DETERMINATION OF ROUTER LOCATION FOR OPTIMIZING COMPUTER NETWORK USING DOMINATING SET METHODS

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***Abstract*— The aims of this research is to develop a system to determine an optimal router location in a computer network. The router location is optimal if the computer network need the minimal number of router without losing the network connectivity. The methods used in order to optimize the router location are dominating set and Greedy algorithm. The data is the router location of computer network in University of Jember. The result showed that the optimal router needed in the networks is 4. These routers were found by using the determination system that implement Greedy algorithm to find the minimum number of dominating set.**

Keywords*— *Router, Dominating Set, Greedy algorithm

I. INTRODUCTION

Implementation of lectures at University of Jember (UNEJ) performed with integrated information system call Sistem Informasi Terpadu (SISTER) UNEJ. SISTER UNEJ is an application that operate using the internet. SISTER UNEJ help lectures to record student and lecturer attendance, archiving subject matter, do the exam, quiz, or evaluation, even do online lectures. With SISTER UNEJ, lectures can be done anywhere at any time as long students and lecturer have access to the internet. To attend attendance, student must scan QR code with SISTER for Student application on their smart phone. The smart phone used must be connected to the internet through the access point of each room where lecture conducted. So that student attendance can be recorded in SISTER UNEJ, lecturers must attend attendance by login in to the subject of lecture conducted. And also lecturers must be login using the internet through the access point of each room where lecture conducted.

In its implementation there are some limitations in SISTER UNEJ used. One of the limitations is the ability of access to the internet. Along with the increasing level of demand and the increasing number of network users who want a form of network that can provide maximum results both in terms of efficiency and improvement of network security itself. One of them is a hotspot that is much popular today. Because of its easy and inexpensive usage in the use of media or devices. Hotspot no longer requires too many cables to be able to share data. Because hotspots rely on wireless transmission media using signals. Hotspot itself requires hardware that can support data sharing without using a cable, hotspot router. A router is a device that sends data packets through a network or the Internet to its destination, through a process known as routing. Routers can be used to connect several small networks to larger networks, called Internetworks, or to divide large networks into several subnetworks to improve performance and also simplify management.

Disruption in internet use that often occurs, among other because of the large number of users who access it at the same time. And router position is also sometimes a problem because it cannot access the internet properly. For example, the position of the router is outside the class which is blocked by a thick wall. Sometime here is another access point with another service set identifier (SSID) from another room detected in the room. Positioning and exact positioning access point are taken into account in order to keep the network maximizing its reach with good fixed network connectivity [1]. It takes the right strategy to determine the position and distance between routers in a area, in order to function every router is maximized. Some researches on router locations determination were done by several authors such as in [2] and [3].

In this study graph theory is used to describe and determine the location of the router hotspot so that the internet network can be used optimally. Placing a router in a strategic place is also expected to minimize the number of hotspot routers that are used so as to reduce the usual procurement of goods and the use of electricity. Optimal position of the router at the University of Jember are represented in graphical form with the route location as a point. The graph is then analyzed using Set Dominate to determine the location and number of routers to be installed. The router is described as a point and the distance between the routers as a line.

Dominating Set is applied to the search point of router location University of Jember to find out which Router dominating other router. Search point dominates using the Greedy algorithm. The Greedy algorithm is one of the most commonly used algorithms in mathematics and computer science. Algorithm Greedy is a type of algorithm that uses a problem-solving approach by finding the maximum value while at each step. This maximum value is known as the local maximum. The Greedy algorithm usually provides a solution that approaches the optimum value in a reasonably fast time.

This study aims to optimize the location of the Router at the University of Jember by using Dominating Set. The search algorithm used to solve the problem is the Greedy algorithm.

II. RESEARCH METHOD

A. Design of System

This study is done by implementing Greedy algorithms and one of topics in Graph theory, namely, Dominating Set to solve the problem. Its was conducted by creating an information system for determining the dominating set on the router graph at the University of Jember. This Information System was built to find out the domination nodes on the router graph as a representation of router location at the University of Jember. The node used is the location of the router and the line between the nodes of the router.

