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The implementation of the Kruskal algorithm for the search for the shortest path to the location of a building store in the city of Bogor

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Abstract. The shortest path is a very important thing in a business sector, especially in sending goods by land. One of the obstacles faced in the shipment of goods is the determination of the trajectory. Determining the best trajectory can minimize shipping costs and time is more efficient A designated algorithm or system is required to search for the shortest and the most optimal traffic path from various numbers of existing alternative pathways. The Kruskal algorithm is one of the algorithms used in solving minimum spanning tree problems by choosing the side that has the smallest weight of each node with the notes that the selected sides cannot form a closed circular. For Case on study, we used data activities is controlled by land transportation from PT. T A. The results showed that with the application of the Kruskal algorithm in the case of finding the closest route to the building store for shipping goods, the optimal path was obtained. The distances of the 12 data that was tried there were 83% data which were smaller than the google map direction API.

1. Introduction

Determination of the trajectory for the delivery of goods is very necessary. in a business sector, especially in sending goods by land. PT T A is a company engaged in the distribution of goods. One of the obstacles faced in the shipment of goods is the determination of the trajectory. Determining the best trajectory can minimize shipping costs and time is more efficient. One of the best pathways is to find the shortest path on the distribution path. The shortest path can be calculated using graph theory. The Kruskal algorithm is one of the algorithms in graph theory in finding the minimum spanning tree to connect each tree in a forest [1]. The basic rule of the Kruskal algorithm is that you have to choose the side that has the smallest weight of each node with the note that the selected sides cannot form a closed circular [2].

The city of Bogor is one of the cities that has very many trajectories or lanes so that to carry out goods delivery requires a lot of time and cost. This paper aims to implement the Kruskal algorithm for the search for the shortest path to the location of a building shop in the city of Bogor and compare the distance obtained by using the Kruskal method and Google map direction Formatting the title, authors and affiliations Please follow these instructions as carefully as possible so all articles within a conference have the same style to the title page. This paragraph follows a section title so it should not be indented.

2. Research Methods

2.1 Graph

The concept of graph theory was first introduced in 1736 to solve the problem of the Königsberg Bridge. The Königsberg bridge problem asks if the seven bridges of the city of Königsberg (left Figure; Kraitchik 1942), formerly in Germany but now known as Kaliningrad and part of Russia, over the river Preger can all be traversed in a single trip without doubling back, with the additional requirement that the trip ends in the same place it began. This is equivalent to asking if the multigraph on four nodes and seven edges (right Figure) has an Eulerian cycle. This problem was answered in the negative by Euler (1736), and represented the beginning of graph theory. Graph G is defined as a set of pairs (V, E) written with a notation G = (V, E), which in this case V is a non-empty set of vertices (vertices) and E is a set of connecting edges a pair of knots[3].

a. Trees

A tree is a data structure made up of nodes or vertices and edges without having any cycle. The tree with no nodes is called the null or empty tree. A tree that is not empty consists of a root node and potentially many levels of additional nodes that form a hierarchy. As an example in Figure 1 graph G there are 2 articles, including v1v2v3v6 and v3v4v5, therefore graph G is not a tree. In Figure 1 an example of a number of trees and not trees is given.

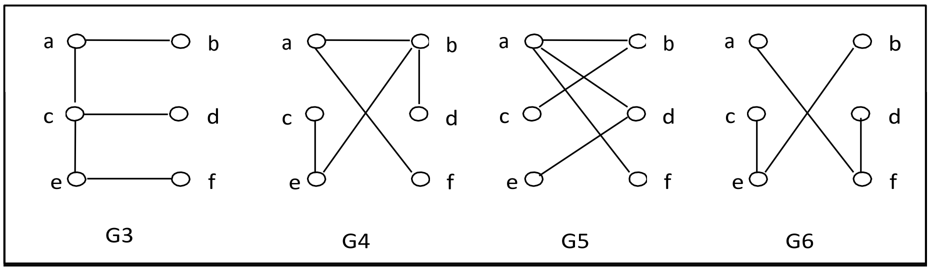


Figure 1. G3 and G4 are a tree, G5 and G6 are not trees

In the example of Figure 1, G3 and G4 are said to be a tree because all the nodes contained in the graph are connected and in G3 and G4 do not contain the particle subgraph. While G5 and G6 are not trees, because even though all vertices in the G5 graph are connected but there are The particle is adf and node in G6 graph is not connected all.

