Secure Planning of Order Picking Systems with the Aid of Simulation

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Abstract

Planning a new logistics center is a quite difficult job. Depending on the requirements there are a great number of possible design versions. The planner has to consider not only the present but also the future requirements. Up to now, the planner decides on the basis of experience which system will perform the requested services best. This paper illustrates the redesign of a new order-picking system in industry supported by a simulation tool of our institute designed especially for the rough planning. With the described project the road capability of the applied simulation concept is underlined. Several versions based on the requirements were investigated and evaluated. Key figures are calculated and a recommendation depending on performance and arising expenses is given.

1. Introduction

Are order picking systems plannable? Is it not rather a gamble that the future requirements of a picking system are interpreted correctly? In many cases it can be observed that the planned capacity of a new system is already insufficient at the start of operation. Thus, for instance, a high bay warehouse of the company Würth in Bad Mergentheim had to double capacity eight months after the start of its operation. Was it a planning error? [Vollmers 2007]

The dilemma during the planning process of picking systems is the sum of changing factors such as the assortment, the order structure, functions and other unexpected changes. [Dörrie 2007] The variety of design options for these systems complicates the selection of an appropriate technology [Dullinger 2005, de Koster 2007]. Research works in the past focus ordinarily on four areas: storage assignment, layout problem, batching & zoning and routing order pickers [Ratliff 1983, Le-Duc 2005, Prandtstetter 2009]. To reduce the risk of planning errors the planning has to be fulfilled for a time horizon instead for a single point in time. [Günthner 2008]

By using scenario analysis for the extrapolation of requirement data the risk for estimating future requirements can be reduced. This can be achieved by changing different influencing factors and setting them into relation. In combination with a modular and scalable design of the picking system the planning dilemma can be resolved.

Even key figures can be calculated by miscellaneous arithmetic techniques interactions can hardly be considered without the usage of simulation.

Simulation offers the opportunity to meet all these requirements but is in our knowledge not used during rough planning because there is not much time to built-up simulation models for all possible versions. So a maximum number up to three versions is built-up in detailed planning where the layout is already almost fixed. For the use of simulation during the early stage of planning - rough planning - there is an necessity of standardisation and automation. The development of standard elements can save much time and makes it able to use simulation to investigate a multiplicity of versions. For the support of the planning process our institute developed a planning software. In addition to the data analysis and extrapolation, creation of simulation models in PlantSimulation can be done quickly by the software. Thus, it is possible to use simulation during the phase of rough planning of picking systems. [Ulbrich 2007]

This paper shortly introduces the developed planning software and gives an practical example for the use by replanning an online trade with the aid of the planning software tool.

2. Architecture of the planning tool

The architecture of the planning software is illustrated in Fig. 1. Main objective of the planning software is to support the planner by the investigation of a great number of possible order picking systems. The planner has the ideas and constructs them into the planning software by configuring the variables & parameters of standard modules. In our system we have already implemented standard modules for the conventional picking (picker to items using ground-level compartment rack, pallets rack or live storage rack), zone-picking (supported by materials handling),

automatical small-parts or pallets warehouse with terminals, reverse picking and automatical warehouses with manual rack feeder.

Parameters of the conventional picking module are the number of lanes, the length and the height of a lane, the number of shortcuts, the dimensions and the position of the base. The routing method can also be varied through a parameter between the S-shape, Return, Mid-point, Largest gap, Combined and Optimal as described in [de Koster 2007]. The usage of standard modules implicates the usage of a standard data format. Therefore the data input of the planner is supported by a windows application written in C#. This application imports existing article and delivery data from any relational database and analyses them about distribution functions.
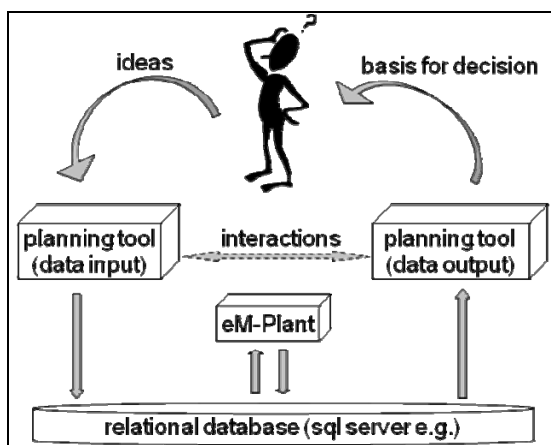

