Stabilized Branch-Price-and-Cut for the Commodity-constrained Split Delivery Vehicle Routing Problem

Timo Gschwind*[1], Nicola Bianchessi[2,3], and Stefan Irnich†[4]

[1]Chair of Logistics Management, Gutenberg School of Management and Economics, Johannes Gutenberg University Mainz – Jakob-Welder-Weg 9, D-55128 Mainz, Germany

[2]Chair of Logistics Management, Gutenberg School of Management and Economics, Johannes Gutenberg University – Jakob-Welder-Weg 9, D-55128 Mainz, Germany

[3]Dipartimento di Informatica, Università degli Studi di Milano – Via Celoria 18 - 20122 Milano, Italia, Italy

[4]Chair of Logistics Management, Gutenberg School of Management and Economics, Johannes Gutenberg University Mainz (JGU Mainz) – Jakob-Welder-Weg 9, D-55128 Mainz, Germany

Abstract

In the commodity-constrained split delivery vehicle routing problem (C-SDVRP), customer demands are composed of sets of different commodities. The C-SDVRP asks for a minimum-distance set of vehicle routes such that all customer demands are met and vehicle capacities are respected. Moreover, whenever a commodity is delivered by a vehicle to a customer, the entire amount requested must be provided. Different commodities demanded by one customer, however, can be delivered by different vehicles. Thus, the C-SDVRP is a relaxation of the capacitated vehicle routing problem and a restriction of the split delivery vehicle routing problem. For its exact solution, we propose a branch-price-and-cut algorithm that employs and tailors stabilization techniques that have been successfully applied to several cutting and packing problems. More precisely, we make use of (deep) dual-optimal inequalities which are particularly suited to reduce the negative effects caused by the inherent symmetry of C-SDVRP instances. One main issue here is the interaction between branching and cutting decisions and the different classes of dual inequalities. Extensive computational tests on existing and extended benchmark instances show that all stabilized variants of our branch-price-and-cut are clearly superior to the non-stabilized version. On the existing benchmark, our algorithm is significantly faster than the state-of-the-art algorithm and provide several new optima for instances with up to 60 customers and 180 tasks. Lower bounds are reported for all tested instances with up to 80 customers and 480 tasks, improving the bounds for all unsolved instances and providing first lower bounds for several instances.

Keywords: routing, vehicle routing, dual, optimal inequalities, column generation, discrete split delivery

*Corresponding author: gschwind@uni-mainz.de

†Speaker