Analysis of Determining the Optimal Route for 3 kg LPG Gas Distribution Using the Saving Matrix and Nearest Neighbor Methods
(Case Study at PT. Rariza Putra)

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Abstract

PT. Rariza Putra is a company engaged in the distribution of Liquefied Petroleum Gas (LPG) 3 kg. The distribution route starts from the Oil Fuel Filling Station (SPBE) to each customer venue. In the distribution method, the company determines the route only by decisions made by the driver, because the company does not have a fixed distribution route. It means that the resulting route is not an optimal route. With the existing problems, the company needs a problem-solving method that would provide a solution to calculate the shorter route to reduce transportation and fuel costs. This research was conducted on the Vehicle Routing Problem (VRP) with the Capacitated Vehicle Routing Problem (CVRP) approach, which determines the route by taking into account the capacity of the vehicle, and also Vehicle Routing Problem with Multiple Trips (VRPMT), which determines the route for each vehicle to make more than one delivery, and Vehicle Routing Problem with Split Delivery (VRPSD), where each base can be visited more than once. The method used in solving this problem is the Saving Matrix and also the Nearest Neighbor methods. These two methods will be compared to the initial route that exists in the company, and the method that gives the optimal results will be chosen. Based on the processing that has been carried out with the both methods, the Nearest Neighbor method is chosen which gives more optimal results in determining the route and also affects the fuel costs incurred. The route generated by the nearest neighbor method in one week is 283,37 km with a comparison of the initial route length of 391,17 km. While the total fuel cost savings that occur every week on the nearest neighbor method is Rp. 208.475 with a cost comparison on the initial route of Rp. 289.773 with a difference of Rp. 81.298. The new distribution route provides 28% savings compared to the initial route in the company.

Keywords
Route Optimization, VRP, Saving Matrix, Nearest Neighbor.

1. Introduction
PT. Rariza Putra is one of the 3 kg Liquefied Petroleum Gas (LPG) gas agent companies. The distribution of 3 kg LPG gas is carried out to the customers in the area of the Eastern part of Sleman Yogyakarta Indonesia. One of the problems faced by the company is the distribution routes is not optimal. Currently, the distribution route is determined only by the driver's decision without any logical and definite basis for consideration. Thus, the decision is not necessarily the best route and can cause the length of the route and will affect the amount of distribution fuel costs incurred. In this company initial routes, each week produces a total distance of 393.87 km and the total cost of distribution fuel is Rp. 289,773.

1.1 Purpose

The first objective of this research is to determine the optimal route of distribution of 3 kg LPG gas using the saving matrix and nearest neighbor methods to minimize distance and cost. And the second is to compare the results of the initial route distance with the proposed route.

2. Literature Review

The problems experienced by PT. Rariza Putra is a problem that is included in the Vehicle Routing Problem (VRP). VRP is a distribution system problem that aims to create the best route for a group of vehicles of known capacity to meet customer demand at a known location and quantity (Amri et al. 2014) (Toth and Vigo 2014) (Dahniar and Khairunnisa 2020). The optimal route is the route that meets various operational constraints as well as the shortest total distance and travel time when using a limited number of vehicles to meet customer demand (Nusmesse et al. 2016).

According to Suprayogi (2007), determining the optimal route is based on various considerations, including the Capacited Vehicle Routing Problem (CVRP), which means that delivery is not allowed to exceed the vehicle capacity, and Vehicle Routing Problem With Multiple Trips (VRPMT), which means that a vehicle is allowed to do more than one route delivery provided that the vehicle leaves and returns to the depot first, and the Vehicle Routing Problem With Split Delivery (VRPSD) which means that a store can be visited more than once due to the limited capacity of the vehicle to make deliveries (Fatnita and Lukmandono 2020) (Tooth and Vigo 2002). The decision in determining the route is very important and will affect various destination factors such as minimizing the shipping costs, minimizing time, and minimizing vehicle mileage (Supriyadi et al. 2017) (Kurniawan et al. 2014) (Tanggono and Pramudyo 2019).

The method used to solve the problem of the optimal route of the 3 kg LPG gas distribution process for all customers are the saving matrix and nearest neighbor. The saving matrix method is a method that can be used to determine the best route with various considerations such as the distance traveled, the number of vehicles used and the number of products that can be loaded by vehicles to be sent to consumers so that distribution can be optimal (Sarjono and Wijaya 2015) (Azizah and Oesman 2015). Meanwhile, the nearest neighbor method is a very simple method. At each calculation step, the nearest customer and the next customer from the last customer will be searched to find the route taken (Rini et al. 2015) (Pamungkas et al. 2013). If there is no suitable location for placing new customers due to limited capacity or time windows then the route will be started in the same way (Braysy and Gendreau 2005).

