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USING MINIMUM SPANNING TREE TO REDUCE COST OF THE CABLE FOR THE INTERNET

Rahaf Ibrahim Tuffaha[1], *Abdulaziz Almaktoom*[2]

[1.2] College of Business, Effat University, Qasr Khuzam St., Kilo. 2, Old Mecca Road.

P.O.BOX 34689, Jeddah 21478, Saudi Arabia.

Email: [1]rituffaha@effatuniversity.edu.sa, [2]abalmaktoom@effatuniversity.edu.sa

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ABSTRACT

Companies always look for ways to be effective and efficient in their business. They seek techniques for maximizing profit and minimizing costs in order to function well and also having a technique that they can rely on when estimating the best way to minimize wastage can assist them to be objective in their endeavors. Therefore, installing internet cable should not be a trial-and-error technique rather an object-oriented method. The aim of this study is to undertake the functioning of the internet of the company and find methods in which it becomes cost effective. Installing cable can be costly especially when there is no mechanism to minimize wastages. This study seeks to establish whether Kruskal can be a reliable method to reduce the cost of installation and maximize profit. The methodology of this study includes using a minimum spanning tree using Kruskal's Algorithm. Kruskal method is a graphical method that focuses on selecting minimum length between two houses progressively until an optimum route is established. The finding showed that using Kruskal algorithm the size of the cable used can be managed adequately to reduce cost and maximize profit. This study concluded that using the Kruskal method companies can reduce the overall cost of installing cable since it assists in establishing the minimum route.

INTRODUCTION

The minimum spanning tree (MST) will deal with issues in the application fields like that of transportation and telecommunication networks to reduce the costs of distribution in the organization through the best route as the costs become high due to finding spaces, drilling the ground and putting in extension cables. The minimum spanning tree, MSTs has become one of the main streams in econophysics as it filters the crucial information contained in stock networks. Minimum spanning trees is utilized for networking issues such as cable networks and telephone [1]. These are used to establish the approximate solutions for the complex mathematical issue.

According to Biswas et al. [2], minimum spanning tree brings about optimization. They also stated that “It is widely applied in various fields of science and technology ranging from computer and communication networks, knowledge engineering, wiring connections, VLSI circuits design to a large class of optimization problems.” It is defined by Vijayalakshmir and Kalaivani [3] as, “A minimum spanning tree (MST) of an edge-weighted graph is a spanning tree whose weight (the sum of the weights of its edges) is no larger than the weight of any other spanning tree”.

Petite and Ramachandran [4] stated, “The minimum spanning tree (MST) problem has been studied for much of this century and yet despite its apparent simplicity, the problem is still not fully understood”. This means that the MST looks simply but is very difficult to formulate as it offers all optimal routes but is very complex to obtain a specific solution.

According to Nesteril et al. [5], “MST problem may be efficiently solved for large sets by several algorithms. These algorithms were studied even before the right complexity measures, and problems were isolated”. Kruskal used disjoint set union algorithm for computing the MST. Nesteril et al. [5] also mentioned that among all the algorithms developed so far, Kruskal’s algorithm has served the problem better and have offered efficient solutions.

Boria and Pachos [6] have also confirmed that “The most popular algorithm for MST is the seminal Kruskal's Algorithm which consists of sorting edges in non-increasing order with respect to their weights, and of inserting them in the current solution if they do not create cycles with those already inserted”. According to MST notes [7], “Kruskal’s algorithm constructs the MST by greedily adding the overall minimum edge”. Not only does it owe to its popularity but Kruskal’s algorithm is also easy to implement in many places.

In network design, companies use a minimum spanning tree to determine points to bury a cable in a given path, and these points are represented using a graph [1]. Through the tree, the company can determine the paths that are expensive since they are longer, or the paths might need the cable to be buried deeper and these paths represented by edges that have larger weights. Kumar and Kumar [8] both claim the applications for minimum spanning tree problem are computer networks, TV cable, telecommunications networks, transportation networks, water supply networks and electrical grids. According to Rainbolt and Schmitt [9], MST is used in physics as well as MSTs have been used in cosmology and astronomy to distinguish distributions of points in a multi-dimensional space.

Every year companies specializing in offering internet services make losses due to wastage of cable. The specialist relies on trial and errors or non-procedural means to lay down cable without regards on how they can do it perfectly to minimize wastage. This study will analyze Kruskal algorithm and applied in laying down the cable in such a way that wastage can be minimized and profit maximized.

