Prims Algorithm and its Application in the Design of University LAN Networks

1 author:

Charles Kinyua
Chuka University, Kenya

ISSN: 2321-7782 (Online)
Volume 3, Issue 10, October 2015
International Journal of Advance Research in Computer Science and Management Studies
Research Article / Survey Paper / Case Study
Available online at: www.ijarcsms.com

Prims Algorithm and its Application in the Design of University LAN Networks

Charles K. Gitonga
Department of Computer Science,
Chuka University
Chuka, Kenya

Abstract: The problem deliberated is that of networking a given set of network nodes with shortest possible cables of direct links. Simple practical procedures have been given for solving this problem. The techniques given are based on prims algorithms.

Problem statement – Given a set of University buildings, connect them by a fibre network cables of direct terminal-to-terminal links having the smallest possible total length (total sum of cable lengths). A set of buildings are connected, if and only if there is an unbroken chain of fibre links between every two buildings in the set.

The purpose of the study was to investigate the effectiveness of PRIMs algorithm in the design of University LAN networks and to establish the effect of prims algorithm in the design of a Campus Network at Chuka University.

Keywords: LAN, Campus, Network, Prims Algorithm, networking, minimum spanning tree.

I. INTRODUCTION

The problem considered is that of planning a large-scale Campus network based on fiber technology. Such networks are expensive to install but are very reliable. Optic fiber network offers fast and reliable network that provides high end internet services.

The reliability and service quality requirements of modern data communication networks and the large investments in communications infrastructure have made it critical to design optimized networks that meet the performance parameters [4]. Therefore for a fast growing institution of higher learning, these services are essential hence the need for a reliable data networks in University campuses. This can be realized by installation of optic fibre network. Optic fibre networks use light for data transmission. According to [11] Optic Fiber is the most important type of media that uses light for data transmission. Data is transmitted in form of light pulses emitting from a light emitting diode travels through glass filaments and are received on the other end by a photosensitive device. Optical fibers are used extensively for data transmission systems because of their dielectric nature and their large information-carrying capacity [9]. Installation of such network in a fast growing institution would therefore improve on the quality and efficiency of data communication.

Installation of fiber network is an expensive affair and proper planning is required to realize a fully functional network. Though it is expensive to install optic fiber networks, this paper proposes a model in their design, that if adopted can reduce on the overall cost of installation. Given a set of University buildings, we propose a model based on Prims algorithm that would enable connection of all buildings to optic fiber network at a minimal cost. A set of buildings will be considered connected if and only if there is an unbroken chain of optic fibre links between every two buildings in the set. A loop is not allowed and a redundant cable is not allowed either as this will increase the cost.

The purpose of the study is to investigate the effectiveness of Prims Algorithm in the design of Campus Networks. The study demonstrates that the overall costs incurred during the interconnection of University buildings to the existing Local Area Network can be minimized.

II. PRIMS ALGORITHM

According to [2] an algorithm can be viewed as tool for solving well-specified computational problem. The problem at hand is that of establishing the shortest distance between all the University buildings. Prims algorithm has an application in finding the minimum length, commonly referred to as the cost of spanning tree. Minimum spanning tree (MST) problem is one of the traditional optimization problems [5].

According to [13], the minimum cost of a spanning tree has a wide application in different areas. It epitomizes intricate problems such as:

- » Minimum distance for travelling all cities at most one (Travelling salesman problem).
- » In electronic circuit design, to connect n pins by using n-1 wires, using the least wire

The minimum cost of a spanning tree can be established by use of Prim's and Kruskal's Algorithm.

In this paper, the objective is to find the minimum cost of connecting University buildings using the Prim's algorithm. Prims algorithm is a greedy algorithm that obtains the minimum spanning tree by use of sets. It processes the edges in the graph randomly by building up disjoint sets.

