OPTIMIZATION OF LOGISTICS PROCESS IN CONTEXT OF SMART LOGISTICS BY USING COMPUTER SIMULATION – CASE STUDY

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Abstract: In the conditions of shipment processing it is important to observe the timetable of dispatch in which the entire processing process is going on. Each element of the processing system is important and it is linked with others by time. This means that the delay of one element causes an avalanche effect. The use of computer simulation helps in optimizing processing processes as a whole. This helps to detect regularities and bottlenecks that have been previously overlooked. The concept of Smart Logistics as part of the Smart Factory using simulation as a tool to estimate the future behaviour of the system. The article describes its own system for determining the number of staff to perform the required activities within the processing process. On the basis of the actual number of shipments, the arrival times and the processing system data, a solution can be described using a simulation tool to determine the number of workers. The simulation helps us to design the number of workers so that they observe the times of truck departures from the processing depot. This guarantees compliance with the timetable at minimum labour costs.

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Keywords: Smart Logistics, shipment processing, computer simulation, number of workers, timetables.

Introduction

The current competitive environment leads companies to search for new solutions that distinguish them from the competition. This environment leads many delivery companies to search for innovative solutions that are reflected both in customer service and in increasing profits by reducing their own costs. At present, customers have the choice of many companies that deliver shipments and thus have postal processes involved in their process. The customer is particularly interested in the delivery speed and the price that this service responds to. Thus, in this competitive environment, the companies who are able to handle their own processes in the entire level from acceptance of the order to delivery at the lowest cost of processing obtain the advantage. Due to the decrease of processing costs, the unit price of the transport can be reduced. In optimal processes, the shipment is delivered in the shortest possible time. Modelling and simulation nowadays play key roles in optimizing processes (Pekarcikova et al., 2014). Thanks to the simulation model on which simulations can be carried out it is possible to validate the decisions, variants of solutions and the consequences that will take on the system without being applied in a physical interference. Today, modelling and simulation are an important part of all larger and smaller companies involved in logistics. Logistics and its problems can also be found in companies that provide delivery services (Fusko et al., 2019). Postal processes are highly sensitive to the time sequence of processes. This means that the delay of one part of the postal process will affect the next part (Gašová et al., 2017). In our case, these are mainly the delayed dispatching of truck semi-trailers from the processing warehouse due to the revaluation of their capacity. The simulation plays an important role, not only in optimizing processes, but also in optimizing the number of workplaces and action in them. In internal logistics, it is possible to use simulations to organize material flows that are reflected in the reduced amount of human resources needed as well as technical facilities. The objective of the article is to describe a case study in which a simulation is used as a tool to optimise the postal processes by specifically optimizing the number of workers at the point of loading of shipments to the

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semi-trailer in direction of Bratislava (BA) to meet the required time recommended for semi-track dispatch.

Literature review

Logistics is an area in which computer simulation has a great use. Krajčovič et al. (2012) defines logistics as the process of planning, implementing and controlling the efficient, powerful flow and storage of final products, services and relevant information from the point of origin to the place of consumption. Today, the available simulation tools commonly allow modelling of various structured material flows and can model various complex logistical processes and postal processes (Gregor et al., 2017). Many examples of the use of simulations in logistics and activities are published in the publications. The authors Yadavalli et al. (2017), in their work, provide an outline of a solution to the problem facing 3PL (logistics sorting as a service), who process different types of packages within their distribution centres. In their work, they dealt with the application of a technique that provides assistance in making the optimal capacity of equipment for sorting the types of consignments to ensure that the company retains transparency and the ability to continuously meet the expectations of customers and the agreements prescribed. In further studies, the authors Clausen et al. (2015) in the context of their research dealt with four different objective functions to improve package transshipment operations, using a discrete simulation approach. Other authors Masel et al (1997) dealt with the use of static models and recounts in assessing the optimal conditions under which processing processes are underway. The author Čujan (2016) devoted himself to the simulation of the internal logistic systems using the Tecnomatix Plant Simulation. The same program for logistics optimisation was used by the authors Trebuña et al. (2020), Woolliscroft et al. (2013), and Ristvej, J. et al. (2013) where, however, it was for production optimisation. However, all these authors pursue one goal and thus make the effort to streamline the activities that the logistics will take away. The postal processes as such are created by sequence of technology procedures. Setting up logistics in these activities is therefore very important. Postal processes can be divided into three stages of receiving a shipment, sorting a shipment and delivering a shipment (Bučková et al., 2017). In each of them, logistics is applied in another way but they work in synergy and follow up. The follow-up of time schedules at a high daily variability in the number of shipments is difficult and often delays occur (Mleczko et al., 2014). A very important part in transporting shipments from the addressee to the recipient is the sorting of shipments as such. Unloading, scanning, weighing and initiation, and loading of shipments are included in the sorting activity. This process has been given a dominant focus on optimisation.