3. Methods

3.1 Saving Matrix Method

According to Pujawan (2005), the saving matrix method is a method that can be used to determine the best route with various considerations such as the distance traveled, the number of vehicles used and the number of products that can be loaded by vehicles to be sent to consumers so that distribution can be optimal. The following are the steps in the saving matrix method.

Step 1: Identify the distance matrix.
Step 2: Identify the savings matrix
Step 3: Allocate stores to vehicles or routes.

3.2 Nearest Neighbor Method

The nearest neighbor method is a method for solving route problems by finding the nearest point at the shortest distance. The nearest neighbor method is a problem-solving technique in VRP that is very effective, runs fast, and usually produces a fairly decent quality (Johnson et al., 1997). The nearest neighbor algorithm uses the following steps:

Step 1: Determine the starting point (depot) based on predetermined rules.
Step 2: Determine the next point closest to the starting point, then connect the points.
Step 3: Repeat the 2nd procedure until all points have been visited.
Step 4: Connect the first point to the last point to complete a series of grooves.

After calculating with the saving matrix and nearest neighbor methods, a comparison of the final results will be carried out so that the optimal method is known.

4. Data Collection

4.1 Warehouse and Base Address Data

The company currently has 25 customers who order LPG gas. The following is a list of base names or station name of the customers, the addresses and the demand or the number of requests for 3 kg LPG gas in March 2022 from PT. Rariza Putra, as shown in Table 1.

Table 1. The station names, code, address and demand of the customers

No	Station Name	Code	Address	Demand
0	SPBE PT. Narada Agung Nugraha	S	Ringin sari, bukoharjo, kec. Prambanan, kabupaten sleman	
1	Gmt Swalayan	P1	Jl. Raya tajem wedomartani ngemplak, sleman	1230
2	Heri P	P2	Dalangan, desa tirtomartani, kalasan, kabupaten sleman	920
3	Ihtiyar	P3	Kadirejo, desa tamanmartani, kalasan, kabupaten sleman	1420
4	Liana	P4	Bromonilan, desa purwomartani, kalasan, kabupaten sleman	1160
5	Muji Rahayu	P5	Keniten, desa tamanmartani, kalasan, kabupaten sleman	1650
6	Ning	P6	Pulerejo, desa bokoharjo, prambanan, kabupaten sleman	2400
7	Noer Hardyasti / Bagyo	P7	Bendungan, desa tamanmartani, kalasan, kabupaten sleman	1200
8	Pipit Shania Prahari	P8	Sambisari rt 004 / rw 002, desa purwomartani, kalasan, sleman	1320
9	Riski Marathus Sholika	P9	Keniten rt 03 / rw 01, desa tamanmartani, kalasan, sleman	1530
10	Rudi	P10	Jl.anggrek, desa bokoharjo, prambanan, kabupaten sleman	1650
11	Rustini	P11	Gunungharjo, desa bokoharjo, prambanan, kabupaten sleman	1890
12	Soegiharto	P12	Purwomartani bromonilan jl.yudistira no.13, purwomartani, kalasan	680
13	Sri Martiana	P13	Brintikan rt 004 / rw 016, desa tirtomartani, kalasan, sleman	860
14	Sudiharto	P14	Gangsiran, desa kalitirto, berbah, kabupaten sleman, di yogyakarta	880
15	Sukip Riyanti	P15	Pulerejo rt 003 / rw 002, desa bokoharjo, prambanan, sleman	1530
16	Sumarjono	P16	Degongan, desa tirtomartani, kalasan, kabupaten sleman, yogyakarta	1160
17	Suyati	P17	Kledokan, desa selomartani, kalasan, kabupaten sleman, yogyakarta	1380
18	Toko Elka	P18	Jl. Nakula no.4 perum purwomartani kalasan sleman	990
19	Toko Habil	P19	Tamanan pabrik, desa tamanmartani, kalasan, sleman	1420
20	Toko Ijo	P20	Tegalsari, desa tirtomartani, kalasan, kabupaten sleman, yogyakarta	1080
21	Toko Sidi	P21	Tegalrejo, desa tamanmartani, kalasan, kabupaten sleman, yogyakarta	1200
22	Tri Raharjo	P22	Bugisan kepatihan rt 004 / rw 002, desa tamanmartani, kalasan, sleman	1390
23	Tukirah	P23	Keniten, desa tamanmartani, kalasan, sleman, yogyakarta	1750
24	Tuti	P24	Klurak baru, desa bokoharjo, prambanan, sleman, dyogyakarta	1700
25	Yuyun Astrana	P25	Gumuk rt 04 / rw 027, desa bokoharjo, prambanan, kabupaten sleman	1530

4.2 Demand Data

The customer of the company has different request of LPG gas in each day. The following is a table of data allocation requests for each customer that has been scheduled in accordance with the agreement and distribution by PT. Rariza Putra in March 2022, as shown in Table 2.