b. Minimum Spanning Tree

A forest is a circuitless graph. A tree is a connected forest. A subforest is a subgraph of a forest. A connected subgraph of a tree is a subtree. A spanning tree of a connected graph is a subtree that includes all the vertices of that graph. Figure 4 is an illustration of a spanning tree T1, T2, T3, and T4 derived from the G7 graph.

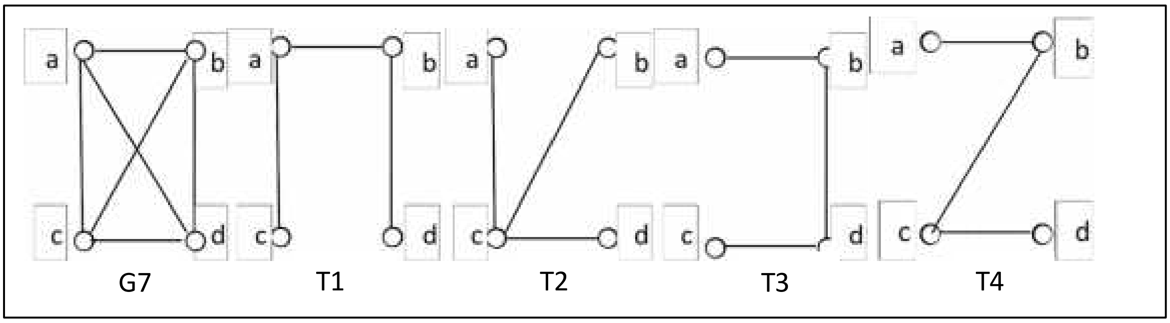


Figure 2. G7 is a graph and T1, T2, T3, and T4 are trees

In Figure 2, it can be seen that G7 is a connected graph and T1, T2, T3, and T4 are spanning tree from G7 graph. The spanning tree has a minimum weight called the minimum spanning tree, as given by Figure 3.

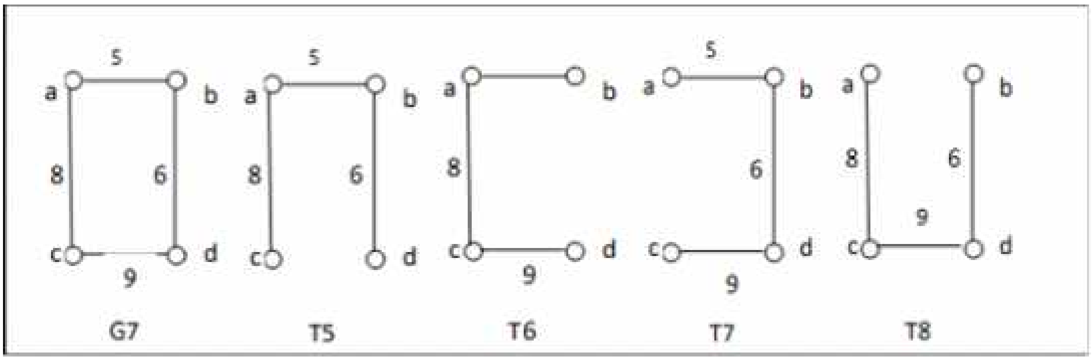


Figure 3. G7 is a simple graph that is connected and weighted,
T5, T6, T7, and T8 is a spanning tree

In Figure 3, it can be seen that G7 is a simple graph that is connected and weighted, that is the weight of each side is 5, 6, 8, 9 and the total weight is 28. The spanning tree T5, T6, T7, and T8 is a spanning tree from G7. The total weight of T5 is 19, the total weight of T6 is 22, the total weight of T7 is 20, and the total weight of T8 is 23. So it can be said that T5 is the minimum spanning tree because the weight of T5 is the smallest weight among the other trees [4].

