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Comparative of prim's and boruvka's algorithm to solve minimum spanning tree problems

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Abstract. Optimization is important in an algorithm. It can save the operational costs of an activity. In the Minimum Spanning Tree, the goal is to achieve how all vertices are connected with the smallest weights. Several algorithms can calculate the use of weights in this graph. The purpose of this study is to find out the Primary electricity distribution network graph model and correct algorithm to determine the minimum spanning tree. By comparing two algorithms, Prim's and Boruvka's algorithm, it will get an efficient algorithm to solve the minimum spanning tree problem. To get the output it takes several steps: Data collection: Designing Model: calculating the minimum spanning tree of Prim's algorithm, the Boruvka's algorithm: Comparing the efficiency of each algorithms. The analysis shows that the Prim's and Boruvka's algorithm have different steps even though the final result in the form of weights obtained in achieving the minimum spanning tree is the same. But in the case of electric network optimization, the Prim's algorithm is more efficient.

Keyword : *Minimum spanning tree*, Prim's Algorithm, Boruvka's Algorithm

1. Introduction

Algorithms development and various fields of mathematical studies have been carried out to in solving the problems of infrastructure development in an area such as the networks of electricity, telephone, clean water, transportation etc. This development certainly requires supporting factors, such as cost, time and energy. Actually this can be overcome by using tree modeling in graphs. Estimating electricity consumption is important for energy planning systems [1]. The speed and security system are important in sending digital information [2]. The Minimum spanning tree (MST) is a tree that connects among the vertices of the results to minimize the weight that is in the complete graph. Graph is a mathematical representation of facts related to distance [3]. Graphs can produce several ranges that have different weights [4]. The smallest weight is MST. In designing the primary electricity distribution network, it is necessary to consider the cost factor which is closely related to the length of the cable used. Calculating the minimum cable length required from a network and considering the cabling arrangement is very important in primary electricity distribution networks. To achieve optimum system performance conditions in the primary electricity distribution network can be achieved by determining MST [5]. There are several algorithms to solve the MST problem, including the Prim's and Solin's Algorithm. Prim's algorithm is suitable for trees with a large number of vertices and will always be able to find a minimum spanning tree but the resulting spanning tree is not always unique without having to sort first [6]. The

Boruvka's algorithm is a minimum spanning tree by examining each node and adding the side with the smallest weight to the spanning tree, without paying attention to the side that has been added, and continuing to merge the side until they form a spanning tree. In solving the MST problem now, researchers generally use The Prim's or the Kruskal's Algorithm while the Boruvka's Algorithm is very rarely discussed by researchers. Therefore, the writer is interested in discussing Boruvka's Algorithm and comparing it with Prim's Algorithm to see which algorithm is better in solving the minimum spanning tree problem in Grand Asia City Housing in Labuhan Ruku by PT.PLN Tanjung Tiram branch in Batubara Regency and making electrical cable network simulation by using a program. In this study a primary electricity distribution network model was designed using a directedless graph connected to G = (V,E) where V is the set of electric poles in those housing, and E is a possible set of connections among the electrical poles such as the form of the length of the network cable. Furthermore, it is calculated and simulated by a computer program to get the MST primary electricity distribution network using Prim's and Boruvka's algorithm. Furthermore, by examining the performance of the Prim's algorithm, the Boruvka's algorithm takes the form of complexity time concerning to the efficiency of algorithm.

2. Methodology

The method used in this research is a quantitative analysis consisting of defining the problem, developing the model, obtaining input data, developing the solution using Prim's and Boruvka's algorithm, testing the solution, analyzing the results, applying the results

2.1. Prim's algorithm

This algorithm was discovered in 1930 by mathematician Vojtech Jarnik and then separately by computer scientist Robert C. Prim in 1957 and rediscovered by Dijkstra in 1959 [7]. Prim's algorithm is one algorithm that works greedy. Prim's algorithm forms step by step MST. At each step, the graph G side has a minimum weight and is connected to the minimum spanning tree that has been formed. Prim's algorithm is used to find the minimum crop of a connected graph by taking the edge that has the smallest weight of the graph, where the edge is adjacent to the measured tree that has been created and which has no cycle [8]

In [4] Prim's algorithm is given as follows.
Input: Undirected - weighted graph
Output: minimum spanning tree T
$T \leftarrow \emptyset$
Example r is any point in V
$U \leftarrow \{r\}$
While $|U| < n$ do
Determine $u \in U$ and $v \in V-U$
So that sides (u, v) is between U and V-U
$T \leftarrow T \cup \{(u, v)\}$
$U \leftarrow U \cup \{v\}$
In general, if G is a weighted connected graph, the steps to obtain MST using Prim's algorithm are as follows:

- T is still empty
- Choose a point randomly and select the related side with minimum weight and enter it in T
- Choose sides (u, v) with minimum weight and side by side at T, but (u, v) do not form a circuit at T. Add (u, v) to T.
- Repeat the above steps n-2 times.

