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Minimization of time distribution of ballots with Greedy algorithms in Jombang Regency

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Abstracts

Travelling Salesman Problem is a problem faced by salesmen in distributing goods by passing all points exactly once. This problem is often encountered in life, not least in the distribution of election ballots from the Komisi Pemilihan Umum Daerah (KPUD) Jombang office to the sub-district office in Jombang Regency. Proper route determination can help to minimize the travelling time between places so that the risk of delaying ballot distribution can be avoided. In determining the solution of Traveling Salesman Problem, a Hamiltonian cycle is required. The Hamiltonian cycle is a closed trail that passes every point exactly one time. The Hamilton cycle can be formed by the Greedy Algorithm. The Greedy Algorithm can quickly determine the next point based on the smallest weight in the form of distance between points. From the problem of ballot distribution in Jombang, the starting point of the route is the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang then through 21 sub-district offices and back to the Komisi Pemilihan Umum Daerah (KPUD) office Jombang. Based on the searching for solutions to minimize the distribution time of ballots in Jombang Regency with Greedy Algorithm, the total distance to pass all existing sub-district offices is 253.1 km with a travel time of 427 minutes or 7 hours 7 minutes.

Keywords: time minimization; distribution of ballots; greedy algorithms; ballots; KPU

1. Introduction

In life, the problem of the distribution of goods is something that often happens. This problem is often called by the Traveling Salesman Problem [1]. Travelling Salesman Problem is a problem in determining the shortest route that can be traversed by salesmen in distributing goods by passing all cities exactly once. It aims to minimize the cost and distance of the trip [2]. The application of TSP in life can be found in the transmission of goods production, transportation and installation of communication networks [3]. Then, in graph theory, this kind of problem often implements the Hamilton cycle. Hamilton Cycle is a cycle in a graph that passes all existing points exactly once [4].

Several studies on Traveling Salesman Problem have been carried out. The study conducted by Awang Harizka and Feddy Setio Pribadi compared the Ant Colony Algorithm and Greedy Algorithm giving the conclusion that the Ant Colony algorithm can provide solutions for Traveling Salesman Problem with low distances and times compared to other algorithms, while the Greedy Algorithm can produce shorter computation time than other algorithms [5]. In addition, research conducted by Wafaa Mustafa Hameed and Asan Baker Kanbar concerning comparisons of several types of crossover operators in Genetic Algorithms that gives results that among several types compared crossover operators, the best type of crossover operator to implement in the Traveling Salesman Problem is Alternating Edges (AL) [6]. Other studies conducted by Majid Yousefikhoshbakht and friends regarding the use of the Genetic Reactive Bone Route Algorithm with Ant Colony System applied to the Traveling Salesman Problem gives the result that the applied algorithm can solve Traveling Salesman Problems in terms of solution quality and better computation time [7]. Other studies related to Traveling Salesman Problems are those carried out by Dinar Anggit Wicaksana and friends about the searching for Traveling Salesman Problem solutions with fuzzy evolution which results in an optimal length of the Traveling Salesman Problem route [8].

The problem of distributing goods can be found in the case of ballot distribution during elections. Ballots as one of the important logistics in election activities need to be distributed in a timely, effective, targeted and appropriate quality [9]. Determination of inappropriate distribution routes can add to the allocation of time needed and a lot of costs for the distribution of ballots. Long travel times can cause delays in distribution and disrupt the electoral process [10]. From these problems can be implemented one of the Traveling Salesman Problem-solving algorithms, that is a Greedy Algorithm. In solving the Traveling Salesman Problem, Greedy Algorithm is able to calculate the optimal local value of each available point then get a global optimization value at the end of the trip [11]. By Greedy Algorithm, the solution of Travelling Salesman Problem can be efficient and closer to the optimal solution [12].

From several studies that have been done, the Greedy Algorithm has not been implemented on the issue of electoral ballot distribution. The application of the Greedy Algorithm in minimizing distribution time is expected to provide solutions in minimizing delivery time so as to reduce the risk of delaying ballots in an area. In this study, the Greedy Algorithm will be implemented in the issue of minimizing the distribution time of ballots in Jombang Regency.

