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Application of Graph Theory to Find Minimal Paths Between Two Places for the Transportation Problem

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Abstract: Graph theory is used for finding communities in networks. Graphs are used as device for modeling and description of real world network systems such are: transport, water, electricity, internet, work operations schemes in the process of production, construction, etc. Although the content of these schemes differ among themselves, but they have also common features and reflect certain items that are in the relation between each other. In this paper, we study on how graph theory can generate transportation problem using shortest path, we designed the solution for practical problem to find a Minimum Spanning Tree(MST) by using Kruskal's Algorithm and minimal path between two places and graph search Dijkstra's algorithm.
Keywords: Graph, Transport, Minimal path, Minimum Spanning Tree, Dijkstra's algorithm.

I. INTRODUCTION

Graph theory provides many useful applications in Operations research. Graph theory is the study of points and lines. In particular it involves the ways in which sets of points called nodes or vertices. It can be connected by lines called edges or arcs. Graphs in this context differ from the more familiar co-ordinates plot that portay mathematical relations and functions. In this paper for a given graph find a minimum cost to find the minimal path between two places. There are different path options to reach from Place A to Place B, but our aim is to find the minimal path with a minimum transportation costs, this requires a lot efforts.

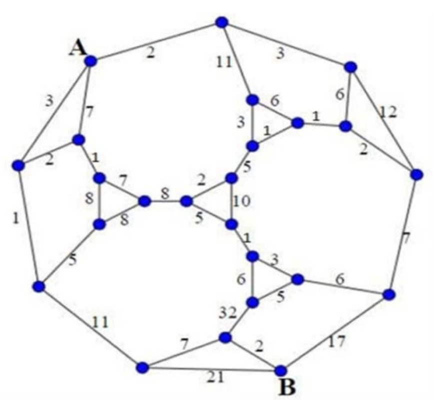

Figure 1 Connected graph

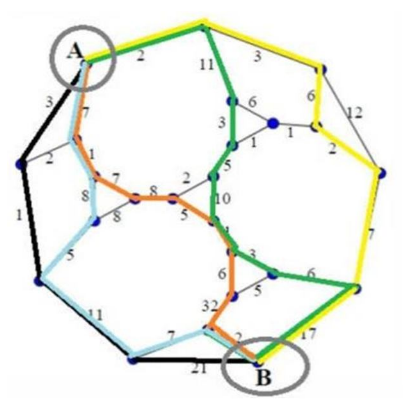

Figure 2 Some of the path option

II. GRAPH

1) Collection of points
2) Collection of lines
3) Points sets in non empty

In this paper for a given graph we find a minimal path of Transportation problem.

III. MINIMUM SPANNIG TREE (MST):

A minimum Spanning Tree(MST) is a subset of edges of a connected weighted undirected graph that connects all the vertices together with the minimum possible total edge weight. To derive an MST, Kruskal's algorithm can be used.

A. *Kruskal's Algorithm*

Let T = Empty Spanning Tree
E = Set of Edges
N = Number of nodes in graph

While T has fever then N-1 edges. { Remove an edge (v, w) of lowest cost (arc or edge) from E. If adding (v, w) to T would create a cycle then discard (v, w) to T}.

B. *Minimum Spanning tree by using Kruskal's Algorithm:*

In this paper the Minimum Spanning tree for the given case isdescribed by several figures given in the following.

Firstly are used all nodes of the given graph without arches, then we will start to put arcs in their place starting from the lowest cost (arc length 1) to the one with higher costs, but having in mind not to create cycles (Figure 3). This process continues by placing the second arc of length 2 (Figure 4).

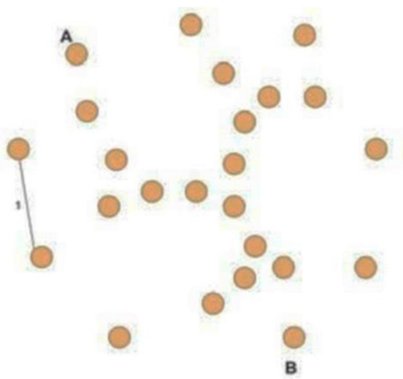

Figure 3

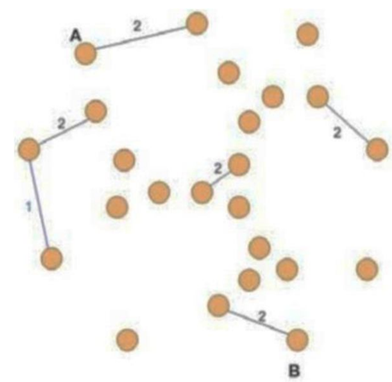

Figure 4

Arch of lower cost that comes after him with units 1 and 2 is the arc of length 3. Again we have processed in the same wayhaving in mind that we should not create cycles (Figure 5).

