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Increasing package delivery efficiency through the application of the prim algorithm to find the shortest route on the expedition route

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ABSTRACT

One of the changes is in terms of shopping. Previously, people shopped through physical stores, but since the emergence of online shopping platforms, people have started to switch to using the marketplace as a place to make buying and selling transactions. This platform utilizes expedition services to send packages in the form of ordered goods from sellers to buyers. This activity presents a new problem, which is related to the efficiency of package delivery by courier services so that goods can arrive as quickly as possible in the hands of buyers. Graph modeling to solve a problem related to the shortest path and the fastest path is adapted in this paper. The algorithm used is Prim's Algorithm, which is an algorithm to determine the minimum spanning tree of a connected weighted graph. The test results show that the algorithm is suitable for increasing packet delivery efficiency by determining the shortest path based on the minimum spanning tree concept. By taking a sample of travel routes on the island of Java, the best route was obtained with a total distance of 1,771 kilometers connecting cities from the city of Jakarta to the city of Banyuwangi.

1. Introduction

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The emergence of the digital era has an impact on various fields of human life, one of which is the economic field. The internet and gadgets that are growing rapidly have made changes to the pattern of people's economic life, namely in terms of shopping. Currently, various online shopping platforms have been widely used by the world community, including in Indonesia. On this platform, people can shop across regions easily from their homes.

Online shopping platforms utilize expedition services to distribute goods from sellers in a marketplace to buyers. This platform allows someone who is in an area to sell or buy goods from other areas with a product packaging system [1]. Globally, Indonesia ranks first in online shopping activities through e-commerce [2]. The ease of transactions is one of the causes of people's consumptive behavior [3]. This activity presents a new problem, which is related to the efficiency of package delivery by courier services so that goods can arrive as quickly as possible in the hands of buyers.

Prim's algorithm is an algorithm developed by Robert Clay Prim in 1957 to determine the minimum spanning tree of a weighted connected graph [4]. A weighted graph is a graph that has a value on each side, where the price depends on the problem being modelled [5]. Globally, Indonesia ranks first in online shopping activities Prim's algorithm is used to solve the MST (Minimum Spanning Tree) problem on a graph to minimize branching through e-commerce [6]. The connected weighted graph is a model that is built from the representation of the existing path on the network. One of the uses of graphs as a model is the problem of the shortest path and the fastest path. In connection with this, in this article, we will discuss the application of Prim's Algorithm to determine the shortest path on the expedition route.

1.1. Literature Review

Amin et al [7] in their research entitled "Minimum Spanning Tree Visualization Using the Kruskal and Prim Algorithm" concluded that the two algorithms produce the same tree structure, although through different compilation processes. The application of the graph as a model is not limited to the problem of the shortest path and the fastest path. The graph is also used as a model for electricity network problems as discussed by Riswan [8] in his research entitled "Determination of Minimum Distances in an Electric Network with Prim Algorithm and QM for Windows (Case Study on Fishermen's Housing in Palopo City)".Based on the research of Suhika et al. [9] entitled "Optimizing Fiber Optic Cabling Plans at ITERA with Prim's Algorithm", this algorithm can be used as a method to find the optimal network at ITERA FO so as to minimize FO cable installation costs. In addition, a recent study by Dili et al [10] entitled "Solving Transportation Problems to Find Optimal Solutions with a Minimum Spanning Tree (MST) Approach Using the Kruskal Algorithm and Prim's Algorithm" resulted in the conclusion that the use of

Prim's Algorithm resulted in a more optimal solution than the Kruskal's Algorithm. in transportation problems with the MST approach.

2. Method

2.1. Graph

A graph is defined as: G = (V, E), where V is a non-empty set of every vertex in the set {v1, v2, ..., vn} and E is the set of edges connecting a pair of vertices in the set {e1, e2, ..., en}. Some basic terminology in graphs that you need to know include:

a. A weighted graph is a graph in which each edge is assigned a weight.
b. Neighboring means that two vertices in an undirected graph if they are connected by an edge. It can be said, if v1 and v2 neighbors, then there must be a side (v1, v2).
c. Side by side means for any side e = (v1, v2), sisi e is said to be adjacent to the dot v1 and v2.
d. Cycle means a path whose starting and ending vertices are the same.
e. A tree is a connected graph with n-1 sisi and n knot.

2.2. Prim Algorithm

Prim's algorithm is used to find the minimum spanning tree of a weighted connected graph by taking the edge/line segment that has the smallest weight from the graph, where the line segment is adjacent to the spanned tree that has been created and does not form a cycle [11]. The steps performed in Prim's Algorithm are as follows:

1) Take an arbitrary vertex (let's say v1 ∈ G) and insert the vertex into graph T which is an empty graph.
2) Add one edge connected to v1 with the least weight (let's say e1) and the other endpoints are connected to T so that T consists of an edge e1 and two vertices which are endpoints of side e1 (one endpoint must contain node v1).
3) In the next step, choose an edge in E(G) that is not E(T) with the following conditions:
   a) The edge connects one of the vertices V(T).
   b) The side has minimal weight.
4) Repeat steps 2 and 3 so that you get (n-1) the inner edge of E(T) where n is the number of vertices in graph G. In other words, repeat the iteration (n-2) times.

