The Multiple Straddle Carrier Routing Problem for loading operation of containers

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Abstract

In this paper a genetic algorithm-based approach is developed to solve the variation of the straddle carriers problem. This problem is solved in the context of optimizing loading operations of outbound containers in a seaport container terminal. The contribution of the work lies in the formulation and subsequent development of a solution strategy for the problem. A numerical experimentation is carried out in order to evaluate the performance and the efficiency of the solution.

Keywords: Container terminal optimization, routing straddle carrier, heuristic, assignment strategy, genetic algorithm.

1 Introduction

Container terminals have become increasingly important and more and more scientific literature is devoted to them. Container terminals are very specific from a material handling point of view, because of the special characteristics of both the containers and the handling equipment. The additional increase in ship sizes makes productivity perfection in container handling more important and therefore more research is to be expected. A handling system for the retrieval and transport of containers are straddle carriers (SCs). SCs are used for the retrieval of containers from the stack and for the transport to the quay cranes. Since inbound containers are usually unloaded into a designated open space, the SCs do not have to travel much during the unloading operation. However, the time for loading depends on the loading sequence of containers as well as the number of loaded containers. In this paper we focus on minimizing the travel time during loading process. Operations research has made important contributions for this problem. The techniques employed vary from mixed integer programming formulations, queuing models and simulation approaches. In this paper, a nonlinear integer programming model for multiple SCs is presented. Based on certain operational concepts, a heuristic genetic algorithm (GA) is designed to solve this problem. Some real cases are analyzed to illustrate the genetic model. Our study can provide companies not only the routing plan of SCs and the estimated period of tasks finished but also the required number of deployed SCs.

2 Genetic model

The most of the model's constraints are as equality form and, therefore, obtaining feasible solutions is a hard task, and the probability of reaching infeasible solutions is more than feasible ones and therefore, a population-based approach such as GA is required to better exploring the routing solution. In our GA model, a candidate solution to an instance of the problem specifies the number of required containers, the possible visited yard bays, the partition of the demands and also the delivery order for each route. Each chromosome represents a feasible solution. A chromosome is a set of containers that can be visited by a SC to perform a Quay Crane (QC) work schedule. For example a QC demands $r_t$containers type h to load them into a containership, SCs have to move toward the yard bays that include this type of containers, and transports them to the QC. Each container has a transportation cost depends on its position inside the storage yard and especially in its chromosome's order. Therefore the genetic procedure starts by exploring the set of required containers from which initial generation of n chromosomes is generated. Each chromosome is created by r_t genes. Each gene represents a required container placed in yard bay i, stack s, level l, and transported by the straddle carrier v.

Where:

$i=1,...,I$ (I: number of yard-bays)

$s=1,...,S$ (S: number of stacks in a yard bay)

$l=1,...,L$ (L: number of levels in a stack)

$v=1,...,V$ (V: number of available straddle carriers)

Let $C_{l,v}^{i,s}$ represents a required container (a gene in GA)

We generate chromosomes having r_t genes selected from the set of (n x V) containers. After applying genetic operators; each feasible chromosome (solution) is divided into partial chromosomes, each one represents the containers that will be transported by a particular SC. The cost of the original solution is the maximum value of costs of its partial chromosomes. The chosen solution will be the chromosome having minimum cost.

3 Experimentation

Comparing our solution with beam search heuristic procedure, and based on some real instances, we get the following results:

real cases	Beam search procedure [5]	Our genetic solution procedure	Gap
1	744.08 (sec)	354.08 (sec)	52,415%
2	1972.96(sec)	1320.4(sec)	33,076%
3	428.88(sec)	162.72(sec)	62.05%
4	345(sec)	204(sec)	40,87%
5	775(sec)	362.66(sec)	53.20%
6	1721,7 (sec)	885,8 (sec)	48.66%

Table1: Performance of the solution procedure

4 Conclusion

New efficient routing principle of straddle is developed based on genetic algorithm. Our solution procedure concentrates on loading process at a container terminal. Numerical examples were generated to show the performance of the proposed heuristic. A container terminal is a complex system, since several operations have to be performed and good coordination between operations is required. Genetic algorithm can be very efficient tool to compare, optimize or synchronize terminal's operations.

References

[1] V. Nunes Leal Franqueira, Single Vehicle Routing in Port Container Terminals, Master thesis, Universidade Federal do Espirito Santo, Brazil. August (2003).

[2] E. Nishimura, A. Imai, S. Papadimitriou, Berth allocation in the public berth system by genetic algorithms, European Journal of Operational Research 131 (2001) 282– 292.

[3] E. Nishimura, A. Imai, S. Papadimitriou, Yard trailer routing at a maritime container terminal, Transportation Research Part E: Logistics and Transportation Review, Volume 41, Issue 1, (2005) 53-76.

[4] F. Soriguera, D. Espinet and F.Robuste, A simulation model for straddle carrier operational assessment in a marine container terminal, Journal of Maritime Research (2006).

[5] K. H. Kim, K. Y. Kim, Routing straddle carriers for the loading operation of containers using a beam search algorithm, Computers & Industrial Engineering 36 (2000) 109-136.