CHAPTER 5

OPTIMIZING TRAVEL ROUTES IN MELAKA

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5.0 INTRODUCTION

Optimizing travel routes is a well-known application of graph theory, aimed at determining the most efficient path that connects multiple key locations while minimizing total travel distance. In urban areas, such as the city of Melaka, transportation networks consist of numerous interconnected roads, each with varying distances and travel times [1]. Identifying the optimal routes within these networks is essential for reducing travel costs, improving traffic flow, and enhancing overall accessibility [2].

One major advantage of utilizing Minimum Spanning Tree (MST) in transportation planning is its ability to minimize infrastructure costs while maintaining full connectivity. Unlike shortest path algorithms that focus on a single source-destination pair, MST ensures that all key locations are connected with minimal total road distance [3]. This is particularly beneficial for cities like Melaka, where tourism and commercial activities heavily rely on well-structured road networks.

Graph-based techniques provide a structured approach to modeling these networks, where locations are represented as nodes and roads as weighted edges. By applying appropriate algorithms, it becomes possible to construct an optimized travel route that minimizes the total distance while ensuring complete connectivity between key destinations. To achieve this, Prim's Algorithm and Kruskal's Algorithm were applied to construct a MST, a fundamental concept in graph theory that connects all nodes with the least possible total edge weight [4]. MST ensures that all locations within the network remain connected without unnecessary redundancies, making it a valuable tool in transportation planning. In this study, MST will be constructed using both Prim's and Kruskal's algorithms.

5.1 METHODOLOGY

The optimization of travel routes in Melaka is a fundamental application of graph theory, aiming to identify the most efficient path connecting multiple key destinations while reducing overall travel distance. This study examines the links between Bandar Hilir, Perigi Hang Tuah, Zoo Melaka, and A Famosa using graph-based methods.

To construct a MST with the shortest possible travel distance, Prim's and Kruskal's algorithms were implemented. The road network is modeled as an undirected, weighted graph, where nodes signify locations, edges represent roads, and edge weights indicate travel distances. In this study, Graph Online [5] was used to create an undirected, weighted graph, as illustrated in Figure 5.1. This graph provides a visual representation of all regions within. The nine nodes symbolize the nine regions, while the edges denote the routes linking these regions. The weights assigned to the edges indicate the travel distances in kilometers (km) between the respective regions. Table 5.1 lists these edges and their corresponding weights.

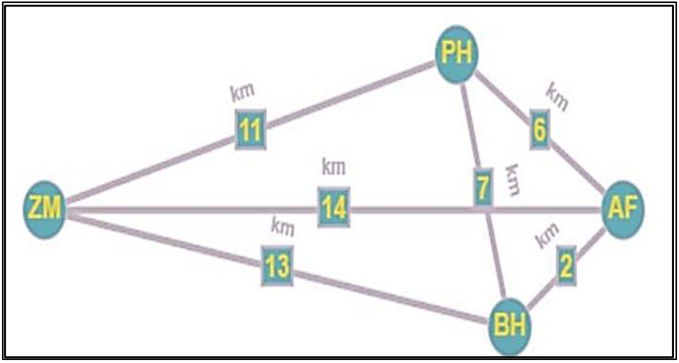

Figure 5.1: An undirected weighted graph representing the regions in Melaka.

The following are the abbreviations to represent each region.
BH - Bandar Hilir
PH - Perigi Hang Tuah
ZM - Zoo Melaka
AF - A Famosa

Table 5.1: All edges and weights

No.	Edges	Weight (km)
1	ZM - PH	11
2	ZM - AF	14
3	ZM - BH	13
4	PH - BH	7
5	PH - AF	6
6	AF - BH	2

5.1.1 Prim's Algorithm

Prim's algorithm builds a MST by starting at a single node and growing the tree one edge at a time. At each step, the algorithm selects the edge with the smallest weight that connects a node already in the tree to a node outside the tree. Prim's algorithm operates using a priority queue to efficiently select the minimum-weight edge at each step. The algorithm begins by choosing an arbitrary starting node and initializing the MST with this node.

Table 5.2: Calculation using Prim's Algorithm

Iteration	Edges	Visited vertices	Unvisited vertices	Weight (km)
1	ZM - PH	ZM, PH	AF, BH	11
2	PH - AF	ZM, PH, AF	BH	6
3	AF - BH	ZM, PH, AF, BH		2
Total Weight				19

Based on Table 5.2, the MST constructed using Prim's algorithm connects all four regions in Melaka with three edges and a total weight of 19 km.

5.1.2 Kruskal's Algorithm

Kruskal's algorithm sorts all the edges by weight and then adds them one by one to the MST. The algorithm avoids cycles, ensuring only the minimum edges are added, ensuring that the final spanning tree connects all vertices with the least possible total edge weight. The algorithm terminates when exactly $V - 1$ edges have been added, where V is the number of vertices in the graph [6].

Table 5.3: Calculation using Kruskal's Algorithm

Iteration	Edges	Visited vertices	Unvisited vertices	Weight (km)
1	AF - BH	AF, BH	ZM, PH	2
2	PH - AF	AF, BH, PH	ZM	6
3	ZM - PH	AF, BH, PH, ZM	-	11
Total Weight				19

Using Kruskal's Algorithms, the optimal path connecting all four locations was determined to be: ZM → PH → AF → BH. The algorithm resulted in a MST with a total travel distance of 19 km, proving their effectiveness in solving such optimization problems.

5.2 CONCLUSION

The study demonstrated the application of graph theory to real-life travel route optimization in Melaka. Both Prim's and Kruskal's Algorithms resulted in the same MST, which confirms their reliability in optimizing travel routes in Melaka, with a total distance of 19 km. This analysis underscores the usefulness of graph-based approaches in practical logistics and transportation planning. However, Prim's Algorithm is generally more efficient for dense graphs, whereas Kruskal's Algorithm performs well for sparse graphs [7]. In future studies, additional factors such as real-time traffic data, road conditions, and weather impact should be considered to improve route optimization further.

5.3 REFERENCES

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