IJSME: International Journal of Science and Mathematics Education
Vol. 1, No.1 Maret 2024
e-ISSN: XXXX-XXXX; p-ISSN: XXXX-XXXX, Hal 29-35

Analysis of the Use of the Boruvka Algorithm Method in Electricity

Nyoman Widhi Wisesa

Ria fitri mawardiningrum

Abstract:*Analysis of the use of the Boruvka algorithm method in the context of electricity supply is an important topic in the development of electricity systems. In this study, we evaluate the effectiveness and application of the Boruvka algorithm in distribution optimization and power grid management. We study ways in which the Boruvka algorithm can be used to identify optimal electricity distribution paths, improve system efficiency, and minimize the potential for grid damage or failure. This research provides a deeper understanding of the potential and limitations of the Boruvka algorithm in the context of modern electricity infrastructure.*

Keywords: *Boruvka Algorithm, Electricity, Distribution Optimization, Network Management, System Efficiency..*

BACKGROUND

Minimum Spanning Tree (MST) is a graph problem that has been widely applied both directly and indirectly in everyday life. The minimum spanning tree problem is almost similar to the shortest path problem, namely connecting all the nodes in the network so that a minimum total route length is obtained (Efendi dkk., 2021).

Lots structure can be represented by graph . Currently graph can be used for optimize the electricity network. The power grid will be represented in form graph *G*connected, directionless, and weighty. So the electricity pole can be represented as a *vertex* , while the installed electricity cables are the sides *(edges)* . The graph representation results will be analyzed by applying a *Spanning Tree* .

In managing Power in amount great , efficiency comprehensive needs to be done for ensure availability every component allocated . In work development which is considered sufficient reliable And quality OK , level price Which more low can ensure process collection And distribution electricity to small towns And area isolated (Tania dkk., 2021).

The existence of electrical energy in every human life is a necessity in the wheel of life. Becoming dependent on the availability of electrical energy is increasing, reviewing the continuity of various daily activities, for example washing machines, lights, fans, etc.

Tanjung Tepi is one of the sub-districts in Siantar Martoba sub-district, Pematangsiantar City, North Sumatra Province. Tanjung Pinggir Village experienced electricity network distribution problems. Due to increasingly dense residential areas, many areas have to be minimized without reducing their function. It is like the electricity network cable that will be installed must be optimal, meaning that the length of the cable installed must be minimal and able to supply electricity to all existing settlements.

The PLN electricity supplier that supplies electricity to the Tanjung Pinggir sub-district is PT. PLN (Persero) UP3 Pematangsiantar. As the number of new housing settlements in Tanjung Pinggir Village increases, the need for electricity to be distributed increases. However, based on monitoring of PT. PLN (Persero) UP3 Pematangsiantar in Tanjung Pinggir sub-district shows the problem that the length of electricity distribution cables installed in each residential area is inefficient and exceeds 2,500 meters. So, PT. PLN (Persero) UP3 Pematangsiantar needs to pay attention and measure correctly, so that no supply of electrical cables is wasted, which can result in inefficient cables and large expenditures of funds.

In electrical network problems, a minimum spanning tree can be used to obtain a solution to an electrical network that requires minimum costs in using cables. Manual work can be used to determine *the minimum spanning tree* but it takes a long time. So, to determine the minimum spanning tree in the research, the algorithm used is the modified Prim algorithm and the Kruskal algorithm which uses the *Hamiltonian path concept.* (Afrianti dkk., 2021).

Based on research by Dani Nur Afandi (2017) entitled Application of the Boruvka Algorithm with the Contracted Graph Method in Determining *the Minimum Spanning Tree* , it was concluded that the Boruvka Algorithm with the Contracted Graph method can find optimal solutions in PDAM pipe networks that have been analyzed (Afandi, 2017).