2.3. Minimum Spanning Tree

A tree is a connected graph that does not contain circuits. Several trees can form a forest (forest), which is a collection of trees that are separated from each other. This tree concept has wide application, both within computer science and outside the field of computer science. If G is a weighted graph, then the weight of the

spanning tree T of G is defined as the sum of the weights of the edges in T. Different spanning trees have different weights. Among all spanning trees in G, the spanning tree with the minimum weight is called the minimum spanning tree. The minimum spanning tree approach using Prim's Algorithm is as follows:

1) Enter the source and destination into the node.
2) Fetch any node.
3) Select all the uncrossed edges from that node into the active edge as long as the edges have no circuits.
   a) If the edge has no circuit, go to step 4.
   b) If the edge has a circuit, take the next edge.
4) Select the node with the smallest edge in the active edge.
5) Mount it into the tree.

2.4. Pseudocode

The following is the pseudocode of the Prim. Algorithm Procedure Prim (input G: graph, output T: Tree)

{Forming a minimum spanning tree T from a connected graph G } Enter: connected weighted graph G = (V, E) where |V| = n

Output: minimum spanning tree T = (V, E′)

Declaration

i, p, q, u, v: integer

Algorithm

Find the side (p, q) of E that has the least weight T ← {(p, q)}
For i ← 1 to n-1 do
Choose the edge (u, v) of E that has the least weight but is adjacent to a vertex in T
T ← T U {(u, v)}
End for

3. Results and Discussion

Based on the concepts that have been described, in this study a sample of existing travel routes on the island of Java was taken.

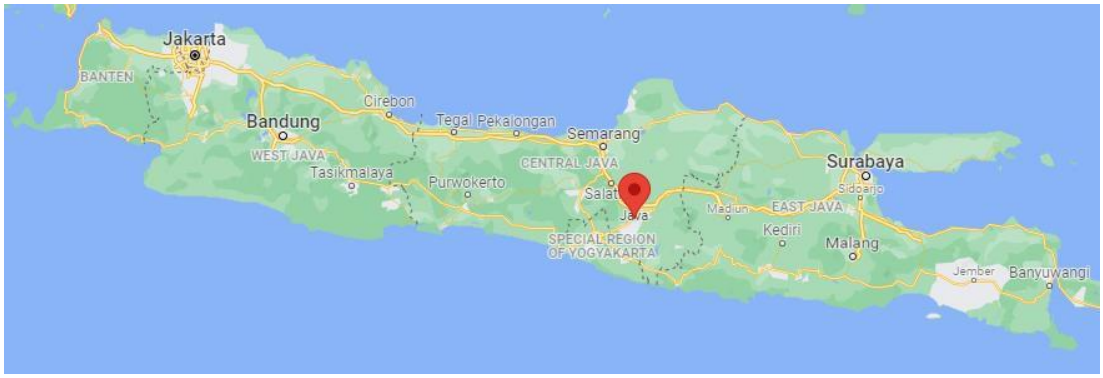

Figure 1. Travel Routes in Java (Source: Google Maps)

The following are the steps to determine the best route based on the minimum spanning tree model in Prim's Algorithm which is described using a flowchart:

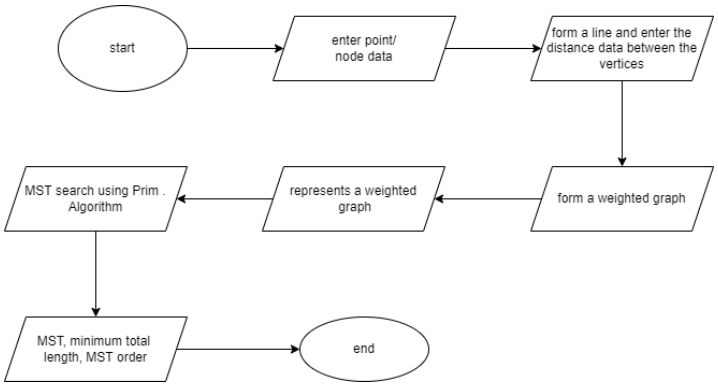

Figure 2. Flowchart Method

Based on the travel route used, a connected weighted graph model can be made as follows:

