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Route Optimization by using Multiple Travelling Sales Person Problem in MANETs

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ABSTRACT
Finding the route between two mobile nodes is one of critical task in Mobile Adhoc Networks (MANETs). In this work mainly focusing on route optimization with nearest neighbour for Multiple Travelling Sales Person Problems (MTSP). MANET is a multi-hop wireless network with mobility feature like mobile phones, computers. Each node will be act as router and communicate without server concept. In the Travelling Sales Person Problem (TSP), all the possible number of routes to be found by a salesperson (Mobile Routing Agent) through cover every node and finally come back to starting point along with possible number of shortest paths. Mobile Routing Agent collects the node and its total information in the network like node position, neighbour node data and message agent (salesperson) helps during the data transmission. The main aim of the proposed concept is to obtain the optimum route between source and destination nodes. With MTSP, Provide acceptable solution to overall network congestion in terms of hop count and distance, the constant updates of the hops and choosing the best path over the network.

Keywords: MANET, TSP, MTSP, Nearest Neighbor Algorithms, Euclidean Distance

I. INTRODUCTION

A. Mobile Ad hoc NETworks

Collection of nodes with mobility feature to communicate each other through radio waves in Mobile Adhoc Networks (MANET). MANETs are also as infrastructure less network because these networks does not require any kind of fixed infrastructure in establishment of network. MANETs are decentralized network; there is no central node to control the remaining nodes. These kind of networks are more flexible and easy to install in many applications. Each node in node can move autonomously and freely and connect another node whose are in its communication range.

The major advantages of MANETs are [1]:

1. Decentralized network.
2. No specific routers required, because each node will act as route itself.
3. Network reconfiguration continuously.
4. Many number of number of nodes will be accommodating even if more number of nodes are adding to the network.
5. Network access from different locations easily and more flexibly.

Now a days, many number of routing algorithms proposed by researchers to achieve Quality of Service (QoS) in MANETs. Due to the dynamic nature of the network, it is complex task to provide quality data transfer between nodes. Due to demand in utilization of network services the quality of service of a network also be a playing a vital role in the finding performance. At service level characteristics of network during transmission data like delay, bandwidth, rate of data packet loss and cost.

To achieve the maximum utilization of the network resources, the strategy of Quality of Service (QoS) is find the various types of traffics in computing paths between nodes. Due to the node mobility, it is a

complex task to find paths with multiple constraints is a complex task and more research solutions is required to improve the performance of the network.

The main goals of QoS routing are:

1) Finding best path between source and destination based on the user constraints.
2) Minimize the network resource utilization
3) To find the avoidable things, which are effecting the performance of the network like congestion, path breaks over the network [2].

B. Travelling Salesperson Problem (TSP)

The traveling salesperson problem (TSP) one of the optimized solution in MANET routing between two nodes via intermediate nodes. This problem taken from a real life analogy. The request/ data packet sending from a depot (source node) and each customer (node). This method deal with optimally visiting customers from a depot to destination node. A very large number of papers and books deal with this problem [3][4].

Mainly two general characteristics of the specified problems are that each node has to service and that, accordingly, the service associated without value. Nevertheless, certain different problems suggest for select nodes based on a profit value that added when the visit arises.

There are many number of problems found optimum path with the help of Travelling Salesperson Problem with profit whenever a vehicle involved. Many common problems where numerous vehicles may be involved. Majorly concentrated on travelling sales person problems using profits with widely the variants also studied.

Majorly Travelling Sales Person(TSP) problem with profits may be comprehended bi-criteria TSPs couple of two contrasted objectives, first one is forceful the salesperson to visit(to find the profit) and the another one stirring to decrease the journey costs (with the right to drop vertices).

This paper describes as follows: In Section 2 (**Related work**), various types of approaches to solve TSPs discussed. In Section 3 (**MTSP in MANETS**), it describes the multiple travelling salesperson assumptions and routing assumptions. Section 4 (**Experiment Results**), brief about the result analysis of proposed MTSP concept. In Section 5 (**Conclusion**), it describes the future concentrations and conclusion of the work.

II. RELATED WORK

The main objective of this TSP problem is to find the optimum feasible solution for all travels. By using "brute force" method mathematicians solve this problem through verifying every possible path between source and destination and finalize the optimum path from those available paths [23] [24]. It is very difficult to find the optimum paths if many routes propagate. Selecting the optimum path at given point by using "greedy algorithm". Many number of applications of TSP is using frequently.

