Decomposition algorithms for the multi-modal ridesharing routing problem

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2 - An exact method for the multi-trip VRP with time windows
Rosario Paradiso, Roberto Roberti, Demetrio Laganà, Wout Dullaert

The Multi-Trip Vehicle Routing Problem with Time Windows, Limited Duration and Loading Times (MTVRPTWLD) is a variant of the VRPTW, where vehicles can perform multiple trips in the planning horizon. A trip is defined as a sequence of visited customers and a departure time from the depot. Each trip cannot exceed a given maximum time duration. In this work, a new two-phase exact method is proposed to solve the problem. The proposed algorithm is based on a formulation where each variable corresponds to a structure, where a structure is a trip without an associated departure time from the depot. In the first phase, a lower bound is computed by using column generation and all structures having a reduced cost w.r.t. the computed dual solution not greater than the gap between an input upper bound and the achieved lower bound are generated. In the second phase, a branch and cut algorithm based on the set of structures generated in Phase 1 is used to find an optimal solution of the problem. One of the features that differentiates our approach from the others in the literature, is that all our formulations are "structures" based, instead of considering one or more routes (a route is a set of consecutive trips performed by the same vehicle). The computational results achieved by the proposed solution method clearly show its effectiveness. The proposed solution method clearly outperforms the exact algorithm in the literature, solving all the instances in less than 30 minutes.

3 - Decomposition algorithms for the multi-modal ride-sharing routing problem
David Piringer, Miriam Enzi, Sophie Parragh, Matthias Prandstetter

Mobility is changing - people are moving from owning a car towards using mobility services. Sustainability and shared economy are rising topics of concern. In this talk we focus on two different sharing concepts: car-sharing and ride-sharing. In car-sharing a community mutually uses a pool of cars while tours are traveled separately. In ride-sharing individual legs can be shared in order to reduce cost and enhance utilization of an integrated fleet.

We introduce the multi-modal ride-sharing routing problem (MM-RRP), in which a pool of cars is used to cover a set of ride requests by the employees. Each route must start in a depot and finish in a (possibly different) depot. Since the employees always have the option of using other modes of transportation (e.g. public transportation) the problem can be seen as a prize-collecting Vehicle Routing Problem defined on an acyclic time-space graph. The problem is solved by use of column generation where the master problem makes sure that each person can only participate in one ride for each leg, and the pricing problem generates new promising routes by solving a (time constrained) shortest path problem in a time-space network. The pricing problem also attempts to include ride-sharing whenever possible. Computational experiments are reported showing that the column generation framework outperforms a compact formulation for large-scale problems.

4 - An exact method for the consistent vehicle-routing problem
Roberto Roberti, Dominik Goeker, Michael Schneider

Vehicle-routing problems (VRPs) with consistency considerations are receiving substantial interest because of the practical importance of providing consistent service in many industries. To boost customer satisfaction, customers should be served at roughly the same time (arrival time consistency, ATC) by the same driver (driver consistency, DC) each time they are served. The Consistent VRP (ConVRP) is a multi-day capacitated VRP with ATC and DC constraints.

A few heuristics are available for the ConVRP, but no exact approach has been proposed yet. Most of the state-of-the-art exact methods to solve VRPs are based on column generation applied to formulations where each variable represents a feasible route, and the pricing problem is solved via dynamic programming. However, these methods cannot be directly extended to solve the ConVRP because the linear relaxation of route-based formulations provides weak lower bounds due to the interdependency between the daily routes, which is caused by the required ATC at customers.

In this talk, we propose an exact method based on column generation applied to a formulation in which each variable represents the set of routes assigned to a vehicle over the planning horizon. The exact method initially takes into account DC only, and addresses ATC at a later stage. Computational results show that the proposed exact method is able to solve small and medium sized instances with up to five planning periods and 30 customers.