Review Paper on Multi-Depot Vehicle Routing Problem

Harnoor Kaur

Abstract- The Multi-Depot Vehicle Routing Problem (MDVRP) is a generalization of classical Vehicle Routing Problem (VRP). MDVRP is a NP-hard problem which is more advantageous than VRP. MDVRP simultaneously determines the routes for several vehicles from multiple depots to a set of customers and then return to the same depot. The objective of this problem is to find the routes for vehicles to service all the customers at a minimal cost which is in terms of number of routes and total travel distance without violating the capacity and travel time constraints of the vehicles.

Keywords- Vehicle Routing Problem, Multi-Depot Vehicle Routing Problem, Nearest-neighbour function

1. INTRODUCTION

In the Single-Depot Vehicle Routing Problem (SDVRP), multiple vehicles leave from a single location (a "depot") and must return to that location after completing their assigned tours. The Multi-Depot Vehicle Routing Problem (MDVRP) is a generalization of SDVRP in which multiple vehicles start from multiple depots and return to their original depots at the end of their assigned tours. The objective in MDVRP is to minimize the sum of all tour lengths, and existing literature handles this problem with a variety of assumptions and constraints [1].

2. VEHICLE ROUTING PROBLEM

The vehicle routing problem (VRP) is a combinatorial optimization and integer programming problem seeking to service a number of customers with a fleet of vehicles. Proposed by Dantzig and Ramser in 1960, VRP is an important problem in the fields of transportation, distribution and logistics. Often the context is that of delivering goods located at a central depot to customers who have placed orders for such goods. Implicit is the goal of minimizing the cost of distributing the goods. Many methods have been developed for searching for good solutions to the problem, but for all but the smallest problems, finding global minimum for the cost function is computationally complex. Since the problem is related with only one depot, the VRP is also named as Single-depot VRP, [5] in which the vehicles leave the depot, serve customers assigned and upon completion of their routes return to the depot. Each customer is characterized by their own demand.

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The Vehicle Routing Problem (VRP) is a generic name given to a whole class of problems in which a set of routes for a fleet of vehicles based at one or several depots must be determined for a number of geographically dispersed cities or customers. The objective of the VRP is to deliver a set of customers with known demands on minimum-cost vehicle routes originating and terminating at a depot.

- Vehicle Routing Problem with Time Windows (VRPTW): The delivery locations have time windows within which the deliveries (or visits) must be made.
- Capacitated Vehicle Routing Problem (with or without Time Windows): CVRP or CVRPTW. The vehicles have limited carrying capacity of the goods that must be delivered.

Hence the vehicle routing problem can be defined as the problem of designing routes for delivery vehicles (of known capacities) which are to operate from a single depot to supply a set of customers with known locations and known demands for a certain commodity. Routes for the vehicles are designed to minimize some objective such as the total distance travelled. The VRP is a well known integer programming problem which falls into the category of NP Hard problem, meaning that the computational effort required solving this problem increases exponentially with the problem size.

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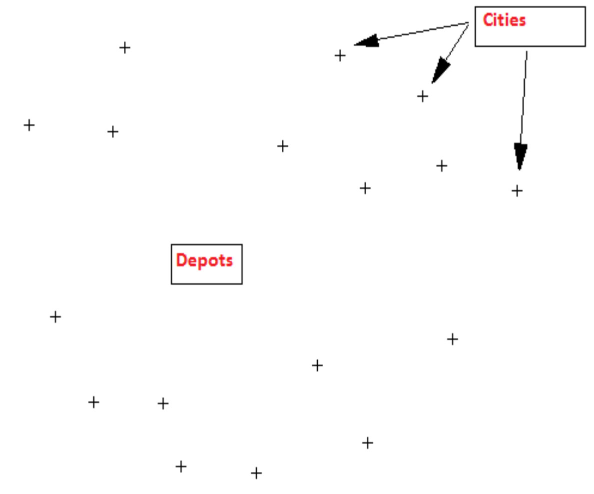

Figure 1: Consider the situation shown above where we have a depot surrounded by a number of cities who are to be supplied from the depot.

