PROTOTYPE TO DESIGN A LEASED LINE TELEPHONE NETWORK CONNECTING LOCATIONS TO MINIMIZE THE INSTALLATION COST

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Abstract

Network flows have many real-life applications and leased-line installation for telephone network is one of them. In the leased line a major concern is to provide connection of telephone to all the locations. It is required to install the leased line network that reaches all the locations at the minimum cost. This chapter deals with this situation with the help of a network diagram in which each node represents the locations and the edge between each node represents leased line. Each edge has a number attached to it which represents the cost associated with installing that link. Aim of the paper is to determine the leased line network connecting all the locations at minimum cost of installation.

Keywords: Weighted network; Minimal spanning tree.

1. Introduction

Gonery et.al (1961) presented multiterminal network flows. Ford and Fulkerson (1962) discussed flows in networks. Naylor et.al. (1966) presented computer simulation techniques on simulation of inventory models. Jansson (1966) discussed different methods of generating random numbers. Pritsker and Kiviat (1969) studied computer simulation in network system. Frank et.al(1971) discussed communication, transmission and transportation networks. Edmonds and Karp(1972) presented theoretical improvements in algorithmic efficiency for network flow problems. Even and Tarjan(1975) considered network flow and testing graph connectivity. Simulation with digital computer was dealt by Deo(1979). Kennington et.al(1980) wrote a book on algorithms for network programming. Tarjan (1983) discussed data structures and network algorithms. Orlin (1988) presented a faster strongly polynomial minimum cost flow algorithm. Vaidya (1988) discussed minimum spanning trees in k-dimensional space. Law and Kelton(1991) presented simulation, modeling and analysis. Ahuja et.al.(1993) discussed network flows: theory, algorithms, and applications. Chan(1998) considered backward analysis of the Karger-Klien-Tarjan algorithm for minimum spanning trees. Stallings (2002) discussed various minimum spanning tree algorithms in a book on "Data and Computer Communications". Katriel et.al.(2003) presented practical minimum spanning tree algorithm using the cycle property. Various network models have been presented by Sharma(2003). Dementiev et.al.(2004) discussed an external memory minimum spanning tree algorithm. Vaidyanathan et.al.(2007) studied a network flow-based approaches to the railroad crew–scheduling problem which assigns train operators to scheduled trains over a time horizon (generally a week) at minimal cost, while honoring several operational and contractual requirements.

Aim of the chapter is to investigate simulation of leased line network to minimize the installation cost of leased line that reaches to all the locations.

2. Model of Real-Life System

A network can be represented by a graph or network diagram which consists of nodes and edges. Nodes are endpoints and are represented by numbered or labeled circles in the diagram. Fig.1 indicates two nodes i and j connected with the help of an edge.

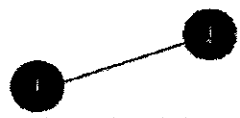

Fig.1. Nodes and edges

Nodes represents points at which a flow originates, terminates or is relayed. Edges are used to connect pairs of nodes, and they indicate a relationship between the connected nodes. Airline routes, telephone wires, pipelines, roadways etc. can also be represented by edges.

A sequence of nodes and edges connecting any two nodes is called a **chain** and when the direction is specified, then it is called a **path.** A **cycle** is a chain that connects a node to itself. A network K is said to be **connected,** if there is at least one path between every pair of vertices in network. A **tree** is a connected set of nodes containing no cycles. If there is a real number associated with each edge of the network, then it is called the **weighted network**(see Fig.2). A tree T is said to be **spanning tree** of a connected network K if T is a sub-network of K and T contains all the nodes of K(see Fig.3). In a weighted network, spanning tree with the minimum weight is called a **minimal spanning tree**(see Fig.4).

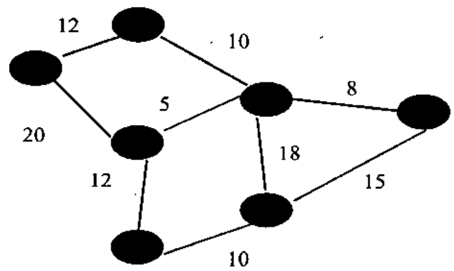

Fig.2. Weighted network diagram

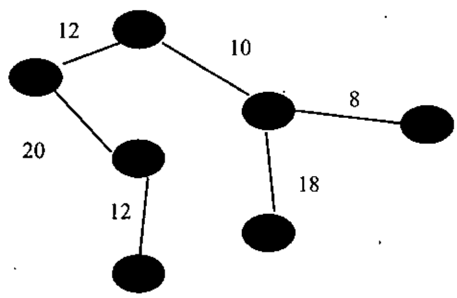

Fig.3. Spanning tree of the weighted network

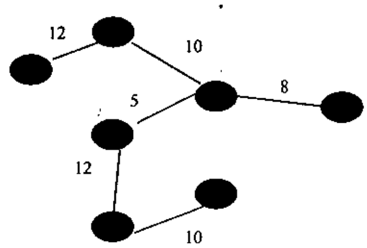

Fig.4. Minimal Spanning tree of the weighted network

There are many algorithms for finding out the minimal spanning tree. One of them is Kruskals algorithm. The following notations are used:

n = set of nodes,
e = edge,
M = set of edges so far incorporated by the algorithm,
$W(e_i)$ = weight of ith vertex,
K = network,
T = Spanning tree.

