ANALYSIS OF WAREHOUSE ORDER PICKING SYSTEMS USING SIMULATION TECHNOLOGY

Rainer Frick

V-Research GmbH
6850 Dornbirn, Austria

rainer.frick@v-research.at (Rainer Frick)

Abstract

Order picking tends to be one of the most important processes occurring in a warehouse because it is directly linked to the ability of the quick and accurate processing of customer orders. The different order picking systems can vary greatly and depend on the characteristics of the handled articles, number of transactions, number of orders, picks per order, quantity per pick, value-added processing such as labeling, weight and volume of the articles, etc. Often a combination of picking systems is needed to handle distinct article and order characteristics. Furthermore picking processes often vary with the season or with an increasing business. Against the background of these influences the question arises if picking systems are plannable and optimizable? The primary goals of optimizing a picking process include increases in productivity, reduction of cycle time and increases in accuracy. Unfortunately these goals conflict with each other and the interactions between the various warehouse processes are too complex to observe. A simulation of the involved processes helps to evaluate different order picking systems for a given article and order structure before changes to the picking system are made in the real world. This work deals with the implementation of order picking systems based on their process level into a simulation model, realizing alternative experiments and a rudimentary interpretation of their simulation results.

Keywords: Eurosim, Simulation, Warehouse logistics, Order picking

Presenting Author's Biography

Rainer Frick. He is currently studying Business Administration and Computer Science at the University of Innsbruck. His main focus is developing software in the simulation field at V-Research company.

1 General

Order picking means the process of collection of customer-friendly amounts of one or more articles to supply them for shipment [1]. It is similar described in the guideline VDI 3590 of the Association of German Engineers [2].

Most often it is a work- and staff-intensive issue and for this reason associated with high costs. As a matter of fact planning and operation of an order picking system is of great importance for any kind of distribution centre [3].

Some recent trends are influencing the order picking structuring. In manufacturing usually smaller batch sizes and cycle time reductions are needed. In the distribution field late ordering and fast delivery are required by the customers. All these trends shorten the time available for order picking [4].

Nowadays all imaginable carrying techniques are used in warehouse and it is highly interlaced with business work flows and information technology which lets increase complexity. Optimizations in this field can be done focusing the efficiency (or productivity) of such order picking systems.

The requirements fulfilled by the picking system are multiple, e.g. the range of articles, orders and number of positions, order weight and volume, defined throughput time, temporal distribution of incoming orders, maximum and medium stock of the articles, error and delay rate, etc. To meet best all these interdependent requirements a continued examination and evaluation of the involved processes is necessary.

The process level of a distribution centre is organized by logically combined and ordered activities. This work observes only the order picking activity. The picking process is delimited most often by the previous roll-in process and the later process which can be the packing or the removal of the goods.

Discrete event simulation is part of operations research and is concerned with modeling dynamic systems. The system is described by time-dependent state variables and these variables are changed by occurring events. Mathematical models make a good job in terms of performance evaluation of order picking methods. Additionally simulation helps modeling more complex process correlations and can be used for comparative analysis [5].

Simulation techniques are used in this work to shape the order picking processes into a simulation model. The obtained model is the base for a following scenario analysis to examine order picking systems for a given article and order structure.

2 Order picking systems

Order picking involves the process of clustering and scheduling the customer orders, assigning stock on locations to order lines, releasing orders to the floor, picking the articles from storage locations and the disposal of the picked articles [4].

An overview of existing order picking systems gives Fig. 1.

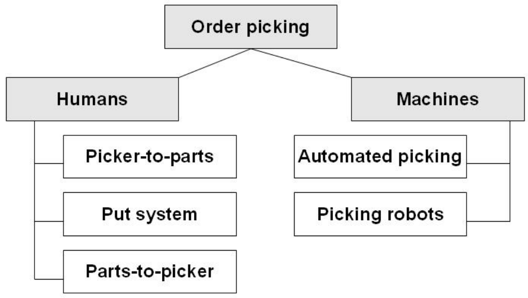

Fig. 1 Order picking methods [4]

This work is concerned with picker-to-parts systems.

Distinct actions and therefore the productivity in order picking systems are determined by different times. The base time means the the time used for the organisational steps, which can be the take over of the order, collecting a picking box, hand over the goods and the final document processing. The pick time consists of reaching and grabbing the goods. The down or dead time is determined by reading, opening packages, searching for goods and checking fulfillment of the order. Finally the travel time is the time to get from the order receiving place to the picking places and back to the hand over place [6]. These times depend on the order structure and the organisational structure of the order picking system. The base and down time can be influenced by an information system, the pick and travel time by the arrangement of the order picking flow.

