INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES (IJNAS), VOL. 2, NO. 1(2007); P. 90 – 96, 3 FIGS.

Shortest path (route) determination in telecommunication network systems in Nigeria

O. A. Ofem *[1] and E. E. Williams[1]

ABSTRACT

An algorithm that is designed essentially to find a path of minimum length between two specified vertices of a connected weighted graph is known as shortest path algorithm. The algorithm for solving a class of these kind of problem was developed by E. W. Dijkstra in 1959. The fundamental aim of this research paper is to establish a means through which data can traverse from one point to another with the minimum distance.

INTRODUCTION

The aim of this research project is to establish a means through which data can traverse from one point to another with the minimum distance (Ahuja V. 1987& The shortest route determination is concerned with finding the shortest route from an origin (source) to a sink (destination) through a connecting network, given the non-negative distance associated with the respective branches of the network.

Given a network of nodes denoted by (1,2, ------, n), corresponding to each arc (i, j) there is a non negative number dij called the distance or transit time from node i to node j. The problem is to find the length of the shortest route from the source node i to the sink node n. However, there are ways of solving the shortest route problem.

The most popular method was developed by E. W. Dijkstra to find the shortest path from a specified vertex in a weighted graph to all other vertices in the graph. It provides the shortest path from a network node to every other node in the network (Winston W.L (1994)

Application of Dijkstra's algorithm

It is assumed that the distance between any two nodes (dij) in the network of n nodes is given, and all the distances are non negative. The algorithm proceeds by assigning to all nodes a label that is either temporary or permanent. The permanent label of a node denotes the shortest path weight from the source node to the current node. In case there is no way of getting from I to j directly, we set dij = + ∞, i.e any node which cannot be reached directly from node 1 is assigned a temporary label of ∞ (infinity), while all other nodes receive temporary labels equal to dij (Lambert et. al. 1998)

ITERATIVE STEPS OF THE ALGORITHM

1. Start
2. Pre-step

Initialize by assigning a permanent label of zero to the source node. All other node labels are temporary and are equal to the direct distance from the source node to that node. Select the minimum of these temporary labels and declare it permanent. In case of ties, choose any one.

Step 1 Suppose node k has been assigned a permanent label most recently. Now consider the remaining nodes with temporary labels. Compare one at a time the temporary label of each node to the sum of the permanent label of node k, and the direct distance from node k to the node under consideration. Assign the minimum of these two distances as the new temporary label for that node. (If the old temporary label is still minimal, then it will remain unchanged during this step).

Step 2 Select the minimum of all temporary labels and declare it permanent. In case of ties, select any one of them (but exactly one), and declare it permanent. If this happens to be sink node then terminate, otherwise return to step 1 (Lambert et. al. 1998)

Prototype network model

The application of this algorithm is described in a network model of the telephone switching system of the Nigeria Telecommunications Limited(NITEL) within the country, whereby each exchange serves as a node Within the network. Assuming a telephone call is to be made for alocal connection, this algorithm finds the shortest path possible for the message to pass through to the secondary exchange. The net work connectivity is made via terrestrial link (Ofem, 2001)

*Corresponding Author:
Manuscript received by the Editor May 11, 2006; revised manuscript accepted October 20, 2006.
[1]Department of Mathematics /Statistics & Computer Science, University of Calabar, Calabar, Nigeria

