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Re-Handling Operations in Small Container Terminal Operated by Reach Stackers

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Abstract**—**In this paper an average number of re-handlings analysis is proposed to solve the problem of finding bays configuration in small container terminal in Gliwice, Poland. Rehandlings in this terminal can be performed only by reachstackers. The goal of the heuristic is to plan the reachstacter moves in the terminal, assuming that the target containers are reached and the number of re-handings is minimized. The real situation requires also to take into account the model of the problem environment uncertainty caused by the fact that many containers are not delivered to the terminal on time, or can not be sent on scheduled time. To enable this, the heuristic uses some assumptions to simplify problem analysis.

Keywords**—**Container Terminal, Re-handling operations, Computational efficiency, WiMax.

I. Introduction

OPERATING in container terminal is a source of many problems: how to load and unload containers, how to organize storage yards, how to plan re-handling operations in dynamic and high uncertain environment, and are widely studied in the literature [9]. Our intention is to propose efficient in time method for support decision-making processes in small container terminal in Gliwice, Poland (www.ptkholding.pl/index). In table I general technical data of this terminal are presented.

TABLE I
GENERAL DATA OF THE TERMINAL

Data	Currently	Project
Area	30.000 m2	74.000 m2
Capacity	1.700 TEU	3.000 TEU
Track length	620m	620m
Number of tracks	2	6

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The loading-unloading situation is schematically shown in the fig.1 and the reachstacker technical data are presented in Table II.

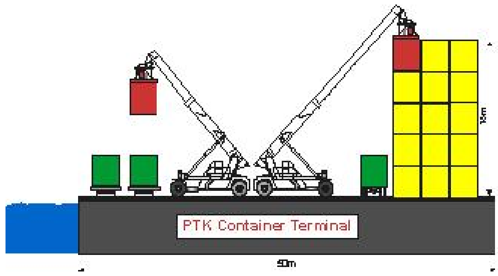


Fig 1. Loading-unloading situation

It should be noted that all operations are performed only by reachstackers. There is an operational difference between cranes that are usually considered in literature [8], and reachstackers. In case of cranes, when a driver of an outside truck requests an inbound container that has other containers on top of it, a crane must remove the containers on top of the target container (it is called ‘re-handling’ operation). In case of reachstackers, also all containers between reachstacker and target container must be removed (compare fig.1). It implies that the number of re-handling operations increases. It is important to minimize re-handlings in order to increase performance of the terminal. We propose to model this problem using STRIPS representation.

TABLE II
REACHSTACKER TECHNICAL DATA

Quantity	currently: 2	project: 4	
Lifting capacity	1st rank - 45 tons	2st rank - 31 tons	3st rank - 15 tons
Stocking height	5 levels		

The goal of the project is to efficient (in time) plan the reachstacter moves in the terminal, assuming that the target containers are reached and the number of re-handlings is minimized.

The size of the planning problem (the container bay) and rails placement is shown in the fig 2. To improve communication between reachstackers and planning module the WiMax communication technology can be used (Wang et al. 2008).

II. Theoretical Background

In many real world applications an initial state of the problem given as a set of predicates is, realistically speaking, an overidealization since model and measurement inaccuracies, disturbances and imperfect processing procedures result in the uncertainty in the problem variables. [9] "At European terminals 30–40% of the export containers arrive at the terminal lacking accurate data for the respective vessel, the discharge port, or container weight. (…) For import containers unloaded from ships the situation is even worse: the landside transport mode is known in at most 10–15% of all cases at the time of unloading a ship, e.g., when a location has to be selected in the yard." It leads to difficulties in efficient terminal planning that are usually resolved by simplifications in problem modeling.

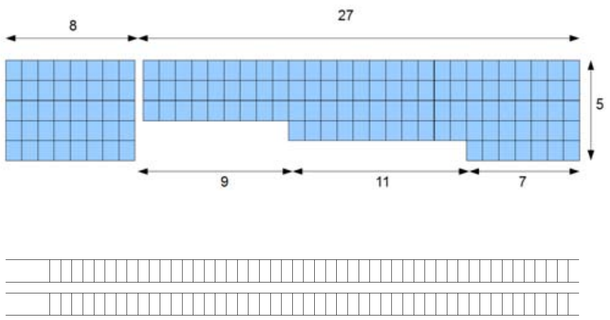


Fig. 2 Container bay and rails – top view

In real situation decision problems at container terminals are more complex and divided into several groups: arrival of a ship (train), unloading and loading of a ship (train), transport of containers from and on a ship (train), stacking of containers (see e.g. www.ikj.nl/container/decisions.html). Since arrival of a ship (train) and containers transport are usually treated as scheduling and allocation problems (e.g. Imai et al. 2001, Bish et al. 2001), problems of loading and unloading and container stacking can be treated as planning problems (e.g. Avriel et al. 1998).

