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Determination of The Shortest Trajectory on The Fertilizer Transportation Line with The Bellman-Ford Algorithm (Case Study: PT. Tidar Kerinci Agung, Kebun Bukit Sembilan (KBS), Afdeling II)

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Abstract: This research focuses on determining the shortest path on a fertilizer transportation route by modeling the distribution network as a weighted graph. The Bellman-Ford algorithm calculates all distances or shortest paths from the starting point to the destination point. The shortest path is the path traversed from one point to another by looking at the smallest edge value. The word shortest in the path problem has the meaning of the process of minimizing the weight on a graph path. This research aims to explore the application of the Bellman-Ford algorithm in determining the shortest path on the fertilizer transportation route because the results will provide the best path connecting the warehouse with the block points where the fertilizer is distributed. The term "fertilizer" in everyday terms refers to a material used to increase soil fertility. In this research, it is hoped that the solution found will have a positive impact and become an example for companies through a better understanding of the application of this algorithm. Based on the results of the iterations that have been carried out, 1 shortest path was obtained on the fertilizer transportation route using the Bellman-Ford algorithm. To reach the end point (B94a) faster, the fertilizer truck will pass through 11 points, namely $e_2 \rightarrow e_5 \rightarrow e_9 \rightarrow e_{14} \rightarrow e_{15} \rightarrow e_{20} \rightarrow e_{22} \rightarrow e_{31} \rightarrow e_{33} \rightarrow e_{34} \rightarrow e_{35}$. The calculation is carried out until the 11th iteration with the minimum distance obtained being 6.59 km.

Keyword: Bellman-Ford Algorithm, Fertilizer Distribution, Shortest Path, Weighted Graph.

INTRODUCTION

PT. Tidar Kerinci Agung (PT. TKA) is a Domestic Investment (PMDN) project located in West Sumatra that has plantations and oil palm processing plants. The company manages 28,029 ha of oil palm plantations. Proper fertilizer transport is essential in the palm oil industry, especially in supporting sustainable agricultural productivity. To increase plantation yields, farmers and companies need fertilizers, which are one of the main raw materials.

Transporting fertilizer from one place to another is often a problem due to changing road conditions, uncertainty about estimated time required, and uncertainty about the cost required. Fertilizer transportation must take into account many things, such as vehicle capacity, road conditions, mileage, and weather, to improve operational efficiency, proper distribution systems and optimal decision-making are essential.

Mathematical methods and shortest track search algorithms in transportation route planning are one way that can be used to solve this problem. The Bellman-Ford algorithm works carefully because it compares the search results to the track that contains the N-1 line, so that the shortest path result is unquestionably correct. In situations like these, graph theory becomes a very important tool for modeling problems related to fertilizer transport. In a distribution network, each point can be thought of as a vertex, while each path connecting the points can be thought of as an edge of a certain weight, which can describe the distance, cost, time, or capacity of the vehicle.

One of the effective algorithms for finding the shortest trajectory in a graph is the Bellman-Ford algorithm. The Bellman-Ford algorithm is one of the paths to find algorithms used to find the shortest path. The Bellman-Ford algorithm is proven to be able to find the shortest path with always correct results, but the time it takes to find the shortest path is long. The Bellman-Ford algorithm calculates all the shortest distances or trajectories from a single source point to the destination point on a weighted graph.

In fertilizer transport, the main goal of the Bellman-Ford algorithm is to find the shortest route or trajectory from the fertilizer warehouse to the various sowing locations or final destinations by taking into account various influencing factors. This shortest track is expected to optimize vehicle usage, speed up travel time, and reduce travel costs. In practice, this calculation involves creating a graph model that depicts the entire transport network, including the current distribution point and the conditions that affect the calculation of the weights on the sides of the graph. The calculation of the shortest track can be done using geographic data, information about road conditions, and vehicle operational parameters.

This study aims to explore the application of the Bellman-Ford algorithm in determining the shortest trajectory on a fertilizer transport line as the results will provide the best path connecting the warehouse with the block points where fertilizer is deployed, which can be used by companies to plan fertilizer transportation efficiently. It is hoped that the solutions found will have a positive impact and set an example for the company through a better understanding of the application of these algorithms.

