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IMPLEMENTING ANT COLONY OPTIMIZATION (ACO) IN TRAVELING SALESMAN PROBLEM (CASE STUDY AT DISTRIBUTION STORE PB)

Widya Nurcahayanty Tanjung[1], Sopiah[2]

Al Azhar University, Kompleks Masjid Agung Al Azhar, Jl.Sisingamangaraja, Jakarta
widya@uai.ac.id

ABSTRACT

Traveling Salesman Problem is an important issue in the distribution system. it problem is generally described as a case in which a salesman must visit a number of cities from a central facility and back to the original point of departure. The purpose of this problem is to minimize the total distance salesman.
Ant Colony Optimization algorithm (ACO) is one method of implementing metaheuristic ant as an agent to pheromone update, to perform the solution search process effective and efficient. There are 5 types of ACO algorithm ASRank, MMAS, EAS and ACS. In this case, the ACO algorithm used is Ant Colony System (ACS). it implementation used is symmetric it the distance from point a to point b is equal to the distance from point B to point A, d_ab = d_ba. find a solution on the distribution schedule X Logistic company PB Store Monday through Saturday. Results obtained from the ACO algorithm for Monday through Saturday Km respectively 4.9374, 5.8512 km, 5.4172 Km, Km 5.1832, 5.4678 and 18.7146 Km Km. With a minimum charge per day in a row that is Rp. 5,431, Rp. 6436, Rp. 5,959, Rp. 5,702, Rp. 6,015 and Rp. 20 586. To produce the optimum, the researchers conducted a 4 parameter tuning ACO with 3 levels using the Taguchi method, the results obtained tuning ants m = 34, α = 4.5, β = 5 and ρ = 0.5.

Keywords *: Traveling Salesman Problem, Ant Colony Optimization, Taguchi*

1. INTRODUCTION

One aspect important role in the company's business is logistics. Companies began to realize that logistics has a significant effect on the cost and logistics will result in a decision on the level of service to different customers. In the supply chain, logistics company is a company that is an important role, because it has a role in terms of the efficiency of the delivery time, cost and use of fleet distribution network [8]. Competitive level of logistics company can be judged from the design of the distribution network that they want.

X Logistic is Indonesia's largest logistics company, serving customers in all parts of Indonesia. November 2012 to date, X Logistic handle distribution products for PB store. But experience delays that cause PB store can not serve the maximum demand customers. The cause of this delay is due to the delivery of goods unstructured.

The number of road or route makes dropper X Logistic difficulties in determining the distribution to all stores PB optimal schedule. Therefore, the required method of determining the proper shortest route to reach that goal. This distribution is done by a salesman who begins and ends at the same starting point ie X Logistic warehouse. This type of problem is called the Travelling Salesman Problem (TSP).

TSP is known as one of the optimization problem. TSP is expressed as a problem in finding the minimum distance covered on a tour of n cities where the cities are there only visited the city once the city is also the beginning of the end. There are 2 types of TSP, the TSP symmetric and asymmetric TSP. In the symmetric TSP, the distance from one city to another city A, city B, together with the distance from city B to city A. While the asymmetric TSP, the distance to go and back between city A and city B is not the same. In this case study researchers mengguunakan symmetric TSP types to minimize total mileage salesman.

In general, the shortest path search can be solved by some existing methods such as exact methods, heuristics and metaheuristics. Exact and heuristic methods easier to understand than metaheuristic methods, but when compared to the results obtained from more varied metaheuristic methods and computational time required is shorter.

The method consists of several kinds of metaheuristic algorithms, such as Simulated Annealing Algorithm, Genetic Algorithm, evolutionary programming, Ant Colony Optimization, Greedy Algorithm and others. Researchers will use the ant algorithm to solve the TSP problem with Matlab software.

Based on an evolutionary approach to the problem of circuit partitioning, genetic algorithms provide a significant advancement results (Shahooker, 1995). Evaluation of Simulated Annealing Algorithm comparison between the genetic algorithm has been done by Manikas and Cane and menunujukkan that genetic algorithms provide better results. While testing of Dawn Saptono, et al (2007) in comparing the performance of the shortest route searching algorithm, namely Genetic algorithm with ant algorithm weights the results prove that using ant algorithm is more stable and has a constant state of weighting the results, so that the resulting graph solution is not much different the optimum value.

Research in the application of TSP problems done and Marco Dorigo and Gambardella (Dorigo, 1997) menunujukkan that in the case of TSP with 75 cities, the algorithm requires only the simulation ant traveling as much as 3,480 times to find the best path, while the genetic algorithm simulation requires 80.0000 times to come across the lane way best travel and other algorithms such as Evolutionary Programming, simulated Annealing and Genetic Algorithm requires even number of simulated trip that much more.

Viewed from speed in searching the shortest route, Aris Feryanto study [5] showed that in the search of the nearest city 442 cities. Brute Force algorithm requires much checking as (442-1)! / 2 = 1.241 x10976 possibility, assuming 1 CPU clock time (in fact definitely take more than 1 clock), then the dual-core processor 2.2 GHz, checking all might take seconds or 3.256 2.821 x10966 x10961 x10958 days or 8,947 years. It is very possible to be used when viewed comparison with ant algorithm that only takes less than 10 seconds to find a near optimal solution.

Ant algorithm (Ant Colony System) is part of the Artificial Intelligent introduced by Moyson and Manderick and extensively developed by Marco Dorigo. This algorithm is able to solve optimization problems, inspired by the behavior of ants to find the shortest path to food, in particular by deploying pheromones are used to guide trail for other ants. The advantages of this algorithm is in the process of finding the optimal results with a relatively short processing time (Dorigo, 1996).

Based on the above, the problem can be formulated as follows:

1. How to build a system of Ant Colony Optimization algorithm to solve the problem Traveling Salesman Problem with Matlab software?
2. What is the value of the result parameter optimum tuning parameters using Taguchi method for Ant Colony Optimization algorithm?
3. How is optimal for scheduling service Monday to Saturday by using Ant Colony Optimization algorithm?
4. What is the minimum cost of the optimal result on Mondays to Saturday?

