Determination of Package Distribution Routes Using the Vehicle Routing Problem Model

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***Abstract*—** This study aims to determine the route of distribution of packages in the province of Central Java from the distribution center to the drop point in each district city. By considering the vehicle capacity as a reference for determining the route, this study examines and analyzes the distance, travel time, and cost factors for determining the optimal route. This study will provide input solutions in the form of optimal routes based on Lingo 13 software in model processing.

The results of the study show a distance savings of 1412 KM or 26% from the existing route with a travel time of 128.040 seconds or 28.65% from the existing route and also costs Rp. 2,146.350, - or 40.90% of the existing route.

***Keywords*—** Distribution Routes, Lingo Software, Linear Programming, Vehicle Routing Problems.

I. INTRODUCTION

Setting the right distribution route will have an impact on the level of service and also on time, especially with the condition of the logistics company which is currently experiencing an increase in line with the pandemic conditions. it is necessary to optimize distribution routes so that the delivery service level agreement from incoming orders to dispatched orders can be achieved. From the research that has been done by other researchers before, the author will raise the problem of Determining Package Distribution Routes

Using the Vehicle Routing Problem Model. Determination of vehicle routes or better known as the Vehicle Routing Problem (VRP) has the aim of minimizing the distance and travel time of vehicle routes when distributing goods from the distribution center to a number of drop points. VRP from distribution center to drop point with vehicle routes to customers geographically dispersed with known delivery requests. (See Table 1).

From Table 1 it can be seen that drop points have different demands, so the distribution center must be careful in determining the delivery route from one point to another. The obstacle that arises in determining the current route is where the current route uses the closest model between one drop point to another, not using a determination method based on good modeling.

Table 1: *Number of Package for Drop Point*

Drop Points	Packages Per Day
KLATEN	155
JEPARA	253
BLORA	71
WONOGIRI	305
DEMAK	241
KENDAL	171
BOYOLALI	156
KARANGANYAR	198
SRAGEN	156
SALTIGA	292
REMBANG	183
SOLO	880
EAST SEMARANG	880
HOLY	411
MARGOYOSO	318
STARCH	267

Source: The results of 2022 data processing

In Figure 1 you can see the distribution of the locations of the drop points that need to be serviced by the distribution center in Central Java. Distribution centers need to create routes in order to achieve efficiency in delivery, because routes play an important role in achieving efficiency in delivery distance, delivery time and also the costs to be incurred.

With the current route, the company uses nine modes of transportation in the form of a double colt diesel unit, each with a capacity of 880 packages. In fact, from the vehicle capacity, it can be seen in table 1 that not all drop point locations have a demand for this capacity.

Table 2: *Capacity Vehicle*

Current Vehicle			
Vehicle Type	Qty	Capacity	Total Capacity
CDD	7	880	6,160
CDE	2	640	1,280

Source: The results of 2022 data processing

Judging from the problem above, it is necessary to minimize the route to determine the shortest route so that the delivery of goods is quickly sent to consumers in the fastest time and at the lowest cost.

Therefore, the researcher conducted a study of determining the route of packet distribution using the Vehicle Routing Problem Model to solve the problem.

