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PLANNING THE LOADING AND UNLOADING PROCEDURES FOR CONTAINERIZED CARGOSHIPS - AN OR CASE-STUDY

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Abstract

The paper gives a short describtion of a computerized method for planning the loading and unloading procedures for containerized cargoships.

Consider a containership in regular service. The ship will unload and load cargo in every port on route. The problem is now to achieve a total optimality (or near-optimality) instead of a total suboptimality through local port optimality. The method described solves the total planning with respect to given stochastic future demands. The objective to be minimized is the total amount of meaningless containeroperations, i.e. the unloading and loading of the same container in the same port.

A comparison of model-experiences and real-world results is given and the method developed is evaluated.

Introduction

Containerization has been a characteristic in the field of cargo transportation in the last decades. More and more cargo are packed into one of a few units - containers - and this developement is still going on. The containers, the containerships, the berths and all the other physical units of a containersystem have increased enormously but unfortunately without a similar increase in the administrative systems and planning tools.

This is indeed the fact in the case of the loading and unloading procedure. The present planning tool is in most cases manual which often results in a non-optimal stowing plan.

As known to the author there has only been a few attempts to solve this problem and none of those incorporates consideration of the future stochastic amount of goods to be transported as done in this paper. The paper is focusing on experiences and possibilities of the shortly presented method.

Problemdescription

Consider a containership in regular service. The ship will unload and load cargo in every port on route. This so-called terminalproces we want to plan in order to achieve minimum terminal cost for the whole route.

A bad or missing planning can result in a bad stacking of containers. The containers to be unloaded are perhaps in the buttom of the ship and all containers above must also be unloaded and loaded again. This means an increase in use of terminal time.

We now have to define/clarify some of the essiential elements in the containersystem considered.

The containership is a Lift-on,Lift-off ship (LI-LI). The containers can be stacked in columns over and under the hatch-covers. To each containership exists a set of restrictions on the distribution of weight of goods arising from stability and shiptecnical considerations.

The containers are the units to be loaded in the ship. There exists basicly two types of units (20'x8'x8' and 40'x8'x8') and these types are ancestres to a serie of specialtypes of the same sizes. The method developed assumes only one size of containers (40-foots) and two 20-foots containers can be placed instead of one 40-foot.

The cargo. It is mentioned that the planning horizon is one whole route. We therefore have to consider the amount of cargo to be transported in the present and in every future port on route. These amounts are considered as stochastic variables with a distribution based upon either forecast or history. Only in the present port we know the amount exactly.

The terminal costs can be divided into two groups, the timedependent costs and the handling costs. The use of time in each port can be assumed and the handling costs are proportional to the number of container-operations which thus can be used as a common measure for the total terminal costs. Achieving minimum terminal costs is then equivalent with achieving minimum number of container-operations.

A shifting is defined as a meaningless containeroperation, i.e. unloading and loading of the same container in the same port. The total number of container-operations consists of necessary container-operations and shiftings.

The problem can now be stated as: Planning the loading and unloading of a LI-LI containership in a port in order to 1) achieve minimum amount of shiftings on the whole route and 2) satisfy all restrictions on the ship. As basis of the planning we have 1) the ship arriving at the port with plans of the containers loaded, 2) the number of containers from this port to any future port (deterministic) and 3) the number of containers from any future port to any other future and later port on route (stochastic).

Method of solution

In figure 1 we have sketched the way of calculation together with the physical course. The aim of the calculation is - as seen - to get a prospect before the loading and unloading takes place of the ship afterwards. With this prospect in hand the unloading and loading procedure can be planned and completed.

