Application of a telematics system to the improvement of transport processes in intelligent high bay warehouses

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ABSTRACT

The paper is devoted to the issue of facilitating transport processes in intelligent high bay warehouses. The presented solutions are based on a real enterprise where inefficiencies and bottlenecks have been identified, processes occurring in the transport system of the high bay warehouse have been analysed. Based on real data, the concept of implementation of a telematics system has been elaborated and verified by means of Anylogic programme. While designing a simulation model of the analysed process, a discrete nature of the phenomena was established (e.g. vehicles coming to the warehouse at different time intervals). The simulation tools reflected non-determining parameters as well as dynamics of phenomena occurring in the transport process. For these purposes research has been done on probability distributions of parameters such as the time for preparation of delivery acceptance zone, the time for unloading a delivery (including transportation to intermediate storage areas), duration of a quality check. The simulation research confirms the adequacy of the elaborated concept.

KEYWORDS: intelligent telematics system, simulations, optimization of a warehouse

1. Introduction

Nowadays the market is governed by globalization and international corporations which have a huge impact on prices in the market. They have their own know-how, invest in searching and implementing the latest solutions which contribute to a reduction in fixed and variable costs as well as to improvement of the quality of goods and services. One of the ways of developing and expanding an enterprise involves acquisitions and mergers which are an alternative to the growth relying on an internal method applied on the basis of own resources and skills or capital investments.

Simulations allow us to design a model of a real process and do experiments aimed at understanding the principles of process operation as well as evaluating various strategies accounting for limitations imposed by a specific criterion or criteria. A significant stage of the simulation consists in modelling, defining as an experimental and mathematical method of researching complex systems, phenomena and processes on the basis of creation of their models.

Development of a model in a complex simulation programme allows us to elaborate optimal routes in a warehouse of vending machines in horizontal as well vertical transportation which is tied up to high storage. When modelling storage processes characterized by a high level of calculation complexity mutual relations between sub-processes should be established. A correct copy of sub-processes allows us to trace and understand their course, gives us a possibility of improving an existing process.

The paper presents an architecture of the modelled system which may be easily adopted in other warehouses. The architecture enables us to run simulation in any warehouse and to generate the best transport solutions for a partially or fully automated warehouse.

The literature distinguishes two approaches to modelling i.e. structural and object-oriented. In the structural approach, a key

role is played by data and processes of processing [1]. It is based on structural programming languages. In the object-related approach, a basic structure of modelling is constituted by an object, a system of collection of objects with defined features completing assigned tasks [1]. Modelling and simulation are used for solving the problem presented further in the paper. The problem has been defined as an evaluation of a warehousing process leading to improvement of its functioning. The warehousing process is presented graphically (a map of a process) and then it is modelled in an object-related simulation tool Anylogic. The combination of the two approaches i.e. a map of the process and a simulation gives a possibility of a very accurate copy in a graphic form of warehousing actions process and recognition of dependencies occurring between them and then reflecting in the simulation tool dynamic phenomena occurring in the warehousing process and taking into account non-determining parameters.

Maps of sub-processes in the warehousing process have been reflected in the Anylogic simulation tool which creates simulation models in sheets. Blocks are put on them as well as connections between them. The objects reflect events and flows of information and goods constituting the basis for the telematics system. Each block is equipped with a dialogue window where value parameters may be entered and it is possible to make changes to objects functioning through modification of the record of an IT code. When designing a simulation model of the analysed process, a discrete nature of phenomena occurring has been established (e.g. vehicles coming to a warehouse at different time intervals). A possibility of reflecting parameters of a non-determining nature in the tool is an important aspect of modelling as well as presentation of dynamics of phenomena occurring in the process. For these purposes, the research was done on the probability distribution parameters such as time of preparing a delivery acceptance area, time of unloading a delivery (including transportation to an intermediate storage area), time of the quality check etc.

Managing processes of goods handling from the movement of picking them up from a forwarder (or a supplier) to the moment of goods leaving the warehouse is done by a WMS system [5]. WMS systems may have a feature of forecasting the stock [2,7]. This is an IT solution managing the traffic of goods in the warehouse accounting for warehousing strategies, supervising the layout of stock, cooperating with ADC techniques [8]. Deliveries from outside the company comprise materials not used by production departments, coming from the returns, shifting goods from the warehouse, deposits as well as finished goods accepted by the warehouse from production departments [3]. The entry check is the next important aspect of accepting goods. It consists in calculating the goods, comparing them with the documentation, measuring, weighing and checking the quality [4].