The algorithm has three steps; step-1 and step-2 are repeated until number of edges in M is equal to n-1.

Step-1: Choose an edge e_1 of the network K such that $w(e_1)$ is the smallest and it is not a loop. $M=\{e_1\}$

Step-2: If $e_1,e_2,e_3.....e_i$ edges have been chosen, then choose an edge e_{i+1} not already chosen such that
(i) the subgraphs having edges $e_1,e_2,....e_{i+1}$ is acyclic,
(ii) weight of e_{i+1}, $w(e_{i+1})$ is the smallest.

Step-3: If there are n nodes, then repeat step-1 and step-2 till there are (n-1) edges in M.

After completion of this algorithm, network diagram K gives a minimal spanning tree T which gives the minimum total cost.

3. Simulation of the Model

In installation of leased line for telephone network, nodes are the locations and the leased-line are considered as edges. Every edge is attached with a real number which is the cost of installing leased line between the two cities. The cost includes cost of wire, labour and equipment. From the network diagram construct a minimal spanning tree which gives the minimum total cost.

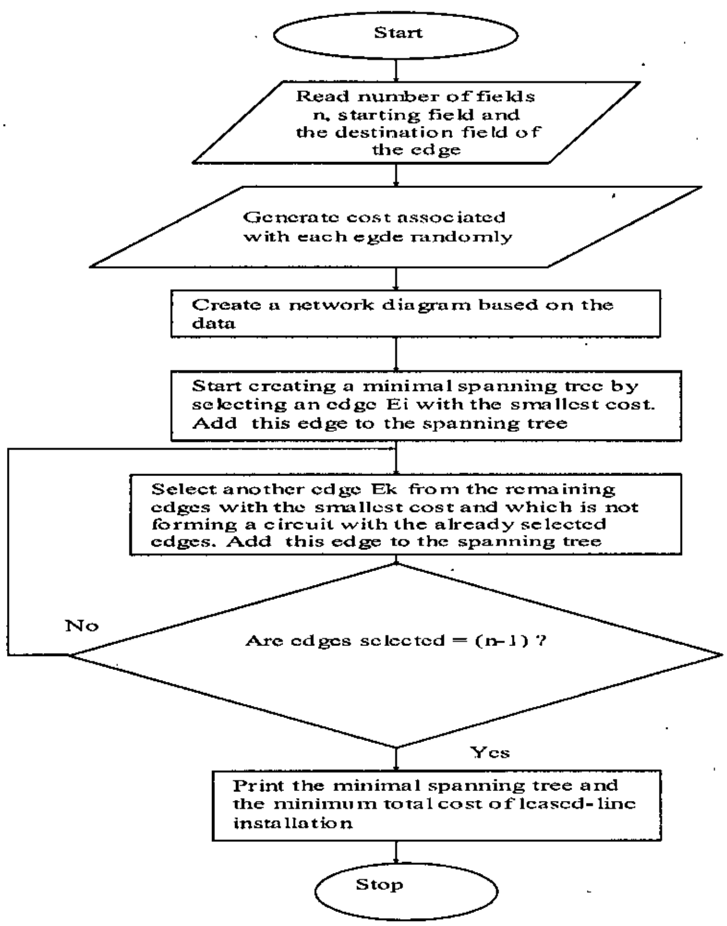

Fig.5. Flowchart of Program

To simulate the leased line model, a programme in C language is prepared. A flowchart of this program is shown in Fig.5. In this model cost of installing leased line is stochastic. This cost is generated from the uniform distribution with the help of a random function. Present model is tested on various datasets. A particular dataset is considered in this paper in which there are 20 locations. The results of the model are obtained and output is taken in Excel Worksheet which is used for generating various graphs from which conclusions are drawn.

4. Results and Discussion

A network flow diagram showing all the connections between the locations is shown in Fig.6. The nodes of the network indicates the locations and the edges indicates the link between the locations and the number represents the cost associated with that particular link. A minimal spanning tree is shown in Fig.7. This network covers all the nodes and the sum of all the costs of edges gives the total installation cost of leased line which is minimum. Table 1 shows the initial data for the network and the spanning tree data.