IOP Conf. Series: Journal of Physics: Conf. Series **1462** (2020) 012043 doi:10.1088/1742-6596/1462/1/012043

The total number of steps in the Prim's algorithm is n-1, which is the number of sides in the spanning tree with n points.
Output : *minimum spanning tree* T
$T \leftarrow \emptyset$

2.2 Boruvka's algorithm

The Boruvka's algorithm is the first algorithm to find the minimum spanning tree of a graph. Boruvka's algorithm was discovered by Otakar Boruvka in 1926. [9]
Boruvka's algorithm for finding the minimum spanning tree in graph :
- Copy the dot from graph G to the new blank graph L
- Whereas L is not connected (it means that forest has more than one tree)
  - For each tree on L, connect one point to another point on the other tree on L by adding the minimum weighted sides [10]

3. Results and discussion

Complexity comparison of the Prim's and the Boruvka's Algorithm in solving MST problems was built using the Python programming language and also designed visual from the results of MST problem solving by the Matlab program. In this research, The built algorithm will be compared and analyzed to see which algorithm is the most efficient based on the complexity of each algorithm. The data used was the data of grand asia city housing located on the sloping market road in Talawi sub-district, Luku Ruku coal district, which consists of 91 houses, they will be connected to the electricity network.

Table 1. Graph weight data with 91 vertices

No	Edge		Weight
	i	J	
1	1	2	6
2	1	89	14
3	1	90	10
4	2	3	6
5	3	4	6
6	4	5	10
7	4	9	14
8	4	89	10
9	5	6	6
10	5	9	10
11	6	7	6
12	7	8	6
13	8	9	14
14	9	10	7
15	10	11	7
16	11	12	7
17	12	13	7
18	13	14	7
19	14	15	7
20	15	16	7
21	16	17	7
22	17	18	7
23	18	19	7

IOP Conf. Series: Journal of Physics: Conf. Series **1462** (2020) 012043 doi:10.1088/1742-6596/1462/1/012043

24	19	20	7
25	20	21	7
26	21	22	7
27	22	23	7
28	23	24	7
29	24	25	7
30	25	26	7
31	26	27	7
32	27	28	7
33	28	29	7
34	29	30	10
35	29	70	10
36	30	31	7
37	30	70	14
38	31	32	7
39	32	33	7
40	33	34	7
41	34	35	7
42	35	36	7
43	36	37	7
44	37	38	7
45	38	39	7
46	39	40	7
47	40	41	7
48	41	42	7
49	42	43	7
50	43	44	7
51	44	45	7
52	45	46	7
53	46	47	7
54	47	48	7
55	48	49	7
56	49	50	10
57	50	51	7
58	51	52	7
59	52	53	7
60	53	54	7
61	54	55	7
62	55	56	7
63	56	57	7
64	57	58	7
65	58	59	7
66	59	60	7
67	60	61	7
68	61	62	7
69	62	63	7
70	63	64	7
71	64	65	7
72	65	66	7
73	66	67	7
74	67	68	7

IOP Conf. Series: Journal of Physics: Conf. Series **1462** (2020) 012043 doi:10.1088/1742-6596/1462/1/012043

75	68	69	7
76	69	70	10
77	70	71	7
78	71	72	7
79	72	73	7
80	73	74	7
81	74	75	7
82	75	76	7
83	76	77	7
84	77	78	7
85	78	79	7
86	79	80	7
87	80	81	7
88	81	82	7
89	82	83	7
90	83	84	7
91	84	85	7
92	85	86	7
93	86	87	7
94	87	88	7
95	88	89	7
96	89	90	7
97	90	91	10
98	91	91	7
Total weight			740

