Shortest Distribution Route Determination Of Pesticides Product Using Tabu Search Algorithm (Case Study: CV. Buana Artha Mandiri, Sidoarjo, Indonesia)

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**Abstract.** Distribution is activity of delivering goods or services from producers to consumers. CV. Artha Buana Mandiri is a company engaged in Agricultural Industrial Chemicals. The products produced by CV. Artha Buana Mandiri are pesticides. With a large area distribution, the company’s distribution process is still considered to be less optimal because there is no fixed distribution route due to the large number of routes used for the East Java distribution area, causing delays in the distribution process of pesticide products. The purpose of this study is to minimize the distance to obtain the optimal distribution route. Optimal route determination is included in the problem of Traveling Salesman Problem (TSP). One solution to solve TSP problems is to use the Tabu Search Algorithm. Tabu Search is a metaheuristic method based on local search. The process of performance moves from one solution to the next by choosing the best solution. The main purpose of this method is to prevent the search process from re-searching the space of the solution that has been traced. From the calculation it can be seen that the optimal route of the Tabu Search method is better than the company route with an optimum route of 251.3 km.

**Keywords:** Shortest Routes, Travelling Salesman Problem (TSP), Tabu Search Algorithm.
1. Introduction

Distribution plays an important role for the company, for products produced by the company could be distributed and marketed to the final consumer. To satisfy consumers, one of the things done by the company is delivering the product or customer requests quickly and accurately. One way companies do to distribute products quickly and precisely is selecting of the shortest delivery route that will affect the distribution cost.

CV. Artha Buana Mandiri is a Agricultural Chemicals Industrial companies that produces pesticides which has 14 kiosks spread across East Java. East Java product distribution is not considered optimal because there is no fixed route in the delivery of products to kiosks, resulting in delays in the product up to the kiosk.

The algorithm for TSP can be categorized into three types which are the exact algorithms, the approximate algorithms and the intelligent optimization algorithms. With the exact algorithms, the optimal circuit is ensured whereas they are not suitable to cope with the large scale of TSP [1]. These algorithms include the traditional search graph algorithms [2], linear programming methods [3], and dynamic programming methods [4].

Tabu search is an algorithm to produce the shortest distance solution in the problem of Traveling Salesman problem [5]. This paper proposes to apply Tabu Search to the Traveling Salesman Problem. Some of the steps used by Tabu for solving TSP are mentioned as follows:

a. Representing the solution:
A feasible solution is represented as a sequence of cities or referred as nodes or vertices, each will be visited only once. Always, the first and the last visited nodes are fixed to 1 [6]. The starting node will not be specified at this stage and by default it is 1. In our case, the solution representation will have the values as

\[ n2 \rightarrow n5 \rightarrow n4 \rightarrow n7 \rightarrow n6 \rightarrow n3 \rightarrow n1 \]

b. Initial Solution:
This step focuses on finding the nearest node starting from the first node. It also finds the nearest unvisited node from the current node until all the nodes are visited.

c. Neighborhood:
At each visit, the neighborhood with the best objective value is selected. The fitness function will be decided here. The exchange of node also takes place at this stage.

d. Tabu List:
This step prevents the process from cycling in a small set of solutions and Tabu list stores the recently visited nodes. The Tabu structure stores the number of iterations for which a given pair of nodes are restricted from swapping [7].

e. Aspiration criterion:
Sometimes, when there is no danger in cycling, the Tabu Search will restrict the moves. So, at these situations, the Tabu Search process needs to be revoked [8].

f. Diversification:
The searching process might get trapped in a space of local optimum at some situations. Those processes should be allowed to search other parts of the solution [9].

Algorithm Tabu Search in the solution must pass through each particular stage that has been set [8]. The Tabu Search algorithm in general is:
Step 1: Choose an initial solution \( i \) in the set \( S \). Set \( i^* = i \) and \( k = 0 \) where \( i^* \) is the best solution and \( k \) is the number of iteration that occurs when the search does best solution \( i^* \).
Step 2: Set \( k = k + 1 \) and produce subsets \( V^* \) of the solution in the solution set of \( N \) (i, k) so taboo and aspirations conditions do not meet the conditions are met.
Step 3: Select the best solution \( j \) in the subset \( V^* \). Set \( i = j \).
Step 4: If \( f(j) \leq f(i^*) \) then set \( i^* = i \).
Step 5: Update taboo and aspirations conditions.
Step 6: If the condition stops (stopping conditions) are met, then the search stops. If not, go to step 2.