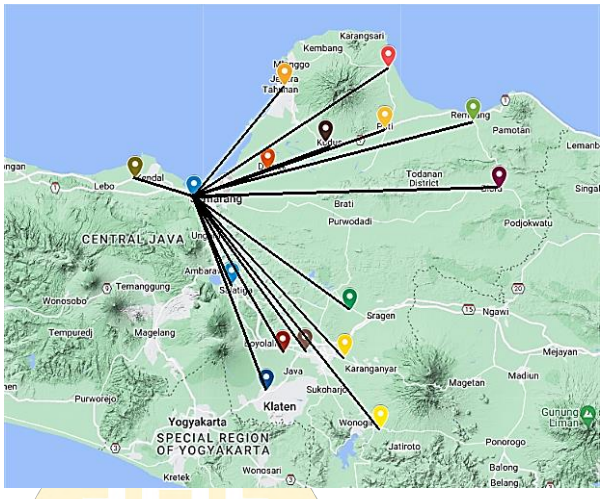

Figure 1: Distribution Map

II. LITERATURE REVIEW

Producers use distribution channels to carry out the process of distributing goods to final consumers or industrial users (Swastha and Bashu, 2014). Broadly speaking, distribution can be interpreted as a marketing activity that seeks to facilitate and facilitate the delivery of goods and services from producers to consumers, so that their use is in accordance with the needs needed (Tjiptono and Fandy, 2015). According to Bowersox (2013) distribution and transportation management can also be referred to as logistics management or physical distribution. Modern logistics can be defined as the strategic management process of moving and storing goods, spare parts and finished goods from suppliers, between company facilities and to customers.

The Vehicle Routing Problem (VRP) was first introduced by Dantzig and Ramser, in 1959 and since then has been widely studied (Suprayogi & Mahaputra, 2017). By Fisher in Kusumawardhani (2019), VRP is defined as a way of finding the efficient use of a number of vehicles that must travel to visit a number of places to drop off and pick up people or goods. The term consumer indicates a stop to drop off and pick up people/goods (Hadhiatma & Purbo, 2017).

III. RESEARCH METHODS

This type of research is descriptive quantitative. This research method focuses on the use of numbers in a detailed, systematic and structured manner. In addition, this study uses tables, graphs, and diagrams to show the results obtained. Problem identification is the basis for descriptive quantitative research. Collecting data and information and analyzing the results of the initial design concept. The data used are primary in nature which is useful for knowing the phenomenon of determining distribution routes that are directly related to the problem studied in the middle mile, to be further processed and analyzed using the Capacity Vehicle Routing Problem (CVRP) method so that it can provide an overview of the research object and can provide solutions to these problems.

IV. RESULTS AND DISCUSSION

The results of the study were made into model 1 using a maximum capacity of 880 packages with each destination location having a different delivery capacity. Model 1 includes simulation of distance routes, time routes and cost routes. Programming results using Lingo as below:

Table 3: *Distance Simulation*

Objective values :1412
Objective bound :1412

VARIABLE	VALUE	REDUCE COST
X(DCSEMARANG, KENDAL)	1.0000	37.0000
X(KENDAL, DEMAK)	1.0000	35.0000
X(DEMAK, SRAGEN)	1.0000	82.0000
X(SRAGEN, SALATIGA)	1.0000	90.000000
X(SALATIGA, DCSEMARANG)	1.0000	52.0000
X(DCSEMARANG, JEPARA)	1.0000	88.0000
X(JEPARA, HOLY)	1.0000	32.0000
X(HOLY, DCSEMARANG)	1.0000	72.0000
X(DCSEMARANG, BLORA)	1.0000	141.00000
X(BLORA, REMBANG)	1.0000	35.0000
X(REMBANG, MARGOYOSO)	1.0000	51.00000
X(MARGOYOSO, PATI)	1.0000	27.0000
X(PATI, DCSEMARANG)	1.0000	98.0000
X(DCSEMARANG, BOYOLALI)	1.0000	91.00000
X(BOYOLALI, WONOGIRI)	1.0000	590000
X (WONOGIRI, KARANGANYAR)	1.0000	430000
X(KARANGANYAR, KLATEN)	1.0000	32.0000

X(KLATEN, DCSEMARANG)	1.0000	105.0000
X(DCSEMARANG, SOLO)	1.0000	0.0000
X(SOLO, DCSEMARANG)	1.0000	0.0000
X(DCSEMARANG, SEMARANGTIMUR)	1.0000	0.0000
X(SEMARANGTIMUR, DCSEMARANG)	1.0000	0.0000