METHOD

This study uses Quantitative Descriptive Approach that focuses on the application of algorithms Bellman-Ford to determine the shortest trajectory on the fertilizer transport line. This approach was chosen because it is able to present mathematical modeling of the transportation network in plantations and produce an optimal trajectory quantitatively based on the distance between distribution points. The research steps include:

1. Data collection

   In this study, data was obtained through direct observation to the company and with the help of the Avenza Maps Application to obtain the distance between plantation blocks. The data collected in this study are in the form of:

   a. Points (nodes), are plantation areas
   b. Side, which is a connecting road between plantations
   c. Weight, is the distance between plantations (in kilometers).

2. Making an initial graph from the map of the Bukit Sembilan Gardens (KBS), PT. Tidar Kerinci Agung.

3. Application of *the Bellman-Ford* algorithm in determining the shortest trajectory of fertilizer transport lines. The common forms of mathematical notation of *the Bellman-Ford* algorithm [10] are as follows:
$$M[i,v] = \min(M[i-1,v],(M[i-1,n]+C_{vn})) \quad (1)$$
Where:
i : Iteration
v : *Vertex*
n : *node neighbor*
C_{vn} : distance between points v and n
4. Conclusions were drawn based on the results of calculating the shortest trajectory of the fertilizer transportation line using *the Bellman-Ford* algorithm.

Based on the stages of research that have been described earlier, the research flow can be seen in the following figure 1:

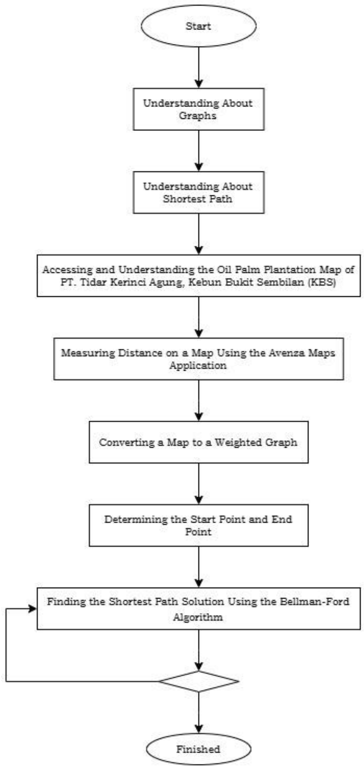

Figure 1. Algorithm Flowchart Bellman-Ford

RESULTS AND DISCUSSION

Data Collection

This study was conducted to determine the shortest trajectory on the fertilizer transportation route from the warehouse to the destination block in Afdeling II, Kebun Bukit Sembilan (KBS), PT. Tidar Kerinci Agung using *the Bellman-Ford algorithm.* This study will apply weighted and directional graphs in modeling fertilizer distribution paths so that it can mathematically describe the relationships between blocks and connecting paths. The following is a map of the fertilizer distribution route of Bukit Sembilan Plantation (KBS), Afdeling II.

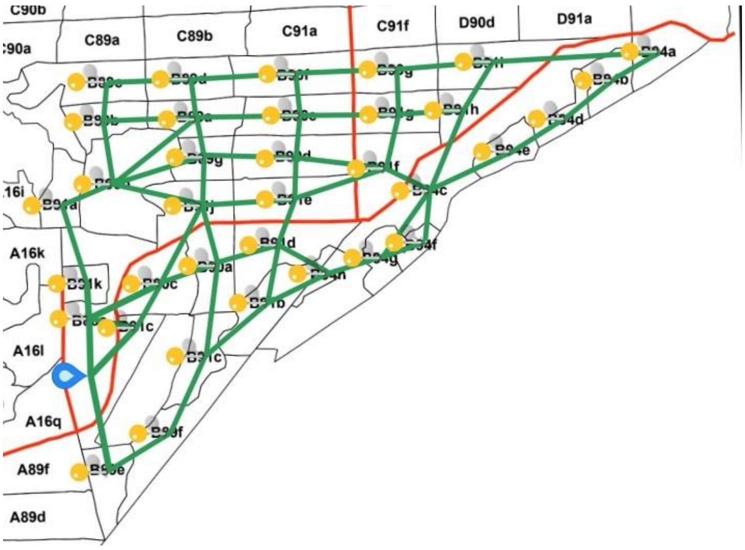

Figure 2. Map Afdeling II Fertilizer Distribution Line

Based on Figure 2, in the graph there are 36 points or nodes, where these points are oil palm plantation areas that will be sprinkled with fertilizer.

