Incorporating axle weight restrictions in a two-dimensional CVRP

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Distributors of goods have to take loading constraints into account to make a realistic planning for their vehicles, while current planning tools generally do not include these constraints. A survey conducted by the authors among several Belgian logistics service providers pointed out that the most common loading problems that are encountered by distributors are multi-dimensional packing constraints, unloading sequence constraints, stability constraints, load-bearing strength constraints and axle weight constraints. Multi-dimensional packing constraints include that items cannot overlap and should be completely enclosed by the vehicle. In a three-dimensional problem, the three dimensions (length, width and height) of the vehicle are considered to check this constraint. In a one-dimensional or two-dimensional problem respectively a single or two dimensions of the vehicle are taken into account. The unloading sequence constraint ensures that when arriving at a customer, no items belonging to customers served later on the route block the removal of the items of the current customer. In a one-dimensional problem this constraint can be referred to as a Last-In-First-Out (LIFO) constraint. Stability constraints guarantee vertical as well as horizontal stability of the cargo in the vehicle. When items are stacked on top of each other in the vehicle, the items have to be supported by other items or by the floor to ensure the vertical stability of the cargo. Vertical stability constraints specify the minimum supporting area of each item (for example as a percentage of the base area of the item). Horizontal stability of the cargo refers to the support of the lateral sides of the items in the vehicle to avoid the items from moving around in the vehicle. The load-bearing strength of an item is the maximum pressure that can be applied on this item (Junqueira et al. 2013). This is considered to prevent items to be damaged because of the pressure of other items that are placed above them. Fragile items can be defined as items that cannot bear much pressure. This may imply that no item can be placed upon fragile items or that only other fragile items can be placed upon them. Not only the total weight of the load inside the vehicle is of importance, but also the distribution of the weight of that load over the axles of the vehicle is an important issue. Axle weight limits impose a great challenge for transportation companies. Transporters face high fines when violating these limits, while current planning programs do not incorporate axle weight constraints. Legislation about axle weight limits varies by country (for an overview of the axle weight limits in Europe, the reader is referred to the International Transport Forum). The axle weight is the total weight (weight of the cargo and weight of the truck) that is placed on the axle.

Until now, axle weight limits have not yet been considered in a VRP. In this presentation, two problem formulations will be provided : a two-dimensional CVRP (2L-CVRP) with sequence based loading without axle weight constraints and a 2L-CVRP with sequence based loading with axle weight constraints. Multiple homogenous vehicles are considered. The demand of the customers consists of europallets. Pallets can be placed in two horizontal rows inside the vehicle. No vertical stacking is allowed. The center of gravity of the pallets inside the vehicle is calculated to determine the axle weights. Numerical experiments demonstrate that both models perform adequately and that not incorporating axle weight limits may lead to infeasible solutions. The variation in the solutions of the two models depends on the weight of the pallets and the number of pallets per customer. Incorporating axle weight limits may play an important role when heavy pallets are considered, while axle weight limits hardly change the model solution when light pallets are analysed.

Références

[1] Junqueira, L., Morabito, R., Sato Yamashita, D., 2012. Three-dimensional container loading models with cargo stability and load bearing constraints. Computers & Operations Research 39 (1), 74–85.