The predominant set is a subset of V' from the set of points (G) where the points that are not on V' are directly connected to a minimum of one point on V'. The smallest size of the dominating set is called the domination number denoted by (G) [4]. The upper limit of the domination number is the number of points on the graph [5]. If there is at least one point needed for domination in graph, then $1 \leq \gamma(G) \leq n$ for every graph with a n order. To find out the optimization in determining the dominating set in any graph by followed Equation (1), where p is the number of points in any graph, $\Delta(G)$ is the greatest degree in any graph, and $\gamma(G)$ is approximate number of Dominating Sets.

$$[1/1+\Delta(G)] \leq \gamma(G) \leq p - \Delta(G) \quad (1)$$

Greedy Algorithm is a type of algorithm that uses a problem solving approach by looking for a maximum temporary value at each step. This maximum value is known locally as local maximum. In most cases, Greedy algorithm will not produce the most optimal solution, so Greedy algorithm usually provides a solution that approaches the optimum value in a fairly fast time. Because of Greedy's nature, the Greedy algorithm is often regarded as an "short sight" and "non-recoverable" algorithm. Therefore, too, the Greedy algorithm is best used on problems that do not attach the optimum solution, and is suitable for simple problems [6].

The Greedy algorithm component consists of: (1) the set of candidate *C* which is the set that contains the solution-forming elements; (2) a set of solutions containing the problem solving elements; (3) the selection function for selecting the most likely candidate from the candidate set to be incorporated into the solution set for the optimal solution to be formed (note that the candidate which is already selected in a step will not be considered in the next step); (4) a feasibility function is a function that checks whether a selected candidate will lead to a viable solution, that candidate together with the set of selected solutions will not violate the prevailing constraints on the problem; and (5) an objective function that maximizes or minimizes the value of the solution [7].

In addition to using the greedy algorithm and dominating sets, this system is made based on the web. system input in the form of router data, user data entered by the system admin, as well as other supplementary data. In addition to the main purpose of determining the location of the installation, this system router also backs up data every time there is a new router data. General description of the system is shown in Figure 1.

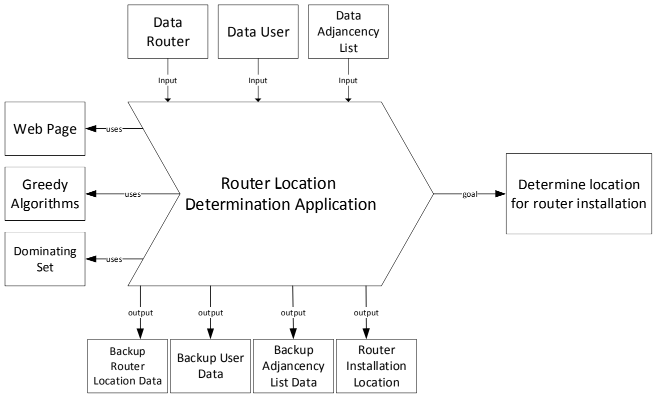

Fig. 1. System Overview

B. Data Analisys

The data used in this research is the location of routers to be installed at University of Jember and map of University of Jember region obtained from tracking process using Geo Tracker application. Tracking results are then processed using GPS Track Editor. The data then was calculated using Dominating Set and Greedy algorithm. The flow diagram of the routers location determinant information system can be seen in Figure 2.

