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Optimization of Skus' Locations in Warehouse

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XXVI. OPTIMIZATION OF SKUS' LOCATIONS IN WAREHOUSE

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Abstract

Many companies, which deal with warehousing, optimize their warehouses. The main business of these companies is to offer to customers the warehousing services. It is possible to note that these companies are specialized in warehousing. On the other hand, we can find companies, which have as the main business the selling of goods to customers. These companies use the warehouses too but in a little bit different way. The arrangement of their warehouses can be very unsuitable and convenient for optimization. Our paper is focused on optimization of stored goods' locations based on market basket analysis. The solution of this task is known as well but not so many authors deal with it. A common problem for many companies is to find sets of products that are sold together. As the source of these information the history of sales transactions is used. The process of the data preparation is mentioned in this paper. The steps described in this paper are applied on real retail store.

1 Introduction

Logistic centres and warehouses constitute integral parts of supply chains. Most of them use the technology just-in-time or its modifications. From this reason it is necessary to pay the increased attention to the speed of orders completion. It is very difficult to use automated systems for goods picking from racks in case of storage of goods which are given into orders in a small amount (particular pieces). Manual completion of orders has very significant share of total operation in warehouse. Unless this activity is performed in optimal way it can lead to deterioration of quality of provided services or to growth of costs. There exist several factors described in [1, 2] which can influence orders completion. Except for warehouse technology and shelves layout the effectiveness of operation in warehouse are influenced by total distance which is necessary to travel in warehouse for one order completion. It was proposed and it is used several methods and algorithms for the best order picking in the warehouse. [3] But most of them are focused only on the shortest way of order picking. In the most cases the locations of particular goods types within warehouse are not solved.

The main goal of this research was to optimize the storage assignment of goods in the warehouse. To optimize the specified warehouse we can use the fact that customers often ordered some goods with others. It seems that the moving of related products to closer positions in a warehouse, should lead to shortening the distance required for the completion of the order. Also, the shortening of time for completion of one order by one worker should be reached. For suggestion of this assumption, we were inspired by the well-known features of e-shops. On e-shop web page, the offer of several related products is automatically shown when one item is inserted into cart. This function is based on market basket analysis.

It is possible to find different methods in the technical resources. One of them is for example decentralized location of one sort of goods within the warehouse. It enables in some cases to pick the item from location which is advantageous (closer) in certain moment. Our approach to determination of goods' locations in the warehouse is based on finding out of amount of particular items and kinds in each order. In other words, the higher turnover of item and presence in the orders the better (closer) location to finishing line. These locations are not fixed but they can be changed according to customers' behavior. The setting of new location is based on turnover of particular item. This approach is further extended by analysis of orders' structure. Using this it is possible to check whether some items are related to the others. For determination of relations among different items the methods of cluster analysis or association methods can be used. Using cluster analysis it is possible to determine the relation among different kinds of goods according to chosen criterion. The frequency of ordered goods will be chosen as this criterion. Related kinds of goods will be assigned into one group. Association method enables to determine relations among goods contained in one order. Based on results of analysis, which will be achieved by this method, it will be possible to estimate the probability of content of order. If the customer orders for example good A and together with goods B it is possible to expect (according to result of analysis) that e.g. the good C will be ordered too. This relation means that the customer orders one sort of items together with another kind. The analysis should discover the connections among some items. These related items should be located close together to minimizing distance which is necessary for their picking. Before assignment of locations to related kinds of goods the chart of warehouse must be created. This chart enables to sort the locations for goods into the groups for example according to distance from depot. Proposed chart must take into consideration the routing policies. The most advantageous locations will be assigned to related groups of goods according to amount of their orders. The primary setting of locations will be done this way. The whole system can be seen as system with pseudo-dynamic behavior. In such type of system it is about adjustment of items locations for better response on customers' behavior. These changes are based on analysis of data which are collected from operation in warehouse. It will lead to shifting of items to the better positions in specified time. The setting of period for items' location change will depend on number of orders processed during defined time. In case that the demand for stored items is dependent on season it is necessary to take into account the season influence for setting of period for items location change. The time and the volume of work which is needed for location change must not exceed savings which the change should bring. It is necessary to forecast the future volume of ordered items. Without this, the items which will not been ordered in next period could be shifted to wrong location.

2 The Definition of the Problem

The basic requirement for location of items in the warehouse is their pick-up in the shortest possible time. Before application of methods for the deployment of goods in the warehouse, it is needed to create its design with regard to the nature of the stored products and the structure of orders. Different arrangement will have e. g. a central warehouse for a chain of supermarkets, which have weekly special offers (use forward-reserved allocation, where the reserved position is occupied by the discounted items). The structure of orders for this type of warehouse is different from a warehouse that shipped goods to large number of customers. There are a number of methods which deal with the deployment of goods in the warehouse. When a method is chosen, it is necessary to deal with question to which customers the orders are intended to be shipped. This may be, for example, the end consumer or retailer. According to the study of literature a five groups of methods of goods storage assignment in the warehouse can be found: random storage, closest open location storage, dedicated storage, full turnover storage and class based storage. A special case of class based storage can be family-grouping. [3]

2.1 The Description of Real Case of Warehouse

In our case, we examined the warehouse where about 2,000 different types of products are stored. Almost all products are the single unit items. Orders are shipped directly to end users. Stored goods are not subject to seasonal influences and range of variation is very slow and not too frequent. However, the quantity of orders throughout the year varies. Currently, the storage assignment of items in the warehouse in our case is random. Individual positions are allocated according to how the goods were added to the warehouse. For this particular store is specific that the items have different shape and size. This also implies a different size of the storage positions. Items are stored in racks in several vertical positions. The warehouse has enough vacant positions and in the future is not expected to be filled very quickly. The number of positions in the warehouse is not a major problem. A fundamental problem identified was the total distance that has to be overcome in the warehouse for completion of one order. Time of order completion is related to the distance. With a large number of orders in one day it was necessary to extend the working hours and pay employees overtime or hire temporary workers. This increase costs and decrease profits, so it is necessary to eliminate these extra costs. The warehouse layout is shown on Fig. 1.