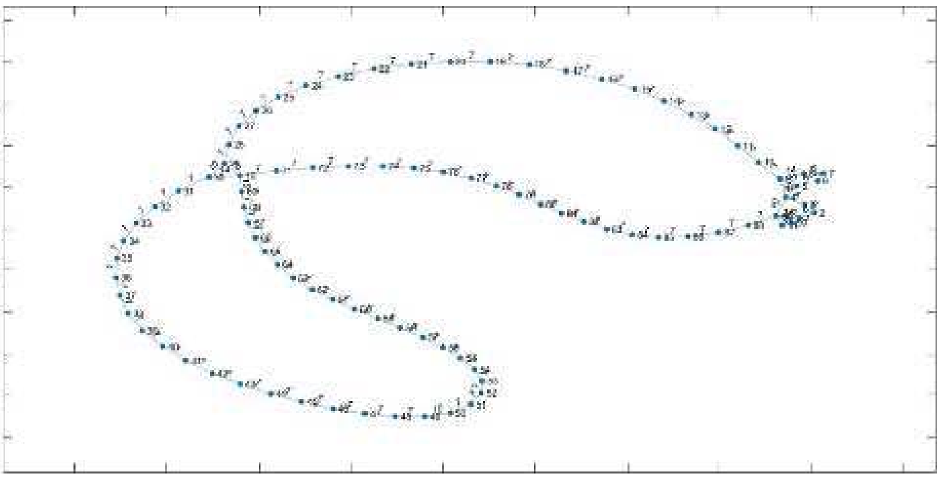

Figure 1. Grand Asia City Housing

From the figure numbers show houses, the numbers in lines show the distance between houses in meters.

3.1 User Interpace Program

At this stage, testing of the program has been done based on each algorithm. Testing on each algorithm is done by having the same treatment, that is using the same data in the form of graphs with 91 vertices.

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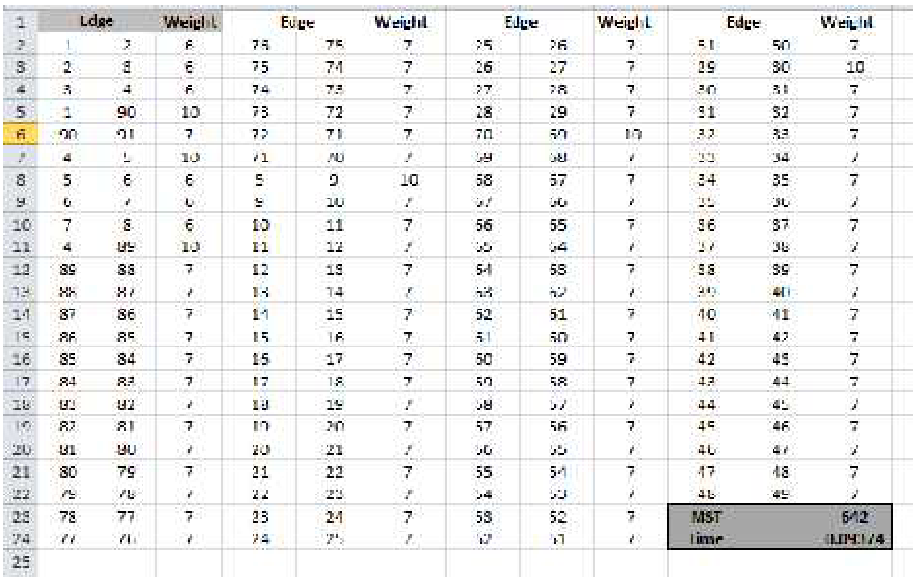
From this testing, it will be known the complexity time required by each algorithm and also vertices connected in the form of solving the MST problem from the graph used

3.1.1 mImplementation of Prim's Algorithm to solve above problem



1	Edge		Weight	Edge		Weight	Edge		Weight	Edge		Weight
2	1	2	6	76	75	7	25	26	7	51	50	7
3	2	3	6	75	74	7	26	27	7	29	30	10
4	3	4	6	74	73	7	27	28	7	30	31	7
5	1	90	10	73	72	7	28	29	7	31	32	7
6	90	91	7	72	71	7	70	60	10	32	33	7
7	4	5	10	71	70	7	69	68	7	33	34	7
8	5	6	6	5	9	10	68	67	7	34	35	7
9	6	7	6	9	10	7	67	66	7	35	36	7
10	7	8	6	10	11	7	66	65	7	36	37	7
11	4	89	10	11	12	7	65	64	7	37	38	7
12	89	88	7	12	13	7	64	63	7	38	39	7
13	88	87	7	13	14	7	63	62	7	39	40	7
14	87	86	7	14	15	7	62	61	7	40	41	7
15	86	85	7	15	16	7	61	60	7	41	42	7
16	85	84	7	16	17	7	60	59	7	42	43	7
17	84	83	7	17	18	7	59	58	7	43	44	7
18	83	82	7	18	19	7	58	57	7	44	45	7
19	82	81	7	19	20	7	57	56	7	45	46	7
20	81	80	7	20	21	7	56	55	7	46	47	7
21	80	79	7	21	22	7	55	54	7	47	48	7
22	79	78	7	22	23	7	54	53	7	48	49	7
23	78	77	7	23	24	7	53	52	7	MST		642
24	77	76	7	24	25	7	52	51	7	Time		0.09374
25												

