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CHOICE OF ORDER PICKING CONCEPTS BY MEANS OF SIMULATION TOOLS

Abstract: The pressure connected with cost cutting parallel to increase in consumer service quality, as well as speeding up the flow of goods are the result of worldwide economy trend connected with a big competition in the market. That's why in modern economy even small movements of goods on short distances are becoming more and more important. Order picking is the most laborious process in a warehouse, and according to different research, it equals to 55–65% of costs of all warehousing operations. On the basis of the existing model of a warehouse, which belongs to a logistic operator, a computer program has been created which examines the influence, of goods allocation in a warehouse and three heuristic concepts of planning the picking route, on the overall order picking time. By means of implemented simulation methods it is possible to match the appropriate order picking process to the needs of a given enterprise.

Keywords: order picking, warehousing, storage system, picking route.

1. Introduction

The pressure connected with cost cutting parallel to increase of quality and speed of service offered, makes everyone interested in every process which directly or indirectly affects consumer satisfaction.

The report prepared by A.T. Kearney for National Council of Physical Distribution Management (NCPDM) showed that costs connected with logistic amount to 21% of American GDP, and 28% of these costs are caused by process related to order picking and storage of goods in a warehouse. The research, carried out in 1984, started a debate and many researches and experiments which aim at improving the efficiency of logistic processes were done (Kearney 1984).

The notion of order picking appeared in the literature (mainly English language) in the early eighties. Since then it has been popular with scientists and logistic managers. Order picking process is one of the basis operations carried out in distribution

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centers and regular warehouses (Goetschalkx, Ashayeri 1989). It is defined as the sum of logistic operational and organizational activities, based on the juxtaposition of given subsets (goods) from the prepared complete set (assortment), on the basis of information about demand in the form of an order. There is also a change of specific state of stored materials in the characteristic state of materials which are given out (Fijałkowski 1987; Ghiani 2004; Kizyn 2006). In order words, order picking is searching and picking goods from the storing places which are on the order list made by the client.

Picking policies focus mainly on the three problems. The first is to divide work among workers so as to minimize the time of order picking. This problem is described in details in the paper: *Simulation as a method of choosing the order picking concept* published in the magazine "Transport and Logistics" 2/2010.

Storing goods (storage policies) is another problem, when it comes to order picking. Storage policy is a strategy which allots goods to storage areas in a warehouse. As far as this strategy is concerned there are two question that can be asked, the first is technical the second connected with management. What kind of tools and techniques should be used to provide the best possible conditions for storing given commodities, and using the storing area of a given warehouse to the utmost in the same time?

The second question concentrates on the implementation of the best possible management strategy which will allow to store a given good in the best accessible place. As a result, a warehouseman should reach this place as quickly as possible. It can also reduce costs and improve consumer service quality. Two policies, which are used when it comes to choosing the storage method, deserve our special attention.

The first called *randomly storage policy* reduces the time needed for putting the good on its storage place, but, very often, it increases the time in the order picking process. The main rule in this policy is that goods are stored in the location where there is a free space in a given time. A warehouseman puts the commodities on randomly chosen space, following the rule of *closest open location*, the closer to the storage space the better (Goetschalkx, Ashayeri 1989).

In the second strategy, called *assign storage policy*, the products in a warehouse are allocated in specific areas. The choice of this areas depends on different factors. The crucial factor is that one has to follow a simple rule which says that commodities, with the fastest rotation time, need to be located as close as possible to warehouse's exits, so as to minimize the order picking time (Ghiani 2004, Kizyn 2006).

Routing policies, the methods of planning a route, are the third important point in essays about order picking. The aim of these research is to minimize the distances and the routes that warehousemen have to cover in the order picking process. Among different algorithms, which try to solve the problem of order picking routes, the most popular are heuristics algorithms. They are very common because they are very easy to implement and they match, in results, to the algorithms with accurate results (Ratlif, Rosenthal 1990). Limitations of using accurate algorithms in the warehouses are caused by the facts that new mathematical models need to be built all the time, and there are a lot of variables which one has to take into consideration while doing calculation.

2. Volume–based storage policies

When it comes to storage policies, strategies called *Volume-based storage* (Petersen *et al.* 2004) play a very important role. They concentrate on allocating the goods in a warehouse according to two main criteria. The first is based on the rule that that products with the highest rotation are stored in the most accessible areas – where a warehouseman can easily pick the ordered good. The second criterion divides products into classes according to the frequency of their appearance on the order picking lists. (the rule ABC is most often used in this strategy).

