International Journal of Conceptions on Computing and Information Technology
Vol. 6, Issue. 1, August' 2018; ISSN: 2345 - 9808

Vehicle Routing Problems With Simultaneous Pick-up and Delivery by Using Nearest Neighbor Algorithm: A Case Study

Prima Denny Sentia and Andriansyah
Laboratory of Industrial Computation and Optimization
Industrial Engineering Department
Syiah Kuala University
Banda Aceh, Indonesia
{primadennysentia, andriansyah}@unsyiah.ac.id

Nissa Prasanti
Industrial Engineering Department
Teuku Umar University
Meulaboh, Indonesia
nissaprasanti@gmail.com

Arisman Vernando
Industrial Engineering Department
Syiah Kuala University
Banda Aceh, Indonesia
arisman8195@gmail.com

Abstract— **Determination of vehicle route is one important factor in distributing goods to consumers. The optimal vehicle route can minimize the distribution distance. The problem discussed in this research is a case study of vehicle routing problem with simultaneous pick-up and delivery (VRPSPD) for the distribution of drinking water Gallons. Each Gallons delivery vehicle can serve several routes during the planning horizon with the same capacity (homogeneous), the vehicle always begins and ends at the depot. The VRPSPD issue will be solved using MATLAB software with Nearest Neighbor (NN) algorithm implementation. Implementation of the NN algorithm in the developed program can provide a solution that is to shorten the distance from the initial conditions with a gap of 6.4%.**

Keywords- Distribution; Vehicle Routing Problem; Simultaneous Pickup and Delivery; Nearest Neighbor

I. INTRODUCTION

Higher levels competitiveness between companies require that companies not only focus on product quality, but can be seen from the way the company itself serves its customers. One way companies in improving services to customers is to distribute products according to customer demand and on time.

PAP is a company engaged in the distribution of gallons of drinking water for Banda Aceh and Aceh Besar areas. Distribution process is done so far is still intuitive that the delivery of goods to customers is determined by the driver by choosing a short distance to minimize the total travel time and minimize the total vehicle mileage. Distribution problems faced is a Vehicle Routing Problem (VRP). It is a problem in the transportation world to establish optimal routes to minimize transportation related costs [1].

Distribution activities Gallons of contents and carriage Empty gallons performed simultaneously for each delivery into the same vehicle and the same quantity. Each vehicle can exit and enter the depot more than once during the distribution planning period. This is due to the limited number of vehicles currently available to meet customer needs.

II. METHODOLOGY

Resolving the problem of determining vehicle route in this study required some data to get solution that can minimize total travel time and minimize total vehicle mileage. The required data are distance matrix, average speed of car, loading and unloading time, administration time, customer data, customer demand data, car capacity, and office hour time.

Demand data totaled 436 gallons from 14 customers scattered around Banda Aceh and Aceh Besar areas. Distance matrix is made to know the distance between depot to customer and distance between customers to customers. The distance between the depots to customers and the distance between customers to customers is obtained with the help of Google Maps.

In this research, the vehicles used are assumed to be homogeneous and have the same maximum capacity of 250 gallons. The speed of the vehicle in the distribution is assumed to be the same and there is no congestion in distributing Cleo Gallons product to the customer that is 45 km / h or 0.75 km / min.

Working hours are used for 480 minutes per day. The required administrative time is 1 minute for each customer. The loading time is moving the Gallon into the vehicle. Each process of moving the gallon into the vehicle in the depot is 20 minutes and each process of moving the empty Gallon from the customer into the vehicle takes 0.05 minutes / gallon. The unloading time is the time to unload the Gallon from the vehicle. Each process to unload the empty Gallon from the vehicle in the depot that is equal to 14 minutes and every

process to unload the gallon of the vehicle at the customer place is 0.2 minutes / gallon.

The design of NN Algorithm is made in programming language using matlab software 2015a by looking at data collected previously. The 2015a matlab software will be used on computers with windows 8.1 pro specifications with Intel Core (TM) processor i5 CPU 2.60 GHz, installed memory (RAM) 4.00 GB, and 64-bit system type operating system.