2. LITERATURE STUDY

2.1. Traveling Salesman Problem (TSP)

TSP problem is one example of the most widely studied in combinatorial optimization. This problem is easy to state but very difficult to resolve. TSP belongs to the class NP-Hard problem and can not be solved optimally in polynomial time computation with an exact algorithm. When completed the exact computation time required increases exponentially with increasing magnitude of the problem. TSP can be stated as a problem in finding the minimum distance covered on a tour of n cities where the cities there is only visited once. TSP represented by using a complete and weighted graph G = (V, E) with the vertex set V represents the set point - the point, and E is the set of edge. Each edge (r, s) ∈ E is a value (distance) d_rs which is the distance from city r to city s, with (r, s) ∈ V. In the symmetric TSP (distance from city r to s point equal to the distance from a point s to a point r), d_rs = d_sr for all edge (r, s) ∈ E (Agus Leksono, 2009).

2.2. *Ant colony Optimization (ACO)*

ACO was adopted from the behavior of ant colonies are known as ant system (Dorigo, et.al, 1996). Ant complex is able to sense their environment to search for food and then back to the nest by leaving pheromone substance on the routes that they take.

Naturally ants were able to find the shortest route on the way from the nest to places food source. Colonies of ants can find the shortest route between the nest and the food source based pheromone on the path that has been traversed. Increasingly many ants who through an trajectory, then the will increasingly obvious pheromone-his or her. This will lead to the path traversed ants in small amounts, the longer it will decrease the density of ants that passed, or even will not be passed at all. Instead the path traversed ants in large quantities, the longer it will further increase the density of ants that passed, or even all of ants going through the track (Dorigo, M., Maniezzo, V., and Colorni, A., 1991a).

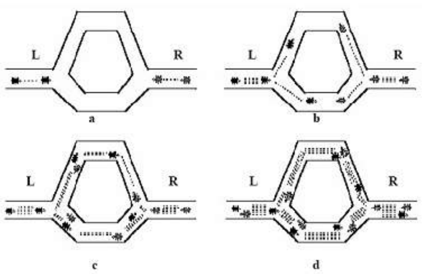

Figure 1. Ant journey from nest to food sources

3. RESEARCH METHODOLOGY

This research was conducted in the X Logistic company which is the largest logistics company in Indonesia, serving customers in all parts of Indonesia. This study focused on the logistics distribution network planning for PB store. The data used in this study is the data delivery schedule in November 2012. Figure 2 shows the flowchart of the study as follows:

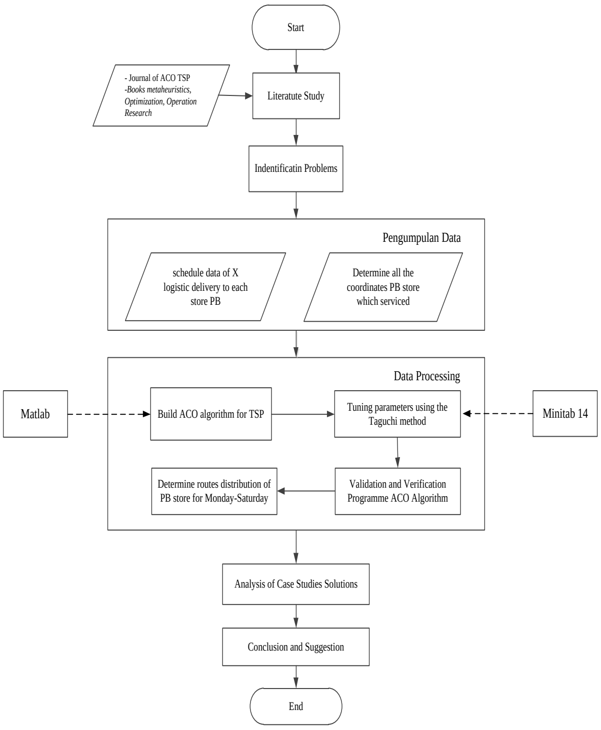

Figure 2. Flowchart of research methodology

4. RESULT AND DISCUSSION

4.1. Data Collection

1) X Logistic Operational Data

Data collection to this research that the X Logistic operational data store for distribution PB shown in Table 1. While to get a PB store delivery schedule on Monday until Saturday on the appendix 1. To get routes distribution network by ACO method is to first look for the point coordinates of 45 PB stores on the appendix 2.

Table 1. Data Distribution Delivery Specification of PB store

The data used in to delivery store PB		
Capaties per destination	20 box	
Truk (CDE)	2 ton	
Work Hours	Mon-Fri	08:00-17:00
	Saturday	08:00-13:00
Overtime costs/hour	15000	min charger 3 hour
Truk capacities	5 Drop/Day	180 km/Day
	250 box	per truck
Additional drop	200000	per drop
Cost	750000	per trip

2) Model of *Constraint Programming* for TSP

To solve the problems of TSP (Pesant, 1998) develop a model of Constraint Programming. Parameters and variables used in this model is *V = {2, ... n}* which represents the cities to be visited, with the city of origin or origin-depot expressed by *V = 1*, while for the destination depot is expressed by *V = n +1*. A tour will be a Hamiltonian path that starts at I and ending in *n +1*, which can be expressed as:

$$V^0 = V \cup \{1\}$$
$$V^d = V \cup \{n+1\}$$
$$V^{0,d} = V \cup \{1, n+1\}$$

Furthermore, c_{ij} show travel costs from city *i* to city *j*, and the central part of the model is a variable S_i, *i = 1, ..., n,* which predisposing to every city (and origin-depot), and which shows the immediate successor in a tour. So the domain is an integer between *2, ..., n +1.* Constraint programming model to TSP can be formulated with:

$$Min \sum_{i \in V^0} C_i, S_i \quad (1)$$

With constraints:

$$S_i \neq S_j, \quad \forall i, j \in V^0, i \neq j \quad (2)$$
$$S_i \neq i, \quad \forall i \in V^0 \quad (3)$$
$$S_i = j => S_{\in j} \neq \beta_i, (\epsilon_j \neq n+1) \ \forall i \in V^0 \quad (4)$$
$$S_i \in \{2, \ldots, n+1\} \quad \forall i \in V^0 \quad (5)$$

Objective function is to minimize the total cost of the tour $c_{i,} s_i$ which is the cost of travel from *i* to the immediate successor S_i (1). Constraints (2) and (5) ensure that each city visited only once, while constraints (3) and (4) is used to eliminate sub-tour.