2. Experiments Procedure

The case of being late logistics distribution in the form of ballots can have an impact on the process of the election. It is necessary to plan the proper distribution route so that it can reduce the risk of being late logistics distribution of ballots [13]. One of the agencies that require a distribution route planning solution is Komisi Pemilihan Umum Daerah (KPUD) Jombang. Geographical factor and development that has not been evenly distributed in Jombang Regency can be one of the factors delaying the distribution of ballots. Based on the official website of Komisi Pemilahan Umum Daerah (KPUD) Jombang, there are several regions with geographical conditions in the form of forests and hills, thus requiring special priority in distribution because they require many labours and time is quite long, namely in the District of Plandaan. With the Greedy Algorithm in planning the distribution route, it can save travel time to various sub-districts that have easier access, so that time allocation can be optimized on a difficult area to reach. Thus the logistics distribution will be in accordance with the plan and there will be no delaying in all sub-districts.

The focus of this study is to determine the minimum travel time from the distribution of ballots using the Greedy Algorithm. In this study, data collection techniques were literature studies and data collection with the Google Map application. Literature studies were conducted to find out in-depth information about the Greedy Algorithm. Data collection with the

Google Maps application was conducted to obtain distance and travel time data between the office of Komisi Pemilahan Umum Daerah (KPUD) Jombang and each sub-district office in Jombang Regency and to know the distance and travel time between the sub-district offices.

From data that has been obtained based on the Google maps application, data is analyzed using the Greedy Algorithm. The Greedy algorithm is an algorithm that can determine the shortest route between each node to be traversed by continuously taking and adding to the route that has been passed [14]. The Greedy algorithm builds solutions in stages through a sequence that continues to evolve until the solution to the problem is found [15].

The optimization problems in the Greedy Algorithm are compiled by several components [16].

1. Set of Candidate (C): The set contains the element forming the solution.
2. Set of Solutions (S): The set of elements is a problem-solving solution.
3. Selection Function: Function in selecting candidates who are most likely to reach the optimal solution.
4. Feasibility Function: A function that checks selected candidates is able to provide a feasible solution.
5. Objective Function: Function that maximizes or minimizes the value of the solution.

Stages in Greedy Algorithm to solve Traveling Salesman Problem [17]:

1. Determine the starting point of the travel route
2. From the starting point, find the optimum local to the next point. The optimum local can be seen from the weight of each side connecting the starting point and the next point.
3. Mark the side to be passed then move to the optimum local that has been determined.
4. Repeat step 1 until all points are visited exactly once and return to the starting point of the level.

From the application of Greedy Algorithm, the results will be the shortest route from the starting point, namely the office of Komisi Pemilihan Umum Daerah (KPUD) to all sub-district offices in Jombang Regency and back to the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang. By obtaining the shortest path so it will be obtained the minimum time and costs to visit all the targeted sub-district offices.

3. Result and Discussion

Based on data obtained from the website of Jombang Regency Government, there are 21 sub-districts and an office of Komisi Pemilihan Umum Daerah (KPUD) Jombang. Points that are representing the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang and sub-district offices are connected to each other to form a side to the graph. The weight on the formed graph is the weight in the form of distance between each point. To obtain data in the form of distance and travel time from the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang to various sub-district offices and between sub-district offices, in this study using the Google Map application. Data retrieval is done on Friday, April 26, 2019, at 14.30 WIB. A list of 21 sub-districts in

