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Determination of Gallon Mineral Water Distribution Route at PT. XYZ Using Capacitated Vehicle Routing Problem (CVRP)

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A B S T R A C T

PT XYZ is experiencing problems, one of which is in the high cost of distribution because there is no special calculation in determining the route. The implementation of the distribution process carried out by PT XYZ is still ineffective and disorganized. The goal of this study is to determine the optimal distribution route design and provide improvements or input to PT XYZ in the process of distributing goods with minimum transportation costs. Solving the route problem at PT XYZ using the Capacitated Vehicle Routing Problem method with the python programming language through the VRPY package by considering factors such as distance and truck capacity. In the first conditions, there were 24 deliveries with a total cost of IDR 2,484,975 and 11 vehicles. After using the Capacitated Vehicle Routing Problem method, there are 23 deliveries with a total cost of IDR 2,380,000 and 8 vehicles, showing a decrease in distance of 115.7 km or 4%.

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1. INTRODUCTION

The bottled drinking water industry started in Indonesia in 1973, with the number of companies reaching 122 in 1991. The Indonesian Ministry of Industry formed the ASPADIN association, namely the Association of Indonesian Bottled Drinking Water Companies. Based on data from the Association of Indonesian Bottled Water Companies, ASPADIN has been active in maintaining business continuity and the interests of its members with various activities. By 2022, ASPADIN members will have reached 300 bottled water factories. Recent data states that the market share of clear gallon bottled water made from Polyethylene Terephthalate (PET) increased by 8%, reaching 50% market share in Indonesia. Various local brands such as Club, Bottled Drinking Water produced by PT. XYZ is one of the products that has been widely recognized by the Indonesian people. However, PT. XYZ is a pioneer company industry with a low consumer level. Based on the results of the Kurious survey from Katadata Insight Center (KIC) in 2023, involving 725 respondents in various regions of Indonesia, PT. XYZ's products ranked fourth among similar companies. The data noted that PT. XYZ brand was only consumed by 93.1% of respondents within the past year. PT XYZ is experiencing problems, one of which is because there is no special calculation in determining the route. In

this case, the route is determined by the driver's wishes without considering the total distance traveled. So that it will result in the high transportation costs required during the trip. The implementation of the distribution process carried out by PT XYZ is still ineffective and disorganized. In addition, from the existing data, it can be concluded that the company does not prioritize the capacity of the fleet and the retail distance to which the shipment is destined. PT XYZ is still experiencing swelling distribution costs because it still uses the direct distribution method without any special calculations in determining the route. Therefore, to solve the related minimization problem, the analytical tool used is to use the Capacitated Vehicle Routing Problem method to determine how many shipments and how the route of each vehicle should be done in order to minimize transportation costs.

According to (Setiani & Lukmandono, 2021) Distribution is a key driver of overall company profitability, because distribution contributes greatly to supply chain costs and direct customer value. A company that produces a product needs a good distribution system for its distribution (Saraswati, Sutopo, & Hisjam, 2017). Supply chain costs are the costs of sales, shipping, and so on that companies incur to market or deliver their products to consumers (Jerrico Nase, Natalin, Ardiansyah, & Artha, 2021). The main objective of planning the distribution of goods is how management can optimize the amount of resources owned to distribute goods to their destination. The resources in question can be in the form of time optimization, transportation cost optimization, mileage optimization and so on (Auliasari, Kertaningtyas, & Lestarining, 2018).

According to (Jerrico Nase, Natalin, Ardiansyah, & Artha, 2021) Vehicle Routing Problem (VRP) is a problem in the distribution system that aims to create an optimal route, with a group of vehicles whose capacity is known, in order to meet consumer demand with a known location and number of requests. One type of VRP is the Capacitated Vehicle Routing Problem (CVRP) which is an optimization method that can be used to determine the number of vehicles and determine the route passed for each vehicle in the distribution process. Capacitated Vehicle Routing Problem (CVRP) is a technique in solving vehicle capacity problems so that the delivery process carried out by the company does not force the capacity of the vehicles owned and the resulting customer distribution route will return to the source after delivery (Sabe & Herlina, 2023). This is an activity planning approach that aims to achieve optimal results, namely results that meet the objectives set in the best way among all existing alternatives (Hillier & Lieberman, 1995). This research refers to previous research, namely (Jerrico Nase, Natalin, Ardiansyah, & Artha, 2021) and (Sabe & Herlina, 2023), regarding the determination of distribution routes with the aim of minimizing transportation costs. The two studies have similarities by using the same method, namely the Capacitated Vehicle Routing Problem. The results of route determination from these studies both produce shorter routes in the problem of determining distribution routes to minimize transportation costs. In general, the problems faced by companies in distributing goods include different distribution quantities for each point, capacity limitations, delivery time limits for each point, city locations, fluctuating demand, distribution routes that must be traveled and so on (Yumalia, 2017). Good routing can shorten mileage and minimize transportation costs, so the end result will be cost savings for the company (Sutoni & Apipudin, 2019). Solving the route problem at PT XYZ using the Capacitated Vehicle Routing Problem method with the python programming language through the VRPY package by considering factors such as distance and truck capacity. By processing data using the python programming language, it will be obtained how many shipments are able to optimize the distribution process and determine the route to be passed, so that it will result in savings in transportation costs for PT XYZ.

2. LITERATURE REVIEW

The selection of delivery schedules and routes has a significant impact on the total distance to be covered, which in turn affects the overall delivery time and cost (Kasih & Maulidina, 2023). The main focus in determining schedules and routes is to optimize costs as efficiently as possible (Chandra & Setiawan, 2018). Fuel consumption efficiency must be achieved to

minimize distribution costs and reduce the negative impact on the environment (Arifian & Pulansari, 2023). In this case, the role of transportation in industry is very important because producers are interested in having their products transported on time, according to a predetermined location, and in optimal conditions to reach consumers (Aqidawati, Rahadian, Haqqoni, Yuniaristanto, & Sutopo, 2017).