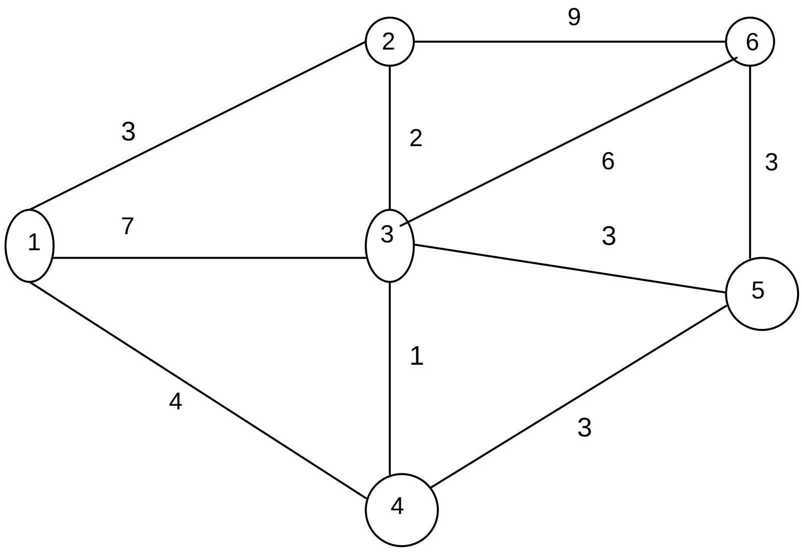


Fig. 1 Undirected Network model

Problem formulation

Consider the undirected network diagram shown in fig. 1, illustrating a network model consisting of six nodes. Nodes 1 to 6 represent 6 different exchanges within a geographical region. The numbers along the arcs (ij) represent distances between nodes. Assume that the distance from i to j is the same as from j to i. The aim is to determine the shortest route of sending information from source node 1 to destination node 6(Ofem, 2001)

.**Overall solution strategy**

Initially, node 1 is labeled permanently as zero, while all other nodes are given temporary labels equal to their direct distance from node 1. Thus the node labels at step 0, denoted by L (0), are L (0) = {0,3,7,4,∞, ∞} *(An asterisk indicates a permanent label).

At Step 1, the smallest of the temporary labels is made permanent. Thus node 2 gets a permanent label equal to 3, and it is the shortest distance from node 1 to node 2. To understand the logic behind this step, consider any other path from node 1 to 2, through an intermediate node j = 3,4,5,6. The shortest distance from node 1 to j will be at least equal to 3 and d_{j2} is non negative since all the distances are assumed to be non negative. Hence any other path from node 1 to node 2 cannot have a distance less than 3, and the shortest distance from node 1 to node 2 is 3.

Thus at step 1 the node labels are:

L (1) = {0, 3,7,4, ∞, ∞). *

For each of the remaining nodes j (j = 3,4,5,6), compute a number which is the sum of the permanent label of node 2 and the direct distance from node 2 to node j. Compare this number with the temporary label of node j, and the smaller of the two values becomes the new tentative label for node j. For example, the new temporary label for node 3 is given by minimum of (3 + 2, 7) = 5

Similarly, for nodes 4, 5, and 6, the new temporary labels are 4, ∞, and 12, respectively and the minimum of the new temporary labels is, made permanent.

Thus at Step 2, node 4 gets a permanent label as shown below: L (2) = {0,3,5,4, ∞, 12}. * *

Now using the permanent label of node 4, the new temporary labels of nodes 3,5, and 6 are computed as 5,7, and 12, respectively. Node 3 gets a permanent label and the node labels at Step 3 are

L (3) = {0,3,5,4,7,12}.* * *

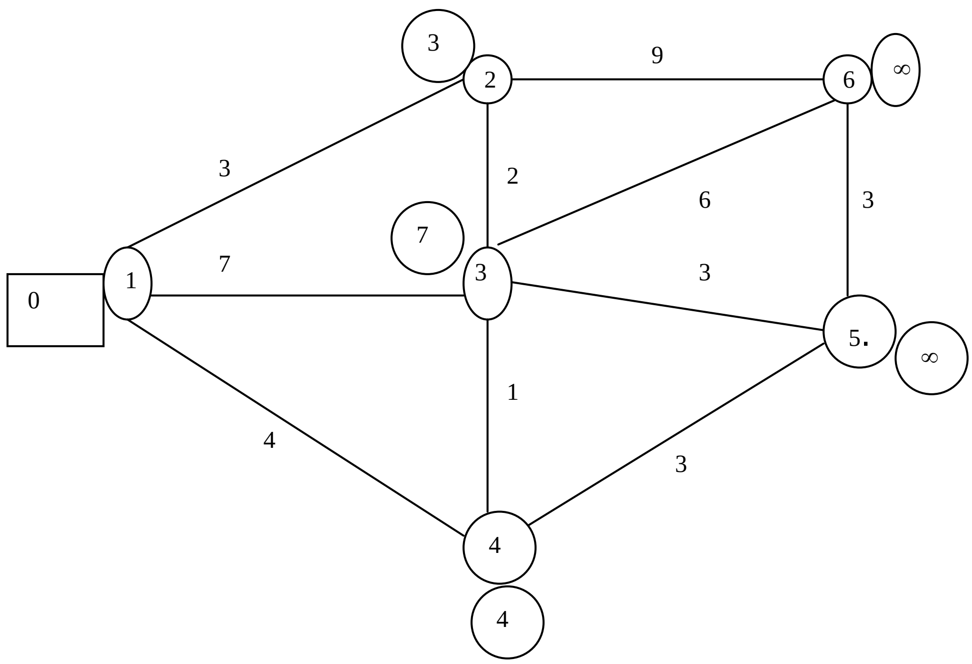
It should be emphasized here that at each step, only the node which has been recently labeled permanent is used for further calculations. Thus at Step 4 the permanent label of node 3 is used to update the temporary labels of nodes 5 and 6 (if possible). Node 5 gets a permanent label and the node labels at Step 4 are using the permanent label of node 4, the new temporary label of nodes 3,5,6 are 5,7,12. Hence node 3 gets permanent label.