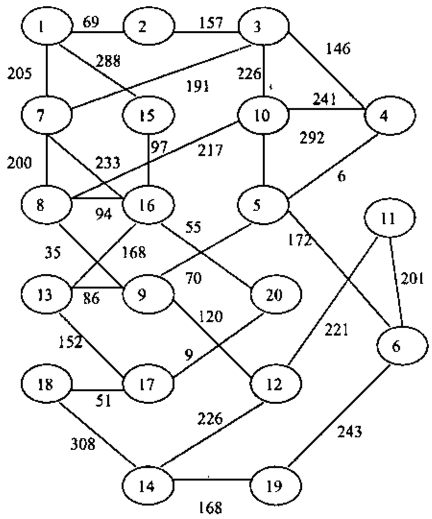

Fig.6. Network diagram showing connections between locations

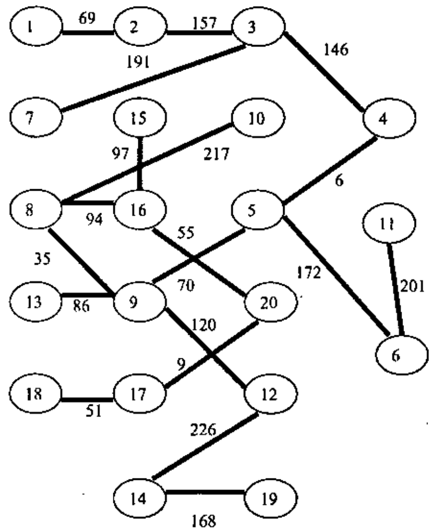

Fig.7. Minimal spanning tree with minimum total cost

Table 1. Network input information and the corresponding minimal spanning tree information

Network input information

Edges	Starting City	Destination City	Cost of installation
1	1	2	69
2	1	15	288
3	1	7	205
4	15	16	97
5	2	3	157
6	3	7	191
7	7	8	200
8	7	16	233
9	16	8	94
10	3	10	226
11	3	4	146
12	8	10	217
13	10	4	241
14	10	5	292
15	4	5	6
16	8	9	35
17	16	13	168
18	16	20	55
19	5	9	70
20	13	9	86
21	20	17	9
22	13	17	152
23	17	18	51
24	9	12	120
25	18	14	308
26	14	12	226
27	14	19	168
28	12	11	221
29	11	6	201
30	5	6	172
31	6	19	243

Minimal spanning tree

Edges	Starting City	Destination City	Cost of installation
1	4	5	6
2	20	17	9
3	8	9	35
4	17	18	51
5	16	20	55
6	1	2	69
7	5	9	70
8	13	9	86
9	16	8	94
10	15	16	97
11	9	12	120
12	3	4	146
13	2	3	157
14	14	19	168
15	5	6	172
16	3	7	191
17	11	6	201
18	8	10	217
19	14	12	226

Minimum installation cost=Rs.2170/-

5. Summary and Conclusion

This model can be practically implemented for reducing the cost of installation. Given n-locations and the cost of installation of leased line between every pair of locations, this model helps in finding out the minimum installation cost by constructing a minimal spanning tree of the corresponding network. This model can be used for reducing the cost of installation in many areas such as fibre optic line, pipeline for refineries, electrical lines in industries etc.

References

[1] Ahuja, R.K.; Magnanti, T.L.; Orlin, J.B(1993): Network Flows: Theory, Algorithms, and Applications, Prentice-Hall, NY.
[2] Chan, T.M.(1998): Backward analysis of the Karger-Klien-Tarjan algorithm for minimum spanning trees Information Processing Letters, 67, pp.303-304.
[3] Dementiev, R.; Sanders, P; Schultes, D.; Sibeyn, J. (2004): Engineering an external memory minimum spanning tree algorithm, In 3rd IFIP International Conference on Theoretical Computer Science.
[4] Deo, N.(1979) : System Simulation with Digital Computer, Prentice-Hall of India Pvt. Ltd., New Delhi.
[5] Edmonds, J. ; Karp, R. M.(1972): Theoretical improvements in algorithmic efficiency for network flow problems, J. ACM , 19, pp.248-264.
[6] Even , S. ; Tarjan, R.E.(1975): Network Flow and Testing Graph Connectivity SIAM J. Comput., 4, pp.507-518.
[7] Ford, L. R. ; Fulkerson(1962): D. R. Flows in Networks, Princeton University Press.
[8] Gonery, R. E.; Hu, T. C.(1961): Multiterminal Network Flows, J. SIAM, 9, pp.551-570.
[9] Jansson, B.(1966): Random Number Generators, Victor Pettersons, Stockholm.

[10] Katriel, I.; Sanders, P. ; Traff, J.L.(2003): A practical minimum spanning tree algorithm using the cycle property, In 11th European Symposium on Algorithms (ESA).
[11] Law, A. ; Kelton, W.D.(1991): Simulation , Modeling and Analysis, McGraw-Hill, New York, 1991.
[12] Naylor, T.H.; Balintfy, J.L.; Burdick, D.S. ; Chu, K.(1966): Computer Simulation Techniques, John Wiley & Sons, New York.
[13] Orlin, J. B. (1988): A faster strongly polynomial minimum cost flow algorithm, Proc. 20th ACM Symposium Theorem of Computing.
[14] Pritsker, A.A.B. ; Kiviat, P.J.(1969): Simulation with GASP II, Prentice-Hall, Englewood Cliffs, N.J.
[15] Sharma, S.D.(2003): Operations Research, Kedarnath Ramnath & Co., Meerut, India..
[16] Tarjan, R. E.(1983) : Data Structures and Network Algorithms, SIAM Press.
[17] Vaidya, P.M.(1988): Minimum spanning trees in k-dimensional space, SIAM Journal on Computing, **17**, pp.572-582.

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