METHODOLOGY

This study used Kruskal algorithm to reduce the cost of the cable for the Internet. The case study is also flexible in such a way that it does not direct the study to use any specific way but allow the study to use different ways to answer “what”, “why” and “how” research questions.

The neighborhood cable connection cannot be analyzed by statistical techniques, instead it needs proper examination of “why” cables need to be installed in particular why and also “what” length of the cable was appropriate. Finally, the study examined “how” the cable was to be installed to ensure there is cost minimization and profit maximization.

Data Collection

Data collection tools Case studies: it is a detailed description of processes, experience and structure of an institution. Case studies can be used to answer “what” and “why” questions [10]. Both quantitative and qualitative techniques are used.

Checklist is a technique structures observation or evaluations. Checklist design can be simple to allow one to enter data by just checking the boxes [10]. The checklist can also include parts for comment to allow fillers to offer personalized opinions.

Observation can be either direct or indirect, be continuous or timed. Carrying out observation should be done in such a way that it cannot affect the behavior of the subject. The problem of direct observation includes Hawthorne Effect and subject interference [10].

Survey/questionnaire: these are the instrument used to collect data in survey research. They usually have standardized questions that focus on a specific topic and cover topics such as demography, opinion, attitude or behavior. The benefit of the survey includes convenience, affordable, and extensive representativeness [10].

Preferred Data Collection Tool

The technique chosen to collect data is observation. The observation technique included measurement of the distance between houses and recording the data. The choice of this technique is based on the need to collect first-hand information. The distance between houses was measured using survey tape measures and the results recorded. The data collected seek to ensure approximate data between houses are collected and recorded. The data collected were primary.

CASE ANALYSIS

Installing cable between buildings can be expensive sometimes especially when there is no defined way to follow. The most suitable solution to solving minimum spanning tree is either by using Kruskal or prim algorithm. However, both methods have challenges based on the size of data to be analyzed. The key challenge of using either of the methods includes simplicity and possibilities to avoiding errors. This study will focus on Kruskal algorithm. The methodology of this study is addressed by a case study to show how the Kruskal algorithm can be used in reducing the cable length when the internet's cables are being installed.

This study utilizes the installed internet cable of the neighborhood. The design of the neighborhood is such that there are combinations of houses separated by roads. The houses are served by two head offices. The design of houses and their layout is as shown in Figure 1.

Figure 1 illustrates MH981 and MH982 are the head office while HH001 to HH005 are houses to be connected to the internet. MH981 and MH982 are the source while HH001 to HH005 are the receivers. MH981 and MH982 would be internet management zone while HH001 to HH005 are the internet consumption base.

Based on

the housing arrangement in Figure 1, there are two neighborhoods each connected to different head offices. These neighborhoods have a combination of houses. The key problem that must be solved is to lay down the cable in such a way that cable length can be minimized. Having a procedural method that can be used to solve tree is very important since it can assist in saving time. In situations where the shortest length needed is determined purely by trial-and-error technique, the result might not be accurate especially when the number of houses in the tree is many.

To carry out the analysis of the Kruskal algorithm all the possible route and connection to the houses must be identified. After identifying the route, the distance for each route is measured. Once the value of each route is known the analysis is carried out through establishing the minimum vertices progressively until all the houses are connected. If the minimum value appears in multiple times, you can select either of them as long as they do not form a cycle. The process repeated for multiple times until minimum spanning tree is formed.