Constraint (5) is only used to determine the domain. Constraint (3) is used to eliminate i from the domain at each S_i, constraints (2) wait until the S_i or S_j be fixed to the value of k, then this constraint will eliminate k from the domain of other variables. At the constraints (4), while S_i fixed to *j*, partial path ending in *i* will join another partial path which begins with *j*.

4.2. Data Processing

1) Build the Algorithm ACO for TSP

The first step in data processing namely to build ACO algorithms using Matlab software. In this study, which ACO algorithm is an algorithm used Ant Colony System (ACS) algorithm flowchart found in Figure 3. In ACS, takes several variables and measures for the TSP case study:

Step 1

1. Initialization algorithm parameters values.
   Parameters that are initialized :
   1. Ant trail intensity between the city and the changes (τ_{ij})
   2. The number of cities (n) including x and y (coordinates) or d_{ij} (distances between cities)
   3. Determination of leaving town and city destination
   4. Constant of cycle-ant (Q)
   5. Constant of intensity controller ant trail (α)
   6. Constant of visibility controller (β)
   7. Visibility of between city = $1/d_{ij}(\eta_{ij})$
   8. Number of Ant (m)
   9. Evaporation constant trail of ants (ρ)
   The maximum number of cycles (NC_{max}) are invariant during the algorithm run, while τij price will always be updated to every cycle algorithm starts from the first cycle (NC = 1 to achieve the maximum number of cycles ($NC=NC_{max}$) or until there is convergence
2. Initialization first city every ant
   Once the initialization is done τ_{ij}, then m ant are placed to the first city which has been determined.

Step 2

Completion of the first cities in the taboo list. The initialization of the first city of ant in step 1 should be entered as the first element of the taboo list. The results of this step is the first element terisinya every ant tabu list with the first city index.

Step 3

Preparation of lane every ant visits to every city. ant colonies that has been distributed to the first town will start to travel from the first city and the hometown of one of the other cities as a destination city. Then from the second city, each ant colony will continue the journey by selecting one of the cities that are not on $tabu_k$ as the next destination. ant colony journey continues until it reaches a predetermined city. If s expressed sequence index visit, the hometown expressed as $tabu_k$ (s) and other cities expressed as {N-$tabu_k$ }, then used for determine the destination city by Dorigo equations, probabilities town to visit the following:

$$P_{ij}^k = \frac{[\tau_{ij}]^\alpha [\eta_{ij}]^\beta}{\sum_{k' \in \{N - tabu_k\}} [\tau_{ik'}]^\alpha . [\eta_{ik'}]^\beta} \text{ for } j \in \{N - tabu_k\}$$

$$P_{ij}^k = 0, \text{for another j}$$

With *i* is an index origin point and *j* as an index point of destination.

Step 4

1. Calculation of the path length each ant.
   Calculation of the path length covered (length closed tour) or L_k each ant is done after the cycle is completed by all ant. Calculations are based on $tabu_k$ each with the following equation:
   $$L_k = d_{tabu(n),tabu_k(1)} + \sum_{s=1}^{n-1} d_{tabu(n),tabu_k(s+1)}$$
   With d_{ij} is distance between cities *i* to *j* which is calculated based on the equation:
   $$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$
2. Search the shortest route
   After L_k each ant is calculated, will obtain a minimum The price a closed path length of each cycle or L_{minNC} and the minimum The price the overall length of the path is closed or L_{min}.
3. Calculation of the intensity of price changes ant footprince between cities.
   Ant colony will leave footprints to the path between cities in its path. To evaporation and the difference in the number of ants passing by, causing the intensity of the possibility of changes in prices between cities ant footprints. the changes equation is:
   $$\Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau_{ij}^k$$
   with $\Delta\tau_{ij}^k$ is the price change between the intensity of pheromone ant trail city each ant is calculated based on the equation:
   $$\Delta\tau_{ij}^k = \frac{Q}{L_k}$$
   for $(i,j)\epsilon$ is origin and destinations in the $tabu_k$, $\Delta\tau_{ij}^k = 0$ for another *(i,j)*.

Step 5

1. The calculation of the intensity of pheromoneant trail acrooss town to the next cycle.
   Price intensity ant footprints across the city to all paths between cities is likely to change due to evaporation and the difference in the number of ants which passed. For the next cycle, the ant will pass through the trajectory of The price intensity has changed. Price intensity ant footprints across the city for the next cycle is calculated by the equation:
   $$\tau_{ij} = \rho . \tau_{ij} + \Delta\tau_{ij}$$
2. The price Reset ant pheromone intensity change of between cities.
   For the next cycle of price changes ant trail intensity between cities need to be rearranged in order to have a value equal to zero.

Step 6

Discharging taboo list, and repeat step two if necessary. Tabu list needs to be emptied for be filled again with a new municipal order to next cycle, if the maximum number of cycles is reached or has not happened yet convergence. Algorithm is repeated from step two with The price parameters between the intensity of ant footprints kotayang been updated. Programme said to be optimal or have reached a state in which the termination is the process of finding the optimal solution has reached the termination criteria. Termination criterion is generally the maximum number of iterations, the maximum computing time, and achieve a state of convergent (the value of the optimal objective function no longer changes) (Price, 2005).

