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Research Paper

The Use of Dijkstra's Algorithm in Determining the Shortest Path of Expedition in Bandarlampung

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Abstract
Delivery of goods is a problem faced by freight forwarders/expedition companies. Determining an efficient route will determine the speed and cost of delivery. This is faced by most expedition companies, including one of the expedition companies in the city of Bandarlampung, namely the J&T Express expedition. There are 20 J&T Express branches in Bandarlampung city. If someone wants to send an item but one of the branches is closed or not available then he will try to determine the next closest branch. In this study, the shortest path from J&T on Pagar Alam to 19 other branches in Bandarlampung will be determined using Dijkstra's Algorithm.

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1. INTRODUCTION

Goods delivery services or expedition services are now increasingly in demand every day by people in Indonesia, especially in this sophisticated era. Technological advances in the era of globalization tend to make people like everything that is easy and practical, especially in terms of sending goods that concern regional affordability. Shipping services will be a solution for those who like the convenience and practicality of sending goods, besides that shipping services are also considered very effective and efficient. The number of people who send goods makes shipping services very important for the community. The distance between the sender and the recipient is increasingly infinite and this distance can be bridged by shipping services.

Technology has provided many conveniences in our lives, such as in sending emails, text messages, social media, and the use of maps. Maps can be used for various purposes, such as finding certain locations, for example restaurants, gas stations, tourist attractions, and schools. When searching for a route from a starting point to another point, the shortest path is usually found [1]. The topic of pathfinding needs to be discussed because it is very relevant to the problems we face in everyday life. In order to make the shortest path search process more efficient, the right search algorithm is needed.

A well-liked method for determining a graph's shortest paths is Dijkstra's algorithm, which is especially helpful in situations like networking and mapping. Starting from a specified source node, it iteratively explores the graph and updates the shortest paths to every other node. The shortest path is always identified since the technique works with graphs whose edge weights are non-negative.

Dijkstra's algorithm was discovered by Edsger W. Dijkstra in 1956 and published three years later in 1959 [2]. The algorithm was discovered while he was sitting in a cafe enjoying coffee and thinking about how to get from Rotterdam to Groningen because he was very tired, and the algorithm was made without using paper or pencil at all. The algorithm was only designed in 20 minutes, and amazingly until today it is still used to solve various problems related to determining the shortest path.

Dijkstra's Algorithm has been applied in many cases, for examples: Aulia et al [3] used it in determining the shortest distance from The Education Authorities of Lampung Province to 30 out of 229 Public Senior High Schools in 15 subdistricts/-

municipalities in Lampung Province. Two public Senior High Schools represent every subdistrict/municipality. Nurhandayani et al [4] implemented Dijsktra's algorithm to fins the shortest path from Bambu Kuning Traditional Market (the biggest traditional market in Bandarlampung city) to other 26 traditional markets in Bandarlampung city. Putriani et al [5] used Dijkstra' Algorithm to find the shortest distance between Lampung Government Hospital (Abdul Muluk hospital) to 41 other hospitals in Lampung Province, and Rudiyanto et al [6] used it to determine the shortest path from the location of traffic accident to evacuate the accident victims to the nearest hospital, while Rahayu et al [7] adopt that algorithm to find the shortest path to UPT. Puskesmas Cilodong, Depok from 38 locations, and it was used by Sembiring et al. [8] to determine the best way to avoid traffic during a peak hour. Cantona et al [9] explore Dijkstra' Algorithm in determining the shortest path to museums in Jakarta, Kai et al [10] implemented Dijkstra's Algorithm in analyzing the system of emergency response, and Sipayung et al [11] used Dijsktra's algorithm for finding the shortest path from Medan city center to tourist location in Medan. Darnita et al [12] implemented Dijsktra's algorithm to determine the location for car travel/rental companies in Bengkulu City, Rahmawati and Gustin [13] analyzed Dijkstra and A * algorithms, and Sebayang and Rosyida [14] used it for searching ojek online shortest route, Bunaen el al [15] implemented Dijsktra'a algorithm to determine the shortest path from Surabaya city center to historical places. Triase and Aprilia [16] implemented that algorithm for online package distribution. Yuliantari, R., & Musabbikhah [17] examined if Dijsktra algorithm is suitable for finding the best shortest path to hospitals. Sharma and Khurana [18] compare some algorithms such as Ant Colony Optimization, PSO, Dijkstra's Algorithm, Genetic Algorithm, Hill climbing, Tabu Search, Floyd-Warshall's, Simulated Annealing, Greedy Algorithms for finding an optimal path. In this study the shortest path from J&T Express in Pagar Alam to 19 other branches will be discussed. The data used are Euclidean distance and Haversine distance.

