

Capacitated Vehicle Routing Problems: Nearest Neighbour vs. Tabu Search

Ilyas Masudin, Risma F. Sa'diyah, Dana M. Utama, Dian Palupi Restuputri, and Ferry Jie

Abstract—The purpose of the Vehicle Routing Problem is to obtain a vehicle route with a minimum mileage in meeting customer demand according to their respective locations. One variant of the Vehicle Routing Problem (VRP) is the Capacitated Vehicle Routing Problem (CVRP), namely VRP with vehicle capacity constraints. Problems with Capacitated Vehicle Routing Problems (CVRP), can be solved by using the nearest neighbour and Tabu Search Algorithm. The step to complete the Tabu Search Algorithm begins with the determination of the initial solution using Nearest Neighbour, determining alternative solutions with exchange, namely to move two points in the solution, evaluate alternative solutions with Tabu list, choose the best solution and set the optimum solution, update tabu list, then if the discharge criteria are met then the process stops and if not, then returns to the determination of alternative solutions. Based on the results of calculations using the Tabu Search Algorithm, the traveling distance is less about 10.01% than the nearest neighbor.

Index Terms—Algorithm Tabu search, capacitated vehicle routing problem (CVRP), vehicle routing problem (VRP).

I. INTRODUCTION

One effort that companies can do to optimize product distribution is to minimize transportation costs by determining the optimal route of a vehicle called the Vehicle Routing Problem (VRP). Vehicle Routing Problem (VRP) is a general term given to problems involving a vehicle route with a depot base that serves scattered customers with certain requests [1]. The Vehicle Routing Problem (VRP) is an NP-Hard Problem because it has complex problems that are difficult to solve. There are several methods that can be used in completing the Vehicle Routing Problem (VRP) in either the heuristic method or the meta-heuristic method.

Capacitated Vehicle Routing Problem (CVRP) is the problem of optimizing the mileage of a vehicle's journey in the distribution of goods from a delivery place (depot) to a number of customer agents so as to produce a route with a minimum total mileage. The simplest form of CVRP considers one depot and vehicle departing from the depot at the beginning and returns to the depot at the end [2]. The Capacitated Vehicle Routing Problem (CVRP) is one of the most common variations of VRP problems, where there are additional constraints in the form of a homogeneous (identical)

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vehicle capacity to visit a number of agents in accordance with their respective requests [3]. In a previous study [4], [5], a study was conducted to resolve the case of the Capacitated Vehicle Routing Problem (CVRP) using the Artificial Bee Colony algorithm. Then, Ren [6] completed the research on the problem of Capacitated Vehicle Routing Problem (CVRP) using the Tabu Search Algorithm.

The Tabu Search algorithm is one of the metaheuristic methods that can be used to find optimal solutions for the Vehicle Routing Problem (VRP). The basic concept of this algorithm is to guide each stage in order to produce the most optimum aspiration criteria without being trapped in the initial solution found during the stage [7]. In a previous study of the Tabu Search Algorithm [8]-[10] proved that the Tabu Search Algorithm can provide an optimal solution in the form of saving travel time in product distribution. The steps to complete the Tabu Search Algorithm include (1) determining the initial solution using Nearest Neighbouring, (2) determining alternative solutions with exchange (exchanging) two points in the solution, (3) evaluating alternative solutions with Tabu lists, (4) choose the best solution and set the optimum solution, (5) update the Tabu list, (6) then if the discharge criteria are met then the process stops and if not, then return to the determination of alternative solutions.

The purpose of this study is to obtain routes and distribution costs using the nearest neighbour and Tabu search algorithm. In addition, the purpose of this study is to compare the route of nearest neighbour and the routes of Tabu search that are formed based on the total distance traveled and transportation costs to be incurred.

II. METHODOLOGY

In this article, there are two initial routes, namely route 1 and route 2 where the number of customers will be visited. These customers are scattered in different locations with demand and distance as shown in Table I. Table I shows customer request data according to customer name, customer address, and customer's code to make it easier to determine the point of the visit. Table II shows the starting route where there is a point of the visit for each route, the total product demand for each route and the total distance for each route in kilometers. Route 1 has 6 customers that must be visited where the vehicle departs from the depot and ends at the depot. In addition, route 1 has a total demand of 425 units de. Route 2 has 9 customers that must be visited where the vehicle departs and ends at the depot, and then the total demand on route 2 is 425 units.

