches based on fuzzy logic sometimes combined with a neural network [2], linear programming [3], genetic algorithms [4], evolutionary algorithms [5], and compromise programming [6]. Managers may be more inclined to adopt a simpler system they can more readily understand. Thus one of our major goals was a straightforward model and system.

A MULTICRITERA SOLUTION

To guide our design, we selected a representative company. We interviewed representatives of a major cell phone company that operates several warehouses and is interested in improved order allocation. We identified three main criteria for order allocation: 1) transportation distance (that implicitly accounts for transportation time and costs), 2) stock gap between warehouses (balanced stock), and 3) stock age (first in first out). For brevity we address only basic versions of these three in this paper. However, there are more sophisticated criteria that should be considered in a complete design. For example, one could use "fastest delivery." Then the computer system may need to select a warehouse that is not the closest to the customer but due to its time zone or working hours may be able to ship the order more quickly and achieve an earlier delivery.

We can measure transportation distance using a table look-up that is based upon geographical distance or upon the road network. Inputs to this look-up may be the zip codes of the source and destination. We could measure stock gap for a specific allocation plan as a binary value that is 0 if the difference in stock levels is within a user-defined bound and 1 otherwise.

After criteria are identified, we need to determine criterion weights to express the importance of each criterion relative to the others. The weights are usually normalized to sum 1. In the case of n criteria, a set of weights is defined as follows: $w= \{w_1, w_2, \ldots, w_n\}$, and $\sum w_i = 1$. Weighting methods include ranking, rating, and analytic hierarchy process. For brevity we describe only a simple rating method because some methods, such as the analytic hierarchy process, are quite complex.

The rating method requires the decision maker to estimate weights on the basis of a predetermined scale, for example 0 to 100. One of the simplest rating methods is the point allocation approach. This method requires the decision maker to allocate 100 points across the criteria of interest. Zero indicates the criterion can be ignored and 100 means only one criterion needs to be considered. The more points a criterion receives, the greater its relative importance. Table 1 show a possible rating applied to our order allocation decision. In this example the user decided transportation distance is the most important criterion.

Table 1. Example Rating Method (Point Allocation)

Criterion	Points	Weight
Transportation distance	70	0.7
Stock gap between warehouses	20	0.2
Stock age	10	0.1

This allocation problem also has constraints, for example, availability, that are calibrated by user-selected parameter values. Another example is the user may specify whether it is allowed to allocate an order for one item to more than one warehouse. In the simplest case each order must be fulfilled by only one warehouse.

INTEGRATION WITH LEGACY SYSTEM

Typical Order Fulfillment Process in a Legacy System

Figure 1 shows a typical current process in a company using an ERP system (the legacy system). The customer sends his order to the sales department which stores the order data in the legacy database. The system considers the quantities available at each warehouse and chooses the warehouse with the highest stock. It sends a picking order to the chosen warehouse. The warehouse management system receives the picking order, checks the quantity availability of the ordered goods and forwards the order to the PC of the employees responsible for picking. After picking and handing over items to the carrier the company sends order status to the customer and the legacy database order records are updated.