2.2 Kruskal Algorithm

The Kruskal algorithm is one of the algorithms used in solving the problem of minimum spanning trees that can be applied in various fields of daily life with the aim of optimization. To solve the problem of finding the shortest path using the kruskal algorithm [5] follows the basic rules of the algorithm shown in pseudocode as follows:

```
MST-KRUSKAL(G, w)
A ← Ø
for each vertex v ∈ V[G]
    do MAKE-SET(v)
sort the edges of E into nondecreasing order by weight w
for each edge (u, v) ∈ E, taken in nondecreasing order by weight
    do if FIND SET(u) ≠ FIND SET(v)
        then A ← A ∪ {(u, v)}
            UNION(u, v)
return A
```

2.3 Determination of the cost between two related points

For each node taken from the point of crossing the road to be passed. To determine the cost between two related points is searched by using google maps direction by looking at the distance from point s to n. The result of measuring the value of cost between two interconnected nodes is the cost node to a is 500m, as illustrated in Figure 4.

2.4 Identification of Problems

To determine the closest path to the location of a building store in the city of Bogor Indonesia, by analyzing the data that has been obtained by finding the shortest path from s (the starting point is on Kranggan No. 100 Keranggan Road, Gunung Putri, Bogor) to 12 store locations with through several nodes from the path graph as in Figure 7. The 12 store locations in Bogor are:

p1 (toko Subur Jaya, Jl. Raya Tajur No. 315 Kec. Bogor Timur, Kota Bogor)	p7 (TB. Pandu Makmur , Jl. Tegal Gundil Kec. Bogor Utara)
p2 (TB. Hutan Mas, Jl. Raya Tajur Ciawi Kec. Bo gor Timur)	p8 (TB. Jawa Jl. Raya Bogor Kedung Halang Km. 55 No. 225 Kec Bogor Utara)
p3 (TB. Kurnia Jl. Raya Tajur No. 63A Pakuan, Kec. Bogor Selatan)	p9 (TB. Abadi Jaya Toko, Jl. Sindang Barang No. 61 Gunung Batu, Kec. Bogor Barat)
p4 (TB. Setia Makmur, Jl. Pahlawan No. 183 Bondongan, Kec, Bogor Selatan),	p10 (TB. Sarana Bangunan, Jl. Raya Semplak No. 196 Atang Senjaya Kemang, Kec. Bogor Barat)
p5 (TB. Prapatan Tegal Lega, Jl. Tegal Lega No. 1, Kec. Bogor Tengah)	p11 (TB. Wahana Agung , Jl. Raya Cibadak - Ciampea Cibadak Tanah Sareal Kota Bogor)
p6 (TB. Setia Abadi, Jl. Pengadilan No. 1 DD Kec. Bogor Tengah)	p12(TB. Purba , Jl. Kayu Manis No. 85 Cibadak Kec. Tanah Sareal Kota Bogor)

