Metaheuristic approach for the clustered VRP

T. Barthélemy†, A. Rossi†, M. Sevaux†, K. Sørensen‡
†Lab-STICC, Université de Bretagne-Sud, Lorient, France
‡University of Antwerp, Belgium
barthelemy.e0300226@etud.univ-ubs.fr,
{andre.rossi,marc.sevaux}@univ-ubs.fr,
kenneth.sorensen@ua.ac.be

1 Introduction

The clustered Vehicle Routing Problem is defined as follows. An unlimited number of identical vehicles is available in the depot, and have to deliver goods to \( n \) customers. The capacity of the vehicles is denoted by \( K \) and the demand of customer \( c_i \) is denoted by \( D_i \) for all \( i \) in \( \{1, \ldots, n\} \). A partition of customers into \( m \) clusters is also provided, and all the customers that belong to the same cluster have to be visited by the same vehicle (or equivalently in the same trip). The problem objective is to visit all the customers exactly once while minimising the total travelled distance.

Such a situation arises in the field of delivery companies, where clusters are defined by zip codes or geographical locations: in that case, all the goods to be delivered to customers in the same cluster are loaded in a single truck. Of course, more than one cluster can be visited in a trip, but once a customer is visited, the vehicle cannot come back to the depot or visit a customer out of the current cluster unless all the customers in that cluster have been visited. Thus, a trip can also be viewed as a sequence of clusters to visit. That clustering constraint implies that the vehicle capacity has to be larger than the sum of the customer demands in any cluster for the problem to be feasible.

The symmetrical problem version is addressed by analogy with the clustered TSP [2]. In this study, we will exploit the simple idea in [2] to solve the Clustered VRP problem empirically. The purpose is not to design a competitive method (which is left to further research) but only to validate this idea.

Given a complete undirected graph, \( d_{ij} \) is the distance between nodes \( i \) and \( j \) for all \((i, j)\) in \( \{0, \ldots, n\} \times \{0, \ldots, n\} \) where vertex 0 models the depot. Modified distances are built as follows: \( d'_{ij} = d_{ij} \) if and only if \( i \) and \( j \) belong to the same cluster, otherwise \( d'_{ij} = d_{ij} + M \), where \( M \) is the penalty for crossing the cluster frontier. The purpose of \( M \) is to be large enough for enforcing clustering constraints, it is set to the sum of the \( d_{ij} \) for all \( i \) and \( j \) in practice. With such modifications on distances, the clustered VRP problem is expected to come down to the classical version of the VRP problem.

2 Solution process

As mentioned before, the purpose of this approach is a preliminary study to test this simple idea of changing the distance measure for customers in different clusters. The performance of the heuristic itself is not important. Nevertheless, it is also a good opportunity to test some new combination of algorithms around the simulated annealing framework.

The classical VRP problem is addressed using a three-step heuristic approach described below. This approach combines a simple heuristic with a local search operator that will be run after moves operated in the simulated annealing procedure.
Initial solution  The first solution is designed by the Clarke and Wright heuristic [1]. This solution is improved using a 2-opt local search. Having this 2-opt local search procedure run will ensure to obtain minimum local solutions for the starting point of the simulated annealing (SA).

Moves  We use the notation defined by [3] (let u a customer and T(u) the trip in which customer u is visited). Two different kind of moves are used in the SA procedure. (i) The first move is designed to reduce the number of trips. It takes two customers u and v at random in two different trips (T(u) ≠ T(v)). Depending on the truck capacity in T(v), customer u is moved in T(v). If the capacity of the truck in T(v) is exceeded, an exchange between customer u and v is attempted (the truck capacities of the two trips need to be checked again). Otherwise, the move is discarded. (ii) The second move consists in exchanging two customers in the same trip. The capacity of the truck is not changed.

Simulated Annealing process  The classical simulated annealing scheme is applied to our problem. To proceed one of the two moves, two customers u and v are randomly chosen. If T(u) ≠ T(v), move 1 is applied otherwise, move 2 is selected. After accepting the solution, the 2-opt local search procedure is applied again.

3 Computational results

The proposed approach has been tested on randomly generated instances. As usual, in the Euclidean space of size 100 × 100, customers are randomly positioned. Cluster is a simple and random geographical partition of the area. Demands are randomly generated in [1, 10] and the truck capacity is 100.

All instances solved here report a solution which is compliant to the clustering constraint. Unfortunately, due to lack of space, no results can be output here, but the presentation will report extensive results.

4 Conclusion

The proposed approach in that paper has confirmed our first conjecture which was that the clustered VRP can be solved by changing the distance measure between different clusters. We are currently developing more efficient moves (taken from [3]) to get better results and a better efficiency of the solution process. A collaboration with other researchers is planned at a short term and results from the pre-Hamiltonian path problem should be inserted in the solution process [4].

We are also trying our approach on larger instances and waiting instances from delivery companies which can count several thousands of customers and clusters can contain more than 200 customers (see [5]).

References