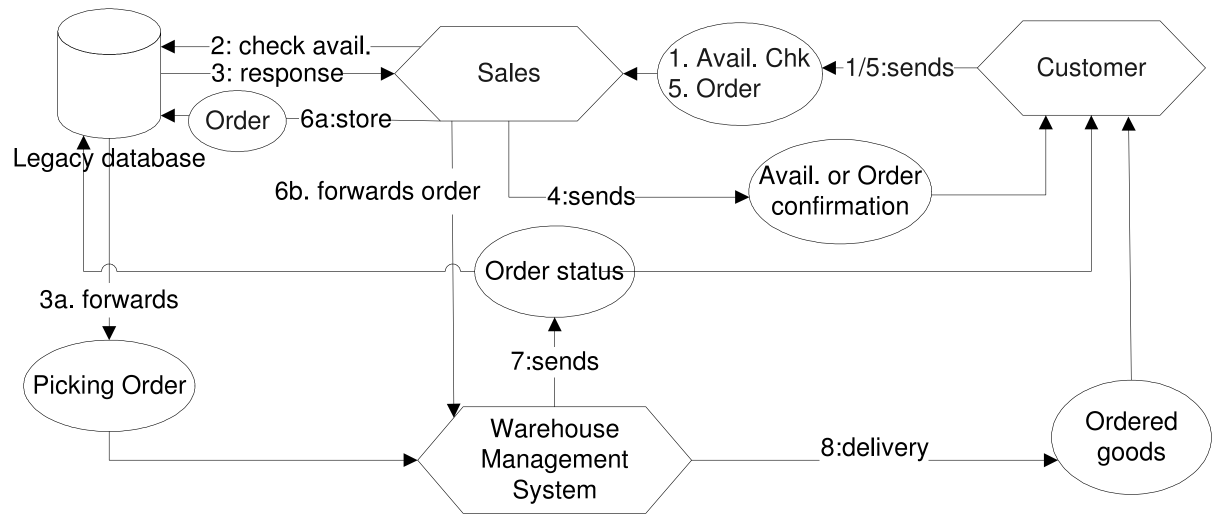

Figure 1. Typical Order Fulfillment Process

Process Modified by New Order Allocation System

We propose inserting a new order allocation process between the order taking and order fulfillment processes (Figure 2). The new process is an intermediary between the legacy order-taking process and the legacy warehouse management system. Because the allocation program appears to the legacy software as a virtual warehouse, the legacy software needs little modification. In other words, to the legacy system it seems like it is working with a single actual warehouse. So this integration scheme works well whether or not the legacy system has a warehouse allocation module.

