ANALYSIS OF WAREHOUSE LAYOUT IMPACT TO ORDER PICKERS ROUTING: THE CASE STUDY OF MILŠPED

Jelena Blažić [a], Aleksandra Cvetković [a*], Miloš Mijatović [a], Kristina Savić [a], Marko Trkulja [a]

[a] University of Belgrade, Faculty of Transport and Traffic Engineering, Department of Logistics, Serbia

***Abstract**: The order picking process represents the most expensive and most voluminous activity in a warehouse management, where quality of service greatly depends on this process. Layout of warehouse can have significant impact on the order picking. In this work we analyse the impact of warehouse layout for warehouse with racks, regarding the aisles and client storage zone, to routing of order pickers. Analysis is based on the real case data of Milšped company which is one of the leading logistics provider in Serbia. We observed 4 variants of layout for 4 different size clients with 50 orders each. To determine order picker routing we used the combination of several common heuristics where this routing resembles to real movement of order picking agent. The results were compared with optimal solutions.*

***Keywords**: Order picking, Warehouse layout, Routing.*

1. INTRODUCTION

Order picking is the acquisition process of certain goods based on the user's purchase order from already existing range of products located in the warehouse (order picking area). This process is very important for the warehouse management since it represents the most expensive and time consuming activity, where service quality greatly depends on it. The presence of new philosophies and strategies such as the delivery of small quantities of goods in a shorter period of time and the expansion of product range in stock in many ways makes order picking one of the most difficult warehouse processes to manage.

Forming a list of order picking and scheduling of goods in order picking zone has a major impact on the quality of the picking process. Allocation of goods in order picking zone is a task in which the goods are located in certain parts of the warehouse. In practice, there is a large number of approaches for allocation of goods in a warehouse and every approach should take care of characteristic factors concerning goods like complementary, compatibility, popularity and size. There are two basic ways for allocating goods in warehouse: (1) Dedicated storage policy - it is known beforehand where specific goods are located (the storage zones are known for certain groups of articles); (2) Randomized storage policy - goods can be stored in any warehouse location and this decision can be made when goods come into the warehouse. Before the order-picker gets the command for picking goods, the order must be processed. Customers purchase

* a.cvetkovic@hotmail.rs

order is made of number of goods and amounts that must be selected. In the warehouse management system, customers purchase order is usually being converted in order picking list which contains (besides of the name and amount of goods) picking locations of pallets with goods (from which goods should be taken). Also, in regards to what order-picking strategy is being used, the lines in the command can be sorted in a way that order-picker can go from location to location and pick goods. Command for order picker can be just one customers purchase order or few of them and that depends on order-picking strategy, size of the orders, customers demands and other factors. Typical way for order-picking is sequential, where order-picker gets picking list that contains one customer order. For processing the order in this way order picker is processing one order list at a time and no additional sorting is needed. This is the mostly used method in practice.

The selection of order picking systems depends on a number of factors such as the volume of goods, flow, the size and number of orders and etc. The typical order picking system, regarding the movement of pickers and goods, are based on a system of "man-to-load" (in the aisle), which means that the picker with hand pallet trolleys goes to the location of the product and takes certain goods. The typical storage technology for goods on pallets are selective racks with single depth (one pallet can be stored in depth of a rack). The lower parts of these racks (usually the floor level) are designed for order picking requirements (order picking zone), while the higher rack locations serves as the reserve zone for replenishment of order picking zone. Order picking can be done with so-called technologies with paper or paperless. Order picking with the paper is based on the fact that the picker receives the order that includes rows with the name of the item, quantity, number of location in the warehouse and sorted so that the order picker takes items from the list by order. Sequence of order picking is usually determined on the basis of heuristics which will be discussed later. Order picking with paperless technology means that picker receives tasks by the warehouse management system by audio or visual commands, or on hand held terminal. In any case, picker must have the order picking list in some form with the sequence of locations from where goods should be picked. This sequence is in fact the routing of order picker in the aisles of warehouse. Minimizing total warehouse routing needed for order picking influences greatly on the efficiency of warehouse processes, by lowering the costs and order fulfillment time.

