ISSN: 2250–3676

[IJESAT] INTERNATIONAL JOURNAL OF ENGINEERING SCIENCE & ADVANCED TECHNOLOGY Volume-2, Issue-3, 760 – 764

DNA BASED COMPUTING FOR VEHICLE ROUTING PROBLEM WITH FUZZY DEMAND

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Abstract

VRP is one of the most challenging optimization task and this paper consider VRP with time window. The vehicle routing problem with time windows (VRPTW) is the type of the vehicle routing problem (VRP) with the additional time constraints. The objective of VRP with time window and fuzzy demand is to minimize the total distance covered by the vehicles and sum of lateness due to violation of time window at the customers. DNA based computing not only will put forward a new concept for VRP with time window for optimal path but also provide a practical opportunity for the theory of DNA computation.

Index Terms: *Vehicle Routing Problem, Time Window,fuzzy demand,DNA based computing*

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1. INTRODUCTION

The Vehicle Routing Problem (VRP) is the well known combinatorial optimization problem which requires the determination of an optimal set of routes used by a fleet of vehicles to serve a set of customers, taking into account various operational constraints.VRP was first introduced by Dantzig and Ramser[1] The vehicle routing problem consist of designing the optimal set of routes for vehicles in order to serve a given set of customers and concerned with:-

--Minimization of transportation cost dependent on distance travel

--Minimization of number of vehicles required to serve all the customers

--Balancing the routes for travel time and vehicle road. Vehicle routing problem belongs to the class of NP-hard problems and in simplest form it can be stated as follows

- There are number of vehicles, each with an identical capacity
- There is single depot, where each vehicle must start and end.
- There are number of customers, each in a different location.
- Each customer has a certain demand which has to be satisfied by a delivery from just one of the vehicle without exceeding capacity of the vehicle
- Each customer can only be visited by one vehicle.
- Each vehicle must visit number of customers, starting and finishing at depot.

Vehicle Routing Problem with Time Window (VRPTW) is an extension of normal VRP, encountered very frequently in making decision about the distribution of goods and services [2]. VRPTW can be divided into two categories: hard time windows and soft time window. Hard time window is that each task must be completed within the specific time. However, soft time window is that if a task cannot be completed within the specific time, given a punishment. The problem (VRPTW) addressed here can be described as the special problem of VRP, in which the routes must be designed in such a way that each point is visited only once by exactly one vehicle within a given time interval, all routes start and end at the depot. Since a lot of problems in the actual life can be modeled as VRPTW, such as postal service delivers, bank deliveries, school bus routing, the train or the bus schedule, whose handles the goodness and badness will have direct impact to the service quality arriving at enterprise. So this problem attracts a lot of focus.

In many environments, the information about demand at each customer is often not enough précised. For example as experienced, it can be said that demand of customer is “about 100 units”, “between 30 and 40 units”, etc. So here we develop fuzzy interference system that adopts fuzzy variables to deal with these subjective, ambiguous, vague and uncertain parameters.

DNA based computation is a form of computing which uses DNA, biochemistry and molecular biology. Adleman is often called the inventor of DNA computing. In 1994,Adleman[3] invented a method for solving a small instance of directed Hamiltonian path problem using DNA encoding. This paper gives new idea for DNA based computing.

2. PROBLEM CHARACTERISTICS

Vehicle routing problem with time window (VRPTW) is defined on a undirected network G=(N,A) with a node set N={1,2…n} and an edge set A . Node 1 is a depot and A'={2,3,,n} represent nodes(customers) to be visited.

The vehicle routing problem, for which the algorithm has been designed, is characterized as follows. From a depot goods must be delivered in given quantities to give customers. For the transportation of the goods a number of vehicles are available, each with a certain capacity with regard to the quantities. Every vehicle that is applied in the solution must cover a route, starting and ending at the depot, on which goods are delivered to one or more customers. The problem is to determine the allocation of the customers among routes, the sequence in which the customers shall be visited on a route, and which vehicle that shall cover a route.

Furthermore, the solution must satisfy the restrictions that every customer is visited exactly once, where the demanded quantities are delivered, and the total demand on every route must be within the vehicle's capacity and given time window.

