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Minimizing fleet operating costs for a container transportation company ☆

Luca Coslovich [a,b,*], Raffaele Pesenti [c], Walter Ukovich [a,b]

[a] *Dipartimento di Elettrotecnica, Elettronica ed Informatica, via A. Valerio, 10, 34127 Trieste, Italy*
[b] *Centro di Eccellenza per la Ricerca in TeleGeomatica ed Informazione Spaziale, Università di Trieste, 34127 Trieste, Italy*
[c] *Dipartimento di Ingegneria Informatica, Università di Palermo, 90128 Palermo, Italy*

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Abstract

This paper focuses on a fleet management problem that arises in container trucking industry. From the container transportation company perspective, the present and future operating costs to minimize can be divided in three components: the routing costs, the resource (i.e., driver and truck) assignment costs and the container repositioning costs (i.e., the costs of restoring a given container fleet distribution over the serviced territory, as requested by the shippers that own the containers).

This real-world problem has been modeled as an integer programming problem. The proposed solution approach is based on the decomposition of this problem in three simpler sub-problems associated to each of the costs considered above.

Numerical experiments on randomly generated instances, as well as on a real-world data set of an Italian container trucking company, are presented.

Keywords: Transportation; Container trucking; Stochastic fleet management; Decomposition; Set covering problem

1. Introduction and problem statement

A core problem faced by container trucking companies deals with a set of transportation orders at minimum cost. The essential decisions to be taken are: how to partition the set of transportation orders so that each subset can be executed by a single driver; to whom to assign such subsets of orders; how to reduce the misplacement of

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* Corresponding author. Address: Dipartimento di Elettrotecnica, Elettronica ed Informatica, via A. Valerio, 10, 34127 Trieste, Italy. Tel.: +39 040 558 7134; fax: +39 040 558 3460.

E-mail addresses: coslovic@units.it (L. Coslovich), pesenti@unipa.it (R. Pesenti), ukovich@units.it (W. Ukovich).

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containers produced by the two previous operations; see, e.g., Crainic and Laporte (1997) and Powell et al. (1995).

This paper addresses the problem that a container trucking company (in the following also called *carrier*) faces trying to minimize the operating costs, over a given time horizon, when carrying on shippers' orders.

Each day, a carrier normally deals with mainly two types of shippers' orders, i.e., *import orders* and *export orders*. In particular:

- an import order requires the carrier to move a given filled container from an origin terminal to a given location specified by the shipper, where the cargo is stripped from the container, and then to move the empty container to its destination terminal;
- an export order requires that a given empty container is moved from an origin terminal to a given location specified by the shipper, where some freight is loaded into the container, and then to move the filled container to its destination terminal.

Less frequently, a third kind of transportation order (in the following referred to as *empty order*) may occur: in this case, the shipper requests the transportation of an empty container from a given container terminal to another one.

For each order, hard time windows may be present at each of the three visited locations. The carrier distributes the orders among some drivers and their trucks. In particular, we assume that each driver is modeled as a driver/vehicle combination (Powell et al., 2002), as it often happens in real-world cases. Within the above context, the carrier must partition the set of orders into feasible sequences of orders (i.e., *order pairings*). The existence of such a partition is guaranteed, since order pairings made of a single order are always feasible. Each pairing must be dealt with by the same driver within the workday.

The carrier takes into account different costs (and constraints) in order to determine the pairings and assign them to the drivers. In particular, three cost components (deeply detailed in the rest of this section) are investigated: *routing costs, resource assignment costs* and *container repositioning costs*.

The cost of the execution of a pairing depends mainly on its structure, e.g., it is usually proportional to the length of the route or to the time necessary to complete it. These cost components in the following are referred to as routing costs. On the other hand, pairing execution costs depend also on the assignment of drivers to pairings; in the following, the couple driver/vehicle will also be referred to as a *resource* and the associated costs as resource assignment costs. In particular, the costs incurred by a resource for reaching the origin terminal of the first order in its pairing must be considered, but also drivers' desire to be close to their domicile after having carried out a pairing is usually taken into account; see, e.g., Taylor et al. (2001) and Taylor and Meinert (2000) for typical needs of professional drivers and related job quality. Moreover, pairings exceeding a given length may be preferably assigned to some specific drivers, due to previous carrier-driver commitments. To reduce the resource assignment costs, the carrier usually assigns resources to pairings such that at the end of the day the vehicles are close to the origin terminals of the next day orders and, possibly, to their domicile (especially at the end of the week). The drivers' desires are usually considered as minor costs, but, when possible, they are satisfied in order to prevent a high turnover of the drivers (Taylor et al., 1999).

In order to introduce the third cost component considered, i.e., the container repositioning costs, let us analyze more in depth the structure of the pairings. In order to reduce the routing costs, the carrier may perform some optimization operations. For example, he may change both the destination terminal of the empty container in an import order and the origin terminal where the empty container is picked up in an export order. As a matter of fact, he can sequence an import and an export order using the same container, as depicted in Fig. 1, where the truck moves from B_1 to B_2 directly, instead of moving from B_1 to C_1, from C_1 to A_2, and from A_2 to B_2 . Moreover, a swap of containers may be required for properly executing the second order of Fig. 1. This can happen, for instance, when the second order involves