To solve the Travelling Sales Person Problem, several approaches are using as mentioned below:

- Heuristic approaches [5, 6]
- Ant colony optimizations [7, 8]
- Simulated annealing [9, 10]
- Genetic algorithms [11, 12]
- Neural networks [13]
- And many TSP variation specific methods.

However, these approaches are not guarantee to find the optimum solutions. Alternatively providing relatively good solutions for problems with the considerable time complexity. Finally, the possible minimization best solution will be obtain the reasonable time.

Previous solution approaches for TSP:

To find the optimum solutions for given weighted graph means find the shortest path using

Hamiltonian cycles (the least summation of edge weights to be consider). The main aim of the research work on Travelling Sales Person problem is to find the best solution with minimizing time and cost. These variety proposals are from normal heuristic algorithm to algorithms based on the physical workings of the human mind to those based on ant colonies. It researchers could not achieve the goals as because it is very complex one. However, algorithms trying to settle to achieve with two minor goals:

a. An accurate and fastest solution
b. To find better good solution.

An excellent answer is one this is near being most useful and the acceptable of these exact solutions is, of route, the highest quality solution itself.

Heuristic Algorithms

The word 'heuristic' means "A rule of thumb, simplification or educated guess that reduces or limits the search for solutions in domains that are difficult and poorly understood. Unlike algorithms, heuristics do not guarantee optimal, or even feasible, solutions and are often used with no theoretical guarantee." In contrast, an algorithm is defined as "a precise rule (or set of rules) specifying how to solve some problem." To combine into a heuristic algorithm, we would have something like "a set of rules specifying how to solve some problem by applying a simplification that reduces the amount of solutions checked".

An algorithm is collection various instruction steps to find the best solution for a problem through apply heuristic mechanisms with the all collection of possible solutions with optimistic manner.

Simulated Annealing

One of the cooling methods of physical things called simulated annealing. The main basic concept behind is that a cost function and temperature. In these MANETs the cost is defined as sum of weights of the edges in the diagram. At initially, one random solution is to be assume to the problem. As per the temperature and cost function, the variation (change) will be evaluated in the each iteration of the process. The variation will accepted if the cost function is decreases. The validation of cost function is the based on the cost function. If the cost function is not reduce of the initial solution the temperature will takes place whether the change is accepted or rejected. The variation may accepted for the better possibility of higher temperature. At the time being, there is no scope for change to occur excluding the cost function reducing when the temperature is decreases [9]. Many research works done to obtain within two units of feasible cost of problems upto the size of 100 [10].

Neural Networks

"A neural network (NN) is a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use. It resembles the brain in two respects:

1. The network through a learning process acquires knowledge.
2. Interneuron connection strengths known as synaptic weights are used to store the knowledge."

This neural network was formed with many number of independent units called as neurons along with connections. These weight-based connections are establish with "learning process". As per the sum of products of adjacent neurons and the weights of connection edges, every neuron finds a value. The Travelling Sales Person problem is apply by assumption with every neuron is assume as city. The process applied to find the distance between cities are by using various calculations [13].

Ant Colony Algorithm

This algorithm based on the simple searching mechanism in optimized manner to find food by group of ants (ant colony). However, all the ants form a systematic line from the origin to food store. If any ant found the food store, the path will be,

establish for all other ants. If the food is over or removed, ants will make trails for a period but will ultimately change in random fashion up to find the another food store. Whatever, the line formed by ant for food source assumed as optimal solution. So many mathematical calculations involved to find the optimal solution in this ant colony optimization or ant colony algorithm

Genetic Algorithms

The behind idea of genetic algorithm is the theory of evolution. Mostly, various random sets of parameters are apply to the concept and the value of fitness is to give back for each. The finest sets combined through the fitness values and all other sets applied repeatedly to the genetic algorithm until the finest optimal set of parameter values to apply. This outcome is usually the genetic algorithm divided into limited parts. Those are like evolution function and fitness function. A series of input bit values yields by the evolution function, after that requests for fitness function for a value of fitness for that string.