Table 2. The scheduled of allocation requests of LPG for each customer in March 2022

No	Code	Station Name	Allocation	Date : March 2022																																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1	P1	GMT Swalayan	1230	0	70	0	0	0	0	220	0	70	0	0	0	0	220	0	70	0	0	0	0	220	0	70	0	0	0	0	220	0	70	0	1230
2	P2	Heri P	920	60	0	60	0	80	0	0	60	0	60	0	80	0	0	60	0	60	0	80	0	0	60	0	60	0	80	0	0	60	0	60	920
3	P3	Ihtiyar	1420	0	100	0	100	0	0	130	0	100	0	100	0	0	130	0	100	0	100	0	0	130	0	100	0	100	0	0	130	0	100	0	1420
4	P4	Liana	1160	0	80	0	80	0	0	110	0	80	0	80	0	0	110	0	80	0	80	0	0	110	0	80	0	80	0	0	110	0	80	0	1160
5	P5	Muji Rahayu	1650	60	50	60	50	90	0	60	60	50	60	50	90	0	60	60	50	60	50	90	0	60	60	50	60	50	90	0	60	60	50	60	1650
6	P6	Ning	2400	160	0	160	0	200	0	0	160	0	160	0	200	0	0	160	0	160	0	200	0	0	160	0	160	0	200	0	0	160	0	160	2400
7	P7	Noer Hadiyastri/Bagyo	1200	80	0	80	0	100	0	0	80	0	80	0	100	0	0	80	0	80	0	100	0	0	80	0	80	0	100	0	0	80	0	80	1200
8	P8	Pipit Shania	1320	0	80	0	80	0	0	150	0	80	0	80	0	0	150	0	80	0	80	0	0	150	0	80	0	80	0	0	150	0	80	0	1320
9	P9	Riski Marathus S	1530	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	1530
10	P10	Rudi	1650	60	50	60	50	90	0	60	60	50	60	50	90	0	60	60	50	60	50	90	0	60	60	50	60	50	90	0	60	60	50	60	1650
11	P11	Rustini/Supri	1890	60	50	60	50	120	0	90	60	50	60	50	120	0	90	60	50	60	50	120	0	90	60	50	60	50	120	0	90	60	50	60	1890
12	P12	Soegiharto	680	0	0	0	70	0	0	100	0	0	0	70	0	0	100	0	0	0	70	0	0	100	0	0	0	70	0	0	100	0	0	0	680
13	P13	Sri Martiana	860	0	60	0	60	0	0	80	0	60	0	60	0	0	80	0	60	0	60	0	0	80	0	60	0	60	0	0	80	0	60	0	860
14	P14	Sudiharto	880	60	0	60	0	70	0	0	60	0	60	0	70	0	0	60	0	60	0	70	0	0	60	0	60	0	70	0	0	60	0	60	880
15	P15	Sukip Riyanti	1530	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	1530
16	P16	Sumarjono/Anik	1160	0	80	0	80	0	0	110	0	80	0	80	0	0	110	0	80	0	80	0	0	110	0	80	0	80	0	0	110	0	80	0	1160
17	P17	Suyati	1380	90	0	90	0	120	0	0	90	0	90	0	120	0	0	90	0	90	0	120	0	0	90	0	90	0	120	0	0	90	0	90	1380
18	P18	Toko Elka	990	0	70	0	70	0	0	90	0	70	0	70	0	0	90	0	70	0	70	0	0	90	0	70	0	70	0	0	90	0	70	0	990
19	P19	Toko Habil	1420	0	100	0	100	0	0	130	0	100	0	100	0	0	130	0	100	0	100	0	0	130	0	100	0	100	0	0	130	0	100	0	1420
20	P20	Toko Ijo	1080	0	80	0	80	0	0	90	0	80	0	80	0	0	90	0	80	0	80	0	0	90	0	80	0	80	0	0	90	0	80	0	1080
21	P21	Toko Sidi	1200	80	0	80	0	100	0	0	80	0	80	0	100	0	0	80	0	80	0	100	0	0	80	0	80	0	100	0	0	80	0	80	1200
22	P22	Tri Raharjo	1390	50	50	50	50	60	0	50	50	50	50	50	60	0	50	50	50	50	50	60	0	50	50	50	50	50	60	0	50	50	50	50	1390
23	P23	Tukirah	1750	70	50	70	50	90	0	60	70	50	70	50	90	0	60	70	50	70	50	90	0	60	70	50	70	50	90	0	60	70	50	70	1750
24	P24	Tutik	1700	110	0	110	0	150	0	0	110	0	110	0	150	0	0	110	0	110	0	150	0	0	110	0	110	0	150	0	0	110	0	110	1700
25	P25	Yuyun Astrana	1530	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	50	70	0	50	60	50	60	1530
		Total	33920	1120	1120	1120	1120	1480	0	1680	1120	1120	1120	1120	1480	0	1680	1120	1120	1120	1120	1480	0	1680	1120	1120	1120	1120	1480	0	1680	1120	1120	1120	33920

