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Analysis of The Use of Sweep Algorithms to Solve Capacitated Vehicle Routing Problems

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ABSTRAK

Studi ini menerapkan Algoritma Sweeb Terhadap permasalahan Capacitated Vehicle Routing Problem (CVRP) dimana terdapat costumer dengan barang yang akan dipasok dari satu titik yaitu Depot. Vehicle Routing Problem (VRP) adalah masalah optimasi penentuan rute yang bertujuan untuk mempercepat proses pendistribusian suatu produk atau barang dan meminimalkan biaya pendistribusian. Vehicle Routing Problem (VRP) terdapat beberapa jenis salah satunya adalah Capacitated Vehicle Routing Problem (CVRP) yang mana pada kasus ini setiap kendaraan memiliki kapasitas angkut yang terbatas. Tujuan penelitian ini adalah untuk mengetahui keefesien penggunaan algoritma sweep terhadap penyelesaian capacitated vehicle routing problem, dengan contoh kasus pengantaran tabung gas LPG 3 kg, sehingga mendapat hasil yang optimum untuk masalah pada proses pendistribusiannya. Pada penelitian ini terdapat satu Depot dan 24 titik agen, jarak antar depot dan masing-masing agen dihitung mengunakan bantuan google earth. Hasil dari penelitian terhadap permasalahan diatas dengan menggunakan CVRP dengan Algoritma Sweep diperoleh 3 Rute pendistribusian dengan perbandingan jarak tempuh dan jumlah penggunaan kendaraan yang berkurang yaitu jarak tempuh perusahaan 133,2 Km, jarak tempuh yang didapatkan pada penelitian ini adalah 118,85 Km. Selisih penggunaan kendaraan yaitu 14,35 Km. Jadi dari hasil diperoleh persentase penghematan jarak tempuh sebesar 10,7732733 %.

Kata kunci: Algoritma Sweeb, Capacitated Vehicle Routing Problem, Nearest Neighbor.

ABSTRACT

This study applies the Sweeb Algorithm to the Capacitated Vehicle Routing Problem (CVRP) problem where there is a customer with goods to be supplied from one point, namely the Depot. Vehicle Routing Problem (VRP) is a problem of optimizing route determination that aims to speed up the process of distributing a product or item and minimize distribution costs. There are several types of Vehicle Routing Problems (VRP), one of which is the Capacitated Vehicle Routing Problem (CVRP), which in this case each vehicle has a limited carrying capacity. The purpose of this study is to determine the effectiveness of using the sweep algorithm for solving capacitated vehicle routing problems, with an example of a case of delivery of a 3 kg LPG gas cylinder, so as to get optimal results for problems in the distribution process. In this study there was one Depot and 24 agent points, the distance between the depots and each agent was calculated using the help of google earth. The results of the study on the above problems using CVRP with the Sweep Algorithm obtained 3 distribution routes with a comparison of mileage and the number of vehicle uses that were reduced, namely the company's mileage of 133.2 Km, the mileage obtained in this study was 118.85 Km. Difference in vehicle use was 14,35 Km. So from the results obtained a percentage of mileage savings of 10,7732733%.

Keywords: *Keywords: Sweeb Algorithm, Capacitated Vehicle Routing Problem, Nearest Neighbor.*

A. Introduction

To obtain an optimal distribution result, the search for an optimal route in everyday life is very necessary. In addition to shortening the time when distributing, the optimal route is also useful for minimizing the distribution costs incurred, especially for large companies that distribute their products every day to be distributed to various distributors or retailers. Good distribution also causes consumers to feel satisfied with the availability of the stock they are looking for which will have an impact on increasing profits for the company. For the problem of finding the optimal route for a

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vehicle, often also called the Capacitated Vehicle Routing Problem (CVRP) is a problem that discusses how to choose the path that must be passed by a number of transport vehicles in a process of distributing goods that combines customer demand with the carrying capacity of a vehicle.

Imam et al in 2019 researched that determining the route with the closest distance will save operational costs. To achieve the ideal use of vehicles, a model needs that can describe various problems in the field of transport.

