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A Comparative Study of Sequential Algorithm and Shortcut Routing Algorithm on Multiple Travelling Salesman Problem

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Abstract — **Multiple Travelling Salesmen Problem is a complex problem that is to assign a route for the salesman who visits the city having difficulty in the congested roads. The existing Sequential Algorithm is used to select the best path and also manages time complexity in the application but this reduces performance of the salesmen by not providing path equally to the salesmen. So the paper shows how the Shortcut Routing (SR) algorithm provides the best result compare than present algorithm. The main purpose of this algorithm is to gain the solution and also satisfying the problem without doing any changes in the limitation of an application. The final result gives best path and also it reduces time complexity.**

Keywords* — *Multiple Travelling Salesman, Road Congestion, Shortcut routing, Sequential algorithm.

I. Introduction

Multiple travelling salesman problems are the well known problem. This can be applied in many fields that are minimizing usage of fuel in spacecraft, in design of global satellite system network and [5] stated that in many real world applications like computer wiring, overhauling gas turbine engine, order-picking problems. [5] Stated in other main applications are school bus routing, interview scheduling, missions planning. Multiple salesmen can also be used to solve the problem in road network. Nowadays congestion became a major problem, so choosing the correct path would make the company to save much fuel. [1] The waiting time gets increases when the vehicle gets stuck in a traffic jam.

There are many methods are used to assign automated traffic with the help of the scheduler for all the vehicles, which follow the routes of vehicles respectively and need to ensure there is no collision or deadlock will occur. But the condition is not same for all the roads that is some roads are smooth to ride and some have many hollow pits. If the salesman uses the same type of vehicle then it ends with congestion. [2] Stated the transport analysis issued by the officers of Indonesia stated that lots of feature affects the flow of traffic. One of the major features is the congestion level of the road. [2] So based on the condition of the road the vehicle type needs to be changed.

In the below sections of this paper, Shortcut Routing Algorithm is explained for MTSP and the comparison result is shown.

II. Multiple Travelling Salesman Problem

The MTSP have ‘b’ salesmen to visit a set of ‘k’ cities and each salesman has to start and reach the place where they have started. Each salesman must visit each city exactly only once that is named as sal, r varies from 1 to b. MTSP can also be defined as a problem of finding the ‘s’ closed circuit paths, given ‘k’ cities and ‘b’ salesmen, that helps to minimize the path lengths.[6] & [7] stated some of different types of MTSP are:

- *Multiple depots:*

If there exist multiple depots with a number of salesmen located at each, a salesman can return to any depot with the restriction that the initial number of salesmen at each depot remains the same after all the travel.

- *Single depot:*

All the salesmen start and end the tour at the same point

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- Number of salesmen:

The number of salesmen in the problem can be a fixed number.

- *Fixed charges:*

If the number of salesmen is a bounded variable, it usually fix cost based on the usage of each an every salesmen.

- *Time windows:*

The Time Windows means some cities must be visited within a specific period of time. [12] This extension of mTSP is referred to as multiple Traveling Salesman Problem with Time Windows (mTSPTW).

- *Other restrictions:*

These additional restrictions can consist of the maximum or minimum distance or travelling duration a salesman travels, or other special constraints.

Symmetric MTS (SMTSP) Problem and Asymmetric (AMTSP) is an another classification of MTS problem. [8] Defined SMTSP represents the cost of travel from node nodi to nodj is the same cost that charges to travel from nj to ni. This is a two-way path i.e. it's an undirected graph. [8] Defined AMTSP represents the cost of travel from nodi to nodj varies from the cost of travel from nodj to nodi. The MultipleTSP handles real world application problem that involves more than one salesman, specified a group of k cities and the distance between any two cities. [10] Assume there is 'b' salesman who starts from that city to visit the group of 'k' cities. Searching shortest journey for each salesman such that those city must be visited only once by one salesman and each salesman returns to the city where they all started.

III. Problem Definition Of Road Congestion

The vehicle routing problem in a MultipleTSP is a different case. [6] It includes fixed charges, time windows, single depot and multiple depots, it also has two paths that is open and closed path. The starting and ending point will be the same for closed path, but the open path does not need to return back to the ending point. The work gives solution to the problem of MTSP which allows salesmen to start from different place and end their trip at the original place. A set of 'k' nodes and 'b' salesmen located at each location is given, the starting position is different but needs to end in original depots the objective is to get the best path, so that each in-between node must be visited only once by a salesman.

Gr = (Ve, Ed, Wei,Con) be a connected graph, vertex Ve ={ve1,ve2,ve3,…..,ven} is a set of cities and Ed = {<ve_i,ve_j>|ve_i,ve_j€Ve, i≠j} is an edge set with a nonnegative cost matrix Wei={weiij| the weight of<vei,vej>} and condition matrix Con={conij|condition of<vei,vej>}.

