The Vehicle Routing as a Multi-Rows Facility Layout Problem

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1 Introduction

The vehicle routing problem (VRP) is a fundamental problem in downstream logistics, particularly distribution [1]. It concerns the problem of transporting goods from the manufacturer's depots to its customers. The VRP is an NP-hard combinatorial optimization problem [2]. Generally, in the literature [5], authors use heuristics and metaheuristics to cope with its variants. Also, commercial solvers are inclined to relay on heuristics due to the size and the side constraints of real world VRPs. Indeed, the VRP has numerous applications in industry [3] and its literature review is very rich. There are many surveys and publications about the definitions, variants, classification, solving techniques and approaches to the VRP problems [3, 4, 5, 6, 7].

The Facility Layout Problem (FLP) is a common industrial problem of allocating facilities with the objective either to maximize adjacency requirement, to minimize the traveling costs, to minimize building costs or to minimize rearrangement costs [8]. The Multi-Row FLP is a variant of this general problem, which consists – for a given number of rows, a set of rectangular facilities, and weights for each pair of facilities – of finding an assignment of facilities to rows and the positions of the facilities in each row so that the total distances between all pairs of facilities is minimized.

The objective of this work is to propose a new formalization of the classical Capacitated Vehicle Routing Problem (CVRP) through the pattern of the Multi-Rows Facility Layout Problem (MRFLP). The idea is to bridge the two classes of problems with the hope of making their solving easier.

In literature, the bin-packing problem and quadratic assignment problem have been used to deal with scheduling problems [9, 10, 11, 12]. The VRP could be seen as a scheduling problem, in which each activity to schedule is the delivery of a quantity to a given customer; and the resources are the vehicles. Thus, the packing approaches and especially FLP could be applied on.

2 Problem statement

The VRP in concerns in our work is the capacitated one, the CVRP. It could be characterized as follows: From a depot, goods must be delivered in given quantities (demands) to given customers. For the transportation of the goods a number of vehicles are available and each vehicle has a fixed capacity. In our case the fleet is homogeneous and then the fixed capacity is the same for all vehicles. Every route, in the solution, must start and end at the depot, and could deliver one or more customers. The costs are related to the travelled distances.

This CVRP problem is formally characterized by a non-oriented graph $G = (V, E)$ such that V is the set of the G's vertices and $E = V \times V$ is the set of arcs in G. In V, the first vertex represents the depot location and the other vertices represent customers' locations. Each vertex, other than the depot, has a weight that represents the demand of the related customer. In E, each arc between two vertices, c1 and c2, represents the link between the two locations (a location is either the depot or a customer) and its weight is the distance between the two locations. All the vehicles have the same capacity C.

2.1 The CVRP through MRFLP

This paper deals with a new approach to handle the traditional vehicle routing problem (VRP). We model it as a multi-row facility layout problem (MRFLP). In this new formulation, each vehicle route is addressed as a single line layout in which a facility represents a customer and the positions of facilities in the final layout represent the order of visiting the customers in the route. The choice of the MRFLP is due to the resemblance between the alignment of facilities in rows and the alignment of customers in routes (see Figure 1).

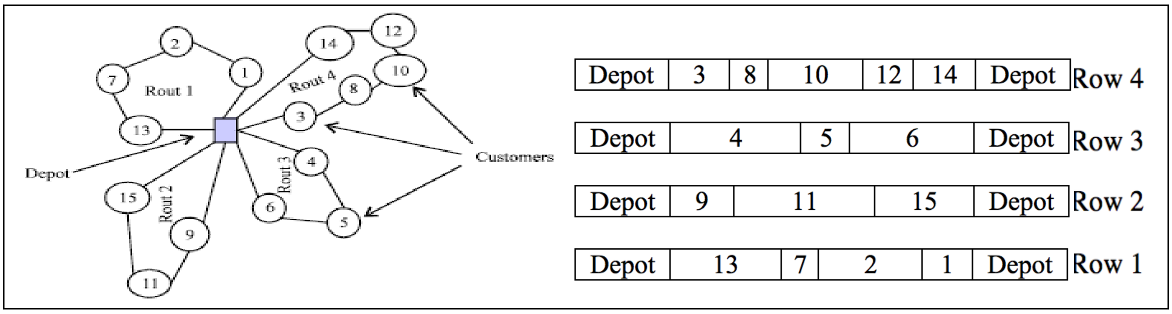

FIG. 1 – The CVRP seeing as MRFLP

To the best of our knowledge, we are the first to use MRFLP to represent a VRP. Thus, to define our new problem for a given fixed number of routes and a set of customers with heights expressing the quantity to be delivered, the VRP consists of finding an assignment of customers to routes and the positions of the customers in each route while avoiding customers' overlapping so that the total weighted sum of the distances between each two adjacent customers is minimized.

To solve this problem a hybrid method is proposed combining a genetic algorithm and a local search heuristic which is incorporated into the mutation, crossover, and selection loops of the GA. This hybridization has proved its efficiency in solving FLP problems by the past. The general algorithm of our approach is presented in Figure 2, Our HGA applies the GA as a global exploration of the selected population, whereas the neighborhood search performs a local exploitation of each chromosome.

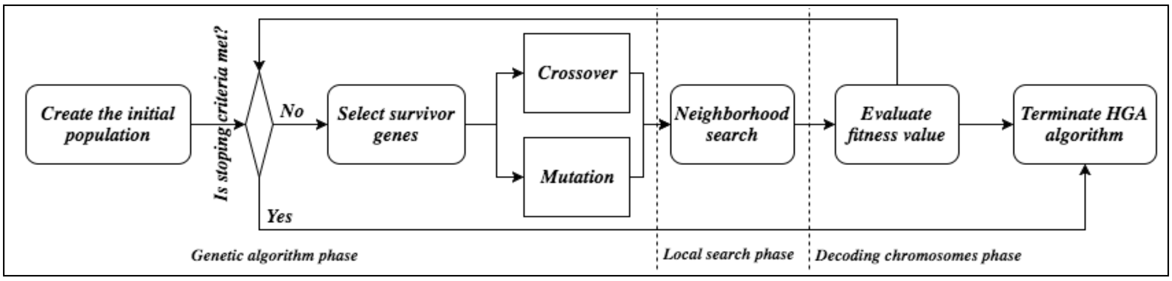

FIG. 2 – The algorithm of our Hybrid GA

The actual allocation of customers to routes is conducted in the chromosome decoding phase. The detailed schedule and fitness value is calculated by the allocation rule. The previous three phases aim to compute the objective function, whereas the function in the decoding chromosome phase describes the real schedule.

3 Conclusions

The main contributions of this paper are the new formalization of the classical CVRP through the pattern of the MRFLP and the development of a hybrid GA to effectively solve it. Our approach has been validated on several instances of VRP from the literature with promising results.

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