Table 1. Sum Vertex and Variable Definitions

(n)	Variable (e_i)	Definition
1	G	Fertilizer Warehouse
2	e_1	B88a (Plantation Area/ Fertilizer Sowing Location)
3	e_2	B91c1 (Plantation Area/ Fertilizer Sowing Location)
4	e_3	B89e (Plantation Area/ Fertilizer Sowing Location)
5	e_4	B91k (Plantation Area/ Fertilizer Sowing Location)
6	e_5	B90c (Plantation Area/ Fertilizer Sowing Location)
7	e_6	B89f (Plantation Area/ Fertilizer Sowing Location)
8	e_7	B91c2 (Plantation Area/ Fertilizer Sowing Location)
9	e_8	B91a (Plantation Area/ Fertilizer Sowing Location)
10	e_9	B90a (Plantation Area/ Fertilizer Sowing Location)
11	e_{10}	B91j (Plantation Area/ Fertilizer Sowing Location)
12	e_{11}	B91b (Plantation Area/ Fertilizer Sowing Location)
13	e_{12}	B90b (Plantation Area/ Fertilizer Sowing Location)
14	e_{13}	B94h (Plantation Area/ Fertilizer Sowing Location)
15	e_{14}	B91d (Plantation Area/ Fertilizer Sowing Location)
16	e_{15}	B91e (Plantation Area/ Fertilizer Sowing Location)
17	e_{16}	B89b (Plantation Area/ Fertilizer Sowing Location)
18	e_{17}	B89a (Plantation Area/ Fertilizer Sowing Location)
19	e_{18}	B89g (Plantation Area/ Fertilizer Sowing Location)
20	e_{19}	B90d (Plantation Area/ Fertilizer Sowing Location)
21	e_{20}	B91f (Plantation Area/ Fertilizer Sowing Location)
22	e_{21}	B91g (Plantation Area/ Fertilizer Sowing Location)
23	e_{22}	B94c (Plantation Area/ Fertilizer Sowing Location)
24	e_{23}	B94g (Plantation Area/ Fertilizer Sowing Location)
25	e_{24}	B94f (Plantation Area/ Fertilizer Sowing Location)
26	e_{25}	B90e (Plantation Area/ Fertilizer Sowing Location)

(n)	Variable (e_i)	Definition
27	e_{26}	B89c (Plantation Area/ Fertilizer Sowing Location)
28	e_{27}	B89d (Plantation Area/ Fertilizer Sowing Location)
29	e_{28}	B90f (Plantation Area/ Fertilizer Sowing Location)
30	e_{29}	B90g (Plantation Area/ Fertilizer Sowing Location)
31	e_{30}	B91h (Plantation Area/ Fertilizer Sowing Location)
32	e_{31}	B94e (Plantation Area/ Fertilizer Sowing Location)
33	e_{32}	B91i (Plantation Area/ Fertilizer Sowing Location)
34	e_{33}	B94d (Plantation Area/ Fertilizer Sowing Location)
35	e_{34}	B94b (Plantation Area/ Fertilizer Sowing Location)
36	e_{35}	B94a (Plantation Area/ Fertilizer Sowing Location)

Early Graph Modeling

Based on Figure 2 and Table 1, the weighted and directional graphs of the map can be modeled as follows:

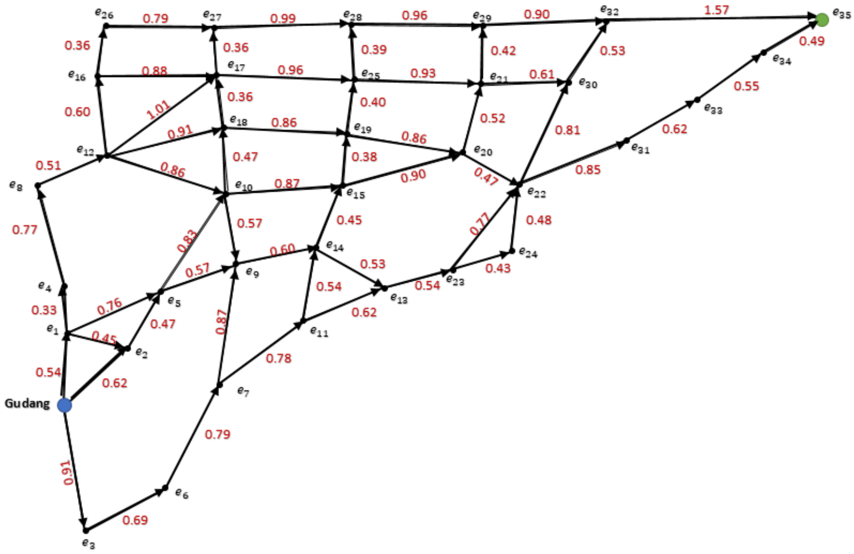

Figure 3. Weighted and Directional Graphs

Application of the Bellman-Ford Algorithm

The completion steps to determine the shortest trajectory from the warehouse to the B94a orchard using the *Bellman-Ford* Algorithm [11] are:

Step 1: Turn the map into a weighted and directional graph

Step 2: Define the starting point and the end point. The starting point on the graph (Figure 3) is the blue point (warehouse) and the end point or destination is the green dot (e_{35}).

Step 3: Value the starting point with 0 and the value ∞ for the other points

Table 2. Initial Table of the Bellman-Ford Algorithm

Iteration	0
warehouse	0
e_1	∞
e_2	∞
e_3	∞
e_4	∞
e_5	∞
e_6	∞

Iteration	0
e_7	∞
e_8	∞
e_9	∞
e_{10}	∞
e_{11}	∞
e_{12}	∞
e_{13}	∞
e_{14}	∞
e_{15}	∞
e_{16}	∞
e_{17}	∞
e_{18}	∞
e_{19}	∞
e_{20}	∞
e_{21}	∞
e_{22}	∞
e_{23}	∞
e_{24}	∞
e_{25}	∞
e_{26}	∞
e_{27}	∞
e_{28}	∞
e_{29}	∞
e_{30}	∞
e_{31}	∞
e_{32}	∞
e_{33}	∞
e_{34}	∞
e_{35}	∞

Step 4: Iterate against all existing points and start from the starting point. The iteration will be done using the common *Bellman-Ford form* (1):
Step 5: iterate repeatedly until the endpoint and get the value on all the points that have been explored.

The iterations that have been carried out using the Bellman-Ford Algorithm:

a. Iteration 1

In the first iteration, the value of each point is still ∞ and the weight of the distance to be traveled from the starting point to the destination point will be added. In the calculation of iteration 1, it starts from the starting point (warehouse) which has a value of 0 plus point e_1 which has a weight of 0.54 Km, point e_2 has a weight of 0.62 Km, and point e_3 has a weight of 0.91 Km with the calculation process as follows:

$$M(1,e_1) = \min\left(M[0,e_1],\left(M[0,Gudang] + C_{v_G n_{e_1}}\right)\right)$$
$$= \min(\infty, 0 + 0{,}54)$$
$$= \min(\infty, 0{,}54)$$
$$= 0{,}54\ Km$$
$$M(1,e_2) = \min\left(M[0,e_2],\left(M[0,Gudang] + C_{v_G n_{e_2}}\right)\right)$$
$$= \min(\infty, 0 + 0{,}62)$$
$$= \min(\infty, 0{,}62)$$
$$= 0{,}62\ Km$$
$$M(1,e_3) = \min\left(M[0,e_3],\left(M[0,Gudang] + C_{v_G n_{e_3}}\right)\right)$$

$$= \min(\infty, 0 + 0{,}91)$$
$$= \min(\infty, 0{,}91)$$
$$= 0{,}91\ Km$$

After doing iteration 1, it was found that from the warehouse to point e_1 it has a weight of 0.54 Km, the warehouse to e_2 has a weight of 0.62 Km, and from the warehouse to point e_3 it has a weight of 0.91 Km, for the other points it still has a value of ∞, because the ones directly related to the starting point "warehouse" are only points e_1, e_2, e_3. The following are the results of the first iteration:

