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COMPERATIVE OF PRIM'S, KRUSKAL'S AND BORUVKA'S ALGORITMA 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. 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 three algorithms, Prim's, Boruvka's and Kruskal'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, the Boruvka's and Kruskal's algorithm: Comparing the efficiency of each algorithms. The analysis shows that the Prim's and Bruvka's and Kruskal'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 in installing of primary electricity distribution in Gand Asia City at Labuhan Ruku by PT.PLN branch Tanjung Tiram, Batubara district.

Keywords: *Minimum spanning tree*, Prim's Algorithm, Boruvka's Algorithm, Kruskal's Algorithm

Abstrak. Optimasi adalah hal penting dalam suatu algoritma. Ini dapat menghemat biaya operasional suatu kegiatan. di *Minimum Spanning Tree,* yang ingin dicapai adalah bagaimana semua *vertex* terhubung dengan bobot terkecil. Beberapa algoritma dapat menghitung penggunaan bobot dalam graf ini. Tujuan penelitian ini mengetahui Model graf jaringan distribusi listrik primer serta algoritma yang tepat untuk menentukan *minimum spanning tree*. Dengan membandingkan tiga buah algoritma yaitu algoritma Prim, algoritma Boruvaka dan algoritma Kruskal akan diperoleh algoritma yang efisien menyelesaikan masalah *nimimum spanning tree*. Untuk mendapatkan outputnya diperlukan beberapa tahap: Pengumpulan data : Merancang Model : Mencari *minimum spanning tree* dari algoritma Prim, algoritma Boruvka dan algoritma Kruskal : Membandingkan keefisienan masing masing algoritma. Dari hasil analisis menunjukkan bahwa algoritma Prim dan algoritma Boruvka dan algoritma Kruskal memiliki langkah yang berbeda – beda meskipun hasil akhir berupa bobot yang diperoleh dalam mencapai penyelesaian *minimum spanning tree* adalah sama . Namun dalam kasus optimasi jaringan listrik algoritma Prim yang lebih efisien. untuk pemasangan distribusi listrik primer di Perumahan Grand Asia City di Labuhan Ruku oleh PT.PLN cabang Tanjung Tiram Kabupaten Batubara.

Kata Kunci : *Minimum spanning tree,* Algoritm Prim, Algoritma Boruvka , Algoritma Kruskal

INTRODUCTION

Algorithm is a step by step method of solving problems derived from the name of ninth-century Arabic mathematician Al-Khowarizmi. Algorithms are based on mathematical principles which play an important role

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in mathematics and computer science (Johnsonbaugh and Richard 1997). Development of Algorithm and various fields of mathematical studies have been carried out to help solve the problem of infrastructure development in an area such as the construction of electricity networks, telephone networks, clean water networks, transportation networks and so on. . This can actually be overcome by using graph modeling in graphs. Estimated electricity consumption is important for energy planning systems (Felix Amankwah Diawuo et all 2019). The speed and security system are important in sending digital information (R. Rahim et all 2018). 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 (A. P. U. Siahaan, Rusiadi 2018). Graphs can produce several ranges that have different weights (Z. Ramadan et al 2018). 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 (Purbasari 2007). 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 (Sam M., Yuliani 2016). 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 in relation to the efficiency of algorithm.

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

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 (K. Srivastava and Ravikant Tyagi 2013). 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 (R. Sedgewick and K. Wayne 2011).

In Prim's algorithm 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 side (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.

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.

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. (Kenneth H. Rosen, 1999)

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

(Chartrand and Ortrud, 1993: 67)

Kruskal's Algorithm

Kruskal's Algorithm is minimum spanning tree algorithm that found minimum weight that may connect two trees in the forest. This is greedy algorithm in the graph theory because it found minimum spanning tree to connected graph that add arc cost increases in every steps it means that. It found subset from *edge* that tree form consists of every vertex, where the total weight each edge in tree is minimized.
If the graph is not connected, then it finds a minimum spanning forest (minimum spanning tree for each connected component). If the selected edge can be recycled, it will not form a spanning tree (Yang, XY and Qian, N. 2009). This algorithm was divided into x steps, where x is the total number of tree edges, It assesses only the edges according to the order in which x edge costs increase at a time. When people consider edges and add them to the selected edge, if a cycle appears, then just leave it. If not, it will be selected for collection.

Steps to solve the problems of *minimum spanning tree* by using Kruskal's

algorithm is as follows (Wibisono & Samuel. 2004)

- Initialize that graf T is still the empty graph
- Initialize the data to be sorted then the data is sorted from smallest weight to the largest weight
- Choose $edge\ (u, v)$ with minimum weight that do not form a circuit in T from the sorted data. Add (u, v) into T. Do this step to $(n-1)$ and formed *minimum spanning tree*solving

RESULTS AND DISCUSSION

Complexity comparative of Prim's, Boruvka's and Kruskal's algorithm in solving MST Problemwas built by using Phyton programming language and also designed visual from the result of MST problem solving by the Matlab program. In this research, 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		Bobot
	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
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
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

