Chapter 8

Variants of VRP to Optimize Logistics Management Problems

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ABSTRACT

The Vehicle Routing Problem (VRP) is a key to the efficient transportation management and supply-chain coordination. VRP research has often been too focused on idealized models with non-realistic assumptions for practical applications. Nowadays the evolution of methodologies allows that the classical problems could be used to solve VRP problems of real life. The evolution of methodologies allows the creation of variants of the VRP which were considered too difficult to handle by their variety of possible restrictions. A VRP problem that includes the addition of restrictions, which represent the variants in the problem, is called Rich VRP. This work presents an algorithm to optimize the transportation management. The authors are including a case of study which solves a real routing problem applied to the distribution of bottled products. The proposed algorithm shows a saving in quantity of vehicles and reduces the operation costs of the company.

INTRODUCTION

The VRP is a generic name given to a whole class of problems. This combinatorial optimization problems considered one of the hardest, defined over 40 years ago by Dantzig and Ramser in 1959. This problem consists in designing the optimal set of routes for a fleet of vehicles in order to serve a given set of customers. The problem objective is to deliver the known demands to a set of customers, minimizing the vehicles routes costs, starting and finishing at the same depot. The
computational experience indicates that VRP is a classic *NP*-hard problem, it is to say, it is difficult to solve optimally. Most real-world vehicle routing problems are solved using heuristic methods (Grer, Golden, & Wasil, 2010).

The VRP has a large number of real-life applications depending on the operation type, for example, picking up and delivering with restrictions like vehicle capacity or multiple depots, among others. Recent researches have shown that an adequate cost minimization in these problems will result in significant savings, approximately from 5% to 20% of the product total cost (Toth & Vigo, 2002).

In our work, we present a case of study which is a real routing problem applied to the distribution of bottled products. The transportation of bottled products is a relevant activity for industrial and commercial processes. The issues related to our research could be divided into three sub-problems: routing, scheduling, and loads allocation.

The *routing and scheduling* can be described as a Rich VRP; this is a complex problem where several VRP variants are combined, in order to find a set of paths that allow satisfying the demands. The sub-problem of the *loads allocation* can be viewed as a Bin Packing Problem (BPP) which must determine a minimum set of containers to distribute the products (Rangel N., 2005).

Our research proposes a methodology of solution based on approximated algorithms. The methodology consists on an integrated system that involves the Ant Colony System (ACS) algorithm (Dorigo, 1997) which solves the routing and scheduling tasks.

We solve the *Routing - Scheduling - Loading Problem (RoSLoP)* addressing it by a Heuristic-Based System for RoSLoP (*HBS-RoSLoPII*). The *HBS-RoSLoPII* works in two stages: in the first, we created a new algorithm called Ant Colony System for the Routing and Scheduling Problem (*ACS-RoSLoP*). In the second stage, we designed an algorithm called DiPro that solves the vehicle load problem, modeling it as a Bin Packing Problem (BPP). In this work we only present and describe the information related to *ACS-RoSLoPII*. In addition, we developed a solution methodology for solving *HBS-RoSLoPII* applied to the distribution of bottled products in a company located in northeastern Mexico.

The proposal of this chapter is to describe the necessary elements to develop this research. First, in the Background section we describe the different concepts related to VRP and *RoSLoP*. In the next sections, we explain how the heuristic algorithm for *RoSLoP* was selected, as well as the solution methodology and the characteristics of real and artificial instances. In addition we describe the strategies used to adapt the classical ACS algorithm in order to solve *RoSLoP*. After that, we describe the experiments that validate the results of the *ACS-RoSLoPII* algorithm. The last section presents the conclusions obtained from the research experimental results, as well as the future work that could be developed to improve the results of solving the *RoSLoP*.

**BACKGROUND**

The section begins with the origin and description of VRP, we continue with a summary of the variants involved in this work, and with the formal definitions of the BPP and *RoSLoP*. To finish, we describe the basic elements that compose the ACS algorithm that will be used for the solution of the *RoSLoP*.

**ORIGIN OF VRP**

The *Traveling Salesman Problem* (TSP) is probably the most studied and known combinatorial optimization problem. In this problem a salesman has to visit a defined number of cities. The salesman must perform a tour through all the cities and return to the starting city in the end of the tour. In other words, given an undirected graph $G = (V,E)$