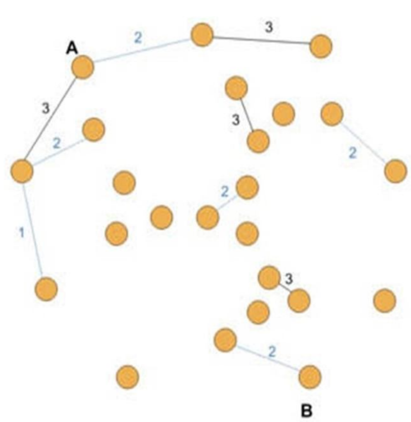

Figure 5

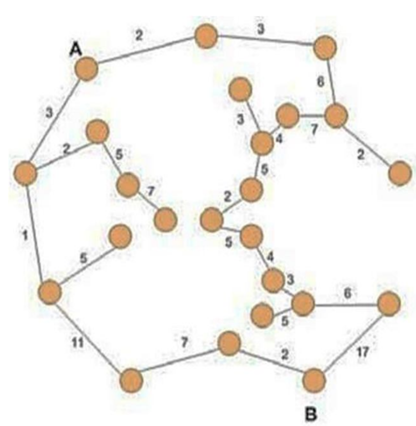

Figure 6

Applying this rule to all arches of the given Graph given, we have gained a minimum Spanning tree which is given in Figure 7. Arches which are removed from the graph are denoted by red colour, this happened because, because their deployment create cycles Figure 7.

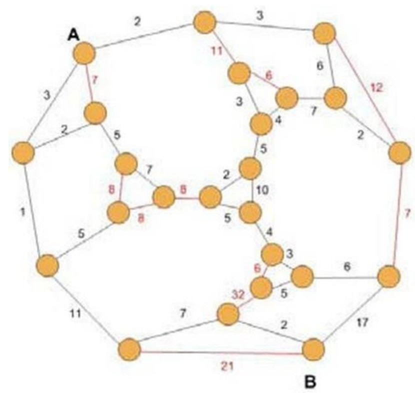

Figure 7

IV. MINIMUM COST PATH

The cost of a path in a costed graph is the sum of the cost of the edges that make up the path. The cheapest path between two places(nodes) is the path between them that has the low cost.

From the Minimum Spanning Tree shown in Figure 4 we are able to find the minimum cost path (trajectory) from node A to node B. As we can see from the Figure 5, there are two alternative ways to reach from Place (node) A to Place (node) B, which are distinguished by dash line.

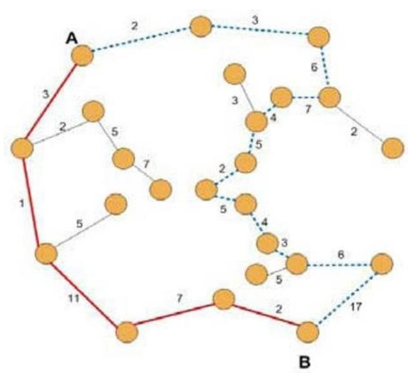

Figure 8

Let's start with first option to calculate the distance from Place A to Place B, the result is as follows:

$$\delta = 2+3+6+7+4+5+2+5+4+3+6+17 = 64 \text{ units}$$

For the second option (full line):

$$\delta = 3+1+11+7+2 = 24 \text{ units}$$

This means that the second option represents the minimumcost path from Place A to Place B.

V. DIJSKTRA'S ALGORITHM

Dijkstra's algorithm is the iterative algorithmic process to provide us with the minimal path from one specific starting node to all other nodes of a graph. It is different from the minimum spanning tree as the shortest distance among two vertices might not involve all the vertices of the graph.

By using Dijsktra's algorithm we are able to find the minimal distances (length of arc) from a place to all other nodes. Firstly, we start from the Place A, which is chosen as permanent Place(node). Analyzing the distances of the neighbourhoods Place(nodes) of the Place (node) A, we are able to find the minimal path to Place 2 (its distance is equal with 2). Afterwards Place 2 is chosen as permanent Place and we have to check the distances from Place 2 to the neighbour Places. To the each neighbour Place is added the length of the permanent Place.

