A three-phase heuristic for a capacitated Vehicle Routing Problem with pickups, time windows and packing constraints

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E-commerce is expanding and as a result, the number of boxes in transit is drastically increasing. Therefore, it is important to solve the vehicle routing problem simultaneously with the loading problem, as proved in [2]. For more efficiency, retailers call on logistics service providers (LSPs) who, since the collection and delivery locations can be geographically spread, carry out the process over two days: collection of the boxes on the first day and delivery on the second. As the LSP returns to the depot between the two days, the loading plan can be changed and the collection problem can be handled separately from the delivery problem. In this work, we focus only on the collection process since it has received less attention in the literature compared to delivery process. Yet, it is subject to more uncertainty as additional pickup requests may pop up or differ from the projection during the day. Furthermore, the collection process is much more able to react to these types of disruptions on-the-fly since vehicles are initially empty.

After surveying LSPs in order to address real-life problems, they usually want to determine routes with an associated schedule and loading plan while minimising transportation distances and not exceeding their vehicle fleet size. Retailers' time windows, which often correspond to regular opening hours, and maximum working hours of the drivers must be respected. Moreover, the loading plan must be valid at each collection location, i.e. it must respect geometric, vertical stability, orientation, and sequential loading constraints. The collection problem gives rise to a Three-Dimensional Capacitated Vehicle Routing Problem with Time Windows (3L-CVRPTW).

Considering the complexity of the integration of the routing and packing problems, exact solution methods are unable to quickly generate solutions. Therefore, we propose a three-phase heuristic to provide a good solution within a short amount of time. During the first phase, we use the savings heuristic of Clarke and Wright ([1]) to build an initial solution. If the number of routes exceeds the fleet size, a route elimination procedure is performed as a second phase. During the last phase, we apply a General Variable Neighbourhood Search ([4]) to improve the solution. We consider neighbourhoods based on typical routing operators such as relocate, swap, and crossover.

We tested our heuristic over the 600 instances from [3] modified to match the characteristics of our problem (namely, densifying customers' locations and the scaling of the boxes dimensions to fit inside the loading space vehicles). Our next step is to tune the heuristic to improve the effectiveness of our method and then to derive some managerial insights for the LSPs.

References

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