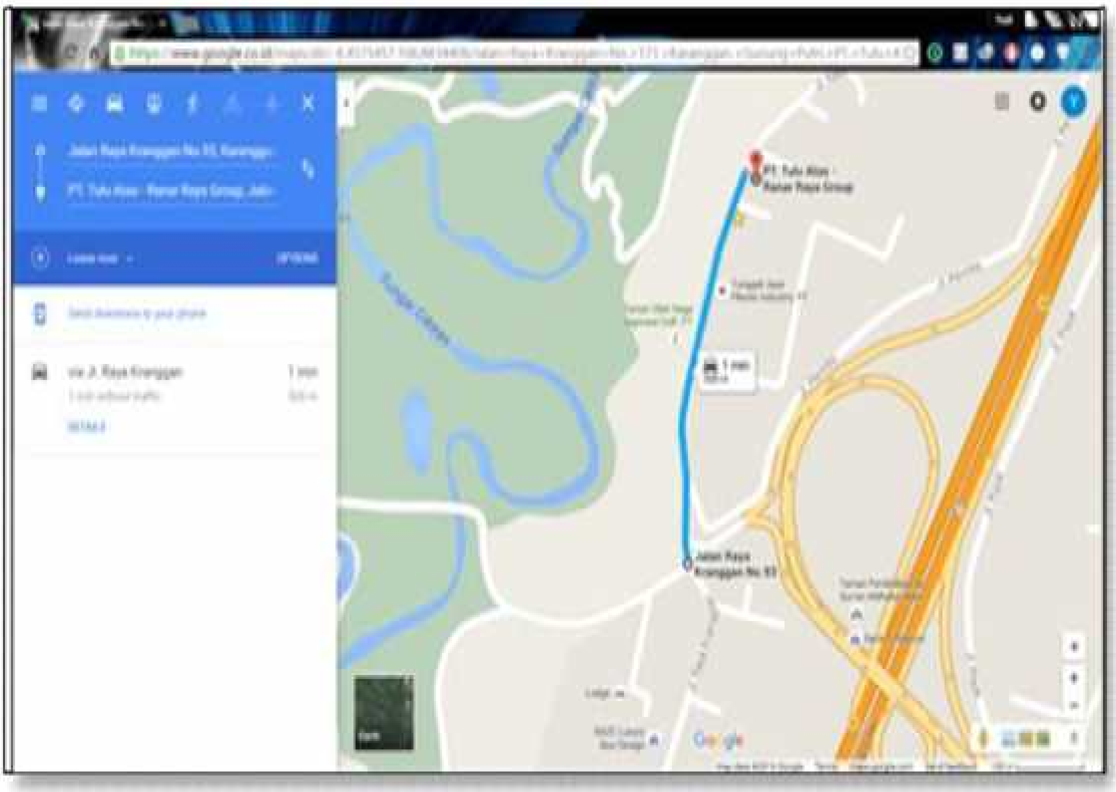


Figure 4. Cost between two Nodes

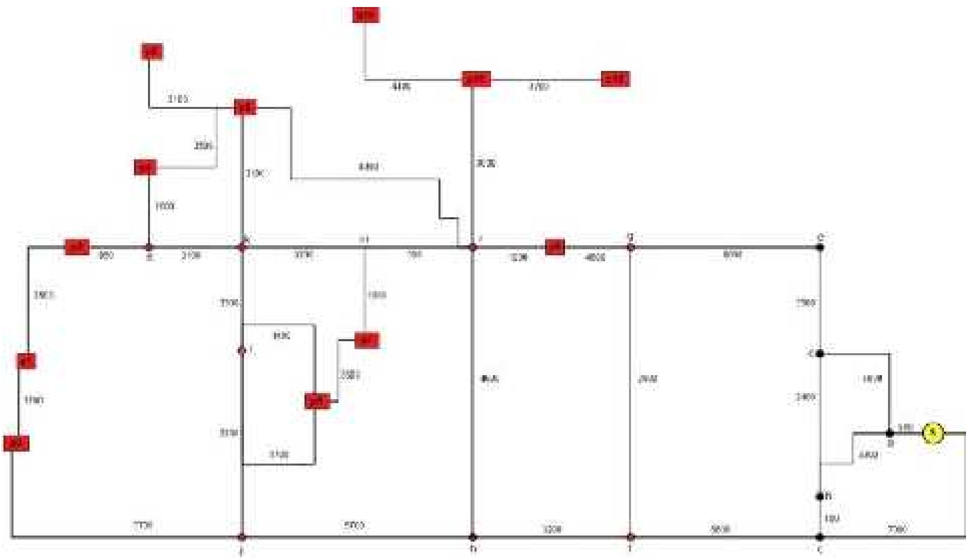


Figure 5. Path Images between Nodes

3. Discussion

Table 1 is a graph data with the distance between vertices, using the Kruskal algorithm step 1 the data is sorted, the results can be seen in table 2. Steps 3 through step 7 can be seen in Figure 8. The results of the path obtained by using the Kruskal algorithm from s to p8 (one of the building stores) are s-a-b-c-f-h-i-p8, the illustration can be seen in Figure 9. The results of testing using the Kruskal algorithm and the results of the calculation of google map direction, from s the 12 building stores can be seen in Table 3.

