Transport Channel Selection

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1 Introduction

The share of logistics and transportation in the overall cost of a product is increasing. Subsequently, there is a growing pressure in the logistics industry for optimization and cost reduction. In this paper, we consider the issue of transport channel selection, a problem that has been overlooked for a long time. Typical choices for transport channels include round-trips from and to the depot, one-way tours (often called "milkruns"), delivery over a hub, or fixed-cost delivery services (e.g. a postal service). The overall optimization problem consists of two interdependent sub-problems: assigning shipments to transport channels, and optimizing the routes within each channel.

In this paper, we propose an evolutionary algorithm (EA) with integrated savings heuristic to solve this two-level problem. Thereby, the EA is responsible for assigning shipments to transport channels. In order to evaluate an assignment within the EA, a vehicle routing problem is solved for each transport channel by means of a savings-based heuristic and subsequent 2-opt improvement. Empirical evaluation on five practical problem instances have shown that optimizing the transport channels by our algorithm can reduce the overall transportation cost significantly compared to the simple heuristics used in industry today.

The paper is structured as follows. In the next section, we specify the considered problem in more detail and give a short overview on how similar problems are typically solved in industry. Our proposed algorithm is described in Section 3. Empirical comparisons are given in Section 4. The paper concludes with a summary and outlook.

2 Transport Channel Selection

2.1 Problem Description

A typical transportation problem with channel selection can be described as follows: n customers have to be serviced from a unique depot. Each customer i has a given demand w_i for goods. There are different possibilities to service a customer, including:

1. Serving the customer by a milkrun.
   A *milkrun* is defined as a tour starting at the depot, serving a number of customers, but *not* returning to the depot. Such tours are typically executed by a hired logistics partner. The way back is not payed, as the logistics provider can service other customers once the milkrun has finished.
2. Sending a dedicated truck directly to the customer.
   This can be seen as a special form of milkrun.
3. Delivering over a hub.
   If the demand of the customer is small but there are several customers in one region, the cheapest way of delivery may be to use a large truck to drive to a hub, and service the customers from the hub with a small truck.
4. Using a delivery service.
   Usually, such delivery services charge a fixed cost depending on size, weight, and volume of the goods that can be looked up in a table.

The cost for servicing a customer through a delivery service or a dedicated tour are independent of how other customers are served. For milkruns and delivery over a hub, however, tours servicing several customers have to be formed, and thus the delivery cost depends on what other customers use the same transport channel. We assume that the cost for milkruns and tours from the depot is proportional to the driving distance. For the hub delivery, we additionally consider a fixed cost for using a hub.

A vehicle i used for delivery has a maximal capacity C_i and can drive a maximal distance D_i before it has to be back at the depot. The goal is to minimize the total transportation cost which is often equated with the total distance driven. A solution to the VRP is a collection of tours starting and ending at the depot, where each customer is assigned to exactly one tour, each tour has length at most D, and the total demand for each tour is at most C.

2.2 Related Work

To our knowledge, this problem has been largely neglected in the scientific literature so far. In industry, transport selection problems are usually solved manually with intuition and experience, or by rather simple heuristics. Variants of the transport channel selection problem are discussed in [4, 3], but without proposing a concrete algorithm.

Because we could not find any algorithm in the literature suitable for the transport channel selection problem as described above, we decided to base our empirical investigation below on a simplified version of the problem that has only two transport channels: milkruns and delivery services (and no hub delivery).

For this simplified problem, the following simple decision heuristics are commonly used in industry, and will be used for comparison:

Weight-based allocation (WA)

With this method, the user sets two weight limits w_{min} and w_{max}. All customers whose demand has a weight less than w_{min} are served via delivery service, all customers whose demand has a weight greater than w_{max} are serviced via a dedicated tour. For all other customers, a vehicle routing problem is solved. In the experiments below, we set $w_{min} = 2t$ and $w_{max} = 0.9C_{max}$ where C_{max} is the capacity of the vehicle.