Research that has been carried out by Miftahul Khoiriah (2010), compares the minimum spanning tree solution using four algorithms, each of which has a different phase in determining the minimum spanning tree. The greatest possibility to determine the minimum spanning tree can be obtained using the Boruvka algorithm. The first stage of the Boruvka algorithm is to determine the forest, with the condition that it does not consider the weight of the selected edges before obtaining the minimum spanning tree (Khoiroh, 2010). So the author is very interested in conducting research on the Boruvka algorithm. The author uses the help of the Python programming language to avoid errors during the modeling process carried out by *human error* .

Based on the background described above, the author is interested in conducting research with the title "Application of the Boruvka Algorithm to Electrical Networks (Case Study in Tanjung Pinggir Village, Siantar Martoba District)".

THEORETICAL STUDY

Theory graph starts at in 1736 when L. Euler considered problem Konigsberg Bridge . L. Euler discovered answer on question from this question by modeling questions as graph . Theory graphs study concepts that related with set node And set side .

An ordinary graph is represented by Ga pair of sets consisting of a non-empty set of elements $v_1, v_2, v_3, \dots v_n$called vertices *and* a set of unordered pairs of vertices $e_1, e_2, e_3, \dots e_n$ called *edges* (Riswan, 2018).

A graph Gcontains two sets, namely a non-empty finite set $V(G)$ obtained from objects called vertices and a finite (possibly empty) set $E(G)$ whose elements are called edges such that each element $e$in $E(G)$ is an unordered pair of vertices in $V(G)$. A set $V(G)$ is called a vertex $G$and a set $E(G)$ is called a set of edges G(Budayasa, 2007).

From this definition it can be interpreted that Vit cannot be empty, while Eit can be empty. So, a graph may not have a single edge, but it must have at least one vertex. And a graph that has only one vertex and no edges is called a trivial graph .

Graphs can be grouped into several types:

- *Based on whether or not there are edges in a graph.*
  - Simple graph *(simple graph), a* graph that does not contain rings or double sides.
  - Unsimple graphs , *graphs* that contain double sides or rings.

Some terms that are often used in graphs are:

a. Adjacent

Two vertices $u$and $v$in a graph $G$are said to be adjacent *(adjacent)* if $u$they v are directly connected by an edge. In other words v_j, adjacent to $v_k$if $\left(v_j, v_k\right)$ is an edge in the graph.

b. Side by side *(incident)*

For any edge $e = (u, v)$, the edge $e$is said to be adjacent to the vertex $u$and vertex v. Bracelet *(loop)*

Loops are edges that connect the same vertex.

c. Cycle

A cycle or circuit is a path that begins and ends at the same node.

d. Connected

Vertices $u$and vertices $v$are said to be connected if there is a path from $u$to v. If there is a path directed from $u$to $v$and a path directed from $v$to u, then the two nodes are said to be strongly *connected* . And if there are only directional paths from $u$and $v$alone it is called *weakly connected.*

e. Subgraphs and Subgraph Complements

For example $G = (V, E)$, a graph. $G_1 = \left(V_1, E_1\right)$ is a subgraph of Gif $V_1 \subset V$and $E_1 \subset E$. Meanwhile, the complement of a subgraph $G_1$of a graph $G$is a graph $G_2 = \left(V_2, E_2\right)$such that $E_2 = E - E_1$and $V_2$is a set of vertices whose members $E_2$are adjacent to it.

f. Weighted graph *(Weighted Graph)*

A weighted graph is a graph where each edge is given a price *(weight).*

A tree is a connected undirected graph that has no circuits. In other words, if $G = (V, E)$ it is a tree, it Vcannot be an empty set but E can be empty.

A spanning tree *is* a subgraph that contains all the vertices *and* has the shape of a tree. In other words, a spanning tree is a subgraph that contains all the vertices and edges that are connected to form a tree and includes all the vertices in the original graph.

If Git is a weighted graph, then the sum of the weights of all edges in $T$is the span weight $T$of G. For each different weight, the spanning tree is different too. A *minimum spanning* tree is said to be so if the spanning tree has minimum weight .

The Boruvka algorithm is a *minimum spanning tree* (MST) algorithm used to find MST solutions in undirected graphs. This algorithm was first discovered by Otakar Boruvka in 1926. The Boruvka algorithm uses an iterative approach to find MST in graphs. This algorithm starts by creating each vertex as a separate component and updates the components by selecting the shortest arc within each component. This process is repeated until there is only one component that covers all the vertices in the graph.