Exemplary heuristics that for re-handlings analysis at sea container terminals can be found in Kap and Kim (2002) and Kap and Hong (2006). In our paper we propose a heuristic that finds bays configuration minimizing number of re-handlings under some assumptions (see section heuristic). It should be noted that such approach can be applied in terminals that operate using reachstackers (not cranes). Please submit your manuscript electronically for review as e-mail attachments. When you submit your initial full paper version, prepare it in two-column format, including figures and tables.

III. Heuristic

There are some limitations when operating by reachstackers. In fig. 3 one can find an illustration of (partial order) plan diagram for reaching target container.

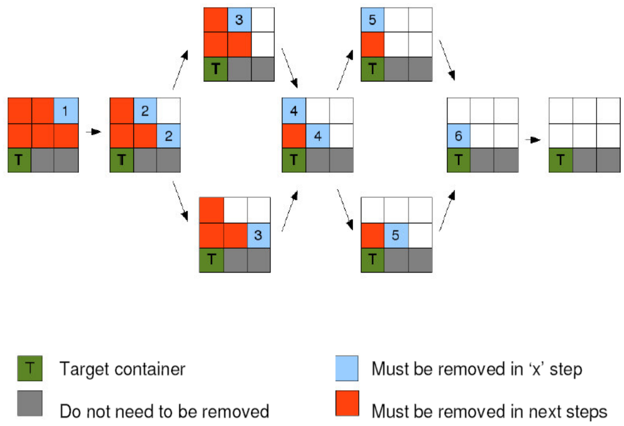


Fig. 3 Plan diagram for reaching a target container within a bay

These limitations have been wider described in our work using so called Block World environment with STRIPS representation characteristic for artificial intelligence planning problems [3]. In fig. 4 the influence of a bay configuration to the number of re-handligs is schematically shown.

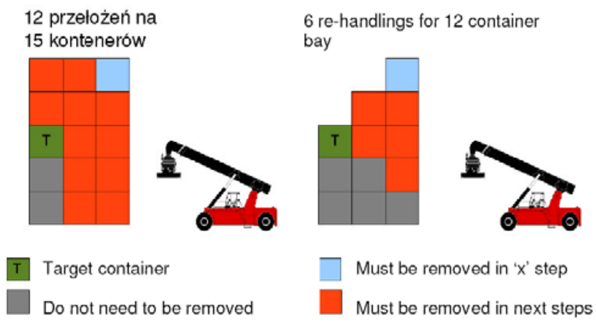


Fig.4 The influence of a bay configuration to the number of re-handligs

It should be noted that small changes in a bay configuration have significant influence on the number of re-handings necessary to reach the target container. It implies that is worth to consider different bay configurations for decreasing the number of re-handlings. In fig. 5 an exemplary configurations and corresponding average re-handling numbers are presented.

Under the notions:

k – number of stacks in a bay,

n – number of stack ($n = 1,2\ldots k$),

$h(n)$ – height of the n-th stack (also the number of containers in n-th stack),

N – number of stack with target container,

p – place of the target container,

$r(n)$ – number of not moved containers in n-th stack,

$g(n)$ – number of moved containers in n-th stack,

G – sum of the re-handling operations for the bay with target container,

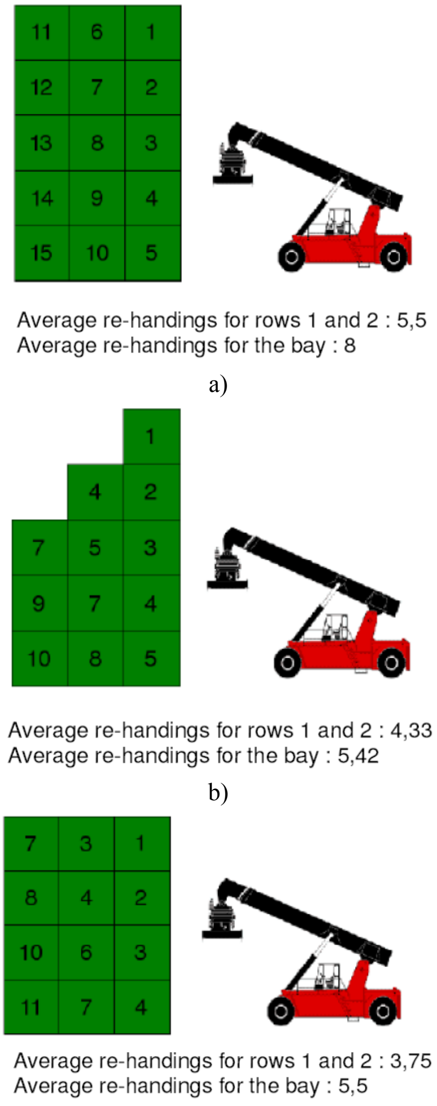


Fig. 5 An exemplary configurations and corresponding average re-handling numbers

the formula for calculating the number of not moved containers for requested target container is:

$$r(n,N,p)=\begin{cases} p & n=N \\ \min(\lfloor\frac{(h(N)+1)\%6}{2}\rfloor,\lfloor\frac{(p+1)\%6}{2}\rfloor) & n=N-1, N>1, n<N \\ \min(-\lfloor\frac{h(N)}{4}\rfloor+1,-\lfloor\frac{p}{4}\rfloor+1) & n=N-2, N>2 \\ 0 & N>3, n\in\langle 1,N-3\rangle \end{cases}$$

then:

$$G=\sum_{n=1}^{n=N}(h(n)-r(n))$$

So the formula for calculating the average number of re-handlings for the bay in the general case (when operating by reachstackers) takes the form:

$$\bar{G}=\frac{\sum_{N=1}^{N=k}\sum_{p=1}^{p=h(N)}G}{\sum_{n=1}^{n=k}h(n)}$$

In Table III the numbers of not moved containers for the target container indicated by (*N,p*) is presented. These numbers are direct implication of technical limitations of used reachstackers schematically shown in fig 6.

TABLE III
NUMBER OF NOT MOVED CONTAINERS
FOR THE TARGET CONTAINER (*N,P*)

$h(N)$,	$r(N)$	$r(N-1)$	$r(N-2)$	$r(N-3)$
5	p	0	0	0
4	p	2	0	0
3	p	2	1	0
2	p	1	1	0
1	p	1	1	0

For the situation presented in this figure the G = 10. This number can be also calculated basing using the general formula introduced earlier:

$$r(n,N,p)=\begin{cases} 2 & n=N=4 \\ \min(\lfloor\frac{(4+1)\%6}{2}\rfloor=2,\lfloor\frac{(2+1)\%6}{2}\rfloor=1)=1 & n=N-1=3, N>1, n<N \\ \min(-\lfloor\frac{4}{4}\rfloor+1=0,-\lfloor\frac{2}{4}\rfloor+1=1)=0 & n=N-2=2, N>2 \\ 0 & N>3, n=1 \end{cases}$$

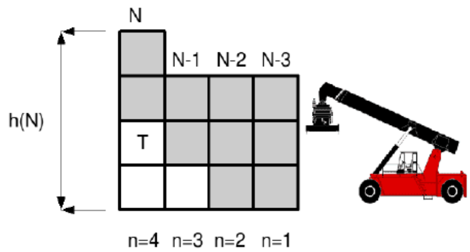
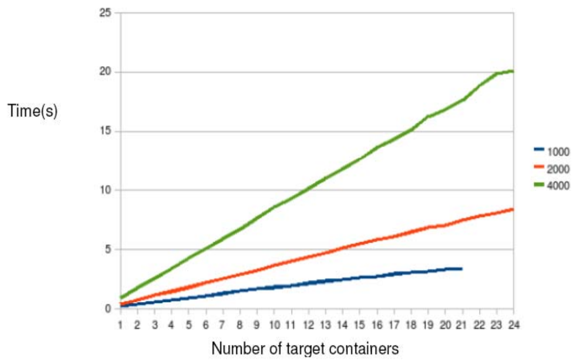