2. ORDER PICKER'S ROUTING

Order picker routing problem consists of finding shortest path in a given warehouse to visit all picking location in some picking list. The visiting order of locations from a picking list has a big influence on the order picker productivity and the quality of operations. In practice, we can use heuristics or optimal algorithms to solve this problem. Heuristics obtain solutions that are applicable in warehouse, but are not optimal. Optimal algorithms are developed for specific layout characteristics of order picking zone but can have solutions that are not "close" to the human reasoning (it is hard for an order picker to fully accept the logic behind the routing sequence). In order to apply the appropriate heuristics in a particular warehouse we must consider characteristics such as picking density, type and characteristics of the technology, characteristics and units of goods, warehouse layout etc. In the following we describe commonly used heuristics in order picker routing. The first heuristics is transitory strategy (S-Shape). In this case, the order picker starts from the base, visits all aisles (until the end) in which there is a requirement for the picking of goods. Order picker doesn’t go in aisles in which there is no requirement for picking. When he finishes the last item, he comes out from the pass and returns to the base from which he started. This heuristic is carried out in warehouses where there is bilaterally order picking, which means that the order picker has a requirement for separation on both sides, and, at the same time he collects products on both sides. This heuristic is the easiest to use in practice and it’s the most frequent. The next strategy is the return strategy in which the order picker always enters in storage from the front, where the base is. Picker enters into the aisle up to the last picking location and turns back to exit on the same side. The next strategy is midpoint strategy in which the warehouse zone is divided in two parts. Order picker passes through the entire aisle only in the first and last pass. In other aisles, on both sides, picker enters up to half way and then returns. It could be used instead of S-shape if there exists only single picking location per aisle. In the third picking strategy, the largest gap, order picker travels over the entire length of first aisle, and in the each following aisle travels up to the picking location with the largest gap to next picking location in the same aisle. In the last aisle, order picker travels over the entire length, and then enters the rest of the aisles again to up to the largest gap. Fourth picking strategy is the combined strategy which represents the combination of transitory and return strategy. In this strategy, decision maker must decide whether it is better to go through the entire length of warehouse aisles or not. This strategy, in most cases represents the lowest risk strategy. The optimal strategy is a strategy in which there are no restrictions as in the above mentioned strategies. To get the shortest possible solution it is necessary to analyze all possible options of movement. This strategy cannot be applied to all types of layout and it can confuse order picker. The time required to carry out the order picking requests, in some cases depends more than 50% on order picker route of movement, and a lot less on other activities such as taking out the racks, searching for products. (Figure 1.)

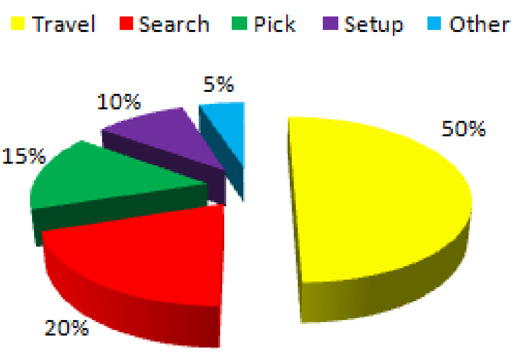

Figure 1. Typical distribution of an order picker's time (Koster et al. ,2006)

3. CASE STUDY MILŠPED

Milšped is the leading logistics company in the region. Successfully operating for 21 years and has more than 1000 employees. The modern way of work, organization of work, challenging ideas and skills to adapt to the market contributed to the successful operations of the company and has built up a unique market approach that integrates services of international road transport, air, sea and rail transport, tariff representation, warehousing and distribution and logistics car. Great work capacity and appropriate technology are able to respond to all the requirements of modern markets and to provide a complete logistics service. Milšped provides a range of integrated services in the field of storage and distribution. It has 70 000 m^2 of closed warehouse space and 40 000m^2 of open warehouse space located at many locations. The fleet consists of 150 vehicles of the latest generation. The company provides warehousing and order picking services, which is the topic of this work.