3. FUZZY DEMAND MODULE

Zadeh[4] in 1965 proposed the fuzzy theory which can use the professional background and experience to generalize the type of the membership function, which makes models solution easier and flexible.

Real world situations are not often deterministic. Some cases that must be taken into account such as the imprecision or uncertainty concerning demand, location, distance, timing, travel time, etc. Fuzzy set theory has provided efficient and meaningful methodologies to formulate and solve mathematical programming and decision making problems of real world in easier way[5]. Fuzzy approaches have been applied to solve a some kinds of fuzzy vehicle routing problems. Dubois and Prade [7] first introduced the fuzzy shortest-path problem in 1980. This further has been investigated by other researchers and generalized to a variety of situations [8].

This paper deal with the vehicle routing problem that vehicles have finite capacities and demands of customers are uncertain.

Fuzzy demand module is developing to deal with uncertain demands of the customers. Fuzzy interference system is created which interprets the value of input, based on user defined rules and assign value to output. Using the GUI editors and viewers in the Fuzzy logic toolbox, the rule set, membership functions and the behavior of a fuzzy interference system is built, defined and analyzed respectively.

Demand is modeled using triangular fuzzy number (dmin d dmax) associated a membership function μA(x).
dmin and dmax are left and right boundary, that the demand will not be less than dmin or greater than dmax. Value of d corresponds to a grade of membership of 1.

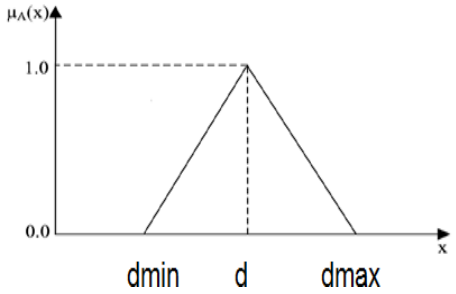

Fig.1 The fuzzy demand

4. DNA CONCEPT

Deoxyribo Nucleic Acid (DNA) is the primary genetic material that is propagated from generation to generation, and contains the instructions on how to build the proteins necessary for a particular organism. All genetic information is stored in the nucleotides of DNA. It is a double stranded sequence composed of four type of nucleotides containing the bases adenine (A), cytosine(C), guanine (G), and thymine (T).Each nucleotide-A, C, T, or G – can be considered a letter in a four-letter alphabet that is used to write our biological messages in a linear "ticker-tape" form. Each strand has, according to chemical convention, a 5' and a 3' end, thus any single strand has a natural orientation. The classical double helix of DNA is formed when two separate strands bond together.[10] Bonding occurs by the pairwise attraction of bases; A bonds with T and G bonds with C. The pairs (A,T) and (G,C) are therefore known as Watson-Crick complementary base pairs. Hence DNA is found to be a promising computing unit [9].

5. DNA BASED COMPUTING

Deoxyribo Nucleic Acid (DNA) is a hereditary material in all living organisms[8]. It contains genetic information that allows all living things to function, grow and reproduce. It was in

1994 that Adleman first used DNA, to solve a simple version of the "traveling salesman" problem. In this classic conundrum, the task is to find the most efficient path through several cities-given enough cities, the problem can challenge even a supercomputer. Adleman demonstrated that the billions of molecules in a drop of DNA contained raw computational power. The basic assumption of DNA based computing is that information is encoded in four nucleotides A,G,T,C of DNA. In order to fully explore the solution space of the defined vehicle routing problem, DNA based computing will be developed to utilize its global search capability. Detailed introduction on some important components of the developed computing are presented as follows:-

STEP 1:
Calculate the DNA savings for every pair (x,y) of demand points.
DNA saving can be calculated using formula,
$D(x, y) = d(x,1) + d(1,y) - d(x, y)$
Where,
D(x,y) = savings associated with adding edge (x,y) to a location sequence.
d = distance between n vertices
Process the savings list beginning with the descending order entry in the list (the largest D(x, y)).