R.Hanafi et al. conducted a study with the result that the sweebb algorithm can determine the optimal set of routes to minimize the amount of use of a vehicle needed and the total distance traveled by all vehicles to serve customers with its case study is PT Eastern Pearl Flour Mills. The result they obtained was that the number of vehicles used at the time of distribution was reduced so that the mileage and utilization of vehicles were increased.

In 2017 Akhan et al researched that the algorithm sweeb performs a savings calculation measured by how much there is a reduction in mileage and time used which is then used to link point to point and make it into a route form based on the largest savings value, namely the distance between the center point and the destination point.

The sweep algorithm consists of two stages, including: the first stage is clustering and the second stage is by determining the route of each cluster using the neighbour method. The first stage is carried out by combining one point to another in one cluster based on the maximum capacity of the vehicle used for its distribution and for the second stage determines the sequence of routes to be traveled by the vehicle used to distribute goods, provided that the demand should not exceed the capacity of the vehicle.

B. Research Methods

1. Distribution

Distribution is one aspect of marketing. Distribution is also often interpreted as a marketing activity where there is an effort to facilitate and facilitate the delivery of a good or service from producers to consumers. The purpose of distribution is to ensure the continuity of production and so that products can be well received by consumers by minimizing distribution constraints.

Distribution includes:

1. Warehousing
2. Control of finished goods inventory
3. Fishing and Traffic
4. Marketing

2. Graf

A graph is a collection of structured objects, where several pairs of objects have a relationship. According to Munir, 2005. A graph is used to describe the relationship from one object to another. Graphs are structured collections of objects in which several pairs of objects relate or have a certain relationship.

3. Vehicle Routing Problem

Vehicle Routing Problem (VRP) is a problem of optimizing route determination that aims to speed up the process of distributing a product or item and minimize distribution costs. When looking for the optimum route, a choice will be made in the form of which route the fleet takes to be delivered to a certain set of customers. According to Wibisono in 2018 the Vehicle Routing Problem or VRP is a problem of setting up a route for several resources in visiting service points, where each resource departs from the same starting point (depot), to visit the point to point in the route only occurs once by paying attention to its operational limitations, then returns again to the starting point, namely the depot.

4. Capacitated Vehicle Routing Problem

Capacitated Vehicle Routing Problem or CVRP is the most basic form of VRP, which can be seen as a formulation of two well-known pre-existing problems.

CVRP is the determination of a route unit where each route distribution process is carried out by a transport vehicle unit whose journey starts from the starting point at the depot and returns to the starting point of the depot (Trip) to meet the demands of customers (customers) with limitations on the carrying capacity of the vehicle. The capacity of the vehicle used must be the same.

The solution of the Capacitated Vehicle Routing Problem uses a sweep algorithm for the delivery of goods (packages) at PT. Tiki Line Nugraha Ekakurir Medan Branch with 200 regional points in the city of Medan obtained 3 routes with the stages of completion, namely the clustering stage and the stage of forming a route.

Where in the final result of the calculation obtained the percentage of savings on the total distance of the route by 32.03%. This shows that solving route set problems using sweep algorithms can reduce the distance from distribution and reduce the cost of expenses from the company (Yesi Septiana, 2018).

A simple model of CVRP as follows:

Minimize Z=$\sum_{i=0}^{n}\sum_{j=1}^{n}\sum_{k=1}^{n} C_{ijk}X_{ijk}$

With delimiters:

1. Each customer is only visited exactly once by a vehicle
   $\sum_{j=1}^{n}\sum_{k=1}^{n} X_{ijk}$=1, *For all I*
2. The demand of all customers in one route does not exceed the capacity of the vehicle
   $\sum_{i=0}^{n}\ di\ \sum_{j=1}^{n} X_{ijk} \leq q$, *For all k*
3. Each route starts from the depot
   $\sum_{j=1}^{n} X_{ojk} = 1$, *For all k*
4. Every vehicle that visits one point will definitely leave the point
   $\sum_{i=0}^{n} X_{ijk} - \sum_{j=1}^{n} X_{ijk}$ = 0, *For all k*
5. Each route ends at depot
   $\sum_{i=0}^{n} X_{ijk}$= 1, *For all k*
6. Decision variables are binary variables
   X_{ijk} = {0,1} *For all i,j,k*

