

Chapter 8

A Genetic Algorithm's Approach to the Optimization of Capacitated Vehicle Routing Problems

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ABSTRACT

This chapter addresses the family of problems known in the literature as Capacitated Vehicle Routing Problems (CVRP). A procedure is introduced for the optimization of a version of the generic CVRP. It generates feasible clusters and, in a first step, yields a coding of their ordering. The next stage provides this information to a genetic algorithm for its optimization. A selective pressure process is added in order to improve the selection and subsistence of the best candidates. This arrangement allows improving the performance of the algorithm. We test it using Van Breedam and Taillard's problems, yielding similar results as other algorithms in the literature. Besides, we test the algorithm on real-world problems, corresponding to an Argentinean company distributing fresh fruit. Four instances, with 50, 100, 150 and 200 clients were examined, giving better results than the current plans of the company.

INTRODUCTION

The competitive pressures faced by companies pushes for the development of new techniques for optimal decision-making. These methods are also intended to be fast enough to achieve highly competitive services. One of the main issues that such techniques should address is the design of plans for the distribution of products. The high complexity of these problems constitutes a roadblock for the creation of

DOI: 10.4018/978-1-4666-9644-0.ch008

methods able to yield optimal outputs for real-world cases in reasonable computation times (Bartolini et al., 2013; Ambrosino & Sciomachen, 2007). Despite the lack of appropriate methodologies, firms have to keep making short, median and long-term decisions with respect to transportation.

The economic importance of moving products requires if not optimal, at least good strategies to handle the problems fast enough, providing competitive solutions (Bodin & Golden, 1981; Kumar & Panneerselvam, 2012). Distribution, for instance, involves different phases, covering from the moment the products leave the firm until they reach the end consumers. The configuration and topology of the ensuing distribution network can be obtained as a solution of the so-called Vehicle Routing Problem (VRP) (Basu, 2012; Laporte & Osman, 1995). The VRP is a combinatorial optimization problem in the NP-Complete class. The academic and industrial motivation for seeking reasonable solutions is related to the hardness to find optimal ones (Pollaris et al., 2015; Mota et al., 2007).

VRP amounts to find the shortest routes of delivery of goods to a set of clients, whose placement in space and demand are known. A single point of departure (a depot) and a given fleet of vehicles are assumed. To this basic setting different operational conditions have been added in time. An immediate incorporation was a constraint on the capacity of the fleet of vehicles (CVRP, Capacitated Vehicle Routing Problem) (Kao & Chen, 2013; Wu et al., 2013; Frutos & Tohmé, 2012; Alba & Dorronsoro, 2008). In this chapter we address specifically the CVRP. To extend our approach in (Frutos & Tohmé, 2012), we add a selective pressure process that improves the performance of the individuals that are selected.

The chapter is organized as follows. First we present the VPR and establish its operational conditions. Then we characterize the CVRP as well as an alternative version. We solve Van Breedam and Taillard's problems using our improved algorithm and compare with already known results. Later we apply the algorithm to a real-world case of an Argentinean fresh fruit delivering firm. Finally, we present the conclusions and discuss possible lines of future research.

ADDITIONAL READINGS

As mentioned above, different extensions to the basic VRP have been developed in the last decade. So for instance, time windows for client attention were added to the basic problem yielding the VRPTW (Vehicle Routing Problem with Time Windows) (Wang, 2012; Desrochers et al., 2002; Khebbache-Hadji et al., 2013). Another way in which VRP has been enlarged is with multiple depots (MDVRP, Multi-Depot Vehicle Routing Problem) (Escobar et al., 2014). Other extensions involve the possibility of returning some delivered goods to the deposit (VRPPD, Vehicle Routing Problem with Pick-Up and Delivering) (Çatay, 2009; Thangiah et al., 2007), or that different vehicles can deliver to a single client (SDVRP, Split Delivery Vehicle Routing Problem) (Aleman & Hill, 2010; Aleman et al., 2010; Belenguer et al., 2010; Derigs et al., 2009; Nagao & Nagamochi, 2007; Moreno et al., 2010; Bolduc et al., 2010). Another addition is that some values (number of clients, their demands, servicing time or in-route time) can be random (SVRP, Stochastic Vehicle Routing Problem) (Zhang et al., 2013) and that some deliveries can be performed in certain dates (PVRP, Periodic Vehicle Routing Problem) (Kurz & Zäpfel, 2013). Finally, some problems combine some of these operational conditions (Belfiore & Yoshizaki, 2009; Nowak et al., 2009).

Algorithms have been developed, solving some of the aforementioned problems in reasonable time. Kao and Chen (2013) solve an instance of CVRP using a hybrid algorithm combining Particle Swarm Optimization (PSO) and Simulated Annealing (SA). The authors' approach is to use the technique known

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