L (4) = {0,3,5,4,7,11}* * * *

Using the permanent labels of nodes 5, the temporary label of node 6 is changed to 10 and is made permanent. The algorithm now terminates, and the shortest distance from node 1 to node 6 is 10. As a matter of fact, we have the shortest distance from node 1 to every other node in the network as shown below:

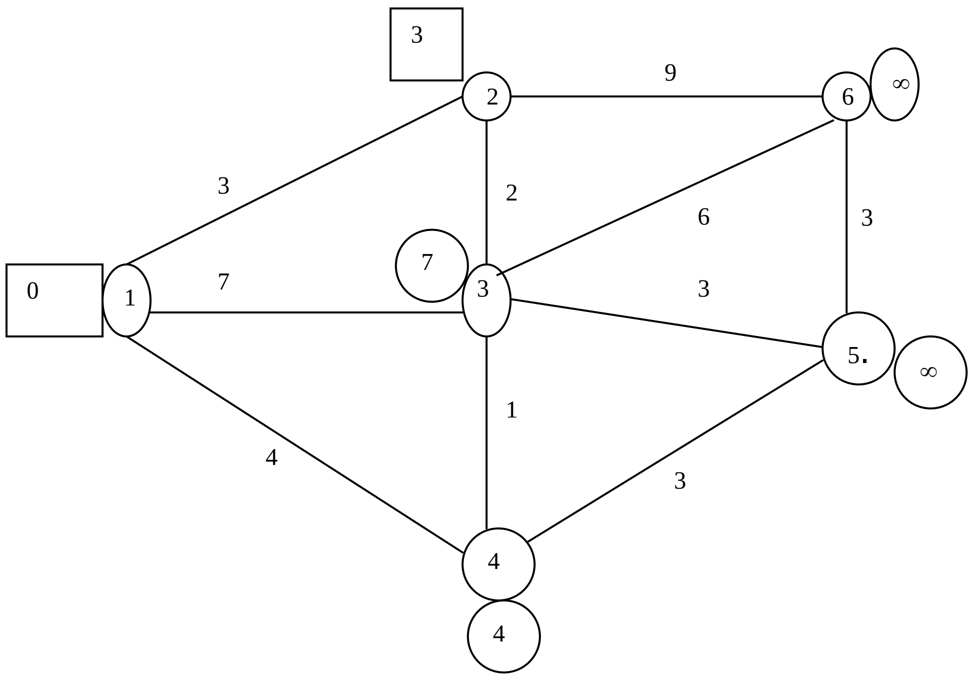
L (5) = {0,3,5,4,7,10}* * * * *

To determine the sequence of nodes in the shortest path from node 1 to node 6, we work backwards from node 6. Node j (= 1,2,3,4,5) precedes node 6 if the difference between the permanent labels of nodes 6 and j equals the length of the arc from j to 6. This gives nodes 5 as its immediate predecessor. Similarly, node 4 precedes nodes 5 and the immediate predecessor of node 4 is node 1. Thus the shortest path from node 1 to node 6 is 1 → 4 → 5 → 6