Figure 1: Planning loop

Usually original data cannot be used because attributes are missing for some data sets. To close the missing attributes and to generate data for the future distribution functions for the attributes acces frequency, volume and weight for the article structure and number of order items, order distribution during the day and quantitiy of an order item have to be analyzed. The C# application generates besides the system load in present and in future bin locations and transforms the delivery orders to picking orders matching the designed picking system layouts. During the simulation which runs automatically on the given configuration all the data collected is saved in an relational database. An simulation test run for small systems takes about one till five minutes but can increase rapidly for greater systems with thousands of articles and delivery orders per day to several hours. After all simulation test runs have been performed from the collected data key figures are calculated with the aid of the planning tool to evaluate the results.

3. Statement of the problem

Meanwhile the planning software is assembled for real planning projects. In the next section a practical example of how to use the tool for the replanning of an online trade will be discussed in depth.

The company has operated a rapidly growing online shop for wholefood products and gluten-free foods for about four years. To meet the increasing cost pressure and master the highly competitive market the company moves to a new logistics center.

With this move the company expects reduced logistics costs and increased capacity for the growth target. To meet the changing requirements the layout of the new logistics center has to be replanned and the resulting costs have to be investigated over the next three years of planning horizon.

4. Requirements

The current process was analyzed by methods time measurement (MTM) during several local appointments in the old logistic centre. With help of the deployed Warehouse Management System (WMS), the current order and assortment structure was reviewed. The actual assortment includes 3.042 articles and the structure of access frequency follows the classical Pareto-distribution. Today, the company forwards about 1.500 orders per day. An average order consists of four lines with a quantity of 1,5 items.

Table 1: expected growth of essential key data

expected growth per year	Scenario positive A	Scenario positive B	Scenario constant
assortment	8 %	4 %	0 %
orders	10 %	5 %	0 %

During a one-day workshop together with the employees of the company the requirements of a new logistics centre were defined. The essential key data are illustrated in **table 1**.

By using the above-mentioned planning software during the workshop the estimation of growth, e.g. three percent more articles p.a., was easily adjusted by pictured diagrams.

5. Planning Versions and modeling

The maximum dimensions of the picking system were already given because the leasing contract of the building which is designed to be the new logistic centre was already concluded. Due to the rapid changes in market segment of online trading the company has excluded extensive investments in automation.

Therefore the new picking system should be based on the classical principle of person to goods. Several planning versions were prepared by our institute and these versions were aligned with the company in a second workshop. In all versions shelved rackings were intended for the picking area. Differences between them are distinct locations of the main lane and the base. For the investigation the following variants were selected:

- The main lane is in front of the lanes – called head lane (type 1a)
- Head lane and one shortcut between the lanes (type 1b)
- Head lane and two shortcuts between the lanes (type 1c)
- Head lane and maximum (five) shortcuts between the lanes
  (type 1d)
- The main lane across the picking area, called central lane and the base is located in front of the picking area, called border base (type 2a)
- Central lane, border base and one shortcut (type 2b)

- Central lane, border base and two shortcuts (type 2c)
- Central lane, border base and maximum (three) shortcuts (type 2d)
- Central lane and the base is located in the middle of the picking area, called central base (type 3a)
- Central lane, central base and one shortcut (type 3b)
- Central lane, central base and two shortcuts (type 3c)
- Central lane, central base and maximum (three) shortcuts (type 3d)