Source: Results of 2022 Lingo data processing

Table 4: *Time Summation*

Objective values :128040
Objective bound :128040

VARIABLE	VALUE	REDUCE COST
X(DCSEMARANG, KENDAL)	1.0000	5820.0000
X(KENDAL, DEMAK)	1.0000	2100,0000
X(DEMAK, SRAGEN)	1.0000	4920,0000
X(SRAGEN, SALATIGA)	1.0000	5400.0000
X(SALATIGA, DCSEMARANG)	1.0000	6720,0000
X(DCSEMARANG, JEPARA)	1.0000	8880.0000
X(JEPARA, HOLY)	1.0000	1920,0000
X(HOLY, DCSEMARANG)	1.0000	7920000
X(DCSEMARANG, BLORA)	1.0000	1260,0000
X(BLORA, REMBANG)	1.0000	2100,0000
X(REMBANG, MARGOYOSO)	1.0000	3060.0000
X(MARGOYOSO, PATI)	1.0000	1680.0000
X(PATI, DCSEMARANG)	1.0000	9480,0000
X(DCSEMARANG, BOYOLALI)	1.0000	9060.0000
X(BOYOLALI, WONOGIRI)	1.0000	3540.0000
X (WONOGIRI, KARANGANYAR)	1.0000	2640.0000
X(KARANGANYAR, KLATEN)	1.0000	1920,0000
X(KLATEN, DCSEMARANG)	1.0000	99000000
X(DCSEMARANG, SOLO)	1.0000	0.0000
X(SOLO, DCSEMARANG)	1.0000	0.0000
X(DCSEMARANG, SEMARANGTIMUR)	1.0000	0.0000
X(SEMARANGTIMUR, DCSEMARANG)	1.0000	0.0000

Source: Results of 2022 Lingo data processing

Table.5: *Cost Simulation*

Objective values :2146350
Objective bound :2146350

VARIABLE	VALUE	REDUCE COST
X(DCSEMARANG, KARANGANYAR)	1.0000	181000.00
X(KARANGANYAR, WONOGIRI)	1.0000	309000.00
X (WONOGIRI, KLATEN)	1.0000	36050.00
X(KLATEN, KENDAL)	1.0000	87550.00
X(KENDAL, DCSEMARANG)	1.0000	121000.00
X(DCSEMARANG, KUDUS)	1.0000	125000.00
X(HOLY, JEPARA)	1.0000	206000.00
X(JEPARA, DCSEMARANG)	1.0000	152000.00
X(DCSEMARANG, PATI)	1.0000	168000.00
X(PATTI, REMBANG)	1.0000	25750.00
X(REMBANG, BLORA)	1.0000	25750.00
X(BLORA, MARGOYOSO)	1.0000	56650.00
X(MARGOYOSO, DCSEMARANG)	1.0000	20000.00
X(DCSEMARANG, SALATIGA)	1.0000	128500.00
X(SALATIGA, BOYOLALI)	1.0000	309000.00
X(BOYOLALI, SRAGEN)	1.0000	36050.00
X(SRAGEN, DEMAK)	1.0000	56650.00
X(DEMAK, DCSEMARANG)	1.0000	75000.00
X(DCSEMARANG, SOLO)	1.0000	0.00
X(SOLO, DCSEMARANG)	1.0000	0.00
X(DCSEMARANG, SEMARANGTIMUR)	1.0000	0.00
X(SEMARANGTIMUR, DCSEMARANG)	1.0000	0.00

Source: Results of 2022 Lingo data processing

The table gives the results of Linear programming in the form of the objective value which is the maximum or minimum value. Variable and Value are constant values of each variable to obtain the objective value. In terms of minimization, Reduce Cost is the minimum value.

