The Park-and Loop Routing Problem with Parking Selection

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This paper presents a variant of the vehicle routing problem considering deliveries to customers in cities with a combination of walking and driving. The objective is first to offer a better model for actual delivery problems where drivers are usually assumed to have a single parking location to deliver each customer. Second, we show that serving some customers through walking trips is more efficient in congested areas. We introduce the *Park-and-Loop Routing Problem with Parking Selection (PLRP-PS)*, which extends the work of [1, 2]. We investigate the case where parking locations should be selected among a large set of parking areas in a variant of Large Neighborhood Search (LNS).

We consider a set of customers N with non-unitary demand who have to be served using a homogeneous vehicle fleet K. We consider that each vehicle starts from and return to a depot 0. It is assigned to a driver who will perform deliveries by walking from a parking location to the customers. We consider a large set P of parking locations. Each parking location $i \in P$ is associated with a parking time pt_i. For each pair of nodes i, j in $\{0\} \cup P$, we assume a driving time t^d_{ij} and distance d^d_{ij} to be known, likewise a walking time t^w_{ij} and distance d^w_{ij} are defined for each $i, j \in P \cup N$.

A *vehicle route* starts from the depot, visits a sequence of parking locations in P, and returns to the depot. The sum of customers demands served by a vehicle route must not exceed the vehicle capacity and a vehicle route duration must not exceed the day duration. A *walking-trip* starts from a parking location in P, visits a sequence of customers, and returns to the same parking location. It must not serve customers whose cumulative demand exceeds the walking capacity. The overall walking distance of each driver should not exceed a given daily limit. A driver may perform several walking-trips from a single and/or multiple parking locations.

The PLRP-PS consists of designing vehicle routes and walking-trips, respecting vehicle capacities, maximum route duration and the maximum walking distance of each driver, such that each customer is served with its demand by exactly one driver, lexicographically minimizing the number of vehicles and the sum of driving times, walking times and parking times. This problem is illustrated on Figure 1, with three vehicle routes (green, grey and blue) starting from the black depot on the left. Walking paths are in red. Red points indicate customers and the dark blue points indicate the selected parking locations. Light blue points indicate unused delivery areas.

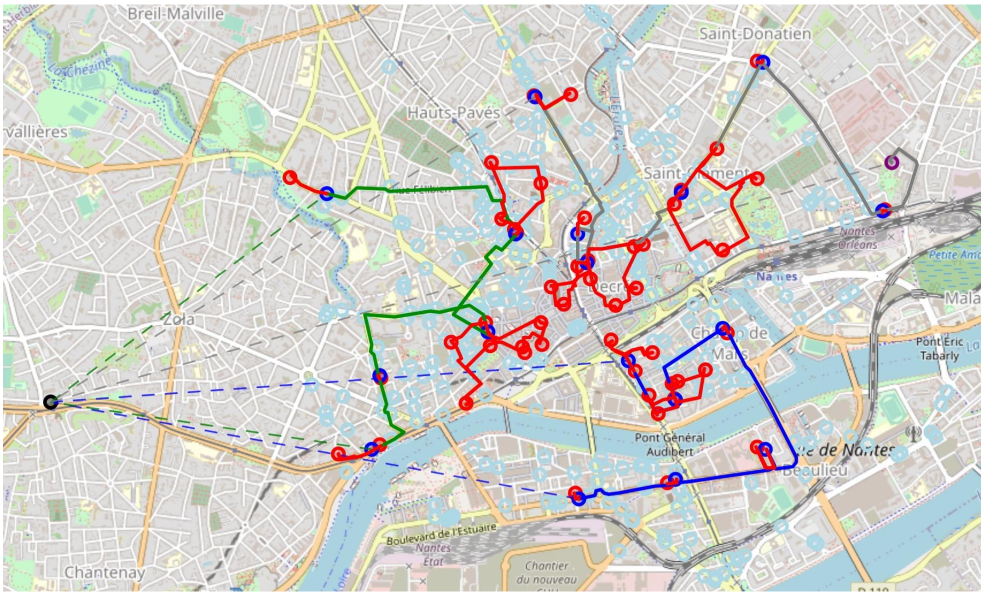

FIG. 1 – Visualization of the best found solution for instance “Nantes-50-1” with 50 customers

To solve the PLRP-PS we introduce the Small and Large Neighborhood Search (SLNS) variant of the LNS metaheuristic. We extend the classical destroy and repair operators to efficiently integrate parking selection. Considering the large number of parking locations that may be available in a city, independently of the number of customers, we focus on comparing different *parking selection strategies* which can be applied in the evaluation of the customer insertion in a vehicle route. We consider two criteria to select which parking to evaluate : the walking time between the parking and the customer, and the ranking of the parking in the list of parking ordered by non-decreasing distance to the considered customer. We then devise two methods to reduce the set of evaluated parkings : filter a priori the parking set from which each customer can be served (keeping the locations below a given threshold on the chosen criterion), and evaluate the parking in non-decreasing order of the chosen criterion with a given probability to stop after each location evaluation.

On realistic instances, we find that combining walking and driving in urban delivery can save 19% of working time on average compared to the classical vehicle routing approach (i.e. CVRP). We also find that the most efficient parking selection method is to evaluate the parking in order of their rank in the list of parking close to the considered customer and to stop according to a geometric distribution on the aforementioned rank. This method proved to be efficient on PLRP benchmarks with respect to the methods of ([2, 1]). A longer description of this work is under review and available on HAL ([3]).

Références

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