4.3 Distance Matrix Data between customers and SPBE station

The measurement of distance between warehouse and each customer station is an important step in the route determination. The following is a collection of distance data between SPBE and bases, and distance from one particular base to another base obtained from the results of the google maps algorithm, as shown in Table 3.

Table 3. The distance matrix of SPBE station and customer stations

Station	S	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25
S	0																									
P1	10.4	0																								
P2	7.1	4.2	0																							
P3	6.7	6	5.1	0																						
P4	7.3	4.4	2.4	3.1	0																					
P5	3.6	7.9	3.6	4.7	4.1	0																				
P6	4.6	7.4	3.2	5.6	5.5	1	0																			
P7	2.6	8.7	4.7	4.5	5.3	2.9	3.9	0																		
P8	7.1	4.6	3.8	1.9	1.3	5.9	7	5	0																	
P9	4.5	8.3	4	5.2	4.7	0.8	0.9	4.1	5.9	0																
P10	6	6	4.2	1.2	2.7	4.7	5.7	3.9	1.5	6.2	0															
P11	0.55	11	6.7	7.1	7.6	3.1	3.5	3.1	7.8	2.6	6.7	0														
P12	7.3	4.5	2.3	3.2	0.67	4.1	5.5	5.2	1.4	6.3	2.2	7.8	0													
P13	1.7	8.9	4.6	5	5.4	2.9	3.8	0.95	5.6	4.3	4.5	2.5	5.4	0												
P14	4.9	10.5	7.3	4.8	7.4	5.8	6.7	3.2	7.3	7.2	6.2	5.4	7.4	4.3	0											
P15	5.5	8.9	4.4	7	6.8	2.5	1.6	5.9	7.7	2	6.6	4.9	6.8	6.3	8.1	0										
P16	3	8.2	4.6	4	4.8	3.1	4.1	0.45	4.7	4.6	3.6	3.5	4.8	1.4	3.1	5.6	0									
P17	7.7	5.2	2.4	7	4.8	4.1	3.6	6.2	6	4.4	6.6	7.2	4.8	5.8	8.4	3.7	5.7	0								
P18	7.4	4.4	2.4	3.1	0.1	4.1	5.6	5.3	1.3	6.3	2.7	7.9	0.15	5.7	7.5	6.8	4.9	4.9	0							
P19	6	8.1	3.6	8	6	3.3	2.8	6.9	7.4	3.1	7.6	5.4	6	7.3	9.1	1.1	6.4	2.9	6	0						
P20	5.8	4.9	0.8	4.2	1.7	2.6	4.5	3.8	3	3.5	3.8	6.3	1.7	4.2	6	5.7	3.3	3.7	1.8	4.9	0					
P21	7	5.9	2	6.6	4.3	3.4	3	5.8	5.8	3.7	6.2	6.5	4.3	5.4	8	3	5.3	0.65	4.4	2.2	3.2	0				
P22	5.2	7.2	3	6.2	5.3	1.5	0.5	5.1	6.8	1.1	5.8	4.6	5.3	5.5	7.3	1.5	4.7	3.4	5.4	2.6	4.3	2.7	0			
P23	4.8	7.4	3.2	3.9	4	1.4	2.4	2.8	4.6	2.9	3.5	4.2	4	3.2	5	3.9	2.3	4	4	4.7	2.5	3.6	2.9	0		
P24	2.6	9.9	5.6	6.4	5.9	2	2.4	5.1	7.1	1.1	6	2.1	5.9	4.6	7.4	2.9	4.9	5.9	6	3.3	4.5	5.2	2.5	2.5	0	
P25	5.9	8.8	4.4	7.2	6.7	2.7	1.4	6.1	8.2	2.2	6.8	5.3	6.7	6.5	8.3	0.4	5.6	3.7	6.8	1.5	5.6	3	1.3	1.3	3	0

5. Results and Discussion

5.1 Numerical Results

A. Saving Matrix Method

1. Identify the distance matrix

The distance matrix is the measurement of distance between warehouse and each customer station, as shown in Table 3

2. Identify the savings matrix

After obtaining the distance matrix, the next step is calculating the savings matrix. The savings matrix is calculated by combining two bases in one route based on the distance between warehouses with bases and the distance from one base to another. This calculation is done using Microsoft excel. The savings matrix can be seen in Table 4.