Figures 1–4 show the idea of four basic approaches in the strategy *Volume-based storage*. They differ in the way of allotting the most accessible areas in a warehouse, which will be designed for goods with the fastest rotation.

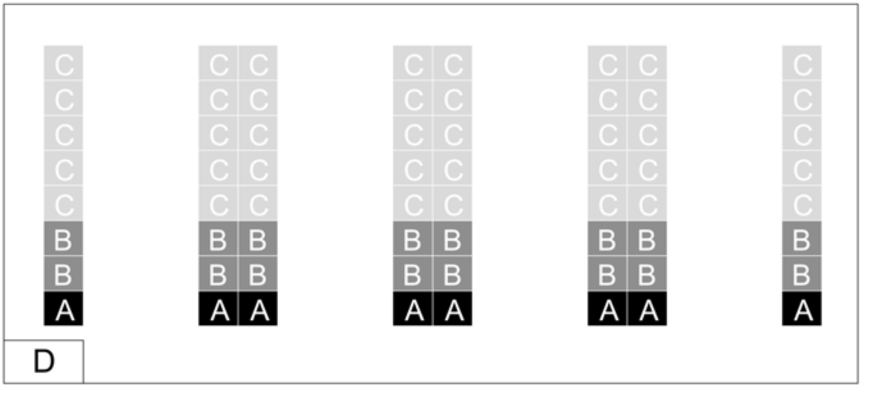

Fig. 1. *Across – Aisle storage strategy*
Source: own elaboration on the basis of De Koster et al. (2007)

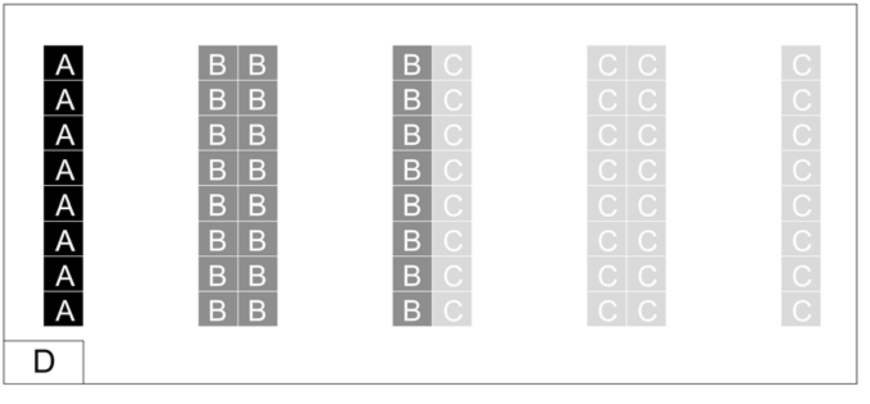

Fig. 2. *Within – Aisle storage strategy*
Source: own elaboration on the basis of De Koster et al. (2007)

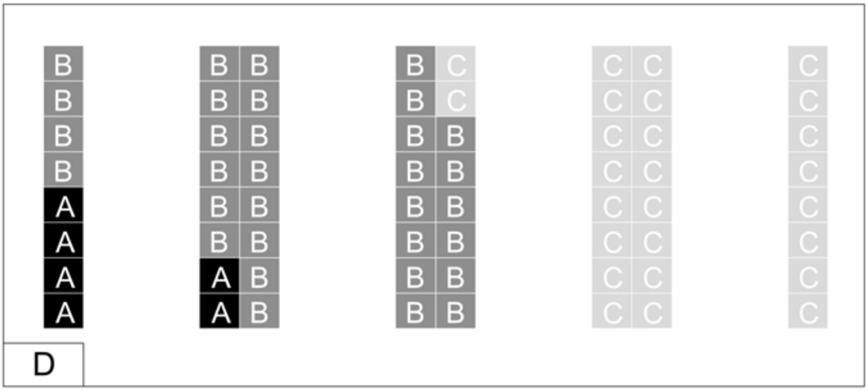

Fig. 3. *Diagonal storage strategy*
Source: own elaboration on the basis of De Koster et al. (2007)