Vehicle Routing Problem (VRP) can be explained as the challenge of finding the least-cost route from a starting point to scattered destinations with varying demand (Cahyaningsih, Sari, & Hernawati, 2015). A traditional VRP is to dispatch vehicles from the depot to serve all the customers and then return to the depot (Huang, Huang, Lee, & Tong, 2023). The result of solving VRP involves determining the optimal route, reducing transportation costs, and achieving the optimal solution for distribution and transportation systems (Kristina, Sianturi, & Husnadi, 2020).

Capacitated Vehicle Routing Problem (CVRP) is one of the basic concepts in the calculation of route determination problems similar to the Vehicle Routing Problem (Kristina, Sianturi, & Husnadi, 2020). This problem is related to the distribution of goods from a depot to a number of customers, using a fleet of homogeneous vehicles that have limited capacity. The objective is to assign a sequence of customers to each fleet vehicle (a route), with the aim of minimizing the total distance traveled, so that all customers are served and the total demand served by each vehicle does not exceed its capacity (Montagne, Sanchez, & Storbugt, 2020). This approach enables more efficient and effective distribution, and encourages companies to meet customer demand more quickly to improve their competitiveness (Kristina, Sianturi, & Husnadi, 2020).

3. RESEARCH METHOD

The type of research conducted is quantitative research. Quantitative research is a type of research that collects and analyzes numerical data or data that can be measured quantitatively. This approach focuses on collecting data in the form of numbers and statistics which are then analyzed objectively. Data acquisition is obtained from the object of observation. Then the data that has been collected will be processed and analyzed using the CVRP python programming language with VSCODE tools. The purpose of using these methods and tools is to simplify calculations in determining adequate solutions used for decision making by minimizing costs. So that it can provide recommendations for improvements to PT. XYZ in distributing products.

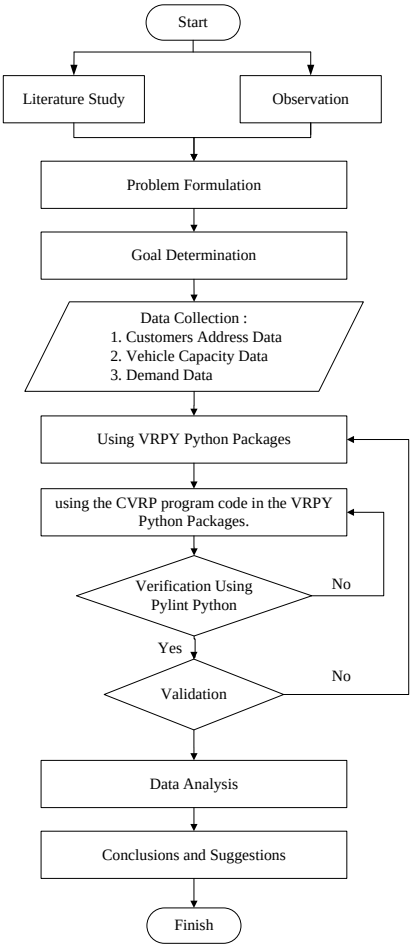

Figure 1. Research framework

The following is an explanation of each stage of the research process carried out by researchers.

Literature Study

The literature study method is also used to compile a literature review as a basis and source in conducting research. The literature review used in compiling this research is as follows: (a) Review of related research, which contains some previous research on the application of the CVRP method and route determination in the process of distributing goods. Capacitated Vehicle Routing Problem is one of the basic

concepts of calculating route determination problems that have similarities with the Vehicle Routing Problem (Kristina, Sianturi, & Husnadi, 2020). The goal is to determine the order of customers for each fleet vehicle (a route), by minimizing the total distance traveled, so that all customers are served and the total demand served by each vehicle does not exceed its capacity (Montagne, Sanchez, & Storbugt, 2020). (b) The concept of using Python VRPY packages in CVRP problems. According to (Montagne, Sanchez, & Storbugt, 2020) VRPY is a Python package that offers an easy-to-use and unified Application Programming Interface (API) for many variants of vehicle routing problems, including Capacitated VRP (CVRP), CVRP with resource constraints, CVRP with time windows, CVRP with simultaneous distribution and collection, CVRP with pickups and deliveries, and CVRP with heterogeneous fleets.

Observation

Observation is a process carried out to collect data and information directly from the location or situation under study. The aim is to gain a deeper understanding of the conditions, characteristics and context of the object under study.

Problem Formulation

After conducting literature studies and observation, the next stage is for researchers to identify existing problems. The problem in question is the lack of calculations related to fleet capacity and the desired route distance at PT XYZ. In addition, from the existing data, it can be concluded that the company does not prioritize fleet capacity, causing an imbalance with demand.

Goal Determination

Researchers determine the goal of this study is to determine the optimal distribution route design and provide improvements or input to PT XYZ in the process of distributing goods with minimum transportation costs.