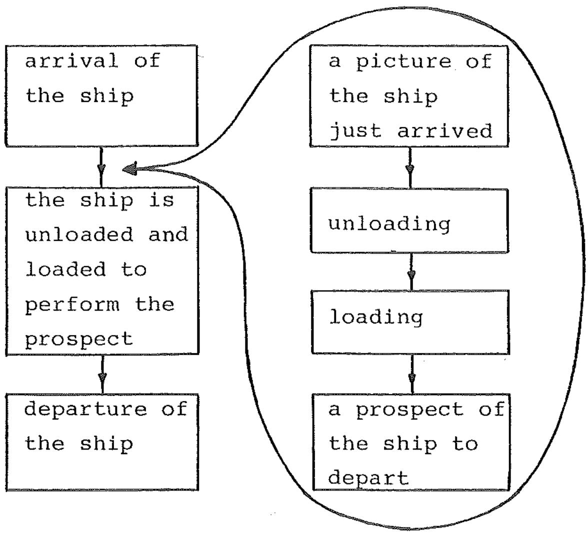

Figure 1. Real life and model flow.

There are two major items in the method of solution which - without loss of generality - are treated independently.

The unloading is performed in two tempi. First of all the containers that necessary have to be unloaded are unloaded, i.e. the containers that as destination have the actual port together with the containers in way of this unloading. If the objective was local port optimality the unloading was finished [1]. But one can imagine a situation where extra unloading, extra shiftings now will save more future shiftings. This future saving is dependent on the future demand for transportation which is assumed stochastically given. The problem arose is therefore a statistical decision problem. For every column in the ship (or rather for every independent part of the ship) the expected future savings due to any extra unloading is calculated by simulation tecnique. If the expected savings are greater than the extra costs imposed by the extra unloading the unloading is done.

The loading is also performed in two tempi. Each container to be loaded has two characteristics, its destination and its weight. Relaxing the

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1) This is indeed what's happening now.

weightproblem the loading only consists of allocating free cells to each destination. Any container to this destination can be placed in any of the cells allocated. The allocation of cells shall satisfie the following proporties:

1 - If at all possible the demands shall be satisfied.
2 - It shall ensure good future planning possibilities.
3 - It shall cause as few shiftings as possible.

The method developed is a heuristic method where a priority calculation for each cell, column and hatch-cover is directing the loading procedure.

With this allocation of cells to destination as input the remaining problem is to place each container in one of the possible sites. The objective is now to satisfie the limitation of stability and of the ships tecnique. A mixed integer programming model is solved to feasibility. If there exists no feasible solution the method changes the priority calculation mentioned above and recalculates the allocation of cells.

Experiences

Testproblem. The method of solution has been tested on a somewhat realistic problem. Due to the assumption that only one size of containers can be treated the problem cannot be fully realistic.

During the project there has been a collaboration with the danish MÆRSK CONTAINER LINE operating in the pacific, see figure 2. The ship, the route and the demands used in the testproblem are real data from this compani converted to one-size containers (40'). The ship contains at most 646 containers of which 352 are above the hatch-covers in 4 layers.

Results. The method has been used for a run through a route with 4 different demand-matrices - little, normal, big and very big chargings. The effectiveness of the method can be measured as the number of shiftings in relation to the chargings. In table 1 the aggregated results for the four problems are shown and in figure 3 more detailed results for problem number three are shown. Finally in figure 4 an example of the final stowing-plan is shown. It should be mentioned that the distribution of the future demands used in the unloading phase is build upon demands in the past.