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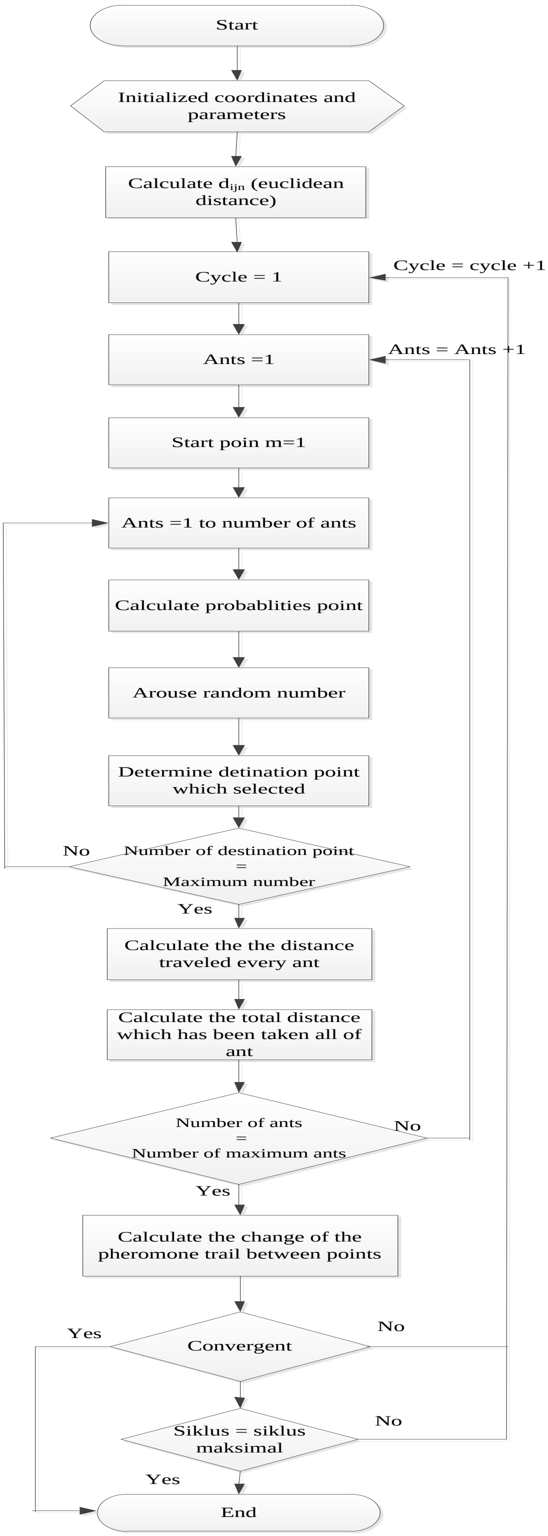

Figure 3. *Flowchart* of ACS algorithm

2) Desain of Eksperiments for Parameter Tuning

Difficulty for identify the parameters and interactions between factors can influence the objective function in determining the best route and total mileage to issue *Travelling Salesman Problem* (TSP). Therefore, we need a method for determine the value of the parameter ACO, Taguchi method is used. Taguchi experimental design is more efficient because it allows for carry out research involving many factors, and generate conclusions regarding the factors and levels of factors which produce optimum response. factors considered were four factors (number of ant, α, β, and ρ) at different levels are high medium and low. Experimental design used for determine appropriate parameter values for ACO to minimize total mileage of warehouse stores throughout the New Testament every day and go back to warehouse and analyze the effect of each factor in the experiment that is true. Using MINITAB 14 software, Taguchi test results can be seen in Figure 5.

Table 2. ACO parameters initiation factor

Faktor	Level		
	High	Medium	Low
m	8	17	34
α	0,5	2,5	4,5
β	1	5	9
ρ	0,4	0,5	0,6

Tabel 3. Matrix of *Orthogonal Array* $L_9(3^4)$

$L_9(3^4)$							
Eksperimen	Level			m	α	β	ρ
	1	2	3				
1	1	1	1	8	0.5	1	0.4
2	1	2	2	8	2.5	5	0.5
3	1	3	3	8	4.5	9	0.6
4	2	1	2	17	0.5	5	0.6
5	2	2	3	17	2.5	9	0.4
6	2	3	1	17	4.5	1	0.5
7	3	1	3	34	0.5	9	0.5
8	3	2	1	34	2.5	1	0.6
9	3	3	2	34	4.5	5	0.4

Taguchi Design

```
Taguchi Orthogonal Array Design

L9(3**4)

Factors:  4
Runs:     9


Columns of L9(3**4) Array

1 2 3 4
```

Figure 4. *Output* of Taguchi Design Minitab 14

```
Response Table for Signal to Noise Ratios
Nominal is best (10*Log(Ybar**2/s**2))

Level    Ant  Alpha   Beta    Rho
1      41,37  45,29  52,75  43,71
2      37,78  34,66  40,91  42,21
3      42,21  30,00  35,62  35,45
Delta   4,43  15,30  17,13   8,25
Rank       4      2      1      3


Response Table for Means

Level    Ant  Alpha   Beta    Rho
1      2,529  2,522  2,514  2,530
2      2,489  2,484  2,473  2,472
3      2,472  2,484  2,503  2,488
Delta  0,057  0,038  0,041  0,058
Rank       2      4      3      1
```

Figure 5. *Output* Taguchi Analiysis Minitab 14

In Figure 6. shows the resulting output shows the Response Table for Signal to Noise Ratios meant to show the values of the parameters which controlled. While Response Table for Means shows the average the results parameter combinations. Selected parameter is the average of the smallest (smaller the better). The following tables summarize the parameter combination ACO.

Table 4. Combinations for optimum parameters

Factor	Value	Level
m	34	Low
α	4.5	Low
β	5	Medium
ρ	0.5	Medium

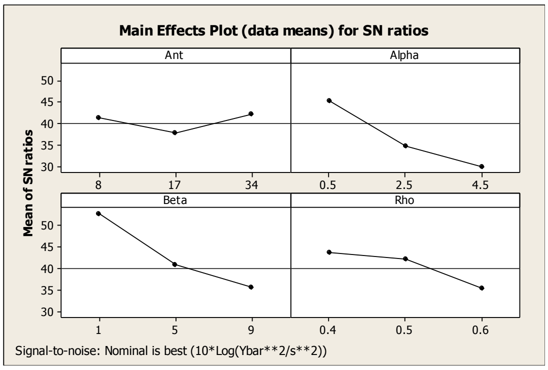

Figure 6. (a) Chart for SN ratios

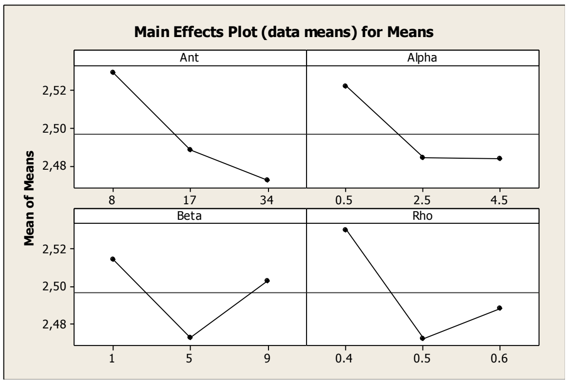

Figure 6. (b) Chart for Data Means

3) Validation and Verification of Progam ACO Algorithm

To solve the problems to distribution logistics TSP PB store, first performed the validation and verification of programs ACO algorithm which has been made. Validation is the stage for see the correspondence between the model program which has been created with the concept of the model that we want. If the program can be run in accordance with the wishes, the program has been verified. One of the indicators which can be done for prove it is when change of to parameter values, the resulting output will also change. For the validation is done by combining the parameters obtained from the tuning parameters using Taguchi method and inserted into the ACO algorithm. For validation, the researchers use a food distribution schedule on Monday. The table below shows the total output of different mileage for Monday.