Table 1. Graph data with each distance between vertices

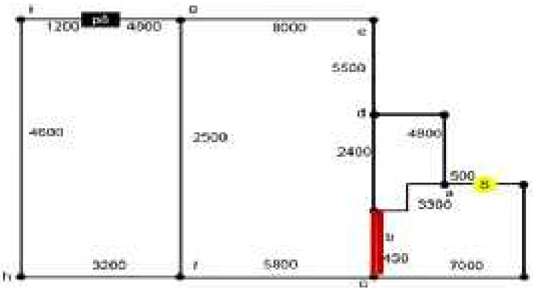
Nomor	From Verte :	To Vertex	Distances	Nomor	From Verte :	To Vertex	Distances
1	s	a	500	8	d	e	5500
2	s	c	7000	9	e	g	8000
3	a	b	3300	10	f	g	2500
4	a	d	4800	11	f	h	3200
5	b	c	450	12	g	P8	4800
6	b	d	2400	13	h	i	4600
7	c	f	5800	14	i	P8	1200

Table 2. Data that has been sorted by distance

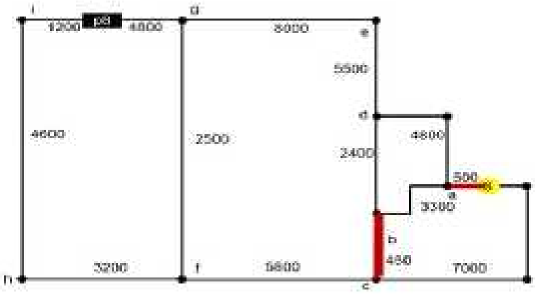
No.	From Vertex	To Vertex	Distances	No.	From Vertex	To Vertex	Distances

1	b	c	450	8	h	i	4600
2	s	a	500	9	a	d	4800
3	i	P8	1200	10	g	p8	4800
4	b	d	2400	11	d	e	5500
5	f	g	2500	12	c	f	5800
6	f	h	3200	13	s	c	7000
7	a	b	3300	14	e	g	8000

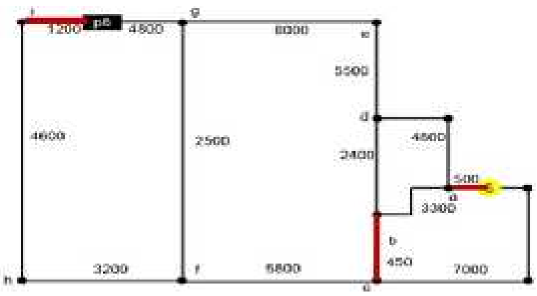
Step 1 (b-c)



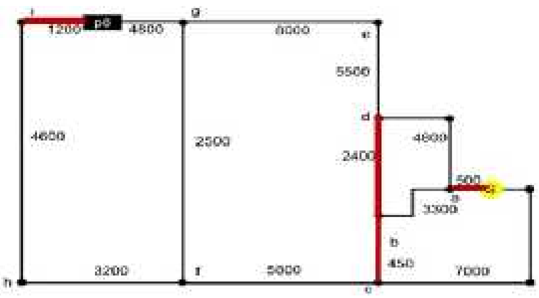
Step 2 (s-a)



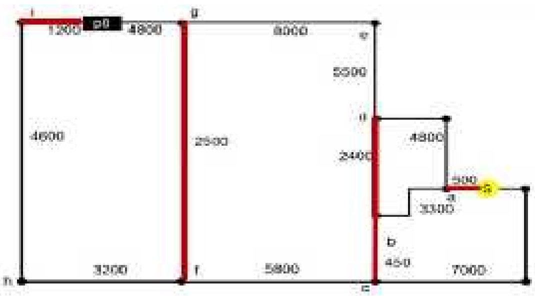
Step 3 (i-p8)