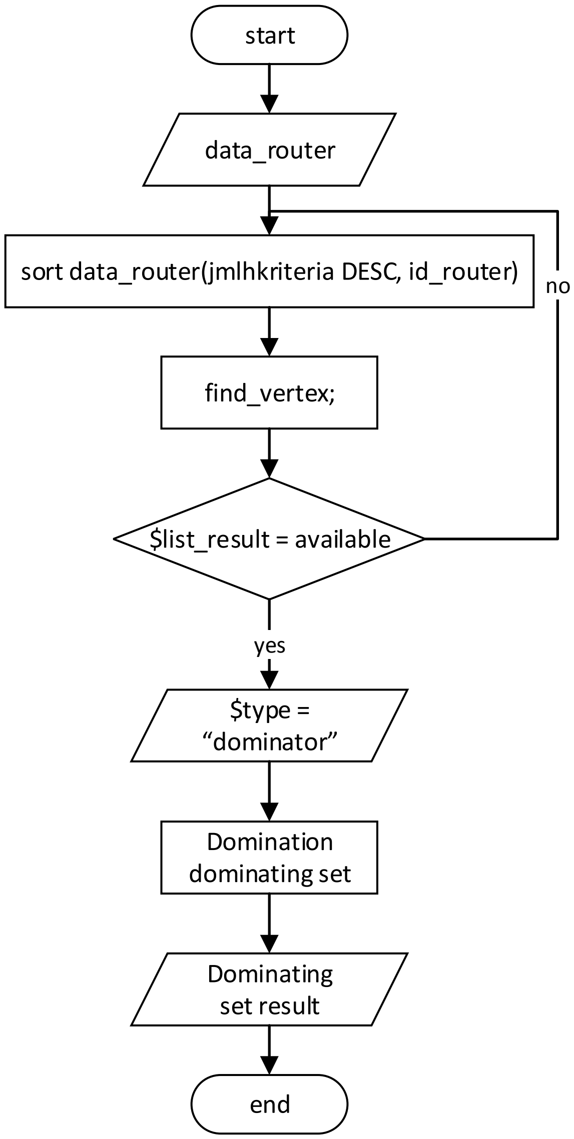

Fig. 2. System Flowchart

For a graph G with a vertex set V and an edge set E, a subset S of V is called a dominating set if every vertex x in V is either in S or adjacent to a vertex in S. The domination number, denoted by $\gamma(G)$, is the minimum cardinality of the dominating set of G [4]. The upper bound of the dominating number is the number of nodes (order) in the graph [5]. if at least one node is need to dominate other nodes in graph, then $1 \leq \gamma(G) \leq n$ for any graph of order n. To know whether the dominating set of any graph is optimal or not, we follow the Equation (2), where n is the order of the graph, $\Delta(G)$ is the maximum degree, and $\gamma(G)$ is the dominating number.

$$[n/(1+\Delta(G))] \leq \gamma(G) \leq n - \Delta(G) \qquad (2)$$

Greedy algorithm is applied to the system to determine the dominating number. Greedy Algorithm is an algorithm that uses a problem solving approach by searching temporary maximum value. This value is known as *local maximum*. In many cases, Greedy algorithm does not provide the most optimal solution. However, this algorithm usually provides solutions that close to the optimum value in a fairly fast time. Because of the Greedy nature, the Greedy algorithm is often regarded as a "short sight" and "non-recoverable" characteristic algorithm. Hence, the Greedy algorithm is best used on issues that are not concerned with the optimum solution, and are suitable for simple problems.

Simple Greedy algorithm is used to find dominating number $\gamma(G)$ as minimal as possible for graph G of order n and size (the number of edge) m. It can be shown that the upper bound is $\gamma(G) \leq n + 1 - \sqrt{(2m+1)}$. Let $V = \{1,2,3,\ldots,n\}$, and $S = \emptyset$. Greedy algorithm adds an edge to S in every step until obtaining a minimal dominating set. A node j is covered if $j \in S$ or any neighbour of j is in S. Any node which is not covered is called uncovered node [8].

III. Implementation of System

System developed refers to the waterfall model [9]. The development process is carried out gradually from the previous stage and runs sequentially. The first stage must be completed first, then proceed with the next stage. In general, the stages in the waterfall model are divided into 5 stages: needs analysis, system design, implementation, testing and maintenance included in the flow diagram Figure 3. This model was chosen because it is easier to manage and more detailed to build the system.