The problem at hand was modeled using a connected undirected graph G= (V,E) where V is the set of University buildings buildings, and E is the set of possible interconnections between pairs of buildings and for each edge (u,v) ϵ E, we have a weight (u,v) specifying the length of the amount of optic fiber cables needed. We then preceded to find an acyclic subset T ϵ E that connects all the vertices and whose total weight w(T) = ϵ w(u,v). (u,v)/[T is minimized.

Since T is acyclic and will connect all the buildings in the University, it will form a tree, referred to as spanning tree [2]. We are interested in the tree that spans the shortest distance within the overall University buildings; we refer to it as the Minimum spanning tree. According to [3], Prims algorithm is a special case of the generic minimum spanning tree with operates for finding the shortest path in a graph. The algorithm has a property in that the edges in the set always form a single tree. The tree starts from an arbitrary root vertex and grows until all the vertices are spanned in V. Each step adds to the tree A a light edge that connects A to an isolated vertex – one on which no edge of A is incident. The algorithm implicitly maintains the set A from GENERIC-MST as

A = {(v,v.π): v ϵ V- {r}-Q}. when the algorithm terminates, the priority Q will thus be empty.

The minimum spanning tree A for G is thus

A = {(v,v.π): v ϵ V- {r}}.

According to [3], MST-PRIM(G,w,r) can be illustrated as follows:

```
A = {(v, π[v]) : v ∈ V - {r}}.
MST-PRIM(G, w, r)
for each u ∈ V [G]
    do key[u] ← ∞
       π[u] ← NIL
key[r] ← 0
Q ← V [G]
while Q ≠ Ø
    do u ← EXTRACT-MIN(Q)
       for each v ∈ Adj[u]
           do if v ∈ Q and w(u, v) < key[v]
                then π[v] ← u
                     key[v] ← w(u, v)
```

Fig. 1 Illustration of Prim's algorithm.

III. Chuka University LAN

Chuka University consists of several buildings and installations. Buildings host offices where internet services are essential. There exist some offices without reliable internet connections. [8] Notes that internet provides several opportunities for the academia with added benefits to teaching, learning and research. The existence of staff offices without this essential facility deprives their occupant of the above opportunities.

The existing LAN at Chuka University covers limited building structures and offices. There remains a challenge of networking all the University building using the optic fiber since it is expensive. By use of prims algorithms, we prove that all the buildings can be connected at minimal cost.

IV. Implementation

Chuka University consists of the various key buildings as illustrated in the map below. To implement the algorithm, we consider all the buildings that require an optic fiber connection. A building would qualify to be connected to fibre network, if it requires a high speed internet connection and can be qualified for point to point communication.

The building under consideration as follows: ICT center, Library, Science Tuition block, Finance, Students and Business recreation center, University Pavilion, Dispensary, Media studio, Business complex, Ladies hostels, Model school, men's hostels amongst other upcoming buildings.

Fig. 2 aerial map of Chuka University, main campus with main buildings visible.

Key [1: Science Tuition Block, 2: Library, 3: Business Complex, 4: Dispensary, 5: Media Studio, 6: Ladies Hostel, 7: University pavilion, 8: Students Business and Recreation center, 9: ICT center, 10: Students Finance, 11:Model School]

The above image shows a topological view of Chuka University with main buildings visible. The study used-scaled sketches to prove that prims algorithms could reduce the overall cost of fiber installation.

