

A Heuristic Solution of Vehicle Routing Problem for the Distribution of Perishable Goods

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ABSTRACT: A vehicle routing problem for the distribution of perishable goods. In this problem, the perish ability represents a critical factor. This particular problem is formulated as a vehicle routing problem where the travel-times between two locations depends on both the distance and the time and Scatter Search Algorithm is used to solve the problem. The classical Solomon's R1 instance is used to obtain the customer coordinates and demand. The VRP definition states that m vehicles initially located at a depot are to deliver discrete quantities of goods to n customers. The solution of the classical VRP problem is a set of routes which all begin and end in the depot, and which satisfies the constraint that all the customers are served only once. Each arc has an associated cost. Each customer location vertex has an associated number of goods to be delivered. Each vehicle has its own capacity and cost associated with its utilization. An increase in the time results in reduction of the quality of the perishable goods

KEYWORDS: Vehicle Routing Problems, Algorithms, customer coordinates.

I. INTRODUCTION

The vehicle routing problem (VRP) is a well-known problem studied by researchers in Operations Research and it deals with distribution of goods from a depot to a set of customers in a given time period by a fleet of vehicles. The vehicle routing problem (VRP) dates back to the end of the fifties of the last century when Dantzig and Ramzer set the mathematical programming formulation and algorithmic approach to solve the problem of delivering gasoline to service stations. The objectives of VRP are maximization of customer's satisfaction grade, minimization of fleet size, distance minimization and waiting time minimization by incorporating the capacity constraint. In the VRP, the road network is represented by a graph with arc and vertices. VRP is NP hard combinatorial optimization problem that can be exactly solved only for small instances of the problem. Although the heuristic approach does not guarantee optimality, it yields best results in practice. The majority of the real world problems are often much more complex than the classical VRP. Therefore in practice, the classical VRP problem by constraints, such as vehicle capacity or time interval in which each customer has to be served, revealing the Capacitated Vehicle Routing Problem (CVRP) and the Vehicle Routing Problem with Time Windows (VRPTW). The capacitated VRP (CVRP) is a problem in which all customer demand must be satisfied, all demands are known, and all vehicles have identical capacity and are based at a central depot. The objective of CVRP is to minimize total transportation cost or time.

II. LITERATURE SURVEY

Amponsah and Salhi (2004) presented an efficient heuristic for the routing problem of the collection of garbage. They considered it as a capacitated arc routing problem (CARP) and minimize the environmental effect due to the smell of the garbage and total collection cost in a bi-objective model.

Braysay (2001) showed that changing the initial customers and using different functions for the evaluation of the insertion costs of the customers (insertion cost represents the additional cost of the route when a new customer is inserted into it) in a sequential constructive heuristic that solves a classical VRPTW, yields much better solutions.

Betner, Bauer, Obermair and Morgenstern (2001) presented a TSP in which they have considered a zone in the city centre with traffic jams in the afternoon and showed how simulated annealing and threshold-accepting algorithms are able to handle such time-dependent problems.

Bogataj and Vodopivec (2005) studied the effects of perturbations in a supply chain (production or distribution part) on the stability of perishable goods in order to keep the product at the required level of quality and quantity for the final delivery.

Faulin (2003) presented the implementation of the mixed algorithm procedure that uses heuristic and exact subroutines in the solution of VRP having specific constraints related to companies in the agribusiness field.

Gendreau, Laporte and Seguin (1996) presented routing problems with stochastic travel-times. The purpose of this review articles is to provide a summary of the scientific literature on stochastic vehicle routing problems.

III. PROBLEM DESCRIPTION

A vehicle routing problem “A vehicle routing algorithm for the distribution of fresh vegetables and similar perishable food” by Ana Osvold and LidijaZadnikStirn for the distribution of fresh vegetables is selected. In this problem, the perish ability represents a critical factor. This particular problem is formulated as a vehicle routing problem with time windows and time-dependent travel-times (VRPTWTD) where the travel-times between two locations depends on both the distance and the time. The difficulty in preserving the nutritional characteristics of fresh food-stuffs during transportation presents a direct problem to food distributors where the perish ability of the product requires it to be handled in ways not necessarily conducive to the traditional view of cost effective distribution activities. The prime objective is to reduce the distance travelled and time taken. An increase in the time results in reduction of the quality of the perishable good.

IV. SCATTER SEARCH

Scatter Search derives its formulation from earlier strategies for combing decision rules and constraints, with the goal of enabling a solution procedure based on the combined elements to yield better solutions than one based only on the original elements. The approach was motivated by the supposition that information about the relative desirability of alternative choices is captured in different forms by different rules, and that this information can be exploited more effectively when integrated by means of a combination mechanism than when treated by the standard strategy of selecting different rules one at a time, in isolation from each other.

A. BASIC SCATTER SEARCH FRAMEWORK

1. Diversification generation - build a set P of P size diverse solutions.
2. Improvement method - apply an improvement heuristic to the solutions in P
3. Update - select the b1 best solutions in P and b2 solutions in P for diversity
4. Set new solutions = true
While (new solutions)
{
New solutions = false
}
5. Subset generation - create the subsets of reference solutions to be combined
6. Solution combination - apply the combination method to all subsets of solutions generated in the previous step and add the new trail solutions to pool
7. Improvement method - apply an improvement heuristic to the solutions in pool
8. Reset updating – update reset with b solutions in reset pool
If (reset changed) set new solutions = true

V. CASE STUDY/IMPLEMENTATION SCATTER SEARCH

Scatter search (SS) is an evolutionary meta-heuristic that has demonstrated merit in the solution of discrete optimization problems. The concepts and basic principles of SS were proposed by Glover 1977, based on strategies to combine decision rules and restriction. Laguna and Marti (2003) and Marti et al. (2006) are relevant SS references where interested readers will find details on basic and advanced SS designs.

