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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 trip or 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 exacts 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 Pisinger, Miriam Enzi, Sophie Parragh, Matthias Prandtstetter

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 but tours are traveled separately. In ride-sharing individual legs can be shared in order to reduce cost and/or 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 a 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 Goeke, 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.

■ MD-06

Monday, 14:30-16:00 - SOUTH BUILDING UV S106

Retail Distribution Planning I

Stream: Demand and Supply Management in Retail and Consumer Goods
Chair: *Heinrich Kuhn*

1 - Branch-and-cut and heuristic algorithms for an inventory routing problem with perishable products

Aldair Alvarez, Jean-François Cordeau, Raf Jans, Pedro Munari, Reinaldo Morabito

In this talk, we present different mixed-integer programming formulations for an inventory routing problem with perishable products. In the problem, the perishability of the products is modeled by considering a fixed shelf-life, i.e., the product expires a certain number of time periods after it is made available at the supplier. To solve the problem we propose branch-and-cut algorithms and a hybrid heuristic method. We report computational experiments with the algorithms using problem instances from the literature.

2 - Order policies for a perishable product in retail

Karin G.J. Pauls-Worm, Eligius M.T. Hendrix

A challenge of inventory control of perishable products in retail is that in general the age distribution of the items in stock is not known. Only the total numbers of items delivered and sold are recorded, resulting in an estimate of the items in stock. The exact number may be different from the inventory status according to the checkout system due to damaged items and more waste than expected. We investigate order policies for a product with a maximum shelf life of 3 days at delivery. Demand is non-stationary during the week, but stationary over the weeks. Lead time is one day. For planning purposes in the supermarket, we search for order policies with fixed reorder days during the week, so we order at least 3 times a week, and at most every day. It is likely to have items of different ages in stock. Customers can pick the items in front of the shelf (FIFO), as preferred and stimulated by the store, or search for the freshest items (LIFO). The store has a target α-service level to meet demand. A Stochastic Programming (SP) model is presented of the situation in the retailer practice. Several policies to determine the order quantity are studied and compared to a policy from literature. The base is a YS order policy where the reorder days Y are fixed and order-up-to levels S are used, with parameter values generated by an MILP approximation of the SP model. Numerical experiments compare the effectiveness of the policies with respect to costs and reached service levels.

3 - On the issuing rules and agreements in a divergent retail supply network to reduce the waste and increase the freshness of perishable products

Rob Broekmeulen, Karel van Donselaar

Our study investigates control rules at and agreements between different stakeholders in a divergent retail supply network for perishables. The objective is to reduce the time between production at the supplier and delivery to the store to maximize the freshness and minimize the waste. We also study the effects on transportation and handling costs.