The simplest case consists of one picker who's picking one order at a time. This is most often called basic order-based picking. An order picker picks the order following a route up and down each aisle until the entire order is picked. This principle make sense where the average picking amount goes conform to the capacity of a picker. It has little preparation affords and the picking list can be the order list itself, or better, the list is sorted in the same sequence as the picking flow. On the other side large orders or many pickers in the same areas slow down the basic picking principle [7]. The next best alternative is the parallel order-based picking where a picker picks multiple orders at a time. Usually the picker uses a separate box for each order. Parallel picking reduces the average travel time per order. Orders should be again listed as a continuous picking sequence.

Basic and parallel picking are order-based and therefore can be determined as single-stage picking systems. In opposition two-stage picking means the separation of picking articles (article-based picking) and combining them into orders. Multiple custom orders are grouped together into small batches and a picker picks one batch at a time and later on the articles are divided into orders. This is also called batch picking or multi-order picking. The information system should be able to find and combine similar orders and sort the picking list to achieve a minimum travel route. Multi-order picking reduces pick and travel time considerably. The accumulation of orders to a batch can create processing delays and the combination of orders into batches can arise in an optimization problem [6].

This work deals with single-stage and two stage picking on the process level.

3 Simulation model

The used simulation technique bases on a simulation software framework provided by the V-Research company where the author is employed. The framework consists of an event-driven simulation tool to execute the simulation model, an graphical editor for defining a warehouse with it's processes, a model-generation software translating a defined warehouse into an executable simulation and a tool for analysing simulation results. An overview of the simulation framework gives Fig. 2.

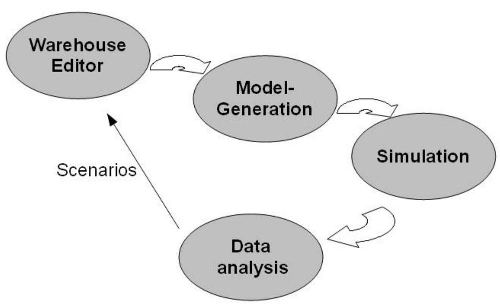

Fig. 2 Simulation framework

Analysing and interpreting simulation result data lead to apply changes to the original simulation model and outcome to various comparable scenarios.

The kernel of the simulation framework is a flexible process editor to design easily an order flow applicable to a warehouse. One part of this flow is usually the order picking process. Without any influences to the warehouse layout (physical representation like racks, forklifts, etc.) it is possible to define different picking processes which are applied to the warehouse afterwards during the simulation.

A sample single-stage picking process shows Fig. 3. Here a picking job is fulfilled when all positions from one or more orders are collected (basic and parallel picking). The order can be brought to the hand over place by the picker.

In the two-stage picking process (Fig. 4), after all positions from all orders are collected, the articles has to be divided into their original orders by the picker or another person or machine. Therefore an additional process step is required (Divide orders).

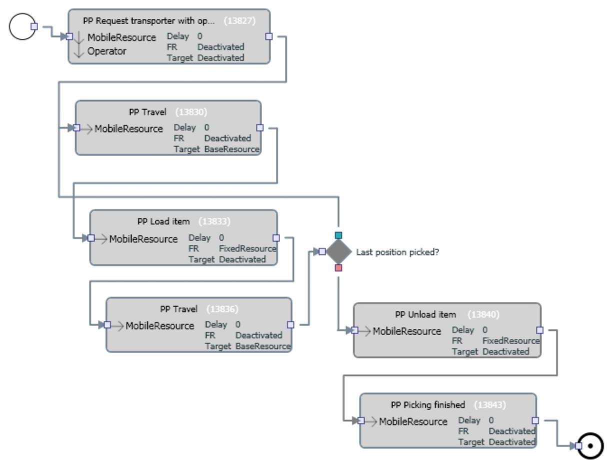

Fig. 3 A sample single-stage picking process

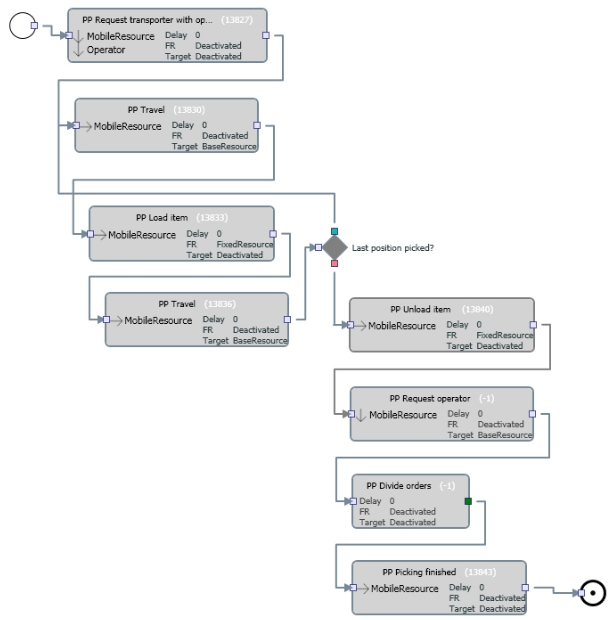

Fig. 4 A sample two-stage picking process

Note that Fig. 3 and Fig. 4 demonstrate only two possible solutions for designing picking and just a slight part of the entire warehouse process model.