The current route that occurs is the following route:

1. DC Semarang - Boyolali - Klaten - DC Semarang
2. DC Semarang - Rembang - Blora - DC Semarang
3. DC Semarang - Solo - Sragen - DC Semarang
4. DC Semarang - Pati - Margoyoso - DC Semarang
5. DC Semarang - Demak - DC Semarang

6. DC Semarang - Kudus - Jepara - DC Semarang
7. DC Semarang - Kendal - Salatiga - DC Semarang
8. DC Semarang - East Semarang - DC Semarang
9. DC Semarang - Karanganyar - Wonogiri - DC Semarang

Based on Table 3 shows that there are six optimal routes taken, namely:

1. DC Semarang - Kendal - Demak - Sragen - Salatiga - DC Semarang
2. DC Semarang - Jepara - Kudus - DC Semarang
3. DC Semarang - Blora - Rembang - Margoyoso - Pati - DC Semarang
4. DC Semarang - Boyolali - Wonogiri - Karanganyar - Klaten - DC Semarang
5. DC Semarang - Solo - DC Semarang
6. DC Semarang - East Semarang - DC Semarang

By using this route, a minimum distance of 1412 km is obtained and a distance savings of 496 km or 26% of the current route is obtained.

Based on Table 4 shows that there are six optimal routes taken, namely:

1. DC Semarang - Kendal - Demak - Sragen - Salatiga - DC Semarang
2. DC Semarang - Jepara - Kudus - DC Semarang
3. DC Semarang - Blora - Rembang - Margoyoso - Pati - DC Semarang
4. DC Semarang - Boyolali - Wonogiri - Karanganyar - Klaten - DC Semarang
5. DC Semarang - Solo - DC Semarang
6. DC Semarang - East Semarang - DC Semarang

By using this route, a minimum time of 128040 seconds is obtained and a time saving of 51420 seconds or 28.65% is obtained.

Based on Table 5 shows that there are six optimal routes taken, namely:

1. DC Semarang - Karanganyar - Wonogiri - Klaten - Kendal - DC Semarang
2. DC Semarang - Kudus - Jepara - DC Semarang
3. DC Semarang - Pati - Rembang - Blora - Margoyoso - DC Semarang
4. DC Semarang - Salatiga - Boyolali - Sragen - Demak - DC Semarang
5. DC Semarang - Solo - DC Semarang
6. DC Semarang - East Semarang - DC Semarang

By using this route, the minimum cost is Rp. 2.146.350, - and obtained a cost savings of Rp. 1,485,500,- 40.90%.

From the modeling results, researchers can make a new route proposal which is expected to reduce 40.90% of the current actual cost of Rp. 3,631,850,- to Rp. 2.146.350,-. Both of these proposals, the company can prioritize its current needs, between needs in the form of distance and time by choosing route 1 (see table 6), or route 2 (see table 7) based on cost minimization.

If we compare the current existing route and the proposed route from the Lingo modeling, we can get significant results using distance, time or cost, where the Lingo modeled route has succeeded in reducing the distance, time and cost of the route that occurred.