The Shortcut algorithm is used to resolve the problem that displayed in the Fig.1. The problem will be solved by taking an account of Road condition as well as capacity based on the result the vehicles that allotted for salesman can travel in that path. Many accurate algorithms were developed to solve TSP one among that is proposed by [13].

IV. Problem Construction

The construction of MTSP is presented as a graph in this city is represented as nodes. [11] Connection between pair of cities denotes edges in a graph. In addition to the edge cost, the edge capacity is also taken into consideration to solve the

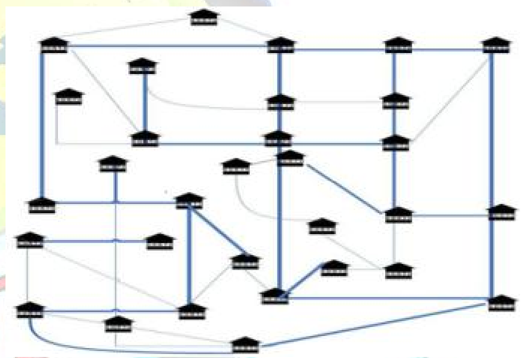

Fig 1. City Network

problem. Let Gr = (Ve, Ed, Wei, Con) be a connected un direct graph, where Ve = {ve1,ve2,……..ven} where k is set of nodes and Ed is the edges. The weight weii,j is associated with each edge and the condition coni,j is also associated with the edges.

The TS Problem is stated that a salesman has been sent to a trip by a company to meet many clients and that salesman needs to reach the original place. The problem in this statement is salesman need to reach the exact place, so to solve this problem assume that the level one salesman takes place the journey by using Airplane or Helicopter but another problem rises here is that level 2 salesman cannot travel in the same mode of transport service to visit some other city to solve these kind of problem the vehicle type has to be assigned for each an every level salesmen like Air, bus, two-wheeler service based on the road condition and capacity. Table 1 gives the clear view of the vehicle type also that used by the salesmen in those four levels. The need of vehicles may

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vary as based on the salesman involved in those levels. The types of vehicles are: vehi1, vehi2, vehi3 and vehi4. The vehicles get change by using the size, condition and capacity of the road and salesperson and vehicle. The vehicle is given directly to salesmen.

TABLE 1: List of Vehicles

Salesman	Level	Type of Vehicle	Vehicles
1	1	Vehi 1	1
4	2	Vehi 2	4
16	3	Vehi 3	16
64	4	Vehi 4	64

V. SHORT CUT ROUTING ALGORITHM

The shortest path given between the nodes in a graph is calculated in the form of simplest way with the given length of edges. [4]The Dijkstra's algorithm is implemented in many difficult problems especially to find the shortest path efficiently but the small drawback is it consumed more time for few applications. So to deal with this problem Shortcut Routing Algorithm is defined. The aim of this algorithm is to get the shortest path and minimize the time complexity by using different levels, [11] for ex the levels of roads are classified into lev1, lev2…levn. The address will be allocated to each city after giving weight to the nodes. For ex the level-one of a city is assigned with four digit integer in the form of thousands. Then those values will be incremented with hundred in level two and finally with one in level three based on this calculation the address will be allocated for each an every city and vehicles will also be assigned for the salesmen.

The level 1 vertex is the starting position of an algorithm. [4] Stated the level one of the salesmen will start their journey from the city that allocated for them and vehicles that assigned for those salespersons in the level-1 that is 'vehi1'. The vehicle Vehi-one will be handled by the salesman one. Here the Shortcut Routing Algorithm is applied to find the shortest path for the salesman. Now the algorithm loads graph Gr (Ve, Ed) and with the set of salesman that is Sal1, Sal2…Saln. The trip of the first salesman gets started from vertex Ver-1 that is the final destination for level one city. The salesmen have the similar ending point at different levels.

The salesman of level one will gives the details to the level two salesmen as the details was not allotted to all the levels so one cannot travel to another city. After receiving the details level2 salesman begins to search the shortest path. The salesman starts the trip with the help of a vehicle that allotted for them and the type of each vehicle varies based on the road condition. The SR Algorithm continues till the salesman travel through all the cities. The algorithm executes in different way for different levels. Thus the shortest path will be achieved by the salesman with the corresponding vehicle.