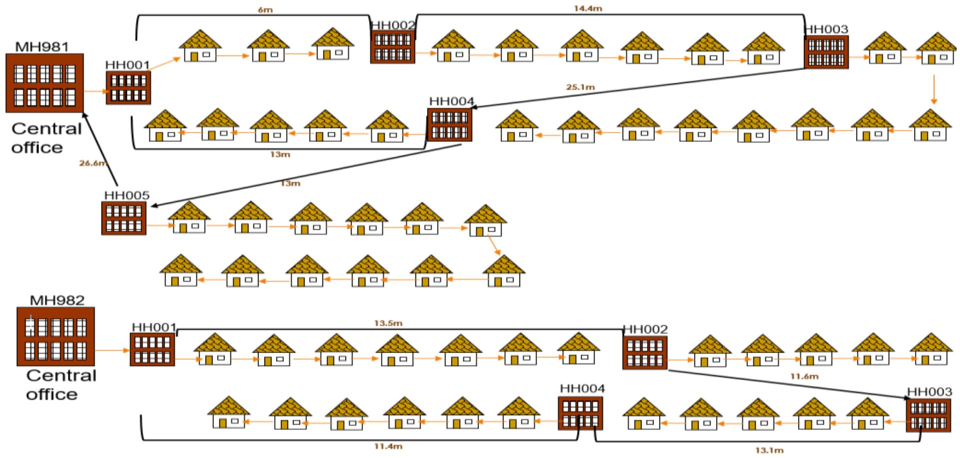

Figure 1: The Houses Layout

RESULT AND DISCUSSION

Final Kruskal Minimum Spanning Tree

The minimum lengths are selected while avoiding forming cycles in the process. The lengthy were obtained progressively. Figure 2 and 3 represent the final minimum spanning tree. The final spanning tree represents the optimized route based on the least length possible. The total size of wire needed according to Kruskal minimization technique in Figure 2 and 3 can be seen that a total of 46.4 meters of cable will be needed for first neighborhood and 38.1 meters for second neighborhood.

If trial and error or nonprocedural technique are considered the following final spanning tree is made. Non-procedural techniques are those techniques that are used to lay down the cable without consideration of proposed techniques such as Kruskal. In this case, the installers rely on guessing and trial and error methods. For example, in laying down the cable, the installer might not consider the length of cable used rather will focus on getting all the houses connected.

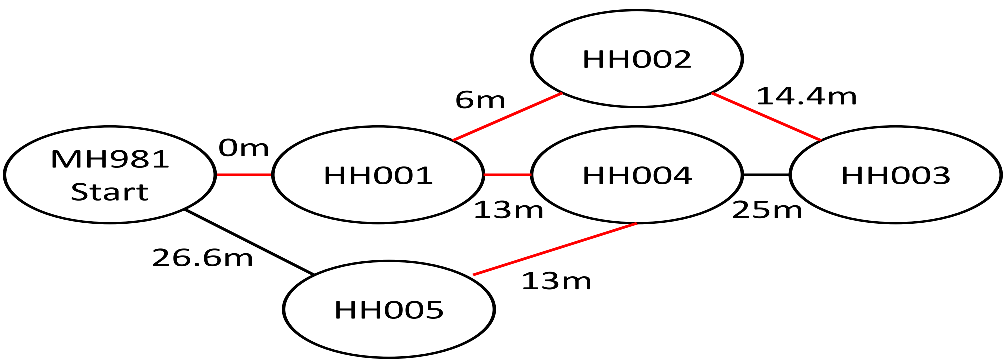

Figure 2: Final Kruskal Minimum Spanning Tree for First Neighborhood (Total Cable Length Needed Is 46.4 Meters)

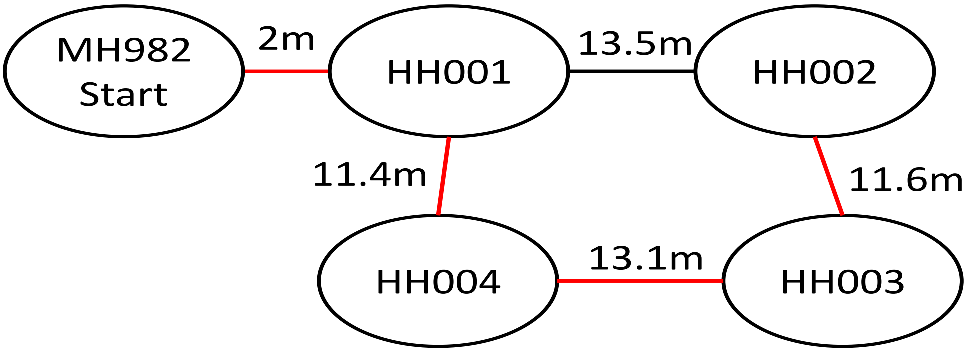

Figure 3: Final Kruskal Minimum Spanning Tree for Second Neighborhood (Total Cable Length Needed Is 38.1 Meters)

Non-Procedural Method 1 Result

The Figure 4 and 5 represent the spanning tree or cable installation layout that has been based on trial and non-theoretical methods. The method using, in this case, is not based on any method, but it was only based on getting each house installed with cables. The method, in this case, was not based on any procedure with any specific aim, but it was based on the fact that cable ought to be installed.

