SOLVING THE MULTI DEPOT VEHICLE ROUTING PROBLEM WITH ASSIGNMENT ALGORITHM

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ABSTRACT
The Vehicle Routing Problem (VRP) involves the design of a set of minimum cost vehicle routes, originating and terminating at a central depot, for a fleet of vehicles that services a set of customers with known demands. This study contains some information about Logistics and Supply Chain Management. In the second part Distribution Management, which is a more related subject with Vehicle Routing, has been explained in a detailed way. The last part of the study contains cluster-first-route-second heuristics for the Multi Depot Vehicle Routing Problem (MDVRP). For this problem has been constructed an assignment algorithm and this algorithm has been solved by LINGO.
Keywords: Assignment algorithm, Distribution Management, MDVRP, VRP.

1. INTRODUCTION

A supply chain is a complex logistics system in which raw materials are converted into finished products and then distributed to the final users (consumers or companies). It includes suppliers, manufacturing centers, warehouses and retail outlets [1].

The twelve categories we define are in supply chain management these are: location, transportation and logistics, inventory and forecasting, marketing and channel restructuring, sourcing and supplier management, information and electronic mediated environments, product design and new product introduction, service and after sales support, reverse logistics and green issues, outsourcing and strategic alliances, metrics and incentives, global issues.

The transportation and logistics category encompasses all issues related to the flow of goods through the supply chain, including transportation, warehousing, and material handling.

This category includes many of the current trends in transportation management including vehicle routing, dynamic fleet management with global positioning systems, and merge-in-transit. Also included are topics in warehousing and distribution such as cross docking and materials handling technologies for sorting, storing, and retrieving products. Because of globalization and the spread of outsourced logistics, this category has received much attention in recent years [2].

The Vehicle Routing Problem (VRP) is a key to efficient transportation management and supply-chain coordination. In broad terms, it deals with the optimal assignment of a set of transportation orders to a fleet of vehicles, and the sequencing of stops for each vehicle [3].

The most elementary version of the vehicle routing problem is the capacitated vehicle routing problem (CVRP) where n customers must be served from a unique depot, each customer asks for a quantity q, while the vehicles have a capacity Q. Since the vehicles' capacities are limited, they must periodically return to the depot for refilling. Therefore a CVRP solution is a collection of tours, where each

customer is visited only once and the total quantity delivered in a tour is at most Q [4].
Whereas the VRP has been studied widely, the MDVRP has attracted less attention. In the MDVRP, customers must be serviced by one of several depots. As with the VRP, each vehicle must leave and return to the same depot and the fleet size at each depot must range between a specified minimum and maximum. The MDVRP is NP-hard, therefore, the development of heuristic algorithms for this problem class is of primary interest.
The MDVRP can be viewed as a clustering problem in the sense that the output is a set of vehicle schedules clustered by depot. This interpretation suggests a class of approach that clusters customers and then schedules the vehicles over each cluster. The MDVRP can be solved in two stages: first, customers must be allocated (assigned) to depots; then routes must be built that link customers assigned to the same depot. Ideally, it is more efficient to deal with the two steps simultaneously. When faced with larger problems, however, this approach is no longer tractable computationally. A reasonable approach would be to divide the problem into as many sub-problems as there are depots and to solve each sub-problem separately [5].

2. SOLUTION METHODS FOR MDVRP

The MDVRP problem can be formulated as a mixed integer linear program. It can be shown that exact methods are suitable for problems of limited size only. Heuristics seem to offer the best way to find good solutions to this large NP-hard problem. One commonly used technique for solving the MDVRP is a two-phase approach; the customers are first allocated to their nearest depots and then for each depot the VRP is solved. Refinements are usually added to improve the obtained solutions. It is developed a composite heuristic where a slight deterioration in the objective function is allowed in their one-point move procedure. Refinements are also added. Some researchers use diversification and intensification in the implementation of their tabu search method [6].
It is worth to note that the assignment problem and the routing problem in the "cluster first route second" approach are not independent. A bad assignment solution will result in routes of higher total cost(distance) than with a better assignment.
All the assignment algorithms described in the following sections assign customers to depots so that the capacity of the depots is not exceeded. Due to the lack of documentation about solutions for the assignment problem, the methods we are about to describe are all, in some sense, adaptations of more or less well known heuristic solutions for the VRP and. These methods are: a) assignment through urgencies, b) cyclic assignment, c) assignment by clusters and d) assignment using the Transport Problem. The algorithms use different measures for the assignment of a customer to a depot. A general description of all the assignment algorithms is the following
Until all customers have been assigned to the depots
determine the next customer to be assigned to a depot taking into account restrictions like the demand of the customers and the capacity of the depot [5]. The heuristics found in the literature can be roughly categorized into three groups: simple heuristics that attempt to solve the whole problem simultaneously, and heuristics that first assign customers to depots, and then solve a classical VRP problem for each depot in a second stage. For single-depot VRP s, the savings method is one of the best fast heuristics available. Several authors have adapted this method to multi-depot VRP s. The simplest two-stage procedure assigns each customer to the closest depot, and then solves a VRP for each depot. The probably best methods for the MDVRP to date are Tabu Search (TS) metaheuristics [7].

3. METHODOLOGY OF APPROACH

In the study, optimum route in a distribution network of a company in Turkey has been investigated. In this network, there were three depots and fourteen demand points. The main goal of the model was to meet the demands of fourteen distribution centers from three depots, using the shortest path, and consequently with a minimum cost, under some constraints. The type of the vehicle routing problem which has been solved here is multi depot vehicle routing problem.

