Universal Simulation Model in Witness Software for Verification and Following Optimization of the Handling Equipment

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Abstract — The aim of this work is to verify the working load of forklifts (generally rolling-stock) based on actual transports and following optimization using a universal simulation model in the software Witness. This aim can be characterized in three following phases. In the initial phase, the actual transport data are obtained for a monitored interval and for the distance matrix between the network points of the actual transports. In the second phase, obtained data are implemented into the simulation model and then the simulation is performed to find utilization of all forklifts. In the last phase, the workload is validated and the optimization is performed using Witness Optimizer.

Keywords-enterprise, model, monitoring data, optimization

1 Introduction

In companies in which high demands on supply logistics are placed, compliance with the agreed delivery times or deadlines, and work organization itself is emphasized in supplying more end work stations [1]. Solving of deterministic transport systems can be found at specialized literature, [1] or [6] etc. Authors of these publications use mostly mathematical methods for searching results. In this work we apply the already known deterministic access and its characteristic into the simulation tool Witness software [4], [5]. Practical applications of using Witness software are at [4] or [7], [8]. From literature it is also known that the specific requirement occurrence for the deliveries, which can be generally characterized as a demand, usually has a time periodic or random character [1], [6], [7]. Randomness is mainly caused by frequent changes of the produced assortment, also accompanied by limiting the capacity or the number of handling equipment, which in practice can be traced.

This paper analyzes full utilization of the current handling equipment under given conditions for specific requirements for deliveries for a given reference period, and subsequently it validates acquired information about the utilization of handling equipment to allow optimization of their number from the point of view of two optimization criteria. Optimization criteria are chosen on the basis of a universal simulation model created in the Witness environment, suitable for tasks of this nature [4], [5], and their implementation in practice is an alternative engineering solution to managerial methods Just-in-time or Kanban implemented in manufacturing enterprises.

2 Analysis of the Current State of Knowledge

Solving the problems mentioned above is closely related regarding the theory to the tasks of planning cycles of vehicles. Planning cycles of vehicles falls within the scientific theory of transport which was once very successfully developed at the University of Transport and Communications in Žilina, Slovakia. To excellent study materials there can be included [6], in which the problem is well formulated and is followed by a theoretical analysis. There are also approaches to the solution and graphical methods of solution, which can be found in [2], and which are complex for the large number of vehicles and trips.

The subject of an analysis of the current status is the finding of several characteristics that are important input data for subsequent verification of the load of handling equipment. The list of necessary input information is given below in indents. Each area is detailed in the subchapter.

- Information on carried out transports - the deliveries during the reporting period in the past,
- The matrix of distance between transmission points of the network,
- The parameters of handling equipment.

2.1 Carried out transports

The information about carried out transports is demanded mainly in terms of the format of records that must be followed for the proper functionality of the simulation model. A preview of the data structure for simulation of transport is given below as Table 1. The length of simulation period is not critical, but for the relevance of the results it is useful to have data only for periods with similar volumes of deliveries (of production).

Table 1. Records of implemented transport

Item	Units
Date a time of Transport	DD.MM.YYYY HH.MM
From - Matrix point	-
To - Matrix point	-
Number of handling Units	Pallets
Material ID	-
Group of handling device	-
Speed (Loaded)	$m.s^{-1}$
Speed (Unloaded)	$m.s^{-1}$
Loading Time	S
Unloading Time	S

A record containing all information required by the above Table is ideal input data for one or more carried out transports related to FROM WHERE – TO WHERE simulation.

Date and time of the transport

- Date and time of the transport (if this information is not traceable, then any time of the earliest traceable track can be used).

From - matrix point

- Point of matrix representing the starting point of transport network, from where the transport was carried out.

To - matrix point

- Point of matrix representing the destination of transportation networks, from where the transport was carried out.

Number of handling units

- The number of handling units transported within one record made about carried out transport,
- The handling unit can be a pallet, crate, it is necessary to follow for the same handling equipment the same types of handling units - possibly convert to volume units, unless it if needed.

Material ID

- Identification of transported material, it's optional data item if it is not necessary to statistically follow a transported amount of material types.

Group of handling device

- Identification of specific handling equipment (a forklift), or a group of handling equipment, performing the same activity. Within the group of handling equipment it is necessary to choose the type of handling equipment which will be promptly available for the carried out transport.

Speed loaded – full, empty

- Indicates the speed in carrying out the handling of the session. There are handlings, which are limited by speed limits for safety reasons, but the speed of handling equipment is usually limited across the transport network (the company).

Loading time, Unloading time

- Specifies the time required for loading (unloading) of a handling unit on (from) handling equipment. Time may vary according to space constraints of locations on the network, depending according to, for example, if it is the floor or a position in a certain height.

