An Enhanced Evolutionary Local Search for the Split Delivery Vehicle Routing Problem

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1 Introduction

In this paper we present a simple and effective metaheuristic algorithm for the Split Delivery Vehicle Routing Problem (SDVRP). The SDVRP is a relaxation of the classical Vehicle Routing Problem in which a customer demand may be serviced by more than one vehicle. The objective is to find a set of least cost trips for a fleet of identical vehicles to service geographically scattered customers with or without splitting. The proposed method is the hybridization between a Variable Neighborhood Search (VNS), an Evolutionary Local Search (ELS) and a Variable Neighborhood Descent (VND). It combines the multi-start approach of VNS and ELS and the VND intensification and diversification strategies. This new method is tested on three sets of instances from literature containing a total of 77 benchmark problems. The obtained results show that the algorithm outperforms all previously published metaheuristics. 62 instances out of 77 are improved.

2 Problem description

The SDVRP is defined on a complete weighted and undirected network G = (N, E, C). N is a set of n + 1 nodes indexed from 0 onwards. Node 0 corresponds to a depot with identical vehicles of capacity W. Each other node i, i = 1, 2, ..., n has a known demand qi. The weight cij = cji on each edge (i, j) of E is the travelling cost between nodes i and j. We assume that no demand qi exceeds vehicle capacity W. Otherwise, for each customer i such that qi > W, an amount of demand W can be deducted from qi to build one dedicated trip with a full load, until the residual demand fits vehicle capacity, as shown in [1].

Partial deliveries are allowed, so some customers (called split customers) can be visited more than once. The objective is to determine a set of vehicle trips of minimum total cost. Each trip starts and ends at the depot and supplies a subset of customers. The number of trips or vehicles used is a decision variable. It is assumed that the triangle inequality holds: in that case, solutions in which each trip visits its customers only once dominate the others. In other words, if one customer is visited several times, these visits are done by distinct trips.

3 General presentation of the solution approach

The metaheuristic proposed in this paper is an enhanced version of a new method called hybrid GRASP × ELS (Evolutionary Local Search) that was applied successfully to the classical Vehicle Routing Problem by Prins [2].

In the hybrid GRASP × ELS, each GRASP iteration generates one starting solution and applies ELS to it. The advantage of this hybridization is the possibility of getting out of local optima when the ELS converge and restart the local search from a new solution. Reghioui [3] proposed a similar method that uses

several greedy randomized heuristics in the first phase, its application to the Capacitated Arc Routing Problem with Split Deliveries have resulted in high-quality solutions compared with those obtained with a memetic algorithm. It is noted that in the ELS phase a Variable neighborhood descent (VND) is used. The final approach is called the enhanced evolutionary local search (EELS).

The EELS proposed for the SDVRP uses two classical VRP heuristics and one SDVRP heuristic to generate the first three initial solutions: the savings heuristic of Clarke and Wright [4], the Sweep heuristic of Gillet and Miller [5] and the Split-Insertion Heuristic (SIH) of Reghioui [3]. The remaining initial solutions are drawn randomly from three neighborhoods around the best solution.

4 Results

The tests were performed on well-known instances and compared to the best lower bounds when available, and to the best known heuristic solutions of the literature. Three sets of instances with a total of 77 SDVRP benchmark problems are used. The obtained results show that EELS improves 41 out of the 42 tested instances, while being 2 times faster than the optimization based algorithm proposed later in literature by [6] Moreover, the average percentage of improvement over the solution obtained with SplitTabu[7]is 2.51% for EELS versus 0.55% for the optimization based algorithm.

5 Conclusion

To sum up, it can be stated that the combination of several components of different metaheuristics can lead to a strong and robust approach with a good alternation between diversification and intensification phases. The enhanced evolutionary local search proposed for the Split Delivery Vehicle routing Problem (SDVRP) combines diversification strategies of the Variable Neighborhood Search and the Evolutionary Local Search by using shaking techniques and perturbation procedures, and the intensification method of the Variable Neighborhood Descent. The resulting approach has been compared to a lower bound and to the best four published metaheuristics for the SDVRP. Computational results confirm the efficiency of this new method: more than 80% of the tested instances are improved.

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