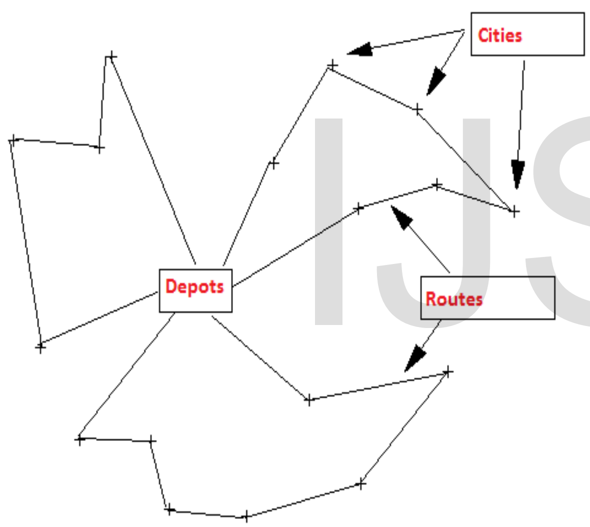

Figure 2: The depot manager faces the task of designing routes (such as those shown above) for his delivery vehicles and this problem of route design is known as the vehicle routing or vehicle scheduling problem.

The problem has attracted a lot of attention in the academic literature for two basic reasons:

- the problem appears in a large number of practical situations; and
- The problem is theoretically interesting and not at all easy to solve.

Traveling Salesman Problem is a VRP is an important optimization issue of many fields such as transportation, logistics and semiconductor industries and it is about finding a Hamiltonian path with minimum cost. To solve this problem, many researchers have proposed different approaches including metaheuristic methods [6]. A new combinatorial version of ABC algorithm is introduced for solving TSP. Experimental results show that this approach gives good solutions for the considered two examples of this NP-hard combinatorial optimization problem.

Travelling Salesman Problem (TSP) is a well known combinatorial optimization problem. Here, [2] the goal is to find a closed tour of minimal length connecting 'n' given cities or customer locations. Each city must be visited once and only once. Vehicle Routing Problem (VRP) is closely related to TSP because it consists of many TSPs with common start and end cities. In VRP, there is single depot (hence sometimes called single depot vehicle routing problem or SDVRP), and 'k' vehicles with capacity and distance restrictions. The objective is to find the minimum cost (overall travel distance) vehicle route so that:

a) every customer location is visited exactly once;
b) all vehicles routes begin and end at the depot;
c) vehicle capacity and distance restrictions are not violated.

3. MULTI-DEPOT VEHICLE ROUTING PROBLEM

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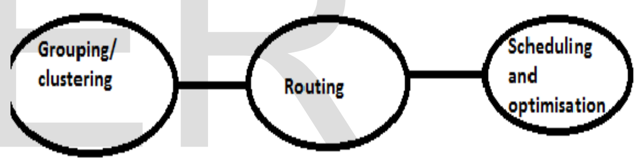

Figure 3: MDVRP Plan

In general, the objective of the MDVRP is to minimize the total delivery distance or time spent in serving all customers. Lesser the delivery time, higher the customer satisfaction. Fewer vehicles mean that the total operation cost is less, thus the objective can also be minimizing the number of vehicles. Though there may be several objectives, the aim of MDVRP is to increase the efficiency of delivery.

The Multi-Depot Vehicle Routing Problem (MDVRP) [1] is a generalization of the Single-Depot Vehicle Routing Problem (SDVRP) in which vehicle(s) start from multiple depots and return to their depots of origin at the end of their assigned tours. The traditional objective in MDVRP is to minimize the sum of all tour lengths, and existing literature handles this problem with a variety of assumptions and constraints.

Multi Depot Vehicle Routing Problem (MDVRP) implicates number of depots instead of only one. In the traditional approach it was considered that each vehicle is assigned same number of nodes, but in MDVRP same number of

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vehicles is assigned to each depot. In the former case i.e in VRP the results were poor thus this technique is accepted as this gives better results than VRP. In most of the real-life VRPs, demands at the customer nodes vary due to various factors, such as location and temporal seasonal factors. A network routing topology generated by solving min-max MDVRP results in a set of daisy-chain network configurations that minimize the maximum latency between a server and client. This can be advantageous in situations in which the server-client connection cost is high but the client-client connection cost is low.Vehicles should start from the depot and then return back to the depot after serving an ample amount of customers. Every customer has a demand which varies stochastically. Vehicles are assigned to the customers and one customer is served by only one vehicle. There are few considerations which should be kept in mind while implementing MDVRP.

1) Vehicle should start and end its route at the depot.

2) A customer is visited exactly once by the vehicle in each cluster.