Table 5. The results validate the combination of parameters

Experiment	m	α	β	ρ	Distance (mil)
1	8	0,5	1	0,4	2,5741
2	17	2,5	9	0,6	2,7666
3	34	4,5	5	0,5	2,4685

Based on the computational the results, Table 5 shows the results for smallest distance distribution schedule is Monday to 3 experiments, the results are consistent with optimum parameter values table 4 ACO algorithms for distribution problems PB store.

After the validation, verification in order for ensure that the program can be made to walk according to function so as to produce the correct output. This program has been verified indicators are doing manual calculations, the results manual calculations the same value as the program the results. Verification is done by using a 5 the point coordinates PB store on Monday indicated in Table 6 and Table 7 shows the parameters used.

Table 6 PB store coordinate point

No.	Name of PB Store	Coordinates X	Coordinates Y
1	**Warehouse X *Logistic***	-6,280272	106,771762
2	PB ABDUL MUIS	-6,176372	106,820007
3	PB BEKASI	-6,246086	106,991209
4	PB BINYAMIN SUEB	-6,144139	106,848822
5	PB CIKINI	-6,186603	106,826795

Table 7 Parameters for verification ACO

Parameters						
τ_{ij} (*Pheromone*)	n (number of cities)	Q (Cycle)	α (constant of *pheromone*)	β (visibility)	m (number of ants)	ρ (Evaporations)
0,0001	5	1	2,5	9	1	0,4

Here is the results calculations using excel manual used to verification phase is shown in Table 8, while for the results of the computation using the program shown in Figure 7.

Table 8. Results Route and Mileage calculations Manually

From	To	d_{ij}	η_{rs}	p (probabilities)	$\tau_{ij\ initial}$	$\Delta\tau_{ij}$
Warehouse X *Logistic*	PB CIKINI	0,11	8,72945057	0,00054969193	0,0001	
PB CIKINI	PB ABDUL MUIS	0,01	81,4462138	23464,938945		1,661907408
PB ABDUL MUIS	PB BENYAMIN SU	0,04	23,1293763	477405,29731		4,25607277
PB BENYAMIN SUEB	PB BEKASI	0,18	5,71034823	0,39001213221		4,384295738
PB BEKASI	Warehouse X *Logis*	0,22	4,50260149	1,07702799276		3,01612756
Distance (Lk)		0,56137				

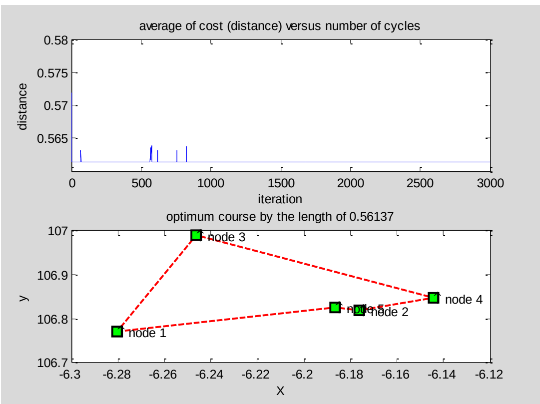

Figure 7. These results and the Mileage Programme

The results of calculations manually generate mileage 0.56137 miles, equal to the the results the program which executed.

The distribution is assumed to start and return to the X Logistic warehouse.

Warehouse X logistic-PB Cikini-PB Abdul Muis-PB Benyamin Sueb-PB Bekasi-Warehouse X logistic.

Based on which verification stage has been shown in Table 8 and Figure 7, it can be concluded that the program has been made in accordance with the running TSP concept and ACO algorithms. In addition, the resulting output is also the same as the results of calculations performed manually. Thus, which program is made otherwise verified.

4) Determine Distribution Route for PB Store Monday to Saturday

Once the program verified, the data is processed by Matlab program obtained the results in the form of routes PB distribution store. In the input data into the program can be seen in table 8. The output of the program that have been made are the distribution schedule to Monday until Saturday. The following are routes the results in Figure 8.

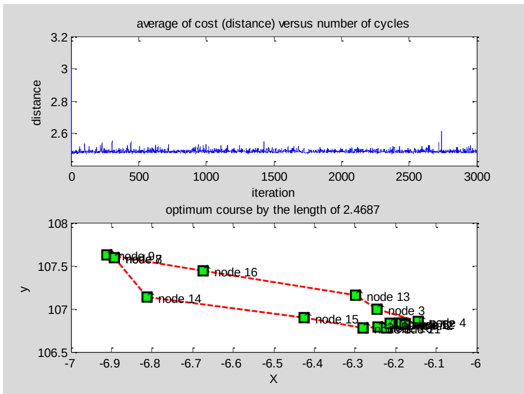

Figure 8 (a) *Output* of on Monday

Route: 1-10-11-17-5-12-6-2-4-3-13-16-9-8-7-14-15-1

Warehouse X Logistic-PB Gandaria-PB Hyundai-PB Kuningan- PB Cikini-PB Industri-PB Ciliitan-PB Abdul Muis-PB Benyamin Sueb-PB Bekasi-PB Jababeka-PB KM 97-PB DaanMogot-PB CIP B-PB CIP A-PB KM 14-PB KM 21-Warehouse X Logistic

