A matheuristic for the truck and trailer routing problem

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In the truck and trailer problem (TTRP), raised for instance by milk collection in rural areas, a heterogeneous fleet composed of m_t trucks and m_r trailers ($m_r < m_t$) serves a set of customers $N = \{1, 2, \ldots, n\}$ from a main depot, denoted as node 0. Each customer $i \in N$ has a non-negative demand $q_i > 0$; the capacities of the trucks and the trailers are Q_t and Q_r, respectively; and the distance c_{ij} between any two nodes $i, j \in N \cup \{0\}$ is known. Some customers with limited maneuvering space or accessible through narrow roads must be served only by a truck; while other customers can be visited either by a truck or by a complete vehicle, e.g., a truck pulling a trailer. These access constraints partition the customers into two subsets : the subset of truck customers N_t accessible only by truck, and the subset of vehicle customers N_v, accessible either by a truck or by a complete vehicle.

Three kinds of trips are allowed from the depot. *Pure vehicle routes*, performed by a complete vehicle, visit a subset of vehicle customers. *Pure truck routes*, performed by a truck without trailer, may visit the two types of customers. *Composite routes* have two levels: A complete vehicle serves a subset of vehicle customers where the trailer can be detached to perform second level routes composed of truck or vehicle customers. The objective for this NP-hard problem is to find a set of allowed routes of minimum total distance, such that: Each customer is visited in a route done by a compatible vehicle, the total demand of the customers visited in a route does not exceed the capacity of the allocated vehicle, and the number of required trucks and trailers is not greater than m_t and m_r, respectively.

After a brief review of the main publications related to the TTRP, the talk will present a two-phase metaheuristic. A hybrid GRASP/VNS detailed in Villegas et al. (2011) is used to generate local optima whose the routes are used as columns of a set-partitioning formulation of the problem. The GRASP uses a randomized nearest-neighbor heuristic to construct giant tours that visit all customers. Each giant tour undergoes an optimal splitting procedure (subject to the sequence) which cuts it into allowed routes. The splitting process is here non-trivial because of the two kinds of vehicles: it is equivalent to a resource-constrained shortest path problem which, fortunately, can be solved in polynomial time $O(n^2.m_t^2.m_r^2)$, using a label algorithm. The set partitioning problem is solved by Gurobi version 3.0 and the best feasible GRASP solution is used as initial upper bound.

The approach outperforms all previous state-of-the-art methods in terms of solution quality and computing time. In one hand, the best variant of our metaheuristic found seven new best solutions for the test bed of Scheuerer (21 instances with 50 to 199 customers, 5 to 10 trucks and 3 to 9 trailers). On the other hand, a fast variant achieved the same average solution quality as the previous best methods, but in shorter computing times.

S. Scheuerer, A tabu search heuristic for the truck and trailer routing problem. *Computers & Operations Research* 33, 894-909, 2006.

J.G. Villegas, C. Prins, C. Prodhon, A.L. Medaglia, N. Velasco. A GRASP with evolutionary path relinking for the truck and trailer routing problem. *Computers & Operations Research* 38:1319-1334, 2011.