In this article, two methods of routing problems are presented to compare the effectiveness of the routes. In this

study, there are two methods that will be compared in solving the problems that occur. The method for determining the vehicle route in product distribution is the Nearest Neighbour and Tabu Search Algorithms. The Nearest Neighbour method has six steps to complete the construction of the route. The Nearest Neighbour steps are selecting the center point as the starting point of delivery or depot (D), determining the point with the smallest distance from the starting point and merging the two points, the last consumer point being the starting point and finding the next consumer with the closest distance from the starting point this, do the repetition process until the capacity of the vehicle is insufficient to carry out the shipment, and the last pull the points on one line so as to form the route of travel.

TABLE I: DEMAND AND THE EXISTING ROUTES

Routes	Route	Demand (unit)	Total Distance (km)
Route 1	D-G1-G2-G3-G4-G5-BU-D	425	45.7
Route 2	D-TL-BS-TR-TC-TK-BK-PS-LS-LM-D	425	58.23
		Total Distance	103.93

The second method is the Tabu Search Algorithm, where there are six steps to complete the Tabu Search Algorithm, including determining the initial solution, determining alternative solutions, evaluating alternative solutions, choosing the best solution, updating the Tabu list, and termination criteria. The first step is determining the initial solution using the Nearest Neighbour. The second stage of the completion of the Tabu Search Algorithm is to determine alternative solutions, namely by exchanging or exchanging two points in the solution. The third stage is evaluating alternative solutions with a Tabu list to see whether the candidate solutions (alternative solutions) are already in the Tabu list, if an alternative solution already exists in the Tabu list then the alternative solution will not be evaluated again, if an alternative solution is not contained in Tabu list, the alternative solution is stored in Tabu list as the best alternative solution. The fourth stage is to choose the best solution and set it as a new optimum solution. The fifth stage is updating the Tabu list by entering a new optimum solution. The sixth step is the dismissal criteria namely, if the dismissal criteria are met, the process stops and the optimum solution is obtained, if not, the repeat process starts from the second stage.

III. RESULTS

A. Determination of Routes Using Tabu Search Algorithm

The first step is to determine the initial solution as the optimum solution with the Nearest Neighbour method in the 0th iteration according to vehicle capacity and customer demand. The Nearest Neighbour method considers the closest distance to get the route with the minimum distance. The first step that must be done is to determine the customer who is the

closest to the depot to be placed at the beginning of the visit, then proceed with finding the next customer with the closest distance to the previous customer to find the customer route that will be passed onwards and so on.

TABLE II: NEAREST NEIGHBOUR RESULTS ROUTE

Cluster	Routes	Demand	Travel (Km)
Route 1	D-G1-TL-G2-G4-G3-BU-D	425	38.5
Route 2	D-BS-TR-TC-TK-G5-LS-LM-BK-P-S-D	425	56.69
		Total Distance	95.19

The second step is determining alternative solutions. At this stage, the route from the results of 0 iterations will be exchanged using the exchange method, which is to move two points in the solution so that the best alternative solution can be obtained, where the exchange method itself is the exchange of places between 2 nodes. At this stage an alternative solution is determined for each route. Table III is an alternative solution search on route 1 for iteration 1.

TABLE III: ALTERNATIVE SOLUTION FOR ROUTE 1 ITERATION 1

Exchange	Alternative Solution	Travel Distance (Km)
G1 TL	D-TL-G1-G2-G4-G3-BU-D	39.7
G1 G2	D-G2-TL-G1-G4-G3-BU-D	44.7
G1 G4	D-G4-TL-G2-G1-G3-BU-D	53.6
G1 G3	D-G3-TL-G2-G4-G1-BU-D	55.4
G1 BU	D-BU-TL-G2-G4-G3-G1-D	44.1
TL G2	D-G1-G2-TL-G4-G3-BU-D	42.8
TL G4	D-G1-G4-G2-TL-G3-BU-D	47.8
TL G3	D-G1-G3-G2-G4-TL-BU-D	49.1
TL BU	D-G1-BU-G2-G4-G3-TL-D	39.2
G2 G4	D-G1-TL-G4-G2-G3-BU-D	43.5
G2 G3	D-G1-TL-G3-G4-G2-BU-D	39.5
G2 BU	D-G1-TL-BU-G4-G3-G2-D	38.2
G4 G3	D-G1-TL-G2-G3-G4-BU-D	38.4
G4 BU	D-G1-TL-G2-BU-G3-G4-D	37.6
G3 BU	D-G1-TL-G2-G4-BU-G3-D	41.6

The third step is to evaluate alternative solutions from the exchange of points that have been tried on the iteration and determine the solution as a temporary optimum solution. On route 1 iteration 1 obtained a temporary optimum solution that is at the exchange of G4 and BU nodes with a distance of 37.6 km which produces the D-G1-TL-G2-BU-G3-G4-D route.