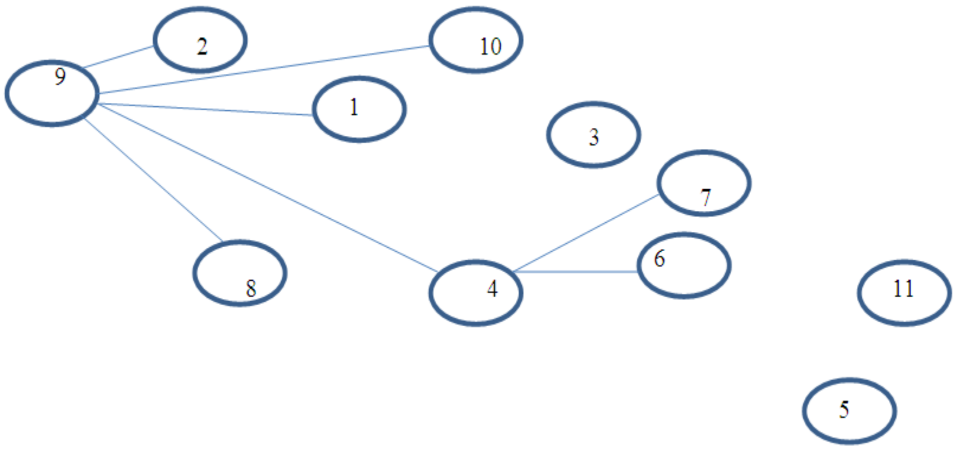

Fig. 3 the existing fibre network at Chuka University

The figure above show the existing fibre network at Chuka University, the direct cable links leads to wastage of fibre cable used. With use of Prims algorithm, the overall length of the cable used would be greatly minimized.

V. Applications of Prims Algorithm

In order to minimize cost, the relative distance of each building installation from the ICT center was measured. The distance from each building to its adjacent building was also measured.

The starting point was ICT center since it forms the root node or the starting point to the entire network.

The results of the measurement are summarized in the table below.

TABLE I

Building	**Relative distance to ICT center in Meters**
ICT Center	0
Library	30
Finance	80
Media Studio	1200
Science Tuition block	25
Student center	45
Business school center	180
University pavilion	150
Health center	300
Female Hostels	200

By applying the Prims algorithm, proceed as follows to establish the shortest link. Let the ICT center forms the root node, then proceed to the nearest building, which is library and science tuition block. Their edges have the minimum weight, therefore added to the queue. Library and the science building becomes our new root. From here we extend towards toward other buildings, always using the shortest link. This continues till we reach all the buildings in the set without forming a loop.

When algorithm completes, the entire length of the required cable will be reduced, saving on the entire cost of connecting all the buildings. The figure below shows the outcome after application of prims algorithm to redesign the existing LAN.

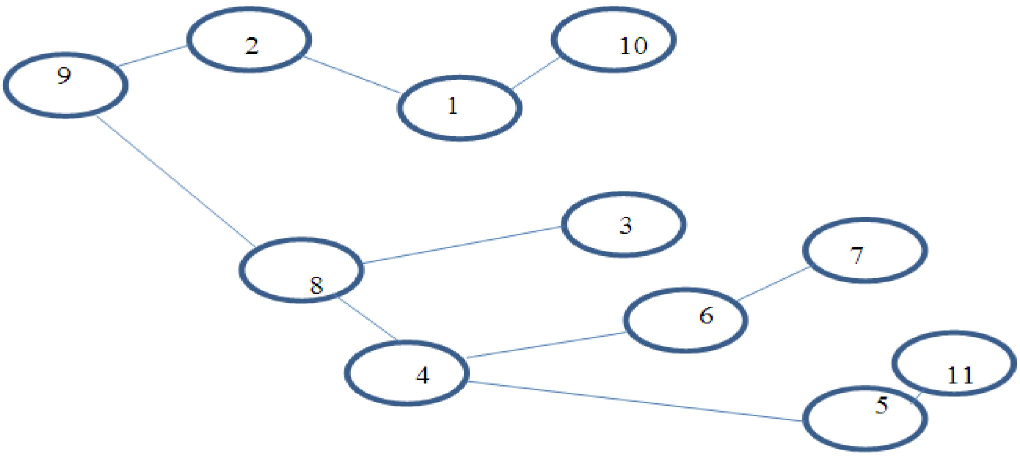

Fig.4 Chuka University fibre LAN, following the application of PRIM's Algorithm.

The application of Prim's algorithm proves to be effective in establishing the above LAN.