3) Total cost to traverse the customers is minimized.

In traditional MDVRP attempt was made to reduce the total distance travelled whereas in this case attempt is being made to reduce the maximum distance travelled by the vehicle. This is done by making clusters based upon the distance of cluster from the depot. Number of routes should be equal to or less than the number of depots. More number of routes increase the number of vehicles required thus reducing the quality of solution. Customers are assigned to different routes. The distance is computed according to the following rule:

- If $D(c_i,A) < D(c_i,B)$, then customer c_i is assigned to depot A

- If $D(c_i,A) > D(c_i,B)$, then customer c_i is assigned to depot B

- If $D(c_i,A) = D(c_i,B)$, then customer c_i is assigned to a depot chosen arbitrarily between A and B.

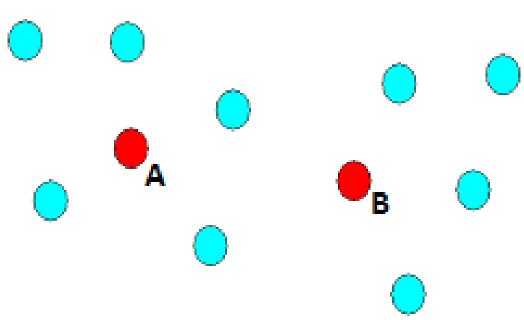

Figure 4.1: Random distribution of cities and depots

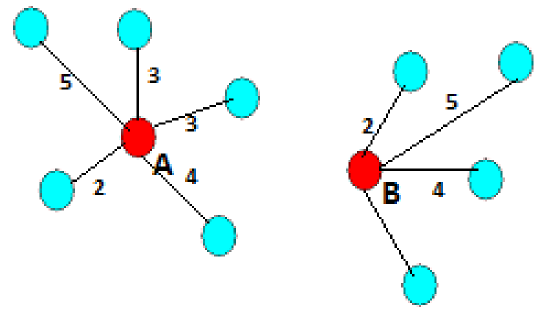

Figure 4.2: Assignment of cities to depots by computing distance using clustering technique

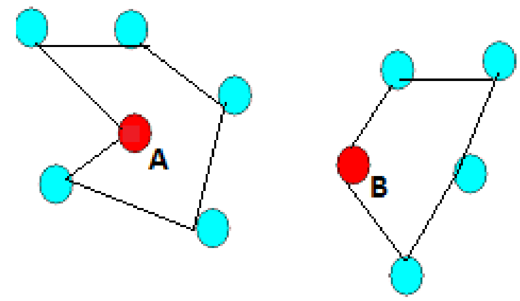

Figure 4.3: Routes formed by taking minimum distance as first choice.

In all the above figures MDVRP is shown and the goal is to visit all the cities by covering minimum distance. Here we cover it by calculating the distances from depots to cities.

Nearest neighbor function

1) Each customer/city is assigned to the nearest depot.

2) Routes are made by traversing the vehicles over the cities (initial solution is made).

3) Local improvement method is applied to the routes initially formed in order to get better results.

In the above diagrams this method is applied to find routes which occur at minimum distance from one another. Each depot serves a set of customers which are given to this depot based upon the distance from the depot. Here the numbers of vehicles are generally equal to the number of depots. The length of tour length generated by this method is comparable to the traditional approaches. This method is capable of processing thousands of customers in seconds, along with the property of a scalability which is becoming increasingly important as networks expand in size. **.** For example, consider a network model in which depots represent servers and customers represent clients. This can be advantageous in situations in which the server-client

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connection cost is high but the client-client connection cost is low.

4. CONCLUSION

The objective of the MDVRP problem is to find routes for vehicles to service all the customers at a minimal cost in terms of number of routes and total travel distance, without violating the capacity and travel time constraints of the vehicles. MDVRP is much more beneficial than VRP because here we have more than one number of depots to serve customers which is done in lesser time as compare to VRP; if time reduces then cost on delivery is also reduced. Travelling salesman problem that is VRP can be solved by many ways and much research has been done on solving VRP by various techniques or methods. Since MDVRP is basically to reduce distance i.e cost so effective techniques such as heuristic methods in swarm intelligence should be taken instead of exact methods like branch and bound method or computational complexities which are not suitable to obtain optimal solutions. Future work includes the use of heuristic search methods which will give optimal solutions to the MDVRP.

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