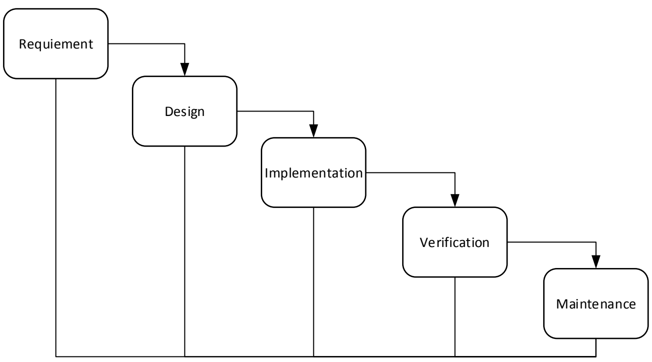

Fig. 3. Waterfall Model [9]

The application of router location determination is a web based system which implements Dominating Set and Greedy algorithm to determine the location of the router. Data input is sourced from router data, user data, as well as neighboring router data. In addition to determining the exact location for the installation of the router, this system can also backup location data router, user data, and point neighbor data.

Features provided in this system are login, router data management, neighbour node data management, displaying greedy algorithm and dominating set calculation results, user management, and displaying router data. This system can be accessed by three types of users, namely superadmin, admin router, and graph admin. The access rights to the features for these three users are as illustrated in Figure 4.

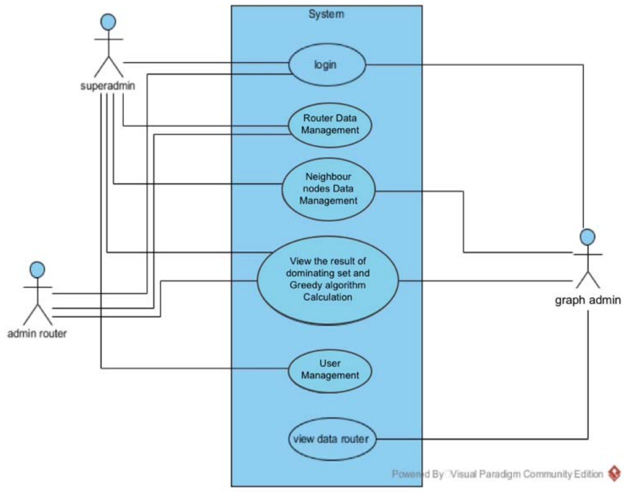

Fig. 4. Usecase Diagram of System

IV. Result And Discussions

The implementation of dominating sets on the system determination of the router location is related to the purpose of this research, that is, to provide a recommendation for the location of the router to be installed in the area of University of Jember. To achieve the purpose, this system has a main feature that is the determination of the router location. This feature applies the calculation of dominating set by searching dominating nodes using Greedy algorithm. The data used in this feature is the node data of router and neighbor node. The data of neighbour node is obtained from the node of router associated with other router.

The process of determining the routine layout of the collection of dominance on the graph is to determine the graph representation of the University of Jember land. Representation of the graph at the University of Jember produces 26 points as in Figure 5. In addition to displaying in the form of images, each node also shows the latitude and longitude position of the node.

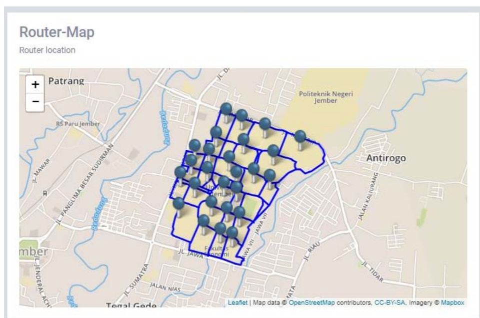

Fig. 5. Map of The Router Location

The first stage is sorting vertex based on the number of the most neighboring points sorted from the largest to the smallest. The first stage of determining vertex can be seen in Table 1. Its indicates that the Router with id 14 and 18 which has the highest number of neighbors in all existing Vertices, has 6 neighbors, while the number of neighbors with the least number of IDs is Router 4, 5, 11, 16, 20, 22 with only 2 neighbors.