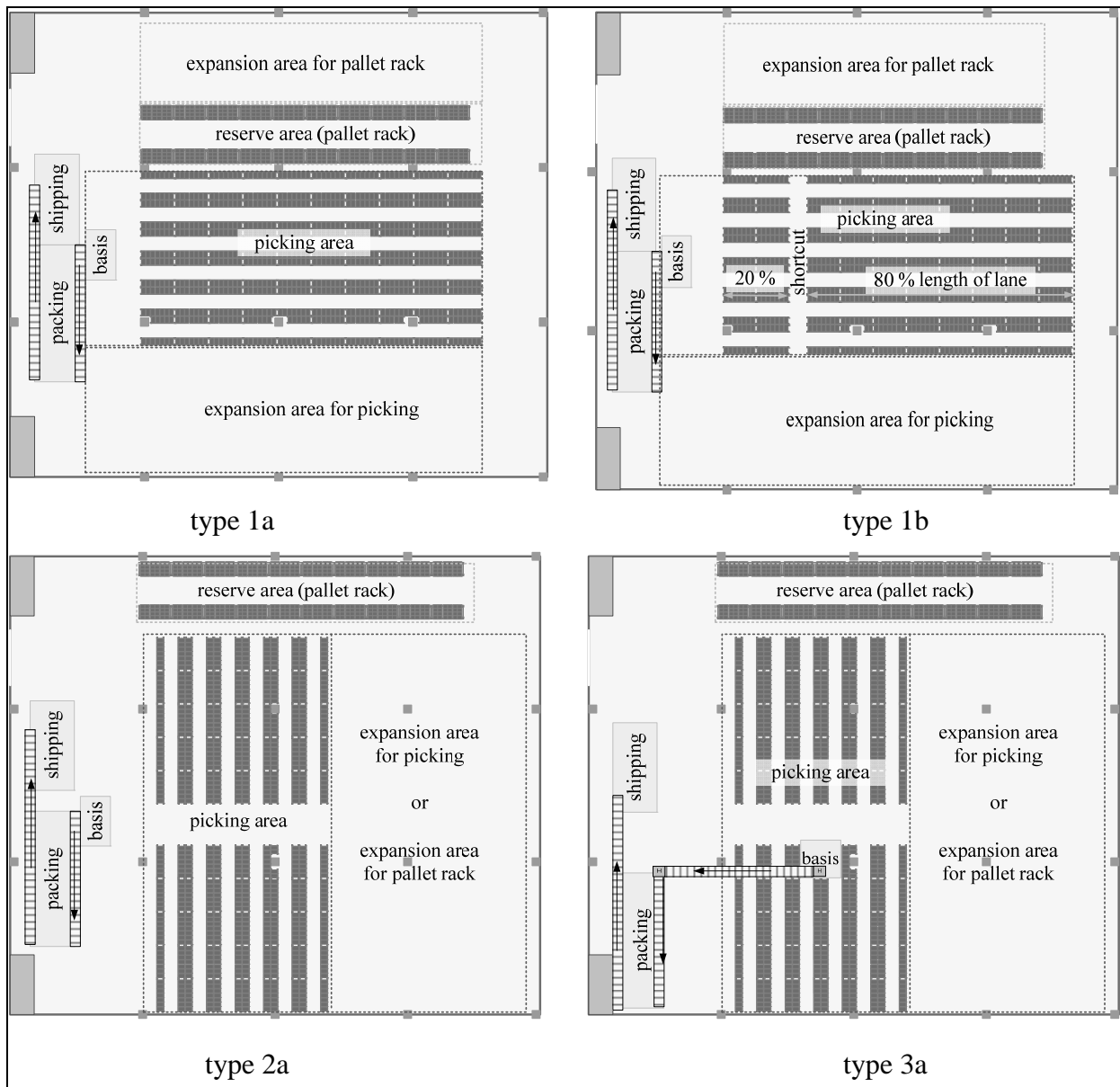Figure 2 illustrates four of the abovementioned versions.