2. Simulation model of creating an architecture of a telematics system

The entire simulation is presented on the basis of 2D and 3 D graphics. It allows us to visually present processes and demonstrate the specification of warehouse activities in the analysed company. Figure 1 presents the main layout of the warehouse with paths and locations of particular units.
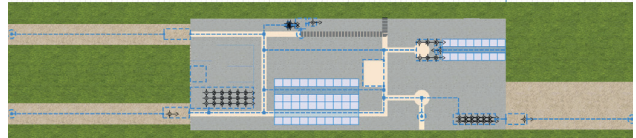

Fig. 1. Map of a warehouse [own study]

On the basis of processes occurring in the high bay warehouse, maps of processes have been prepared for the purposes of creating simulations. The programme enables only general presentation of phenomena so picturing an example pallet labelling will be replaced with longer duration of this activity (Figure 1).

Then the paper will describe how particular stages of processes translate into appropriate connections of task blocks of Anylogic programme (Figure 3) and will characterise them briefly. Also, it will be significant to present applied parameters defining actions, their representation and duration time. The architecture of the entire learning system in ANYLOGIC is shown in figure 2.

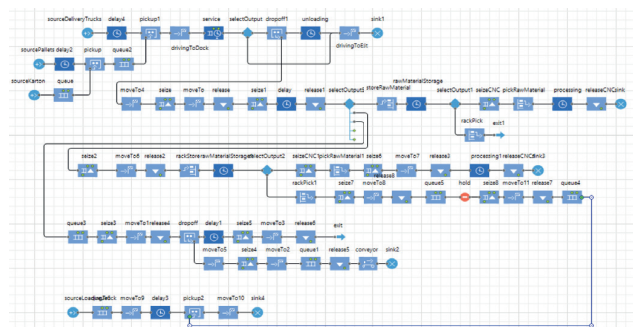**Fig. 2. Process of unloading and inspecting pallets [own study]**

Fig. 3. Architecture of the high bay warehousing in ANYLOGIC programme [own study]

2.1. Driving to a ramp. Visual inspection of a delivery

The block diagram in Figure 4 begins with a truck driving into a warehouse. We add "SourceDeliveryTruck" which makes it appear on the simulation. In order to use further parts of the simulation, an object must be assigned and belonging to particular Agents i.e. a truck or a pallet. To do that we use "pick-up" which assigns the number of packages or pallets and pallets to a truck. Then a full truck comes to unlaoding (drivingToDock) where an employee is sent (service) to check the quality of the delivery. After this stage, a decision block is created (selectOutput) which is to show whether the truck is fit for unloading or not. If not, the truck drives away from the ramp (drivingToExit) and disappears through the block "sink1". In case of proper loading of goods, we proceed to unloading (dropoff1). The unloading block reflects the time needed for unloading and it is designated for putting the last pallet on shelf.
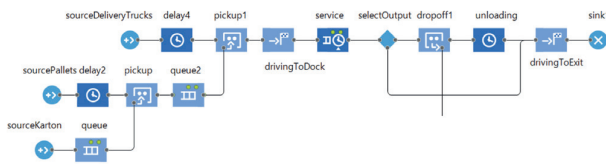

Fig. 4. The Architecture of the system of visual inspections of a delivery in ANYLOGIC programme [own study]

2.2. Unloading, transporting a delivery to PZ area. Quantity and quality check.

The next blocks in Figure 5 are responsible for physical unloading the goods. Firstly, data of a pallet must be sent to the place of collection (moveTo4). Then, it is important to call for appropriate resources (seize [forklifts]) to transport the pallets from a trailer to the goods reception area. Forklifts get back to their place after unloading is finished and using the block "release". Then by using the block seize1 we assign controllers responsible for the quantity and quality check of pallets. In order to define the time necessary for the control and labelling pallets we use the delay function. The last stage in the case of forklifts is releasing controllers by using release1block.

Fig. 5. Architecture of the system of unloading and transporting to an intermediary storage area in a high bay warehouse in ANYLOGIC programme [own study]

2.3. Picking up a pallet for transport, putting goods in the area of IS.TMP or in front of a shelf. Placement in the right location.

In this part of designing the simulation we proceed to a decision block Figure 6 used for limiting the flow of pallets between specific locations. The first one is presented in the diagram below. The

number of pallets defined by probability will be transported to wide shelves where forklifts are going to put the goods in the right place of the rack (storeRawMaterial). The block rawMaterialStorage informs about the time of storing the pallets.
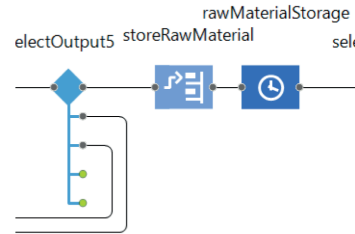

Fig. 6. Architecture of the system of measuring pallet storage in a high bay warehouse in ANYLOGIC programme [own study]

The second possibility of transporting goods is moving them in front of narrow racks (moveTo6) Fig 7 from where a system forklift will pick them up and put them in right locations (rackStore).