In the model, it is assumed that depots have a limited capacity and amounts of the load demanded by distribution centers are stable in the investigated period. Altough the vehicles which use the routes of the same depot have a constant capacity, capacities of the vehicles that use the routes belonging to different depots may be different from each other. Total amount of demands of the customers which are assigned to the route of a vehicle can't exceed the capacity of the vehicle. Also, total amount demanded by fourteen customers mustn't be higher than the total capacity of three depots. Each vehicle has to return to the same depot which was its starting point. There is no vehicle tour between three depots. In addition to these, any one of the demand points is permitted to receive goods from more than one vehicle belonging to different depots unless demand of it can be met by one depot in an optimum route. This property can be seen in split delivery vehicle routing problems. But only one vehicle is allowed to visit a demand point from one depot. The total amount that will be transferred into a distribution center from vehicles of different depots must be at least equal to the demand of distibution center.

A two level approach has been used here in order to determine the optimum route of the distribution network. At first level, taking into account the capacities of the depots, demands of the customers and trasportation costs between depots and customers, an assignment model has been solved. According to the assignments as a result of this solution, fourteen demand points were seperated into groups around different depots. By this way, the problem has been transformed into a classic vehicle routing probem that has unique depot. At second level, classic vehicle routing problem has been solved for each depot. LINGO has been used in these solutions. Capacities of the depots, demands of distribution centers, and calculated values of transportation costs between depots and distribution centers are seen below:

Table 1. Capacities of the depots, demands of distribution centers

CAPACITY	1000000	4000000	3000000	Unit
Erzurum	6125	7285	4385	70000
Trabzon	5415	6725	3825	50000
Diyarbakır	6825	7115	4560	140000
Sivas	4465	5115	2215	130000
Adana	4695	4480	2450	80000
Kayseri	3860	4335	1595	150000
Konya	3340	2730	1290	260000
Antalya	3620	2225	2725	310000
Manisa	2645	180	2810	200000
Denizli	3245	1120	2390	250000
Samsun	3685	4995	2095	530000
Balıkesir	1970	865	2665	610000
Bursa	1215	1610	1910	540000
Adapazarı	740	2400	1525	620000
	İstanbul	**İzmir**	**Ankara**	DEMAND

Solving the model above by LINGO, distribution centers that would be assigned for the depots and amounts of loads that would be sent to the assigned distribution centers from depots have been determined. These results are seen below.

In the model depot in Izmir has a capacity of 4000000 unit and according to the results of assignment model, it meets demands of distribution centers in Manisa(200000), Antalya (310000), Denizli(250000), Bursa(160000), Balikesir(610000). In fact total demand of Bursa is 540000, but larger amount of demand must be met by depot in İstanbul in order to be able to complete the distribution with a minimum cost. Depot in Istanbul is closer to Bursa than depot in Izmir, so demand of Bursa must be met from depot in İstanbul as much as possible and remaining amount of demand can be met by depot in Izmir. Capacity of the vehicle which make distributions in this network is 700000unit. Problem for Izmir network that is described here is solved by LINGO and here are the results: There are three vehicle and accordingly three route in the network. This is the minimum number we can reach under current constraints. First vehicle travels its route which is composed of Izmir-Manisa-Bursa-Izmir. Second vehicle in the second route visits Izmir-Denizli-Antalya-Izmir in order. When total distance taken by three vehicle in this work is calcuated, it is seen that the value of the objective function which gives the minimum distance is 940 km.

Capacity of the depot in Ankara is 3000000 and the cities assigned to its distribution network and demands of these cities are Konya(260000), Adana(80000), Diyarbakir(140000), Erzurum(70000), Trabzon(50000), Sivas(130000), Kayseri(150000), Samsun(530000). When the problem is solved by the same way as the previous one, minimum number of routes is calculated as three again. Routes and visiting order of the cities in the routes are like this: Ankara-Konya-Adana-Ankara; Ankara-Kayseri-Sivas-Trabzon-Erzurum- Diyarbakir-Ankara; Ankara-Samsun-Ankara. Capacity of the vehicle sent from Ankara is 550000 unit

Depot in Istanbul has a capacity of 1000000 and it must serve to Adapazari and Bursa whose demands are 620000 and 380000. According to the solution two route must be followed in this network. These routes are: Istanbul-Adapazari-Istanbul and Istanbul-Bursa-Istanbul. Capacity of the vehicle is 700000 unit. Total distance taken by vehicles is 655 km. Here if the capacity of depot had been larger than 1000000 unit, all of the demand of Bursa could have been met by the depot in Istanbul and this would be more economic for the whole system.

4. CONCLUSION

In this paper, we have considered the multi-depot vehicle routing problem (MDVRP). In the study, optimum route in a distribution network of a company in Turkey has been investigated.A two level approach has been used here in order to determine the optimum route of the distribution network. At first level, taking into account the capacities of the depots, demands of the customers and trasportation costs between depots and customers, an assignment model has been solved. According to the assignments as a result of this solution, fourteen demand points were seperated into groups around different depots. By this way, the problem has been transformed into a classic vehicle routing probem that has unique depot. At second level, classic vehicle routing problem has been solved for each depot. LINGO has been used in these solutions.

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