The fourth step is to choose the most optimum solution among all lists of alternative solutions. If the solution is smaller than the initial solution, the solution will be chosen as the new optimum solution. The optimum solution value in iteration 1 is smaller than the initial solution, so the optimum solution is chosen as the new optimum solution.

The fifth step is updating the Tabu list. Previously there was a new optimum solution, the new optimum solution would be included in the Tabu list which would later be used as the next solution or iteration.

The sixth step is dismissal if all the criteria have been

fulfilled, the search stops, but if not then it will return to step 2. The new route results from the Tabu Search algorithm calculation can be seen in Table IV:

TABLE IV: NEW ROUTES RESULT OF TABU SEARCH ALGORITHM

Cluster	Routes	Demand	Travel Distance (Km)
Route 1	D-G1-TL-G2-BU-G4-G3-D	425	37.6
Route 2	D-BS-TR-TC-TK-LM-LS-G5-BK-P-S-D	425	55.81
		Total Distance	93.41

The new route using the Tabu Search Algorithm produces 2 routes. Route 1 produces a total mileage of 37.6 km with a total request of 425 units. The detail distribution route 1 as shown in Fig. 1 could be explained as follow: route 1 starts from the depot (warehouse) by transporting the product according to customer demand with a total of 425 units, then the vehicle departs from the depot and visits the first customer point, the customer with G1 code with a total demand of 25 units and the distance from depot to G1 is 9.6 km . After visiting G1 customers then the vehicle visits the next customer point ie TL with a distance of 0.9 km and the number of product requests is 50 units. Furthermore, from TL customers go to G2 customers with a distance of 2.4 km and the number of product requests are 25 units. Then the vehicle visits G4 customers from a G2 customer point with a distance of 2.9 km and has a total demand of 25 units. Vehicles from the G4 customer point visit the next customer point, the G3, with a total demand of 100 units and a distance of 1.3 km. Furthermore, the vehicle visits the last customer point, BU with a distance of 5.4 km from the G3 customer point, where BU has a number of product requests of 200 units. After the vehicle visits all customer points, then the vehicle returns to the depot (warehouse). Route 2 has a total request of 425 units with a total distance of 55.81 km.

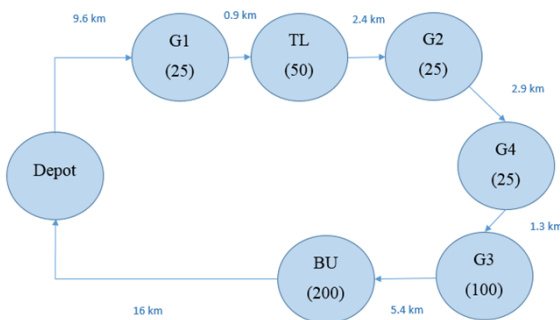


Fig. 1. Route 1 using the Tabu search algorithm.

Then the route of the visit on route 2 can be seen in Fig. 2 which shows the number of requests and the distance between customer points and the depot (warehouse). The distribution routing for the 2nd route can be explained (Fig. 2) as follow: Route 2 of the vehicle starts from the depot (warehouse) by transporting the product according to the customer's request with a total of 425 units, then the vehicle departs from the depot and visits the customer points on route 2. First, the

vehicle visits the customer with a BS code that has a request of 50 units and distance travel from BS to warehouse is 19 km. After visiting BS customers then the vehicle visits the next customer point, namely TR with a distance of 0.03 km and the number of product requests are 25 units. Then from TR customers to TC customers with a distance of 0.01 km and the number of product requests is 50 units. Then the vehicle visits TK customers from the TC customer point with a distance of 0.01 km and has a demand amount of 25 boxes. Vehicles from the TK customer point visit the next customer point, namely LM, with a total demand of 25 units and a distance of 4.06 km. Departing from the LM customer point, then the vehicle visits the LS with a total demand of 25 units and the distance is 0.02 km. Moving from LS then the vehicle goes to the G5 customer point with the number of requests for 50 units and takes a distance of 1.1 km. Then the vehicle goes to the BK customer point with a distance of 7.3 km and the number of requests is 150 units. Then the vehicle visits the last customer point, PS with a distance of 2.3 km from the BK customer point, where PS has a total product demand of 25 units. After the vehicle visits all customer points, then the vehicle returns to the depot (warehouse).

