A SIMULATED ANNEALING APPROACH TO SOLVE A VEHICLE ROUTING PROBLEM IN A FMCG COMPANY

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ABSTRACT

Fast Moving Consumer Goods [FMCG] are the goods that are sold quickly and are low in cost. The companies dealing with the delivery services of FMCG need to deliver the goods keeping in mind logistics costs and customer satisfaction (pertaining to on-time delivery). They have to even deal with additional constraints such as time slots where the goods are delivered to the customers within the prescribed time slots by the company. Thus vehicle scheduling needs to be done in an efficient manner. When more than one delivery vehicle is used for the problem set, the problem becomes non-polynomial. These problems are called Vehicle Routing Problems with Time Slots (VRPTS). A simple explanation of Vehicle Routing Problem (VRP) is that the delivery trucks have to cover a geographically dispersed customer set using optimal routes while satisfying constraints such as vehicle capacity and the customer demands. Vehicle routing problem is used to cover a set of customers, by finding a set of routes, starting and ending at a depot that together covers a set of customers. There are many algorithms to solve a VRP each having their own advantages and limitations. Most of the algorithms are heuristics. Heuristic methods are quick and provide the user with near optimal solutions and optimization that give a solution which is not guaranteed to be optimal. Solving a VRP to be exact optimal is too exhaustive, hence the algorithms used for VRP are heuristics and they give us a solution that is near optimal in a quick time.

Key words: Transfer of Property Act, Section 92, Subrogation, Mortgage, Repayment, and Loan.

http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=8&IType=11

1. INTRODUCTION

Combinatorial methods for optimization problems are unmanageable as the number of objects become large. The Traveling sales man problem is a typical example of combinatorial
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optimization and is NP hard. For problems of these types, the simulated annealing algorithm is the practical algorithm to solve such problems. This Simulated annealing technique does not result into an optimum solution but in the presence of noisy data it yields good solution. Simulated annealing can be easily adopted to solve the traveling salesman problem. The main objective of the TSP is to minimize the distance traveled in touring the cities. The salesman can start from any city and pairwise trade with the cities so that the distance can be reduced with exchange of cities. The problem with this approach is that the SA easily finds the local optima but from there it cannot get to Global optima.

There are two tricks by which the Simulated annealing algorithm improves its strategy. Metropolis algorithm is the first trick by which some trades which does not reduce the distance between the tours is accepted (Metropolis et al. 1953). The second trick is, displayed by lowering the temperature which is similar to annealing of a metal. By lowering the temperature and after making many tour exchanges the bad trades can be minimized. When several times the temperature is lowered which is akin to quenching in annealing process there will be acceptance of good trades and it will result into the local minima of the cost function. The results are not sensitive when we apply the annealing schedules for lowering the temperature.

2. LITERATURE REVIEW
Vehicle Routing Problem (VRP) was introduced by Dantzig and Ramser [1]. VRP is one of Non-Polynomial hard problems; many improvements have been done on it over the years. Capacitated Vehicle Routing Problem (CVRP) is one of its kinds. It involves design of optimal delivery routes reaching out to different customers located at different locations, the constraint being the vehicle capacity [2]

CVRP can be solved using differed algorithms. These algorithms can be mainly classified as given under
- Constructive Heuristics,
- Local Improvement Heuristics,
- Meta Heuristics,
- Hybrid Meta Heuristics and
- Parallel and Cooperative Meta Heuristics.

A brief explanation of these heuristics is given below.

Constructive Heuristics otherwise called as greedy algorithms, gives more emphasis on obtaining a feasible solution rather than computational time. These algorithms are low on complexity, they iterate only after obtaining a feasible solution. Most common examples of these types of algorithms are Savings Algorithm (Clarke and Wright, Holmes and Parker), Sweep Algorithm and so on.

Local Improvement Heuristics: These algorithms are used to optimize the solution obtained by using other algorithms i.e. they are mainly used for post optimization of the solutions obtained. Examples of Local Improvement Heuristics are 2-opt, 3-opt and k-opt methods.

Meta Heuristics: These are heuristics guiding other Heuristics. They function using two different type of searches, one is the local search and other is the population search. An effective search is made in case of a local search and moved on to the next step after ensuring
a strong solution in the neighborhood. Simulated annealing technique and Tabu search are two algorithms that use this principle. Population search is a method of maintaining a pool of good solution (parent solutions) and then they are combine together to give better results (offspring). Genetic algorithm works on this principle. These algorithms are very high in complexity.

**Hybrid Meta Heuristics:** They are combinations of different Meta heuristics. Recently more of the research is going on in the field of Meta heuristics and Hybrid Meta heuristics and even these algorithms are high on complexity. Thus, to meet the requirements for the delivery of FMCG constructive heuristics have been found to be most suitable as they ensure low complexity, low computational time and medium accuracy [3]. Some exact algorithms have also been proposed but they have been found inadequate for solving problems consisting of large customer sets [4]. Famous constructive heuristics are Clarke and Wright Savings algorithm [5], Sweep Algorithm [6] and the Cluster First and Route Second Fisher and Jaikumar [7] algorithm, Holmes and Parker algorithm [8] and a popular local improvement heuristic is K-Opt Exchange method [9]. Among the heuristics, which were low on complexity and computational time, the constructive heuristics (or the greedy heuristics) fits the requirements of company dealing with FMCG goods [3].

3. ALGORITHM BASED ON SA

Step1 The starting point is defined by  $\mu(0)$, $\alpha$ is set as the termination criterion. A high value is assigned to $T$, $n$ is the number of iterations to be performed at a particular temperature, and set $t=0$.

Step2 $\mu(t+1) = N(\mu(t))$ is defined as the neighboring point. In the neighborhood is created usually, a random point.

Step3 $\Delta t = (\Delta t(\emptyset^\wedge((t+1)) - \tau(\emptyset^\wedge(t))) < 0$, set $t = t + 1$; Else create a random number ($r$) in the range $(0,1)$. If Else go to step2.

Step4 If $|\emptyset^\wedge((t+1)) - \emptyset^\wedge(t)| < \alpha$ and as $T$ becomes small, Terminate the solution; Else if ($t \mod n) = 0$ then reduce $T$ according to a cooling schedule go to step 2;

4. IMPLEMENTATION OF ALGORITHM

The data for TSP shown in Table 1. has been tested with simulated annealing algorithm on MATLAB Version 2016. The data of FMSCG has been collected in Bangalore. The distance between the various locations of Bangalore has been recorded in terms of latitude and longitude. In this algorithms the different results have been displayed taking the various temperature.

<table>
<thead>
<tr>
<th>Customer No.</th>
<th>X-Co-ordinate</th>
<th>Y-Co-ordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depot</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>45</td>
<td>68</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
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</tr>
<tr>
<td>10</td>
<td>35</td>
<td>66</td>
</tr>
</tbody>
</table>
5. RESULTS
The Simulated annealing performs better at temperature of 100 deg. The demand of all 50 Customers is optimally selected for the best route. The SA performs well at 100 deg compared to 95 deg and 120 deg. The shortest route solved thru simulated annealing has performed well in obtaining the desired results. The shortest route obtained at different temperatures are given in Figure 1-3. Thus the authors want to reiterate that Simulated annealing best suits for such problems.

Figure 1 Results of TSP using SA Algorithm at Temperature 120 deg.

Figure 2 Results of TSP using SA Algorithm at temperature 100 deg.
Figure 3 Results of TSP using SA Algorithm at temperature 95 deg.

REFERENCES

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