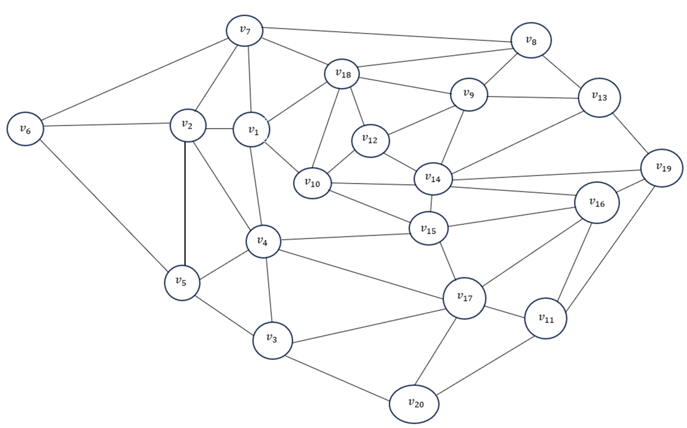

Figure 1. The Graph Representation of the J&T Express in Bandarlampung

2. METHODS

2.1 Graph

A Graph $G(V, E)$ is a structure with the set $V(G) = u_1, u_2, u_3, \ldots, u_n$ is a non-empty set whose members are called nodes or vertices, while the set E(G) (which may be empty) is the set of lines connecting nodes in the set V(G) whose members are called lines/edges. If, associated with every line u_{ij} there exist a cost $c_{ij} \leq 0$, the graph is called as weighted graph. Graphs are used as a tool to represent problems due to their flexible nature. In general, there is no requirement on how to draw lines on a graph (except for planar graphs, where in drawing the graph on a plane, there must be no lines that intersect each other). Lines can be drawn as straight lines, curves, or others [19]. Graph theory has applications in a wide range of domains due to its capacity to model and evaluate interactions between items. By depicting items as nodes and their relationships as edges, it offers an organized method for comprehending complicated systems. This makes it possible to use a variety of algorithms to address optimization issues and learn more about network architectures. A thorough examination of the applications of graph theory in social networks and computer science can be found in [20].

2.2 The Shortest Path Problem

A walk is a limited series of edges and vertices that alternate and start and finish at a vertex. In a walk, each edge is adjacent to the vertex both before and after it. A walk in which no vertex is passed more than once is called a path. If the initial and terminal vertices of a path are the same, it is referred to as a closed path. Unless the graph is a tree, it is feasible to identify many paths between a pair of vertices in a graph. The path with the lowest sum of edge weights is the shortest path between two vertices in a network. Finding the shortest path between two or more points in a path is the aim of the shortest path problem, one of the most well-known algorithmic issues in graph theory. The challenge of choosing which path to take in order to arrive at the destination with the shortest total weight is known as the shortest path problem.

2.3 The Dijkstra Algorithm

Before starting the iterative steps of Dijkstra's Algorithm, an initialization process is performed by creating a set N, which initially contains only the starting node (let's call it i). The algorithm then proceeds with iterations. Dijkstra's method has two main steps:

1. First, from the set of nodes V N (i.e., all nodes not yet in N), identify the node with the shortest direct distance from the starting node.
2. Second, add this node to set N and remove it from V. Next, update the distances from i to all remaining nodes in V, checking if any paths become shorter due to the newly added node in N. Among all possible paths from i to nodes in V, select the one with the shortest distance-either a direct path or a path that goes through nodes already in N. Repeat this process until every node from V is included in N.