2.2 Distance matrix of points in transport network

Since the simulation model works with the real speed of handling equipment, it is also necessary to have real scale of distances between points of transport networks, i.e. points, among which transport is carried out. For the purpose of the simulation model it is sufficient if the carried out transports are completed with information about the distances of all the uniquely determined transport sessions, therefore in any clearly designated routes from - to.

Table 2. Fragment of distance matrix for the simulation model

FROM / TO	1	2	3	4	5	6	7	8
1	0	88.2	87.3	87.7	87.7	87.4	87.5	87.7
2	88.2	0	1.7	1	0.9	1.6	1.6	1.2
3	87.3	1.7	0	1.3	1.1	0.5	0.6	0.8
4	87.7	1	1.3	0	0.6	1.2	1.3	0.9
5	87.7	0.9	1.1	0.6	0	0.7	0.7	0.3
6	87.4	1.6	0.5	1.2	0.7	0	0.2	0.4
7	87.5	1.6	0.6	1.3	0.7	0.2	0	0.4
8	87.7	1.2	0.8	0.9	0.3	0.4	0.4	0

The simulation model reads the requirements from MS Excel workbook, which includes a macro to generate a complete matrix of distances between all points of the network. The generated matrix is read as input to the simulation model. A preview of the distance matrix (network points are indexed) is shown below as Table 2.

2.3 Handling equipment specifications

Among the main parameters of the handling equipment is speed in a loaded and empty status, and duration of loading and unloading. These parameters must be completed either as a global value, which means that it applies to all transports, or is valid for each transport carried out according to Table 1 in particular. The speed of movement is filled in as the basic unit [ms^{-1}] and the duration of loading or unloading in seconds [s].

3 Load of Handling Equipment - Current State

After implementing into the MS Excel control workbook simulation experiment can be carried out, reflecting the load of handling equipment in the monitored period, which correspond to the input data.

The output of the simulation model in this phase of work is load charts of all handling equipment, subject to the simulation. The simulation model takes into account parameters such as shifts of handling equipment (their service), or technological operations such as refueling, replacement of battery, etc. Graphical workload is always relative to the useful time shift for the handling equipment. A preview of obtained graphs is shown below as Figure 1.

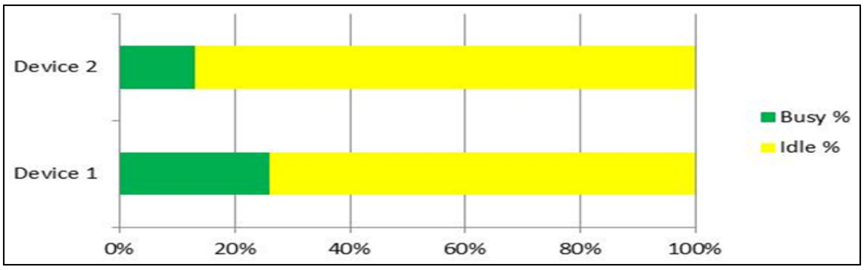

Figure 1. Graphic preview of the handling equipment load for the simulation of the current state

4 Optimizing the Number of Handling Equipment Using Witness Optimizer

At the moment, when we are working with more handling equipment within each group, it makes sense to deal with the question of the number of those actually required handling equipment. This question can be approached in a dynamic simulation using the Witness Optimizer tool. This tool allows us to change the input parameters of simulation and subsequently compare observed characteristics, which directly reflect the impacts of these changes.

The optimization module used in this work allows us to change the number of handling equipment within the group of handling devices (device within a group performs the same group of operations) [5]. Optimization can be done with several different algorithms that seek the best solutions according to the defined optimization criteria. These algorithms use heuristic approaches with the possibility to restrict the set of all possible combinations, thus with a finite number of iterations performed. The found solution is therefore not possible to declare with certainty to be the optimal (it would be possible in the simulation case for ALL Combination) [5], but due to the real time given for simulation it is considered the best possible.

The optimization module used in this work is programmed so that you can choose from two contradicting optimization criteria. The first is the cumulative load handling equipment in the group, which can be further understood as a weighted average of all loads of handling equipment belonging to the same group. The second one is the average time required to meet specified requirements for handling. This is the time interval that elapses between the entry requirement for transport until the object is unloaded at the destination point of transport network. Contradicting criteria are chosen to reflect the optimization of the negative impacts. It can be characterized in such way that if we attempt to minimize the average time to meet the need for transport, the negative effect is increasing the number of handling equipment and therefore reducing the value of their cumulative workload. On the other hand, in an effort to maximize the value of the cumulative load, the average time to meet the demand for transport negatively increases.