   Where:

   i : Starting point index
   j : Destination point index
   k : *Vehicle index*
   d : *Demand*
   d_i : Demand at a starting point
   d_{ij} : Demand that starts from the starting point to the destination point
   q : Vehicle capacity
   qi : Vehicle capacity starting from the starting point
   C_{ijk} : The distance from the starting point to the destination point carried out by the vehicle
   X_{ijk} : Its decision variable (the decision variable is a binary variable that identifies point i, point j is performed by the vehicle k)

5. Sweep Algorithm

The sweep algorithm is one of the grouping techniques in the first route second cluster which is included in the classical heuristic approach. The quality of the solutions obtained is no guarantee as globally optimal because the heuristic approach does not really explore the solution space. The sweep algorithm is the simplest clustering method to solve CVRP problems. The sweep algorithm has 2 types of methods in its absorption. These two methods are distinguished by the direction of radial line rotation. These methods are forward sweep and backward sweep. Forward sweep itself is a grouping of customers with a radial line rotation direction starting from an angle of 0° to an angle of 360°. This direction of rotation is often referred to as counter clockwise or more commonly called counterclockwise. Backward sweep has the opposite direction of rotation. The radial line rotation direction in the second method in this sweep algorithm moves from the largest angle, which is a 360° angle to the smallest angle of 0°. This direction of rotation can also be called clockwise rotation (Akhand dkk, 2017).

C. Results And Discussion

This section discusses the solution of the Capacitated Vehicle Routing Problem (CVRP) problem which includes solving it using the Sweep Algorithm method and paying attention to the effectiveness of the method in solving the Capacitated Vehicle Routing Problem.

Table 1. Agent and Depot points

No. Pangkalan	Pangkalan	Alamat
1	Agen (depot)	Jalan Rumah Sakit No.66, Cinambo, Kota Bandung, Jawa Barat 45474, Indonesia
2	Ella Triandara	Margahayu Raya Barat, Buahbatu, Kota Bandung, Jawa Barat 40286, Indonesia
3	Sandi	Cipadung Wetan, Panyileukan, Kota Bandung, Jawa Barat, Indonesia
4	Itang	Cigagak, Cibiru, Kota Bandung, Jawa Barat 40615, Indonesia
5	Nanang	Jalan Cipadung, Cibiru, Kota Bandung, Jawa Barat, Indonesia
6	Yanto	Jalan Desa Cipadung, Cibiru, Kota Bandung, Jawa Barat, Indonesia
7	Eden	Jalan Haruman 3 cigending

8	Dedi Junaeidi	Jalan Paledang, Ujung Berung, Kota Bandung, Jawa Barat 40617, Indonesia
9	Dedi Sarifudin	Jalan Sukaasih Raya No.8A, Mandalajati, Kota Bandung, Jawa Barat 40293, Indonesia
10	Harun Ridwan	Babakan Penghulu, Cinambo, Kota Bandung, Jawa Barat, Indonesia
11	Timbul Tampubolon	Jalan Pasir Impun No.7, Mandalajati, Kota Bandung, Jawa Barat 40195, Indonesia
12	Triyono	Jalan Cijambe No.15, Ujung Berung, Kota Bandung, Jawa Barat 40619, Indonesia
13	Sumber Urip	Jalan Cijambe No.44, Ujung Berung, Kota Bandung, Jawa Barat 40619, Indonesia
14	Ayi	Jalan Pangaritan No.5, Panyileukan, Kota Bandung, Jawa Barat 40614, Indonesia
15	Ragil	Panyileukan, Kota Bandung, Jawa Barat 40292, Indonesia
16	Hj. Lilis	Jalan Pasir Jati No.10, Ujung Berung, Kota Bandung, Jawa Barat 40611, Indonesia
17	Willy	Jalan Pasar Kaler, Ujung Berung, Kota Bandung, Jawa Barat 40618, Indonesia
18	Hj. Neni	Jalan Cijawura Girang II, Buahbatu, Kota Bandung, Jawa Barat 40286, Indonesia
19	Ernawati	Jalan Cibangkong, Batununggal, Kota Bandung, Jawa Barat 40273, Indonesia
20	Polin	Jalan Cilengkrang 2 No.2, Cibiru, Kota Bandung, Indonesia
21	Christian	Jalan Kiara Asri Raya, Kiaracondong, Kota Bandung, Jawa Barat 40285, Indonesia
22	Endri Suherman	Pangkalan LPG, Jalan Warna Cinta, Bojongloa Kidul, Bandung, Jawa Barat 40236, Indonesia
23	H. eni	Jalan Terusan Pasir Koja No.75, Astanaanyar, Kota Bandung, Jawa Barat 40242, Indonesia
24	H. Isoh	Jl. Caringin No.73, Babakan Ciparay, Kota Bandung, Indonesia
25	Vianti Lolita	Jalan Pesantren, Arcamanik, Kota Bandung, Jawa Barat, Indonesia