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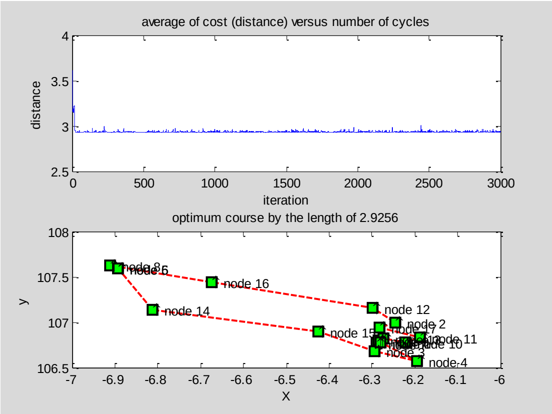

Figure 8 (b) *Output* of routes on Tuesday

Route: 1-7-9-13-10-11-17-2-12-16-8-6-5-14-15-4-3-1

Warehouse X Logistic-PB Cirendeu-PB Fatmawati-PB Kemang-PB Hyundai-PB Industri-PB Kodau-PB Bekasi-PB Jababeka-PB KM 97-PB Daan Mogot-PB CIP B-PB CIP A-PB KM14-PB KM 21-PB Cafe UPMS 3-PB BSD 1-Warehouse X Logistic

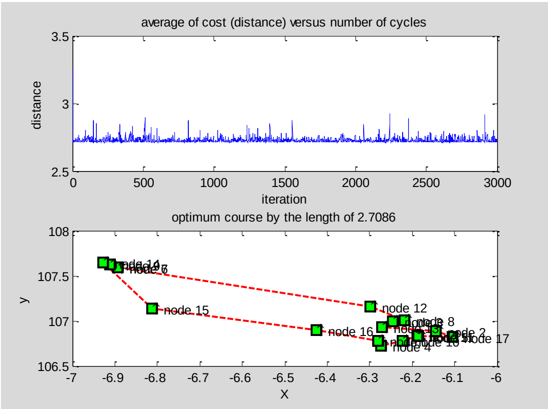

Figure 8 (c) *Output* of routes on Wednesday

Route: 1-4-10-11-5-2-17-13-3-8-12-7-6-9-14-15-16-1

Warehouse X Logistic-PB Bintara-PB Hyundai-PB Industri-PB Cikini-PB Artha Gading-PB KM 62-PB Jatiwaringin-PB Bekasi-PB Cut Mutia-PB Jababeka-PB CIP B-PB CIP A-PB Daan Mogot-PB Kiara Condong-PB KM 14-PB KM 21-PB Warehouse X Logistic

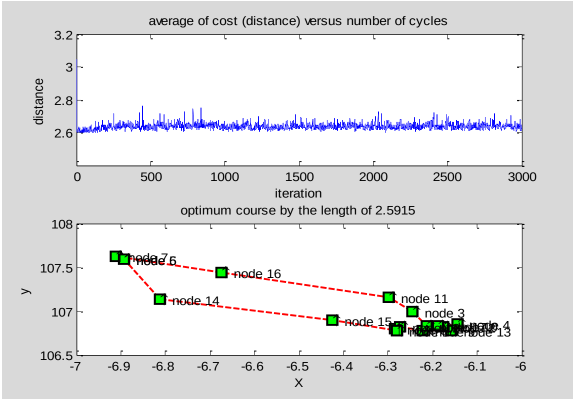

Figure 8 (d) *Output* of routes on Thursday

Route: 1-8-12-9-13-4-2-10-17-3-11-16-7-5-6-14-15-1

Warehouse X Logistic-PB Fatmawati-PB Kemang-PB Hyundai-PB Kemaggisan-PB Benyamin Sueb-PB Abdul Muis-PB Industri-PB Kuningan-PB Bekasi-PB Jababeka-PB KM 97-PB Daan Mogot-PB CIP B-PB CIP A-PB KM 14-PB KM 21-Warehouse X Logistic

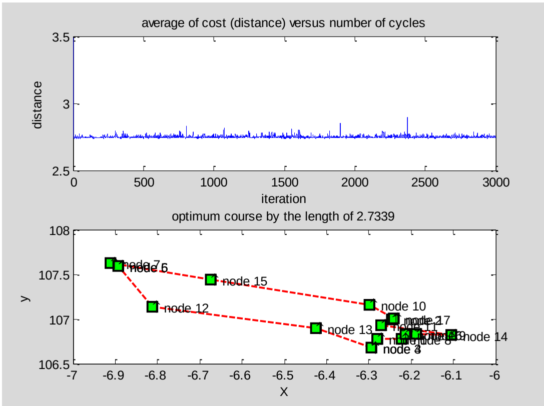

Figure 8 (e) of routes on Friday

Route: 1-8-16-9-14-11-2-17-10-15-7-6-5-12-13-3-4-1

Warehouse X Logistic-PB Hyundai-PB Kuningan-PB Industri-PB KM 97-PB Daan Mogot-PB CIP B-PB CIP A-PB KM 14-PB KM 21-PB BSD 1-PB BSD 2-Warehouse X Logistic

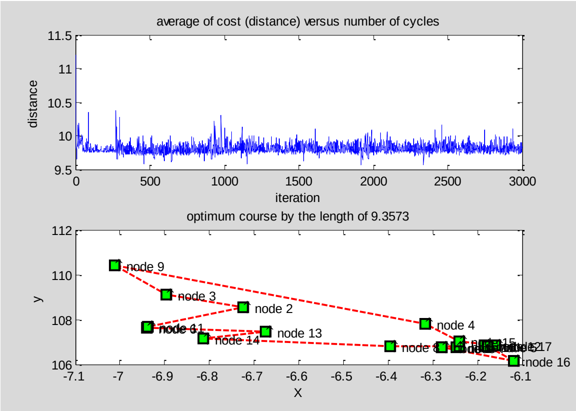

Figure 8 (f) *Output* of routes on Saturday

Rute: 1-7-10-12-17-5-15-13-6-11-2-3-9-4-14-8-16-1

Warehouse X Logistic-PB Warung Jambu-PB Tendean-PB Tambun-PB Samanhudi-PB Tomang-PB Lippo Karawaci-PB KM 97-PB UJB 1-PB Soehat BDG-PB Kaligangsa-PB Pamanukan-PB KM 14-PB Sawangan-PB Serang-Warehouse X Logistic

