Hybrid modeling framework for large-scale dial-a-ride problems

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The Dial-a-Ride Problem (DARP) is a challenging special case of the Pickup and Delivery Problem (PDP). Since the loads are passengers, the number of requirements is higher in a DARP (e.g. not only minimizing the transportation costs is important but also the travel time of such distinguished load). To account for the DARP particularities in a parsimonious manner, we propose a hybrid modeling framework which combines: i) a space-time-state formulation and (ii) a continuum approximation (CA) approach. Within the hybrid model, the space-time-state formulation depicts the decisions regarding the sequence of subregions visited by each vehicle, its schedule and the passenger-vehicle assignment. To complement this, the CA approach estimates the time spent within each locally homogeneous subregion during the pickup and drop-off process, according to optimal tour strategies. By dividing the DARP into these two components, the size of the problem is reduced significantly. In addition, the dial-a-ride multi-vehicle problem can be reformulated into a series of easy-to-solve shortest path sub-problems, through relaxation. In this way, this approach is suitable for providing near-optimal solutions to large-scale DARP instances.