Figure 2: layout of selected planning versions

In addition to the layout versions several process versions were analyzed and worked out. An important question was, how many orders should be handled by the picker on a collective round tour through the picking area. Picking more than one order by a person at the same time is called multipicking. The advantage is that the picking density is higher by using multipicking than collecting only single orders at the same time. Because of the average article weight and

volume it was determined that a maximum of six orders can be processed by a single collective round tour.

One of the next questions was which path strategy should be used for picking? In a preliminary investigation different picking strategies such as the classical picking, serpentine picking or largest gap picking strategy were thoroughly discussed. Depending on the path strategy for picking a compatible storage strategy for articles in the picking area had to be selected. The preliminary investigation reasoned that depending on this article structure the branch aisle strategy with a concentration of fast movers around the base is advantageous and recommended [Roodbergen 2008, Petersen 2004, ten Hompel 2007].

These strategies are used for all versions, thus the number of simulation test runs can be bounded. In the following morphological box the analyzed influencing variables are illustrated (cf. Fig.3). For the analysis 2.160 simulation test runs were performed. A simulation test run needs approximately three minutes of computing time.

Figure 3: Combinations of layout, organization and load version for analysis

The processes which were developed within the second workshop, were described by means of MTM which is aided by the planning software. The outcome of this are determinated times describing various process steps, e.g. the grasp at a single item. These times are provided for the simulation model.

The entire planning software environment uses a relational data base on the bottom layer of its architecture. In the database all information needed for simulation are saved during the planning steps and the several versions of the picking system are described in a formal structure with the aid of the planning software. This description includes the layout, the processes and the load scenarios. Simulation models in

PlantSimulation can be generated completely and automatically by the information saved in the database. One of these generated models can be viewed in figure 4.
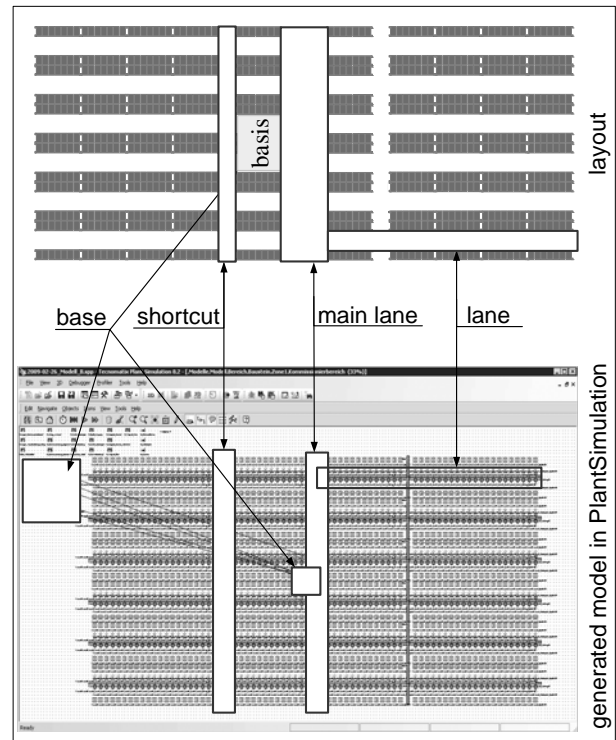

Figure 4: Generated model for type 3b compared with the layout

The automatical generation of simulation models become possible through the definition of standard elements which are strung together according to the values of the parameters set in the database by the planner.

6. Results and interpretation of simulation outputs

Consecutively the results for the average time per order line in minutes simulated by PlantSimulation are illustrated in **table 2**.

