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A variable neighborhood search algorithm for the capacitated vehicle routing problem

Marwa Amous[a] [1] Said Toumi[a,b] [2] Bassem Jarboui[a,c] [3] Mansour Eddaly[a,d] [4]

[a] *MODILS Lab, Université de Sfax, FSEGS, route de l'aéroport km 4, Sfax 3018 Tunisie*

[b] *Al majmaah University. College of Business Administration. Academic City, P.O Box 66, Majmaah 11952 - Kingdom of Saudi Arabia*

[c] *Emirates College of Technology, Abu Dhabi, United Arab Emirates*

[d] *Université de Gafsa, Institut Supérieur d'Administration des Entreprises, Tunisie*

Abstract

This paper studies the capacitated vehicle routing problem (CVRP). Since the problem is NP-hard, a variable neighborhood search (VNS) algorithm is proposed for the CVRP with the objective to minimize the total traveled distance. The proposed algorithm includes a variable neighborhood descent (VND) algorithm based on several different neighborhood structures to intensify the search effort. Various benchmark problems including the number of customers, the capacity of vehicles are tested to evaluate the performance of proposed methodology. The experimental results indicate that the proposed algorithm provides superior solutions for well-known benchmark problems compared to those reported in the literature.

Keywords: Vehicle routing problem, capacity constraints, variable neighborhood search, variable neighborhood descent

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1 Introduction

The transportation problems play a key role in the supply chain management because a product is rarely produced and consumed in the same place and also reducing the transportation cost leads to enhance the performance of companies. The classical Vehicle Routing Problem (VRP) consists in determining a set of routes for an identical vehicles to serve a set of customers while minimizing the total cost of transportation. In the capacitated variant, denoted by CVRP, only capacity restrictions for vehicles are considered in addition to the basic features of the problem such that the demand of each customer, the distance between each pair of customer and the departure node (the depot). The common objective is to minimize the total cost (or length) of routes.

Over the years, several solution methods for the CVRP have been developed by researchers. Toth and Vigo [9] presented a review of models and exact approaches based on the branch and bound algorithms used to solve CVRP. The authors studied both the symmetric and asymmetric cases. The proposed exact algorithms solved the asymmetric problems with up to 300 nodes and 4 vehicles. In Mazzeo and Loiseau [7], an Ant Colony Optimization (ACO) algorithm was developed. The obtained results showed that the ACO is in competition with other metaheuristic to solve CVRP and it can find the optimal solution for the problem with less than 50 nodes. Lin et al. [6] applied hybrid algorithm of simulated annealing and tabu search. Juan et al. [5] proposed a methodology named "SR-GCWS" that combines the Clarke and WrightŠs Savings (CWS) heuristic and the Monte Carlo Simulation (MCS).

The Variable Neighborhood Search (VNS) algorithm is a metaheuristic proposed by Mladenović and Hansen [8], for solving combinatorial optimization problems, whose basic idea is the systematic change in neighborhood of a local search. The VNS algorithm has two main features; a shaking phase to escape from local optima (Diversification) and a local search phase to seek an improvement in the neighborhood of the current solution based on predefined neighborhood structures (Intensification). It uses the following findings [4]:

- a local minimum with respect to a neighborhood is not necessarily an optimal with respect to another;
- a global minimum is a local minimum with respect to all neighborhoods possible.

[1] Email: mraywaammous@hotmail.fr
[2] Email: saidtoumy@gmail.com
[3] Email: bassem_jarboui@yahoo.fr
[4] Email: eddaly.mansour@gmail.com