Data and methodology

The following chapter discusses the description of the input data for the model needed as well as a description of the processes that are running in the depot. The conclusion of the chapter is devoted to the ingestion methodology. The process of sorting consists of various activities, however, together their nature is as follows:

Sorting – distribution of postal items to groups according to predetermined criteria, i.e. according to a certain system such as the categories of postal items, the direction of destination, etc. (Kolarovszki et al., 2014). There are three ways to sort shipments in the processing depot. The sorting of mail shipments, oversized shipments and classic parcel shipments. Mail shipments are transported in bags to the processing depot, from here they are sorted into plastic boxes for specified directions. Oversized shipments are, after unloading, scanned and where appropriate filtered manually into pallets, from which the manipulating devices are moved to the place of loading. The classic parcels are those which meet the weighting and dimensional limit specified by the conveyor manufacturer. Shipments are sorted on the conveyors automatically or manually to the intended direction. Unloading, scanning, weighing and labelling, and loading of shipments are included in the sorting activity.

Unloading of shipments - the purpose of this operation is to unload shipments from a non-sorted semi-trailer or courier delivery at the place of shipment processing. Unloading of shipments is made in pieces or handling units. Telescopic conveyor or roller conveyors are used for the unloading of shipments.

Scanning shipments – is the operation of the barcode loading by a manual scanner for the purpose of determining the shipment position in the processing system. Shipment which are not scanning will be in the next process labelled, but also are those that have already been reported from another processing warehouse.

Weighing and labelling shipments-this is the activity where the shipment is weighed and subsequently labelled. The labelled activities consist of scanning a shipment and print a label that shows where the shipment will be further sorted.

Loading of shipments-loading operations consist in the deposit of the shipments into a semi-trailer so that the maximum space is used. After sorting, the letter shipments are re-scanned and loaded into bags and stored into a semi-trailer. Scanning helps determine the position of the shipment in the processing process. It is thus possible to detect the loading of the shipment into the wrong semi-trailer. In the same way, oversized and classic parcel shipments that have undergone a sorting process are also scanned. They are then stored in the code specified by the semi-trailer. Shipments are stored in semi-trailers freely on the ground, on palettes or in metal buffers.

For the modelling a delivery company was chosen in which postal processes take place. To compile the model, it was necessary to identify the information data that can be divided into two groups of constant and dynamic inputs (Furman et al., 2017).

- Constant inputs: the length and width of the conveyers, the speed of the conveyor, conveyor belt weight and length restrictions, the dimensions of the boxes for small parcels.
- Dynamic inputs: number of shipments, arrival time, dimensional size of shipments, unloading point, number of workers, capacity of the conveyor, frequency of shipment to the given direction, number of mailed items, the time of arrival of the mailed items (in bags), the dimensional size of the mailed items, the sorting place of the mailed consignments, the capacity of the box for mail, and other random factors.

Based on this data, the simulation model of the sorting depot in Tecnomatix Plant Simulation 15 Figure 2 was compiled. This model consists of 385 objects which together create a simulation model. The methodology shown in Figure 1 has been chosen to produce the model and to carry out the experiments.

Figure 1: Methodology of creating simulation model with realization of simulation runs

Results and Discussion

As a problem for the analysis and design of the solution in the simulation, the determination of the number of workers in the direction of the BA was chosen as well as a recommendation for the selection new arrival time of one semi-trailer intended for sorting, which is involved in reducing worker occupancy on the BA direction. A depiction of the direction and length of the material flow and final loading point is in figure 3. The assessment criterion for the establishment of an optimal number of workers will be the time for which the last package is carried out, the utilization of workers and the blocking of the conveyor system. When analysing and optimizing the arrival time of the non-sorted trailer, we will observe the departure time of the semi-trailer towards BA, as well as the workload. On the basis of the experiments, a time is recommended as well as the optimal amount of workers to load the BA direction.

Figure 2: 2D and 3D Visualization of modelled processes

Source: Authors

Figure 3: Depiction of the direction and length of the material flow for shipments to BA and a visualization of the final loading point for direction BA.

Source: Authors

Analysis of the current state

For now, is on solving workplace one worker. A worker performs all activity by himself. During his work he scans and loads shipments into a semi-trailer. Shipments comes along the conveyor belt as well as oversized shipments that are stored on the pallet. The times for checking the correctness of the direction, scanning the shipment and saving are taken into account in the simulation. The definition of

the problem is: "How many workers are needed, and the arrival of which non-sorted semi-trailer is to be changed so that the semi-trailer on the BA route has gone on time, which is at 5:20:00 of the simulation time, while the workload of workers and the blocking of the line were adequate?". The limit of workers used in the experiment are 4 workers. For analysis and evaluation, 3 variants were selected. The limit that was designed for the maximum change of arrival time for one semi-trailer is 20 minutes.