Algorithm : *Shortcut Routing Algorithm (SR)*

Load: Graph Gr = (Ve, Ed, Wei) with edge weights

1. Let Sal [r] be the set of salesman with R = 1, 2…k.

//Sal be the salesman array

2. Let Pro[r] be the set of processor with R = 1,2,…k

//Pro be the processor array

3. The adjacency matrix is portioned by Sal-vectors

//Partition the array of salesman

4. For each salesman r of k

//start the loop for each portioned salesman array

5. Values are allocated to the processor Pro[r]

6. Get the adjacency Matrix off or Pro[r] denoted by T

//get the values for P

7. For every vertex Ve in T

//read the vertices in T

8. Dista [srce] = 0

//Distance of source vertex is initially zero

9. A: =set of all node in T //

put the T vertex set to A

10. While A not empty

//the loop will get start, A is not empty

11. C = vertex in A with smallest distant dista [];

//find mini element from A named as 'c'

12. Take from A //remove 'c' from queue

13. for each neighbor ve of c.

//find the adjacent node of 'c'

14. Shpa = dista[c] + dista-between (c, ve) ;

//find the shortest path

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15. If shpa < dista[ve]:

16. Dista[ve]: = shpa;

17. Prev[ve]: = c;

18. Reduce-key ve in A;

19. End if

20. End for//end of for loop

21. Node is reported to T-vector

//result is sent to T

22. End for

//do shortcut routing for all r values of Pro

23. End while

//end while

24. Return dista;

//end

The algorithm makes use of shortcut algorithm technique suggested by [4], to find the shortest path. The SR involves allotting the adjacency vertex in T blocks with the assigned salesman to the vertex. First Salesman is situated in one vertex, second vertex is for second salesman, third vertex in for third salesman and so on. Each vertex set is located in the processor based on that salesman is allotted into different processor. The node nodi, nodj of every processor has same capacity. The node is reported into all the processor and the T-vector is updated.

VI. RESULT

The time complexity for four levels of cities are evaluated by using Sequential algorithm and displayed in Table 2. The computational issue of an existing algorithm for more number of cities is high in the series of O (n^3). Table 3 shows the computational complexity of the SR algorithm. The algorithm runs in 85 processor in the form of four nodes in each processor. From this time complexity is calculated and result is shown.

TABLE 2: Sequential Algorithm

Processor	Nodes	Sequential
1	4	64
1	12	1728
1	48	110592
1	192	7529536

TABLE 3: SR Algorithm

Processor	Nodes	Shortcut Routing
1	4	64
4	12	432
16	48	6912
64	192	117649

VII. DISCUSSION

The calculation time for Shortcut Routing algorithm is evaluated by $Ti_p \approx O(n^3/p)$, the complication is less when compared with Sequential algorithm. The existing algorithm runs sequentially by using one of the processor. Fig02 Displays the computational complexity with exponential structure. Fig.3 Shows the computational complexity of the SR algorithm with exponential structure. The comparison chart exhibited in the Fig.2 and Fig. 3 represents the complexity of Shortcut Routing Algorithm is less time consuming than Sequential Algorithm.

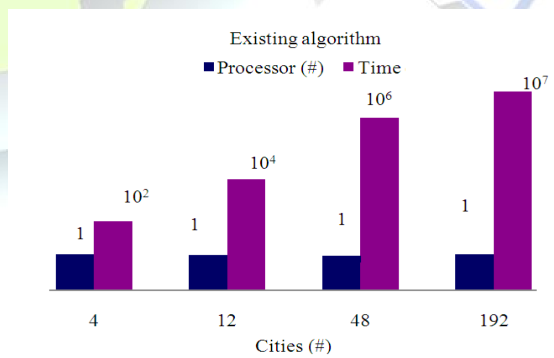

Fig 2. Performance of Sequential Algorithm

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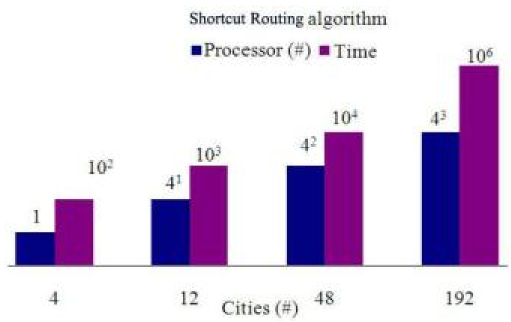

Fig 3. Performance of Shortcut Routing Algorithm

VIII CONCLUSION

The Multiple Travelling Salesmen problem is resolved by taking into account of road congestion and the solution to the problem is satisfied by comparing the Shortcut Routing Algorithm with the Sequential Algorithm. The merit of this algorithm is that reduced time complexities, but the road condition is also need to be considered, that is the similar type of vehicles are not to be used by the salesmen and different transport facilities have to be maintained for different roads. This helps to increases the better usage of vehicles. In future this SR algorithm can be applied for the many MTSP applications.

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