A Deterministic Annealing Algorithm For Simultaneous Routing Of Loaded And Empty Containers

K. Braekers, A. Caris, and G.K. Janssens

Hasselt University, Transportation Research Institute (IMOB),
{kris.braekers,an.caris,gerrit.janssens}@uhasselt.be

Abstract

This paper addresses a full truckload vehicle routing problem for transporting loaded and empty containers in drayage operations. The objective is to minimize first the number of trucks used and then the total distance traveled. Two solution approaches, a sequential and an integrated approach, are presented. A deterministic annealing algorithm is proposed to solve the problem. Results show that for both solution approaches good solutions are obtained in a small amount of time.

Keywords: Deterministic Annealing, Vehicle Routing, Drayage

Drayage operations in the hinterland of a port are concerned with the transport of loaded and empty containers between shippers, consignees, inland container terminals and container terminals at the port. Reducing costs of drayage operations is essential as these costs constitute a large part of the total cost of an intermodal transport.

This paper addresses a full truckload vehicle routing problem for transporting loaded and empty containers in drayage operations. A single vehicle depot, one or several container terminals and a number of customers (consignees and shippers) are located in the considered region. Loaded containers need to be transported from container terminals to consignees (inbound containers) and from shippers to container terminals (outbound containers). For each container, the terminal to be used is predefined so that for all loaded container transports the origin and destination are known in advance. Hard time windows are imposed on the start of service for these transports. For empty container transports, either the origin or destination is not known in advance. A shipper may request an empty container to be delivered before a specific point in time. The origin of this empty container is irrelevant. On the other hand, a consignee may have an empty container available from a certain point in time after unloading an inbound loaded container. This empty container has to be picked up before the end of the day. The destination of the container is a choice to the decision maker.

The problem is to find efficient vehicle routes performing both loaded and empty container transports. The objective is to first minimize the number of trucks used and then the total distance traveled. A homogenous fleet of trucks with a single container capacity is assumed. All trucks start and end their route at the vehicle depot. Waiting is allowed at no cost.

Two solution approaches are presented for this problem: a sequential and an integrated approach. With the sequential approach, the origins and destinations of empty containers supplied and demanded are determined in a first phase by an allocation model. This allocation model, formulated as a Transportation Problem, finds the best distribution of empty containers based on total distance. Vehicle routing aspects are ignored. In a second phase, vehicle routes for performing loaded and empty containers are created. The routing problem is a Full Truckload Pickup and Delivery Problem with Time Windows (FT-PDPTW), which can be reduced to an asymmetric multiple vehicle Traveling Salesman Problem with Time Windows (*am*-TSPTW). An insertion heuristic is proposed to find an initial solution. This solution is then improved by five local search operators which are embedded in a deterministic annealing framework. Neighboring solutions which are better than the current solution are always accepted, while neighboring solutions which worsen the objective value are accepted if the worsening is smaller than a threshold.

With the integrated approach, empty container allocation and vehicle routing decisions are made simultaneously. It is shown that this problem may be formulated as an *am*-TSPTW as well and hence the deterministic annealing algorithm can be used to solve it. However, the problem is more complex than the routing problem of the sequential approach. To obtain good results, different variations of the deterministic annealing algorithm are tested.

An experimental design is set up to test both solution approaches. In total 48 random problem instances are created, distributed among 16 problem classes. Results show that for both approaches the deterministic annealing algorithm is able to find solutions close to the lower bounds in a small amount of time. On average, the integrated approach gives the best results.

Future work will focus on the bi-objective variant of the problem instead of the problem with a hierarchical objective function assumed now. Preliminary results are presented which show that when the number of trucks used is increased, total distance traveled can often be reduced considerably.