Whenever numerous string have been allotted fitness value, the evolution function proceeds with best strings, combines them together, at times tosses in a "mutation" to the strings, and then directs the effects back as novel input strings. This would treated as in biotic equivalence is to a genes of human. Generally, the input string called as a chromosome and the bits of string are to be mention as genes. The fitness function is to be evaluate to this genetic algorithm by taking in a string of inputs and runs them completes the process that being estimate. The function yields the fitness value based on the performance of inputs.

Through the lot of observations, to find the solution for TSPs through profit must outcome a not at all lesser result set, by means of a group of optimal solutions like that neither impartial to be enhanced deprived of failing the another one. The many number of the research people showing their interest in finding the solutions in single criterion format.

According to this either the dual objectives stand with weighted and shared linearly, or single objective is forced with a quantified certain value. To find the solutions, attempts made with bicriteria problems [6] [7], where called as multiobjective vending problem, nevertheless those methods involve the chronologically resolving single criterion kinds of the problem. However, many number of research outcomes handle with the another types of multicriteria TSPs[8].

Apart from that the researchers concentrates to introduce many number of techniques to minimize the congestion control using Ant Colony Optimization for MANETs.

This Travelling Sales Person problem is enhancement of Ant Colony Algorithm [14]. In the Ant Colony Algorithm, the entropy value updating as per the dynamic nature of initial ants and prevention of sluggishness attitude along with early conjunction with help of using distribution strategy.

Only one path will be considered and compared with among all possible paths, those are hypothetically deliver maximum speed and capable to discover innovative the movement level when the nodes are moved the positions frequently in the updated Ant Colony Algorithm [15].

In Meta heuristic range, an impressive novel Ant Colony Optimization technique applied to obtain the optimal solution [16]. It used to design the finest pattern of available paths.

In another different distributing process, the model using for ant system is establish on the criteria of the population of agents [17]. Each agent directed with an autocatalytic procedure engaged by materialistic strength. If the agent unaided then the autocatalytic procedure and materialistic strength will be finished the agent handling to a part of finest tour through the exponential rapidness.

A meta-heuristic novel Ant Colony Optimization is the extension of Ant Colony Algorithm is using the travelling sales person problem and routing applicable in the packet switch networks[18][19]. The various types of three following guidelines for this optimization technique is:

- ✓ The easiest type of ant system with simple properties.
- ✓ An Ant Net QOS applications implementation.

The implementation of combinational optimization problems.

III. MTSP in MANETs

A. Definition and Properties

For this assume G=(V,A) is the graph and V={ v_1, v_2,……v_n } with n vertices and A is arcs sets with directed profit or undirected profit edges.

The profit P_i is connected through every vertex $v_i \in V$ with initial $P_1=0$ and the distance C_{ij} will be accompanying with every edge or arc $(v_i, v_j) \in A$. The inference of customers on vertices and the expenditure of the travel and as given below. Initially vertex v_1 is assumed as source. Travelling Sales Persons is like simple track and every vertex should be travelled at most once in the journey and the total travel cost and the composed profit will be evaluated.

There is no specific condition for the distances between cities in travelling sales person with profits. In the reverse statement, the distances are to be fulfil trio dissimilarity and nonnegative. With this extends the graph is finish.

Mainly the travelling sales person with profits indicates that the travel is simple and basic thing stating that the profit is gain once at every vertex. With this hypothesis, establishing the fresh arcs when the optimal path between vertices with nonadjacent manner and apply to the total arc set in the tour. Here if any vertices other than the source are having negative or zero profit, those vertices will be eliminating from the vertex set when the all the specified all the conditions satisfied.

Here major three common issues arisen in travelling sales person with profits, based on the method the two issues are discussed:

1. Both issues are united in the independent role; minimized the cost of total travel minus collected profit is the entire tour cost.
2. The main objective of the cost in the entire tour stating that exploits composed profit, which cannot surpass a stipulated value C_{max}.
3. The main objective of the profit in the entire tour that reduces the journey cost which cannot lesser than a stipulated value P_{min}.