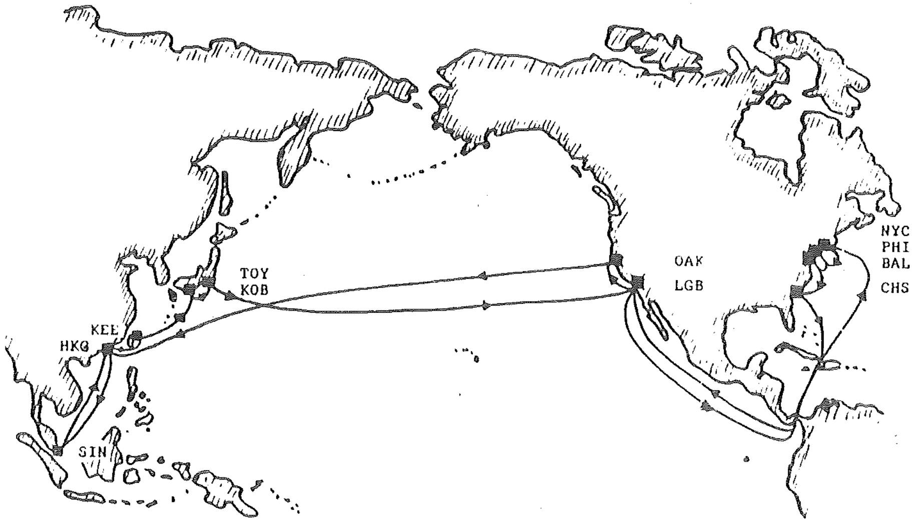

Figure 2. MÆRSK CONTAINER LINE´s route USA - the far east.

Problem	average filling	maximum filling	number of shiftings
1	48.3%	85.0%	0
2	59.8%	90.0%	0
3	60.1%	100.0%	1
4	68.1%	100.0%	12

Table 1. Aggregated results for the four testproblems.

Evaluation. In the winther 75/76 data was collected from MÆRSK CONTAINER LINE. These real-life results shows, that there for each run through a route was approximately 135 shiftings (converted to 40' containers). This is for a ship of the same size as the tested ship and the average and maximum fillings were not greater than the ones in testproblem two.

Savings by use of the method described are of considerably size. Of

destination port \ origin port	SIN	HK2	KEE	KOB	TOY	LG2	NYC	PHI	BAL	CHS	LG1	OAK	HK1
HK2	12												
KEE	5	1											
KOB	16	5	1										
TOY	8	1	o	o									
LG2	37	25	39	38	35								
NYC	81	56	4o	6o	6o	o							
PHI	11	8	6	11	11	o	o						
BAL	2o	11	12	35	27	o	o	o					
CHS	9	6	6	12	5	o	o	o	o				
LG1	o	o	o	o	o	o	o	o	o	o			
OAK	o	o	o	o	o	o	o	o	o	o	19		
HK1	o	o	o	o	o	o	95	16	3o	1o	43	3o	
SIN	%	o	o	o	o	o	87	9	22	7	55	67	19

port	SIN	HK2	KEE	KOB	TOY	LG2	NYC	PHI	BAL	CHS	LG1	OAK	HK1
fillings in %	32	47	63	84	1oo	74	59	55	47	44	62	74	41
number of shiftings	o	o	o	o	1	o	o	o	o	o	o	o	o
refused containers	o	o	o	o	27	o	o	o	o	o	o	o	o

Figure 3. Results from testproblem 3.

course a comparison cannot be made directly due to the assumption of only one size of containers, but if we without too much trouble can improve the method to include several sizes of containers a very cautious estimate of the amount of shiftings saved will be 90%. A part of this saving could of course be achieved by means of more thoughtfull manual planning, but this would include more expencives in man-hours than the method in EDP-time.