STEP 2:
Information is stored in A,G,T,C of DNA as
A--neither x nor y assigned to route, new route is initiated including both x and y
G--exactly one of (x or y) is included in existing route and that point is not interior to that route, link(x,y)is added to same route
T--both x and y included in two different routes and
neither point is interior to its route then two routes are merged.
C--continue steps A,G,T till saving list D(x, y) has not been exhausted, otherwise stop and the solution of routing path is created.
Main working of DNA based computing is as per information stored in nucleotides of DNA.

STEP 3:
Any points that is not assigned to route during steps A,G,T,C must be serve by vehicle route that begins at the depot 1 visits the unassigned point and returns to depot 1.

The flow chart gives in short detail information of DNA based computing concept and also total execution.

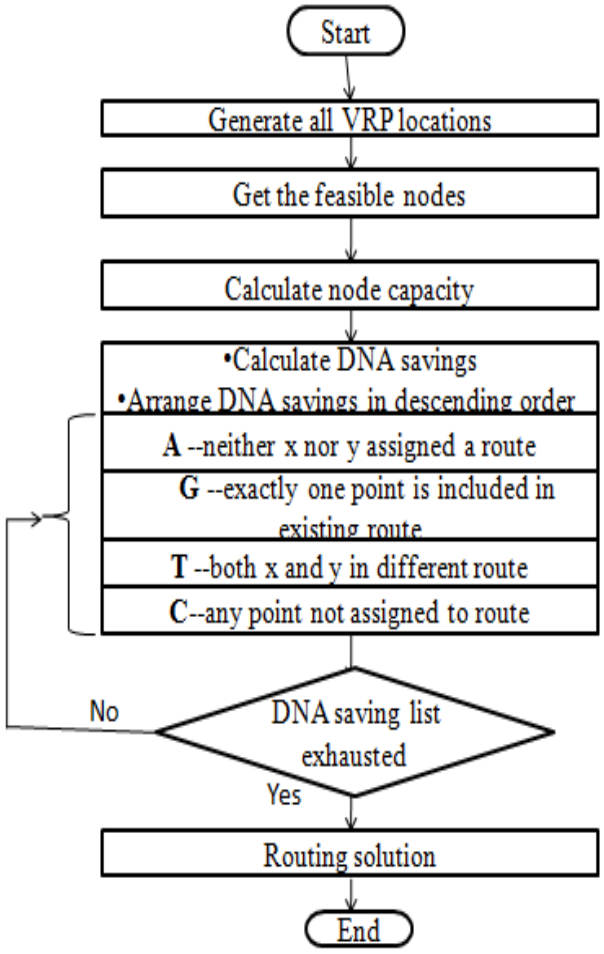

Fig. 2 Flow chart for DNA based computing

6. COMPUTATIONAL EXAMPLE

In this paper four VRP locations are considered, such as Maharashtra map, Jaipur map, Pench map and Sonega on map .Each map have different number of customers and one depot. Sonega on map is considered as an illustrative example. Firstly duration of time window and vehicle speed is set. Depending on speed of vehicle map showing customer nodes is generated. In Fig.1 which is showing Sonegaon map there are 46 customer nodes. These 46 customers are served within given time window 3 hrs. from/to depot by vehicles originated at depot. Vehicle capacity is 100 units. Demand for each customer is generated from fuzzy demand module. Location of depot and customer nodes are shown in Fig.3

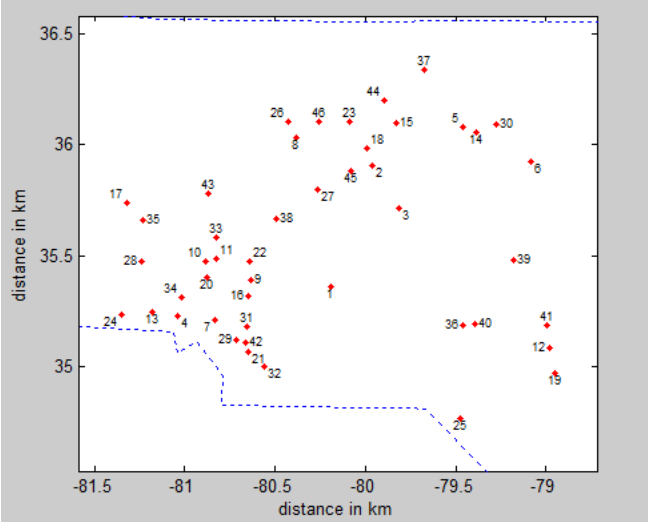

Fig. 3 Locations of depot and customer nodes

The best solution found by the proposed approach is illustrated in Fig. 4
Eight vehicles and each having capacity of 100 units served 46 customer nodes through:

Route 1: {depot, 4,44,15,31,6,39,42, depot}
Route 2: {depot, 5,24,11,33,22,27,9, depot}
Route 3: {depot,19,2,3,23,29, depot}
Route 4: {depot, 36,35,45,41,7,10, depot}
Route 5: {depot, 12,34,20,21,16,46,28, depot}
Route 6: {depot, 26,30,13,14, depot}
Route 7: {depot, 40,37,8,43,38, depot}
Route 8: {depot, 32,17,18,25, depot}

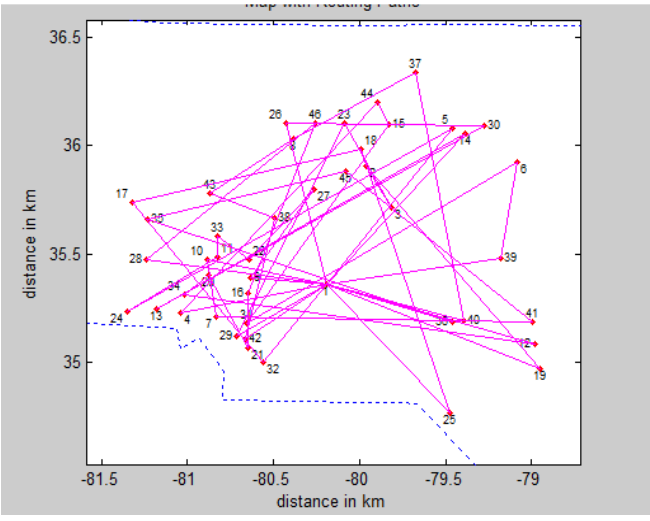

Fig. 4 Routes for solution

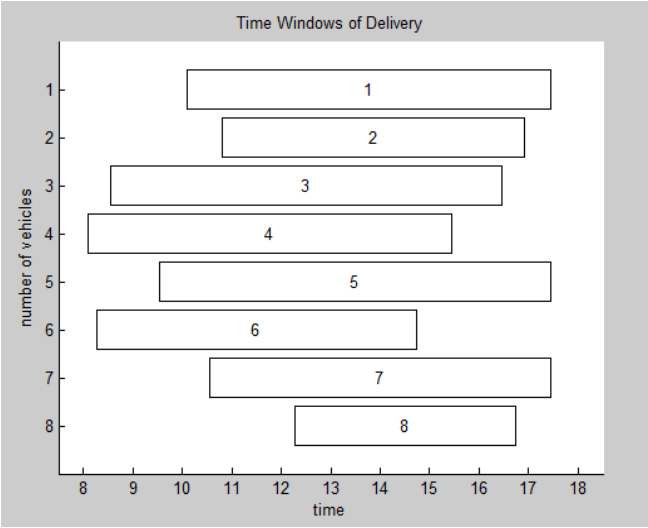

Fig.5 Time window=3hrs Vehicles=8

Fig.5 illustrate the distribution of time spend by each vehicle while serving the customers. Within the given time window vehicle covers all the customers.

CONCLUSIONS

Vehicle routing problem with time window is receiving lots of attention due to its applications in real life. This paper presents a different approach of DNA based computing for solving the VRPTW with fuzzy demands. The computational example shows that solution obtain by DNA computing is effectively fulfilling problem characteristics within given time window.
Further more advanced VRPs, such as Capacitated Vehicle routing problem and simultaneous pickup and delivery can also be solved using DNA based computing approach.

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BIOGRAPHIES

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