3.1 Test instances

In our test instances we had predetermined layout, client zoning and goods locations for all 4 variants (se Figure 1) are predetermined. Based on these data, it is necessary to determine the order picking list (sequence of picking) for each of the 4 variants so that the order picker's total routing is minimized. In all variants, warehousing is based on a single selective racks. In the first layout variant storage consists of one block of parallel storage areas where the transition from one aisle to another is possible only at their ends (Figure 1.a). As for the second variant, the previous block is divided in half and order picker can only enter a aisle at one side of aisle (Figure 1.b). A third example is a layout in which the block selective racks are divided with middle aisle, where picker can enter an aisle from three pints (Figure 1.c). Finally, we have a warehouse that is similar to first variant, but with the difference in aisle length (Figure 1.d). In the last two variants, due to the layout with middle aisle, total storage capacity of the picking area is decreased by 80 pallet positions (on one line racks 4 places in the first and 4 places in the second level). We analyzed four customer with 50 orders where each order has a minimum of 5 locations for picking. Clients have different sizes of picking zones, namely: 1 client has 216 locations, the client 2 has 193 locations, the client 3 has 143 locations, and the client 4 has 181 location.

3.2 Routing methods and computational results

Data analysis was done in Excel, since the test data submitted in Excel. The first step was to determine exact location of all gods in picking area for each of the four layouts, in accordance to the rules given in advance from company Milšped. In the second step, for variant and client, it was necessary to determine order picker routing for each of the 50 orders. This step represents the goal of the work. To determine the movement of order picker we used two approaches: using the heuristic method described in Section 2; and applying the optimal algorithm (Roodbergen and de Koster, 2001), which was specially developed for layouts that are observed in this study. Figure 2 presents the optimal movement of order picker for one order of client 1. The reason for observation of heuristic and optimal approach lies in the fact that some studies show that order pickers harder accept the picking determined by an optimal algorithm. That is, heuristic solutions are more "friendly" from pickers point of view and therefore more acceptable. On the other hand, observing the optimal order picker's routing can obtain insight into the quality of heuristic methods, regarding total routing distance. There are often difficulties with order pickers to adopt optimal movement because it is natural that a human has a resistance and suspicion to computer guidance. In heuristic approach, we determined the picking sequence of each order which included enter/exit points at each aisle (see Figure 2). Based on this sequence, by using Excel, we determined length of each order picking observing Euclidian distance. By summing order picking distances for all 50 orders in each variant we obtained results presented in Table 1. Additionally, results from optimal algorithm is also given in Table 1.

Table 1. The total distance of order picker's routing for each layout variant and each client (50 orders per client)

CLIENT	LAYOUT 1		LAYOUT 2		LAYOUT 3		LAYOUT 4	
	Heur.*	Opt.**	Heur.	Opt.	Heur.	Opt.	Heur.	Opt.
1	6286.6	6209.0	7715.0	7437.1	6275.8	6161.4	6742.8	6427.7
2	5587.8	4631.9	7016.7	6506.1	5236.1	4950.0	7250.6	5449.4
3	5331.4	4858.7	5224.0	4976.7	5098.5	4629.3	4750.7	4190.8
4	7068.8	6570.1	9333.4	8978.5	7036.6	6601.1	9243.3	7372.8
Sum	24274.6	22269.6	29289.1	27898.3	23647.0	22341.7	27987.4	23440.7

* Total order picker's routing distance obtained by heuristic method
** Total order picker's routing distance obtained by optimal algorithm