Bisides savings, the simplicity of the resulting stowing-plan can be

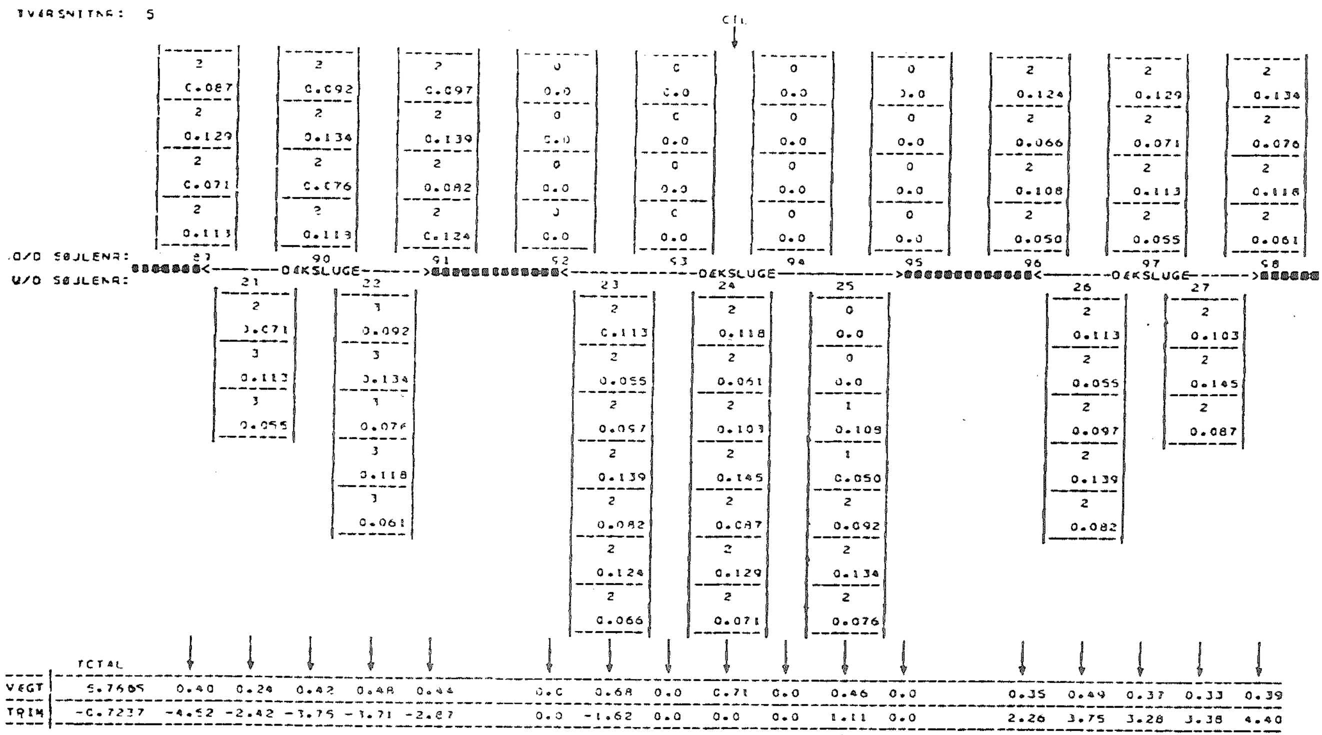

Figure 4. Example of the stowing plan for bay no. 5. The upper number in each cell is the destination and the lower number is the weight of the container.

considered as a measure of the goodness of the method. And it really produces simple stowing-plans where only one or two destinations are mingled in every independent part of the ship (e.g. columns). This means that the stowing-plans are easy to carry out in practice. Containers to the same destination will be loaded in groups.

As mentioned above the method is not very EDP-time consuming. In each port the total time spent is in average 40 sec. on an IBM 370/165 . Furthermore there will be an expence caused by datacommunication. Even with these expences there would be a total saving on about 4 mill. danish kroner pr. year if the method was applicated on the route described in figure 2.

Completion of the method

There is only one condition that prevents the method to be applicated on real-world containersystems - the assumption of only one size of containers. How can the method be improved to solve problems with e.g. two types. The author claims that this can be done rather easy be dividing the problem in two parts. Some of the 20'-containers can be connected together in order to make 40'-containers.The rest of the 20'-containers should be loaded in special 20'-cells (often few in numbers) and then there remains only a 40'-container problem to solve. This work has not yet been carried out.

Implementation of the method

A problem of more practical/tecnical kind arises before implementation takes place. Shall the method work centrally or decentrally?

The decision depends naturally on the existing communicationsystem. In both cases the method is activated just before the unloading and loading takes place, and at that time all the necessary data should be present. The most critical data are the actual demands. So if you have a communicationsystem that is not extremely fast you will only be able to solve the problem in the actual port - decentrally - due to the fact that containers arrive to the terminal just before or at the same time the ship arrives. This means a rather great exchange of data between the ports on route.

Another advantage of the decentrally system should be mentioned. If you impute a centrally decision system on somebody and thereby deprive him the possibility to decide (a good or bad decision) he will feel some kind of alienation from the system and fight against it. This can cause an even bader stowing than without any intervention at all. The decentrally system will not have the same effect, the method is just a tool of planning.

A conclusion of this will be a recommandation of the decentrally system in most cases, but it should be noticed that there also are disadvantages hereby.

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