B. Multiple Travelling Salesperson Problem (MTSP)

Multiple Travelling Salesperson Problems (MTSP) are an extension of TSP in finding the optimum routing path between source and destination. This problem relates to accommodating real world problems where there is a need to account for more than one salesperson. The MTSP can be generalize to a wide variety of routing and scheduling problems.
The MTSP with ability constraint:

In the multiple travelling problems (MTSP), set of m salespersons and set of n cities. The following constraints to be follow by the salesperson in the MTSP problem is:

- ✓ Every salesperson should visit each every city from group of cities is main condition of MTSP.
- ✓ After visit, the every city the salesperson should reach the same started city.
- ✓ Each city must visited by salesperson is only once during the journey.
- ✓ In this problem, each city must be visited exactly once by only one salesperson and its objective is to find the minimum of total distances travelled by all the salespersons.

In proposed MTSP, a number of cities have to be visit by a salesperson who must return to the same city with the solution of shorter routes. A salesperson

travels around a given set of cities, and return to the beginning of the path (from where he started), covering the smallest total distance. The traveling sequence has to comply with a constraint that is the salesperson will start at a city, visit each city exactly once, and back to the start city. The resulting route should incur a minimum cost.

In solving, the problem one tries to construct the route in such a way that the total distance traveled by the salesperson is minimize. To solve the TSP, nearest neighbour method is used.

The nearest neighbour algorithm was one of the first algorithms used to determine a solution to the travelling salesperson problem. In this, the salesperson starts at a random city (or node) and repeatedly visits the nearest city (or node) until all have been visited once. Thus, it obtains a shorter tour, but usually not the optimal one. The nearest neighbour method is comparing the distribution of the distances that occur from data point to its nearest neighbour in a given data set with the randomly distributed data set [9].

C. Routing Algorithm

Routing is the path selection process from source to destination node. For routing between source and destination, point will be possible using of different types of routing algorithms. An ideal routing algorithm is one, which is able to send the packet data to its destination with minimum amount of delay. It must be adaptive and intelligent enough to make the decisions. The routing tables are every time updated by exchanging routing information between the routers.

For find the near neighbour using Euclidean distance method. To find the nearest neighbour of the corresponding node with the help of Euclidean distance formula. As per the Euclidean Distance formula, the distance between two points in the plane with coordinates (p, q) and (r, s) is given by Distance $((p, q), (r, s)) = \sqrt{(p - r)^2 + (q - s)^2}$

Very rarely this approach may fail in finding the shortest distance between nodes because of its "greedy" nature. However, this approach is the fastest and simplest nearest neighbour algorithm. Thus, there is a disadvantage of greedy strategy in this method, due to which some errors occur such as the optimal path obtained is not exactly the shortest path, time required to find the optimal path is more, etc [9].

The overall network information hold by the routing table of every node. The routing table kept neighbour node's information like distance, status of every node. A node will alive and be respond whenever the routing request received by itself from another node over the network along with neighbour node information.

The algorithm will works as follows [9]:

1. Choose a node as randomly, and call it as source node.
2. Find the neighbor node(s) along with the distance from the previous visited node if the path was available.
3. Choose the nearest (shortest) neighbor from the current node.
4. Repeat the 2nd and 3rd steps until all nodes visited by all nodes i.e reaches to the source node.

Based on this information found between the nodes, the routing table will be update every time. Because of the mobility feature, the routing table will be update whenever a node want to send data to another node by follow the nearest neighbor approach. It is typical task updating the routing table every time, but it a simple task finding the shortest path between source and destination from the network routing table.

D. Travelling Salesperson Problem with MTSP

The Travelling Sales Person problem is one of the popular and proved optimization technique. For this,

the enhancement of TSP is the Multiple Travelling Sales Person Problem (MTSP). Whenever more than one salesperson required to a problem, that time this concept will be rising. This MTSP majorly depends on only the selection of routing and time scheduling problems. MTSP is mainly focusing on complexity of routing issues and preferring the better feasible solution method.

Still, for all minor size problems, the MTSP found optimal solutions by using NP-Complete problem concept. The traditional feasible processes are unsatisfactory for this problem. To reach the maximum complexity of computation, better heuristic techniques will be using in the finding the solution of MTSP problems. Ant colony optimization techniques and genetic algorithms concepts are examples of recent heuristic techniques for the MTSP problem.

In the proposed MTSP problem, m number of salespersons (sources) and n nodes (call it as cities). Based on the travelling sales person problem, the sales person has to visit n+m-1 nodes through the m-1 nodes as like n+1, n+2, …. , n+m-1 nodes. To find the solution from multiple travelling sales person problem to normal travelling sales person problem is very difficult thing. However, the result will be extremely immoral.