Table 4. The saving matrix (km)

Location	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24
P1																								
P2	13.3																							
P3	11.1	8.7																						
P4	13.3	12	10.9																					
P5	6.1	7.1	5.6	6.8																				
P6	7.6	8.5	5.7	6.4	7.2																			
P7	4.3	5	4.8	4.6	3.3	3.3																		
P8	12.9	10.4	11.9	13.1	4.8	4.7	4.7																	
P9	6.6	7.6	6	7.1	7.3	8.2	3	5.7																
P10	10.4	8.9	11.5	10.6	4.9	4.9	4.7	11.6	4.3															
P11	-0.05	0.95	0.15	0.25	1.05	1.65	0.05	-0.15	2.45	-0.15														
P12	13.2	12.1	10.8	13.93	6.8	6.4	4.7	13	5.5	11.1	0.05													
P13	3.2	4.2	3.4	3.6	2.4	2.5	3.35	3.2	1.9	3.2	-2.25	1.6												
P14	4.8	4.7	6.8	4.8	2.7	2.8	4.3	4.7	2.2	4.7	-0.75	4.8	2.3											
P15	7	8.2	5.2	6	6.6	8.5	2.2	4.9	8	4.9	-0.55	6	0.9	2.3										
P16	5.2	5.5	5.7	5.5	3.5	3.5	5.15	5.4	2.9	5.4	-0.05	5.5	3.3	4.8	2.9									
P17	12.9	12.4	7.4	10.2	7.2	8.7	4.1	8.8	7.8	7.1	1.65	10.2	3.6	4.2	9.5	5								
P18	13.4	12.1	11	14.6	6.9	6.4	4.7	13.2	5.6	10.7	5.25	14.55	3.4	4.8	6.1	5.5	10.2							
P19	8.3	9.5	4.7	7.3	6.3	7.8	1.7	5.7	7.4	4.4	-1.05	7.3	0.4	1.8	10.4	2.6	10.8	7.4						
P20	11.3	12.1	8.3	11.4	6.8	5.9	4.6	9.9	6.8	8	2.55	11.4	3.3	4.7	5.6	5.5	9.8	11.4	6.9					
P21	11.5	12.1	7.1	10	7.2	8.6	3.8	8.3	7.8	6.8	1.35	10	3.3	3.9	9.5	4.7	14.05	10	10.8	9.6				
P22	8.4	9.3	5.7	7.2	7.3	9.3	2.7	5.5	8.6	5.4	-0.05	7.2	1.4	2.8	9.2	3.5	9.5	7.2	8.6	6.7	9.5			
P23	7.8	8.7	7.6	8.1	7	7	4.6	7.3	6.4	7.3	1.85	8.1	3.3	4.7	6.4	5.5	8.5	8.2	6.1	8.1	8.2	7.1		
P24	3.1	4.1	2.9	4	4.2	4.8	0.1	2.6	6	2.6	-2.85	4	-0.3	0.1	5.2	0.7	4.4	4	5.3	3.9	4.4	5.3	4.9	
P25	7.5	8.6	5.4	6.5	6.8	9.1	2.4	4.8	8.2	5.1	-0.35	6.5	1.1	2.5	11	3.3	9.9	6.5	10.4	6.1	9.9	9.8	9.4	5.5

3. Allocate stores to vehicles or routes.

This determination is made by sorting routes based on distance savings that have the largest value to the smallest savings, namely two routes can be combined in one route which is carried out continuously until no longer suitable route combinations are found and meet the vehicle capacity and delivery separately for one time fulfillment of the request (split delivery). At this stage, an additional delivery for each route has been selected so that the number of delivery loads is equal to the truck capacity 560 pcs LPG. Selection of the next bases is determined by the combination of the distances from the last base on travel routes with other bases and the distance from the selected base to warehouse. Furthermore, the demand from the selected base will be reduced by the remaining load on the vehicle. The detail allocation of shipping can be seen in Table 5.