Data Collection

The types of data in this study are primary data and secondary data. In collecting primary data, researchers used a survey method involving interviews with one of the employees PT XYZ in the Logistics department. Meanwhile, secondary data is used to utilize evidence, records, or historical reports that already exist and are relevant to the research being conducted*: (1) VRPY Python Packages*. In this research, the author chose to use the VRPY package. The use of this package provides an efficient implementation in solving vehicle routing problems or other tasks (VRPY, 2023). The VRPY package for this CVRP case uses a heuristic approach, namely the Clarke & Wright approach and the greedy approach, (2) CVRP Codings. In this research coding uses VRPY packages, with 3 modules, namely Networkx, Numpy, and VRPY modules. The coding is done in accordance with the reference material in the VRPY website documentation (VRPY, 2023). *(2) Verification*. In this code verification stage, the author used the Pylint tool. Pylint acts as a Python code quality evaluation tool that provides feedback on syntax errors, writing style, and performance issues (PYLINT, n.d.). Its function is to improve code quality and consistency. *(3) Validation*. At this stage the author validates the results that have been calculated. These results are in accordance with the reality of the problems that occur in the research conducted. *(4) Data Analysis.* At this stage of data analysis, a comparison will be made between the existing conditions and the improved conditions. So, the author can conclude improvement suggestions for PT. XYZ in the future. *(5) Conclusions and Suggestions.* The conclusion of the results that will be generated will show how to plan the optimal route by considering the destination distance and vehicle capacity at PT. XYZ to minimize transportation costs. The suggestions given will relate to providing input to PT XYZ regarding the implementation of the recommendations that have been proposed.

4. RESULT AND DISCUSSION

4.1 Data Collection

Data collection used document studies and interviews. The data collected will be used in the analysis and calculation process in the python programming language with the VSCODE application.

a. Customers Address Data

Costumers address data obtained from PT.XYZ Pandaan, with a total of 30 agents Surabaya sent directly from sources in Pandaan. The data is shown in Table 1.

Table 1. Agent Surabaya address data of PT.XYZ

Destination Codes	Address
J1	Jl Panjangjiwo Permai 2 No 16

Destination Codes	Address
J2	Jl.Raya Jambangan No 4 Jambangan
J3	Makarya Binangun, Singgahan
J4	Jl. Darmokali No.71, Kel. Darmo, Kec. Wonokromo,
J5	Jl. Villa Bukit Mas Monaco Tb-9/Rm-5
J6	Jln. Margorejo Tangsi 143 Wonocolo
J7	Jl. Raya Darmo
J8	Jl. Demak 113
J9	Jl. Demak -361 Bubutan
J10	Ploso Baru 30 B
J11	Galaxi Bumi Permai Blok H5 No
J12	Jl. Karang Gayam I-2
J13	Ruko Royal Town Rb 30 Gunung Anyar Tambak
J14	Jl. Mulyorejo Utara 111
J15	Raya Tenggilis C13-149
J16	Jl. Made Timur No. 10 Rt 01 Rw 04 Kec. Sambikerep
J17	Jl. Dukuh Kupang Barat 16/32-34
J18	Jl. Raya Pasar Banjar Sugihan 008/004, Tandes, Surabaya
J19	Jl. Kelasi 1
J20	Jl. Raya Lidah Kulon No 1281, Lidah Kulon, Kel. Lakarsantri,
J21	Jl. Raya Lontar Kulon No. 80 Surabaya
J22	Jl. Margomulyo Indah No 27a, Buntaran, Tandes, Surabaya
J23	Boomber 10 Lontar, Sambikerep
J24	Simpang Darmo Permai Selatan 1
J25	Jl. Lempung Perdana 72, Lontar,
J26	Jl Asem No 10 Asemrowo
J27	Jl. Kalimas Barat No 18 C Krembangan Utara, Pabean Cantikan,
J28	Jl. Kalimas Barat (Sebelah Depo Kelasi)
J29	Jln. Kedung Cowek 194
J30	Jl. Demak Surabaya

b. Distance Matrix Data

Distance matrix data is required to determine the distance from the source to each agent to the distance between each agent. The following matrix data is obtained through google maps using kilometers (KM). The results of the distance data collection can be seen in Table 2.