Table 1. Location of Twenty Branches J&T Express in Bandarlampung

Node	Location	Node	Location
1	J&T Express Pagar Alam	11	J&T Express Kedamaian
2	J&T Express Rajabasa	12	J&T Express Way Halim
3	J&T Express Ahmad Yani	13	J&T Express Pulau Damar
4	J&T Express Panglima Polim	14	J&T Express Kimaja
5	J&T Express Imam Bonjol	15	J&T Express Keyra
6	J&T Express Kemiling Perum	16	J&T Express Sukarame
7	J&T Express Rajabasa Raya	17	J&T Express Antasari
8	J&T Express Way Kandis	18	J&T Express Untung Suropati
9	J&T Express Tanjung Senang	19	J&T Express Pulau Pisang
10	J&T Express Labuhan Ratu	20	J&T Express Tanjung Gading

Table 2. The Haversine Distance among the 20 Branches J&T Express in Bandarlampung

	v_1	v_2	v_3	v_4	v_5	v_6	v_7	v_8	v_9	v_{10}	v_{11}	v_{12}	v_{13}	v_{14}	v_{15}	v_{16}	v_{17}	v_{18}	v_{19}	v_{20}
v_1	0	0.01	∞	2.2	∞	∞	2.4	∞	∞	1.6	∞	∞	∞	∞	∞	∞	∞	2.3	∞	∞
v_2	0.01	0	∞	2.2	2.5	3.4	2.4	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
v_3	∞	∞	0	3.2	3.4	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	2.3	∞	∞	2.4
v_4	2.2	2.2	3.2	0	1	∞	∞	∞	∞	1.9	∞	∞	∞	∞	13	∞	3	∞	∞	∞
v_5	∞	2.5	3.4	1	0	3.8	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
v_6	∞	3.4	∞	∞	3.8	0	3.6	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
v_7	2.4	2.4	∞	∞		∞ 3.6	0	5	∞	∞	∞	∞	∞	∞	∞	∞	∞	2.1	∞	∞
v_8	∞	∞	∞	∞	∞	∞	5	0	1.1	∞	∞	∞	0.7	∞	∞	∞	∞	3	∞	∞
v_9	∞	∞	∞	∞	∞	∞	∞	1.1	0	∞	∞	2	1	2.5	∞	∞	∞	2.1	∞	∞
v_{10}	1.6	∞	∞	1.9	∞	∞	∞	∞	∞	0	∞	0.7	∞	1.3	1.6	∞	∞	2.3	∞	∞
v_{11}	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	0	∞	∞	∞	∞	3	0.9	∞	4.6	2.1
v_{12}	∞	∞	∞	∞	∞	∞	∞	∞	2	0.7	∞	0	∞	1.1	∞	∞	∞	2.1	∞	∞
v_{13}	∞	∞	∞	∞	∞	∞	∞	0.7	1	∞	∞	∞	0	3.4	∞	∞	∞	∞	2.3	∞
v_{14}	∞	∞	∞	∞	∞	∞	∞	∞	2.5	1.3	∞	1.1	3.4	0	0.9	2.5	∞	∞	3.9	∞
v_{15}	∞	∞	∞	13	∞	∞	∞	∞	∞	1.6	∞	∞	∞	0.9	0	2.9	1.8	∞	∞	∞
v_{16}	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	3	∞	∞	2.5	2.9	0	3.2	∞	1.6	∞
v_{17}	∞	∞	2.3	3	∞	∞	∞	∞	∞	∞	0.9	∞	∞	∞	1.8	3.2	0	∞	∞	2.5
v_{18}	2.3	∞	∞	∞	∞	∞	2.1	3	2.1	2.3	∞	2.1	∞	∞	∞	∞	∞	0	∞	∞
v_{19}	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	4.6	∞	2.3	3.9	∞	1.6	∞	∞	0	∞
v_{20}	∞	∞	2.4	∞	∞	∞	∞	∞	∞	∞	2.1	∞	∞	∞	∞	∞	2.5	∞	∞	0

2.4 The Data

There are 20 J&T Express in Bandarlampung which will be the data in this study with the starting node J&T Express Pulau Damar. That location is chosen as the original location because J&T Express in Pulau Damar is one of the branches whose location is close to Institut Teknologi Sumatera (Itera). Figure 1 is a representation of the locations of J&T Express in Bandarlampung in a graph along with a description with nodes represent J&T Express locations and lines represent distances among the branches.

Table 1 gives information about the twenty (20) branches J&T in Bandarlampung. The J&T Express Pulau Damar is chosen as initial node, while Table 2 displays the Haversine distance (in km) among the 20 locations of J&T Express in Bandarlampung, where ∞ denote that there is no direct distance between those two locations.