The simulation model is build automatically from the defined warehouse layout in combination with other necessary informations like the mobile resources, the shift schedule, the process model and many more. The defined process model, containing the picking processes is translated by the generation software from a process-based model to an event-based model. This is also known as data-driven modeling. Taking altogether a simulation model is created which can be run by the simulation software.

3.1 Scenario analysis

Scenario analysis is commonly defined as a process of analyzing possible activities by considering alternative possible outcomes (scenarios). Often it is described by carrying out experiments.

As mentioned in the previous section different scenarios can be achieved by building up a base warehouse simulation model and afterwards varying distinct parameters.

The base model contains as picking process the basic order picking. As a first step another process containing the multi-order picking can be established and compared to the simulation results from the basic picking. Layout and order data should remain the same in both scenarios. This answers which picking process brings out better picking times for a given warehouse and a given article and order structure.

Another analysis consists of leaving picking processes constant but varying other aspects of the warehouse, i.e. the distribution of the picking areas or the article and order structure. What occurs to average picking times if more orders has to be processed because of seasonal fluctuation, a crisis or the loss of a customer? What happens when a further article is added to the product line?

Such and other questions can arise operating a warehouse and simulating experiments (scenarios) of the picking system helps evaluating different acting alternatives.

The analysis of simulation results is the first step for the evaluation of planning the picking system. Different picking versions can be compared by performance which means comparing the average picking time. But the simulation results also provide the base for a monetary evaluation [8]. Therefore a finance system can be applied to the results containing cost factors for picking times, pickers and mobile resources such as forklifts. With these factors average picking costs are calculated which bring out potential savings.

To compare single-stage and two-stage picking by their picking time it is necessary to define a default warehouse layout with some storage area and a view articles and orders which is called the system load. Simulating each alternative generates picking times for every order. The overall picking time over all orders can be compared for the two picking systems.

The analysis of described single-stage and two-stage picking versions is currently under progress. But first analysis with the sample order data demonstrates the strong correlation between the picking version and the order structure. Increasing article amounts of the order positions or increasing the number of order positions itself so that the pickers capacity is exceeded, picking time for single-stage picking increases as expected because less orders can be picked at the same time. If orders do not challenge pickers capacity, i.e. little amounts or small articles, so single-stage picking processes about the same amount of orders at the same time like two-stage picking does.

4 Summary

The simulation of order picking systems can help to achieve a better understanding of the processes working in the background. Picking times can be evaluated depending on the underlying picking system or other warehouse parameters like the layout or the articles.

A software framework and data-driven modeling reduce simulation model building time tremendously. The process editor as the heart of the framework provides the capability of modeling distinct versions of picking alternatives including them in the rest of the entire warehouse process model. This technique enables comparison of order picking versions.

Future work will be concerned refining and improving existing picking implementations, adding other picking alternatives and the development of a picking finance system to compare picking versions monetarily. Also further result analysis detecting relations between order structure or warehouse layout and picking version will be required.

5 References

[1] Jens Wisser. *Der Prozess Lagern und Kommissionieren im Rahmen des Distribution Center Reference Model (DCRM)*. Universittsverlag Karlsruhe, Karlsruhe, 2009.

[2] Vdi. `http://www.vdi.de`, May 2010.

[3] Michael Ten Hompel and Thorsten Schmidt. *Warehouse Management, Automatisierung und Organisation von Lager- und Kommissioniersystemen*. Springer, Berlin, 2005.

[4] R. Koster, T. Le-Duc, and K. Roodbergen. Design and control of warehouse order picking: A literature review. In *European Journal of Operational Research 182*, 2007.

[5] Heung Suk Hwang and Gyu Sung Cho. A performance evaluation model for order picking warehouse design. In *Computers and Industrial Engineering 51*, 2006.

[6] Michael Ten Hompel and Thorsten Schmidt. *Warehouse Management, Organisation und Steuerung von Lager- und Kommissioniersystemen*. Springer, Berlin, 2008.

[7] Dave Piasecki. Order picking: Methods and equipment for piece pick, case pick, and pallet pick operations. `http://www.inventoryops.com/order_picking.htm`, Jun 2010.

[8] A. Ulbrich, S. Galka, and W. Guenthner. Secure planning of order picking systems with the aid of simulation. In *Proceedings of the 43rd Hawaii International Conference on System Sciences*, 2010.