Table 2: average time per order line in seconds for the load scenario "positive A & 2009" (average over five simulation test runs)

	number of orders per tour		
	one	three	six
Head lane (type 1a)	21,60	13,20	9,84
Head lane and one shortcut (type 1b)	19,80	12,60	9,90
Head lane and two shortcuts (type 1c)	18,82	12,61	10,05
Head lane and maximum (five) shortcuts (type 1d)	18,86	12,63	10,90
Central lane and border base (type 2a)	19,80	12,00	9,18
Central lane, border base and one shortcut (type 2b)	19,75	12,20	9,66
Central lane, border base and two shortcuts (type 2c)	19,78	12,21	9,84
Central lane, border base and maximum (three) shortcuts (type 2d)	19,80	12,22	10,38
Central lane and center base (type 3a)	18,00	11,40	8,88
Central lane, center base and one shortcut (type 3b)	18,10	11,70	9,24
Central lane, center base and two shortcuts (type 3c)	18,25	11,72	9,50
Central lane, center base and maximum (three) shortcuts (type 3c)	18,30	11,73	10,00

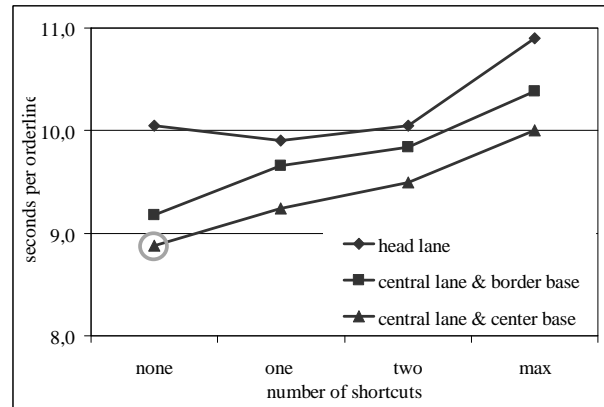In figure 5 the various layout versions are shown with the calculated seconds per orderline.

Figure 5: seconds per order line by six orders per tour

As illustrated in figure 5 with the circle marked point, the best version depending on the seconds per orderline is type 3a. This is caused by the central location of the base which reduces the time units for changing lanes. One of the main disadvantages is the transport of the bins from the base to the shipping area. Because our client required a continous flow of the bins the need for material handling between base and shipping area was indispensable. Although this could be solved through a material handling for level changing the investment increases so that version type 3 is too expensive in comparison with the other versions. The outcome of this is the necessity for the calculation of the investment and arising expenses before the best version can be identified. This will be done in the next step.

7. Versions benchmark

The analysis of simulation results is the first step for the evaluation of planning versions. Besides the comparison of different versions by performance, the results of simulation together with the formal description of the picking systems provide the basis for the monetary evaluation.

If a rough calculation of investment and operational costs is sufficient for the comparison of versions, the planning software can be used. Therefore several cost rates are defined in the database. With the information from the formal description and the cost rates the software can calculate the rough investments value. The operational costs as depreciation and maintenance costs for instance derive from the calculated investment. The approach is shown in. 6.
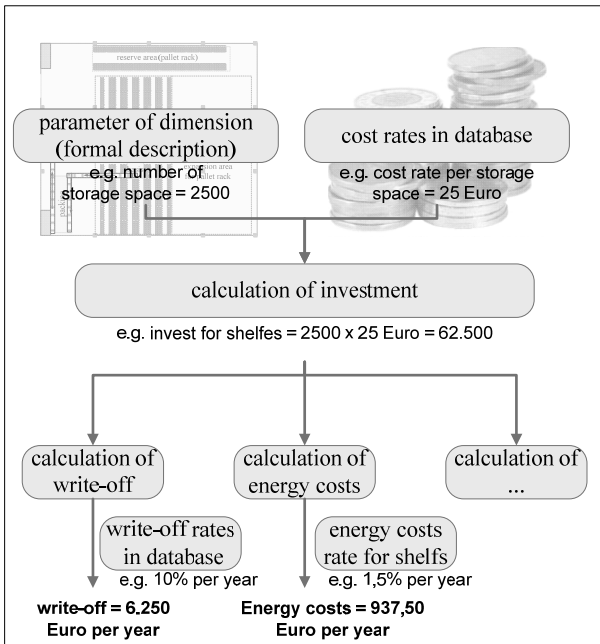
Figure 6: approach to calculate the investment and costs

Personnel costs were defined in agreement with the company. Therefore the demand of staff is identified and described depending on the system load. Based on this demand, the number of appointed employees is fixed under consideration of absent and sick days.

