

A Variable Neighborhood Search for the Capacitated Arc Routing Problem with Intermediate Facilities

Michael Polacek⁽¹⁾, Karl F. Doerner⁽¹⁾,
Richard F. Hartl⁽¹⁾, Vittorio Maniezzo⁽²⁾

(1) Institute for Management Science, University of Vienna, Bruenner Strasse
72, 1210 Vienna, Austria

`{Michael.Polacek, Karl.Doerner, Richard.Hartl}@univie.ac.at`

(2) Department of Computer Science, University of Bologna, Mura Anteo
Zamboni, 7, 40100 Bologna, Italy
`maniezzo@csr.unibo.it`

Abstract

In this talk we present a unified Variable Neighborhood Search (VNS) algorithm for the Capacitated Arc Routing Problem (CARP) and some of its variants - the Capacitated Arc Routing Problem with Intermediate Facilities (CARPIF) and the Capacitated Arc Routing Problem with Intermediate Facilities and Length restrictions (CLARPIF).

Routing problems represent one of the most prominent classes of models within computational logistics, and within combinatorial optimization in general. Being both of practical and theoretical relevance, they have provided a primary arena for validating new metaheuristics and for determining comparative efficiency.

While the first application problem for a metaheuristics has usually been a node routing problem such as the travelling salesman problem (TSP) or the vehicle routing problem (VRP), several of these methods have also been applied to arc routing problems. The capacitated arc routing problem (CARP) originally proposed by Golden and Wong [3] is one of the prototypical routing problems, asking a fleet of vehicles to service a set of clients which are distributed on the arcs of a road network. While every CARP instance can be transformed into an equivalent VRP instance, this comes at the cost of obtaining a graph which has a number of nodes equal to the number of arcs of the original CARP graph, which is usually very large. Therefore, there is ample room for research that works directly on the CARP formulation.

Several real-world applications like urban waste collection, mail collection or delivery, snow removal or street sweeping can be modelled as a CARP. However, some of them are more appropriately formulated as capacitated arc routing problems with intermediate facilities (CARPIF) introduced by Ghiani et al. [1]. In addition to the depot, where the vehicles are located, the vehicles can be loaded or unloaded at intermediate facilities. For example in most cities the garbage collecting vehicles are assigned to a depot whereas the garbage is dumped at waste incinerating plants or special dump sites. When a tour length restriction is introduced, this problem is called a CLARPIF [2].

In this contribution we use the metaheuristics Variable Neighborhood Search (VNS) introduced by Mladenovics and Hansen [5]. In previous work, VNS has already been applied to a number of variants of vehicle routing problems with excellent results, e.g. [6]. Now we apply VNS to the arc routing problems CARP, CARPIF, and CLARPIF. The basic idea in local search is 2-opt, thus changing the orientation of sequences of edges, while in the shaking phase a 3-opt operator is employed.

Our algorithm shows excellent behaviour in all three problem classes considered. The so far best metaheuristics for the CARP, the memetic algorithm developed by Lacomme et al. [4], is outperformed especially for the larger instances of the well studied classical CARP benchmark problems introduced by Eglese. We also improve the results provided by the tabu search algorithm developed by Ghiani et al. for the CARPIF and the CLARPIF instances [1, 2] significantly.

References

- [1] Ghiani, G., Improta, G., Laporte, G., and Whittin, T.M., "The capacitated arc routing problem with intermediate facilities." *Networks*, **3** (2001) 134–143.
- [2] Ghiani, G., Guerriero, F., Laporte, G., Musmanno, R., "Tabu search heuristics for the arc routing problem with intermediate facilities under capacity and length restrictions". *Journal of Mathematical Modelling and Algorithms*, **3** (2004) 209–223.
- [3] Golden, B. L. and Wong, R. T., "Capacitated arc routing problems", *Networks*, **11**, pp. 305–315, 1981
- [4] Lacomme, P., Prins, C., Ramdane-Cherif, W. (2003): "Competitive Memetic Algorithms for Arc Routing Problems" **131**, pp. 159–185.
- [5] Mladenović, N. and Hansen, P. (1997): "Variable Neighborhood Search". *Computers and Operations Research* **24**, pp. 1097–1100.
- [6] Polacek, M., Hartl, R. F., Doerner, K. F., Reimann, M. (2004): "A variable neighborhood search for the multi depot vehicle routing problem with time windows" *Journal of Heuristics*, **10**(6), pp. 613–627.