Clarke and Wright Savings Algorithm as Solutions Vehicle Routing Problem with Simultaneous Pickup Delivery (VRPSPD)

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Abstract. This study aims to establish the mathematical model *Vehicle Routing Problem with Simultaneous Pickup and Delivery* (VRPSPD) on 3 kg of LPG gas distribution and its solution using the method of *Clarke and Wright Savings*. Data used include a list of areas of consumers, service delivery company, the amount of consumer demand, vehicle type and vehicle capacity. The data is then processed to be modeled as hereinafter *Vehicle Routing Problem with Simultaneous Pickup Delivery*(VRPSPD) problems solved by the method of Clarke and Wright Savings[1]. Based on the calculation, the result for the total mileage of the vehicle is 160 km while the total mileage of the vehicle this company is 201km. *Thus Clarke and Wright savings* algorithm capable of providing mileage savings with a percentage of 20.03%.

Keywords: Optimization, FMOLP, network analysis

1. Introduction

Distribution is a process of shipping goods from companies to consumers. Distribution is one of the most important instruments in the world of commerce where the right distribution will provide benefits to all parties. Process efficient and effective food distribution will be one factor for achieving customer satisfaction. Satisfaction customers can be caused by the goods arrive on time, not damaged, according to demand, the speed of goods up to the customers, and the sales price cheapness Distribution goods are one of the activities that are often carried out by a particular company. Determining the optimal route is one way to minimize the total cost of distribution. In mathematics, the distribution problems can be solved by using the *Vehicle Routing Problem with Simultaneous Pickup and Delivery* (VRPSPD)[1]. *Vehicle Routing Problem with Simultaneous Pickup and Delivery* (VRPSPD) is one variant of the Vehicle Routing Problem that considers two types of services, namely the delivery and retrieval of products made at once while visiting a customer[2]. The purpose of the problems *Vehicle Routing Problem with Simultaneous Pickup Delivery* (VRPSPD)is to obtain the

minimum travel route for each company where the vehicle has a single termination for retrieval and delivery of goods[3]. Completion of this *Vehicle Routing Problem with Simultaneous Pickup and Delivery* (VRPSPD) used by *Clarke and Wright Saving* method, because this method can provide a solution to the problems of vehicles where the collection of these routes at every step in exchange for getting a better set of these[4]. The calculation process in this method uses the distance as a parameter, to obtain the value of the largest savings are then compiled into the best route. The goal is to find a solution that minimum total financing vehicles, and the requirement that each consumer has only visited once, and the total demand on a route must be within the capacity of the vehicle. The core of the algorithm Clarke and Wright Saving is calculating savings is measured by how much do the reduction of mileage and time spent by linking nodes that exist and make a route based on the value of the savings of the largest is the distance between the starting node and the destination node.

2. Method

Step completion of *Clarke and Wright Savings* algorithm is as follows:

1. Preparing the data required, namely: the number of vehicles and the capacity, the number of consumers served, the distance data between consumers and between businesses and consumers to establish a distance matrix[5].
2. Calculate the value of savings (S_{ij}) and matrix-saving formula :
   $S_{ij} = C_{oi} + C_{oj} - C_{ij}$
   where
   C_{oi} = Distance from the company to the node i,
   $_{ij}$ = Distance from the node i to node j.
   S_{ij} = The distance savings from node i to node j.
3. Selecting the value of the largest savings (S_{ij} Max) and then create a second route to the selected node. Then choose the closest distance to the next track[6]. This method starts with a solution that every customer is served by a separate service. Then the merger of two consumer s i and j resulting in savings (savings) in the form of mileage for $S_{ij} = C_{oi} + C_{oj}–C_{ij}$ with Cij = distance from consumer to consumer ij. In general, if two routes $(0, \ldots i, 0)$ and $(0, \ldots j, 0)$ simultaneously can be combined into a single route $(0, \ldots i, j, 0)$, there will be savings of distance by $S_{ij} = (C_{oi} + C_{io} + C_{jo}) - (C_{oi} + C_{jo}–C_{ij}) = C_{io} + C_{oj} + C_{ij})$.

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3. Result and Discussion

3.1. Data Collection

Table 1. List of consumer names

No	Customer's	Addres	Total Delivery
1	Andre Gas	Jl. Perjuangan	200
2	Jannah Gas	Jl. Kemuning	130
3	Doli Saputra Gas	Jl. Mawar	230
4	Nanda Indah Gas	Jl. Mesjid	80
5	Hisyam Gas	Jl. Murni	80
6	Abadi Gas	Jl. Kenanga Sari	200
7	Kemala Gas	Jl. Kenanga Raya	200
8	Reza Gas	Jl. Abdul Hakim	160
9	Siti Aisah Gas	Jl. Harmonika	200
10	Sri Yanti Gas	Jl. Bunga Cempaka	200
11	Indri Gas	Jl. Melati	80
12	Rahmat Gas	Jl. Bunga Wijaya	80
13	Bayu Gas	Jl. Karya Indah	100
14	Indah Gas	Jl. Bunga Melur	100
15	Sibutarbutar Gas	Jl. Sempurna	200
16	Widya Gas	Jl, Kaktus Raya	150
17	Hidayat Gas	Jl. Sei Asahan	70
18	Keyna Gas	Jl. Inti Sari	260
19	Dandi Gas	Jl. Sei Serayu	150
20	Herman Gas	Jl. Setia	280
21	Annisa Gas	Jl. Setia Belatu	130
22	Roni Gas	Jl. Kesatria	100
23	Alex Gas	Jl. Sei Bilah	80
24	Doni Gas	Jl. Laksana	230
25	Riski Agustin Gas	Jl. Sepakat	150
26	Sitompul Gas	Jl. Ampera	230
27	Rezeky Gas	Jl. Abadi	220
28	Kemala Gas	Jl Pasar 1	80
		Total	4370