Preparing decision-making some important monetary key figures are calculated to benchmark the different planning versions. The main key figures are the performance in time per orderline, the costs per orderline and the costs concerning an order. The values are illustrated in figure 5 and figure 7 for some selected versions.
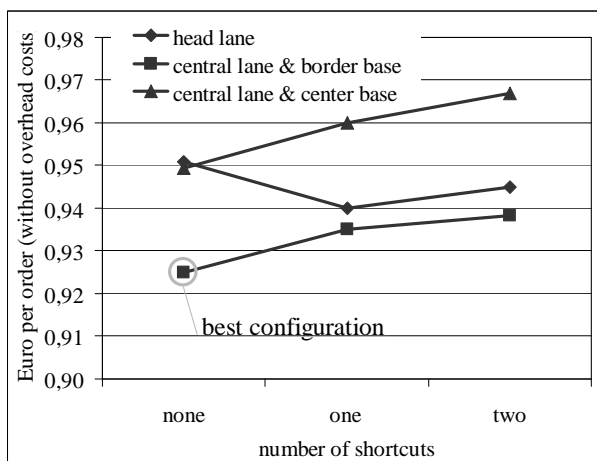

Figure 7: cost comparison between selected versions

Best performance is reached by the versions of type 3 but the transport of bins from the center of the picking area is complex and requires a larger investment because a level change is necessary (vertical conveyer needed).

Considering the monetary benchmark the versions of type 2 and 1 are more profitable. This is a typical result which can be compared with the studies of Schulte [Schulte 2003].

Additionally, the future fulfillment of requirements had to be considered in the evaluation of the planning versions. The trend of the cost structure over the life cycle of a system has to be considered in the benchmark. Figure 8 shows the cost per order over the planning horizon depending on the different load scenarios for version type 2a.
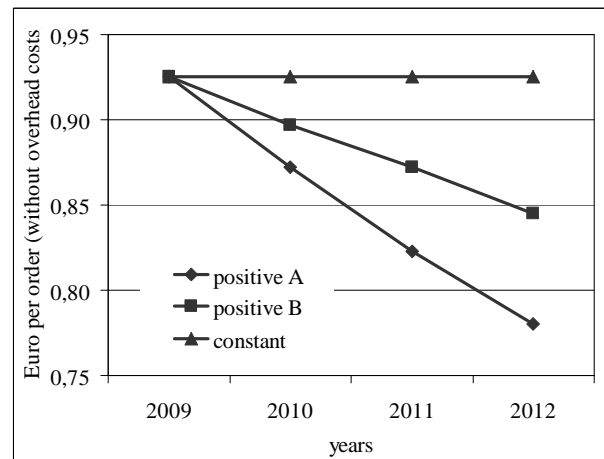

Figure 8: cost schedule for planning version type 2a

With these key figures, the planning versions can be compared quickly. In addition, an efficiency analysis was performed in agreement with the employees of the company. Some of the central concerns were the process safety and ergonomics.

Based on all the above-mentioned information the company could choose one of the planning versions, which will lastly lead to the detailed planning.

Finally the central lane with the base at the border was selected justified by the best cost structure and expansion options.

8. Conclusion

First, the order picking then the stock planning – In the order picking area usually the most staff is employed whereby the customer service and the logistics quality are decided. The highest costs are incurred in this area. [Gudehus 2006] The planning of an order picking system is characterized by the complexity of the system, due to the many interactions between the influencing factors and the multitude of design options. The simulation is the appropriate tool to investigate these interactions.

In the phase of rough planning a large number of versions have to be examined, so that the creation of simulation models has to be mandatory fast. The planning software and the simulation modules with its parameters in PlantSimulation offer this opportunity.

Thus, an efficient use of simulation in rough planning becomes possible.

With the aid of consolidated results from rough planning, the company has created a set of specifications. Currently the tender is running and the implementation is scheduled for spring 2009, so that the new logistics center can be obtained in the slack summer months.

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