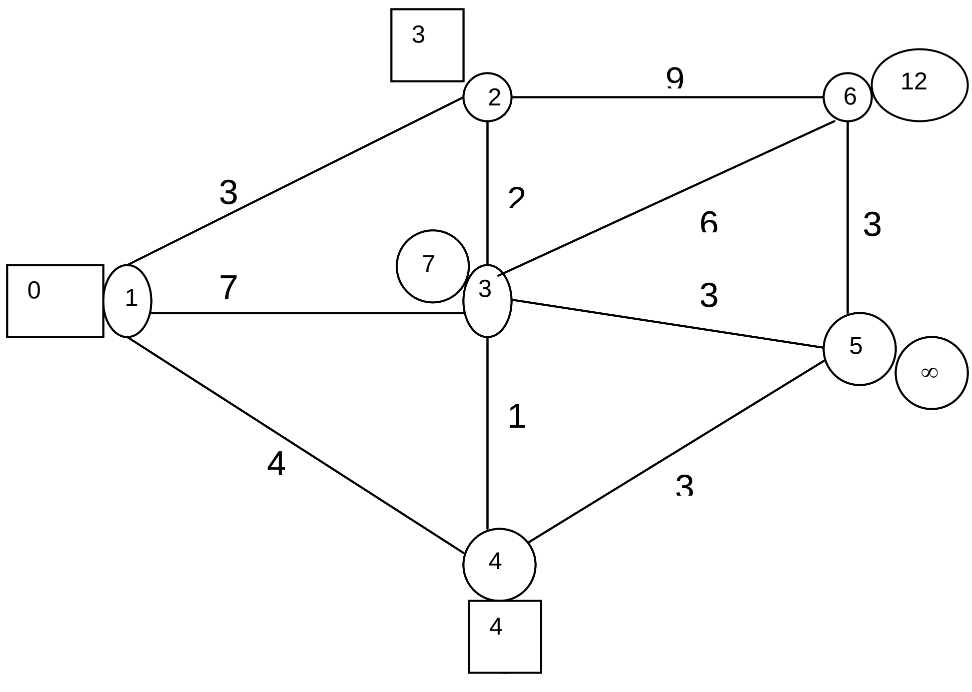


Stage 1 of the algorithm in fig.1

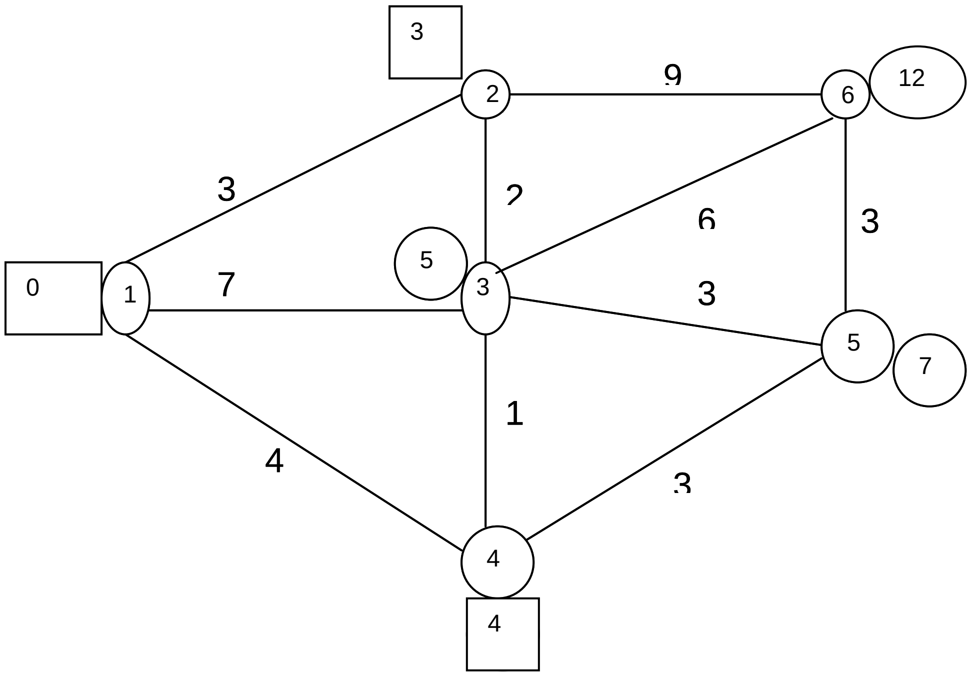
Shortest path determination in telecommunication network