Table 9. Summary of Results Output Optimal Route Algorithm

No	Day	Shortest Route
1	Monday	1-10-11-17-5-12-6-2-4-3-13-16-9-8-7-14-15-1
2	Tuesday	1-7-9-13-10-11-17-2-12-16-8-6-5-14-15-4-3-1
3	Wednesday	1-4-10-11-5-2-17-13-3-8-12-7-6-9-14-15-16-1
4	Thursday	1-8-12-9-13-4-2-10-17-3-11-16-7-5-6-14-15-1
5	Friday	1-8-16-9-14-11-2-17-10-15-7-6-5-12-13-3-4-1
6	Saturday	1-7-10-12-17-5-15-13-6-11-2-3-9-4-14-8-16-1

In addition to looking for the shortest route, to TSP problem also calculate the cost of the required minimum distribution for their tour to PB store. The cost is calculated by multiplying the cost of diesel fuel valued at Rp. 5.500/liter with a total mileage of each day. Types of used cars are diesel trucks colt ankle (CDE) with solar charging fuel oil with a ratio of 1:5 means that 1 liter can cover the distance Solar 5 Km, so the cost of transportation is 1/5 x Rp. 5.500 = Rp 1100/Km. Table 10 shows the costs required for routes distribution, the output the results of the program are in units of miles and converted into units of Km for researchers to use Google Maps with a straight line, which is a mile units used. In Google Maps for 1 mile is equal to 2 km.

Table 10. Minimum Fee Mileage

No	Day	Distance (mil)	Distance conversion (km)	Cost
1	Mon	2,4687	4,9374	Rp 5.431,-
2	Tue	2,9256	5,8512	Rp 6.436,-
3	Wed	2,7086	5,4172	Rp 5.959,-
4	Thur	2,5916	5,1832	Rp 5.702,-
5	Fri	2,7339	5,4678	Rp 6.015,-
6	Sat	9,3573	18,7146	Rp 20.586,-

5. CONCLUSION

Based on the analysis and discussion that has been done in the previous chapter, it can be deduced as follows:

1. Build ACO algorithm to solve the problem Traveling Salesman Problem by Ant Colony System algorithm (ACS). With the advantages of ACS algorithms are global pheromone update rule is only done on edge-edge which is the best part of the tour, so the ant will be easier to determine the next point.
2. Parameter tuning results obtained using the Taguchi method is optimum parameter values for the number of ants (m) = 34, constant pheromone (α) = 4.5, visibiliti (β) = 1 and evaporation (ρ) = 0.5.
3. Optimal routes and mileage for Monday through Saturday the results obtained from the ACO algorithm as follows:

Table 11 Conclusion of the optimal routes and distance

No	Day	Shortest Route	Distance (mil)
1	Monday	1-10-11-17-5-12-6-2-4-3-13-16-9-8-7-14-15-1	2,4687
2	Tuesday	1-7-9-13-10-11-17-2-12-16-8-6-5-14-15-4-3-1	2,9256
3	Wednesday	1-4-10-11-5-2-17-13-3-8-12-7-6-9-14-15-16-1	2,7086
4	Thursday	1-8-12-9-13-4-2-10-17-3-11-16-7-5-6-14-15-1	2,5916
5	Friday	1-8-16-9-14-11-2-17-10-15-7-6-5-12-13-3-4-1	2,7339
6	Saturday	1-7-10-12-17-5-15-13-6-11-2-3-9-4-14-8-16-1	9,3573

4. Optimum costs obtained for Monday to Saturday each Rp. 5,431, Rp. 6436, Rp. 5,959, Rp. 5,702, Rp. 6,015 and Rp. 20 586

6. REFERENCES

a) Agus Leksono (2009). *Algoritma Ant Colony Optimization (ACO) untuk Menyelesaikan Travelling Salesman Problem* (TSP). UNDIP. Semarang.

b) Budi Santosa, Paul Willy. (2011). *Metode Metaheuristik Konsep dan*

Implementasi Edisi pertama. Surabaya: Guna Widya.

c) Dorigo M and Gambardella LM. (1996), "*Ant Colony System*: *A Cooperative Learning Approach to the Taravelling Salesman Problem*". Universite Libre de Bruxelles, Belgium.

d) Dorigo M and L.M G., (1997), "*Ant Colonies for Travelling Salesman Problem*". Belgia

e) Feryanto A. (2009). "*Ant Colony System untuk Penyelesaian Masalah Travelling Salesman Problem*". ITB. Bandung.

f) Ig. Joko Mulyono, Rulianto Utomo (2008). *Optimasi Faktor Kontrol yang Berpengaruh Terhadap Proses Pembuatan Duck Nuggets dengan Menggunakan Metode Taguchi*. Universitas Katolik Widya Mandala. Surabaya.

g) I Nyoman Sutapa, I Gede Agus Widyana (2003). *Studi Tentang Travelling Salesman Problem Dengan Time Windows* (Jurnal).

h) Mutakhiroh I, (2007). "*Menentukan Jalur Terpendek Menggunakan Algoritma Semut*". Universitas Islam Indonesia, Yogyakarta.

i) Paulus Bangun Martua, (2011). "*Perancangan Algoritma Ant Colony Optimization untuk Penyelesaian Vehicle Routing Problem*". Jurusan Teknik Industri, Fakultas Teknik, Universitas Indonesia.

j) Pujawan, I Nyoman, (2005). *Supply Chain Management*. PT. Guna Widya, Surabaya.

k) Rosenkrantz, D. J., Stearns, R. E., and Lewis, II, P. M. (1977). *An analysis of several heuristics for the traveling salesman problem*. SIAM Journal on Computing.

l) Saptoto F et al., (2007). "*Perbandingan Performansi Algoritma Genetika dan Algoritma Semut Untuk Penyelesaian Shortest Path Problem*". Jurusan Teknik Informatika, Fakultas Teknologi Industri, Universitas Islam Indonesia.

m) Shahooker K and Mazumder. (1995). "*Genetic Multiway Partitioning*". International Conference on VLSI Design. New Delhi.

n) Taguchi, G. Cnowdhury, S and Taguchi, S.(1999). *Robust Engineering. Mc. Graw Hil Book Co.*

o) Wardy, I. S. (2007). *Penggunaan graph dalam algoritma semut untuk melakukan optimisasi*, Program studi Teknik Informatika, ITB, Bandung.

p) Widya Nucahayanty Tanjung (2009). *Implementasi Algoritma K-Ant Colony Optimization (K-ACO) untuk Menyelesaikan Masalah Lokasi-Alokasi* (Jurnal).