Fig. 6 Technical limitations of used reachstackers

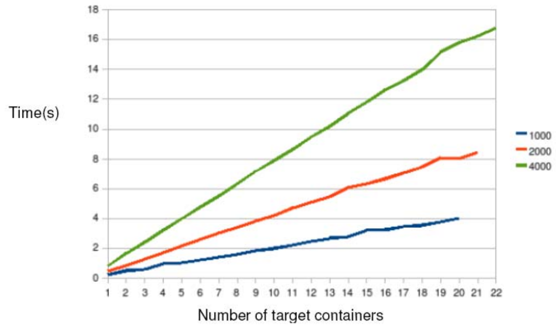
The analysis of possible configurations leads to conclusion that if the number of stored containers does not reach the capacity of the terminal bays then it is worth to search for the bay configurations that minimize the average number of re-handlings. Such approach will lead to minimization of real number of re-handlings if the probability that a container is a target container is the same for all containers within a bay. Such assumption (and simplification) is justified since the complete container data are often unknown when the decision of stacking must be done (Steenken et al. 2004).

IV. SIMULATION RESULTS

Tests for the efficiency of the heuristic have been performed for 3 capacities of the terminal: 1000, 2000 and 4000 containers and corresponding number of bays: 50, 100, 200. Each bay consists of 5 stacks and the stack height changes from 3 to 5 (see fig. 5b). The current capacity of the terminal is 1700 2TEU containers. Presented tests are for two different minimal heights of stack: 3 and 1 (fig. 6a and 6b).



a) tests for the minimal stack height = 3



b) test for the minimal stack height = 1

Fig. 7 Simulation results

V. Conclusion

In the paper the problem of moving containers by reachstackers in small terminal is presented and analyzed. The heuristic that finds the optimal bay configurations in such terminal is presented and efficiency test are shown. The time of calculations is short and allow to apply the heuristic directly before the operating with target containers. It should be noted that this efficiency and (also) simplicity of the solution results from the very small size of analyzed problem but, in our opinion, it should not be treated as a toy problem comparing to big sea terminals, since the degree of lacking the complete container data when operating within the terminal is very big.

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References

[1] Avriel, M., Penn, M., Shpirer, N., Witteboon, S. 1998. Stowage planning for container ships to reduce the number of shifts, Annals of Operations Research 76, 55--71

[2] Bish, E.K., Leong, T.Y., Li, C.L., Ng, J.W.C., Simchi-Levi, D. 2001. Analysis of a new vehicle scheduling and location problem, Naval Research Logistics 48, 363--385

[3] Gałuszka A., Skrzypczyk K.2008. Moving containers in small terminal as STRIPS planning problem – preliminary results. Proc. Int. North American Simulation Technology Conference. Montreal, Canada, August 13-15 2008, str. 107-109

[4] Howe A.E., Dahlman E. 2002. A Critical Assessment of Benchmark Comparison in Planning. Journal of Artificial Intelligence Research 17, 1--33

[5] Imai, A., Nishimura, E., Papadimitriou, S. 2001. The dynamic berth allocation problem for a container port, Transportation Research B 35, 401—417

[6] Kap Hwan Kim, Hong Bae Kim. 2002. The optimal sizing of the storage space and handling facilities for import containers. Transportation Research Part B (2002) 36:821-835

[7] Kap Hwan Kim, Gyu-Pyo Hong. 2006. A heuristic rule for relocating blocks. Computers & Operations Research (2006) 33:940-954

[8] Kim K.H and H.B. Kim.2002. The optimal sizing of the storage space and handling facilities for import containers, Transportation Research B 36, 821—835

[9] Steenken D., Voß S., and Stahlbock R. 2004. Container terminal operation and operations research – a classification and literature review. OR Spectrum (2004) 26: 3–49

[10] Swierniak A., A. Galuszka. 1999. Betweenness and indistinguishability in modelling and control of uncertain systems, Proc. of 18th IASTED Conference Modelling, Identification and Control, (Innsbruck 1999), 56—58

[11] Wang F. , A. Ghosh, C. Sankaran, P. J. Fleming, F. Hsieh, S. J. Benes. (2008). Mobile WiMAX systems: performance and evolution. Communications Magazine, IEEE, Vol. 46, No. 10. (2008), pp. 41-49.