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Searching the shortest route for distribution of LPG in Medan city using ant colony algorithm

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Abstract. National energy needs and efforts to meet needs are currently the topic of issues to be discussed and resolved. One of the problems is LPG (Liquid Petroleum Gas) in the form of environmentally friendly petroleum gas products. Gas scarcity that occurs in each region is different where not all regions experience gas shortages, there are also areas that have excess LPG stock. Therefore, the application of the search route on the LPG base is very necessary. This application applies the ant colony algorithm search method to find the fastest route for the gas base location in the Medan Amplas district area. The Ant Colony algorithm looks for the best solution to solve a problem, in this case the Ant Colony algorithm is the algorithm most often used in mapping distribution locations. From the results of this research, the LPG distribution and distribution process uses an android based application.

1. Introduction

Indonesia as the largest country in Southeast Asia is a country that has reserves of energy resources in the form of mining materials such as oil, gas and coal, while non-mining energy sources such as wind, water, geothermal and biomass. One of the energy sources that is owned is petroleum. National energy needs and efforts to fulfill them are currently the topic of problems to be discussed and resolved [1]. Liquefied Petroleum Gasses (LPG) is a fuel in the form of liquefied gas and is a petroleum product that is environmentally friendly and widely used by households and industries. The kerosene to LPG conversion program implemented by the Indonesian government since 2007 has now reached almost all regions of Indonesia. This causes a lot of public demand for LPG, especially 3 Kg LPG. This LPG product is one of Pertamina's most widely used products, because it is practical and has the cheapest price [2].

Currently 3 Kg LPG (three kilograms) is the most sought after item by the community, especially housewives since the conversion of kerosene to gas. 3 Kg of LPG has become a basic necessity that is difficult to replace, unlike other basic goods originating from many producers specifically for 3 Kg LPG the distribution is regulated by Pertamina. The problem that often arises is the scarcity of LPG 3 Kg, even though the gas supply from the agent still exists but because the stock is limited not all retailers are part of [3]. Pertamina has created a distribution system that is from SPBE which is a 3 kg LPG filling company and then



distributed by Agents who are large distributor companies and finally is a sub agent or base that is the spearhead of this 3 kg LPG distribution.

The government through Pertamina has determined the price that must be accepted by the community, the oil and gas business activities currently have an important role in the national economy because of the high demand from the community for these products causing scarcity in the market. This makes the government have to provide 3 Kg LPG on a large scale [2]. Problems with LPG scarcity are not the first time this has happened. In the past few months, people in a number of regions have complained about the scarcity of subsidized LPG gas, this situation is certainly difficult for the community. Not only does it hamper community activities, this scarcity also makes gas refill prices more expensive than usual.

Distribution is the process of sending a product from one party to another. Product producing companies sell products to distributors, then distributors sell products to retailers or customers [5]. To overcome this, the application of Geographic Information System (GIS) is a computer-based information system for storing, managing and analyzing, and invoking geographic reference data that has developed rapidly in the last five years. The benefits of GIS are to provide convenience to users or decision makers to determine policy [4]. In determining the location to produce an alternative route [6].

To solve this problem, it is proposed to use the ant colony method. Ant colony is a method designed to solve problems, inspired by the behavior of ant colonies in finding the shortest path from the nest to the food source. Using the ant colony method [8]. The process of finding the shortest path for the distribution of LPG distribution is much better because it uses applications that are based on android. Android is an option because technology is not inferior to other smartphones. It is very popular if people because of the advanced features offered, are open source so that demand from year to year is increasing [7].

2. Methodology

The ant colony is adopted from the behavior of an ant colony known as the ant system, which is a probabilistic technique for solving computational problems by finding the best path through the graph[9]. Naturally the ant colony is able to find the shortest route on the way from the nest to food source places.

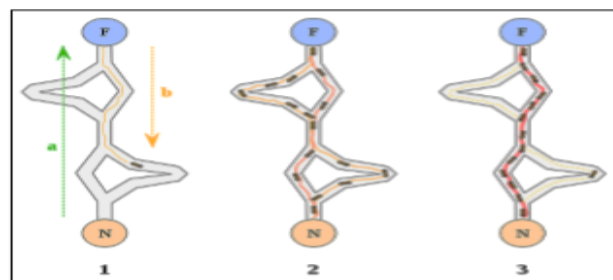


Figure 1. Ant finding travel food source

In searching for the shortest path with the Ant Algorithm, several variables and steps are needed to determine the shortest path [10]. That is:

Step1:

- a. Price initialization of algorithm parameters.