3. RESULTS AND DISCUSSION

Table 3 simplifies the calculation process with Dijkstra's algorithm. The column N contains the nodes that are closest to the starting node, according to the iteration performed. It can be seen in Table 3, that initially, the first node in set N is v_{13} (the origin), $N = v_{13}$. Then, in the first iteration, the closest node to v_{13} is node v_8, with a distance of 0.7 km, so $N = v_{13}, v_8$. Then on the second iteration, the closest node to v_{13} and put into N is node v_9 which is 1 km away from v_{13}, and the set N is update to $N = v_{13}, v_8, v_9$. Next, on the third iteration, node v_{19} is the closest node to v_{13} with distance 2.3 km, then $N = v_{13}, v_8, v_9, v_{19}$. On the fourth iteration, the closest point that has direct distance with node v_{13} is node v_{14} with distance 3.4 km. However, the distance of node v_{13} to node v_{12} is 2.3 km (no direct distance from v_{13} to v_{12}, but there is a path between those two nodes via node v_9, so that $d(v_{13}, v_{12}) = d(v_{13}, v_9) + d(v_9.v_{12}) = 1 + 2 = 3$,

Table 3. The Simplification of the Calculation of Dijsktra's Algorithm for J&T Express

Iteration	The Nodes in Set N	v_1	v_2	v_3	v_4	v_5	v_6	v_7	v_8	v_9	v_{10}	v_{11}	v_{12}	v_{13}	v_{14}	v_{15}	v_{16}	v_{17}	v_{18}	v_{19}	v_{20}
0	$\{v_{13}\}$	∞	∞	∞	∞	∞	∞	∞	0.7	1	∞	∞	∞	0	3.4	∞	∞	∞	∞	2.3	∞
1	$\{v_{13}.v_8\}$	∞	∞	∞	∞	∞	∞	∞	0.7	1	∞	∞	∞	0	3.4	∞	∞	∞	∞	2.3	∞
2	$\{v_{13}.\ v_8.v_9\}$	∞	∞	∞	∞	∞	∞	5.7	0.7	1	∞	∞	∞	0	3.4	∞	∞	∞	3.7	2.3	∞
3	$\{v_{13}.\ v_8.v_9.v_{19}\}$	∞	∞	∞	∞	∞	∞	5.7	0.7	1	∞	∞	3	0	3.4	∞	∞	∞	3.1	2.3	∞
4	$\{v_{13}.v_8.v_9.v_{19}.v_{12}\}$	∞	∞	∞	∞	∞	∞	5.7	0.7	1	∞	6.9	3	0	3.4	∞	∞	∞	3.1	2.3	∞
5	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}\}$	∞	∞	∞	∞	∞	∞	5.7	0.7	1	3.7	6.9	3	0	3.4	∞	∞	∞	3.1	2.3	∞
6	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}\}$	5.4	∞	∞	∞	∞	∞	5.7	0.7	1	3.7	6.9	3	0	3.4	∞	∞	∞	3.1	2.3	∞
7	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}\}$	5.4	∞	∞	∞	∞	∞	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	∞	3.1	2.3	∞
8	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}\}$	5.3	∞	∞	5.6	∞	∞	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	∞	3.1	2.3	∞
9	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1\}$	5.3	∞	∞	5.6	∞	∞	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	∞
10	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2\}$	5.3	5.31	∞	5.6	∞	∞	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	∞
11	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4\}$	5.3	5.31	∞	5.6	7.81	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	∞
12	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4.v_7\}$	5.3	5.31	8.8	5.6	6.6	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	∞
13	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4.v_7.v_{16}\}$	5.3	5.31	8.8	5.6	6.6	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	∞
14	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4.v_7.v_{16}.v_{17}\}$	5.3	5.31	8.8	5.6	6.6	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	∞
15	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4.v_7.v_{16}.v_{17}.v_5\}$	5.3	5.31	8.4	5.6	6.6	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	8.6
16	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4.v_7.v_{16}.v_{17}.v_5.v_{11}\}$	5.3	5.31	8.4	5.6	6.6	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	8.6
17	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4.v_7.v_{16}.v_{17}.v_5.v_{11}.v_3\}$	5.3	5.31	8.4	5.6	6.6	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	8.6
18	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4.v_7.v_{16}.v_{17}.v_5.v_{11}.v_3.v_{20}\}$	5.3	5.31	8.4	5.6	6.6	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	8.6
19	$\{v_{13}.v_8.v_9.v_{19}.v_{12}.v_{18}.v_{14}.v_{10}.v_{15}.v_1.v_2.v_4.v_7.v_{16}.v_{17}.v_5.v_{11}.v_3.v_{20}.v_6\}$	5.3	5.31	8.4	5.6	6.6	8.71	5.7	0.7	1	3.7	6.9	3	0	3.4	4.3	5.9	6.1	3.1	2.3	8.6

then $N = v_{13}, v_8, v_9, v_{19}, v_{12}$. The other shortest path from point to other points are calculated in similar way according to Dijkstra's algorithm. Note that the number last iteration for every column shows the shortest distance of the node in the column from the origin node v_{13}.

