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Optimisation Of Fibre Optics Connection Pathway in All Main Buildings of UTM Johor Bahru Campus Based on Prim's Algorithm

Noor Shaadah Abdullah Zawawi, Wan Rohaizad Wan Ibrahim
Department of Mathematical Sciences, Faculty of Science, Universiti Teknologi Malaysia
*Corresponding author: wrohaizad@utm.my

Abstract
The transition from copper cable technology to fibre optic has led to significant advancements in data transmission speed and accuracy. However, the installation of fibre optic cables can be costly if not optimized effectively. This research paper focuses on optimizing the fibre optics connection pathway in all main buildings of the UTM Johor Bahru Campus using Prim's algorithm, a minimum spanning tree algorithm. By calculating the minimum spanning tree on the branches used for fibre optic cable installation, this algorithm enables the interconnection of all points according to their designated locations, thereby minimizing the required cable length and reducing excessive costs. The application of Prim's algorithm aids in saving construction expenses associated with fibre optic deployment. The proposed optimization technique based on Prim's algorithm offers a practical solution to enhance the performance and efficiency of fibre optics connectivity in large campus environments.

Keywords: Prim's Algorithm; Optimization; Shortest Path Network; Minimum Spanning Tree;

1. Introduction

The sector of telecommunications has seen a revolution because of the switch from conventional copper cable technology to fibre optics, which allows for quick and precise data transmission (Aggarwal & Moore, 1994). The installation of fibre optics is becoming more crucial as the demand for high-speed internet connectivity rises (Nyarko-Boateng et al., 2020). However, installing fibre optics is expensive, which is a major obstacle. It is crucial to optimise the fibre optic connection line effectively and economically to overcome this problem (Yang & Ren, 2010).

This research examines how to best connect fibre optics to all of the campus's major buildings at the Universiti Teknologi Malaysia (UTM) Johor Bahru campus. The campus needs reliable, fast internet service to assist numerous academic and administrative tasks because it is a centre for educational and research activity. Using Prim's algorithm, a popular minimum spanning tree approach, this research seeks to identify the most advantageous and economical path for tying the principal buildings together with fibre optic cables.

The research focuses on the utilization of Prim's algorithm for the optimization of fiber optics connection pathways in all main buildings of UTM Johor Bahru Campus. The application of Prim's algorithm aims to determine the most efficient and cost-effective route for installing fiber optics cables, thereby ensuring high-speed internet coverage throughout the campus while minimizing installation expenses (Dian Sano et al., 2020).

The main goal of this research is to keep the overall cost of the fibre optics installation as low as possible while maintaining dependable and fast internet connectivity across the campus. By using

Prim's algorithm, this research can determine the minimum spanning tree that, considering elements like cable length, accessibility, and network requirements, connects all the buildings for the lowest total cost. The results of this study will have a big impact on the UTM Johor Bahru Campus since this research will give important knowledge on how to optimise network connectivity and fibre optic installation. The implementation of Prim's algorithm is anticipated to result in cost savings, increased effectiveness, and improved internet connectivity throughout the university.

Overall, this study seeks to contribute to fibre optics optimisation by offering useful tips and suggestions for ensuring economical and effective connectivity in campus settings. This research can fully utilise fibre optics technology and open the door for improved communication infrastructure in educational institutions like UTM Johor Bahru Campus by utilising Prim's algorithm.

Materials and methods

Prim's algorithm is a popular minimum spanning tree algorithm that can be used to optimize the connection of nodes in a network (Yang & Ren, 2010). The algorithm works by iteratively adding edges to build a spanning tree with the minimum total weight or cost (Chang et al., 2010). In the context of fibre optics installation and network connectivity optimization, Prim's algorithm can be applied to determine the most efficient and cost-effective pathway for connecting nodes or buildings within a campus. The algorithm starts with an initial node and repeatedly selects the edge with the minimum weight that connects a node already included in the tree to a node not yet included. By doing so, it gradually expands the tree, ensuring that the minimum weight connections are added at each step (Kumar, 2015). When applied to the installation of fibre optics, the nodes represent the different buildings or points where the cables need to be connected. The weight of each edge corresponds to the cost or distance associated with laying the fibre optic cable between two nodes. Prim's algorithm allows for the optimization of the connection pathway by selecting the edges with the lowest cost at each step (Aggarwal & Moore, 1994). This ensures that the fibre optic cables are laid in the most efficient and cost-effective manner, minimizing unnecessary cable usage and reducing installation expenses. The data used for this research are from the coordinates of the main buildings in Universiti Teknologi Malaysia (UTM) Johor Bahru Campus.

The main buildings consist of the main offices of the 14 faculties in UTM Johor Bahru namely are Centre for Information and Communication Technology, Faculty of Civil Engineering, Faculty of Mechanical Engineering, Faculty of Electrical Engineering, Faculty of Chemical and Energy Engineering, Faculty of Bioscience and Energy Engineering, Faculty of Computing, Faculty of Science, Faculty of Built Environment and Surveying, Faculty of Social Sciences and Humanities, Faculty of Education, Faculty of Islamic Civilisation, UTM Space and Faculty of Management. Apart from the main buildings of faculties, there are 10 main buildings of UTM Johor Bahru colleges. The lists are Kolej Tun Fatimah (KTF), Kolej Rahman Putra (KRP), Kolej Tun Razak (KTR), Kolej Tun Hussein Onn (KTHO), Kolej Tuanku Canselor (KTC), Kolej Tun Dr Ismail (KTDI), Kolej 9 (K9) & Kolej 10 (K10), Kolej Perdana (KP), Kolej Datin Seri Endon (KDSE) and Kolej Dato Onn Jaafar (KDOJ).