On Monday route 1 delivery, the maximum value from the saving matrix is 14.6 combining P18 with P4 with a demand for P18 of 90 LPG gas and P4 of 110 LPG gas < truck capacity of 560 LPG gas. The next saving is 14.55 combining P18 with P12 with a total of 90 P18 shipments and 100 P12. P18 is already included in the allocation of route 1, so P12 can be combined in the allocation of route 1. The next step is to keep looking for the next largest savings matrix until no more feasible savings matrix is found. Furthermore, after P12 the biggest savings were 13.4 combining from P18 with P1. Requests of 90 and 220. Subsequent savings are 13.2 combined from P18 and P8 with requests of 90 and 150. The last shipment on the first shipment was made on P8, but the amount sent did not meet the demand, namely the demand for 150 LPG gas and the remaining vehicle capacity 40 LPG gas.

In route 2, the largest savings distance is 11.9 combining P8 with P3 with a total of 110 P8 shipments which are the remainder from route 1 deliveries and a total of 130 P3 < vehicle capacity of 560 LPG gas. After P3 the next biggest savings were 11.6 merging of P8 and P10 with requests of 110 and 60. Then P10 entered the route sequence. Furthermore, the biggest savings are 11 combinations of P15 and P25. The requests are 50 and 50. Then P15 and P25 are included in the next route sequence, then the next biggest savings is 10.4 merging of P15 and P19 with requests 50 and 130, then P19 enters the next route. The next biggest savings is 9.9 combining P8 and P20 with requests of 110 and 90. In the second delivery, the remaining truck capacity is 30, so 30 P20 has only been delivered and will be split delivery on the next shipment.

In shipping 3 the biggest savings were 8.6 combined from P22 and P9 with requests of 50 and 50 < truck capacity of 560. With that P22 and P9 were included in the route sequence. The biggest savings were 8.1 combined from P23 and P20 with 60 and 60 requests (leftover from 2 deliveries). Then P23 and P20 are included in the order of the delivery route. Furthermore, a savings of 7.3 merging from P9 and P5 with requests of 50 and 60, then P5 is included in the route sequence, then a savings of 5.5 merging of P20 and P16, with requests of 60 and 110, then P16 is entered in the route sequence, then a savings of 3.3 combined from P16 and P13 with requests 110 and 80, then P13 enters the order of delivery. Finally, the savings of 2.55 combined from P20 and P11 with requests of 60 and 40, with that P11 entered the order of delivery as the last store visited.

Table 5. Allocation of shipping location to vehicle shipment and route

Delivery Fleet	Day	Saving Matrix Route	Total Distance (km)	Total Capacity	Allocation
Shipment 1	Monday	S-P18, P4, P12, P1, P8-S	24.37	560	560
	Tuesday	S- P17- P21- P2- P15- P25-P22-P23- P6-S	26.35	560	560
	Wednesday	S-P4- P18-P1-P8-P3--P10- P20- P15- S	34.5	560	560
	Thursday	S- P17- P21- P2- P15- P25-P22-P23- P6-S	26.35	560	560
	Friday	S- P4- P18- P12- P8- P3- P10-P20-P15-S	27.05	560	560
	Saturday	S-P17-P21-P2-P15-P25-P22-P23-S	24.15	560	560
Shipment 2	Monday	S-P8-P3-P10-P15-P25-P19-P20-S	30.4	560	560
	Tuesday	S- P9-P6- P5- P24- P10-P7-P14-P11-S	27.45	560	560
	Wednesday	S-P25-P15-P19-P22-P9-P5-P23-P16-P13-P11-S	20.05	560	560
	Thursday	S- P9-P6- P5- P24- P10-P7-P14-P11-S	27.45	560	560
	Friday	S-P25-P15-P19-P22-P23-P9-P5-P16-P13-P11-S	24.15	560	560
	Saturday	S-P9-P6-P5-P23-P10-P24-S	19.9	560	560
Shipment 3	Monday	S-P22-P9-P23-P20-P5-P16-P13-P11-S	21.85	560	560
	Tuesday				
	Wednesday				
	Thursday				
	Friday				
	Saturday	S- P14-P7-P24-P11-S	15.85	360	360
Total			349.92	7,640	7,640

It is known that the distance that must be covered by the first delivery fleet is 162.77, the second delivery is 149.4 km, and the third shipment is 37.7 km with a total allocation of 3 kg LPG gas that must be sent to customers, which is 7,640.