The basic algorithm SS consists of the following 5 methods:

Method 1: A set of initial solutions are built by diversification generation method

Method 2: An improvement method is applied to modify trail solutions

Method 3: High quality and highly diverse solutions are chosen by a reference set update method.

Method 4: A subset generation method determines which subsets of reference solutions will serve as the basis for creating new solutions.

Method 5: New solutions are generated by a solution combination method



VI. ILLUSTRATION

In this selected vehicle routing problem the prime objective is to reduce the distance travelled and time taken. An increase in the time results in reduction of the quality of the perishable good.

The model selected to solve the vehicle routing problem is scatter search algorithm.

A. CONVENTIONAL METHOD

The conventional method is applied on the sequence that yielded optimum output. The array P ranges are 1 to 100. The new diversified solution is formed by combining different subsequence. The new diversified sequence is defined by the following expressions.

5,15,25,8,35,45,55,3,65,75,85,6,95,4,14,24,10,34,44,54,7,64,74,84,94,2,13,23,33,9,43,53,63,1,73,83,11,93,12,22,32,42,52,62,72,16,82,92,17,18,21,31,41,19,51,61,71,20,81,91,30,40,26,50,60,70,27,80,90,100,28,29,39,49,59,69,79,89,36,99,37,38,48,58,68,78,88,98,46,47,57,67,77,56,87,97,66,76,86,96.

Vehicle (1) starts from the depot and serves 12 customers. Each customer is associated with specified demands and the maximum demand for each vehicle is said to be 160. Associated distance is calculated for the fleet of vehicle. This criterion is applied to the remaining vehicles.

Vehicle(1)= 5,15,25,8,35,45,55,3,65,75,85,6	Distance= 509.02km	Total demand=154
Vehicle(2)=95,4,14,24,10,34,44,54,7,64	Distance= 312.76km	Total demand=153
Vehicle(3)= 74,84,94,2,13,23,33,9,43,53,63,1	Distance= 382.42km	Total demand=154
Vehicle(4)= 73,83,11,93,12,22,32,42,52,62,72,16	Distance= 534.86km	Total demand=160
Vehicle(5)= 82,92,17,18,21,31,41,19,51,61,71,20,81,91,30	Distance= 485.05km	Total demand=155
Vehicle(6)=40,26,50,60,70,27,80,90	Distance= 264.4km	Total demand=156
Vehicle(7)=100,28,29,39,49,59,69,79,89	Distance= 241.49km	Total demand=159
Vehicle(8)= 36,99,37,38,48,58,68,78,88,98,46,47	Distance= 428.1km	Total demand=159
Vehicle(9)=57,67,77,56,87,97,66,76	Distance= 388.82km	Total demand=130
Vehicle(10)=86,96	Distance= 44.02km	Total demand=61

Total distance = 3590.94
Time taken = 89.77 hrs



B. SCATTER SEARCH METHOD

Result obtained by scatter search method on the sequence.

5,15,25,8,35,45,55,3,65,75,85,6,95,4,14,24,10,34,44,54,7,64,74,84,94,2,13,23,33,9,43,53,63,1,73,83,11,93,12,22,32,42, 52,62,72,16,82,92,17,18,21,31,41,19,51,61,71,20,81,91,30,40,26,50,60,70,27,80,90,100,28,29,39,49,59,69,79,89,36,99, 37,38,48,58,68,78,88,98,46,47,57,67,77,56,87,97,66,76,86,96.

Vehicle (1) starts from the depot and serves 12 customers. Each customer is associated with specified demands and the maximum demand for each vehicle is said to be 160. Associated distance is calculated for the fleet of vehicle.

Vehicle(1)=5,15,25,8,35,45,55,3,65,75	Distance= 450.2954km	Total demand=126
Vehicle(2)=85,6,95,4,14,24,10,34,44	Distance= 314.629km	Total demand=154
Vehicle(3)=54,7,64,74,84,94,2,13,23,33,9	Distance= 328.99km	Total demand=160
Vehicle(4)= 43,53,63,1,73,83,12,93,11,22,32,42	Distance= 486.634km	Total demand=160
Vehicle(5)= 52,62,72,16,82,92,17,18,21,31,41	Distance= 315.217km	Total demand=147
Vehicle(6)= 19,51,61,71,20,81,91,30,40,26,50,60,70	Distance= 429.28km	Total demand=159
Vehicle(7)=27,80,90,100,28,29,39,49,59	Distance= 323.876km	Total demand=156
Vehicle(8)=69,79,89,36,99,37,38,48,58	Distance= 248.534km	Total demand= 136
Vehicle(9)=68,78,88,98,46,47,57,67,77,56	Distance= 301.302km	Total demand=138
Vehicle(10)=87,97,66,76,86,96	Distance= 274.302km	Total demand=126

TOTAL DISTANCE = 3198.7659
TIME TAKEN = 79.969hrs

VII. CONCLUSION

Scatter search algorithm is used to obtain the desired optimum solution in the selected VRP model. SS is an evolutionary meta-heuristic that has demonstrated merit in the solution of discrete optimization problems. It is observed that the proposed scatter search algorithm performed well on number of test problems. It is noteworthy that Scatter Search algorithm yields better solutions for the large number of instances.



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