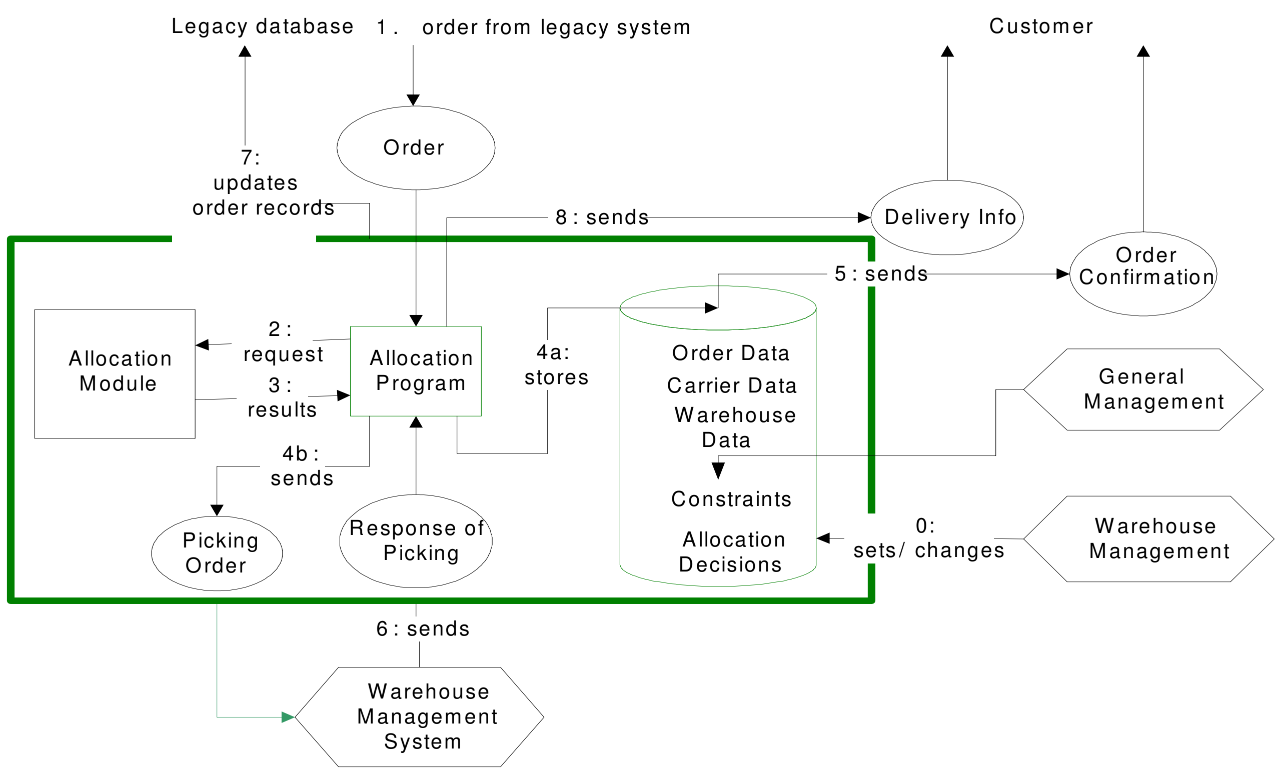

Figure 2. Proposed New Process Integrated With Legacy System

Table 2 provides an overview of the main steps in the new order allocation process.

Table 2. Steps in the Order Allocation Process

Step	Action
1	Receive order data from the order taking process
2	Request order allocation from allocation module
3	Respond with allocation decision
4a	Store allocation decision in database
4b	Forward picking order to warehouse
5	Notify customer of confirmed order
6	Receive order fulfillment status from warehouse
7	Update order data in legacy database

To support its processes, the new system needs a few new database tables in addition to the normal tables typically available in the legacy database, such as orders and products. The following types of database tables can support the new processes: management constraints, weighted priorities for decision variables, carrier data (such as shipping costs and speed), and the allocation module's allocation decision (allocation_id, allocation_date, order_id, product_id, product_quantity, warehouse_id).

CONCLUSIONS

Companies using a simple, single criteria warehouse allocation method may benefit from a system that considers multiple criteria. Such a system could be integrated with a legacy system rather painlessly if it is structured as a virtual warehouse. Then legacy software simply connects to this one rather than an actual warehouse. The decision process still needs to be relatively simple because even reasonable-looking optimization problems in this area can be very complex computationally. For example, consider the following problem: Can m orders be satisfied from k warehouses with at most m shipments? Xu showed this problem is very complex (NP-complete) [7]. However, the point allocation method we described is not very complex and it allows a manager to describe preferences in an intuitive way.

REFERENCES

1. Ambrosino, D. (2005). Distribution network design: New problems and related models. *European Journal of Operational Research 165*(3), 610-624.
2. Cha, Y. & Jung. M. Satisfaction assessment of multi-objective schedules using neural fuzzy methodology. *International Journal of Production Research 41*(8), 1831-1849.
3. Downing, C. & Ringuest J. An experimental evaluation of the efficacy of four multi-objective linear programming algorithms. *European Journal of Operational Research 104*(3), 549-558.
4. Min, H., Zhou, G., Gen, M. & Cao, Z. (2005). A genetic algorithm approach to the balanced allocation of customers to multiple warehouses with varying capacities. *International Journal of Logistics: Research & Applications 8*(3), 181-192.
5. Toffolo A. & Lazzaretto A. Evolutionary algorithms for multi-objective energetic and economic optimization in thermal system design. *Energy 27*(6), 549-567
6. Tseng, C. & Chang, N. Assessing relocation strategies of urban air quality monitoring stations by GA-based compromise programming. *Environment International 26*(7), 523-541.
7. Xu, P. (2003) *Order fulfillment in online retailing: What goes where*. M.S. thesis. Massachusetts Institute of Technology.
8. Yahya S. & Kingsman B. (2002). Modelling a multi-objective allocation problem in a government sponsored entrepreneur development programme. *European Journal of Operational Research 136*(2), 430-448.