TABLE I. VERTEX SEQUENCE

Id_Router	Number of neighbors	*latitude*	*longitude*
14	6	-8.16329911	113.716636
18	6	-8.16209903	113.717698
21	5	-8.1628743	113.719811
23	5	-8.16415934	113.718406
26	5	-8.16509391	113.71626
1	4	-8.16661257	113.712999
6	4	-8.16693118	113.716493
7	4	-8.16651699	113.715348
8	4	-8.16520011	113.714168
12	4	-8.16406376	113.715048
13	4	-8.16275748	113.715198
19	4	-8.16098392	113.719211
24	4	-8.16436112	113.717151
25	4	-8.16548685	113.717172
2	3	-8.16661257	113.712999
3	3	-8.16840205	113.715988
9	3	-8.16443015	113.713151
10	3	-8.16357523	113.7139
15	3	-8.16155741	113.71572
17	3	-8.16038918	113.717537
4	2	-8.16870472	113.716861
5	2	-8.16728164	113.717398
11	2	-8.16252384	113.714157
16	2	-8.1599219	113.716421
20	2	-8.16187601	113.721771
22	2	-8.16463724	113.719586

The next second step is to determine the dominator point based on the list of neighboring points, if the list of neighboring points has not been dominated by other points then that point becomes a dominator. The second stage of determining the dominator point can be seen in Table 2. The list that is marked by red is the neighbor list that has the dominator point as the Router id whose list of neighbors has been dominated by other points cannot be used as dominators, because it can be said dominator if the Router ID has a neighbor list that is not dominated by other points. The Dominator Router Id is marked with a blue color of 5, namely 14, 1, 4, 16, 20.

TABLE II. DOMINATOR POINTS

Id_router	Number of neighbors	list	declaration
14	6	12,13,18,23,24,26	dominator
18	6	14,15,17,19,21,23	not
21	5	18,19,20,22,23	not
23	5	14,18,21,22,24	not
26	5	7,8,12,14,24,25	not
1	4	2,7,8,9	dominator
6	4	3,5,7,25	not
7	4	2,6,8,26	not
8	4	1,7,9,12	not
12	4	8,10,13,26	not
13	4	11,12,14,15	not
19	4	17,18,20,21	not
24	4	14,23,25,26	not
25	4	6,23,24,26	not
2	3	1,3,7	not
3	3	2,4,6	not
9	3	1,8,10	not
10	3	9,11,12	not
15	3	13,16,18	not
17	3	16,18,19	not
4	2	3,5	dominator
5	2	4,6	not
11	2	10,13	not
16	2	15,17	dominator
20	2	19,21	dominator
22	2	21,23	not

The third stage then searches for points that have not been dominated by dominator points. The point is marked with yellow which can be seen in Table 3. Its shows the router id that has not been dominated by the dominator point, marked in yellow. Router IDs 6, 25, 10, 11, 22 are router ids whose list is not dominated by the router id that is router id 14, 1, 4, 16, 20. The purpose of finding this remaining point is to find the router id that has not been dominated by the dominator point where this remaining point can later be used as another dominator point.

TABLE III. RESIDUAL POINT

id_router	Number of neighbors	list	decleration
14	6	12,13,18,23,24,26	dominator
18	6	14,15,17,19,21,23	no
21	5	18,19,20,22,23	no

23	5	14,18,21,22,24	no
26	5	7,8,12,14,24,25	no
1	4	2,7,8,9	dominator
6	4	3,5,7,25	no, the rest
7	4	2,6,8,26	no
8	4	1,7,9,12	no
12	4	8,10,13,26	no
13	4	11,12,14,15	no
19	4	17,18,20,21	no
24	4	14,23,25,26	no
25	4	6,23,24,26	no, the rest
2	3	1,3,7	no
3	3	2,4,6	no
9	3	1,8,10	no
10	3	9,11,12	no, the rest
15	3	13,16,18	no
17	3	16,18,19	no
4	2	3,5	dominator
5	2	4,6	no
11	2	10,13	no, the rest
16	2	15,17	dominator
20	2	19,21	dominator
22	2	21,23	no, the rest

The fourth stage is to find the domination point from the point in the third stage of determining the remaining points that produce router id 6, 25, 10, 11, 22. The fourth stage to find the domination point can be seen in table 4. The dominator is router id point 6 and 10, while router id 22 becomes the dominator itself because the router id of the 22 list neighbor is not dominated by the remaining router id, id 6, 25, 10, 11.