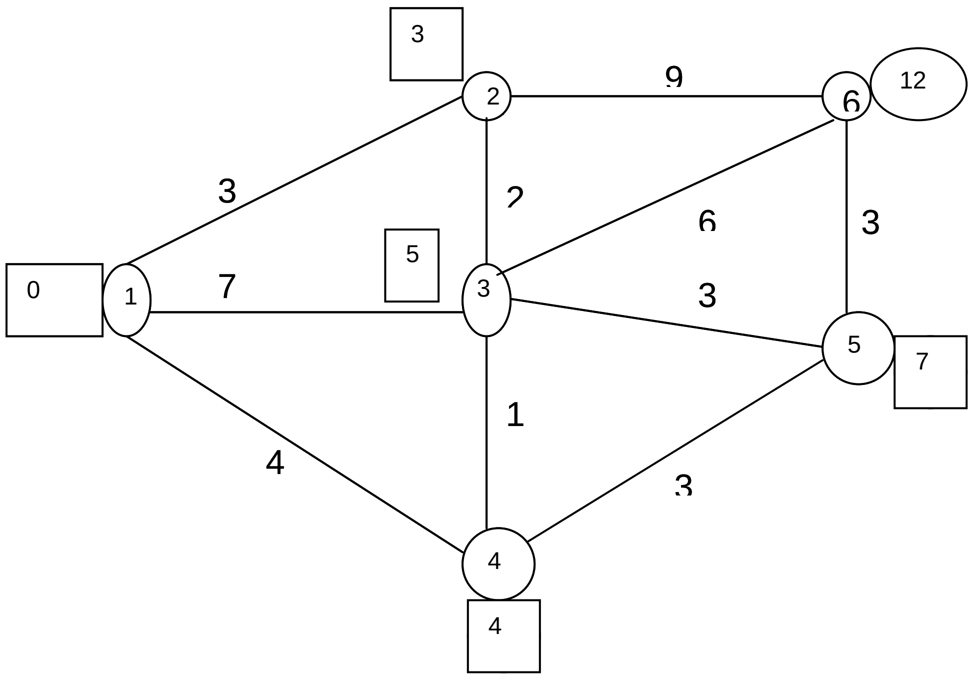
Stage 2 of the algorithm in fig.1



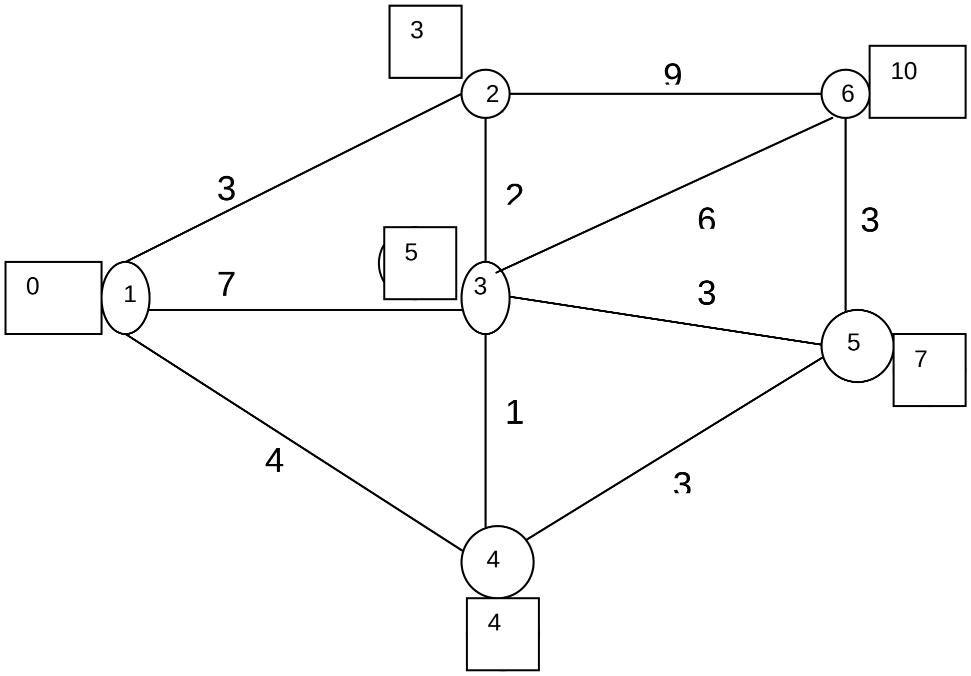
Stage 3 of the algorithm in fig.1



Stage 4 of the algorithm in fig.1



Stage 5 of the algorithm in fig.1



Stage 6 of the algorithm in fig.1

Key notes: Represent a permanent label while Represent a Temporary label of each node at various stages in the model.