B. Nearest Neighbor Method

1. Start by determining the starting point (depot)

For example, on Monday's delivery route, the first route, the first step is starting from the warehouses of all distributed bases, starting from base 1 to base 25. The distance from warehouse to base varies, namely the closest distance is 0.55 km and the farthest distance is 10.4 km then the base closest to the warehouse is chosen, which is 0.55 in P11 with a demand of 90 LPG gas < truck capacity, which is 560 LPG gas so that the base is chosen as the first customer visited, as shown in Table 6.

Table 6. The station distance from warehouse and demand

Station	Distance from Warehouse	Demand
P1	10.4	220
P3	6.7	130
P4	7.3	110
P5	3.6	60
P8	7.1	150
P9	4.5	50
P10	6	60
P11	0.55	90
P12	7.3	100
P13	1.7	80
P15	5.5	50
P16	3	110
P18	7.4	90
P19	6	130
P20	5.8	90
P22	5.2	50
P23	4.8	60
P25	5.9	50

2. Determine the closest point from the starting point

The next step is to determine the point closest to the starting point, then connect the points. Next, look for the base closest to the selected initial base, namely from P11. The distribution distance of P11 to other bases resulted in the shortest distance being 2.5 km and the longest distance being 7.9 km. then the base is chosen with the closest distance of 2.5 km on P13 with a demand of 80 LPG gas < truck capacity of 560 LPG gas, as shown in Table 7.

Table 7. Distance from initial base (P11) and demand

Station	Distance from P11	Demand
P1	11	220
P3	7.1	130
P4	7.6	110
P5	3.1	60
P8	7.8	150
P9	2.6	50
P10	6.7	60
P12	7.8	100
P13	2.5	80
P15	4.9	50
P16	3.5	110
P18	7.9	90
P19	5.4	130
P20	6.3	90
P22	4.6	50
P23	4.2	60
P25	5.3	50

3. Repeat Procedure

The next step is to repeat the 2nd procedure until all points have been visited. The next step is to look for the closest route from the last route chosen by taking into account the vehicle capacity, as shown in Table 8.

Table 8. Determination of the closest point from the starting point

Station	Distance from P13	Demand	Station	Distance from P16	Demand	Station	Distance from P23	Demand	Station	Distance from P25	Demand	Station	Distance from P15	Demand
P1	8.9	220	P1	8.2	220	P1	7.4	220	P1	8.8	220	P1	8.9	220
P3	5	130	P3	4	130	P3	3.9	130	P3	7.2	130	P3	7	130
P4	5.4	110	P4	4.8	110	P4	4	110	P4	6.7	110	P4	6.8	110
P5	2.9	60	P5	3.1	60	P5	1.4	60	P5	2.7	60	P5	2.5	60
P8	5.6	150	P8	4.7	150	P8	4.6	150	P8	8.2	150	P8	7.7	150
P9	4.3	50	P9	4.6	50	P9	2.9	50	P9	2.2	50	P9	2	50
P10	4.5	60	P10	3.6	60	P10	3.5	60	P10	6.8	60	P10	6.6	60
P12	5.4	100	P12	4.8	100	P12	4	100	P12	6.7	100	P12	6.8	100
P15	6.3	50	P15	5.6	50	P15	3.9	50	P15	0.4	50	P18	6.8	90
P16	1.4	110	P18	4.9	90	P18	4	90	P18	6.8	90	P19	1.1	130
P18	5.7	90	P19	6.4	130	P19	4.7	130	P19	1.5	130	P20	5.7	90
P19	7.3	130	P20	3.3	90	P20	2.5	90	P20	5.6	90	P22	1.5	50
P20	4.2	90	P22	4.7	50	P22	2.9	50	P22	1.3	50			
P22	5.5	50	P23	2.3	60	P25	1.3	50						
P23	3.2	60	P25	5.6	50									
P25	6.5	50												

C. Cost Calculation and Comparison

The transportation costs or fuel cost on the type of truck used at PT. Rariza Putra that is Mitsubishi fuso HD 125 PS is Rp. 5,150 per 7 km. So the total transportation cost is the price of fuel per liter divided by by 7 km and then multiplied by the total distance per route. Total Transportation Cost = (Rp5,150/7) × Total Mileage. The result comparison of distance and cost can be seen in Table 9.