The design of the NN algorithm made can be said to be verified if the solution obtained does not exist that violate the prescribed constraints such as the maximum capacity of the vehicle and all customers have been visited. If the solution obtained violates the constraints that have been determined, then need to be repaired back to the design process with the application of NN algorithm that has been made. The verification process will continue until all conditions are met. Once verified, the distance and time generated will be calculated from the NN algorithm planning program that has been completed.

In this study, the assumptions used are:

a. Vehicles in conducting distribution activities begin and program on the depot

b. The demand data used is data that is deterministic

c. The vehicles used are homogeneous

d. Administration, unloading and loading time are assumed to be the same for depot and at customer's place.

Vehicles are not allowed to exceed the maximum capacity of a predefined vehicle

III. RESULT AND DISCUSSION

The system that will be discussed in this study is the system of simultaneous vehicle route picking and delivery problems simultaneously in the distribution of gallons to customers by using vehicles that are homogeneous within one working day. Vehicles used in distribution are permitted to carry out more than one travel route while still within business hours established by the company. The total number of customer requests is not allowed to exceed the maximum capacity of the vehicle in one delivery route to the customer. All customers must be served and can only be visited once a day. All the Gallons delivery process starts from the depot and ends at the depot.

A. Characteristics of the Distribution System

Characteristics of the distribution system in the PAP is a deterministic system, because demand can be known for certain during the process of distributing Gallon products to customers. The following is a figure of the problem of simultaneous route of pickup and delivery vehicle (VRPSPD) can be seen in Figure 1.

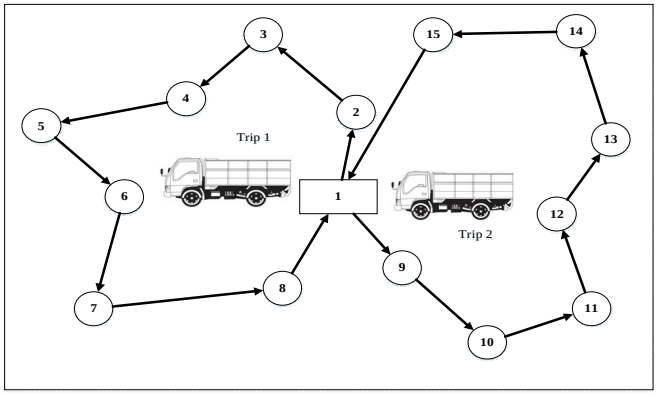

Figure 1. VRPSPD illustration

Explanation:

= Depot

= Costumer

From Figure 2 it can be seen that the vehicle can serve customers more than one route along the planning horizon and does not exceed the working hours called a compound trip. Vehicles also have the same carrying capacity.

B. Nearest Neighbor Algorithm Design

Here are the steps to solve vehicle routing problem with simultaneous pick-up and delivery using NN algorithm.

Step 1. Input time data that has been assumed that time LT1 (Loading Time in Depot), UT1 (Unloading Time in Depot), LT2 (Loading Time in Customer), and UT2 (Unloading Time in Customer). To input data required from customer request data (D), vehicle capacity (Q), distance data (d), vehicle speed (v), and working hours (PH).

Step 2. If the total customer request = 0, then there is no distribution process.

Step 3. If customer request = 0, then the customer is not served.

Step 4. Change the value of 0 on the distance matrix to a very large value

Step 5. Determine the day for distribution to customers

Step 6. Conduct a trip determination for distribution to customers

Step 7. Initialize route 1 is the starting location = depot. Calculating Gallon removal process to vehicle (loading time (LT1)) = 20 minutes for vehicle capacity (Q) = 250 gallons.

Step 8. Finding existing customers by selecting the shortest distance from the last visited location based on the distance matrix that has been made and calculating the travel time (WT) from the depot (Code 1) to selected

customers or between customers with the distance formula divided by the speed of the vehicle during the distribution process.

Step 9. Calculate the amount of remaining capacity available in the vehicle as well as calculate unloading time (UT2), loading time (LT2) according to customer demand (D) at customer site, and administration time (W) for each customer. If the remaining capacity is> 0 and customer demand is met then go to step 10. The process will continue until all customers are served and the last visited customer location becomes the starting location in determining the next subscriber to be visited. If the total time of completion is ≤ working hours, then return to the depot back to step 6

Step 10. If capacity = 0 and if customer request (D) is met back to depot, return to step 6 and if not go to step 11. If total amount of settling time ≤ working hours, then back to depot and return to step 6

Step 11. If the total turnaround time ≤ working hours for all customers has been served during the planning horizon, then the distribution process is complete.