Table 3. Iteration Calculation Results 1

Iteration	0	1
warehouse	0	0
e_1	∞	0,54
e_2	∞	0,62
e_3	∞	0,91
e_4	∞	∞
e_5	∞	∞
e_6	∞	∞
e_7	∞	∞
e_8	∞	∞
e_9	∞	∞
e_{10}	∞	∞
e_{11}	∞	∞
e_{12}	∞	∞
e_{13}	∞	∞
e_{14}	∞	∞
e_{15}	∞	∞
e_{16}	∞	∞
e_{17}	∞	∞
e_{18}	∞	∞
e_{19}	∞	∞
e_{20}	∞	∞
e_{21}	∞	∞
e_{22}	∞	∞
e_{23}	∞	∞
e_{24}	∞	∞
e_{25}	∞	∞
e_{26}	∞	∞
e_{27}	∞	∞
e_{28}	∞	∞
e_{29}	∞	∞
e_{30}	∞	∞
e_{31}	∞	∞
e_{32}	∞	∞
e_{33}	∞	∞
e_{34}	∞	∞
e_{35}	∞	∞

To find the value at the next point, a second iteration process will be carried out on the point that is directly related to the point, $e_1 e_2$, e_3.

b. Iteration 2

In iteration 2 points to be counted are the points that are directly connected to the point e_1, e_2, e_3. Here is the calculation process:

$$M(2, e_4) = \min\left(M[1, e_4], \left(M[1, e_1] + C_{v_{e_1} n_{e_4}}\right)\right)$$

$$= \min(\infty, 0{,}54 + 0{,}33)$$
$$= \min(\infty, 0{,}87)$$
$$= 0{,}87\ Km$$
$$M(2, e_5) = \min\left(M[1, e_5], \left(M[1, e_1] + C_{v_{e_1} n_{e_5}}\right)\right)$$
$$= \min(\infty, 0{,}54 + 0{,}76)$$
$$= \min(\infty, 1{,}3)$$
$$= 1{,}3\ Km$$
$$M(2, e_2) = \min\left(M[1, e_2], \left(M[1, e_1] + C_{v_{e_1} n_{e_2}}\right)\right)$$
$$= \min(\infty, 0{,}54 + 0{,}45)$$
$$= \min(\infty, 0{,}99)$$
$$= 0{,}99\ Km$$
$$M(2, e_5) = \min\left(M[1, e_5], \left(M[1, e_2] + C_{v_{e_2} n_{e_5}}\right)\right)$$
$$= \min(\infty, 0{,}62 + 0{,}47)$$
$$= \min(\infty, 1{,}09)$$
$$= 1{,}09\ Km$$
$$M(2, e_6) = \min\left(M[1, e_6], \left(M[1, e_3] + C_{v_{e_3} n_{e_6}}\right)\right)$$
$$= \min(\infty, 0{,}91 + 0{,}69)$$
$$= \min(\infty, 1{,}6)$$
$$= 1{,}6\ Km$$

After doing the second iteration, the values for e_4 are 0.87 Km, e_2 0.99 Km, e_6 1.6 Km and e_5 1.3 Km and 1.09 Km. Because e_5 they have two values, we will take the minimum value which is e_5 1.09 Km. For the value of e_2, it is still considered 0.62 Km because 0.62 < 0.99. The results of the second iteration can be seen in the following table:

Table 4. . Calculation Results of Iteration 2

Iteration	0	1	2
warehouse	0	0	0
e_1	∞	0,54	0,54
e_2	∞	0,62	0,62
e_3	∞	0,91	0,91
e_4	∞	∞	0,87
e_5	∞	∞	1,09
e_6	∞	∞	1,6
e_7	∞	∞	∞
e_8	∞	∞	∞
e_9	∞	∞	∞
e_{10}	∞	∞	∞
e_{11}	∞	∞	∞
e_{12}	∞	∞	∞
e_{13}	∞	∞	∞
e_{14}	∞	∞	∞
e_{15}	∞	∞	∞
e_{16}	∞	∞	∞
e_{17}	∞	∞	∞
e_{18}	∞	∞	∞
e_{19}	∞	∞	∞
e_{20}	∞	∞	∞
e_{21}	∞	∞	∞