Figure 2. Prim's Algorithm Program

From figure 2, it can be obtained that the distance can minimize the total use of cables in Grand Asia City housing, it is 642 meters of 0.0937 seconds

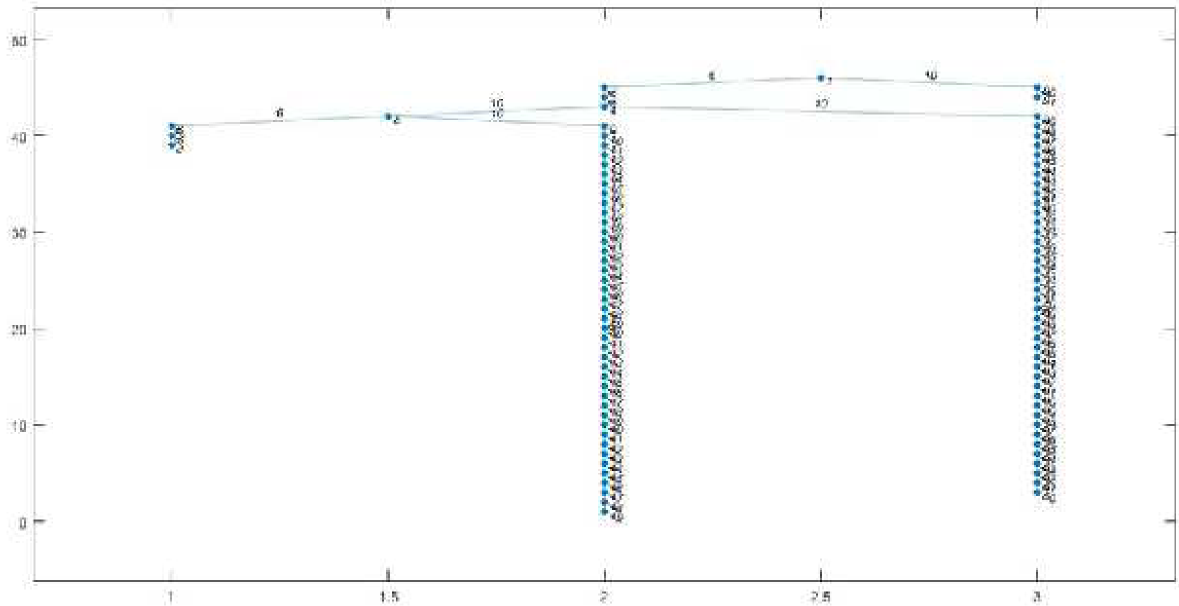


Figure 3. Graph of MST formed from Prim's Algorithm

3.1.2 Implementation of the Boruvka's Algorithm

IOP Conf. Series: Journal of Physics: Conf. Series **1462** (2020) 012043 doi:10.1088/1742-6596/1462/1/012043