Step 12. If all customers are not served all with the remaining capacity> 0 then return to step 6. If all customers have not been served all then with the remaining capacity ≤ 0 then go to step 13

Step 13. Return to depot, calculate vehicle time and unloading time at depot (UT1). If the completion time ≤ time of working hours has been established, then a new route is formed. If the completion time> hours worked then go to step 14.

Step 14. If the process of distributing to a programmed costumer is canceled, then return to the depot and calculate the unloading depot (UT1) time and the canceled costumer will be in for the next day.

Step 15. If the distribution process has been completed, then the program can be created to recap the results generated program.

C. NN Algorithm Design Results

Based on the result of NN algorithm design, it can be seen that the total customer demand on trip I is 246 gallons with total distance traveled by the vehicle in serving 6 customers is 22.75 km. On the distribution of trip II can serve eight customers with total demand of 190 gallons with the total mileage of the vehicle in serving customers of 82.70 km. The illustration of NN algorithm design results in completing VRPSPD is shown in Figure 2.

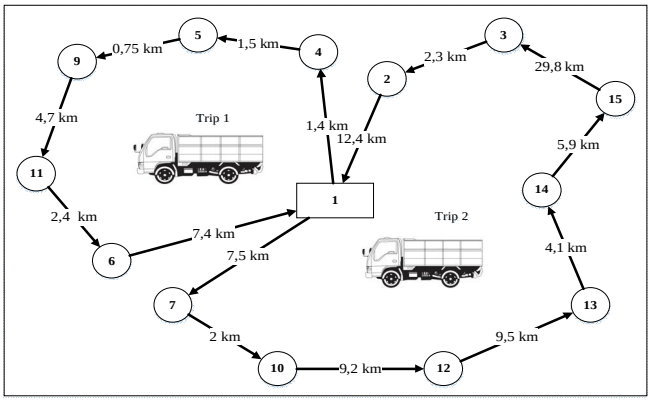

Figure 2. VRPSPD Illustration Design Results Using NN Algorithm

D. Verification of NN Algorithm Design Results

The design result of NN algorithm is verified by checking the conformity of the calculation result with predetermined limits such as not exceeding the maximum capacity of the vehicle and all the customers are visited.

1) Does not violate the vehicle's maximum capacity: Vehicles performing the distribution process should not transport the total number of products beyond the maximum capacity of the vehicle. Table I shows the verification of capacity results.

TABLE I. Verification of Capacity Results

Trip	Capacity	Distance total	Demand
I	250 Gallons	22.75 km	246 Gallons
II	250 Gallons	82.70 km	190 Gallons

Based on the results of Table I above, a trip vehicle I with a maximum capacity of 250 gallons' vehicle with a total distance traveled by the vehicle in serving customers of 22.75 km and customer demand of 246 gallons. This indicates that the distribution with trip I does not exceed the maximum vehicle capacity of 246 gallons (≤ 250 gallons) and it can be stated that trip I does not violate the maximum capacity of the vehicle set by the company.

On the distribution of the trip II the maximum capacity of 250 gallon vehicles with total vehicle mileage in serving customers of 82.70 km and customer demand of 190 gallons. This indicates that the distribution with trip II does not exceed the maximum capacity of 190 Gallon (≤ 250 Gallon) vehicles and it can be stated that the trip II does not violate the maximum capacity of vehicles set by the company.

2) All customers have been served: Table II shows the results of customer verification in the distribution process as follows:

TABLE II. Verify the Results of Costumers Served

Trip	Route	Distance total (Km)
I	1 => 4 => 5 => 9 => 8 => 11 => 6 => 1	22.75
II	1 => 7 => 10 => 12 => 13 => 14 => 15 => 3 => 2 => 1	82.70

Based on the results shown in Table II it can be seen that all customers have been served in two trips. Trip 1 serves 6 customers with vehicle mileage of 22.75 km, while for trip 2 serves 8 customers with vehicle mileage of 82.70 km. It can be stated that no customer is not served or the result of the calculation has been in accordance with the existing limits.