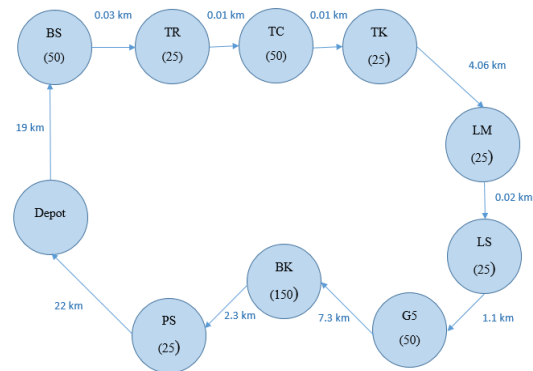


Fig. 2. Route 1 using the Tabu search algorithm.

B. Nearest Neighbour vs. Tabu Search

TABLE V: RESULTS COMPARISON OF THE NEAREST NEIGHBOUR AND THE TABU SEARCH ALGORITHM

	Routes	Rute	Demand (unit)	Distance traveled (km)	Total distance (km)
Nearest Neighbour	Route 1	D-G1-G2-G3-G4-G5-B-U-D	425	45,7	103.93
	Route 2	D-TL-BS-T-R-TC-TK-BK-PS-LS-LM-D	425	58.23	
New Route	Route 1	D-G1-TL-G2-BU-G4-G3-D	425	37.6	93.41
	Route 2	D-BS-TR-TC-TK-LM-LS-G5-BK-PS-D	425	55.81	
Total Distance			93.41		

On the company's initial route, there are 2 routes to distribute products to 15 customers in Malang City, Indonesia.

As for the new route using the Tabu Search Algorithm, there are 2 routes with a different total distance. The comparison of the initial route and the new route using the Tabu Search Algorithm can be seen in Table V. Analyzing new routes in graphical form that can be seen in Fig. 3. Fig. 3 shows that the total distance on the route 1 is 37.6 km and the total distance on the route 2 is 55.81 km.

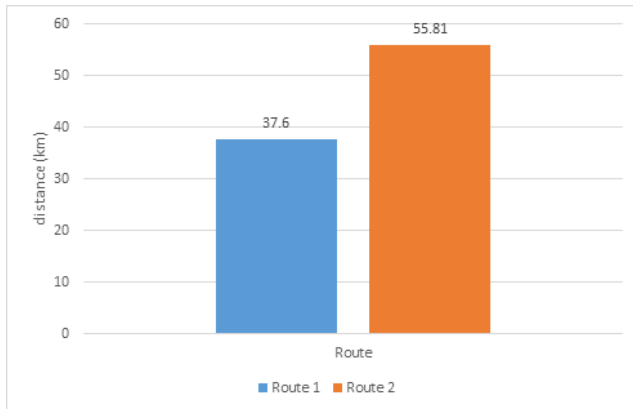


Fig. 3. Total travel distance of the routes.

In Table V it can be seen that the total distance on the nearest neighbour is 103.93 km and the total distance on the route using the Tabu Search Algorithm is 93.41 km. The Tabu search route has a total mileage smaller than the nearest neighbour route with a difference of 10.52 km.

The lower of travel distance using Tabu search could impact significantly on the distribution costs comparing to the initial approach using the approach of nearest neighbor. For example, from the results of calculations obtained indicate that the costs incurred by the company to fulfill the demand on the two routes using the Tabu Search approach are 2.7 per cent smaller than the routing approach used by the company by using nearest Neighbor. As it is known that to complete both distribution routes, the company takes two days, so that the distribution cost savings that can be done by the company if using the Tabu Search approach for one year business would be significant.

IV. CONCLUSION

Based on the research conducted, the determination of the route using the Tabu Search Algorithm results in a more minimum total distance, namely the route distance of 37.6 km and the distance of route 2 by 55.81 km. The total distance traveled on the nearest neighbour route is 103.93 km, while the total distance traveled on the route using the Tabu Search Algorithm is 93.41 km. The total mileage of the route using Tabu search is less than the route using nearest neighbour and has a distance difference of 10.52 km or saving the distance of 10.12%.

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