Chapter 13
A Memetic Algorithm for the Multi-Depot Vehicle Routing Problem with Limited Stocks

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ABSTRACT

The Vehicle Routing Problem (VRP) is one of important combinatorial problems, which holds a central place in logistics management. One of the most widely studied problems in the VRP family is the Multi-Depot Vehicle Routing Problem (MDVRP), where more than one depot is considered. In this chapter, the authors focus on a new extension of the MDVRP in which goods loaded by the vehicle are restricted due to limited stocks available at warehouses. More specifically, this extension consists in determining a least cost routing plan that can satisfy all the customs demands by delivering available stocks. Indeed, this problem is often encountered when goods are shortage in some warehouses. To deal with the problem efficiently, a memetic algorithm is proposed in this chapter. The authors study this approach on a set of modified benchmark instances and compare its performance to a pure genetic algorithm.

INTRODUCTION

The success of optimization techniques has been impacted on the economic system. Their applications help decision-makers to operate in many area, including industrial, economics, business and financial systems (Dieu & Ongsakul, 2012; Vasant, 2012; Cebi, Kahraman, & Kaya, 2012; Sadrnia, Nezamabadi-Pour, Nikbakht, & Ismail, 2013; Purnomo & Wee, 2013; Vo & Schegner, 2013; Dostál, 2013; Senvar, Turanoglu, & Kahraman, 2013; Vasant, 2013; Zelinka, Vasant, & Barsoum, 2013).

How to find efficient vehicle routes is not only an academic problem, but also has immense value in practice due to its high impact on cost and customer satisfaction. This problem, referred to the Vehicle Routing Problem (VRP), consists in finding a set of routes satisfying all the constraints while minimize

DOI: 10.4018/978-1-4666-7258-1.ch013

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the overall cost. Although the VRP has been studied for several decades, the field of this problem is still active as witnessed by a large number of recent papers appeared in the literature. That might be due to its applications in various real-world situations, resulting in different version of the VRP. Often, the VRP is often defined on a graph $G = \left(V_c \cup V_d,\ E\right)$, where $V_c = \left\{v_1, v_2 \ldots, v_n\right\}$ is the customer set, $V_d = \left\{v_{n+1}\right\}$ is the depot set and $E = \left\{(v_i, v_j) : v_i, v_j \in V_c \cup V_d, i \neq j\right\}$ is the edge set. Generally, each customer must be assigned to exactly one of the vehicles. The total demand for customers on any routes must not exceed the vehicle capacity. By optimizing this problem, companies can save money and increase customer satisfaction. Hence, it plays an important role in the fields of transportation, distribution and logistics. Realizing this importance role, a lot of efforts have been made in finding efficient way to solve this issue since Dantzig and Ramser (1959) first introduced this problem. In essence, the elementary version of the VRP, called the capacitated vehicle routing problem (CVRP), can be stated as follows: a set of customers with known demand are to be serviced by a homogenous fleet of vehicles with limited capacity. The VRP consists of designing a set of vehicle routes satisfying the following constrains:

1. Each customer is visited exactly once by a vehicle,
2. Each vehicle route begins and ends at the depot,
3. The total demand serviced of any rout does not exceed the limited capacity of vehicle. Obviously, the main objective of the VRP is that the total cost of all vehicle routes is minimized.

As its various occurrences in practical problems, the VRP has been studied extensively. The multi-depot vehicle routing problem (MDVRP) is one of its variants in which more than one depot is considered. Although the MDVRP is well studied in the literature, some of its aspects that arise in real applications have not received much attention from researchers. For example, it usually assumed that unlimited goods available at each depot can be loaded by vehicles. However, in some contexts, this assumption is not validated in real-world applications. In addition, we often assume that each vehicle perform only one route when addressing the VRP. In many practical situations, this assumption is also not realistic. This is because more than one route can be assigned to the same vehicle and thus use fewer ones in a given planning period. Usually, this kind of problems is referred to as the vehicle routing problem with multiple trips (also called the multil trip VRP or the vehicle routing problem with multiple routes). These researches can be found in the literature (Taillard, Laporte, & Gendreau, 1996; Brandão, & Mercer, 1998; Fleischmann, 1990; Mingozzi, Roberti, & Toth, 2013). In order to overcome the mentioned limitations, we examine the multi-depot vehicle routing problem with limited stocks (MDVRPLS). In the MDVRPLS, some new features are considered when compared with the classical MDVRP of literature. For example, in addition to capacity constrains for vehicles, it deals with the limited stocks at depots. Also, it takes sharing vehicles for warehouses into account. This chapter aims at studying this special version of the MDVRP whose objective is to minimize the number of vehicles and the total operation cost (also called the total travel distance) taking account of a set of constraints. In fact, its ultimate objective can be also interpreted as minimizing the total operation cost, since fewer vehicles used imply that the operation cost is reduced. Within the research covered in the literature, to our knowledge, there is scare research work on this problem. Therefore, it might be worth to study such a member of the VRP family.

Due to the fact that the computational complexity makes both the VRP and its variants NP-hard problems, solving the MDVRPLS to optimality is an extremely time-consuming procedure. In the literature, using metaheuristics are general solution strategies. Evolution algorithm is an important

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