Vehicle Routing Problem Using Genetic Algorithm

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***Abstract*—In this proposal, I will talk about a kind of application of evolution algorithm, vehicle routing problem. First, I will start from my motivation. Then, I will introduce the definition of vehicle routing problem, and show the reason to use genetic algorithm to solve the vehicle routing problems. Finally, I will temporary**

I. INTRODUCTION

In NTHU, there are many school buses that pick students up to Humanities and Social Sciences Building (HSS) or TSMC Building (TSMC), vice versa. During peak hour, the buses come every five minutes.

For my personal experience, since buses come every five minutes, and most of the students go to the station 10 to 15 minutes before the class starts, it always happens that some of the students cannot arrive at the class on time due to limited capacity of the bus. Besides making students go to station earlier, increase the capacity of the bus or decrease the average time the buses pick up students are possible way to deal with this problem. Then, how much capacity should the bus increase or how short should the average time picking up students can be evaluated by vehicle routing problem (VRP), which will be talked about later.

II. VEHICLE ROUTING PROBLEM DEFINITION

Vehicle routing problem (VRP) is a problem which was first introduced by George Dantzig and John Ramser in 1959. Its motivation is to find out what is the optimal set of routes for a fleet of vehicles to traverse in order to deliver to a given set of customers.

The description of VRP will be: given a depot with M vehicles (v_1, v_2, … , v_M), each vehicle v_i has capacity Q_i. There are N customers (c_1, c_2 … c_n), each has demand D_i. To emulate VRP, there must have costs or time spent between a vehicle v_i and a customer c_j. What we need to do is to use these vehicles to satisfy all customers' requirements. According to the constraints, we may skip some customers' requirements to reach the optimal solution. Fig. 1 is a solution to a VRP.

VRP can be apply on multiple situation. For example, 1) bus or airline scheduling. 2) Letters or newspaper transmission. 3) Product transportation, and so on. According to its application, the goal of VRP can be 1) to minimize the cost of the total transportation, 2) to minimize the number of vehicles used to satisfy the needs of customers, 3) to maximize the profit. Generally, There are three types of VRP: 1) VRP with one starting point and one end point, both of which are identical. 2) VRP with one starting point and one end point, both of which are different. 3) VRP with multiple starting points and end points.

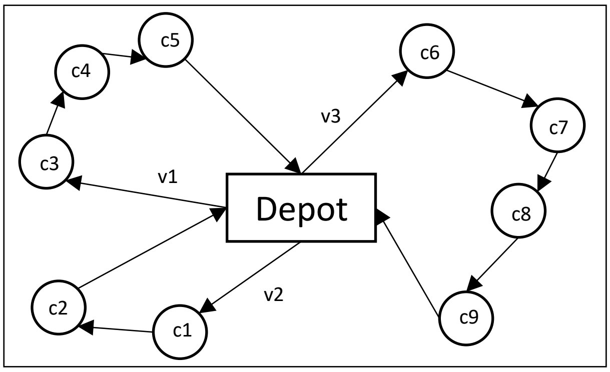

Fig. 1 A kind to solution to VRP.

III. REASONS TO USE GENETIC ALGORITHM

As the description, the travelling salesman problem (TSP) is a variation of VRP by allowing to use only one vehicle (the salesman), make the demands of all customers to be zero and the capacity to be ∞. Because TSP is a NP-hard problem and TSP can convert into VRP in polynomial time, VRP is also a NP-hard problem. Since VRP is a NP-hard problem, if using brute-force method or other deterministic algorithm, it will take exponential time to do so. Thus, using some heuristic algorithms to get near-optimal solution is preferable.

There are many kinds of number-optimization algorithm in evolution algorithm (EA) such as genetic algorithm (GA), evolution strategy (ES). In this term project, I'll use GA to solve VRP. GA is an algorithm used in optimization, and since there is a permutation representation, I can use permutation to represent a solution to VRP because it is based on a graph. Then, by defining the fitness and constraints, I think it's possible to solve VRP by permutation-based GA.

IV. DESIGNS OF THE PROBLEM AND GA

To deal with the problem of NTHU buses, I assume that every bus has limited capacity Q, and there are 10 stations s_1, s_2, …, s_{10}. For each station s_i, there are n_i students waiting for the bus. Then, I assume that the start station and end station are both s_1, which stands for the north main gate station. The goal is to satisfy all stations and minimize the time spent.

As for GA design, I will use order-based GA with generational population model. All strategies of crossover and mutation will be tried to find out which has the highest solution quality. As for the selection operators, I will use tournament selection for both parent selection and survivor selection for convenience. If there is enough time, I'll spend more time to expend this question, such as making the capacity of every bus different or make every station has students that want to arrive that station and students that want to leave.