AUTHOR BIOGRAPHIES

Widya Nurcahayanty Tanjung is a lecturer in Department of Industrial Engineering, Faculty of Sains and Technology, University of Al Azhar Indonesia, Jakarta. She received her Master of Industrial Engineering from Indonesia University. Her research interests are in the area of Supply chain management and artificial intelligent. Her email address is <widya@uai.ac.id>.

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Appendix 1

Table 12. Distribution schedule Monday to Saturday

No.	Monday	Tuesday	Wednesday
1	**Warehouse X *Logistic***	**Warehouse X *Logistic***	**Warehouse X *Logistic***
2	PB ABDUL MUIS	PB BEKASI	PB ARTA GADING
3	PB BEKASI	PB BSD 1	PB BEKASI
4	PB BINYAMIN SUEB	PB CAFÉ UPMS 3	PB BINTARA
5	PB CIKINI	PB CIP A	PB CIKINI
6	PB CILILITAN	PB CIP B	PB CIP A
7	PB CIP A	PB CIRENDEU	PB CIP B
8	PB CIP B	PB DAAN MOGOT	PB CUT MUTIA
9	PB DAAN MOGOT	PB FATMAWATI	PB DAAN MOGOT
10	PB GANDARIA	PB HYUNDAI	PB HYUNDAI
11	PB HYUNDAI	PB INDUSTRI	PB INDUSTRI
12	PB INDUSTRI	PB JABABEKA	PB JABABEKA
13	PB JABABEKA	PB KEMANG	PB JATIWARINGIN
14	PB KM 14	PB KM 14	PB KIARA CONDONG
15	PB KM 21	PB KM 21	PB KM 14
16	PB KM 97	PB KM 97	PB KM 21
17	PB KUNINGAN	PB KODAU	PB KM 62

Table 12. Distribution schedule Monday to Saturday (con't)

No	Thursday	Friday	Saturday
1	**Warehouse X *Logistic***	**Warehouse X *Logistic***	**Warehouse X *Logistic***
2	PB ABDUL MUIS	PB BEKASI	PB DARSONO
3	PB BEKASI	PB BSD 1	PB KALIGANGSA
4	PB BINYAMIN SUEB	PB BSD 2	PB PAMANUKAN
5	PB CIP A	PB CIP A	PB TOMANG
6	PB CIP B	PB CIP B	PB UJB 1
7	PB DAAN MOGOT	PB DAAN MOGOT	PB WARUNG JAMBU
8	PB FATMAWATI	PB HYUNDAI	PB SAWANGAN
9	PB HYUNDAI	PB INDUSTRI	PB SULTAN AGUNG
10	PB INDUSTRI	PB JABABEKA	PB TENDEAN
11	PB JABABEKA	PB JATIWARINGIN	PB SOEHAT BDG
12	PB KEMANG	PB KM 14	PB TAMBUN
13	PB KEMANGGISAN	PB KM 21	PB KM 97
14	PB KM 14	PB KM 62	PB KM 14
15	PB KM 21	PB KM 97	PB LIPPO KARAWACI
16	PB KM 97	PB KUNINGAN	PB SERANG
17	PB KUNINGAN	PB LIPPO KARAWACI	PB SAMANHUDI

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Appendix **2**

Table 13. Coordinates Point PB store

No.	Name of PB Store	Coordinate X	Coordinate Y
1	**Warehouse X *Logistic***	-6,280272	106,771762
2	PB ABDUL MUIS	-6,176372	106,820007
3	PB ARTA GADING	-6,143179	106,891304
4	PB BEKASI	-6,246086	106,991209
5	PB BINTARA	-6,272109	106,724904
6	PB BINYAMIN SUEB	-6,144139	106,848822
7	PB BSD 1	-6,293373	106,680508
8	PB BSD 2	-6,293118	106,680593
9	PB CAFÉ UPMS 3	-6,194518	106,565409
10	PB CIKINI	-6,186603	106,826795
5	PB CILILITAN	-6,186571	106,826495
11	PB CIP A	-6,893878	107,590742
12	PB CIP B	-6,892685	107,591343
13	PB CIRENDEU	-6,290259	106,769192
14	PB CUT MUTIA	-6,217503	107,005523
15	PB DAAN MOGOT	-6,911234	107,626515
16	PB DARSONO	-6,723512	108,537712
17	PB FATMAWATI	-6,284887	106,795837
18	PB GANDARIA	-6,244145	106,789033
19	PB HYUNDAI	-6,221279	106,781516
20	PB INDUSTRI	-6,186734	106,826763
21	PB JABABEKA	-6,299537	107,152576
22	PB JATIWARINGIN	-6,269762	106,930357
23	PB KALIGANGSA	-6,8962	109,105632
24	PB KEMANG	-6,273132	106,818073
25	PB KEMANGGISAN	-6,158518	106,776356
26	PB KIARA CONDONG	-6,928131	107,642841
27	PB KM 14	-6,813092	107,131119
28	PB KM 21	-6,424484	106,892166
29	PB KM 62	-6,105053	106,824188
30	PB KM 72	-6,399919	106,892853
31	PB KM 97	-6,673836	107,439144
32	PB KODAU	-6,281856	106,936111
33	PB KUNINGAN	-6,213642	106,831484
34	PB LIPPO KARAWACI	-6,24022	107,002029
35	PB PAMANUKAN	-6,317687	107,82197
36	PB SAMANHUDI	-6,159513	106,836113
37	PB SAWANGAN	-6,394972	106,81283
38	PB SERANG	-6,118089	106,159322
39	PB SOEHAT BDG	-6,936933	107,694431
40	PB SULTAN AGUNG	-7,011623	110,423584
41	PB TAMBUN	-6,184929	106,846161
42	PB TENDEAN	-6,239687	106,82539
43	PB TOMANG	-6,177548	106,798629
44	PB UJB 1	-6,939548	107,648335
45	PB WARUNG JAMBU	-6,247046	106,750031