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3.2. Data processing

Table 2. matrix distance to 1-5 (km)

From	0	V1	V2	V3	V4	V5
0	0	8.9	3.4	8.4	5.6	5
V1	8.9	0	5.5	0.5	3.3	3.9
V2	3.4	5.5	0	5	2.2	1.6
V3	8.4	0.5	5	0	2.8	3.4
V4	5.6	3.3	2.2	2.8	0	0.6
V5	5	3.9	1.6	3.4	0.6	0

Result mileage distance matrix between stores depot and the distance between stores. Mileage indirectly will present travel time of the vehicle.

Table 3. matrix of time to 1-5 (h)

From	0	V1	V2	V3	V4	V5
0	0	0.17	0.6	0.16	0.11	0.13
V1	0.17	0	0.43	0.01	0.06	0.7
V2	0.6	0.43	0	0.44	0.49	0.3
V3	0.16	0.01	0.44	0	0.5	0.6
V4	0.11	0.6	0.49	0.05	0	0.1
V5	0.13	0.7	0.3	0.6	0.1	0

1. Matrix savings
   Step-step matrix savings are as follows:
   1. Determine the pair will be counted.
   2. Perform calculations using the formula
      Example $s_{12} = C_{12} + C_{20} - C_{12}$
      $= 8,9 + 3,4 - 6,2$
      $= 6,1$

   Furthermore, the advanced calculation for all of the couple, consumers are grouped into these routes from the consumer to the value of savings from the largest to the smallest by showing the vehicle capacity.[7]

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Table 4. Grouping These

Route	Customer	Total Delivery	Total Demand
1	1	200	560
	9	200	
	11	80	
	12	80	
2	3	230	470
	8	160	
	23	80	
3	15	230	530
	22	80	
	26	230	
4	4	80	560
	7	200	
	19	150	
	21	130	
5	5	80	510
	10	200	
	25	150	
	28	80	
6	28	80	510
	13	260	
	16	150	
	18	100	
7	2	130	300
	14	100	
	17	70	
8	17	70	500
	20	280	
	27	220	
9	24	230	430
	26	200	

3.3. Ordering route with the Nearest Neighbor

Formed by the *Nearest Neighbor* algorithm

a The route 1 node that are formed is 0-1-9-11-12-0 with the distance of 21.9 km.

b The route 2 node that are formed is 0-3-8-23-0 with the distance of 23 km.

c The route 3 node that are formed is 0-6-15-22-0 with the distance of 34.3 km.

d The route 4 node that are formed is 0-4-7-19-21-0 with the distance of 21.9 km.

e The route 5 node that are formed is 0-5-10-25-28-0 with the distance of 22.7 km.
f The route 6 node that are formed is 0-13-16-18-0 with the distance of 17.7 km.
g The route 7 node that are formed is 0-2-14-17-0 with the distance of 12.5 km.
h The route 8 node that are formed is 0-20-27-0 with the distance of 5.9 km.
i The route 9 node that are formed is 0-6-24-0 with the distance of 1.3 km.

3.4. Analysis and Interpretation of Results

Table 5. These Company

Route to	Travel Sequence	Number of Request	Mileage (km)
1	0-1-2-3-0	560	30.7
2	0-4-5-6-7-0	560	29.2
3	0-8-9-10-0	560	27
4	0-11-12-13-14-15-0	560	31.4
5	0-16-17-28-18-0	560	19.9
6	0-19-20-21-0	560	12.6
7	0-22-23-24-25-0	560	28.5
8	0-26-27-0	450	21.7
	Total	4,370	201

Table 6. These Clarke and Wright Savings Algorithm

Route	Travel Sequence	Number of Request	Mileage (km)
1	0-9-1-11-12-0	560	21.9
2	0-23-3-8-0	470	23
3	0-22-15-26-0	530	34.3
4	0-21-7-4-19-0	560	21.9
5	0-10-25-28-5-0	510	22.7
6	0-13-18-16-0	510	17.7
7	0-17-14-2-0	300	12.05
8	0-27-20-0	500	5.9
9	0-24-6-0	430	1.3
	Total	4370	160.75

From tables 5 and 6 can be obtained total mileage are:

$$= \frac{The\ total\ distance\ of\ company's\ route - Total\ distance\ of\ the\ route\ clarke\ and\ wright\ savings}{the\ total\ distance\ of\ the\ company's\ route} \text{ x } 100\ \%$$

$$= \frac{201-160,75}{201} \text{ x } 100\ \%$$

4. Conclusion

Based discussion on the resolution of the *Vehicle Routing Problem with Simultaneous Pickup Delivery* (VRPSPD) algorithm using *Clarke and Wright Savings* produce 9 routes with mileage 160. This algorithm successfully saving a mileage of 20.03%. This shows that the algorithm *Clarke and Wright Savings* able to reduce the cost of distribution depot.

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