Table 2. Distance matrix data

Lokasi	Pandaan	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	J20	J21	J22	J23	J24	J25	J26	J27	J28	J29	J30
Pandaan	0	55,3	53,2	49,2	54	56	52	55	60,9	61	62,2	60,8	60,4	59,9	64,1	53,3	65,2	55,6	63,1	64,6	57,3	58,4	64,1	59,5	56,2	62,4	61	65,4	65,7	64,3	60,9
J1	55,3	0	9	10,6	5,9	10	4,5	5,8	12,1	13,6	9,9	5,3	8,5	11,6	8	2,5	19,7	10,9	16,9	14,3	15,3	15,3	16,2	11,4	12,7	16,1	12,6	15	14,5	13,2	14,3
J2	53,2	9	0	7,4	4,9	4,2	6,3	5,9	13,6	13,7	13,1	11,6	13,7	10,1	13,5	7,7	14,3	8	15,8	17,3	8,9	8,4	16,8	8,4	9,1	15,1	13,7	18	17,5	15,1	13,2
J3	49,2	10,6	7,4	0	9,1	13,8	7	10,2	14,8	16,3	17,4	14,4	15,5	4,6	16,5	8	22,6	13,8	19,5	17,6	16,6	17,8	18,8	14	15,5	18,7	15,2	18,3	17,8	19,4	16,9
J4	54	5,9	4,9	9,1	0	6,4	3	2,3	6,9	8,4	8,1	7,4	6,2	9,7	9,4	5	14,5	5,9	11,6	9,7	11,2	12,8	10,9	6,1	7,7	10,9	7,4	10,4	9,9	11,1	9
J5	56	10	4,2	13,8	6,4	0	8,8	6,4	7,2	9,8	13,2	12,2	11,3	15,5	13,5	10,8	10,9	2,3	9,8	11,2	9	6	9,1	3,1	4	8,1	9,6	15	14,4	17,8	10
J6	52	4,5	6,3	7	3	8,8	0	4,9	9,5	11	11,1	8,6	9,2	8,4	10,6	2,5	17,2	8,6	14,2	12,4	11,2	14	13,6	8,8	10,3	13,5	10	13,1	12,5	14	11,6
J7	55	5,8	5,9	10,2	2,3	6,4	4,9	0	6,1	7,6	7,8	7,1	5,9	10,8	9,1	6,7	13,9	5,3	10,8	8,9	12	10,7	10,1	5,3	7	10,1	6,5	9,6	9,1	10,7	8,2
J8	60,9	12,1	13,6	14,8	6,9	7,2	9,5	6,1	0	1,5	7,8	13,4	6,8	16,9	9,7	12,2	14	6,9	8,8	5,1	13,4	10,7	7,5	4,9	9	8	1,4	5,8	5,3	8,7	2,1
J9	61	13,6	13,7	16,3	8,4	9,8	11	7,6	1,5	0	8,4	14,6	7,5	18,1	10,3	13,3	14,7	7,6	9,5	3,8	14,1	11,4	8,8	6,7	9,7	8,7	2,7	4,5	4	9	2,5
J10	62,2	9,9	13,1	17,4	8,1	13,2	11,1	7,8	7,8	8,4	0	7,6	2,5	17,5	1,9	10	20,2	11,1	15,7	8,3	18,3	17	14	10,2	13,4	14,9	8,5	7,7	8	4,6	8,6
J11	60,8	5,3	11,6	14,4	7,4	12,2	8,6	7,1	13,4	14,6	7,6	0	7	15,5	4,7	6,7	21,8	12,4	16,9	13,5	19	18,6	16,2	11,3	14,9	15,8	13	13	13,3	9,9	14,5
J12	60,4	8,5	13,7	15,5	6,2	11,3	9,2	5,9	6,8	7,5	2,5	7	0	16,6	3,7	9,1	19,2	10,2	14,3	6,7	17,4	16,2	12,4	9,3	12,5	13,5	6,8	6,4	6,7	4,1	7
J13	59,9	11,6	10,1	4,6	9,7	15,5	8,4	10,8	16,9	18,1	17,5	15,5	16,6	0	15,4	7,3	21,5	12,7	18,4	16,5	13,2	25,4	17,7	12..9	14,4	17,6	14	17,2	16,6	18,3	15,8
J14	64,1	8	13,5	16,5	9,4	13,5	10,6	9,1	9,7	10,3	1,9	4,7	3,7	15,4	0	9,6	21,1	12	16,6	9,1	19,2	17,9	15,9	11,1	14,2	15,8	9,3	8,9	9,2	5,7	9,5
J15	53,3	2,5	7,7	8	5	10,8	2,5	6,7	12,2	13,3	10	6,7	9,1	7,3	9,6	0	21	12,4	18	16,1	15	17,8	17,3	12,5	14,1	17,3	13,7	16,8	16,3	15,7	15,4
J16	65,2	19,7	14,3	22,6	14,5	10,9	17,2	13,9	14	14,7	20,2	21,8	19,2	21,5	21,1	21	0	10,3	4,6	18,3	5,4	2,8	7,6	11	7,1	6,2	12,1	19	18,5	23	15,3
J17	55,6	10,9	8	13,8	5,9	2,3	8,6	5,3	6,9	7,6	11,1	12,4	10,2	12,7	12	12,4	10,3	0	7,9	9	9,5	8,2	7,2	0,85	4,6	6,2	5,1	9,7	9,1	11,9	6,8
J18	63,1	16,9	15,8	19,5	11,6	9,8	14,2	10,8	8,8	9,5	15,7	16,9	14,3	18,4	16,6	18	4,6	7,9	0	13,6	8,5	3,8	2,9	7,8	7,8	2,6	7,5	14,3	13,8	18,3	9
J19	64,6	14,3	17,3	17,6	9,7	11,2	12,4	8,9	5,1	3,8	8,3	13,5	6,7	16,5	9,1	16,1	18,3	9	13,6	0	18,9	14,9	11	8,9	14	12,2	5,5	0,75	0,24	6,2	4,7
J20	57,3	15,3	8,9	16,6	11,2	9	11,2	12	13,4	14,1	18,3	19	17,4	13,2	19,2	15	5,4	9,5	8,5	18,9	0	4,7	10,1	9,7	5,8	7,7	11,9	18,6	19,6	21,2	14,5
J21	58,4	15,3	8,4	17,8	12,8	6	14	10,7	10,7	11,4	17	18,6	16,2	25,4	17,9	17,8	2,8	8,2	3,8	14,9	4,7	0	5,4	7,4	3,9	3	9,1	17,6	17,3	21,2	10,6
J22	64,1	16,2	16,8	18,8	10,9	9,1	13,6	10,1	7,5	8,8	14	16,2	12,4	17,7	15,9	17,3	7,6	7,2	2,9	11	10,1	5,4	0	6,7	6,8	1,9	6,4	12,8	12,2	15,6	8
J23	59,5	11,4	8,4	14	6,1	3,1	8,8	5,3	4,9	6,7	10,2	11,3	9,3	12..9	11,1	12,5	11	0,85	7,8	8,9	9,7	7,4	6,7	0	4,8	5,9	4,1	10,2	9,7	14,3	6,2
J24	56,2	12,7	9,1	15,5	7,7	4	10,3	7	9	9,7	13,4	14,9	12,5	14,4	14,2	14,1	7,1	4,6	7,8	14	5,8	3,9	6,8	4,8	0	4,1	6,8	14,3	14,6	17,1	8,1
J25	62,4	16,1	15,1	18,7	10,9	8,1	13,5	10,1	8	8,7	14,9	15,8	13,5	17,6	15,8	17,3	6,2	6,2	2,6	12,2	7,7	3	1,9	5,9	4,1	0	6,4	12,7	12,1	15,6	7,9
J26	61	12,6	13,7	15,2	7,4	9,6	10	6,5	1,4	2,7	8,5	13	6,8	14	9,3	13,7	12,1	5,1	7,5	5,5	11,9	9,1	6,4	4,1	6,8	6,4	0	6,9	6,4	9,6	2,4
J27	65,4	15	18	18,3	10,4	15	13,1	9,6	5,8	4,5	7,7	13	6,4	17,2	8,9	16,8	19	9,7	14,3	0,75	18,6	17,6	12,8	10,2	14,3	12,7	6,9	0	0,5	7,2	5,1
J28	65,7	14,5	17,5	17,8	9,9	14,4	12,5	9,1	5,3	4	8	13,3	6,7	16,6	9,2	16,3	18,5	9,1	13,8	0,24	19,6	17,3	12,2	9,7	14,6	12,1	6,4	0,5	0	6,6	4,8
J29	64,3	13,2	15,1	19,4	11,1	17,8	14	10,7	8,7	9	4,6	9,9	4,1	18,3	5,7	15,7	23	11,9	18,3	6,2	21,2	21,2	15,6	14,3	17,1	15,6	9,6	7,2	6,6	0	9,2
J30	60,9	14,3	13,2	16,9	9	10	11,6	8,2	2,1	2,5	8,6	14,5	7	15,8	9,5	15,4	15,3	6,8	9	4,7	14,5	10,6	8	6,2	8,1	7,9	2,4	5,1	4,8	9,2	0