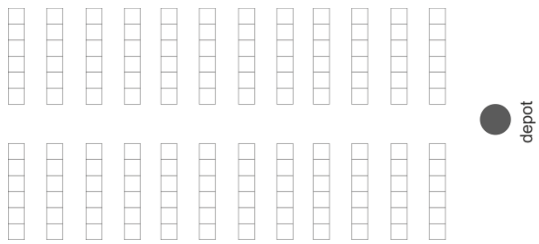

Figure 1: A Warehouse Layout.

2.2 Used algorithms

To optimize the positions within the warehouse the following procedure was chosen. First, an analysis of the structure of orders for the previous period (one year) was made. In the analysis, it was investigated how many unique items on average in the order occurs and which items are often ordered together.

Table 1: Data example

Item	Amount	Customer	Transaction	Date
10526	5	Z2040	14054221	24-May-2014
32541	2	Z2040	14054221	24-May-2014
14528	7	Z0852	14073845	28-May-2014
41201	3	Z2040	14079658	12-Jun-2014

To find related items one of the methods of association rule learning were used. The most suitable was Apriori algorithm. It proceeds by identifying the frequent individual items in the database of orders and extending them to larger and larger item sets as long as those item sets appear sufficiently often in the database.

The first step of the Apriori algorithm generates sets of market baskets. I_k is defined as the set of frequent items with k items bought together. Firstly, the algorithm filters the items with a frequency that is higher than the minsup, generating I_1. The minsup is a parameter used to control the combinatorial expansion of the exponential algorithm. In the following stages, for each I_k it generates the I_{k+1} candidates, such as $I_{k} \leq I_{k+1}$. For each I_{k+1} candidate, the algorithm removes the baskets, which are lower than the minsup. The cycle ends when it reaches I_{max_k}.

In the second step, the Apriori algorithm generates sets of market baskets and then generates association rules Left → Right. For each rule, the support measure and the confidence measure are calculated. The outputs of the Apriori algorithm are easy to understand and many new patterns can be identified. However, the sheer number of association rules may make the interpretation of the results difficult. A second weakness of the algorithm is the computational times when it searches for large item sets, due to the exponential complexity of the algorithm. [4]

When using this algorithm it was necessary to set the threshold at which the items will be marked as often ordered together. To determine the threshold value the cluster analysis was used. The purpose of this algorithm is to join together objects (e.g., items) into successively larger clusters, using some measure of similarity or distance. A typical result of this type of clustering is the hierarchical tree. As an attribute to assign to clusters, the frequency of items in orders during the reporting period was chosen. Seasonal periodicity equals to the considered period, in our case one year. This eliminated a case where during some weeks some items were not presented in orders at all, even though its total rate was among the highest. With the detected number of products within clusters it was possible to decide in the next step how many items in one order will be deemed as related. In the final step, the groups of related items were created. Not all items were assigned to some group because they were already below the threshold. Given that one item could be in several groups at a time, it was necessary to analyze the differences among created groups.

The last problem was the location of each group in the warehouse. The layout with respect to the distance from the depot was chosen. In the case of equivalent locations the second criterion was selected. As this criterion the number of operations that are needed to move items to new locations in the warehouse was chosen. Within the group at the assigned position the items were organized in honeycomb. The most ordered item was placed in the middle position of the rack. The middle position is set according to the vertical distance from floor to the highest point from that the item can be picked by worker without any other device. This middle position can be called as the most ergonomic for the picker, because he does not have to bend down.

3 Results

According to the methodology mentioned above, we analyzed over 30,000 orders that were shipped during one year. It means about 130 orders per working day that need to be completed. The lowest number per day was 53 orders; the highest volume of orders was 179 in one day. Between May and September the number of orders was above average. The most unique items in one order was 34, average number of products per one order was 22. According to this number we set the number of members of related group. Results from cluster analysis showed that the threshold value for Apriori algorithm is 1587. It means that the products within the groups are related together if such group were represented in order set in higher count. We created 8 groups of related products, but 28 % of items were contained in more than one group. Because there are enough free or non-occupied positions in the warehouse, we decided that some items will be stored in several positions. Finally we compared the total travel distance for storage assignment before and after optimization. The distance was about 14 % shorter than before optimization, because the groups of related products were moved towards depot. The new storage assignment was verified by the simulation. All orders from the day with the highest number of orders were completed during the regular work time.

4 Conclusion

Based on data mining methods we were able to reduce the total distance that the workers must go through in the warehouse to complete all orders. The methods and above mentioned procedure can be used only for similar type of warehouse. It is not applicable to warehouse where the orders are very similar and differs only in the volume of items (typically the warehouses for supermarket chain).

In a future work we want to focus on comparison to influence of number of items in one order. The question to investigate is whether there is any threshold value for average number of products in one order for which is advantageous to use family-grouping.

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