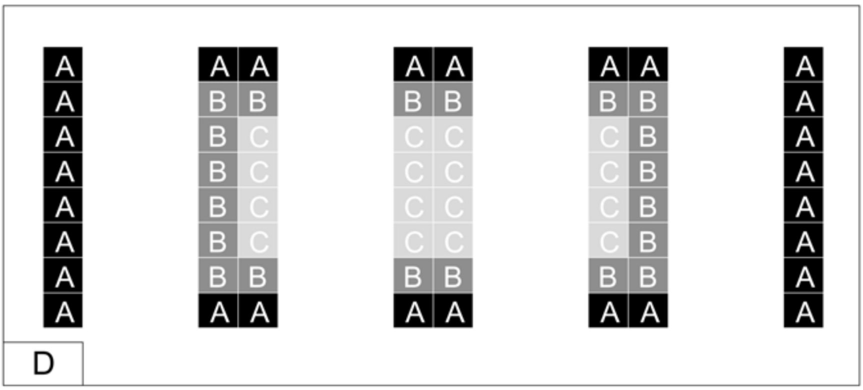

Fig. 4. *Perimeter storage strategy*
Source: own elaboration on the basis of De Koster et al. (2007)

In the Figures 1–4, the letter D stands for the start and finish points where a warehouseman, working in the order picking process, starts and finishes his way in which he picks the goods designed for shipment. The grayscale colors ABC stand for the three classes of goods and their location in the warehouse.

In *Across – Aisle storage strategy* (Fig. 1) the goods with the highest rotation are located as close as possible to the main passage which directly adjoins the point denoted by letter D. On the other hand, in *Within – Aisle storage strategy* (Fig. 2) the same classes of products are located in first rows of the warehouse counting from the point where order picking starts and ends.

In *Perimeter storage strategy* (Fig. 4) the goods with the highest rotation are located on the parts of pallet racks adjacent to the most outer passages in a warehouse.

In *Diagonal storage policy* (Fig. 3) the locations in a warehouse where order picking is the least time consuming are perceived as the most accessible areas allotted for goods with the highest rotation.

3. Heuristics approach to planning order picking routes

Examining order picking processes in a warehouse, one cannot neglect issues connected with planning and choosing the order picking route. *S-shape (traversal strategy)*, *midpoint strategy* and *return strategy* are the three main approaches to planning order picking routes.

The *method S-shape* is one of the simplest approaches to plan a route for the person who works on completing the order. A warehouseman who works according to this strategy moves between the pallet racks, where the commodities for order picking are placed, in a particular way: Starting the route at the beginning of the passage and proceeding to the next one, only when all goods have been collected from the previous passage. The whole order picking route resembles the letter "S" , this is presented in the Figure 5.

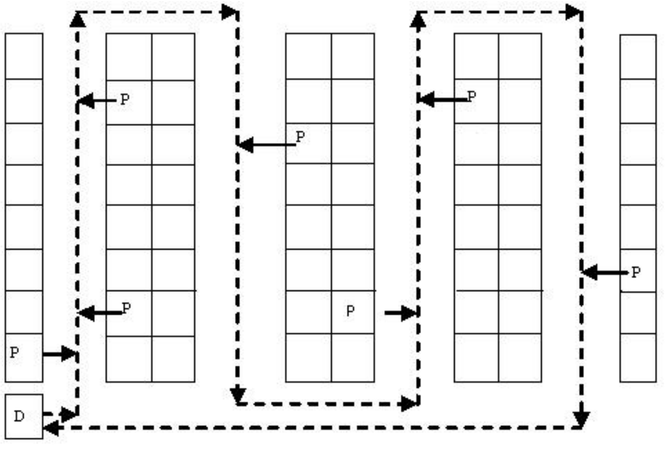

Fig. 5. *S-shape (traversal strategy)*
Source: own elaboration on the basis of De Koster et al. (2007)

In the Figures 5–7 the letter D denotes the start and end point where a warehouseman, working on order picking, starts and finishes his route during which he picks the goods (represented by letter P) for shipment.

Midpoint is another strategy which plans the order picking routes. In this strategy, a warehouse is divided into two zones. Here, a warehouseman moves, through the passage, only to the middle of the warehouse which is a border point of the first zone. The remaining commodities, which are located in the second zone of the warehouse, are picked on his way back. The outline of the *midpoint* method is shown in the Figure 6.