c. Vehicle Capacity Data

This vehicle data is secondary data obtained from PT XYZ. The following data is needed to determine the type and capacity of the vehicle used. The data is presented in Table 3.

Table 3. Vehicle type and capacity data

Vehicle Codes	Vehicle Type	Load Type	Capacity (Galon)
K1	Fuso Tronton	Galon	1350
K2	Fuso Tronton	Galon	1350
K3	Fuso Tronton	Galon	1350
K4	Fuso Tronton	Galon	1350
K5	Fuso Tronton	Galon	1350
K6	Fuso Tronton	Galon	1350
K7	Fuso Tronton	Galon	1350
K8	Fuso Tronton	Galon	1350
K9	Fuso Tronton	Galon	1350
K10	Fuso Tronton	Galon	1350
K11	Fuso Tronton	Galon	1350

d. Demand Data

Demand data refers to information about the

needs or demands that must be met at each customer location or delivery point. Demand data at PT.XYZ during January 2023 is presented in Table 4.

Table 4 Demand data PT. XYZ

Destination Codes	Demand (Galon)
J1	350
J2	700
J3	1000
J4	800
J5	360
J6	700
J7	1100
J8	700
J9	1050
J10	1240
J11	404
J12	700
J13	1000
J14	800
J15	1050
J16	350
J17	350
J18	800
J19	800
J20	1000
J21	700
J22	750
J23	1000
J24	1100
J25	700
J26	360
J27	460
J28	1200
J29	1000
J30	800

e. Transportation Cost Data

The cost data obtained is an assumed cost based on the cost of fuel needed during the distribution process. The fuel used for trucks at PT.XYZ company is subsidized diesel fuel. According to (Fitra, 2023), the price of subsidized diesel fuel as of January 2023 is known to be IDR 6800/liter. According to (Setiawan, 2021), it is stated that the fuel consumption required for trucks is generally an average of 8km/liter. If calculated, the fuel cost required is IDR.850/km. So it can be concluded that the distribution costs needed will be multiplied by the value of the distance traveled at each destination.

f. Existing Condition of Distribution

The following data collection is obtained through data recap at the company for 1 full month, namely January 2023. The grouping of each delivery and demand in the distribution process at PT.XYZ is presented in Table 5.

Table 5. Existing Condition of PT. XYZ

Dest. Codes	Route	Demand	Vehicle Capacity	Vehicle Codes
J1	1	350	1350	K1
J2		700		
J28	2	1200	1350	
J29	3	1000	1350	K2
J19	4	800	1350	
J16		350		
J24	5	1100	1350	K3
J23	6	1000		
J20	7	1000	1350	K4
J6	8	700	1350	
J17		350		
J11	9	404	1350	K5
J27		460		
J14	10	800	1350	
J8	11	700	1350	
J4	13	800	1350	K6
J5		360		
J3	13	1000	1350	
J30	14	800	1350	K7
J26		360		
J12	15	700	1350	
J10	16	1240	1350	K8
J22	17	750		
J9	18	1050	1350	K9
J25	19	700		
J7	20	1100	1350	K10
J21	21	700		
J15	22	1050	1350	K11
J13	23	1000	1350	
J18	24	800	1350	

Based on the data above, it can be seen that PT XYZ has a total of 24 shipments made on 11 vehicles used.

4.2 Data Processing Results

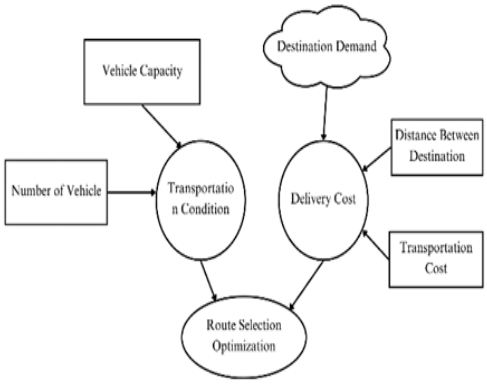

Figure 2. Influence diagram
(source : processed Data)

The problem that occurs at PT XYZ is that there is no calculation of route determination in accordance with the limits of vehicle capacity owned, so that the current distribution process at PT XYZ has more transportation costs. The amount of shipping costs is influenced by

destination demand, distance between destinations, and transportation costs. This shipping cost will affect route selection optimization. Transportation routes are influenced by the condition of the delivery car which was previously influenced by the capacity of the vehicle and the number of vehicles. Transportation costs in this study are assumed to be the cost of fuel required during the process of distributing goods. Therefore, the Transportation route is a controllable input from the influence diagram. This variable reflects decisions or actions that can be taken by decision makers to influence the system or process being analyzed.