The parameters initialized are:

1. The trace intensity of all cities and their changes (τ_{ij})
 2. Many cities (n) include coordinates (x, y) or distances between cities d_{ij}
 3. Departing city and destination city
 4. Ant-cycle constant (Q)
 5. Set to control the intensity of the ant trail (α), the value of $\alpha = 0$
 6. Set to control visibility (β), the value ($\beta = 0$)
 7. Visibility between cities (M_{ij}) = $\frac{1}{d_{ij}}$
 8. Many ants (m)
 9. As for the evaporation of the ant trail (ρ), the value of ρ must be > 0 and < 1 to prevent infinite pheromone traces.
 10. The maximum number of cycles (NC_{max}) is fixed as long as the algorithm is executed, while the number will always be updated in each algorithm cycle starting from the first cycle ($NC = 1$) until the maximum number of cycles is reached ($NC = NC_{max}$) or until convergence occurs.
- b. Initialize the first city of each ant.
After τ_{ij} initialization is done, then m ants are placed randomly in the first city.

Step 2:

Recording of cities traversed by ant objects. Each ant object that carries out a destination city search will record the name of the city it passes through so that we can find out the ant's route.

Step 3:

Arranging the route of each ant's visit to each city. Before selecting the destination city in tracing the city, a list of intercity relationships was created. This list of relationships contains cities that have city relations from which they travel. Ant colonies that have been distributed to a number or each city, will begin to travel from the first city each as the original city and one of the other cities as the destination city [10].

$$\left\{ \begin{array}{l} p_{ij}^k = \frac{[\tau_{ij}]^\alpha \cdot [\eta_{ij}]^\beta}{\sum [\tau_{ik'}]^\alpha \cdot [\eta_{ik'}]^\beta}, \text{ For } j \in \{N - \text{tabu}_k\} \\ k' \in \{N - \text{tabu}_k\} \\ p_{ij}^k = 0, \text{ For other } j \end{array} \right\}$$

Step 4:

- a. Calculation of the length of each ant's route. Calculation of the closed route length or L_k for each ant is carried out after one cycle has been completed by all ants. This calculation is based on the length of the path:

$$L_k = \sum_i^n d_{ij}$$

with d_{ij} is the distance between city i to city j which is calculated based on the equation:

$$d_{ij} = \sqrt{\sum (x_i - x_j)^2}$$

- b. Search for the shortest route

After L_k for each ant is calculated, a minimum length of closed route will be obtained for each cycle or L_{min} NC and the minimum price for the total closed route or L_{min} .

- c. Calculation of changes in the intensity of ant footprints between cities. The ant colony will leave footprints on the inter-city trajectory it passes. There is a difference in the number of ants that pass.

$$\Delta\tau_{ij} = \sum_{k=1}^m \Delta\tau_{ij}^k$$

With $\Delta\tau_{ij}^k$ is the change in the intensity of the ant footprints between cities for each ant calculated according to the equation.

$$\left\{ \begin{array}{l} \Delta\tau_{ij}^k = \frac{Q}{L_k}, \text{ for } (i, j) \in \text{hometown} \\ \text{and destination city } T_k \\ \Delta\tau_{ij}^k = 0, \text{ for } (i, j) \text{ others} \end{array} \right\}$$

Step 5:

- a. Calculation of the intensity of ant footprints between cities for the next cycle. The price of ant footprint intensity between cities on all inter-city tracks is likely to change due to differences in the number of ants that pass through. For the next cycle, the ants that will pass through the trajectory have changed in intensity. Henceforth it is calculated by equation [10].

$$\tau_{ij}(\text{new}) = \rho \cdot \tau_{ij} + \Delta\tau_{ij}$$

- b. Adjust the change in intensity of ant footprints between cities. For the next cycle the change in the price of the intensity of ant trails between cities needs to be rearranged to have a value equal to zero.

Step 6:

If the maximum cycle (N_{cmax}) has not been fulfilled, the algorithm is repeated again from step 2 with the updated parameter price of the ant footprint between the cities.

