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The waste collection vehicle routing problem with time windows in a city logistics context

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Abstract

Collection of waste is an important logistic activity within any city. In this paper we study how to collect waste in an efficient way. We study the Waste Collection Vehicle Routing Problem with Time Window which is concerned with finding cost optimal routes for garbage trucks such that all garbage bins are emptied and the waste is driven to disposal sites while respecting customer time windows and ensuring that drivers are given the breaks that the law requires. We propose an adaptive large neighborhood search algorithm for solving the problem and illustrate the usefulness of the algorithm by showing that the algorithm can improve the objective of a set of instances from the literature as well as for instances provided by a Danish garbage collection company.

Keywords: Waste collection; vehicle routing; reverse logistics; optimisation; case study

1. Introduction

The recent years' intense focus on reduction of emissions has together with the ever-ongoing urbanization of Western world countries led to an increased interest in urban freight transport. According to the European Commission [9] 24% of the goods vehicles which operate in Europe are empty and urban traffic accounts for 40% of the total CO2 emission caused by the transport sector. Thus, a great potential for substantial economic as well as environmental savings lies in reducing urban transport.

The processes for planning, optimizing and controlling logistics and transport activities in urban areas are often referred to as "City Logistics" (see Taniguchi et al. [21]). City logistics can be divided into

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forward and reverse logistics operations dealing with the flow of goods from the producers to the consumers and the flow from the consumers to recycling or disposal facilities, respectively. Thus, the collection of waste is a central component in the logistic set-up of a large city.

The waste collection problem consists of routing vehicles to collect customers waste within given time window while minimizing travel cost. This problem is known as the Waste Collection Vehicle Routing Problem with Time Windows (WCVRPTW). WCVRPTW differs from the traditional VRPTW by that the waste collecting vehicles must empty their load at disposal sites. The vehicles must be empty when returning to the depot. Multiple trips to disposal sites are allowed for the vehicles. The problem is illustrated in Fig. 1 for a single vehicle and multiple disposal sites.

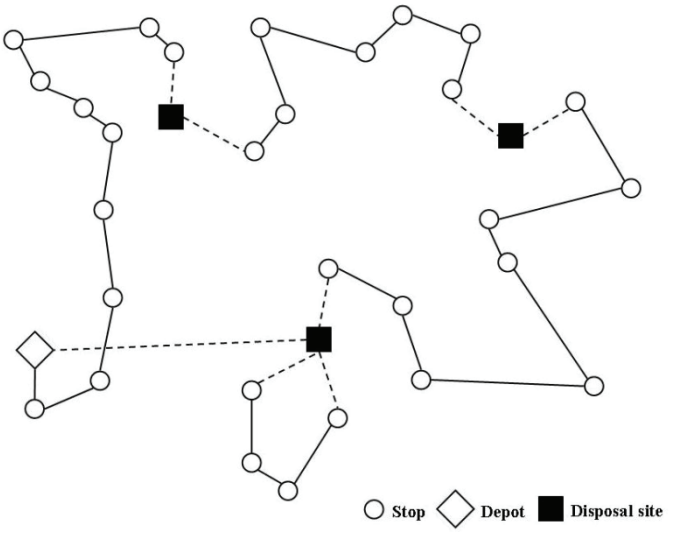

Fig. 1. A route sequence of one vehicle considering disposal operations with multiple disposal sites

1.1. Structure

The structure of the present paper is the following: Section 2 discusses the literature which has previously studied WCVRPTW or other similar and relevant problems. The WCVRPTW is then formulated formally and modeled in section 3. The subsequent section 4 deals with two case studies on real-life waste collection problems. The two cases have different additional constraints which are modeled. Section 5 presents the selected solution method ALNS and discusses the problem specific modifications which has to be made. Section 6 discusses the results obtained. Finally, our concluding remarks are given in section 7.

2. Literature

The waste collection VRPTW has received some attention in recent years. Kim et al. [11] address a real life waste collection VRPTW with consideration of multiple disposal trips and drivers' lunch breaks. They address the problem by using an extension of Solomon's well-known insertion approach (Solomon, [20]). Ombuki-Berman et al. [15] address the same problem by using a multi-objective genetic algorithm on a set of benchmark data from real-world problems obtained by Kim et al. [11]. Benjamin and Beasley [5] improve the results when minimizing travel distance using a tabu search and variable neighborhood