Table 9. Results comparison

Day	Initial Route		Saving Matrix Method		Nearest Neighbor Method	
	Distance (km)	Cost (Rp)	Distance (km)	Cost (Rp)	Distance (km)	Cost (Rp)
Monday	87.4	Rp.64.301	76.67	Rp.56.407	64.92	Rp.47.762
Tuesday	58.9	Rp.43.333	53.8	Rp.39.581	34.8	Rp.25.602
Wednesday	65.75	Rp.48.373	54.55	Rp.40.133	51.2	Rp.37.668
Thursday	58.9	Rp.43.333	53.8	Rp.39.581	34.8	Rp.25.602
Friday	58.82	Rp.43.274	51.2	Rp.37.668	43	Rp.31.635
Saturday	64.1	Rp.47.159	59.9	Rp.44.069	54.65	Rp.40.206
Sunday	391.17	Rp.289.773	349.92	Rp.257.439	283.37	Rp.208.475

5.2 Proposed Improvements

Based on the calculation and analysis that has been done with the saving matrix and nearest neighbor methods, the routes generated by the two methods have shorter distance than the company's initial route. Of the two methods, the nearest neighbor method provides more optimal result. The nearest neighbor method generates a shorter route that is more optimal, and also reduces the total transportation costs. The following is the proposed route generated from the nearest neighbor method, as shown in Table 10.

Table 10. Proposed route generated from the Nearest Neighbor method

Delivery Fleet	Day	Nearest neighbor Route	Total Distance (km)	Total Shipment (pcs)
Shipment 1	Monday	S- P1, P13, P16, P23, P25, P15, P19 - S	15.55	560
	Tuesday	S- P11, P24, P9, P5, P6, P22, P25-S	13.25	560
	Wednesday	S- P11, P13, P16, P5, P9, P22, P25, P15, P19, P 23-S	21.7	560
	Thursday	S- P11, P24, P9, P5, P6, P22, P25-S	13.25	560
	Friday	S- P11, P13, P16, P13, P5, P9, P22, P25, P15, P19, P23-S	22.95	560
	Saturday	S- P11, P24, P9, P5, P6-S	10.15	560
Shipment 2	Monday	S- P5, P9, P22, P19, P20, P4, P18, P12-S	24.47	560
	Tuesday	S- P7, P23, P2, P21, P17, P15, P10, P14-S	21.55	560
	Wednesday	S- P23, P20, P4, P18, P8, P10, P3, P1-S	29.5	560
	Thursday	S- P7, P23, P2, P21, P17, P15, P10, P14-S	21.55	560
	Friday	S- P23, P20, P4, P18, P12, P8, P10, P3-S	20.05	560
	Saturday	S- P7, P23, P25, P15, P22, P6, P21- S	19.1	560
Shipment 3	Monday	S- P10, P3, P1, P8-S	24.9	560
	Tuesday			
	Wednesday			
	Thursday			
	Friday			
	Saturday	S- P14, P10, P2, P17-S	25.4	360
Total			**283.37**	**7,640**

5.4 Validation

Based on the analysis that has been done with the saving matrix and nearest neighbor methods, the proposed routes generated by the two methods have shorter distance than the company's initial route. The comparison of distance of the initial route and the proposed route can be seen in Table 11 and Table 12. The savings percentage of saving matrix method is 11% and the nearest neighbor method is 28 %.

Table 11. Savings percentage of saving matrix method

Day	Total Distance (km)		Savings Percentage
	Initial Route	Saving Matrix Method	
Monday	87.4	76.67	12%
Tuesday	58.9	53.8	9%
Wednesday	65.75	54.55	17%
Thursday	58.9	53.8	9%
Friday	58.82	51.2	13%
Saturday	64.1	59.9	7%
Total	391.17	349.92	11%

Table 12. Savings percentage of nearest neighbor method

Day	Total Distance (km)		Savings Percentage
	Initial Route	Nearest Neighbor Method	
Monday	87.4	64.92	26%
Tuesday	58.9	34.8	41%
Wednesday	65.75	51.2	22%
Thursday	58.9	34.8	41%
Friday	58.82	43	27%
Saturday	64.1	54.65	15%
Total	391.17	283.37	28%

6. Conclusion

From the results of the discussion of determining the optimal route of distribution of 3 kg LPG gas at PT. Rariza Putra by comparing the initial route, the saving matrix method and the nearest neighbor obtained route and cost savings, namely the initial route obtained a total distance of 391.17 km and a total fuel cost of Rp.289,773, In the saving matrix method obtained a total distance of 349, 92 km and a total fuel cost of Rp257,439 and the nearest neighbor method obtained a total distance of 283.37 km and a total fuel cost of Rp208,475.

From these results, it is known that the saving matrix and nearest neighbor methods are able to provide savings in vehicle mileage and distribution fuel costs. However, from the two methods, the nearest neighbor method gives higher savings than the saving matrix method.

From the results obtained from the nearest neighbor method has savings percentage of 28% compared to the initial company route and it can be concluded that the nearest neighbor method generates more optimal route.

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