A Cubic-Genetic Algorithm for Vehicle Routing Problem with Time Windows and Heterogeneous Fleet

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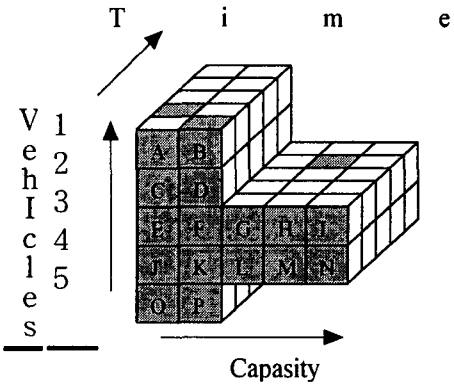
Abstract

The problem to be studied here is the minimization of the distance used for delivering a set of goods into each customer with vehicles. That is called VRP(Vehicle Routing Problem). The classical VRP involves a set of delivery cities to be serviced by a set of vehicles housed at a distribution center. There are many variations of the problem. The basic components of the problem are a fleet of vehicles with fixed capabilities(time, capacity, distance, etc.). The objective of the VRP is to develop a set of routes such that all delivery cities are serviced, the demands of the points assigned to each route does not violate the capacity of the vehicle which services the route, and the total distance by all vehicles is minimized. Vehicle routings must also satisfy a variety of constraints arising from factors such as fixed vehicle capacity, fixed operating time, and fixed number of vehicles.

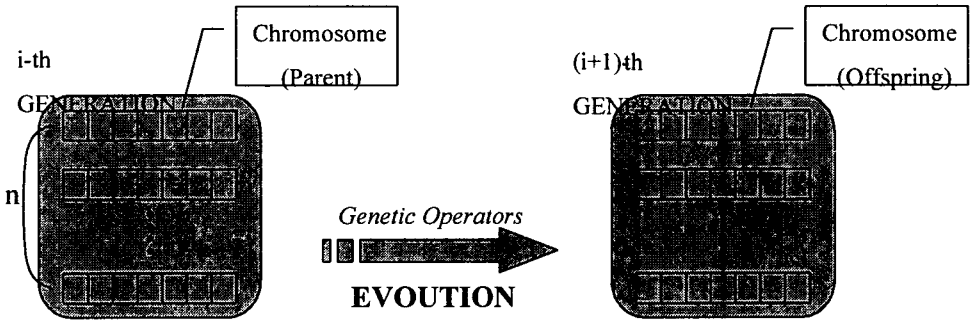
VRPTW(Vehicle Routing Problem with Time Windows) is more complex as it involves servicing customers with time windows using multiple vehicles. So each vehicle must visit a city at time interval [earliest time, latest time]. The constraints of the problem require the vehicles to service the customers while not overloading and to visit the customers after the earliest service time and before the latest service time. A vehicle waiting time happens if one arrives at a customer location before the earliest service time and has to wait until the customer is ready for service. On the contrary a vehicle that arrives at a customer after the latest service time is considered to



[Figure 1] Cubic Chromosome

be tardy. The objective of the VRPTW is to obtain a feasible solution while minimizing the number of vehicles and the distance traveled by the vehicles. In this paper GA(Genetic Algorithm) which is modified to solve the VRPTW(Vehicle Routing Problems with Time Window) is presented.

Recently, GAs(Genetic Algorithms) have been widely reckoned as a useful vehicle for obtaining high quality or even optimal solutions for a broad range of combinatorial optimization problems. GAs have been deeply investigated in the last decade as a possible method for solving optimization and combinatorial problems. GA was invented by John Holland in the 1960s and was developed by Holland and his students and colleagues at the University of Michigan in the 1960s and the 1970s. The idea of GA is to evolve a population of candidate solutions to a given problem, using genetic operators, crossover and mutation, inspired by natural genetic variation and natural selection at each generation. During evolving each chromosome has a fitness value associated with it and a set of the best fit chromosomes from each generation survive into next generation. A schematic diagram of the basic structure of a genetic algorithm is shown in figure 2.



[Figure 2] Schematic diagram of GA

Unlike classical GA, the chromosome of the proposed GA has the new structure that is the 3-dimension like figure 1. It is called 'Cubic-GA'. The new suggested Cubic-GA in this paper means the 2-D GA including GLS(Genetic Local Search) algorithms. Besides, the chromosome consistes of several building blocks which have the high flexibility that others do not have. We mapped the X-axis to the capacity of vehicle, the Y-axis to the number of vehicles and the Z-axis to time window for VRPTW. The Cubic-GA in this paper means the 2-D GA including GLS(Genetic Local Search) algorithms.

A few of researchers have studied VRPTW using GA. But they assumed homogeneous fleet. There are no works VRPTW with heterogeneous fleet using GA. We proposed GAs(Genetic Algorithms) which have the cubic-chromosome for VRPTW with heterogeneous vehicles. The algorithm was coded in Visual C and the experiments were executed on a PentiumII with Solomon's instances.