RESEARCH METHODS

This type of research is a case study. The data used is electricity distribution network data obtained from Tanjung Pinggir Village by taking data on the distance between houses and electricity poles to determine the length of electricity cables needed for electricity distribution.

The procedures carried out in conducting this research are as follows:

1. Conduct a literature study on basic graph theory that supports the discussion.
2. Taking data which is a map of the electricity distribution network that has been installed in Tanjung Pinggir Village from PT. PLN (Persero) UP3 Pematangsiantar.
3. Converting data that was originally in the form of a map into data in the form of a weighted connected graph.
4. Identifying data.

a. What matters is the length of the power cable.
b. Length of power cable as side.
c. Home as a node.
5. Processing data that has been changed to determine *the minimum spanning tree* with the Boruvka Algorithm.
6. Using the Python programming language to check *the minimum spanning tree* .
7. Draw a conclusion.

RESULTS AND DISCUSSION

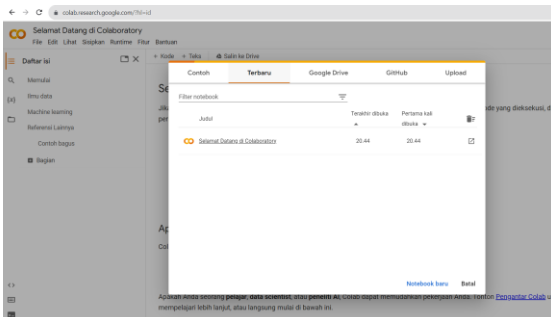
This research was conducted in Siantar Martoba District which is located in Tanjung Pinggir Village and the time required for the research was approximately two months.

This research uses data obtained from PT. PLN (Persero) UP3 Pematangsiantar. This data includes information regarding electricity distribution cable lines in Tanjung Pinggir Village, which is one of the Villages located in Siantar Martoba District. The electricity distribution network used in Tanjung Pinggir Village is a primary distribution network with a radial pattern, because it uses Medium Voltage Air Lines (STUM) which is a common pattern used in the Tanjung Pinggir Village area.

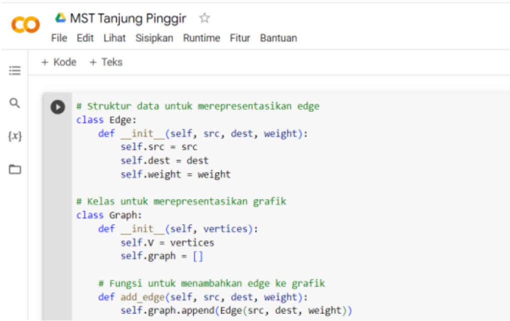
From the data obtained, the house is identified as a node, the length of the electric cable as the edge, and the weight in meters. The total length of electric cables installed in Tanjung Pinggir Village is 2,632 meters, consisting of 190 nodes and 191 sides.

Steps to determine *the Minimum Spanning Tree* from electricity distribution data in Tanjung Pinggir Village using Python via Google Colab:

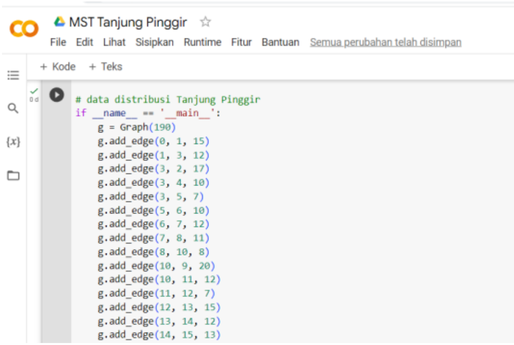
- Open Google Colab (https://colab.research.google.com/)
- Create a new notebook by clicking the "+ Notebook" or "File" > "New Notebook" button.