The mathematical formulation of the Capacitated Vehicle Routing Problem (CVRP) is a mathematical representation that defines a complex optimization problem in routing vehicles with limited capacity. The basic mathematical formulation of CVRP can be explained as follows:

Parameters

- N : Total number of customers (including the depot as the 0th customer).
- Q : Maximum capacity of each vehicle.
- d_{ij} : Distance between customer i and customer j.
- q_i : Customer demand i.
- K : Number of vehicles available.

Decision Variable

- X_{ij}^k : A binary decision variable indicating whether the route of vehicle k involves a direct trip from customer i to customer j. (X_{ij}^k = 1 if yes, X_{ij}^k = 0 if not).

Objective Function

- Minimize

$$Z = \sum_{k=1}^{K} \sum_{i=0}^{N} \sum_{j=0, j \neq i}^{N} d_{ij} \cdot X_{ij}^k \quad (1)$$

Constraints

- Each customer must be served exactly 1 time :

$$\sum_{k=1}^{K} X_{ij}^k = 1, \quad \forall i = 1, 2, \ldots, N \quad (2)$$

- Each vehicle may only leave and return to the depot once. :

$$\sum_{i=1}^{N} X_{i0}^k = 1, \quad \forall k = 1, 2, \ldots, K \quad (3)$$

- Each customer can only be served by one vehicle :

$$\sum_{k=1}^{K} X_{ij}^k = 1, \quad \forall j = 1, 2, \ldots, N \quad (4)$$

- Vehicle capacity of the vehicle must not exceed the limit :

$$\sum_{i=1}^{N} q_i \cdot X_{ij}^k = 1, \quad \forall k = 1, 2, \ldots, K \quad (5)$$

The results of data processing state that PT.XYZ can still cut the number of routes to 23. The results obtained are proven to affect the cost to be more minimum compared to the previous condition. The following is a recap of programming coding that has been carried out using the Capacitated Vehicle Routing Program method with the python language using the "VRPY" package can be seen in Table 6.

Table 6. Data processing results

Route	Dest. Codes	Total Load	(KM) Total	Fuel Costs
1	0-14-16-0	1150	150.4	IDR 127,840
2	0-25-0	700	124.8	IDR 106,080
3	0-9-0	1050	122	IDR 103,700
4	0-7-0	1100	110	IDR 93,500
5	0-24-0	1100	112.4	IDR 95,540
6	0-18-0	800	126.2	IDR 107,270
7	0-17-21-0	1050	122.2	IDR 103,870
8	0-20-0	1000	114.6	IDR 97,410
9	0-28-0	1200	131.4	IDR 111,690
10	0-13-0	1000	119.8	IDR 101,830
11	0-23-0	1000	119	IDR 101,150
12	0-1-4-0	1150	115.2	IDR 97,920
13	0-22-0	750	128.2	IDR 108,970
14	0-6-0	700	104	IDR 88,400
15	0-3-0	1000	98.4	IDR 83,640
16	0-10-0	1240	124.4	IDR 105,740
17	0-29-0	1000	128.6	IDR 109,310
18	0-30-0	800	121.8	IDR 103,530
19	0-15-0	1050	106.6	IDR 90,610
20	0-11-12-0	1104	128.2	IDR 108,970
21	0-19-26-0	1160	131.1	IDR 111,435
22	0-5-8-0	1060	124.1	IDR 105,485
23	0-2-27-0	1160	136.6	IDR 116,110
Total			**2800**	**IDR 2,380,000**

Based on the data above, it can be seen that the number of shipments obtained is less, namely 23 shipments.

4.3 Data Analysis

Utilizing the latest technology and sophisticated data analysis can allow companies to ensure that every trip is taken with careful consideration to achieve the optimal balance between operational efficiency and cost savings. By determining the optimal number of deliveries, companies can avoid the risk of cost overruns in the distribution process. A comparison of the results of data processing in existing conditions and improved conditions is described in Table 7.