1	Edge		Weight	Edge		Weight	Edge		Weight	Edge		Weight
2	1	2	6	76	75	7	25	26	7	51	50	7
3	2	3	6	75	74	7	26	27	7	29	30	10
4	3	4	6	74	73	7	27	28	7	30	31	7
5	1	90	10	73	72	7	28	29	7	31	32	7
6	90	91	7	72	71	7	70	69	10	32	33	7
7	4	5	10	71	70	7	59	68	7	33	34	7
8	5	6	6	5	9	10	58	67	7	34	35	7
9	6	7	6	9	10	7	57	66	7	35	36	7
10	7	8	6	10	11	7	55	65	7	36	37	7
11	4	89	10	11	12	7	55	64	7	37	38	7
12	89	88	7	12	13	7	54	63	7	38	39	7
13	88	87	7	13	14	7	53	62	7	39	40	7
14	87	86	7	14	15	7	52	61	7	40	41	7
15	86	85	7	15	16	7	51	60	7	41	42	7
16	85	84	7	16	17	7	50	59	7	42	43	7
17	84	83	7	17	18	7	59	58	7	43	44	7
18	83	82	7	18	19	7	58	57	7	44	45	7
19	82	81	7	19	20	7	57	56	7	45	46	7
20	81	80	7	20	21	7	56	55	7	46	47	7
21	80	79	7	21	22	7	55	54	7	47	48	7
22	79	78	7	22	23	7	54	53	7	48	49	7
23	78	77	7	23	24	7	53	52	7	MST		642
24	77	76	7	24	25	7	52	51	7	time		0.78123

Figure 4. Boruvka's Algorithm Program

From figure 4, it can be obtained that the distance can minimize the total use of cables in Grand Asia City housing, it is 642 meters of 0.78123 seconds

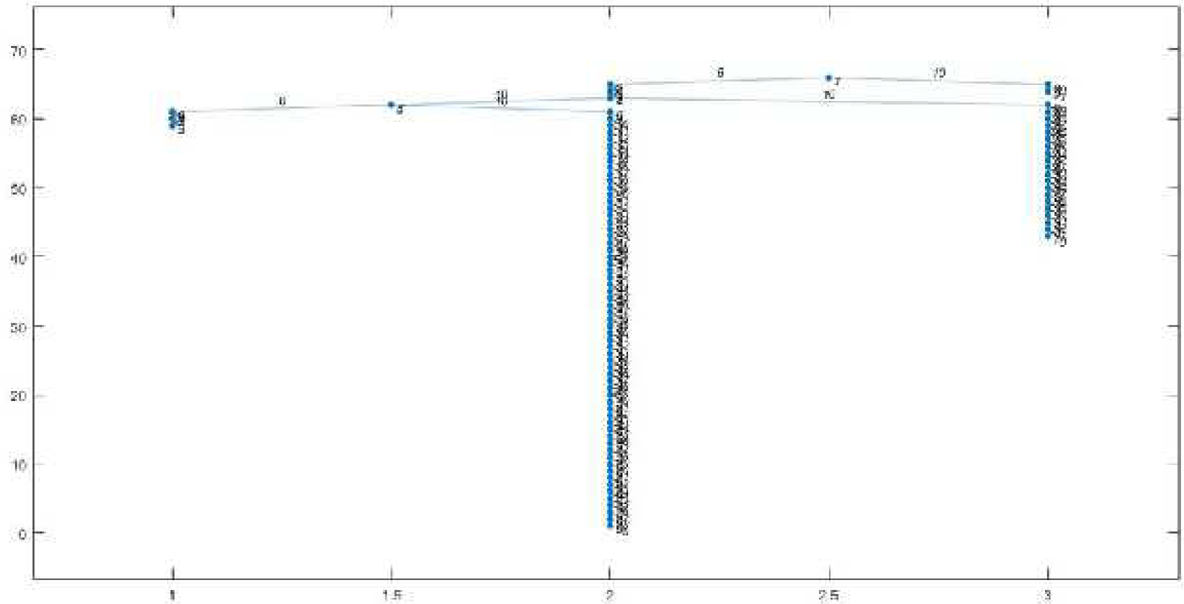


Figure 5, Graph of MST formed from Boruvka's Algorithm

3.1.3 Comparison of Prim and Boruvka's Algorithms

Based on the steps used by each algorithm in solving MST problems, it can be seen that a comparison between Prim's Algorithm and Boruvka's Algorithm are:

- The minimum number of weights produced as an MST solution on the Prim's and Boruvka's algorithm are the same as 642 meters
- The number of edges formed after stretching trees is the same for both algorithms ,that is 90 edges
- The time taken by each algorithm to complete MST is different, that is 0,0937 seconds for Prim's algorithm, and 0.78123 seconds for Boruvka's algorithm.

4. Conclusions

The Prim's and Boruvka's algorithm are algorithms used in solving MST problems. In Prim's algorithm, the minimum weight obtained is 642 meters by computing time of 9.0937 seconds. In the Boruvka's algorithm, the minimum weight obtained is 642 meters by computing time of 0.78123 seconds. From the two algorithms used, the prim's algorithm is more efficient.

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