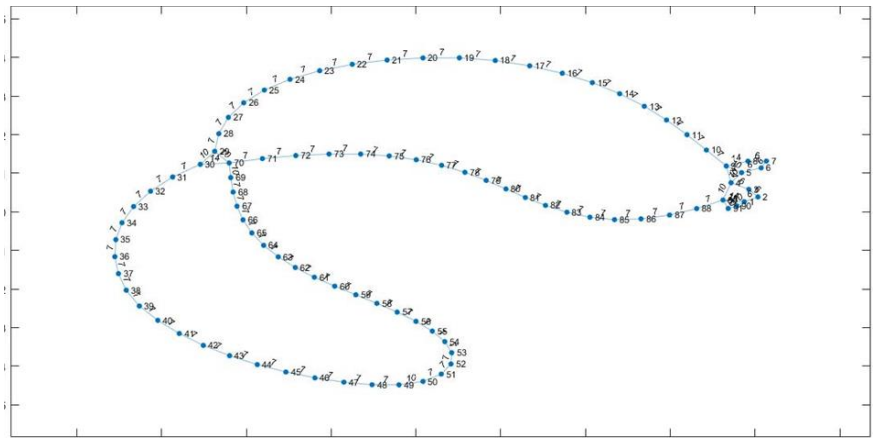

Figure 1. Grand Asia City Housing

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

Implementation of Prim's Algorithm Prim from the Above Problem

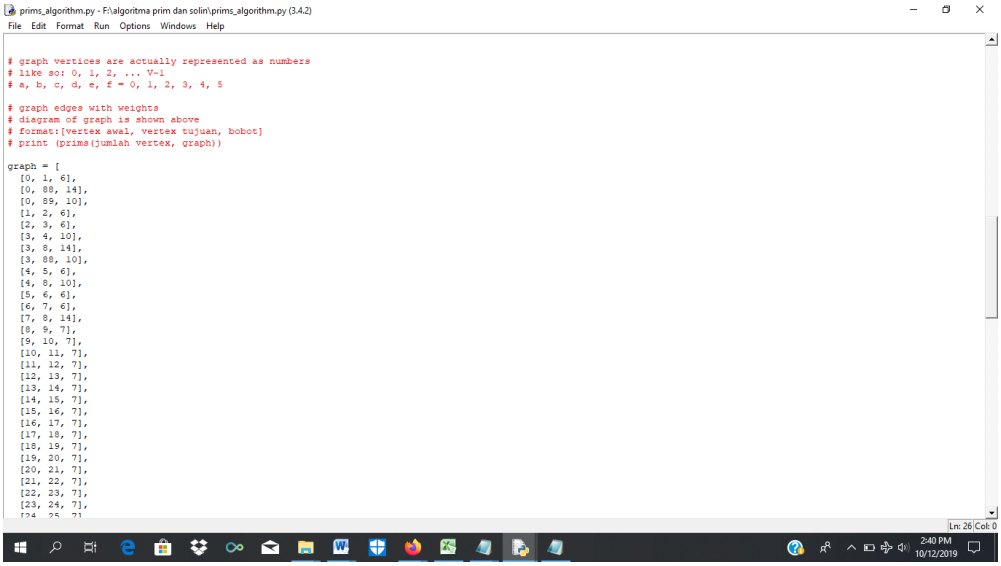

Figure 2. Prim's Algorithm Program

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

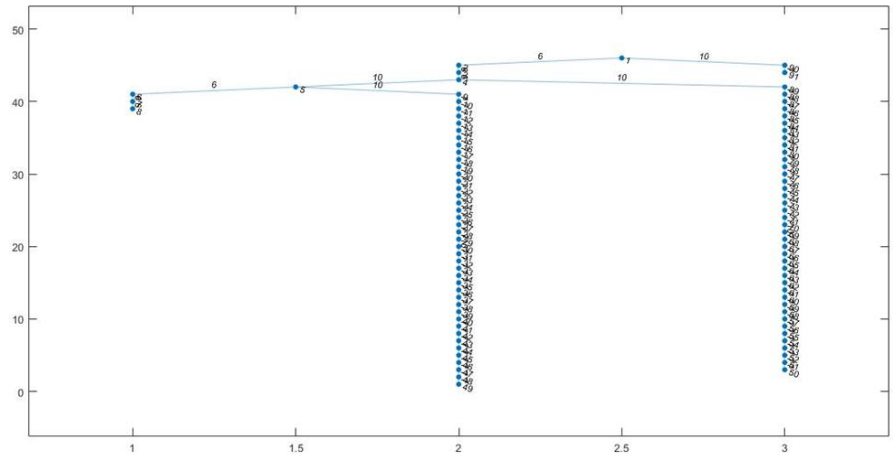

Figure 3. Formed Graph by Prim's Algorithm

Implementation of Boruvka's Algorithm for the above problem

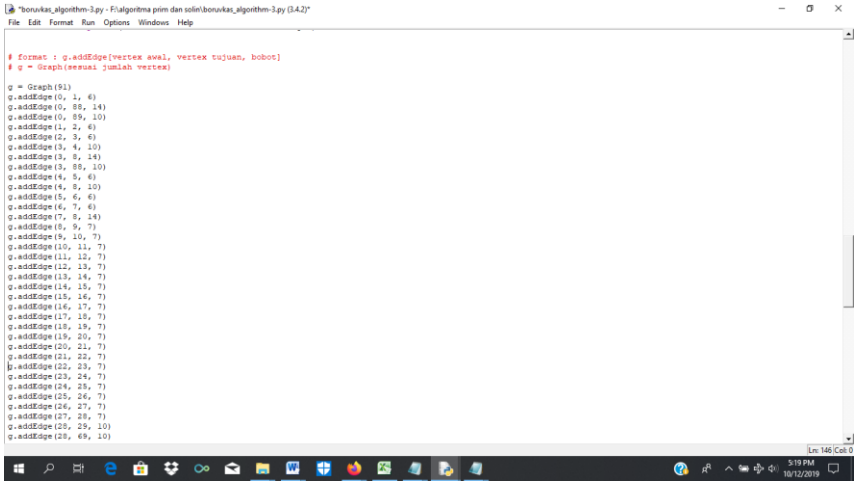

Figure 4. Boruvka's Algorithm Program

From figure 4 it can be obtained the distance can minimize the total use of cable in Grand Asia City housing is 642 meters of 0.78123 second

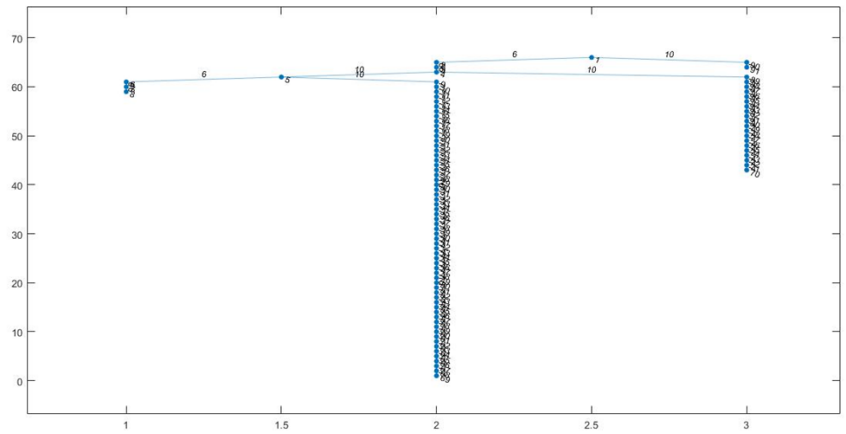

Figure 5, Formed Graph by Boruvka's Algorithm

Implementation of the Kruskal's Algorithm for the above problem

Figure 6. Program of Kruskal's Algorithm

From figure 6 it can be obtained that the distance can be minimize the total use of cable in Grand Asia City housing is 642 meters of 0.79721 seconds