The stop condition (stopping conditions) to be fulfilled if:
Step 1: \( N(i, k + 1) = \emptyset \) or if no solution is possible around the solution \( i \).
Step 2: The value of \( k \) is greater than the maximum allowable iteration.
Step 3: The number of loops that occur from start to repair the solution \( i \) is greater than the amount specified.

Where:
\[ i = \text{Solution found} \]
\[ i^* = \text{The best solution from the solution found} \]
\[ k = \text{Recurrence} \]
\[ j = \text{Solution found for the next iteration} \]
\[ S = \text{The set of possible solutions} \]
\[ V^* = \text{Subset of N (i, K)} \]
\[ N(i, k) = \text{The set of possible solutions to all loops} \]
The purpose of the study is to minimize the distance to obtain the optimal distribution route.

2. Material and Method
This research does not use material.
In this research, Tabu Search is used to solve the problem. Tabu Search mechanism can be shown in Figure 1.

![Figure 1. Tabu Search Mechanism](image)

3. Result and Discussion
3.1. Company Distribution Route
Shipping routes for each route are:

**ROUTE 1:**
CV Artha Buana Mandiri – Mekar Jaya – UD Anugrah Tani Makmur – UD Joyo Lugito – Dwi Tani Jaya Farm shop – Surya Shop – Sumber Jaya Tani Farm shop – Joyo Farm shop – Cahaya Tani – Bumi Makmur Farm shop – Setya Tani – Sumber Agro Farm shop – Sumber Tani Farm shop – UD Permai Agro – Sumber Rejeki – CV Artha Buana Mandiri.

**ROUTE 2:**
CV Artha Buana Mandiri – Mekar Jaya – UD Anugrah Tani Makmur – Surya Shop – Dwi Tani Jaya Farm shop – UD Joyo Lugito – Joyo Farm shop – Sumber Jaya Tani Farm shop – Sumber Rejeki – UD Permai Agro – Sumber Tani Farm shop – Cahaya Tani – Sumber Agro Farm shop – Bumi Makmur Farm shop – Sumber Rejeki.

**ROUTE 3:**
CV Artha Buana Mandiri – Mekar Jaya – UD Anugrah Tani Makmur – Sumber Rejeki – UD Permai Agro – Setya Tani – Bumi Makmur Farm shop – Sumber Agro Farm shop – Sumber Tani Farm shop – Cahaya Tani – UD Joyo Lugito – Surya Shop – Dwi Tani Jaya Farm shop – Joyo Farm shop – Sumber Jaya Tani Farm shop – CV Artha Buana Mandiri.

Table 1. Mileage Distribution Route for The Company (Km)

| Route | Mileage (Km) | Total Mileage per Route (Km) |
|-------|--------------|-----------------------------|
| 1     | 30.2 + 21.9 + 38.6 + 10.5 + 16.5 + 14.9 + 7.2 + 21.8 + 25.6 + 12.6 + 15.9 + 5.4 + 26.4 + 3.4 + 90.6 | 341.5 |
| 2     | 11.1 + 21.9 + 30.2 + 16.5 + 10.5 + 16.9 + 22.8 + 24.2 + 3.4 + 26.4 + 11.4 + 13.6 + 14.7 + 12.6 + 114 | 350.2 |
| 3     | 43.5 + 21.9 + 30.2 + 3.4 + 47.8 + 12.6 + 14.7 + 5.4 + 11.4 + 31.3 + 25.7 + 16.5 + 6.4 + 7.2 + 68.4 | 346.4 |
| **Total** | 1038.1 |

3.2. Distribution Routes of Tabu Search Method
3.2.1. Creating a Node Initialization
Table 2. Node Initialization

| Node | Name                          |
|------|-------------------------------|
| 0    | CV Artha Buana Mandiri        |
| 1    | Mekar Jaya                    |
| 2    | UD Anugrah Tani Hasil        |
| 3    | Sumber Jaya Tani Farm Shop    |
| 4    | Dwi Tani Jaya Farm Shop       |
| 5    | Joyo Farm Shop                |
| 6    | Surya Shop                    |
| 7    | UD Joyo Lugito                |
| 8    | Cahaya Tani                  |
| 9    | Sumber Tani Farm Shop         |
| 10   | Sethya Tani                  |
| 11   | Sumber Agro Farm Shop         |
| 12   | Bumi Makmur Farm Shop         |
| 13   | Sumber Rejeki                |
| 14   | UD Permai Agro               |
3.2.2. Determining the Initial Solution

Based on the initial node in the previous stages, then obtained a series of solutions beginning with the $0 - 3 - 9 - 12 - 7 - 11 - 14 - 1 - 10 - 2 - 6 - 5 - 4 - 13 - 8 - 0$ by the rules of the depiction of the nodes as following:

![Fig. 2. The figure is Early Solution Route](image)

3.2.3. Determining Alternative Solutions

This stage loops into the neighboring solution, wherein the solution at the moment of the first iteration, the current solution is the initial solution of random results. This process is carried out continuously until the process is completed and looping neighbors get the best available solution. In this neighbor iteration number of iterations is determined by the following formula:

$$k = \frac{n!}{2\times 15!}$$

$$= \frac{1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9 \times 10 \times 11 \times 12 \times 13 \times 14 \times 15}{2(15)}$$

$$= 43,589,145,600$$

So we get the number of iteration performed amounted to $43,589,145,600$ iterations. Then obtained looping neighbors solution as follows:

1) $0 - 3 - 9 - 12 - 7 - 11 - 14 - 1 - 2 - 6 - 5 - 4 - 13 - 8 - 10 - 0$
2) $0 - 3 - 9 - 12 - 7 - 11 - 10 - 8 - 13 - 4 - 5 - 6 - 2 - 1 - 14 - 0$
3) $0 - 12 - 6 - 5 - 4 - 13 - 8 - 10 - 11 - 7 - 12 - 9 - 3 - 14 - 0$, and so on.

In this step, the search term will expire if the solution has met the criteria to stop. If the solution is *i.i. solutions* for all alternative solutions. But if the solution *i.i. solutions* obtained is not better than the previous optimum solution, then go back to step determine alternative solutions.

![Fig. 3. The figure is Distance Solutions Graph Against The number of iterations](image)

The experiments conducted based on above conditions and did the iterations with different parameters to obtain optimal delivery route conditions. Most changes affect the outcome of the calculation is the parameter changes the number of iterations. On the condition of above 47 times iteration significantly reduced from $43,589,145,600$ times as many as the number of iterations, so the total distance delivery route change significantly while at iteration below 47 times already obtained results the optimal route for a total distance delivery route is no longer changed. Then the stop condition has been fulfilled and continued to the next step.

3.2.4. Tabu Update List

The data processed with Tabu Search algorithm is a sequence of optimal routes stalls that have been determined by the total mileage that is smaller than the total mileage of the initial solution. The results are obtained by performing multiple iterations to get optimal results. Updating the taboo list by adding the best solution obtained from each iteration that has reached the stopping criteria after all iterations are met.

3.2.5. Optimal Route of Tabu Search Method

Based on the data processing with the help of MATLAB software, found that the shortest distance obtained for the optimal route amounted to 251.3 km by the time i * 47th route as follows:

node : $0 - 12 - 6 - 4 - 7 - 12 - 10 - 11 - 9 - 8 - 14 - 13 - 3 - 5 - 0$

Route : CV Artha Buana Mandiri – Mekar Jaya – UD Anugrah Mandiri – Surya Shop – Dwi Tani Jaya Farm shop –
UD Joyo Lugito – Bumi Makmur Farm shop – Sethya Tani – Sumber Agro Farm shop – Sumber Tani Farm shop – Cahaya Tani – UD Permai Agro – Sumber Rejeki – Sumber Jaya Tani Farm shop – Joyo Farm shop – CV Artha Buana Mandiri.

Fig. 4. The figure is Optimal Method These Tabu Search

From the research Tabu Search Method for Solving the Traveling Salesman Problems conducted by Alkallak and Sha'ban obtained optimal results for the small size with 5 cities with 7 iterations. According to them the introduction of different neighbourhoods is necessary to reduce the computation time for taboo search, in which the approach swaps between cities is efficient and creates good solutions, a neighbourhood search algorithm searches among the neighbours of a candidate to find a better one [10]. Similar to the research, through this Taboo method can also be obtained Shortest Distribution Route Determination of Pesticides in CV. Buana Artha Mandiri Sidoarjo. Thus it can be said that the Tabu Search method is useful to help the search move away from previously visited portions of the search space and perform more extensive exploration.

4. Conclusions

These pesticide product distributions for Route 1 is 341.5 km; Route 2 is 350.2 km; and Route 3 is 346.4 km, while the Tabu Search method obtained a distance of 251.3 km. Tabu Search route distribution method is better than the company strategies with a difference distance to Route 1 is 90.2 km and the percentage of savings is 26%; Route 2 is 98.9 km and the percentage of savings is 27%; Route 3 is 951.1 km and the percentage of savings is 28%. From those result, the shortest route is Route 1 which is 341.5 km. In conclusion, the most optimal route is Route 1.

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