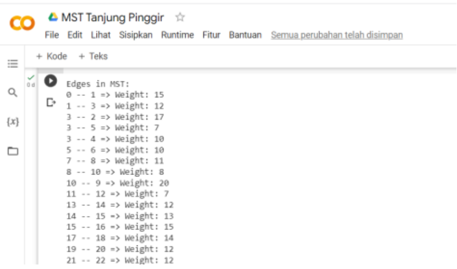
- Input coding that can be used to determine *the Minimum Spanning Tree.*



- Input electricity network distribution data.



- Click the run icon to run the program.
- Next, the program will display *the Minimum Spanning Tree output.*



Minimum Spanning Tree calculations on the electricity distribution graph using the Boruvka algorithm, we obtained 189 paths, 190 nodes and a cable length of 2,591 meters. So the use of electrical cables is 41 meters more efficient. Before being optimized, the cable length used was 2,632 meters, 191 lines and 190 nodes. Using Python to determine *the Minimum Spanning Tree* produces *a Minimum Spanning Tree* with the same number of paths as the number of paths obtained from manual calculations.

CONCLUSION

Based on the results of research and discussion regarding the application of the Boruvka Algorithm to the electricity network in determining *the Minimum Spanning Tree* in Tanjung Pinggir Village, Siantar Martoba District, the following conclusions can be drawn:

1. Before data processing, there were 191 lines, 190 nodes and a cable length of 2,632 meters. After applying the Boruvka Algorithm to determine *the Minimum Spanning Tree*

produces 189 lines, 190 nodes and a cable length of 2,591 meters. So the use of electrical cables is 41 meters more efficient.

2. For calculations *Minimum Spanning Tree* with the Boruvka Algorithm and Python via Google Colab can determine the minimum distance for electricity distribution in Tanjung Pinggir Village, Siantar Martoba District.

REFERENCE LIST

Afandi, N. (2017). *Application of the Boruvka Algorithm, Contracted Graph Method in Determining the Minimum Spanning Tree (Case Study: PDAM Gunungkidul, Wiladeg and tinggi regions)* .

Afrianti, Effendi, & Welyyanti, D. (2021). Determining the Minimum Spanning Tree Using a Modified Algorithm from the Prim and Kruskal Algorithm in Efficient Tourist Route Planning. *Unpam Journal of Science and Mathematics* , *3* (2), 103–110.

Budayasa, IK, (2007). Graph Theory and Its Applications, Unesa University Press, Surabaya.

Diestel, R. (2005). Graph Theory. In *Springer* . Springer.

Efendi, R., Susilo, B., & Prasetyo, Y. (2021). Comparison of the Boruvka Algorithm and Sollin Algorithm in Optimizing Fiber Optic Cable Needs, Bengkulu University. *Journal of Scientific and Applied Informatics* , *4* (2), 175–181.

Khoiroh, M. (2010). *The effectiveness of using the Boruvka algorithm, Prim algorithm, Kruskal algorithm, and Sollin algorithm in determining the minimum spanning tree* .

Mulki, A., Suhaedi, D., & Permanasari, Y. (2022). Electrical Distribution Network Optimization with Minimum Spanning Trees Using the Python Programming Language. *Bandung Conference Series: Mathematics* , *2* (1).

Munir, R. (2010). Discrete mathematics. In *Bandung Informatics* (4 ed.). Bandung Informatics.

Rahayuningsih, S. (2018). *Graph Theory and Its Applications* .

Riswan, R. (2018). Determining the Minimum Distance in an Electric Network using the Prim Algorithm and QM for Windows (Case Study of Fishermen's Housing in Palopo City). *Al-Khwarizmi: Journal of Mathematics and Natural Sciences Education* , *6* (1), 77–88. https://doi.org/10.24256/jpmipa.v6i1.460

Tania, J., Firza, D., & Cahyadi, I. (2021). Application of Minimum Spanning Trees in Optimizing Electrical Networks in Depok Indah Housing Complex I. *Bulletin of Applied Industrial Engineering Theory* , *2* (2).

VanderPlas, J. (2016). *Python Data Science Handbook*.

Wibison, S. (2008). *Matematika Diskrit* (2 ed.). Graha Ilmu