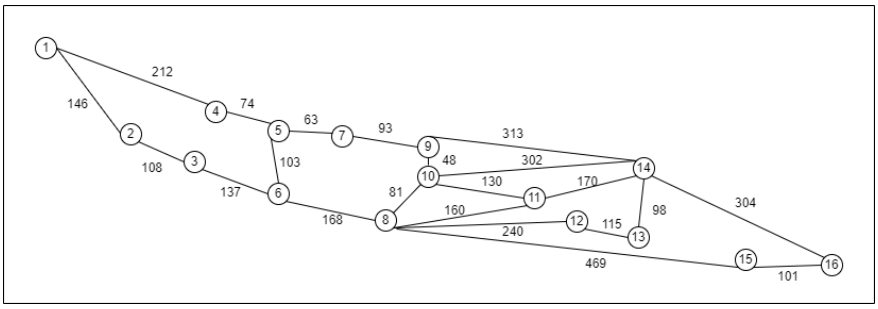

Figure 3. Graph of Travel Route in the Java Island

In this graph, the cities in Figure 1 are represented as nodes with numbers 1 s.d. 16 and has an edge with a weight that represents the distance from one city to another according to the vertices that represent the city.

Table 1. City and Nodes

City Name	Node Number	City Name	Node Number
Jakarta	1	Semarang	9
Bandung	2	Salatiga	10
Tasikmalaya	3	Madiun	11
Cirebon	4	Kediri	12

Tegal	5	Malang	13
Purwokerto	6	Surabaya	14
Pekalongan	7	Jember	15
Yogyakarta	8	Banyuwangi	16

The process of applying Prim's Algorithm to determine the minimum spanning tree consists of several steps, namely.

Step 1. Select an edge (9, 10) with a weight of 48 so that a T(9, 10) is formed.

Step 2. Select an edge (8, 10) with a weight of 81 so that a T(8, 9, 10) is formed.

Step 3. Select the side (7, 9) with a weight of 93 so that it forms T(7, 8, 9, 10).

Step 4. Select the side (5, 7) with a weight of 63 so that it forms T(5, 7, 8, 9, 10).

Step 5. Select the side (4, 5) with a weight of 74 so that it forms T(4, 5, 7, 8, 9, 10).

Step 6. Select the side (5, 6) with a weight of 103 so that it forms T(4, 5, 6, 7, 8, 9, 10).

Step 7. Select the side (10, 11) with a weight of 130 so that it forms T(4, 5, 6, 7, 8, 9, 10, 11).

Step 8. Select the side (3, 6) with a weight of 137 so that it forms T(3, 4, 5, 6, 7, 8, 9, 10, 11).

Step 9. Select a side (2, 3) with a weight of 108 so that it forms T(2, 3, 4, 5, 6, 7, 8, 9, 10, 11).

Step 10. Select the side (1, 2) with a weight of 146 so that it forms T(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11).

Step 11. Select the side (11, 14) with a weight of 170 so that it forms T(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14).

Step 12. Select the side (13, 14) with a weight of 98 so that it forms T(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14).

Step 13. Select the side (12, 13) with a weight of 115 so that it forms T(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14).

Step 14. Select the side (14, 16) with a weight of 304 so that it forms T(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 16).

Step 15. Select an edge (15, 16) with a weight of 101 so that it forms T(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16).

After performing the above process, the following minimum spanning tree is formed.

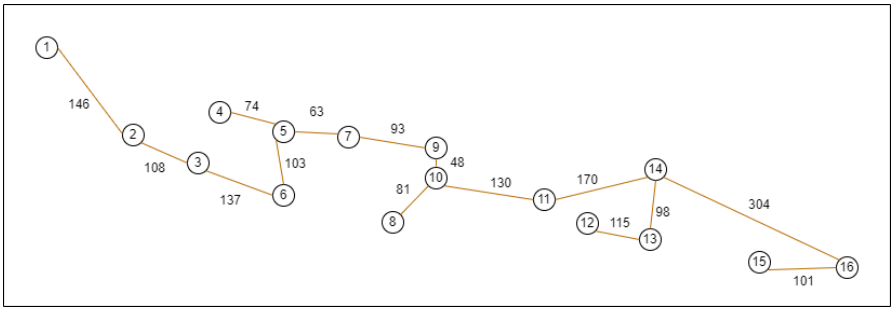

Figure 4. Minimum Spanning Tree

The minimum spanning tree represents the best route that can be used as an expedition route in Java that connects the cities listed in Figure 1. The resulting total weight is 1,771 or equivalent to 1,771 kilometers.

4. Conclusion

Based on the results that have been described, it can be concluded that Prim's Algorithm is suitable for increasing packet delivery efficiency by determining the shortest path based on the minimum spanning tree concept. By taking a sample of travel routes on the island of Java, the best route is obtained with a total distance of 1,771 kilometers that connects cities from the city of Jakarta to the city of Banyuwangi. After carrying out a series of tests, it is hoped that there will be other research with more accurate data and the use of algorithms that have been modified to be more efficient in order to obtain better and more accurate results when applied in the future.

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