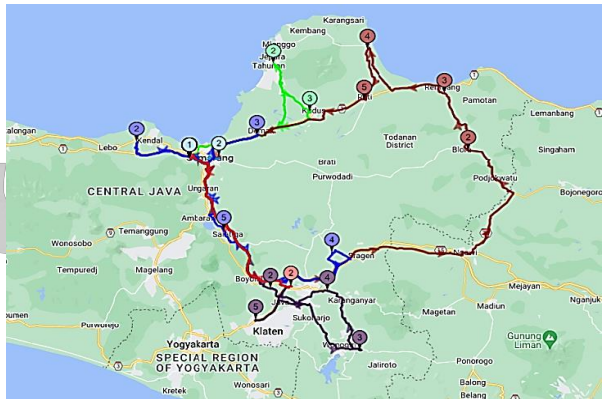

Figure 2: *Map of Proposed Route 1*

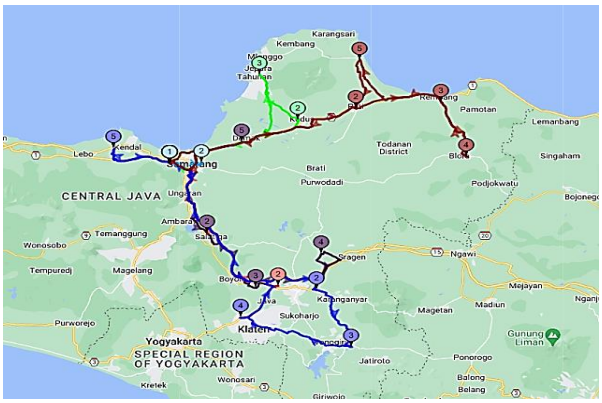

Figure 3: *Map of Proposed Route 2*

Table 6: *Proposed Route 1*

VARIABLE	Remark
X(DCSEMARANG, KENDAL)	ROUTE 1
X(KENDAL, DEMAK)	

X(DEMAK, SRAGEN)	
X(SRAGEN, SALATIGA)	
X(SALATIGA, DCSEMARANG)	
X(DCSEMARANG, JEPARA)	ROUTE 2
X(JEPARA, HOLY)	
X(HOLY, DCSEMARANG)	
X(DCSEMARANG, BLORA)	ROUTE 3
X(BLORA, REMBANG)	
X(REMBANG, MARGOYOSO)	
X(MARGOYOSO, PATI)	
X(PATI, DCSEMARANG)	
X(DCSEMARANG, BOYOLALI)	ROUTE 4
X(BOYOLALI, WONOGIRI)	
X (WONOGIRI, KARANGANYAR)	
X(KARANGANYAR, KLATEN)	
X(KLATEN, DCSEMARANG)	
X(DCSEMARANG, SOLO)	ROUTE 5
X(SOLO, DCSEMARANG)	
X(DCSEMARANG, SEMARANGTIMUR)	ROUTE 6
X(SEMARANGTIMUR, DCSEMARANG)	

Source: Results of 2022 data processing

Table 7: *Proposed Route 2*

VARIABLE	Remark
X(DCSEMARANG, KARANGANYAR)	ROUTE 1
X(KARANGANYAR, WONOGIRI)	
X (WONOGIRI, KLATEN)	
X(KLATEN, KENDAL)	
X(KENDAL, DCSEMARANG)	
X(DCSEMARANG, KUDUS)	ROUTE 2
X(HOLY, JEPARA)	
X(JEPARA, DCSEMARANG)	
X(DCSEMARANG, PATI)	ROUTE 3
X(PATTI, REMBANG)	
X(REMBANG, BLORA)	
X(BLORA, MARGOYOSO)	
X(MARGOYOSO, DCSEMARANG)	
X(DCSEMARANG, SALATIGA)	ROUTE 4
X(SALATIGA, BOYOLALI)	
X(BOYOLALI, SRAGEN)	
X(SRAGEN, DEMAK)	
X(DEMAK, DCSEMARANG)	
X(DCSEMARANG, SOLO)	ROUTE 5
X(SOLO, DCSEMARANG)	
X(DCSEMARANG, SEMARANGTIMUR)	ROUTE 6
X(SEMARANGTIMUR, DCSEMARANG)	

Source: Results of 2022 data processing

V. CONCLUSION

From the research by the author, it can be concluded that, among others:

1. The first route generated by Lingo software based on distance and time consists of six routes, namely:

1. DC Semarang - Kendal - Demak - Sragen - Salatiga - DC Semarang
2. DC Semarang - Jepara - Kudus - DC Semarang
3. DC Semarang - Blora - Rembang - Margoyoso - Pati - DC Semarang
4. DC Semarang - Boyolali - Wonogiri - Karanganyar - Klaten - DC Semarang
5. DC Semarang - Solo - DC Semarang
6. DC Semarang - East Semarang - DC Semarang

The second route generated by Lingo software based on costs consists of six routes, namely:

1. DC Semarang - Karanganyar - Wonogiri - Klaten - Kendal - DC Semarang
2. DC Semarang - Kudus - Jepara - DC Semarang
3. DC Semarang - Pati - Rembang - Blora - Margoyoso - DC Semarang
4. DC Semarang - Salatiga - Boyolali - Sragen - Demak - DC Semarang
5. DC Semarang - Solo - DC Semarang
6. DC Semarang - East Semarang - DC Semarang

2. From these routes, the resulting route with a minimum distance of 1412 KM or 26% of the existing route with a travel time of 128,040 seconds or 28.65% of the existing route and also costs Rp. 2,146,350, - or 40.90% of the existing route.