Iteration	0	1	2
e_{22}	∞	∞	∞
e_{23}	∞	∞	∞
e_{24}	∞	∞	∞
e_{25}	∞	∞	∞
e_{26}	∞	∞	∞
e_{27}	∞	∞	∞
e_{28}	∞	∞	∞
e_{29}	∞	∞	∞
e_{30}	∞	∞	∞
e_{31}	∞	∞	∞
e_{32}	∞	∞	∞
e_{33}	∞	∞	∞
e_{34}	∞	∞	∞
e_{35}	∞	∞	∞

Next, a third iteration process will be carried out on the points that are directly related to the points e_4, e_5, and e_6.

c. Iteration 3

In this iteration, the points to be calculated are those directly connected to points e_4, e_5, and e_6. The calculation process is as follows:

$$\begin{aligned} M(3,e_8) &= \min\left(M[2,e_8],\left(M[2,e_4]+C_{v_{e_4}n_{e_8}}\right)\right) \\ &= \min(\infty, 0{,}87+0{,}77) \\ &= \min(\infty, 1{,}64) \\ &= 1{,}64\ Km \end{aligned}$$

$$\begin{aligned} M(3,e_{10}) &= \min\left(M[2,e_{10}],\left(M[2,e_5]+C_{v_{e_5}n_{e_{10}}}\right)\right) \\ &= \min(\infty, 1{,}09+0{,}83) \\ &= \min(\infty, 1{,}92) \\ &= 1{,}92\ Km \end{aligned}$$

$$\begin{aligned} M(3,e_9) &= \min\left(M[2,e_9],\left(M[2,e_5]+C_{v_{e_5}n_{e_9}}\right)\right) \\ &= \min(\infty, 1{,}09+0{,}57) \\ &= \min(\infty, 1{,}66) \\ &= 1{,}66\ Km \end{aligned}$$

$$\begin{aligned} M(3,e_7) &= \min\left(M[2,e_7],\left(M[2,e_6]+C_{v_{e_6}n_{e_7}}\right)\right) \\ &= \min(\infty, 1{,}6+0{,}79) \\ &= \min(\infty, 2{,}39) \\ &= 2{,}39 Km \end{aligned}$$

The results of the third iteration can be seen in the following table:

Table 5. Iteration 3 Calculation Results

Iteration	0	1	2	3
warehouse	0	0	0	0
e_1	∞	0,54	0,54	0,54
e_2	∞	0,62	0,62	0,62
e_3	∞	0,91	0,91	0,91

Iteration	0	1	2	3
e_4	∞	∞	0,87	0,87
e_5	∞	∞	1,09	1,09
e_6	∞	∞	1,6	1,6
e_7	∞	∞	∞	2,39
e_8	∞	∞	∞	1,64
e_9	∞	∞	∞	1,66
e_{10}	∞	∞	∞	1,92
e_{11}	∞	∞	∞	∞
e_{12}	∞	∞	∞	∞
e_{13}	∞	∞	∞	∞
e_{14}	∞	∞	∞	∞
e_{15}	∞	∞	∞	∞
e_{16}	∞	∞	∞	∞
e_{17}	∞	∞	∞	∞
e_{18}	∞	∞	∞	∞
e_{19}	∞	∞	∞	∞
e_{20}	∞	∞	∞	∞
e_{21}	∞	∞	∞	∞
e_{22}	∞	∞	∞	∞
e_{23}	∞	∞	∞	∞
e_{24}	∞	∞	∞	∞
e_{25}	∞	∞	∞	∞
e_{26}	∞	∞	∞	∞
e_{27}	∞	∞	∞	∞
e_{28}	∞	∞	∞	∞
e_{29}	∞	∞	∞	∞
e_{30}	∞	∞	∞	∞
e_{31}	∞	∞	∞	∞
e_{32}	∞	∞	∞	∞
e_{33}	∞	∞	∞	∞
e_{34}	∞	∞	∞	∞
e_{35}	∞	∞	∞	∞