TABLE IV. RESIDUAL POINT OF THE DOMINATOR

id_router	Number of neighbors	list	keterangan
6	1	3,5,7,25	residual dominator
25	1	6,23,24,26	no
10	1	9,11,12	residual dominator
11	1	10,13	no
22	0	21,23	stand along

In the development of the router determination system, the comparison of manual and system calculations is the same. Here is a calculation of dominating sets to assess the optimization of the result of dominating node. The number of routers is 26, with the largest degree is 6, as well as the estimated number of dominating number is 8. By following Equation (2), we have:

$$[26/(1+6)] \leq 8 \leq 26 - 6 = 4 \leq 8 \leq 20$$

From the calculation, $4 \leqslant 8 \leqslant 20$ where 4 is the minimum number of dominating number, 8 is the dominating number generated from Greedy algorithm calculation, and 20 is the maximum number of dominating number. It can be concluded that the node obtained by using the Greedy algorithm has been optimal, since it is the minimum number. The location of the router which is represented by the dominating node can be seen in Table V and mapped as in Figure 6.

Column Id_Router in Table 1 shows the location of router that dominate other nodes which is illustrated as a blue (larger) dot in Figure 4. While column List in Table 1 shows which routers are dominated by dominating router which are illustrated as green (smaller) dots in Figure 4.

TABLE V. ROUTER LOCATION OBTAINED BY DOMINATING SET

Id_Router	List	Latitude	Longitude
1	2,7,8,9	-8.166612574832754	113.71299868449572
4	3,5	-8.168704716603795	113.71686106547716
10	9,11,12	-8.163575232750972	113.71389990672472
14	12,13,18,23,24,26	-8.163299109598052	113.71663575991988
16	15,17	-8.159921895592236	113.71642135083677
20	19,21	-8.161876010321398	113.7217713519931
22	21,23	-8.164637243098513	113.71958618983629
25	6,23,24,26	-8.16548684934311	113.71717220172289

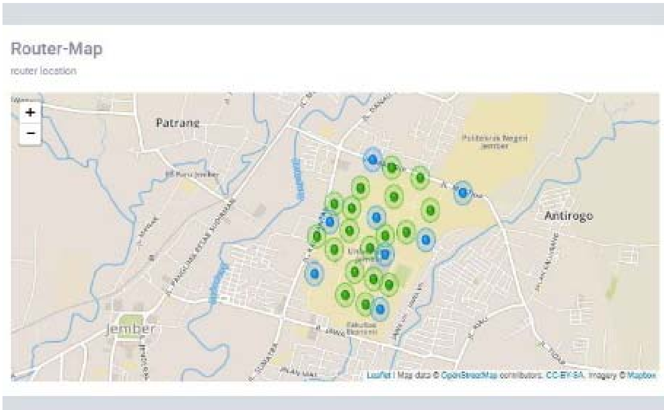

Fig. 6. Router Mapping

V. CONCLUTION

The Greedy algorithm is implemented in the system to determine dominating set as a representation of router location of computer network in University of Jember. From the calculation, it is obvious that $4 \leqslant 8 \leqslant 20$ where 4 is the minimum number of Dominating Set, 8 is the Dominating set generated from the Greedy algorithm calculation, and 20 is the maximum number of Dominating Set. It was concluded that the point finding result using the Greedy algorithm was optimal, since the number of Dominating Set found from the Greedy algorithm calculation approached the minimum number of Dominating Set.

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