An assignment-and-routing decomposition matheuristic for the time-dependent Inventory Routing Problem

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1 Introduction

The inventory routing problem (IRP) integrates two operational problems of the supply chain : inventory management and routing. The objective of the decision-maker is to decide, for each period of the time horizon, whether a client should be replenished, with which quantity and following which route, optimising both the inventory and transportation costs.

When evolving in an urban logistics context, one problem that can be faced is the volatility of the travelling times between locations. This volatility is represented in this paper by considering the travelling times as time dependent. As time-dependent problems tend to be harder to solve than their basic counterpart [1], it is necessary to propose new efficient algorithms. In this paper, a matheuristic that decomposes the problem into first assigning the clients to visit at each period and then solving a time-dependent travelling salesman problem (TD-TSP) is proposed.

2 Time-dependent travelling time functions

Rifki et al. (2020) [2] propose a benchmark based on the traffic conditions of the city of Lyon in France, using a dynamic microscopic simulator of traffic flow. Based on data collected from sensors placed in the axes of the city, a time dependent travelling time function is defined for a time interval of 12 hours and is decomposed into time steps. The benchmark yields a set of constant piece-wise travelling time functions between each two different locations with different time granularity/time steps $\mathcal{M}$ such that : $|\mathcal{M}| = \{1, 12, 30, 60, 120\}$. An example of these travelling time functions between two random locations is presented in figure 1. Such constant-piece wise travelling time functions tend to not enforce the First In First Out (FIFO) property. Therefore, a transformation to convert them into linear step-wise function that do enforce the FIFO property is conducted.

3 An assign-and-route matheuristic

A comparison of the structure of optimal solutions of the IRP($|\mathcal{M}| = 1$) and TD-IRP solutions ($|\mathcal{M}| > 1$) shows that the difference between the two solutions lies mostly in the sequence in which the clients are visited, and rarely in the set of clients visited at each period and inventory levels. Therefore, we propose a matheuristic to solve the TD-IRP by decomposing the problem into two parts : First, defining the inventory level, the quantities to send for each client and the clients to visit for each period by solving an IRP($|\mathcal{M}| = 1$). Second, defining the sequence

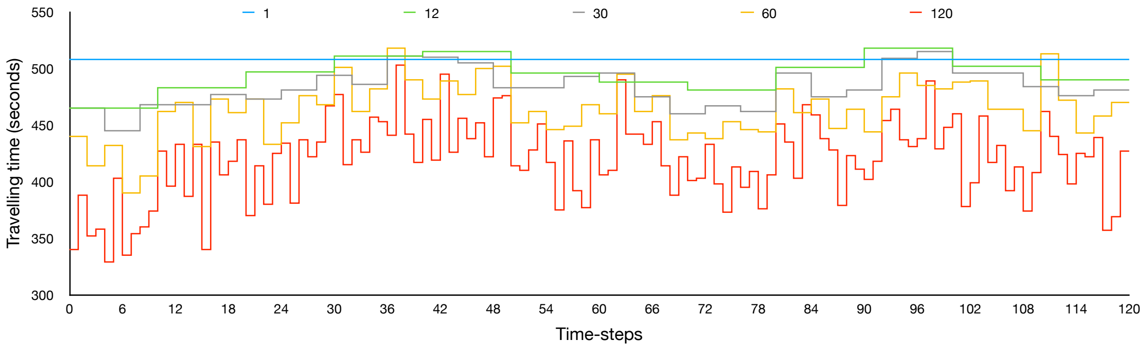

FIG. 1 – A travelling time function between two random locations for $|\mathcal{M}| = \{1, 12, 30, 60, 120\}$

in which the clients will be visited and the departure time steps from each location by solving a TD-TSP($|\mathcal{M}| > 1$).

4 Results

Numerical experiments are conducted to assess the performances of the matheuristic by comparing the results of an exact branch-and-cut procedure of the TD-IRP set with a time limit of 3600 seconds and the matheuristic proposed. Figure 2 shows the average gap of the matheuristic to the upper bound of the exact approach and to the best lower bound found. The figure shows that the upper bounds are improved up to 2.2% and that when optimal solutions are found with the exact method, the gap goes up to a maximum of 0.8%.

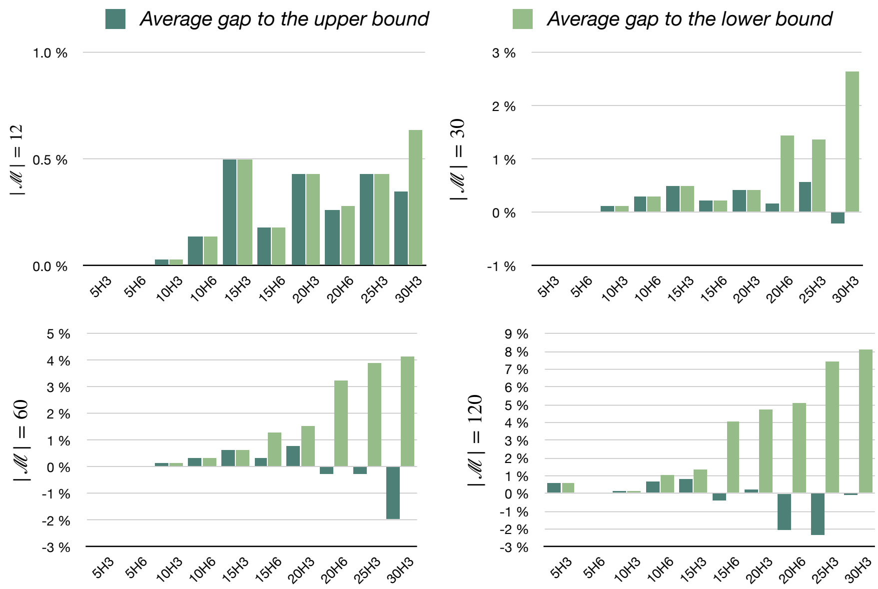

FIG. 2 – Performances of the matheuristic. nHT : n = number of clients, T = number of periods

Références

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