The Commodity-Split Multi-Compartment Capacitated Arc Routing Problem

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This paper presents a matheuristic to solve the Commodity-Split Multi-Compartment Capacitated Arc Routing Problem (CSMC-CARP), arising in curbside waste collection of household waste. The CSMC-CARP is defined on an undirected graph where there exists a set of required edges with a positive demand for one or more waste types (called waste fraction), which are collected by a limited heterogeneous fleet of multi-compartment vehicle types located at a central depot. The objective is to determine a set of least-cost routes starting and ending at the depot, such that the demand of each edge for each waste fraction is collected exactly once by one vehicle, without violating the capacity of any compartment. The CSMC-CARP consists of three decision levels: selecting the number of vehicles of each type, assigning waste fractions to the compartments of each selected vehicle, and routing the selected vehicles. We present a three-phase algorithm to solve the problem that decomposes it into incomplete solution representations and heuristically solves one or more decision levels at a time. The first phase selects a subset of attractive compartment assignments from all possible assignments of all vehicle types. The second phase is a routing phase that solves a variant of the CSMC-CARP with an unlimited fleet using the set of attractive assignments as input. This is done by our C-Split Tour Splitting Algorithm, which can simultaneously split a giant tour of required edges into feasible routes while making decisions on the fractions that are collected by each route. The final phase solves a set partitioning problem to select, among the set of all routes obtained in the routing phase, the set of least-cost routes collecting all fractions of all required edges without exceeding the number of vehicles available of each type. The algorithm is tested on a set of real-life instances arising in the context of curbside waste collection in Denmark, with a degree of sorting of the waste in 3, 4, and 6 waste fractions.