Since there are still nodes that have not been explored, the iteration will continue until all nodes are explored.

d. Iteration 11

In this iteration, points that are directly related to the point e_{34} will be calculated, the point is a point e_{35} with a weight of 0,49. Here is the calculation process:

$$M(11,e_{35}) = \min\left(M[10,e_{35}],\left(M[10,e_{34}] + C_{v_{e_{34}}n_{e_{35}}}\right)\right)$$
$$= \min(\infty, 6{,}1 + 0{,}49)$$
$$= \min(\infty, 6{,}59)$$
$$= 6{,}59Km$$

After performing the calculation of iteration 11, then all points and sides have been explored and have values so that the iteration can be stopped and the shortest trajectory to get to the end point can be determined.

Table 6. Calculation Results of Iteration 11

Iteration	0	1	2	3	4	5	6	7	8	9	10	11
warehouse	0	0	0	0	0	0	0	0	0	0	0	0
e_1	∞	0,54	0,54	0,54	0,54	0,54	0,54	0,54	0,54	0,54	0,54	0,54
e_2	∞	0,62	0,62	0,62	0,62	0,62	0,62	0,62	0,62	0,62	0,62	0,62
e_3	∞	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91	0,91
e_4	∞	∞	0,87	0,87	0,87	0,87	0,87	0,87	0,87	0,87	0,87	0,87

Iteration	0	1	2	3	4	5	6	7	8	9	10	11
e_5	∞	∞	1,09	1,09	1,09	1,09	1,09	1,09	1,09	1,09	1,09	1,09
e_6	∞	∞	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6
e_7	∞	∞	∞	2,39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2,39
e_8	∞	∞	∞	1,64	1,64	1,64	1,64	1,64	1,64	1,64	1,64	1,64
e_9	∞	∞	∞	1,66	1,66	1,66	1,66	1,66	1,66	1,66	1,66	1,66
e_{10}	∞	∞	∞	1,92	1,92	3,01	3,01	3,01	3,01	3,01	3,01	3,01
e_{11}	∞	∞	∞	∞	3,17	3,17	3,17	3,17	3,17	3,17	3,17	3,17
e_{12}	∞	∞	∞	∞	2,15	2,15	2,15	2,15	2,15	2,15	2,15	2,15
e_{13}	∞	∞	∞	∞	2,26	2,26	2,26	2,26	2,26	2,26	2,26	2,26
e_{14}	∞	∞	∞	∞	2,79	2,71	2,71	2,71	2,71	2,71	2,71	2,71
e_{15}	∞	∞	∞	∞	2,39	2,39	2,39	2,39	2,39	2,39	2,39	2,39
e_{16}	∞	∞	∞	∞	∞	2,75	2,75	2,75	2,75	2,75	2,75	2,75
e_{17}	∞	∞	∞	∞	∞	2,75	2,75	2,75	2,75	2,75	2,75	2,75
e_{18}	∞	∞	∞	∞	∞	2,79	2,79	2,79	2,79	2,79	2,79	2,79
e_{19}	∞	∞	∞	∞	∞	3,09	3,09	3,09	3,09	3,09	3,09	3,09
e_{20}	∞	∞	∞	∞	∞	3,61	3,61	3,61	3,61	3,61	3,61	3,61
e_{21}	∞	∞	∞	∞	∞	∞	3,33	3,33	3,33	3,33	3,33	3,33
e_{22}	∞	∞	∞	∞	∞	∞	3,11	3,11	3,11	3,11	3,11	3,11
e_{23}	∞	∞	∞	∞	∞	∞	3,11	3,11	3,11	3,11	3,11	3,11
e_{24}	∞	∞	∞	∞	∞	∞	3,49	3,49	3,49	3,49	3,49	3,49
e_{25}	∞	∞	∞	∞	∞	∞	4,13	4,13	4,13	4,13	4,13	4,13
e_{26}	∞	∞	∞	∞	∞	∞	4,08	4,08	4,08	4,08	4,08	4,08
e_{27}	∞	∞	∞	∞	∞	∞	∞	3,79	3,79	3,79	3,79	3,79
e_{28}	∞	∞	∞	∞	∞	∞	∞	3,88	3,88	3,88	3,88	3,88
e_{29}	∞	∞	∞	∞	∞	∞	∞	4,55	4,55	4,55	4,55	4,55
e_{30}	∞	∞	∞	∞	∞	∞	∞	4,74	4,74	4,74	4,74	4,74
e_{31}	∞	∞	∞	∞	∞	∞	∞	∞	4,93	4,93	4,93	4,93
e_{32}	∞	∞	∞	∞	∞	∞	∞	∞	5,27	5,27	5,27	5,27
e_{33}	∞	∞	∞	∞	∞	∞	∞	∞	∞	5,55	5,55	5,55
e_{34}	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	6,1	6,1
e_{35}	∞	∞	∞	∞	∞	∞	∞	∞	∞	6,84	6,84	6,59