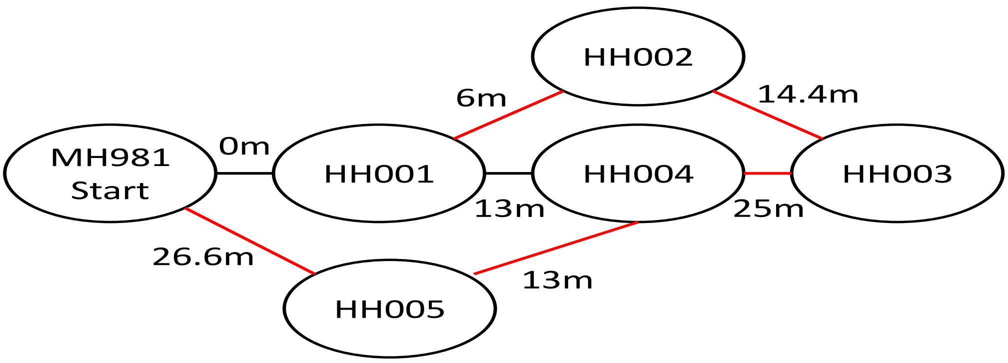

Figure 4: Method 1 Result for First Neighborhood (Total Cable Length Needed Is 85 Meters)

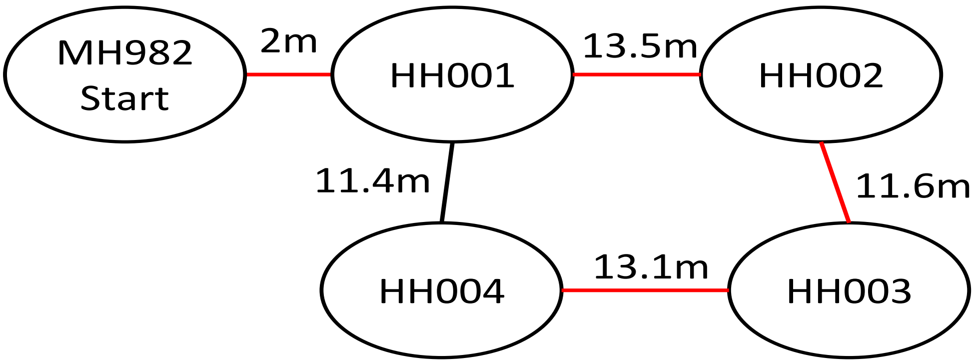

Figure 5: Method 1 Result for Second Neighborhood (Total Cable Length Needed Is 40.2 Meters)

This is one of the final spanning trees that can be obtained from guessing or laying down cable without the following procedure. The total length of wire that would be needed in this case is 85 meters for first neighborhood and 40.2 for second neighborhood. The length in first neighborhood is 83.18% more than Kruskal value in the first neighborhood. The length for second neighborhood when compared to Kruskal final spanning tree is 5.51% more. Having cables installed without agenda usually, result in wastages. Using this method shows how companies waste money when they do not follow proven means when installing the cables. This method act as means of reminding cable installers that there is need to have agenda when doing installation since without an agenda from the beginning there is no way the cable can be installed to be effective in improving the profitability of the company.

Non-Procedural Method 2 Result

Similar to Figure 6 and 7, this is another method that the cables could be installed without following any procedure. In this method, the focus is to get the job done but not to reduce the cost. The installers are more focused on end result rather than how to get to that result. The choice is to get the job done on time without consideration on the length of the cables.

With this tree, the company will be expected to have a total of 83.6 meters and 40 meters of cable for neighborhood 1 and 2 respectively. This amount is equivalent to 80.17% more length of wire than what Kruskal technique promises to offer in first neighborhood and 5% more for second neighborhood. Clearly, it can be noted that using this technique can result to the longer cable being used as compared to using Kruskal technique.