5 Results of the simulation

After each performed iteration, the initial configuration of the number of handling equipment in each group are recorded in the resulting table as well as values of both optimization criteria. If necessary, it is possible to add other statistics that are needed (amounts transported, the number of trips undertaken, the size of stocks in various parts of the logistics chain, etc.). A preview of the table obtained after optimization is shown below as **Table 3**.

Table 3. Fragment of the resulting comparison of all simulated variants in the optimization

Watching parameter	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
AVG waiting for execution of demand	144	148	148	152	154	155
No of Group 1	8	8	7	8	8	7
No of Group 2	4	4	4	3	4	3
No of Group 3	1	1	1	1	1	1
No of Group 4	7	5	7	7	6	7
No of Group 5	2	2	2	2	2	2
No of Group 6	1	2	2	1	1	2
Summary	23	22	23	22	22	22
Warehouse 1	6294	6294	6294	6294	6294	6294
Warehouse 2	8.609	8.609	8.609	8.609	8.609	8.609
AVG Busy	31.561	33.012	31.587	32.996	32.996	33.023
Busy Group 1	51.364	51.364	58.734	51.365	51.364	58.734
Busy Group 2	15.098	15.098	15.098	20.131	15.098	20.131
Busy Group 3	51.143	51.143	51.143	51.143	51.143	51.143
Busy Group 4	19.636	27.49	19.636	19.636	22.909	19.636
Busy Group 5	17.304	17.304	17.304	17.304	17.304	17.304
Busy Group 6	31.396	15.885	15.885	31.396	31.396	15.885

A compromise between both contradicting criteria, see Figure 2, can be called the point of balance. The balance point in this case is understood as a generic term. A preview of an intersection of the two criteria is also shown in Figure 2.

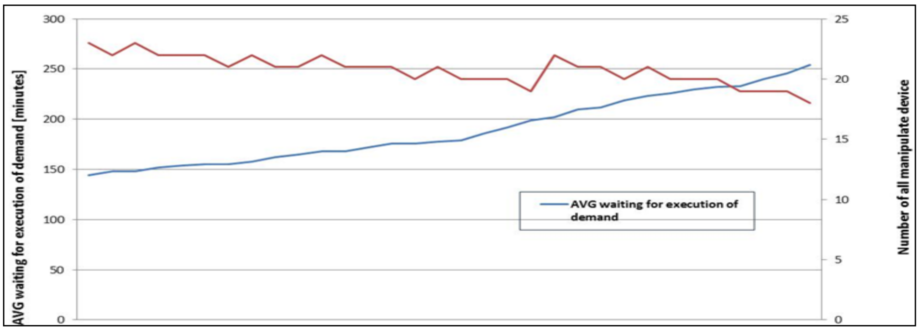

Figure 2. Contradiction of optimization criteria

6 Conclusion

This work dealt with an analysis of handling equipment load at specified conditions, using tools from the Witness simulation environment to allow optimization of the number of them from the point of view of two optimization criteria. The chosen optimization criteria are based on a heuristic search for optimal solutions in the final set of defined options. The methodology used in this work is applicable to tasks with a similar focus to find the optimum parameters for the operation of such systems in practice.

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7 References

1 Daněk, J., Křivda, V. Fundamentals of Transport (in Czech Základy dopravy). VŠB - Technická univerzita Ostrava, Ostrava (2003) 192 s. ISBN 80-248-0410-7

2 Černý, J., Kluvánek, P. Fundamentals of Mathematical Theory of Transport (in Slovak Základy matematickej teórie dopravy). VEDA, Bratislava (1991) 279 s. ISBN 80-224-0099-8

3 Plesník, J. Graph Algorithms (in Slovak Grafové algoritmy). Bratislava: VEDA, 1983. 343 s.

4 WITNESS Getting Started Materials. Lanner Group Limited. (2010)

5 WITNESS OPTIMIZER - Optimizer Module. Lanner Group Limited. (2010)

6 Kluvánek, P., Brandalík, F. Operational Analysis (in Slovak Operační analýza). ALFA, Bratislava (1982)

7 Holík, J. Resultes of Selected Systems of Queoing Theory on Simulating program Witness and Theoretic Calculation Comparison (in Czech Komparace výsledků simulace vybraných systémů hromadné obsluhy v simulačním programu WITNESS) VŠB - Technická univerzita Ostrava, Ostrava (2009)

8 Dorda, M, Teichmann, D. Simulation Using for Modelling of Marshalling Yard Hump Operating (in Czech Využití simulace při modelování provozu na svážném pahrbku seřaďovací stanice). 13. Ročník mezinárodní konference Witness 2010, Vysoké učení technické v Brně, Brno (2010), p. 47-56. ISBN 978-80-214-4107-1