Table 4 shows the shortest path distance from J&T Express Pulau Damar to 19 other branches using Dijkstra's algorithm implemented on Haversine distance. Among 19 other branches of J&T Express, the shortest distance from J&T Pulau Damar is to J&T Express Way Kandis with 0.7 km, while the farthest is J&T Express Kemiling with distance from J&T Express Pulau Damar is 8.71 km.

Table 4. The Shortest Path from J&T Express Pulau Damar to other 19 Branches Using Dijkstra's Algorithm on Haversine Distance

Original Node	Destination	Path	Distance (km)
J&T Express Pulau Damar (v_{13})	J&T Express Way Kandis (v_8)	v_{13}-v_8	0.7
J&T Express Pulau Damar (v_{13})	J&T Express Tj. Senang(v_9)	v_{13}-v_9	1
J&T Express Pulau Damar (v_{13})	J&T Express Pulau Pisang(v_{19})	v_{13}-v_{19}	2.3
J&T Express Pulau Damar (v_{13})	J&T Express Way Halim(v_{12})	v_{13}-v_9-v_{12}	3
J&T Express Pulau Damar (v_{13})	J&T Express Untung Suropati(v_{18})	v_{13}-v_9-v_{18}	3.1
J&T Express Pulau Damar (v_{13})	J&T Express Kimaja(v_{14})	v_{13}-v_{14}	3.4
J&T Express Pulau Damar (v_{13})	J&T Express Labuhan Ratu(v_{10})	v_{13}-v_9-v_{12}-v_{10}	3.7
J&T Express Pulau Damar (v_{13})	J&T Express Keyra(v_{15})	v_{13}-v_{14}-v_{15}	4.3
J&T Express Pulau Damar (v_{13})	J&T Express Pagar Alam(v_1)	v_{13}-v_9-v_{18}-v_1	5.3
J&T Express Pulau Damar (v_{13})	J&T Express Rajabasa(v_2)	v_{13}-v_9-v_{18}-v_1-v_2	5.31
J&T Express Pulau Damar (v_{13})	J&T Express Panglima Polim(v_4)	v_{13}-v_{14}-v_{15}-v_4	5.6
J&T Express Pulau Damar (v_{13})	J&T Express Rajabasa Raya(v_7)	v_{13}-v_8-v_7	5.7
J&T Express Pulau Damar (v_{13})	J&T Express Sukarame(v_{16})	v_{13}-v_9-v_{16}	5.9
J&T Express Pulau Damar (v_{13})	J&T Express Antasari(v_{17})	v_{13}-v_{14}-v_{15}-v_4-v_{17}	6.1
J&T Express Pulau Damar (v_{13})	J&T Express Imam Bonjol(v_5)	v_{13}-v_{14}-v_{15}-v_4-v_5	6.6
J&T Express Pulau Damar (v_{13})	J&T Express Kedamaian(v_{11})	v_{13}-v_{19}-v_{11}	6.9
J&T Express Pulau Damar (v_{13})	J&T Express Ahmad Yani(v_3)	v_{13}-v_{14}-v_{15}-v_4-v_3	8.4
J&T Express Pulau Damar (v_{13})	J&T Express Tanjung Gading(v_{20})	v_{13}-v_{19}-v_{11}-v_{20}	8.6
J&T Express Pulau Damar (v_{13})	J&T Express Kemiling (v_6)	v_{13}-v_9-v_{18}-v_1-v_6	8.71

4. CONCLUSIONS

Based on the results and discussion above, it can be concluded that the shortest path from J&T Express Pulau Damar which is the direct distance from $v_{13} - v_8, v_{13} - v_9, v_{13} - v_{19}, v_{13} - v_{14}$, i.e J&T Express Pulau Damar to J&T Way Kandis , from J&T Express Pulau Damar to J&T Tj Senang, from J&T Express Pulau Damar to J&T Pulau Pisang and from J&T Express Pulau Damar to J&T Kimaja, while the farthest distance is to J&T Express Kemiling by going through three other branches.

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