An Adaptive Large Neighborhood Search for a Vehicle Routing Problem with Multiple Trips and Driver Shifts

Yasemin Arda[1], Yves Crama[1], Véronique François[1]

QuantOM, HEC - Management School of the University of Liège
14 Rue Louvrex, Bât N1, 4000 Liège, Belgique
{yasemin.arda, yves.crama, veronique.francois}@ulg.ac.be

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1 Problem description

In this study, we analyze a rich vehicle routing problem, whose features are inspired from the practical case of a Belgian distribution company. We consider a distributor who has to satisfy the demand of two types of customers : the delivery and backhaul customers. The considered problem can be classified as a *one-to-many-to-one pickup and delivery problem* [2] meaning that there is a single depot from which every delivery customer must be served and to which every pickup demand of backhaul customers must be carried back. In a given route, backhaul customers can only be visited after all delivery customers of the route are served. Multiple trips [6] are allowed, meaning that each vehicle can perform more than one route during its working shift. The different routes of a given vehicle form a tour. There is a single commodity. Split deliveries and pick-ups are not allowed.

A time window is associated with each client, imposing his service to begin within the bounds defined by the time window. The vehicle can wait in case of early arrival but must not be late. Each customer has also a given service time. Moreover, loading and unloading times at the depot must be taken into account.

The distributor owns a fleet of vehicles with heterogeneous capacities and equipment. The problem includes site-vehicle dependencies [1], meaning that not every customer can be served by a given type of vehicle. Each vehicle can be used during a given period related to the shift of its driver. The usual shift duration can be exceeded but this implies an overtime cost. The distributor can also hire additional vehicles with homogeneous capacities, which are supposed to be available at any required time for a given maximal duration.

The objective function includes a distance cost for both fleets, a fixed cost for the use of external vehicles, and a time cost which depends on the considered fleet type. In the case of the external fleet, the complete working time is taken into account (traveling time, waiting time, and service time). In contrast, an overtime cost is incurred for internal vehicles.

2 Solution method

An adaptive large neighborhood search (ALNS) [5, 4] is used in order to solve the considered problem. The underlying repair-and-destroy principle is well adapted to the problem which is very constrained.

At each iteration of the algorithm, a removal heuristic and an insertion heuristic are chosen in order to build a new solution. The chosen removal heuristic builds a new partial solution that ignores a certain number of customers, whereas the insertion heuristic fixes this partial solution by reinserting the removed customers.

Concerning the insertion heuristics, specific multi-trip insertion operators have been built to allow the creation of new routes or the splitting of existing ones during the insertion process.

Indeed, feasible insertion of a customer at a given position in a tour may require to come back at the depot before and/or after serving this customer. Removal heuristics remove routes of a given tour only if these are empty. Moreover, after a given number of iterations, route merging procedures are used in order to reduce the number of routes in a vehicle tour if necessary.

The number of customers that are removed and reinserted at each iteration varies in order to alternate between intensification and diversification phases. The choice of the heuristics at each iteration is randomized but oriented such as to favor removal/insertion couples which have already led to amelioration in the objective function. Acceptance of a newly created solution as the incumbent solution is done in a simulated annealing fashion.

3 Experiments

The testing part of the research is ongoing. The experiments are designed not only to show that the algorithm is suitable to solve the described problem but also to gain insight into the reason why chosen features and parameter values constitute good choices. Well-known Gehring and Homberger instances [3] ranging from 200 to 1000 customers have been adapted to our problem for these purposes.

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