VI. Conclusion

Applications of Prims algorithm can be valuable and useful tool in the design of large LAN networks. This is because of its greed nature since at each step it adds to the tree the shortest edge that will contribute the minimum weight of the tree formed. The algorithm would cater for the existing and emerging buildings. The cost of such is highly reduced as the algorithm always results in the minimum overall distance. The savings on cost could be used to expand the network to other buildings and installation. This would enable the connections to several buildings enabling more people to be connected to the internet. Though the study was carried out on the existing LAN at Chuka University, its findings can be applied to any other network setup that uses optic fibre to minimize on the installation cost.

Acknowledgment

The author acknowledges the work well done by staff at ICT department, Chuka University during the study survey. I also acknowledge Chuka University Senior management for their unyielding support and availing staff to support the study. The author will work with all stakeholders during the next implementation phase to realize a cost effective fiber network installation.

References

1. Prim, Robert Clay. "Shortest connection networks and some generalizations." Bell system technical journal 36, no. 6 (1957): 1389-1401.
2. Cormen, Thomas H. Introduction to algorithms. MIT press, 2009.
3. Chu, Chao-Hsien, G. Premkumar, and Hsinghua Chou. "Digital data networks design using genetic algorithms." European Journal of Operational Research 127, no. 1 (2000): 140-158.
4. Zhout, Gengui, and Mitsuo Gen. "An effective genetic algorithm approach to the quadratic minimum spanning tree problem." Computers & Operations Research 25, no. 3 (1998): 229-237.
5. Barr, R. S., R. V_ Helgaon, and Jeffery L. Kennington. "Minimal spanning trees: An empirical investigation of parallel algorithms." Parallel Computing 12, no. 1 (1989): 45-52.
6. Kaminow, Ivan, Tingye Li, and Alan E. Willner. Optical fiber telecommunications VB: systems and networks. Academic press, 2010.
7. Jagboro, Kofoworola. "A study of Internet usage in Nigerian universities: A case study of Obafemi Awolowo University, Ile-Ife, Nigeria (originally published in February 2003)." First Monday (2007).
8. Keiser, Gerd. Optical fiber communications. John Wiley & Sons, Inc., 2003.
9. Gerla, Mario, and Leonard Kleinrock. "On the topological design of distributed computer networks." Communications, IEEE Transactions on 25, no. 1 (1977): 48-60.
10. Comer, Douglas E. Computer networks and internets. Prentice Hall Press, 2008.
11. Leiserson, Charles E., Ronald L. Rivest, Clifford Stein, and Thomas H. Cormen. "Introduction to algorithms." The MIT press 5 (2001): 2-2.

12. Google Maps (2015). [Chuka University, Chuka] [street map], retrieved from: https://www.google.co.uk/maps/place/Chuka+University/@-0.3198544,37.6575912,293m/data=!3m1!1e3!4m2!3m1!1s0x1827b892813e10f7:0xec0f5cfbc84c391c

13. Abhilasha, R. "Minimum cost spanning tree using Prim's algorithm." International journal of advance Research in computer science and management studies 1.1 (2013).

AUTHOR(S) PROFILE

Charles K. Gitonga, received the M.Sc Degree in Computer Science from the University of Hull, United Kingdom in the year 2013. During 2011-2013, he was studying for Msc. In Computer Science at the University of Hull where he specialized in software development and computer Security. Gitonga had earlier graduated with BSc. Degree in Computer Science from Maseno University, Kenya in the 2009. He now Works at Chuka University as Lecturer in the Department of Computer Science. His research interests are in the field of Theoretical Computer Science. More specifically, He is interested in the Design and Analysis of Algorithms, Combinatorial and Number Theoretic Algorithms as well as their applications. Other areas that interest him are in Quantum Computing, Theory of Computation, Complexity Theory and Geometric Algorithms. His long-term goal is to be actively in research and teaching in the field of computer science.