System implementation

System implementation refers to the process of assembling the elements of the computer package whether it is for prototype or final products.

After the analysis and design phase it is note worthy to implement the system. This enables us to determine the usability of the system that is, if the system conforms to the design precepts and roles.

Our implementation involves putting the proposed prototype model of a telephone network system, NITEL into effect. In making telephone calls, there are two parties involved, the caller and the receiver, represented in the system as the source and destination respectively (Ofem, 2001). In the transmission of message between these two points in a telephone network the shortest path through which communication link is established can be determined amidst the congestion caused by heavy traffic in the network. This is essentially what this concept on shortest path algorithms is trying to achieve that is the shortest route connecting the source node and the destination node.

CONCLUSION

From the analysis of the foregoing shortest path (route) problem of the exchange of messages or communication signals from a source node (1) to a destination node (6) as depicted in the prototype network models of undirected network of fig 1 above, the shortest route from node 1 to node 6 is $1 \rightarrow 4 \rightarrow 5 \rightarrow 6$

Thus the shortest route from the source node (1) to the destination node (6) is 10 which is the sum of the distances from node 1 to node 4, from node 4 to node 5, and from node 5 to node 6, i.e., 4 +3+3.

This value of the shortest route from the source node (1) to the destination node (6) is the accumulated permanent label on the destination node (6) as depicted in the prototype network model analysis fig. 2.

The study of this research paper, is aimed at establishing a means through which data can traverse from one point to another. Amongst the several algorithms available, Dijkstra's algorithm (a method developed by E. W. Dijkstra) was used due to its simplicity.

In conclusion, implementation of this algorithm in data communication and other areas of application no doubt increases efficiency in addition to other benefits previously mentioned.

Government should embark on policies that would enhanced communication network expansion. However, these policies should be implemented using qualified network expertise in order to prevent excessive cost of expansion.

RECOMMENDATION

1. To obtain a high data communication efficiency coupled with reliability, the network experts or designers must have good understanding of all the available techniques of data communication even at the expense of greater complexity.

2 Repeaters stations/bridges should be sited in strategic geographical locations to enhanced the quality of data from the originating source when being transferred to a / some destination(s), this reduces attenuation rate.

3 Government should embark on policies that would enhanced communication network expertise in order to prevent excessive cost of expansion Ed Tittel. (2002)

Related work

bShortest path algorithm has applications in communications, transportation and electronics such as;

Air route problem

This can be applied to shortest air route determination where airports serve as the nodes, and the distance between successive nodes serve as the arc represented as ί and j in a directed graph network systems.

Road transport problem

In this area, the car parks or bus stops serve as the nodes, and the distances between successive car parks or bus stops serve as the weights on the edge or arc in the directed graph of the network system.

This aims at reducing the total cost of transportation by reducing the fuel to be consumed and consequently reducing the wear and tear rate of mechanical parts.

Traveling sales man problem

Where information/letters are to be dispatched to offices (nodes), and the distances between successive offices in the network serve as the weights in the directed graph network system.

The aim here is to reduced the cost of traveling as well as the duration of traveling. Thus the application of shortest path algorithms in real life situations cannot be over emphasized.

This research paper is to analyze the application of shortest path algorithm in data communication network using a prototype model, NITEL, whereby each exchange serves as a node within the network.

In summary, the application of shortest route algorithm in data communication network system cannot be over emphasized because it provides the transmission of data from a source to its destination in a more reliable and cost effective way.

REFERENCES

Ahuja, V. (1987). *Design and Analysis of Computer Communication Network.* , McGraw-Hill Book Company ,New York, USA.

Ed Tittel (2002). *Schaum's Outlines, Theory and problem of computer networking.* second edition. Austin Community College. McGraw-Hill Company, New York, USA.

Lambert, K. A and Thomas L. Naps (1998) Fundamental of Programme Design and data Structures with C++ Washington and Lee University South Western Educational Publishing and International Thomson Publishing Company (I T P*). Washington

Ofem, O. A. (2001) Application of Shortest Path Algorithm in Telecommunication Network System. Unpublished M.Sc Thesis, Department of Computer Science University of Lagos, Nigeria

Winston, W. L. (1994) *Operations Research Application and Algorithms.*Indiana University, International Thomson Publishing Company Belmont California.