Table 1: The coordinates of the main buildings

Number	X	Y
0	22	29
1	39	34
2	50	58
3	63	20
4	77	53
5	83	26
6	96	45
7	20	56

Number	X	Y
12	145	138
13	157	117
14	157	72
15	190	77
16	210	80
17	177	21
18	207	121
19	142	20

8	47	78
9	80	76
10	115	96
11	37	124

20	128	13
21	100	20
22	121	23
23	67	61

2.0 Results and discussion

In this research project, the focus is on implementing Prim's algorithm to calculate the minimum distance required to connect all the main buildings in UTM Johor Bahru campus. The algorithm is applied to a set of given locations represented as nodes in a graph. By calculating the Euclidean distance between each pair of locations, the program generated the necessary edges to form the Minimum Spanning Tree (MST) of the graph.

$$d(x,y) = \sqrt{\sum_{i=1}^{n}(y_i - x_i)^2} \quad (1)$$

x, y = two points in Euclidean n-space

y_i, x_i = Euclidean vectors, starting from initial point

n = n-space

By using the programming language of C++, the generateMST function utilizes the fiberOpticRoute map to retrieve the distance between two locations. It then constructs the MST by adding the minimum weight edges and continues the process until all locations are visited.

Table 2: Minimum Spanning Tree Edges of Main Building in UTM Johor Bahru

Location 0 to Location 1
Location 1 to Location 2
Location 2 to Location 23
Location 23 to Location 4
Location 23 to Location 9
Location 2 to Location 8
Location 4 to Location 6
Location 6 to Location 5
Location 5 to Location 21
Location 21 to Location 22
Location 22 to Location 20
Location 20 to Location 19
Location 5 to Location 3
Location 0 to Location 7
Location 19 to Location 17
Location 9 to Location 10
Location 10 to Location 13
Location 13 to Location 12
Location 13 to Location 14
Location 14 to Location 15
Location 15 to Location 16
Location 16 to Location 18

Location 8 to Location 11

The generated visual representation of the Minimum Spanning Tree (MST) provides valuable insights into the connectivity of the main buildings in UTM Johor Bahru campus. The MST highlights

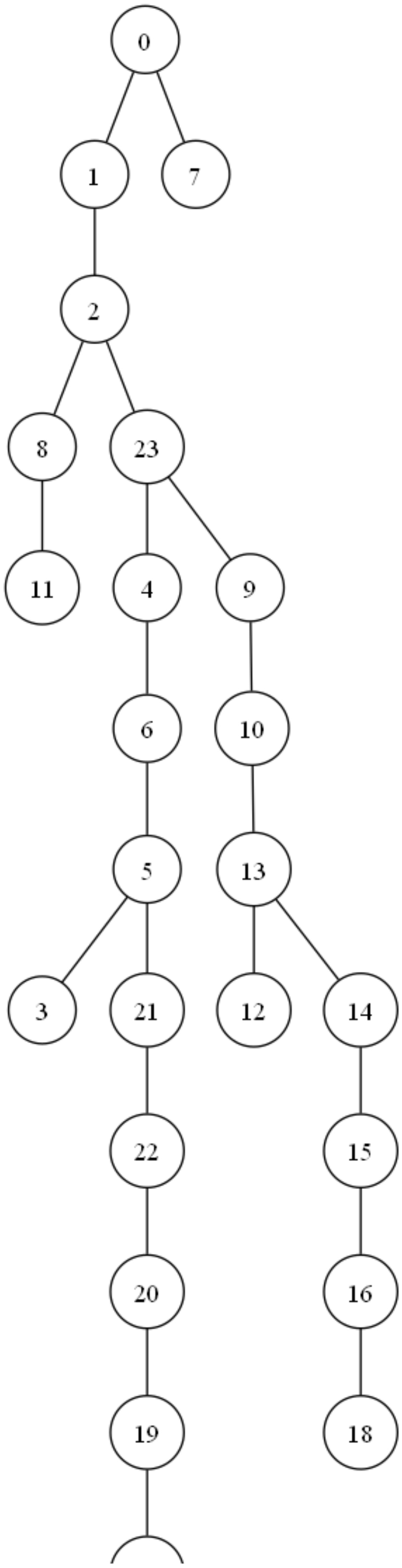

Figure 1: The nodes and edges of Main Buildings from MST

the most efficient and direct routes between the buildings, revealing the key connections required for seamless navigation across the campus.

Conclusion

The research outcome from this research provides a comprehensive understanding of Prim's algorithm and its application in generating a Minimum Spanning Tree (MST) for fibre optics network of main buildings in UTM Johor Bahru campus. The codes successfully calculate the distances between the buildings and generate the MST, which represents the optimal connectivity between the buildings. The MST also provides insights into the relative importance and influence of each building in the campus network. Buildings with higher degrees of connectivity, appearing as central nodes in the MST, can be considered key hubs in the campus infrastructure. They serve as pivotal points for communication and movement, contributing to the overall efficiency and functionality of the campus.This research contributes to the existing body of knowledge in multiple ways. Firstly, it showcases the practical implementation of Prim's algorithm, a widely used algorithm in network optimization, specifically in the context of campus infrastructure. The code provides a clear example of how to calculate distances between locations and generate an MST using a priority queue. This knowledge can be valuable for researchers, students, and practitioners interested in network optimization and graph algorithms.

Overall, the research outcome presented by these codes offers a solid foundation for further exploration and improvement in campus infrastructure planning. By continuing to refine and expand upon these findings, researchers can contribute to the development of more efficient, sustainable, and user-friendly university campuses.

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