Metaheuristics for the Traveling Salesman Problem with Pickups, Deliveries and Handling Costs (TSPPD-H)

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This study focuses on designing efficient metaheuristic algorithms for a variant of the One-to-Many-to-One Single Vehicle Pickup and Delivery problems (SVPDP) that incorporates the handling cost incurred when rearranging the load at the customer locations. Our previous study (Battarra et al., 2010) of TSPPD-H shows that the simultaneous optimization of routing and handling costs is difficult and the resulting loading patterns are hard to implement in practice. We have proposed some simplified policies applicable to such contexts. In addition, branch-and-cut algorithms based on integer linear programming formulations are proposed, in which routing and handling decisions are simultaneously optimized, but the handling decisions are restricted to three simplified policies. The proposed methods have been extensively tested on instances involving up to 25 customers and hundreds of items.

In this study, the subproblem of handling when routing decisions are fixed is analyzed, under the assumption of using the previously proposed handling policies. A dynamic programming algorithm for this problem with a complexity of $O(n^2)$ is presented. However, the application of this algorithm to evaluate the routing decisions becomes prohibitive for even 1-OPT and 2-OPT neighborhoods. To decrease this cost, the handling subproblem is further studied and a special case of it as has been modeled as a convex nonlinear optimization problem, which allows a closed form solution. This closed form solution of this special case is then adapted for the general case as a linear time heuristic. Extensive testing on randomly generated instances shows that the average deviation of the results of this linear heuristic is 8% and the worst-case deviation decreases as the instance size increases.

Metaheuristic algorithms for TSPPD-H are then devised, using the linear time heuristic to evaluate the neighborhood of routing solutions, and the dynamic programming algorithm to determine the optimal handling decisions for the selected neighbor. A tabu search, an iterative local search, and an iterative tabu search (an iterative local search algorithm for which the local search is replaced by a tabu search algorithm) are implemented. The algorithms are tested on instances adapted from the literature and computational results are presented.

References:

M. Battarra, G. Erdogan, G. Laporte, and D. Vigo. The traveling salesman problem with pickups, deliveries, and handling costs. Transportation Science, 44:383–399, 2010.