A Large Neighborhood Search for the Daily Drayage Problem

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1 Introduction

Intermodal container transportation is composed of three parts : pre-/end-haulage which are inland container movements, and main-haulage which are maritime container movements. Drayage operations are inland container movements executed by trucks. It is now well established that combining multiple means of transportation reduces the total transportation costs [1]. However, drayage operations account for a large part of the transportation costs and are generally under-optimized. In contrast, researchers have only recently begun to address the issue of drayage where the majority of the proposed studies does not allow to deal with the problem in its real complex settings. Thus, there is a need to enrich them in order to meet industrial objectives and constraints. In the literature, the problem that we are dealing with in this work is known as the Daily Drayage Problem with Time Windows (DDPTW) [2].

The DDPTW can be seen as a generalization of the Pickup and Delivery Problem with Time Windows (PDPTW). In our problem, in addition to traditional PDP constraints for picking and delivering containers, we should satisfy a precedence constraint between two interrelated requests by introducing a minimum time-lag constraint between some pairs of pickup and delivery requests. Our problem is formulated as a PDPTW with precedence constraints between requests and heterogeneous fleet of vehicles and containers. In order to solve the problem efficiently, we develop a Large Neighborhood Search (LNS) heuristic. LNS heuristics are mainly based on destroy and repair operators that consist in removing and inserting a set of requests in an iterative schema. In our problem, routes are strongly interdependent due to interrelated requests. It is import to check quickly if inserting a request into a partial solution is feasible or not. In this work, we present an approach to check the feasibility of request insertion in constant time.

2 Problem Description

We define the DDPTW as follows. A truck company owns an heterogeneous fleet of trucks. The trucks carry different container sizes (most common sizes are 20 ft and 40). Thus, a truck with a maximal capacity of 40 ft can carry one 40 ft container or two 20 ft containers. The company receives a set of missions to serve, with well defined orders of pick-up and delivery. An import mission consists in moving a full container from a terminal to a customer (request 1 : a full import request), then moving the empty container from the customer to a terminal or a depot (request 2 : an empty repositioning request). An export mission consists in supplying an empty container from a depot or terminal to an industrial customer (request 1 : an empty supply request), followed by moving a full container from the customer to a terminal (request

2 : a full export request). Other possible movements include the movements of empty containers between different depots or terminals upon request. Thus, a location can be at the same time a pickup and a delivery node.

One of the main characteristics of our problem compared to the classical PDP are precedence constraints between import/export requests. We introduce a set of precedence constraints between requests to differentiate between a single request k and a composite request defined by two requests k and k' with a precedence constraint. For example, an import mission can be a composite request composed of two single requests : a full import request k followed by an empty repositioning request k', where k must be executed before k'. Note that these two requests can be done by different trucks. Note also that some temporal constraints are added in order to consider the customer treatment and service times.

In addition, each location has a defined time window. A given truck must arrive at visited nodes within their given time windows and return to the yard before the end of the working day. The planning horizon is set to one working business day, while the trucks operate on a local area of different multimodal terminals with a limited maximal shift-time. All trucks start their day from the yard and must end their day at the yard. The objective of the planning is to maximize the number of satisfied transport requests while minimizing the total traveling time for the fleet of trucks.

3 Solution Method

To solve the problem efficiently, we propose a LNS heuristic based on a constant-time feasibility check. The proposed LNS heuristic follows the classical scheme that uses destroy and repair operators completed with simulated annealing and a local search based on intra-route, inter-route and exchange requests improvement of all routes. In our method, the main difficulty of the insertion operator comes from precedence constraints between requests that may imply several routes. So inserting a location within a given route can have an impact on the timing of linked routes and thus, affect the feasibility of the solution. Since we proposed a heuristic, it is critical to evaluate efficiently the feasibility of inserting a new request so to be able to explore a larger part of the space solutions without affecting the computational time. Hence, to reduce the complexity induced by insertion operations, we introduce some pre-processing procedures that are based on the concept of sub-routes concatenations introduced by Kindervater and Savelsbergh [3].

4 Experimental Results

Experiments have been conducted on real data provided by two transportation companies in the region of Marseille-Fos, France, to demonstrate the effectiveness and efficiency of our approach. The first company is characterized as a small instance of 26 heterogeneous requests, while the second company is a large instance of 76 heterogeneous requests. Additionally, we tested our heuristic on a set of generated realistic instances. Furthermore, detailed experimental results will be presented in the conference.

Références

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