Table 7. Comparison of existing and improved distribution conditions

Existing Condition					Improvement Condition				
Vehicle	Route	Load Total	(KM) Total	Transp. Cost	Vehicle	Route	Load Total	(KM) Total	Transp. Cost
1	0-1-2-0	1050	117.5	IDR 99,875	1	0-14-16-0	1150	150.4	IDR 127,840
	0-28-0	1200	131.4	IDR 111,690		0-25-0	700	124.8	IDR 106,080
2	0-29-0	1000	128.6	IDR 109,310		0-9-0	1050	122	IDR 103,700
	0-19-16-0	1150	148.1	IDR 125,885	2	0-7-0	1100	110	IDR 93,500
3	0-24-0	1100	112.4	IDR 95,540		0-24-0	1100	112.4	IDR 95,540
	0-23-0	1000	119	IDR 101,150		0-18-0	800	126.2	IDR 107,270
4	0-20-0	1000	114.6	IDR 97,410	3	0-17-21-0	1050	122.2	IDR 103,870
	0-6-17-0	1050	116.2	IDR 98,770		0-20-0	1000	114.6	IDR 97,410
5	0-11-27-0	864	139.2	IDR 118,320		0-28-0	1200	131.4	IDR 111,690
	0-14-0	800	128.2	IDR 108,970	4	0-13-0	1000	119.8	IDR 101,830
	0-8-0	700	121.8	IDR 103,530		0-23-0	1000	119	IDR 101,150
6	0-4-5-0	1160	116.4	IDR 98,940		0-1-4-0	1150	115.2	IDR 97,920
	0-3-0	1000	98.4	IDR 83,640	5	0-22-0	750	128.2	IDR 108,970
7	0-30-26-0	1160	124.3	IDR 105,655		0-6-0	700	104	IDR 88,400
	0-12-0	700	120.8	IDR 102,680		0-3-0	1000	98.4	IDR 83,640
8	0-10-0	1240	124.4	IDR 105,740	6	0-10-0	1240	124.4	IDR 105,740
	0-22-0	750	128.2	IDR 108,970		0-29-0	1000	128.6	IDR 109,310
9	0-9-0	1050	122	IDR 103,700		0-30-0	800	121.8	IDR 103,530
	0-25-0	700	124.8	IDR 106,080	7	0-15-0	1050	106.6	IDR 90,610
10	0-7-0	1100	110	IDR 93,500		0-11-12-0	1104	128.2	IDR 108,970
	0-21-0	700	116.8	IDR 99,280		0-19-26-0	1160	131.1	IDR 111,435
11	0-15-0	1050	106.6	IDR 90,610	8	0-5-8-0	1060	124.1	IDR 105,485
	0-13-0	1000	119.8	IDR 101,830		0-2-27-0	1160	136.6	IDR 116,110
	0-18-0	800	126.2	IDR 107,270					
	Total		**2915.7**	**IDR 2,478,345**		**Total**		**2800**	**IDR 2,380,000**

Determining the shortest route is a major factor in minimizing the transportation costs of a company. For example, in the previous Table 6, the existing condition of route 0-1-2-0 with a total mileage of 117.5, becomes route 0-1-4-0 which has a total mileage of 115.2. On the existing condition, the total distance traveled in meeting the demand of the destination in 1 month is 2915.7 km with 11 vehicles, where each vehicle can have 2 to 3 routes. For the proposed improvement conditions, the total distance traveled to meet the destination demand for 1 month is 2800 km. With the previous assumption that 1 vehicle can have 2 to 3 routes, the fulfillment of demand for 1 month can be met with only 8 vehicles, 7 vehicles have 3 routes and 1 vehicle has 2 routes. This shows a decrease in the distance traveled for 1 month of 115.7 km or 4% under the proposed conditions. In this case, optimizing freight transport against vehicle capacity is the second priority. For example, on the initial route 0-19-16-0 with a load of 1150 on a vehicle with a capacity of 1350, it can be noted that there is still potential to improve transportation efficiency. By adjusting the route to 0-19-26-0 and increasing the load to 1160 on a vehicle with a capacity of 1350, the company can optimize the use of vehicle capacity more effectively. Such optimization also reflects the company's efforts to maximize operational efficiency to reduce costs.

From the existing data obtained in Table 7, it can be seen that the total distribution cost assumed by using the fuel costs collected according to the data recap in the gallon distribution activities distributed to each main destination for 1 month in January 2023 is IDR 2,484,975. After improving the solution, a more minimum distribution cost is obtained, which is IDR. 2.380.000. In the results of data processing, it is found that the price of fuel does not have a significant effect, but if there is an assumption of other variable costs added in one shipment there are several costs such as driver salaries, loading and unloading salaries, toll fees, and so on, then cutting the number of shipments to 23 can be an adequate solution for PT.XYZ for now. If it is assumed that there is a driver fee with a calculation in 1 delivery, and a loading and unloading courier fee per 1 gallon,

then the results of obtaining transportation costs will have a more significant cost difference calculation.

5. CONCLUSION

The existing conditions of distribution at PT XYZ can still minimize the transportation costs required by cutting the number of distribution shipments so as to obtain a minimum operational cost. The results of this acquisition are known, namely in the existing condition the total number of shipments of 24 fuel distributions amounted to IDR. 2,484,975 with 11 vehicles. After calculating using the Capacitated Vehicle Routing Problem method with python programming syntax through VRPY packages, a total of 23 shipments were obtained with a total fuel distribution cost of IDR. 2,380,000 with 8 vehicles. This shows a decrease in the distance traveled for 1 month of 115.7 km or 4% under the proposed conditions. PT.XYZ needs to cut the number of delivery routes that previously reached 24 shipments to 23 delivery routes. In addition, with the number of delivery routes, assuming that 1 vehicle can have 2 to 3 routes, the company should only have 8 vehicles. This is done to optimize the process of distributing goods, so that if there is an assumed cost of vehicle maintenance, it can reduce the assumed cost of vehicle maintenance.

REFERENCES

Aqidawati, E. F., Rahadian, N., Haqqoni, Z., Yuniaristanto, & Sutopo, W. (2017). Optimasi Distribusi Semen PT. XYZ Dengan Modifikasi Model Transportasi. *Jurnal Rekayasa istem & Industri, 4*(2), 187 - 191. https://doi.org/10.25124/jrsi.v4i02.288

Arifian, R., & Pulansari, F. (2023). Determination of the Shortest Distribution Routes to Minimize Fuel Consumption and CO2 Emission Using Sweep and Clarke & Wright Saving Algorithms. *Indonesian Journal of Industrial Engineering & Management (IJIEM), 4*(2), 146-156. http://dx.doi.org/10.22441/ijiem.v4i2.20493