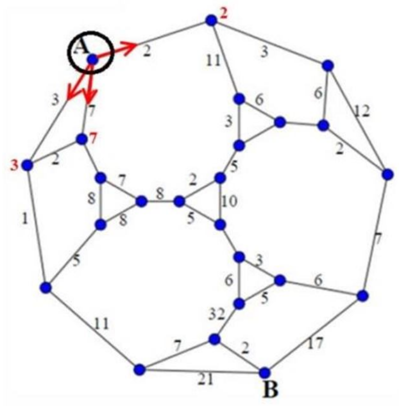

Figure 9. Minimum Path.

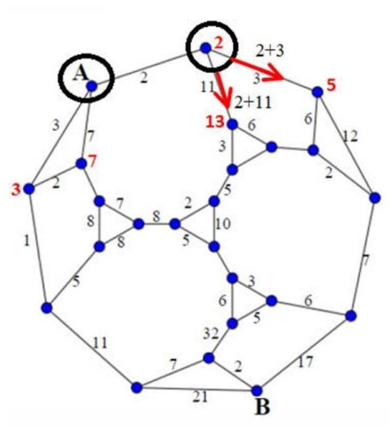

Figure 10 Minimum Path

Now is chosen the minimum distance from Place A. Minimum distance is chosen as permanent Place, since the 3+2 distance is shorter than 7, this means that distance 7 is not going to be considered anymore and we have to use the distance 5.

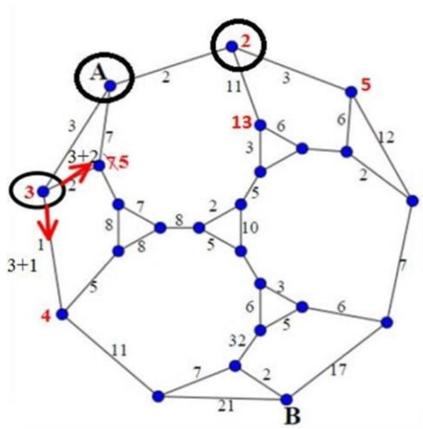

Figure 11 Minimum Path

Now is chosen the minimum distance from Place A. For this case the permanent node is chosen the minimum distance 4, this means that to all neighbour Place is added the distance of permanent node.

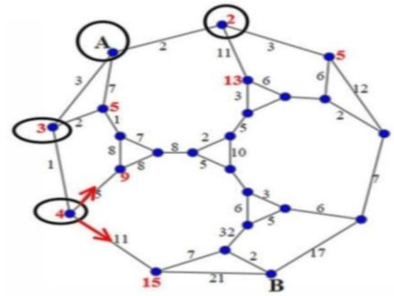

Figure 12. Minimum Path

This process is repeated for each node respectively.

