State of the art of vehicle routing problems with loading constraints

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The most studied combinatorial optimization problem in transport and logistics is the vehicle routing problem (VRP). The goal of the vehicle routing problem is to find a set of routes for a fleet of vehicles which optimises the objective function (e.g. total distance, routing costs). Every demand needs to be fulfilled and vehicle capacities need to be respected. Many solution methods exist for the 'classic' VRP with aforementioned constraints. In real-life however, companies are faced with several other types of constraints that greatly increase the complexity of the problem. Examples of such complicating constraints are time windows, maximum route length and duration, incompatibilities between goods and vehicles and loading constraints. 'Rich' VRPs are routing problem that take into account some of these additional realistic constraints. This paper deals with the results of an extensive literature study about VRP with loading constraints, which is a fairly recent domain of research. Besides an overview of topics that have already been studied in this field, research gaps and possibilities for future research are discussed.

Loading problems arise when goods cannot be placed freely in the container or truck because several constraints have to be taken into account such as the measurements of the goods, the fragility of the goods, weight distribution inside the vehicle and the sequence of delivery. Carriers often employ a Last-In-First-Out loading or sequence-based loading strategy which ensures that when arriving at a customer, the items of the customer can be removed from the truck without having to move items of other clients. Loading constraints have been studied in combination with the capacitated vehicle routing problem (CVRP), as well as with the Pickup and Delivery Problem (PDP) [3]. In the CVRP, the capacity of the vehicle presents upper limit on the total weight or on the total number of items to be placed in the vehicle. In practice however, the capacity of the vehicle is not only determined by its weight or by the number of items it can contain, but also by its measurements and the fragility and stability of the goods to be placed in the container. Gendreau et al. (2006) [1] are the first to address the three-dimensional capacitated vehicle routing problem (3L-CVRP). They develop a Tabu Search method to solve the problem which takes into account sequence-based loading,

fragility and stability constraints and a fixed vertical orientation of the items in the vehicle. To our knowledge, exact methods have not yet been proposed for the 3L-CVRP. When items cannot be stacked on top of each other in the vehicle, the three-dimensional problem can be reduced to a two-dimensional one. Gendreau et al. (2008) [2] propose a Tabu Search algorithm for the two-dimensional CVRP which includes sequence-based loading and a fixed orientation constraint. Iori et al. (2007) [4] develop a branch-and-cut method for a similar 2L-CVRP. As mentioned already, PDPs with loading constraints have been studied as well. Xu et al. (2003) [5] present a PDP with FIFO loading (PDPF) which includes heterogeneous vehicles, multiple time-windows and weight capacity constraints of the vehicles. A practical problem that has not yet been studied in literature is the combination of VRP and a balanced weight distribution of the cargo in the vehicle. The centre of gravity of the cargo is important for the stability of the vehicle. Another line of future research could entail combining different loading constraints from several studies and finding a solution method for the integrated problem.

Références

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