Fig. 7. Architecture of the system of moving pallets through narrow shelves into a system forklift and allocating them in a high bay warehouse in ANYLOGIC programme [own study]

The last element of this process Fig 8 consists in transporting a pallet through a loading station (moveTo1). Here pallets are loaded off (dropoff) and boxes are put on a roller (moveTo2). Then goods go to an automatic warehouse (conveyor). The dropoff block enables a second path's exit as created by the pallets. Through "delay1" a pallet "waits" for the boxes to be unloaded and it is moved to an intermediary storage area for pallets (moveTo3).
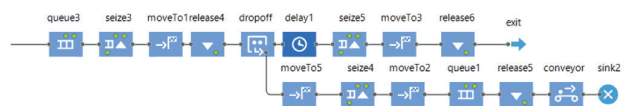

Fig. 8. Architecture of the system of transporting goods through an automatic loading station in a high bay warehouse in ANYLOGIC programme [own study]

2. Final transportation project in a high bay warehouse

An example optimization of a high bay warehouse will be presented below. Simulations allow us to elaborate the best solutions of parameters. Stations of stock replenishment of HPL racks [a], originally functioning as a separate exit on the scanner solely used for completing HPL locations. The rack is flow-through, slanting towards a collating person. During the project, the station has been reprogrammed into a two-function station. Trays with products for completing locations and boxes containing collation tasks came

simultaneously from sections 14 to 27 from the first five rows of racks looking from the top of the picture. The picture is explanatory and analogical changes have been made to all HPL stations for all sections (14-27) and for all rows (5 per station).

A lift going up one way and carrying boxes for orders and trays with goods to be laid out in the target station on the first or second floor of the mezzanine, also enforcing "empty runs" for all boxes and trays even if all picking and putting tasks were on the ground floor. In the project a conveyor [b] with a scanner was completed enabling the lift to go and get collated boxes as fast as possible to the packaging station [c]. The conveyor also deals with ready trays with goods for laying out as their exit is located in the south part of the mezzanine [d].

The racks in the HAO area [e] include numbered sections from 01 to 27. Each bay contains 3 sections. Each section has levels from 01 to 04. Along the main conveyor, the numbers go from 01 to 30 (15 two-side racks0.

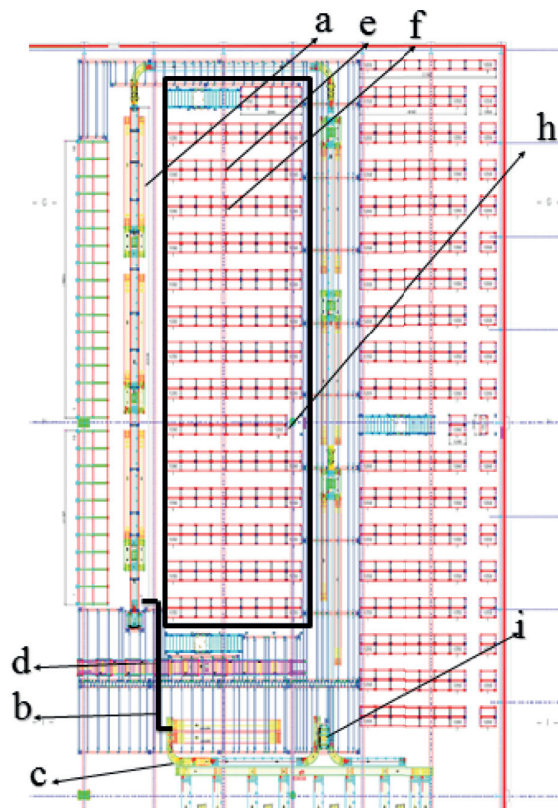All markings with letters may be seen in Figures 9 and 10.