Auliasari, K., Kertaningtyas, M., & Lestarining, D. W. (2018). Optimalisasi Rute Distribusi Produk Menggunakan Metode Traveling Salesman Problem. *Jurnal Sains, Teknologi dan Industri, 16*(1), 15 - 23. http://dx.doi.org/10.24014/sitekin.v16i1.6109

Cahyaningsih, W. K., Sari, E. R., & Hernawati, K. (2015). Penyelesaian Capacitated Vehicle Routing Problem (CVRP) Menggunakan Algoritma Sweep untuk Optimasi Rute Distribusi Surat Kabar Kedaulatan Rakyat. *Prosiding Seminar Nasional Matematika dan Pendidikan Matematika Universitas Negeri Yogyakarta*. Retrieved from http://eprints.uny.ac.id/id/eprint/77519

Chandra, A., & Setiawan, B. (2018). Optimasi Jalur Distribusi dengan Metode Vehicle Routing Problem (VRP). *Jurnal Manajemen Transportasi & Logistik (JMTRANSLOG), 5*(2), 105 - 116. http://dx.doi.org/10.54324/j.mtl.v5i2.233

Fitra, K. S. (2023, Januari 16). *ekonomi.bisnis.com*. Retrieved Oktober 2023, from https://ekonomi.bisnis.com/read/20230116/44/1618412/daftar-lengkap-harga-bbm-per-16-januari-2023-ada-yang-turun

Hillier & Lieberman. (1995). *Pengantar Riset Operasi*. Jakarta: Erlangga.

Huang, H. S., Huang, H. Y., Lee, C. H., & Tong, Y. Y. (2023). A New Hybrid Algorithm for Solving the Vehicle Routing Problem With Route Balancing. *International Journal of Indstrial Engineering and Management (IJIEM), 14*(1), 51-62. http://doi.org/10.24867/IJIEM-2023-1-324

Jerrico Nase, Natalin, J. N., Ardiansyah, M. N., & Artha, P. G. (2021). Perancangan Rute Distribusi Pengiriman Barang Menggunakan Model Mixed Integer Linear Programming untuk Meminimasi Biaya Transportasi pada PT. XYZ. *Jurnal Proceeding of Engineering*, *8*(5), 8032. Retrieved from https://openlibrarypublications.telkomuniversity.ac.id/index.php/engineering/article/view/16127

Kasih, P. H., & Maulidina, Y. (2023). Penentuan Rute Pengiriman untuk Meminimasi Jarak Tempuh Transportasi Menggunakan Metode Saving Matrix. *Jurnal INTECH Teknik Industri*

Universitas Serang Raya, *9*(1), 53-62. https://doi.org/10.30656/intech.v9i1.5680

Kristina, S., Sianturi, R. D., & Husnadi, R. (2020). Penerapan Model Capacitataed Vehicle Routing Problem (CVRP) Menggunakan Google OR-Tools untuk Penentuan Rute Pengantaran Obat pada Perusahaan Pedagang Besar Farmasi (PBF). *Jurnal Telematika*, *15*(2), 101-106. https://doi.org/10.61769/jurtel.v15i2.359

Montagne, R., Sanchez, D. T., & Storbugt, H. O. (2020). VRPy : A Python package for solving a range of vehicle routing problems with a column generation approach. *The Journal of Open Source Software*, *5*(55), 1-6. https://doi.org/10.21105/joss.02408

PYLINT. (n.d.). *docs.pylint.org*. Retrieved November 2023, from https://docs.pylint.org/intro.html#what-is-pylint

Sabe, K., & Herlina. (2023). Usulan Rute Distribusi Produk Gula Pasir dengan Menggunakan Metode Vehicle Routing Problem pada Distributor CV.XYZ Surabaya. *Prosiding Senakama*, *2*(1), 163-178. Retrieved from https://conference.untag-sby.ac.id/index.php/sentek/article/view/2091

Saraswati, R., Sutopo, W., & Hisjam, M. (2017). Penyelesaian Capacitated Vehicle Routing Problem dengan Menggunakan Algoritma Sweep untuk Penentuan Rute Distribusi Koran : Studi Kasus. *Jurnal Manajemen Pemasaran*, *11*(2), 41-44. https://doi.org/10.9744/pemasaran.11.2.41-44

Setiani, I. A., & Lukmandono. (2021). Optimasi Rute Distribusi Obat Untuk Meminimalkan Biaya Transportasi Dengan Menggunakan Metode Savings Matrix. *Seminar Nasional Sains dan Teknologi Terapan IX*, *ISSN 2685 - 5875*, 87 - 94. Retrieved from http://ejurnal.itats.ac.id/sntekpan/article/view/2197

Setiawan, A. (2021, April 26). *Oto.com*. (Oto) Retrieved Oktober 06, 2023, from https://www.oto.com/truk-baru/mitsubishi/fuso-fn-527-ml/faq/berapa-konsumsi-bbm-per-kilometer

Sutoni, A., & Apipudin, I. (2019). Optimalisasi Penentuan Rute Distribusi Pupuk untuk Meminimalkan Biaya Transportasi dengan Metode Saving Matrix. *Jurnal Spektrum Industri*, *17*(2), 143 - 155. https://doi.org/10.12928/si.v17i2.13139

VRPY. (2023). *vrpy.readthedpcs.io*. Retrieved November 2023, from https://vrpy.readthedocs.io/en/latest/examples.html#cvrp

Yumalia, A. (2017). Minimasi Biaya Distribusi Dengan Menggunakan Metode Travelling Salesman Problem (TSP). *Seminar Nasional Sains dan Teknologi*, *p-ISSN 2407 - 1846*(e-ISSN 2460 - 8416), 1-8. Retrieved from https://jurnal.umj.ac.id/index.php/semnastek/article/view/2051/1692