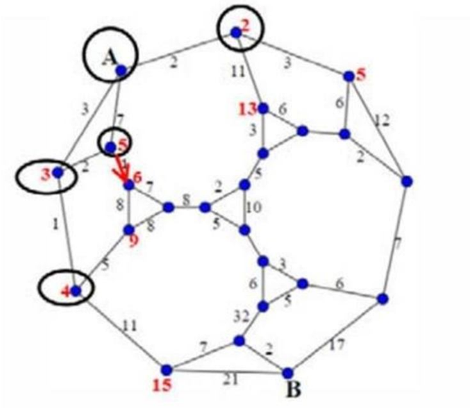

Figure 13

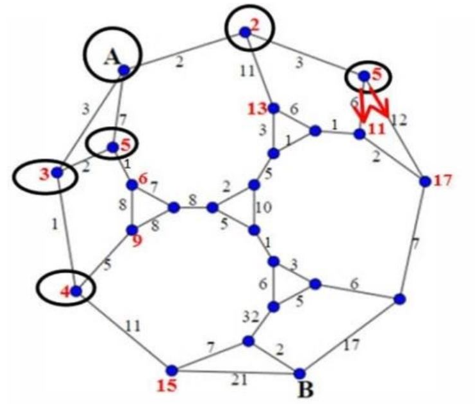

Figure 14

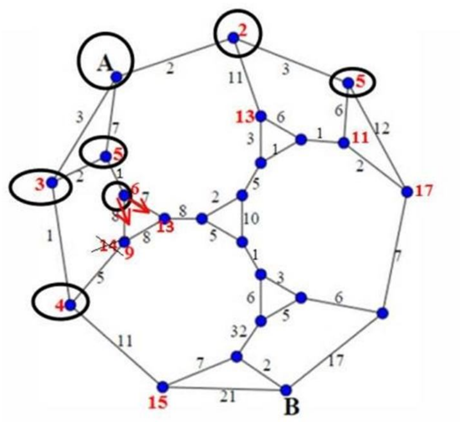

Figure 15

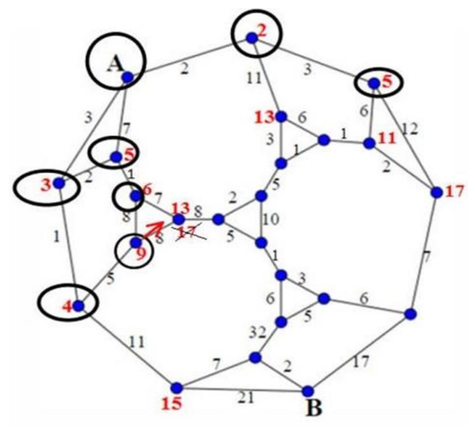

Figure 16

For example, for the permanent node 6 by adding distances 6+8=14, is shown that 14 > 9, this means that the previous distance 9 remains, while the distance 14 is not considered anymore. This means that node 9 is chosen as permanent node and the procedure is similar to the previous cases.