Fig. 9. Map of level 0 on the mezzanine [own study]

Figure 9 shows a map of the ground floor of the mezzanine with marked racks and conveyors whereas figure 10 illustrates placement of PLC scanners and places of transmitting and receiving signals including a direction of rollers in the zone. Changes to WMS software (LV3 Mantis) comprised a change to an algorithm of assigning a destination station for boxes with tasks in bays 14-27.
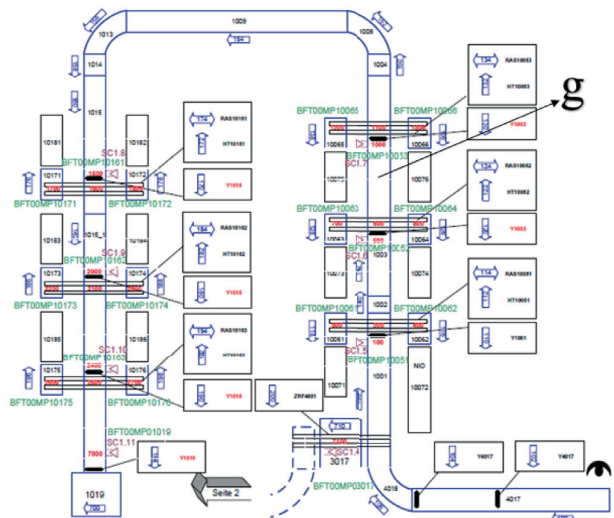

Fig. 10. Layout of scanners and directions of traffic on level 0 on the mezzanine [own study]

On the basis of the above diagrams, the task of accepting [f] in figure 9 has a collection from 9th row, 15 bay and 3rd level (coding name HAO0901503) and in the original configuration, the box containing collections from the above locations would go to BFT00MP10065 (figure 42). Then a worker would have to go 50% of the corridor to collect the goods and get back to a starting station and let the box go on the middle conveyor [g] which would go to the next station with a task to take figure 10.

This way is not optimal so scanners have been reprogrammed so that the above collection could be handled by BFT00MP10172 station. The worker has a much shorter way to go.

Knowing that on the ground floor we have about 40% of collections within the entire day, the so called "quick square" [h] has been created in Figure 9 which contains only highly rotating goods "A". Goods marked with "B" rotation were placed in the part of the mezzanine on the other side of the conveyor. The second floor was designated for rotation "C". Before changes goods were laid out according to rotation in each rows as follows:

- First 10 bays – „A"
- Next 13 bays – „B"
- Last 4 bays – „C"

The construction of an additional conveyor [b] was the most significant mechanical change in Figure 9. It enables us to finish orders within the "quick square", movement of the lift going up and then going directly to the packaging station.

As the system of roller conveyors on the mezzanine is one way, each box with tasks only on the ground floor had to do an "empty run" in the lift going up, around the entire floor up to the lift down [i] in figure 9 which went to the packaging area. The positions of lifts are the same on each floor.

3. Conclusion

The paper presents a method of designing a high bay warehouse. Due to a high complexity (NP complete) of defining optimal storing processes, a simulation programme ANYLOGIC has been used. It was indicated that the optimal paths may be designed and show permeation of various processes by means of this tool. The suggested architecture of the model may be adopted for designing various warehouses. It is particularly useful in warehouses using complex systems of automation and telematics. Beyond doubt, simulations of complex warehousing processes enhance transparency as well as efficiency of management through simplification of structures and concentration on more homogenous entities. Modern logistic solutions, investing in people, automation, software and process improvement are necessary to succeed in the competitive market of logistics services.

The paper is of a research nature and constitutes a case study. The suggested model may be modified in the future for the purposes of a fully automated warehouse.

Bibliography

[1] BUDA M.: Ocena procesu magazynowego z wykorzystaniem modelowania i symulacji. Politechnika Poznańska, Poznań, 2014 (nr 2/DzM/LT/13/14).

[2] CHATFIELD CH.: Holt-Winters Forecasting: Some Practical Issues. The Statistician, vol. 37, pp. 129-140, 1986.

[3] DUDZIŃSKI Z.: Poradnik organizatora gospodarki magazynowej w przedsiębiorstwie, Polskie Wydawnictwo Ekonomiczne, Warszawa, s.90, 2012.

[4] KRZYŻANIAK S., et al.: Organizacja i monitorowanie procesów magazynowych, Biblioteka Logistyka, Poznań 2014.

[5] MAJEWSKI J.: Informatyka w magazynie, Wyd.ILIM Poznań, s.170, 2006.

[6] OLCZYK D.: Modelowanie strukturalne – definicje, notacja, techniki i narzędzia. Warszawska Wyższa Szkoła Informatyki, Zeszyty Naukowe, nr 4, s. 87-98, 2010.

[7] YAR M., CHATFIELD CH.: Prediction Intervals for the Holt-Winters Forecasting Procedure. International Journal of Forecasting, vol. 6., pp. 127-137, 1990.

[8] Automatic Data Capture – automatyczne identyfikowanie i gromadzenie danych.