3. Results and discussion

3.1 Calculation of the Ant Colony Method

Calculate the shortest distance using the ant colony algorithm, based on the LPG agent graph as follows:

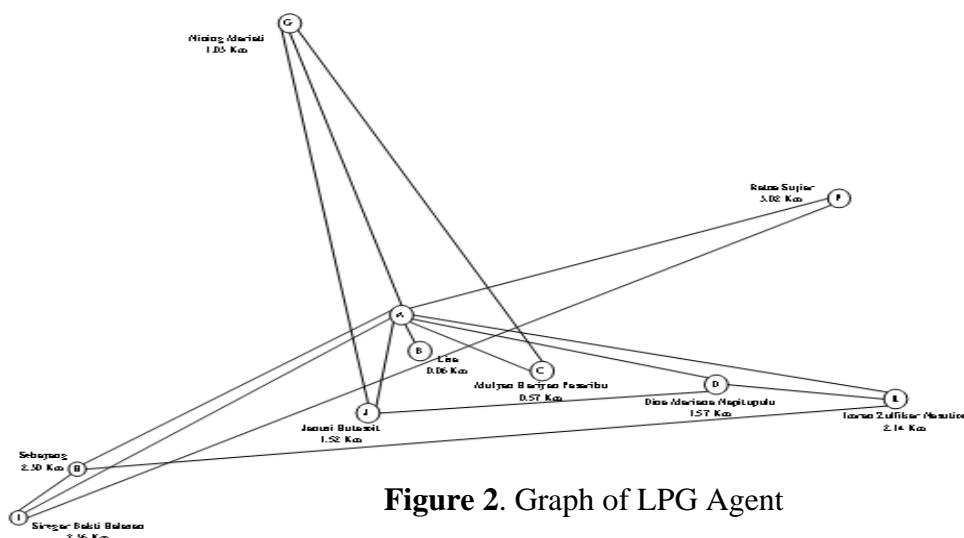


Figure 2. Graph of LPG Agent

Table 1. Description of LPG Graph Image

Code	Address of Base Agent	Distance (Km)
A	User Position	0 Km
B	Garu I No.178	0,06 Km
C	Garu III No.30	0,57 Km
D	Garu VIII Gg. Serasi No.66	1,57 Km
E	Asmara Widuri No.387	2,14 Km
F	Sakti Lubis No.30	3,02 Km
G	Persamaan Gg.Syukur No.39 B	1,03 Km
H	Swandaya No.147	2,3 Km
I	Swandaya Gg.Tengah No.162 A	2,36 Km
J	Sumber Bakti Gg. Langgar	1,52 Km

Based on the graph above, the closest route will be searched, the following calculation steps use the Ant Colony Method with the parameters used as follows:

$$\text{Alfa } (\alpha) = 1.00$$

$$\text{Beta } (\beta) = 1.00$$

$$\text{Rho } (\rho) = 0.50$$

$$\tau_{ij} \text{ early} = 0.01$$

$$\text{Maximum cycle } (NC_{max}) = 2$$

$$\text{Ant cycle constant } (Q) = 1$$

$$\text{Many ants } (m) = 5$$

With a distance between bases (d_{ij}) as follows:

Table 2. Distance Between Location of LPG Agent Base

	A	B	C	D	E	F	G	H	I	J
A	0	0.06	0.57	1.57	2.14	3.02	1.03	2.3	2.36	1.52
B	0.06	0	0	0	0	0	0	0	0	0
C	0.57	0	0	0	0	0	0.57	0	0	0
D	1.57	0	0	0	1.57	0	0	0	0	1.57
E	2.14	0	0	2.14	0	0	0	0	0	0
F	3.02	0	0	0	0	0	0	0	0	3.02
G	1.03	0	1.03	0	0	0	0	0	0	1.52
H	2.3	0	0	0	2.3	0	0	0	2.3	0
I	2.36	0	0	0	0	2.36	0	2.36	0	0
J	1.52	0	0	1.57	0	1.57	0	0	0	0

Calculate visibility as an information medium. From the base distance which has been known, visibility between bases (η_{ij}) = $1/d_{ij}$. A to B (η_{ij}) = $1/0.06 = 16.66666667$. The next results can be seen in the table below:

Table 3. Intermediate Visibility of LPG Agent Base

	A	B	C	D	E	F	G	H	I	J
A	0	16,6666 6667	1,75438 5965	0,63694 2675	0,46728 972	0,331125828	0,97087 3786	0,43478 2609	0,42372 8814	0,657894 737
B	16,6666 6667	0	0	0	0	0	0	0	0	0
C	1,75438 5965	0	0	0	0	0	1,75438 5965	0	0	0

D	0,63694 2675	0	0	0	0,63694 2675	0	0	0	0	0,636942 675
E	0,46728 972	0	0	0,46728 972	0	0	0	0,46728 972	0	0
F	0,33112 5828	0	0	0	0	0	0	0	0	0,331125 8280,657
G	0,97087 3786	0	0,97087 3786	0	0	0	0	0	0	0,9708737 0
H	0,43478 2609	0	0	0	0,43478 2609	0	0	0	0	0,43478 2609
I	0,42372 8814	0	0	0	0	0,4237288140,63 6942675	0	0,42372 8814	0	0
J	0,65789 4737	0	0	0,63694 2675	0	0	0	0	0	0

The probability of base A, to each subsequent base can be calculated by the following equation, where the next base cannot be found on the ant track.

$$p_{ij}^k = \frac{[\tau_{ij}]^\alpha \cdot [\eta_{ij}]^\beta}{\sum [\tau_{ik}]^\alpha \cdot [\eta_{ik}]^\beta} \text{ for } j \in \{N - tabu_k\}$$

For $\sum [\tau_{ik}]^\alpha \cdot [\eta_{ik}]^\beta = (0,01*0) + (0,01*16,66666667) + (0,01*1,754385965) + (0,01*0,636942675) + (0,01*0,46728972) + (0,01*0,331125828) + (0,01*0,970873786) + (0,01*0,434782609) + (0,01*0,423728814) + (0,01*0,657894737) = 0,223436908$ Is the Final Result of Probability.

Table 4. Calculation Results for Starting Points

	A	B	C	D	E	F	G	H	I	J	PROBABILITY
A	0	0,1666 66667	0,0175 4386	0,006369427	0,0046 72897	0,0033 11258	0,00970 8738	0,0043 47826	0,0042 37288	0,00657 8947	0,2234 36908
B	0,1666 66667	0	0	0	0	0	0	0	0	0	0,1666 66667
C	0,017 54386	0	0	0	0	0	0	0	0	0	0,0350 87719
D	0,0063 69427	0	0	0	0,0063 69427	0	0	0,0046 0,0046	0	0,00636 9427	0,019 10828
E	0,0046 72897	0	0	0,0046 72897	0	0	0	72897	0	0	0,0140 18692
F	0,0033 11258	0	0	0	0	0	0	0	0	0,0033 11258	0,0066 22517
G	0,0097 08738	0	0,0097 08738	0	0	0	0	0	0	0,0065 78947	0,0303 44249
H	0,0043 47826	0	0	0	0,0043 47826	0	0	0	0,0043 47826	0	0,0086 95652
I	0,0042 37288	0	0	0	0	0,0042 37288	0	0,0042 37288	0	0	0,0127 11864
J	0,0065 78947	0	0	0,0063 69427	0	0,0063 69427	0	0	0	0	0,0191 7801

Thus the probability can be calculated from the A base to each LPG base.

$$\begin{aligned}
 B &= (0.01)^{1.00} \cdot (0.06)^{1.00} / 0,223436908 = 0,007459227 \\
 C &= (0.01)^{1.00} \cdot (0.57)^{1.00} / 0,223436908 = 0,000785182 \\
 D &= (0.01)^{1.00} \cdot (1,57)^{1.00} / 0,223436908 = 0,000285066 \\
 E &= (0.01)^{1.00} \cdot (2,14)^{1.00} / 0,223436908 = 0,000209137 \\
 F &= (0.01)^{1.00} \cdot (3,02)^{1.00} / 0,223436908 = 0,000148197
 \end{aligned}$$