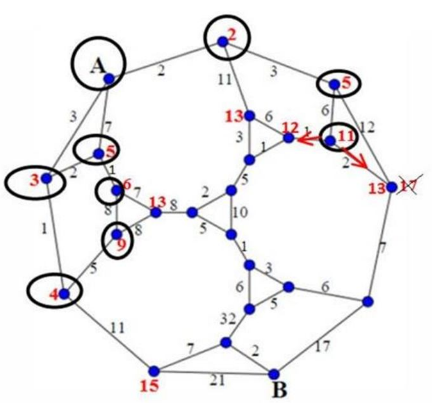

Figure 17

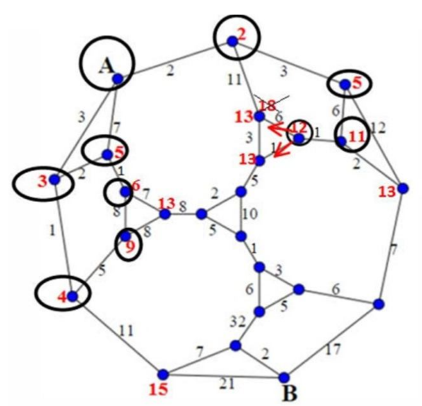

Figure 18

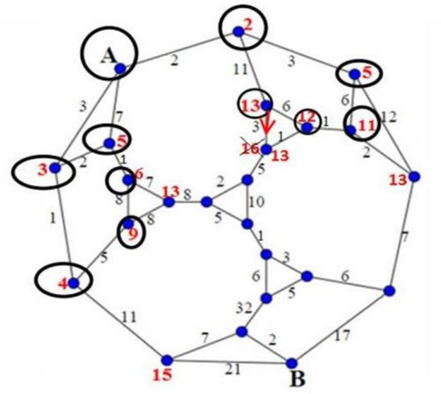

Figure 19

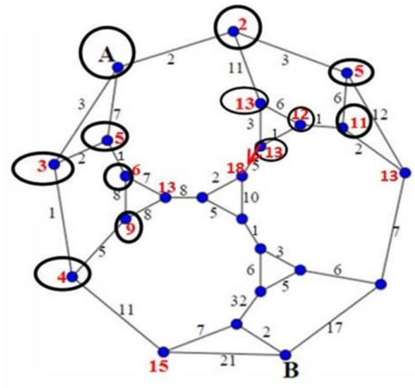

Figure 20

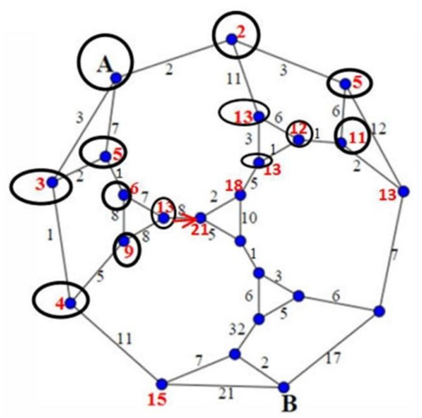

Figure 21

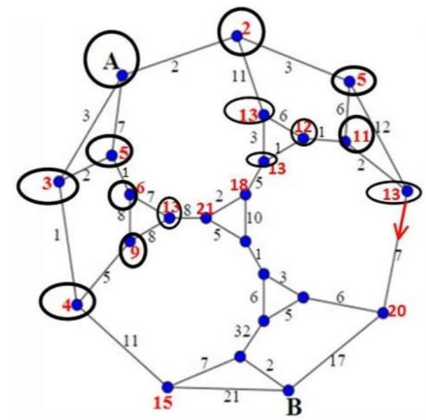

Figure 22

VI. MINIMUM PATH BETWEEN PLACE A AND B

Let’s find the shortest path from Place A to Place B; this is done starting from the node B, by substituting from this node the distance for each neighbour Place.

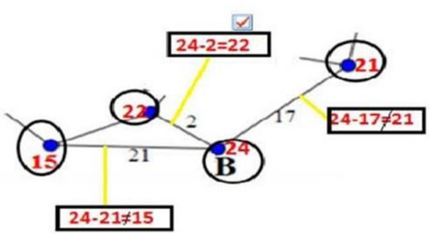

Figure 23

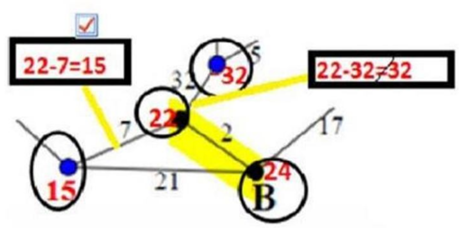

Figure 24

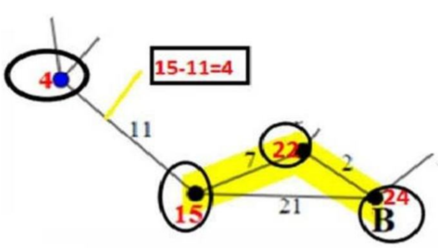

Figure 25

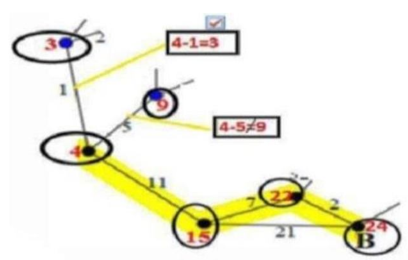

Figure 26

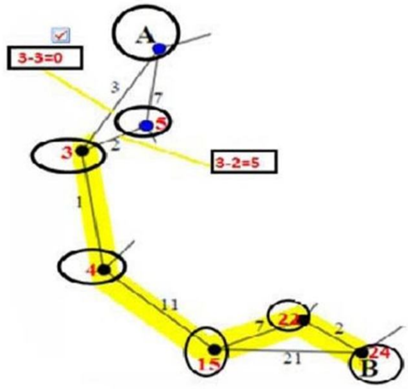

Figure 27

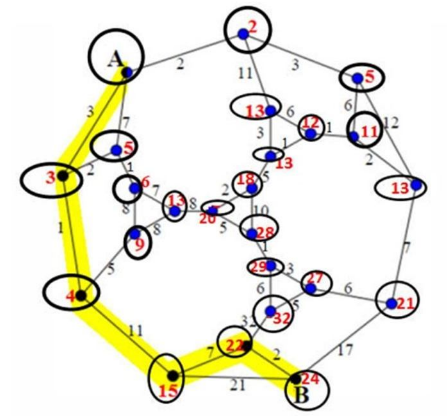

Figure 28. Minimum Cost Path from Place A to Place B

VII. CONCLUSION

Dijkstra's algorithm will find the shortest path between two Places(nodes).The results which are obtained for the given example shows that Algorithm Dijsktra is very effective tool to find the path with lowest cost from Place A to Place B. Same results have been obtained also for Minimum Spanning Tree by using Kruskal algorithm, but this case the procedure is much simpler with a minimum spanning tree to reach node B from node A with the lowest total cost. We have tried also to find the worst scenario to reach node B from node A which is approximately 63% more expensive from the first case.

VIII. ACKNOWLEDGEMENT

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