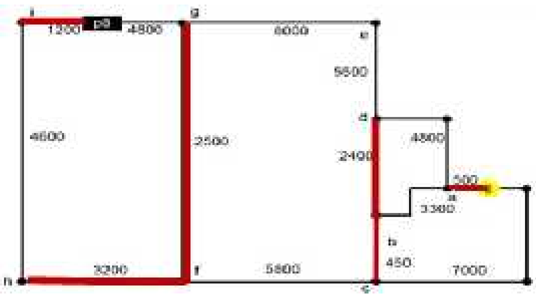
Step 4 (b-d)



Step 5 (f-g)



Step 6 (f-h)



Step 7 (a-b)

Step 8 (h-i)

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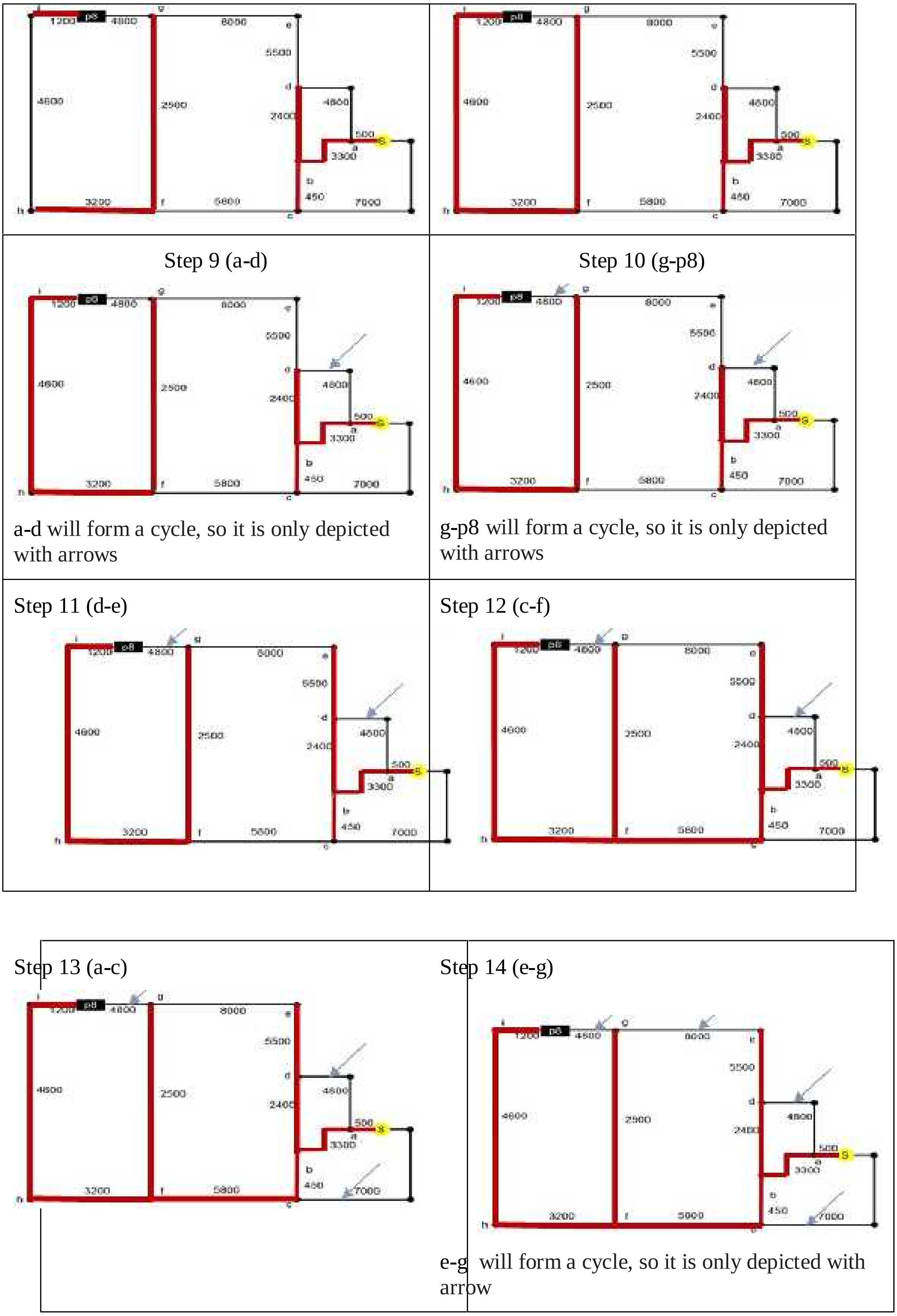