Based on the results of the calculation of iteration 11, the value for the end point is 6.59 Km, while in iteration 9 the value of the end point is 6.84 Km. Because there are two values at the end point, the minimum value will be taken, which is 6.59 Km. So that it can be determined which trajectory will be crossed to reach the end point with the shortest route. Here is a graph image of the shortest trajectory traversed to reach the endpoint based on the results of the iteration calculation:

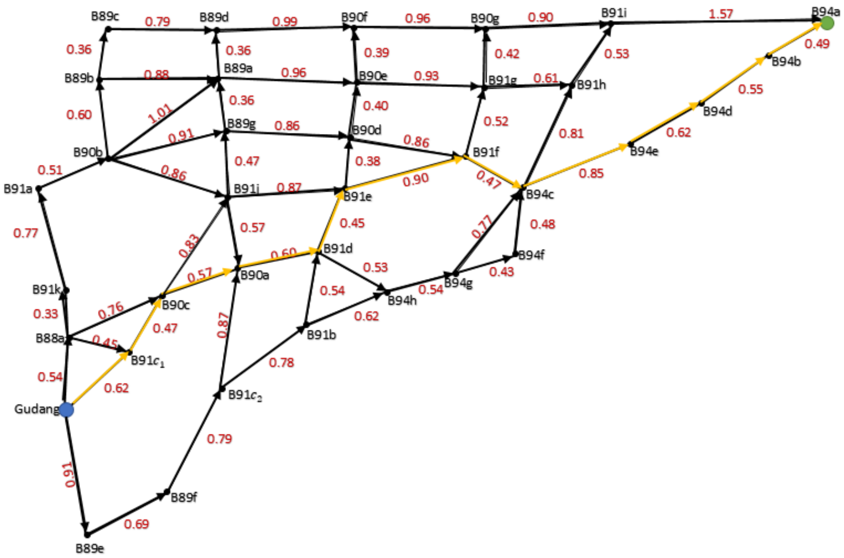

Figure 4. Shortest Track Finish

Conclusion

Based on the results of the iteration that has been carried out, there is one shortest trajectory of fertilizer transportation based on *the Bellman-Ford* algorithm with 11 points passed to reach the end point ($\boldsymbol{e_{35}}$) with a minimum distance of 6.59 Km.

CONCLUSION

Based on the results of the iteration that has been carried out, a solution to the problem of determining the shortest trajectory on the fertilizer transportation line using the *Bellman-Ford* algorithm is 1 shortest trajectory from the warehouse to $\boldsymbol{e_{35}}$ the minimum mileage. To get to the end point ($\boldsymbol{e_{35}}$) to make it faster, the fertilizer transport truck will pass through 11 points, namely $\boldsymbol{e_2} \rightarrow \boldsymbol{e_5} \rightarrow \boldsymbol{e_9} \rightarrow \boldsymbol{e_{14}} \rightarrow \boldsymbol{e_{15}} \rightarrow \boldsymbol{e_{20}} \rightarrow \boldsymbol{e_{22}} \rightarrow \boldsymbol{e_{31}} \rightarrow \boldsymbol{e_{33}} \rightarrow \boldsymbol{e_{34}} \rightarrow \boldsymbol{e_{35}}$. The calculation was carried out until the 11th iteration with the minimum mileage obtained which was 6.59 km.

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