Table 5. Probability Calculation Results

	A	B	C	D	E	F	G	H	I	J
A	0	0,00745 9227	0,00078 5182	0,00028 5066	0,00020 9137	0,0001481 97	0,00043 4518	0,000194 589	0,000189 641	0,00029 4443
B	0,01	0	0	0	0	0	0	0	0	0
C	0,005	0	0	0	0	0	0,005	0	0	0
D	0,003333 3330	0	0	0	0,00333 3333	0	0	0	0	0,00333 3333
E	0,003333 3330	0	0	0,00333 3333	0	0	0	0,003333 3330	0	0
F	0,005	0	0	0	0	0	0	0	0	0,005
G	0,003199 531	0	0,00319 9531	0	0	0	0	0	0,001432 834	0,00216 8104
H	0,005	0	0	0	0,005	0	0	0	0	0
I	0,003333 333	0	0	0	0	0,0033333 33	0	0,003333 333	0	0
J	0,003405 64	0	0	0,00329 718	0	0,0032971 8	0	0	0	0

After we know the next probability we add up each route that is traversed so that we find the results of the cumulative probability as follows: Cumulative Probability Results = 0.007459227 0.008244409 0.008529475 0.008738612 0.008886809 0.009321327 0.009515915 0.009705557 0.01

Table 6. Cumulative Probability Calculation Results

	B	C	D	E	F	G	H	I	I
A	0,00745 9227	0,00824 4409	0,00852 9475	0,00873 8612	0,00888 6809	0,0092 1327	0,0091 5915	0,00970 5557	0,01
B	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
C	0,005	0,005	0,005	0,005	0,005	0,01	0,01	0,01	0,01
D	0,00333 3333	0,003333 333	0,00333 3333 0,003333	0,00666 6667	0,00666 6667	0,0066 66667	0,0066 66667	0,006666 667	0,01
E	0,00333 3333	0,003333 333	0,003333 0,005	0,00666 6667	0,00666 6667	0,0066 6667	0,01	0,01	0,01
F	0,005	0,005	0,006399	0,005	0,005	0,005	0,005	0,005	0,01
G	0,00319 9531	0,00639 9063	0,0063 0,005	0,006399 063	0,00639 9063	0,0063 99063	0,0063 99063	0,007831 896	0,01
H	0,005	0,005	0,003333	0,01	0,01	0,01	0,01	0,01	0,01
I	0,00333 3333	0,003333 333	0,003333 0,006702	0,003333 333	0,00666 6667	0,0066 66667	0,01	0,01	0,01
J	0,00340 564	0,003405 64	82	0,006702 82	0,01	0,01	0,01	0,01	0,01

Then the chosen route is the selected Path A => B, that is (0.01) The Nearest Agent Lisa is located at Garu I No.178. This will repeat until it matches the specified N_{max} or has reached.

3.2 System Implementation

The following is the display system application mapping LPG Gas distribution location 3 Kg in the city of Medan using the Ant Colony algorithm based on Android, there are two views

that are used in this application, namely: display of nearby agent form and display route form

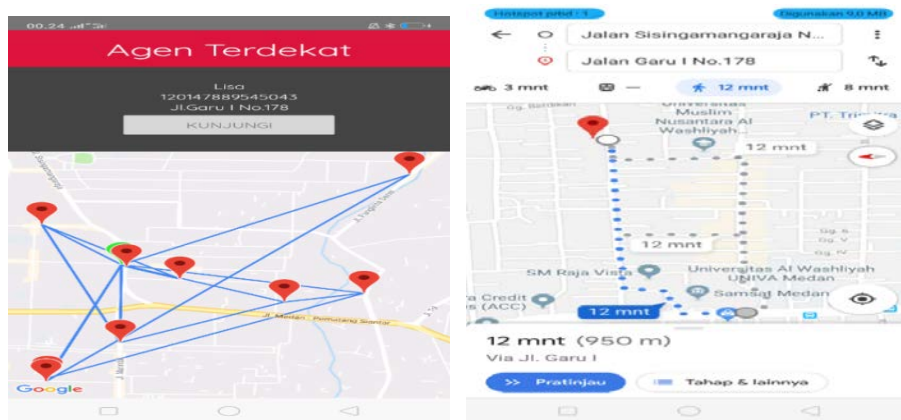


Figure 3. Nearby agent form and view of the route

4. Conclusion

This study resulted in a search application for the shortest route for distribution of 3 Kg LPG distribution from several distribution routes in the city of Medan. From the results of the implementation and calculation using the ant colony algorithm in the application of LPG agent mapping, the shortest path chosen is $A \Rightarrow B$, that is (0.01) with the nearest agent Lisa, with the address at Garu I No.178. With this application the search for the shortest path for the distribution process of LPG Gas distribution is much faster because it uses applications that are based on Android.

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