The first variant is the solution when the arrival of the non-sorted semi-trailer is shifted from the TT_SE direction. He currently comes and starts unloading around 5:00:00 of the simulation time. The proposed variant counts with the advent of the semi-trailer for unloading by 4:40:00 of the simulation time.

The second variant is the solution when the arrival of the non-sorted semi-trailer is shifted from the TN_PD direction. He currently comes and starts unloading around 4:00:00 of the simulation time. The proposed variant counts with the advent of the semi-trailer for unloading by 3:40:00 of the simulation time.

The third variant is the solution when the arrival of the non-sorted semi-trailer is shifted from the PP direction. He currently comes and starts unloading around 3:30:00 of the simulation time. The proposed variant counts with the advent of the semi-trailer for unloading by 3:10:00 of the simulation time.

The beginning of the simulation is 0:00:00 of the simulation time which is 19:30 in real time.

The graph in figure 4 shows the percentage of activities performed by the worker on the BA loading point for the current state.

Figure 4: Graph of the percentage of activities performed by the worker on the BA loading point for the current state.

Source: Authors

The current departure time of the BA truck semi-trailer is 5 hours 42 minutes and 26 seconds. In the analysis of the proposed variants, 12 experiments with 100 replications were carried out on the simulation model. The data that was acquired is summarized in table 1 and table 2. The graphical representation is shown in figure 5.

Table 1: Utilization of workers in loading point for direction BA (%)

	Variant	1 worker	2 workers	3 workers	4 workers
	Variant 1	68.3 %	36.8 %	26 %	26 %
	Variant 2	66.2 %	35.1 %	24.8 %	24.8 %
	Variant 3	66.2 %	35.6 %	25.1 %	25.1 %

Source: Authors

Table 2: Departure time of sorted semi-trailer to direction BA

	Variant	1 worker	2 workers	3 workers	4 workers
	Variant 1	5:31:59.87	5:07:49.44	5:07:49.44	5:07:49.44
	Variant 2	5:42:26.80	5:21:52.39	5:21:52.39	5:21:52.39
	Variant 3	5:42:26.80	5:21:52.39	5:21:52.39	5:21:52.39

Source: Authors

Figure 5: Graphical representation of the departure of the sorted trailer to the direction BA with changing numbers of workers.

Source: Authors

After comparing the current state and the results from individual variants it was concluded that the current situation of the trailer goes to the Bratislava direction by 5:42:26.80. The occupancy rate of one worker is 66.2% of total working time. From the analysis it was found that at variant 1, assuming two workers, the trailer leaves 5:07:49.44, while the capacity of the workers is 36.8%. This percentage can be increased by involving workers in other workplaces. In the end, the time of departure of the trailer will decrease for BA direction by 10.11% and its departure is in agreement with exit criterion 5:20:00.

In the context of the discussion, it can be noted that:

- Dynamic simulation is and will be an important tool for decision-making in postal processes: In the context of literature review, some foreign studies have been described, showing the need to use simulations in the optimisation of postal processes;
- The results of the simulation must be valid with modelling system: the level of conformity of the simulation model with the real system is decided primarily by abstraction. The high level of abstraction is involved in the higher speed of model creation as well as on the lower claims for computational performance. However, this leads to distortion of the results of the simulation and the rate of validation decreases. It is important to choose key processes that achieve low abstraction and side processes for simulation, and some non-important processes neglect. This was also in our case where the sorting processes in which the shipment is sorted are according to the street address;
- It is necessary for a company to create data-delivery databases: The accuracy of simulation experiment results depend on input data. It is necessary for companies to form databases that are actual as soon as the freight forwarder delivers the shipment. It is essential that the number of shipments incoming for sorting for the intended semi-trailers as well as the individual percentage for the direction are known. If we do not have data for today, it can be based on statistical analysis of past data, and with predictive data to perform a simulation.

Conclusion

Modelling and simulation play a major role in reducing costs at present days. They can be used to detect problems, then check the solution for the problem on the simulation model and apply it in real practice. In particular in postal processes, bottlenecks can be detected. Based on a situation, different variants of problem removal to increase capacity utilisation of processes and activities can be run. The article content was to describe the use of computer simulations to optimise the number of workers in a place where shipments towards the direction BA are sorted and loaded into the trailer. This was done through the discovery of the current use of the worker and the implementation of various variants of sorting intended for semi-trailers arrival times where the results of experiments were obtained by changing the number of workers. The variant with two workers is chosen as the most optimal. The condition which

was defined at the beginning of the simulation project was met so that the truck followed the departure time towards the BA direction.

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