The main aim of the multiple travelling sales person problem is to diminish the sum of travelling path weight count will called as smallest criterion. Sales persons has to select nearest cities from m-1 cities in the entire journey. Finally, the travelling sales person problem n-m+1 nodes to be left. For this the m-1 salesperson are to be visit one city during trip and one sales person wants to journey n+m-1 nodes. The outcome of the procedure is not upto the mark. The ability limitation is more suitable for practical problem in MTSP.

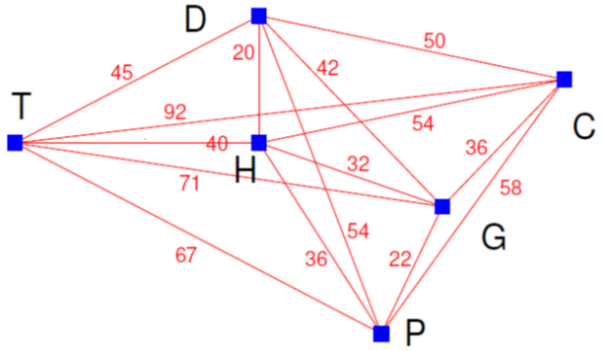

Figure 1. Mobile Nodes with Distance and outgoing transmission queue

Paths are, by which each salesperson completed his tour and path distances are.

To define the following variables and parameters of MTSP:

First calculate total path distance:

Formula for calculate:

$$\mathbf{tdi} = (\mathbf{ni} + \mathbf{li} + \mathbf{1}) * \mathbf{tdi} \ldots\ldots\ldots\ldots (1)$$

Where l_i is maximal number of cities salesperson i ($1 <= i <= M$) can travel, and n_i is the real number of cities the salesperson i ($1 <= i <= M$) has travelled, td_i is the total distance salesperson i ($1 <= i <= M$) has travelled, define the penalty function is if $n_i > l_i$.

Then calculate the minimum total distance (td_i) for each phase

$$\text{Min} \sum_{i=1}^{m} \text{tdi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Using Equation No (2) the minimum total path distance and path.

Single path for Travelling Sales Problem is a cyclic graph, which the total distance travelled over the network.

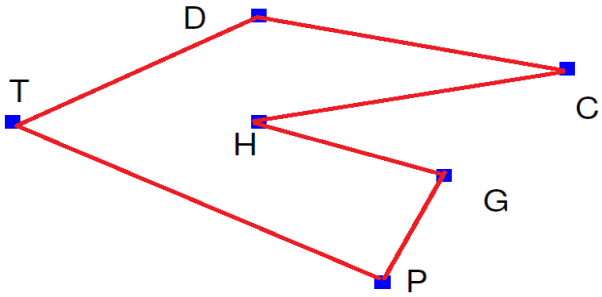

Figure 2. Single Path TSP path in Cyclic Graph

IV. EXPERIMENT RESULTS

The proposed MTSP algorithm implemented by using MATLAB on PIV @3.4GHz along with 4.00GB RAM. All the results compared with all variants of travelling sales person problems. In addition, these are designed for number of cities and evaluated with various types of medium, large and small space issues. Finally found optimal solutions and compared. Various main metrics are measured and compared with proposed algorithms which are end-to-end delay, throughput and control overhead of the network nodes. Thorough this, observed various success rates of final routes between source node and destination nodes. To determine the above mentioned performance metrics, chosen approximately 50 nodes. Via multiple travelling sales person problem along with Quality of service with route, repair concept carried out in networks to find the above mentioned performance metrics by changing the damaged nodes. If more number of cities are using in this proposed one the complexity of computation in $O(n^3)$.

V. CONCLUSION

A major challenging issue of MANETs in routing due to mobility of nodes in infrastructure less preinstalled multi-hop network. Many numbers of approaches were introduced, but suitable for few applications. In this paper, the multiple travelling sales person problem the congestion control by using total queue length in MANETs. In the proposed algorithm, the congestion control done in indirectly in the network by reducing the hop distance and queue length. This future work may investigate the results in network simulator for better output values with high network load. Furthermost, not entire the metrics would be specific to only one specific TSP and some system could be used to evaluate the best inputs for some of variable in subjective TSP.

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