Further Research Advice

With this proposed route, it can be used as an option for companies to prioritize competitiveness with competitors by considering delivery time and distance, or saving factors by considering shipping costs, and the proposed route can be used as vehicle savings proposals either in the form of rental or maintenance costs. and also vehicles that can currently be used for package conditions outside of normal and can also be used for other company business strategies, so that existing vehicles can be utilized properly.

REFERENCES

[1] Purnomo, Agus. (2017). "Analysis of Distribution Routes Using the Capacity Problem Method

(CVRP) on Coca Cola Products at the Bandung Distribution Center". Competitive, Vol 12.No.2, December 2017 ISSN : 0216-2539.

[2] Pujawan, I Nyoman and Mehendrawathi Er. (2017). Supply Chain Management. Edition 3. ANDI. Yogyakarta.

[3] Donald J. Bowersox, David J. Closs, and M. Bixby Cooper, 2013, Supply Chain Logistics Management, The McGraw-Hill Companies, Inc.

[4] Irman SM, Ade; Ratna Ekawati, and Nuzulia Febriana. (2017). "Optimization of Quelle Drinking Water Distribution Route with Clarke & Wright Saving Algorithm and Vehicle Routing Problem Model". National Seminar on Innovation and Application of Technology in Industry 2017, ITN Malang.

[5] Kusumawardhani, Octarifia and Sugiyono. (2019). "Determination of Distribution Routes Using the Vehicle Routing Problem Model".

[6] Toth, Paolo and Daniele Vigo. (2014). Vehicle Routing Problems, Methods, and Applications. 2nd ed. MOS-SIAM Series. United States of America.

[7] Sitek, Pawel Sitek and Jarosław Wikarek. (2019). "Capacitated vehicle routing problem with pick-up and alternative delivery (CVRPPAD): model and implementation using a hybrid approach". Ann Oper Res (2019) 273:257–277.

[8] Nurprihatin, Filscha. (2021). "Optimizing rice distribution routes in Indonesia using a two-step linear programming considering logistics costs". Journal of Physics: Conference Series.

[9] Fitriani, Nur Anisa, Rama Aditya Pratama, Siti Zahro, Putranto Hadi Utomo, and Titin Sri

[10] Martinie. (2021). "Solving capacitated vehicle routing problem using saving matrix, sequential insertion, and nearest neighbor of product 'X' in Grobogan district". AIP Conference Proceedings 2326.

[11] Mohammed, Mazin Abed, Mohd Khanapi Abd Ghani, Raed Ibraheem Hamed, Salama A. Mostafa, Mohd Sharifuddin Ahmad, and Dheyaa Ahmed Ibrahim. (2017). "Solving Vehicle Routing Problem by Using Improved Genetic Algorithm for Optimal Solution". Journal of Computational Sciencehttp://dx.doi.org/10.1016/j.jocs.2017.04.003.

[12] Borˇcinov´a, Zuzana. (2017). "Two models of the capacitated vehicle routing problem". Croatian Operational Research Review CRORR 8(2017).

[13] Syarie H, Rizal Zamah. (2019). "Proposed Product Distribution Route Using The Clarke And Wright Savings Algorithm Method To Minimize Distribution Costs At IKM Nugraha In Cihaurbeuti District". Journal of Media Technology Vol. 06 No. 01 August 2019.G. Eason, B. Noble, and IN Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. soc. London, vol. A247, pp. 529–551, April 1955. (references)

[14] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp. 68–73.