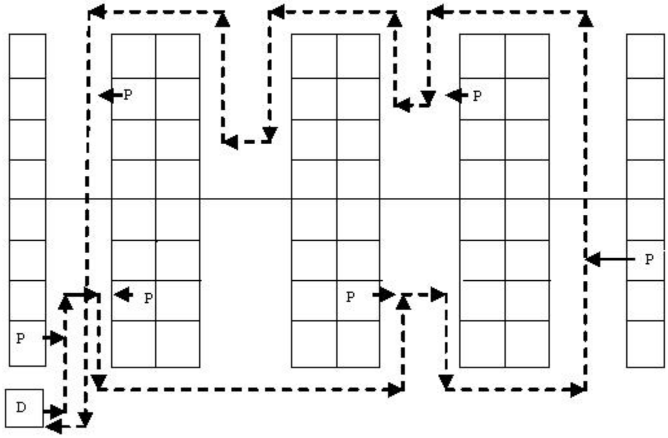

Fig. 6. *Midpoint strategy*
Source: own elaboration on the basis of De Koster et al. (2007)

The return strategy (Fig. 7) is the last heuristics approach, which plans the order picking routes in a warehouse, described in this paper.

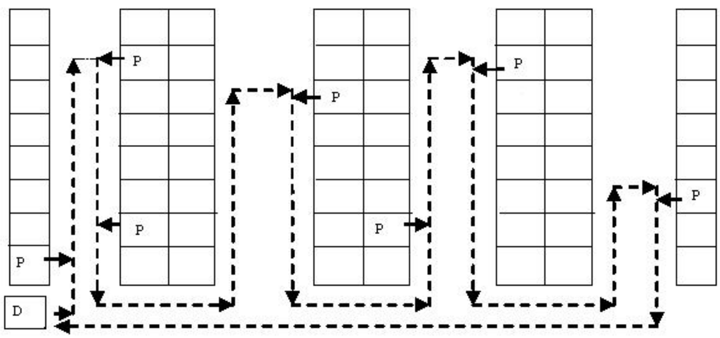

Fig. 7. *Return strategy*
Source: own elaboration on the basis of De Koster et al. (2007)

According to this strategy, a warehouseman moves along the passage up to the last commodity which is itemized on the order picking list, and located on the racks which are adjacent to the passage. After collecting the products, a warehouseman goes back to the main passage, which is at right angles to the racks, and proceeds to the next items on order picking list following the above-mentioned rule.

Heuristics algorithms outlining the order picking routes are especially popular in some warehouses where the order picking process is done by human. Simplicity of their implementation and correspondence, in results, to the algorithms with accurate results are the main reasons for this situation (Ratlif, Rosenthal 1990). Limitations of using accurate algorithms in the warehouses, where order picking process is done by hand, are caused by the facts that new mathematical models need to be built all the time, and there are a lot of variables which one has to take into consideration while doing calculation.

Furthermore, a warehouseman would have to learn the new routes, which would change along with the order picking list, all the time. Owing to heuristics algorithms, a warehouseman can learn certain habits while moving through the warehouse. These habits are unchanging, and in this way the threat of possible mistakes is minimized. A completely different situation occurs in the automatic warehouses of AS/RS type, where the algorithms with accurate results are in the lead. In these warehouses the order picking systems are supported by the computers with a big computing power. Computers are able to outline the optimal route for a given order picking list in a very short time. Due to the fact that the order picking process is done automatically by a machine, which moves to the places indicated by the main computer, mistakes are almost impossible to happen.

4. Description of research

In this research we take into consideration a warehouse of a logistic operator, who thinks about starting a cooperation with one of the biggest companies in Poland which trades in car parts (Fig. 8). This company resigns from some of its warehouses and plans to make the logistic operator responsible for the management of the warehouse and all warehouse operations like: reception, storage, shipment, and order picking.