Table 1. Sub-district names and KPUD with symbols on the graph

No	District Name	Symbol on Graph
1	Sub-district Wonosalam	A
2	Sub-district Bareng	B
3	Sub-district Ngoro	C
4	Sub-district Gudo	D
5	Sub-district Diwek	E
6	Sub-district Mojowarno	F
7	Sub-district Mojoagung	G
8	Sub-district Sumobito	H
9	Sub-district Jogoroto	I
10	Sub-district Jombang	J
11	Sub-district Perak	K
12	Sub-district Bandar Kedung Mulyo	L
13	Sub-district Megaluh	M
14	Sub-district Peterongan	N
15	Sub-district Kesamben	O
16	Sub-district Tembelang	P
17	Sub-district Ploso	Q
18	Sub-district Kudu	R
19	Sub-district Ngusikan	S
20	Sub-district Kabuh	T
21	Sub-district Plandaan	U
22	Office of Komisi Pemilihan Umum (KPUD) Jombang	W

Jombang Regency and an office of Komisi Pemilihan Umum Daerah (KPUD) Jombang along with symbols on graphs are presented in Table 1.

Location of each places both the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang and sub-district offices in Jombang Regency are presented in Figure 1.

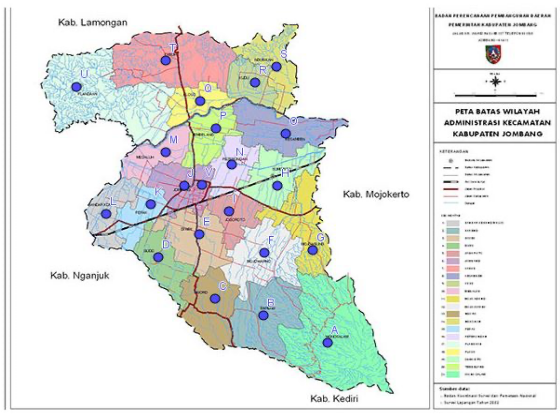

Figure 1. Map of Jombang Regency along with the location of KPUD and sub-district offices

In searching for Traveling Salesman Solutions, each point in Figure 1 is connected to each other so that a complete graph is formed. From 22 locations in Jombang Regency, a complete graph is represented page Figure 2.

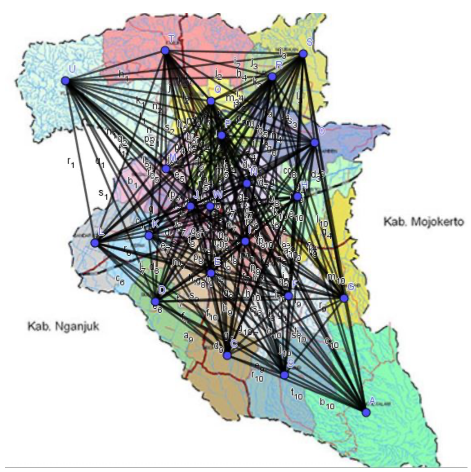

Figure 2. Complete graph on the map of Jombang Regency

To calculate the number of sides d from a complete graph with n points, use the formula in (1).

$$|E(Kn)| = \frac{n(n-1)}{2} \quad (1)$$

where | E (Kn) | is many sides of a complete graph with n points and n is the number of points on a complete graph.

From the data of the Jombang Regency Government, there are 21 sub-districts and an office of the Jombang Regional Election Commission, so the number of points on the graph is 22 points. Substitution n = 22 in (1).

$$|E(Kn)| = \frac{n(n-1)}{2} \quad (1)$$

$$|E(K_{22})| = \frac{22(22-1)}{2}$$

$$|E(K_{22})| = \frac{22(21)}{2}$$

$$|E(K_{22})| = \frac{462}{2} = 231 \text{ sisi}$$

So, it is obtained the number of sides of the complete graph page Figure 1 is 231 sides.

A complete graph is a simple and regular graph so that it has the same degree of point, k. In determining the degree of a complete graph, you can use a handshaking lemma [18].

Handshaking Lemma[19]. The number of degrees of all vertices on a graph is even, which is twice the number of sides on the graph. In other words, if G = (V, E), then

$$\sum_{v \in G} d(v) = 2|E| \quad (2)$$

with d (v) is the point in a graph and | E | are many sides of the graph.

The number of degrees of simple and regular graphs is the product of many points and degrees of each point. So that it can be expressed in (3).

$$\sum_{v \in G} d(v) = n \text{ x } k \quad (3)$$

for n are many points on simple and regular graphs, while k is the degree of each point.

