Simulation Model Research of Warehouse Order Picking Process

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Abstract
This research endeavour is focused on the warehouse order picking process – the retrieval of goods from specified storage locations according to picking lists, formed according to customers’ orders. This process is one of the most costly and laborious in the most warehouses, especially in retail networks and online shops. Generally it consumes up to 70% of all warehouse labour activities. Different routing schemes can significantly improve results and dramatically reduce costs. We have researched the impact of routing methods on picker travel distance in a wide-aisle shelving work area of a warehouse. In order to determine potential travel distance savings, a simulation computer model was created. Routing methods in a wide-aisle shelving warehouse and other order picking process optimisations are analysed through simulation. The presented results show that by choosing appropriate combination of optimisation methods, the picker travel distance can be reduced by about 50%. The simulation model also helped to visualise the benefits that would accumulate through the use of jobs optimisation and reduction of the non-value added time in warehouse operations.

Keywords: logistics, simulation, picking, warehouse, Ukraine

1. Introduction
A critical topic in modern warehouse management practice is finding ways to answer the question ‘How to increase picking productivity and how to be more efficient?’ This research pays special attention to a picking process with the aim of improving warehouse operational efficiency. Order picking is the retrieval of products from specified storing locations on the basis of customer orders. The order picking process is one of the most laborious of all warehouse processes. Generally it consumes almost 70% of all labour activities in the warehouse. In this case study, a manual picking process is analysed. An order picker receives a pick list at a computer station, goes to certain picking locations to retrieve products according to the pick list, delivers them to a marshalling area and then moves to a computer...
station to confirm the completed job and quantities of delivered products (Григорків В. 2009).

2. Description of picking process
Order picking is the retrieval of products from specified locations according to customer orders. A picker always starts the route at a marshalling area. In changing aisles, the picker moves in the direction of the closest cross-aisle. The routing algorithm chooses the shortest way for each aisle individually: the picker needs to return back to the front cross-aisle or to cross the aisle through its entire length to the rear cross-aisle. In a warehouse with two storage blocks, the middle cross-aisle operates as the rear cross-aisle for the first storage block and as the front cross-aisle for the second storage block. This route may be called a composite route and is displayed in Figure 1.

![Composite route (grey specified locations)](image)

Figure 1. Composite route (grey specified locations)

Seeking to improve the picking process efficiency, the research analyses different strategies including:

- Warehouse layout
- Storage strategies
- Customer orders
- Routing methods in a wide-aisle warehouse

The aim of this case is to minimize the picker travel distance in a sample warehouse. While two types of travel distances for order picking are used in practice: average travel distance per
order and total travel distance (for a set of orders), the case study focuses on the latter. By minimizing the average travel distance, the total travel distance is also minimized.

A schematic picture of the reference warehouse with multiple aisles is shown in Figure 2. The width of aisles is 1.2 meters. Items are stored on shelves and are usually picked in boxes. The considered warehouse, called a sample warehouse, has eight parallel aisles, and each aisle contains one hundred picking locations. The cross-aisle in the middle of the warehouse separates it into two storage blocks and allows three possibilities to switch between aisles: at the front, at the rear and in the middle. Products are picked from ground locations. According to the schematic picture of the warehouse, one cell represents one location. In the case study, a computer station and a drop-off point are represented by the marshalling area. The location of the marshalling area, where the picker starts and ends picking, can be freely chosen by the user before performing simulation.

![Figure 2. Warehouse layout](image)

The explored simulation model is flexible. The model allows one to study other possibilities (which can be studied without schematic changes):
• The middle cross-aisle can be removed and the number of storage blocks can be reduced.

• The number of aisles can be reduced. It can be decreased from any side of the warehouse, if the number of picking locations for the retrieval in those aisles is equal to zero.

In Figure 3, five routing methods in a wide-aisle warehouse are shown. Each method shows a route in which the picker is expected to move from the current location to the neighbouring one according to the pick list.

The description of each method (according to Figure 3) is given below:

1. The first method (Figure 3, I): first, all locations on one side of the aisle are visited; later the picker visits all locations on the other side.

2. The second method (Figure 3, II): after visiting two locations on one side of the aisle, the picker moves to the other side of the aisle one location up or down (depends on the direction). Each location, according to the logic of this method, receives an identification number. Identification numbers are used for directing the picker inside the aisle.

3. The third method (Figure 3, III): when a location has been visited on one side of the aisle, another parallel location is visited on the other side of the aisle.

4. The fourth method (Figure 3, IV): after visiting three (or four) locations on one side, the picker moves to the other side and visits same amount of parallel locations. Then the picker returns.

5. The fifth method (Figure 3, V): after four locations are visited on one side of the aisle, the picker moves to the other side of the aisle one location back.

In the case study, the above five routing methods in a wide-aisle warehouse are integrated with the composite route and can also be used as a part for other warehouse layout, storage strategies and pick list size tests.
Figure 4. Zigzag travelling in the racking area

The zigzag travelling method is illustrated in Figure 4. Here one pick list is processed. All locations specified for this picking are not placed in front of each other, and therefore it is difficult to use methods from Figure 3. In order to define the most efficient routing method in a wide-aisle warehouse and to analyse possibilities to optimize the order picking process, a simulation model for the sample warehouse was created.