Figure 6. Stages using the Kruskal algorithm

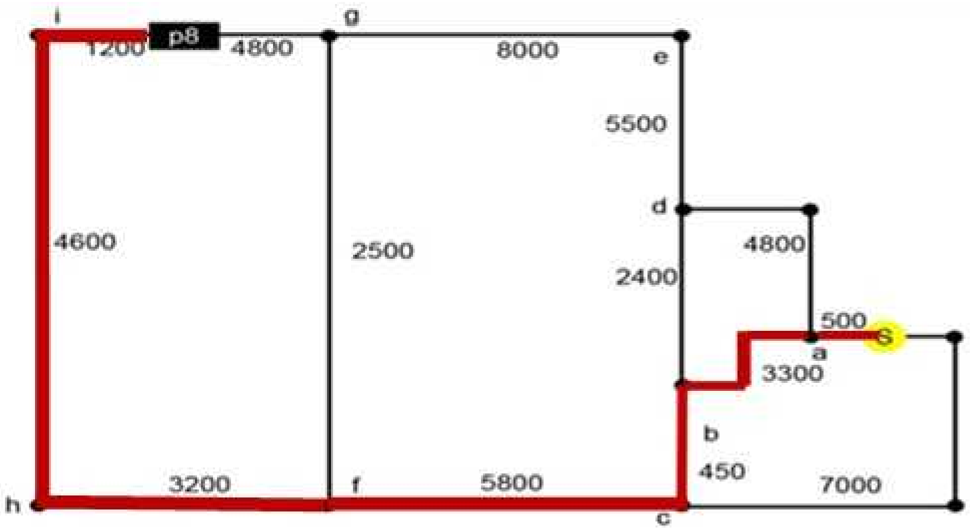

Figure 7. Pathway results using the Kruskal algorithm

Table 3*. Results of the Kruskal Algorithm*

Ket.	Starting point	Location Destination	Algoritma Kruskal (km)	*Direction API (km)*	Differences
p1	-6.453397, 106.884287	-6.644528, 106.839962	30.3	*29*	*-1.3*
p2	-6.453397, 106.884287	-6.653122, 106.845728	31.5	*31*	-0.5
p3	-6.453397, 106.884287	-6.627004, 106.822351	27.5	*29.1*	1.6
p4	-6.453397, 106.884287	-6.617562, 106.805694	28.5	*30.5*	2
p5	-6.453397, 106.884287	-6.591769, 106.814624	22.95	*24.7*	1.75
p6	-6.453397, 106.884287	-6.591890, 106.793374	22.7	*26.4*	3.7
p7	-6.453397, 106.884287	-6.571830, 106.816978	19.3	*21.9*	2.6
p8	-6.453397, 106.884287	-6.555761, 106.816577	19.0	*20*	1
p9	-6.453397, 106.884287	-6.588110, 106.774094	27.8	*28.2*	0.4
p10	-6.453397, 106.884287	-6.549278, 106.760727	28.6	*31*	2.4
p11	-6.453397, 106.884287	-6.556291, 106.778665	24.2	*27.3*	3.1
p12	-6.453397, 106.884287	-6.536932, 106.773841	25.3	*28*	2.7
			Means		1.6

4. Conclusion and future research

The results of testing using the Kruskal algorithm and the results of the calculation of google map direction, from s the 12 building stores can be seen in Table 3. From these results it can be concluded that the comparison of the route distance found for the distance of each route, Kruskal algorithm is 83% better than the Google direction API. Thus, a future research are expected to be developed by adding the travel time and traffic conditions at the actual time, and can compare with other shorted path methods.

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