By substituting (3) and results (1) in (2), obtained:

$$\sum_{v \in G} d(v) = 2|E| \qquad (2)$$

$$n \times k = 2 \times 231$$
$$22 \times k = 462$$

$$k = \frac{462}{22} = 21$$

So the degree of each graph point in Figure 2 is 21.

After knowing the number of sides and the degree of each point graph Figure 2, then determine the Hamilton cycle based on weights, namely the distance between starting point from the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang based on the Greedy Algorithm. Hamilton Cycle is a closed trail that passes each point exactly once[20]. The determination of routes based on the Greedy Algorithm is:

1. Determinating of starting point, namely the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang.
2. Looking for the smallest weight from the side that connects point W, that is the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang to other points, that is the sub-district office in Jombang Regency by comparing each weight from the related side.
3. After finding the destination point, from that point, the smallest weight that connects with other points is searched, but the point that has been crossed cannot be re-elected.
4. Repeat step 3 until all points are passed and return to point W that is the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang.

By the Greedy Algorithm, the Hamiltonian cycle is obtained in Figure 3.

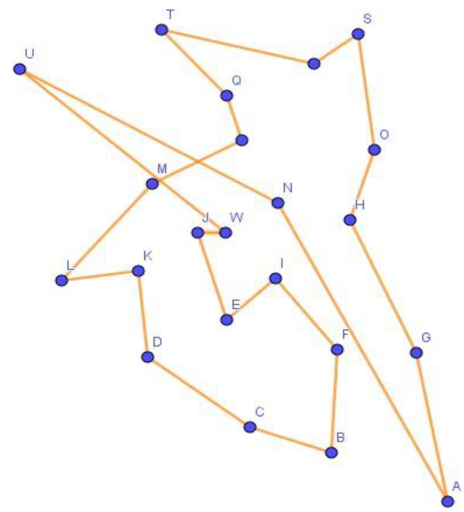

Figure 3. Graph maternal cycle map of Jombang Regency

After obtaining the Hamilton cycle based on the Greedy Algorithm, then all the weights of each side in Figure 2 are summed. By summing

Table 2. Total distance and travel time formed from the Hamilton cycle

Side	Distance (km)	Time (minutes)
WJ	2.7	6
JE	4.7	8
EI	4.3	8
IF	8.3	13
FB	6.3	12
BC	5.7	12
CD	13	16
DK	9.9	14
KL	3.3	6
LM	9.4	16
MP	8.2	15
PQ	6.6	9
QT	5.3	6
TR	12	15
RS	14	20
SO	40	76
OH	7.6	15
HG	5.8	11
GA	20	35
AN	30	51
NU	17	27
UW	19	36
Total	**253,1**	**427**

the weights, it is obtained the total distance from the office of Komisi Pemilihan Umum Daerah (KPUD) to all sub-district then back to starting point. In addition, it is obtained the total travel time needed to visit all sub-district offices in Jombang Regency was based on the Greedy Algorithm. The total distance and travel time based on the Hamiltonian cycle in Figure 3 are presented in Table 2.

The calculation in Table 2 can be determined travel time in the distribution of ballots from the office of Komisi Pemilihan Umum Daerah (KPUD) Jombang to all sub-district offices in Jombang Regency and return to the office of Komisi Pemilihan Umum Daerah (KPUD), which is 427 minutes or 7 hours 7 minutes.

4. Conclusion

The application of Greedy's Algorithm to the issue of distribution of ballots from the Jombang Regional Election Commission to sub-districts in Jombang Regency needs to be done because it can provide solutions in minimizing distribution time. Minimum distribution time allocation can prevent the risk of late distribution of ballots to each sub-district so that they can smooth general election was achieved. Based on route planning based on the Greedy Algorithm, minimum time was obtained in the distribution of ballots in Jombang Regency, which amounted to 427 minutes or 7 hours 7 minutes with a distance of 253.1 km.

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