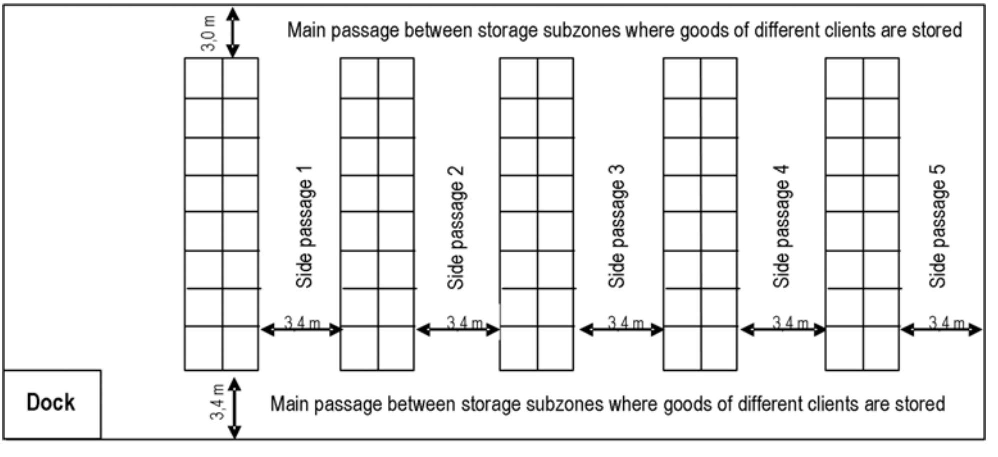

Fig. 8. *The plan of warehousing zone for the company which trades in car parts*

The logistic operator has got a furnished zone in a warehouse designed for a potential customer. In this zone there are forty four-row pallet racks, everyone is 48 metres long. There are 3200 storage places. The location of the racks, length and width of passages, and size of the zone where goods are ready for shipment (dock or letter D in the Figures 5–8) cannot be changed.

Our main objective is to design an order picking system which would reduce the time needed for order picking car parts. The influence, of different variants of products allocation and applied routing strategy in the warehouse, on the order picking time needs to be examined. Car parts are packed in cardboard boxes of different size. Euro pallets are used for storage and shipments to the shops which cooperate with this company. The examined company, which trades in car parts, has been present in the Polish market for over ten years. Owing to this, the company has been able to observe the automotive industry and knows its demand for their products.

In order to plan the arrangement of warehouse's zone designed for his customer the logistic operator has to analyze (according to ABC method – Tab. 1) the demand, in terms of quantity, for car parts. Following abovementioned rule all the products were divided into three categories. The goods ordered most often are in the group A, in group C there are products with the lowest demand, group B are the products with medium demand.

Table 1. *The results of ABC analysis for car parts*

Group	Percentage of stocks	Percentage of orders
A	13	78
B	21	16
C	67	6

Source: own elaboration on the basis of company's data

The division of car parts into categories is used to allocate products in the warehouse, in such a way that goods with the highest rotation are located in the most convenient places for order picking. Four systems of goods allocation and three heuristics methods of planning order picking routes are considered. In this way we have twelve different order picking systems (Tab. 2).

Table 2. *Order picking systems according to storage policies and heuristic routing strategies*

Storage policies	Heuristic routing strategies		
	Traversal strategy	**Return strategy**	**Midpoint strategy**
Arross – Aisle storage	Arross – Aisle storage – Traversal strategy	Arross – Aisle storage – Return strategy	Arross – Aisle storage- Midpoint strategy
Within – Aisle storage	Within – Aisle storage – Traversal strategy	Within – Aisle storage – Return strategy	Within – Aisle storage – Midpoint strategy
Diagonal storage	Diagonal storage – Traversal strategy	Diagonal storage – Return strategy	Diagonal storage – Midpoint strategy
Perimeter storage	Perimeter storage – Traversal strategy	Perimeter storage – Return strategy	Perimeter storage – Midpoint strategy

The order picking process, in the examined company, starts when the order is made, (a warehouse man is given an order picking list), it lasts till all the products, which are on the list, are picked, and finished when the goods are put in dock. One of the limitation, taken into consideration by this research, is the capacity of euro pallet, which is the main carrier in the order picking route. Its capacity can be determined on the maximum level of 15 products.

In the research the time norms for forklift truck are used (Tab. 3). They are created on the basis of observation of warehousemen work during transportation cycle.

Table 3. *Unit time norms of the basic movements of an accumulator forklift truck*

Lp.	The basic forklift movements	Load	Unit	Time norm [min.]
1	2	3	4	5
1.	Acceleration , empty or loaded (It appears every time when the forklift accelerates from the stop to the full speed)	empty	full period	0.03
		loaded		0.03
2.	Moving forward at a full speed (It starts, when the forklift reaches full speed after finishing the acceleration, and ends when the forklift starts to break)	empty	per 1 metre	0.008
		loaded		0.009
3.	Stoppage (It includes breaking in order to stop the forklift from the top speed to the stoppage)	empty	full period	0.03
		loaded		0.04
5.	Right turn while moving forward	empty	full operation	0.055
	(change the direction of movement to the right)	loaded	full operation	0.055
6.	Left and right turn moving backward	empty	full operation	0.055
		loaded	full operation	0.055
7.	Unpacking and loading the unit of product on the pallet		full operation	0.1