E. Comparison of Initial Condition With Design Results

The result of data processing using Matlab software with NN algorithm implementation can be done comparison of result of initial condition with program condition. Initial condition is the condition of distributing process that has been done by the company in serving the customer, while the condition of the program is a solution that is produced by using NN algorithm in solving vehicle routing problem with simultaneous pick-up and delivery.

TABLE III. Comparison of Calculation Results

Condition	Trip	Route	Distance (Km)	Distance total (Km)
Initial	I	1 => 2 => 3 => 4 => 5 => 6 => 7 => 8 => 1	45.12	112.72
	II	1 => 9 => 10 => 11 => 12 => 13 => 14 => 15 => 1	67.60	
Program	I	1 => 4 => 5 => 9 => 8 => 11 => 6 => 1	22.75	105.45
	II	1 => 7 => 10 => 12 => 13 => 14 => 15 => 3 => 2 => 1	82.70	
Amount of Decrease				7.27

Table III shows the comparison of total vehicle mileage calculation at the initial condition that serves trip I and trip II of 112.72 km, while for program condition the total vehicle mileage in serving trip I and trip II is 105.45 km. It can be seen that there is a decrease of distribution distance of 7.27 km (6.4%).

IV. CONCLUSION

The application of NN algorithm to the program can provide a solution in the form of reduction of distribution distances. The results obtained from the distribution program is divided into two tours namely trip 1 and trip 2. Trip 1 with 6 customers that can be served with the distance traveled by vehicle of 22.75 km. Trip 2 with 8 customers that can be served with a distance traveled by a vehicle of 82.70 km. So the total distance on the distribution of 105.45 km with the number of locations that can be served is 14 customers in one day with a total demand of 436 gallons. This shows that with the application of NN algorithm using matlab 2015a software to solve vehicle routing problem with simultaneous pick-up and delivery (VRPSPD) can shorten the distance of 7.27 km (6.4%) from the initial condition of the distributed by the company.

In this study still use assumptions and Algorithm NN is one part of the heuristic approach that will result in an optimal local solution. For further study may violate these assumptions and use metaheuristic approach to obtain a better solution to solve problems VRPSPD.

REFERENCES

[1] Toth, P., and Vigo, D. Vehicle Routing Problem, Methods, and Application, 2nd ed, Philadelphia: Society for Industrial and Applied Mathematics Philadelphia (SIAM), 2014.

[2] Koc, C., Bektas, T., Jabali, O. and Laporte, G., "Thirty years of heterogeneous vehicle routing", European Journal of Operational Research, vol. 249 (1), pp. 1-21, February 2016.

[3] Tasan, A.R., and Gen, M., "A genetic algorithm based approach to vehicle routing problem with simultaneous pick-up and deliveries", Computers & Industrial Engineering, vol. 62, pp. 755-761, November 2011.

[4] Ai, J., and Kachitvichyanukul, V., "A particle swarm optimization for the vehicle routing problem with simultaneous pickup and delivery", Computers & Operations Research, vol. 36 (5), pp. 1693-1702. May 2009.

[5] Dell'Amico, M., Righini, G., and Salani, M., "A branch-and-price approach to the vehicle routing problem with simultaneous distribution and collection", Transportation Science, vol. 40(2), pp. 235–247, May 2006.

[6] Shahdaei, A. M., and Rahimi, A. M., "Solving Vehicle Routing Problem with Simultaneous Pickup and Delivery with The Application of Genetic Algorithm", Indian Journal of Fundamental and Applied Life Sciences, vol. 6 (S1), pp. 247-259, 2016.

[7] Pop, P. C., Sitar, C. P., Zelina, I., Lupse, V., and Chira, C., "Heuristic Algorithms for Solving the Generalized Vehicle Routing Problem", Int. J. of Computers, Communications & Control, vol. VI (1), pp. 158-165, March 2011

[8] Bhatia, N., and Vandana, "Survey of Nearest Neighbour", International Journal of Computer Science and Information Security, vol. 8 (1), pp. 302-305, 2010.