3. Model description

For the case study, an Excel simulation model was created that consists of the following parts:

- Warehouse layout and location names database
- Location visit identification numbers database
- Pick lists database
- Simulation on warehouse layout algorithm

Efficiency of the picking process is measured in the model by the picker travel distance, the number of picked orders and the number of locations visited (Григорків В. 2009).

The simulation algorithm uses the pick lists database, where picking tasks and a sequence in which locations shall be visited are defined. For picking in accordance with the next pick list, the picker first returns to the marshalling area.

Simulation of the picking process involves movements of the order picker inside aisles, cross-aisles, as well as returns to the marshalling area, which are modelled by macro commands in Visual Basic.
During simulation, the current pick list gets its reference number for identification purposes automatically. Such numbers can also be indicated manually by the user, if needed, before simulation, to check which locations are chosen for the specific pick list. If the pick list number is not indicated, the number of visits to each location from the ‘pick list’ sheet is summarised in a schematic picture of the warehouse (it can be checked how often pick lists for each location are created and how the storage strategy is used). The number of visits can be ranged by different criteria values. For displaying ranged data, the MS Excel Conditional Formatting function is used. Locations coloured dark grey are the most visited; locations coloured light grey are visited more often than locations coloured white. For the proper ranging function, the user has to check which location has the highest number of visits and how big the number of visits is and, after that, to change range values. The best option is to divide the highest number of visits per location into three equal parts but other possibilities can also be used. Picker movements are shown in a schematic picture in the sheet ‘Picking’. Picking can be started with the macro command button ‘Picking’. Generally, during simulation the picker is moving on the right side of the corridor and is stepping to the left side only by a pick list request. The picker is moving according to the schematic picture of the reference warehouse. For simulation, the following changes in the reference warehouse (described above) can be used without changes in the schematic picture: middle cross-aisle location and number of aisles. The results of each routing method are displayed in separate rows.

**Total travel distance calculation.** The aisle width is 5 metres; the total width of a corridor is 3.4 metres. These numbers are used for total travel distance calculation. When the picker moves horizontally, the simulation algorithm checks each column type. Inside the corridor, it is considered that the picker walks 0.3 metres away from the shelves. When the picker is retrieving a product, 0.6 metres (0.3 metres from location and 0.3 metres back) are added to the total travel distance.

If the picker steps from the right side of the corridor to the left side or from the left to the right side, the distance of 2.8 metres for changing sides is added. The length of each location is 1.2 metres. The middle cross-aisle is 4.8 metres wide; it is used in the reference warehouse to handle the traffic.

**Simulation algorithm logic.** A macro command is used to calculate the total travel distance according to the selected routing method. On average, it takes five minutes to run a simulation.
for 800 locations and eight pick lists. Using such possibilities, the user can test either one routing method with different layout and pick list size combinations or different routing methods for the same situation.

Three macro command blocks are used for the algorithm:

- The first two command blocks – for moving between even or odd locations.
- The third command block – for returning to the marshalling area.

For simulating picker movements, a blue colour is used. When the picker moves into a new cell in the schematic picture, the colour in the previous cell is removed and the new cell is coloured. When the picker moves across, the differences in rows and columns of previous and current locations (cells) for total distance calculations are taken into account. If the picker moves between different aisles, the algorithm checks which cross-aisle is closer to the previous and next locations, and indicates the closest cross-aisle for the next picker movements.

If the user is willing to run more tests for the efficiency analysis, he has to copy results of the previous simulation.

4. Verification and validation

Verification and validation of the model were performed.

Verification tests:

- Calculation of the total travel distance for picking in a warehouse with one storage block was corrected in the macro command algorithm.
- In reality, when the last pick list is finished, the picker returns to the marshalling area; this point was accordingly corrected in the macro command.
- Unused data was removed from the tables.
- Additional functionality of checking statistical data (the number of visits for each location) was entered into the model; this information can be automatically updated from the ‘Pick lists’ sheet to the ‘Picking’ sheet.
- When the picker is moves inside the corridor from the left side to the right side to return to the marshalling area, the total travel distance does not increase.

Validation tests:

- The simulated model meets real processes which occur in an ordinary warehouse. Pick lists were created based on the date, customer, pick lines and location visit identification numbers.
• In reality, many pickers are picking big orders, but the calculation of travel distance implemented in the model represents a summary of all pickers’ travel distances.
• In practice, the picker can return to the marshalling area through different cross-aisles or corridors. In that case, the total travel distance of the composite route can be the same or longer, as the macro command algorithm chooses the shortest route.

5. Conclusions
The described experiment demonstrates that in the considered situation the efficiency of the picking process can be improved by about 50% by choosing the right routing method.
The target of this case is to have a possibility of evaluating five routing methods in a wide-aisle warehouse at the pick list creation moment in order to create the pick list according to the best one.
For five routing methods in a wide-aisle warehouse, the total travel distance and its parts were calculated through simulation; it was found that:
• The zigzag distance influences the total travel distance from 2% to 57% (the third routing method in a wide-aisle warehouse).
• The zigzag distance increases when the number of picks per aisle is higher, but it is not affected by the marshalling area location.

The concluding remarks for the travel distance are as follows:
• The total travel distance is higher when the number of aisles included in the pick list is odd.
• The difference between all five routing methods is more considerable when the number of locations included in the pick list is higher.

References
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