Source: on the basis of own research and Fijałkowski (1987, pp. 68–69)

The research of different order picking systems is carried on four different, in total, order types. Small order – with 5 products on the list, medium order – 10 products on the list, and big order – 15 products on the list. Thanks to the data from the company, the analysis of order picking systems, according to the average size of an order which is 11 items on the list, has been carried out. Storage area has been divided into 3 zones consistent with the rules described in this paper in point 2. In every strategy for goods from the A class 401 pallet places were allotted, for B class – 662, and for C class – 2136. The differences in the allocation of places for different products are shown in the Figures 1–4.

5. Results of the research

Simulation methods, for which a program written in JAVA was created, were used in the research. The program takes data from an input file where four groups of information need to be determined:

a) data concerning the form of a warehouse(number of pallet racks, number of rows in a rack, number of shelves in one row, the width of a shelf, the length of the section between the first rack and the middle of the warehousing dock, the width of the racks);
b) data concerning the order – (number of products in the order, number of orders, the percentage share of products from classes ABC in the order);
c) unit time norms of the basic movements of an accumulator forklift truck (Tab. 3);
d) storage system (*Across aisle storage*, *Within – Aisle storage*, etc...) and the area, in the storage zone, allotted for different classes of stored goods).

The Main function of the program takes data from the input file, and calculates order picking time according to three, implemented in different classes, heuristics algorithms: *Traversal*, *Return*, *Midpoint*.

In the program there are options to create random orders and to simulate different goods allocation variants. The data, generated and saved in the program, has got the form of four dimensional board which is the computer reflection of the warehouse and the main structure of data. The measurements have got the following meaning:

– the first measurement is the number of a row (the rows are numbered from 0);
– the second measurement denotes left or right side of the rack (0-left, right-1);
– the third measurement is the number of a shelf (they are numbered from 0);
– the fourth measurement is the number of a row (they are numbered from 0).

The results of the research were obtained on the basis of 1000 randomly generated orders. The orders were created on the basis of actual orders from 2009 (150 actual orders) provided by the company which trade in car parts. Because of this information it was possible to determine the share of given product groups in the generated orders.

Order picking times, with the implementation of 12 different order picking systems, were calculated on the basis of simulation. The results of different order picking concepts are shown in the Tables 4–7. In every table the average order picking times of three heuristics strategies, with the use of 4 methods of product allocation, are presented.

Table 4. *Average order picking times (in minutes) with the use of Across aisle storage*

Number of items in the order	Heuristic strategies of route planning		
	Traversal	Return	Midpoint
5	14.49	10.043	17.048
10	22.639	14.36	21.322
11	24.248	15.093	22.046
15	30.029	19.61	25.542

Table 5. *Average order picking times (in minutes) with the use of Within aisle storage*

Number of items in the order	Heuristic strategies of route planning		
	Traversal	Return	Midpoint
5	12.685	13.797	18.874
10	16.837	19.285	24.118
11	17.255	19.815	24.785
15	20.429	23.763	28.414

Table 6. *Average order picking times (in minutes) with the use of Perimeter storage*

Number of items in the order	Heuristic strategies of route planning		
	Traversal	Return	Midpoint
5	14.048	14.938	17.588
10	20.898	23.204	21.795
11	22.081	24.524	22.53
15	27.085	30.295	26.281

Table 7. *Average order picking times (in minutes) with the use of Diagonal storage*

Number of items in the order	Heuristic strategies of route planning		
	Traversal	Return	Midpoint
5	10.689	11.837	17.951
10	14.207	16.187	21.345
11	14.72	16.69	21.933
15	18.464	21.873	24.751

The above mentioned results prove that the combination of diagonal storage strategy, for goods allocation, and *Traversal (S-shape)* heuristics method of planning order picking routes is the best order picking system in the examined case. The results indicates that this is the best order picking system for all types of order where the number of products on order picking list varies.

6. Conclusions

The implementation of simulation programs allows us to check different order picking variants. We are also able to choose the variants which are the best in a given situation. Simulation methods help to make decisions, when it comes to designing, management and execution of different activities in a warehouse. The computer program, which was created, enables us to examine and consider different order picking variants for different warehouses and in different conditions.

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