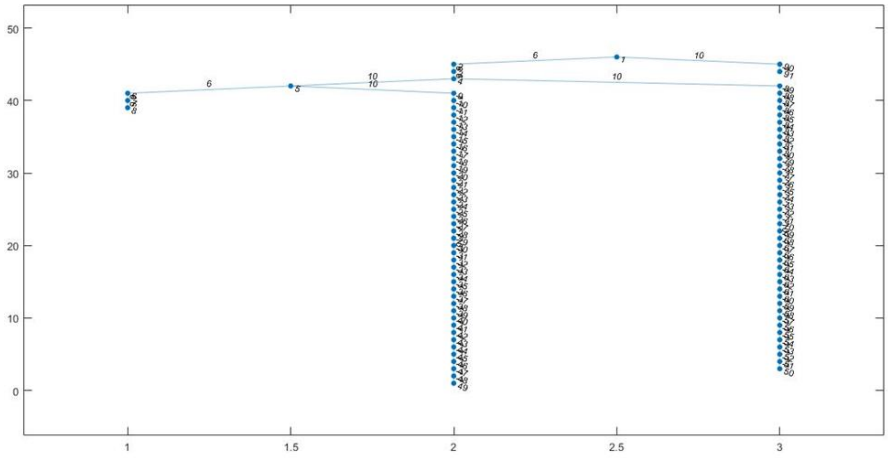

Figure 7. Graf Fromed from Kruskal's Algorithm

Comparative of Prim's, Boruvka's and Kruskal's Algorithm

Based on the steps used by each algorithm in solving MST problems, it can be seen that a comparative among Prim's, Boruvka's and Kruskal's Aalgorithm, are:

- The minimum number of weights produced as MST solution on the Prim's, Boruvka's and Kruskal's algorithm are t
- he same.
- The number of edges formed after getting spanning trees are the same for all three algorithms
- The steps taken by each graph in Prim's, Boruvka's and Kruskal's algorithm to form MST are different
- The time taken by each algorithm to complete MST problems is different

CONCLUSION

Prim's, Boruvka's and Kruskal's algorithm are algorithems that can be used in solving MST Problems. The process used in getting the result is different but the final result he final result in the form of the weighted value obtained is the same. The running time needed to solve the MST problem is different.

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