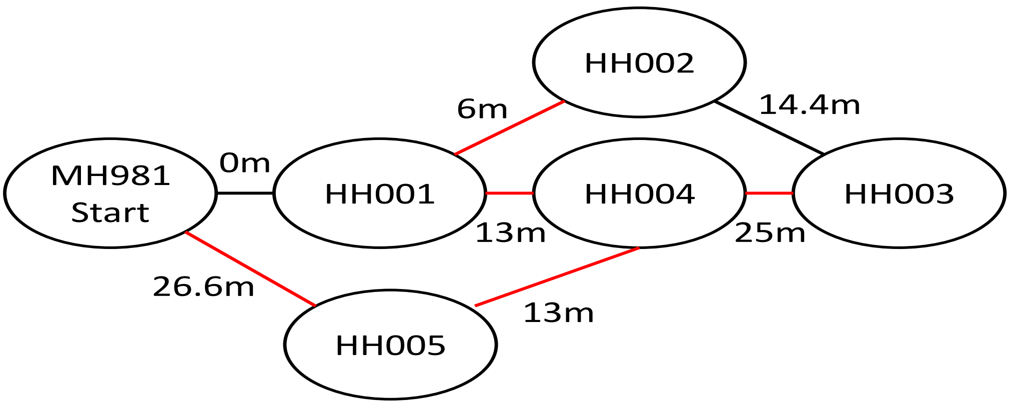

Figure 6: Method 2 Result for First Neighborhood (Total Cable Length Needed Is 83.6 Meters)

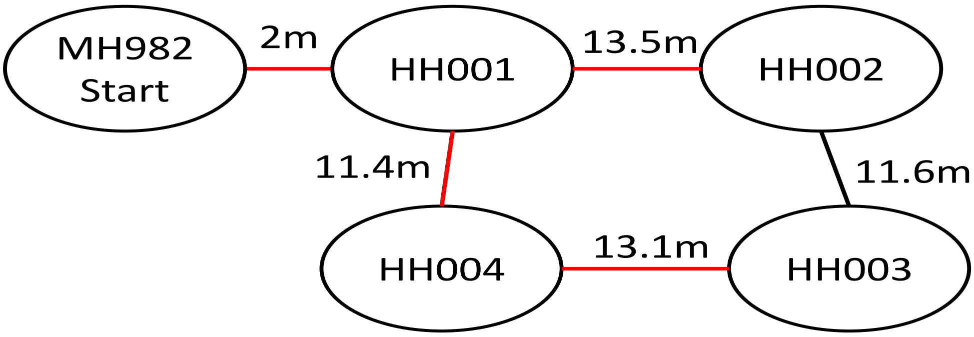

Figure 7: Method 2 Result for Second Neighborhood (Total Cable Length Needed Is 40 Meters)

Therefore, it is advantageous to use Kruskal method since it focuses on reducing cable length and maximizing profit. Nonprocedural method is a method without agenda which only focuses on getting the clients the internet connection. Without goals and agenda from the beginning, there is high chance that wastage cannot be managed effectively and that is why it takes it longer cable to connect houses when compared to Kruskal. The key assumption made in this case study is that there is no cable wastage when installing them. However, in real life scenario cables can be wasted due to need to cutting and reconnecting.

Findings and Discussion

The analysis starts with connecting head office and each house with as many cable directions as possible. The distance for each direction is measured and data recorded on the data collection manual. The main aim of using Kruskal algorithm is to find the minimum length connecting each house to another. If the least length between houses can be identified, the cost of cable can be reduced thus minimizing wastage and maximizing profits. The use of Kruskal algorithm, in this case, was clearly shown to be advantageous since it assisted in reducing the total length of the cable needed. For example, using of random means to establish the route the cable should take when laid lead to wastage of cable by even more than 80% when compared to what Kruskal technique provided. With the assumption that all the cable will be bought from the same supplier regardless of the method used, i.e., non-procedural or Kruskal, it can be seen that Kruskal algorithm offers the best minimum spanning tree that can minimize cable size needed and cost associated with it. Therefore, it is an appropriate method that can be used in maximizing profits.

CONCLUSION

This study demonstrates that the Kruskal algorithm optimal solution is conducted by a procedural selecting minimum length in ascending order. The main rule of the process is to avoid forming a cycle. With Kruskal algorithm, it was clearly shown that the process reduces the cost, especially when compared to a situation where the cable is installed without any proper procedures. However, in a situation where the algorithm has many vertices and edges it can be difficult to identify all weights with the same value.

Generally, Kruskal has advantages, but it has challenges especially when there are so many vertices and edges involved.

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