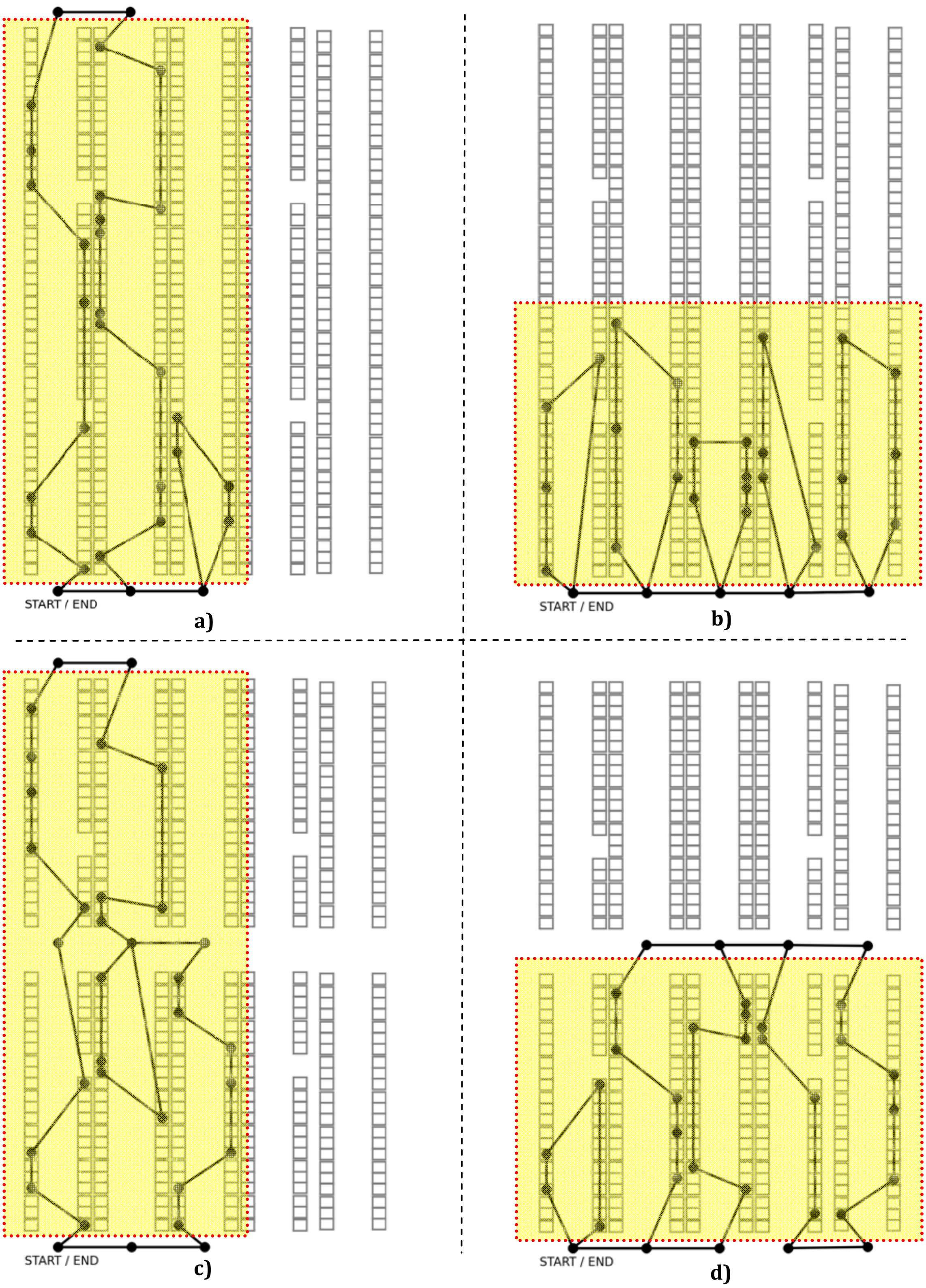

Figure 2. Example of order picker's optimal routing for an order of first client for four observed layouts (in each variant picking zone for first client is marked)

4. CONCLUSION

From the obtained results the best are layout 3 and layout 1 with a small difference between them. On the other hand, layout 2 proved to generate largest order picker's routing distance. Result are not consistent over all clients and all layout variants. For the third client layout 4 gives best results, while the layout 1 gives worst results. All other clients results per each layout variant is generally consistent to total rang. Considering the quality of heuristic approach to optimal algorithm, results show the following: for layout 1 heuristics gives 9.0 % higher routing distance, for layout 2 heuristics gives 5.0 % higher routing distance, for layout 3 heuristics gives 5.8 % higher routing distance, for layout 4 heuristics gives 19.4 % higher routing distance. In the limits of this analysis, which layout is the best, decision maker should consider the loss of locations in picking zone (for layouts 3 and 4) as well as ratio of solutions quality to "solution friendliness" (heuristics gives more human "friendly" solutions and largest travel distance compared to optimal algorithm). The results inconsistency is related to relatively small sample of observed orders and for more reliable analysis future research should include more clients and orders. Additionally, in depth and more detailed simultaneous observation of layout, goods location and orders batching, together with order picker's routing could lead to better optimization of warehouse processes.

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