Tabel 2. Customer Data and Number of Requests

Base No	Base	Number of Requests
1	Agen (depot)	0
2	Ella Triandara	105
3	Sandi	30
4	Itang	65
5	Nanang	85
6	Yanto	50
7	Eden	30
8	Dedi Junaeidi	100
9	Dedi Sarifudin	70
10	Harun Ridwan	110
11	Timbul Tampubolon	60
12	Triyono	30
13	Sumber Urip	50
14	Ayi	50
15	Ragil	30
16	Hj. Lilis	65
17	Willy	s30
18	Hj. Neni	50
19	Ernawati	30
20	Polin	70
21	Christian	85
22	Endri Suherman	100
23	H. eni	60
24	H. Isoh	70
25	Vianti Lolita	30

Figure 1. depot and agent areas

Table 3. Company routes

Kelompok	rute	Rute Pendistribusian	Wilayah	Jumlah Permintaan	Jarak Tempuh(Km)	Total Jarak
1	1	Depot - ayi - nanang - polin - itang – depot	4	270	12.9	31.7
	2	Depot - ragil - yanto - harun - sandi – depot	4	220	18.8	
2	1	Depot - hj neni - chris - ella - ernawati – depot	4	270	34	70.1
	2	Depot - h isoh - heni - endri – depot	3	230	36.1	
3	1	Depot - dedi j - vianti - eden - triyono - willy - sumber – depot	6	270	20.5	31.4
	2	Depot - dedi s - hj lilis - timbul – depot	3	195	10.9	
		Total	24	1455	133.2	133.2

Table 4 . Route of Algoritms Sweeb

Kelompok	Rute	Rute dan Jarak	Wilayah	Total jarak (Km)		Permintaan
1	1	Depot-Willy-Eden-Hj.lilis-Sumber Urip-Triyono-Itang-Depot	6	15.15	25.6	270
	2	Depot- Dedi S-Vianti L - Timbul T-Depot	3	10.4		160
2	1	Depot-Ernawati-H.eni-H.Isoh- Endri S-Depot	4	35.7	55.4	260

	2	Depot-Ella T-Hj Neni-Christian-Depot	3	19.7		240
	1	Depot-Ragil-Ayi-Sandi-Harun Ridwan-Depot	4	10.05		220
3	2	Depot-Polin-Nanang-Yanto-Depot	3	7.85	37.9	205
	3	Depot-Dedi J- Depot	1	20		100
Total			24	118.85	118.85	1455

Table 5. Comparison of Corporate Route Distances and Routes of the Sweeb Algorithm

Kelompok	Perusahaan		Algoritma Sweeb	
	Permintaan	Jarak (Km)	Permintan	Jarak (Km)
1	490	31.7	430	25.6
2	500	70.1	500	55.4
3	465	31.4	525	37.9
Total	1455	133.2	1455	118.85

In the data there are 24 agent points (bases) and 3 vehicles with a carrying capacity of 270 LPG gas 3 Kg / vehicle. The mileage obtained at the distribution of the company's data amounted to 133.2 km. In this problem, the Sweeb Algorithm is needed to optimize the use of vehicles and minimize the cost of expenses from the company, so the capacitated vehicle routing problem method is used with the Sweeb Algorithm as the optimal solution. After using the Sweeb Algorithm, it was obtained, 118.85 km. When compared to data from the company, there is a difference of 14.35 km for the distribution mileage. So from the results obtained the percentage of mileage savings of 10.7732733%.So in the use of the sweeb algorithm in solving CVRP problems, the result is that the use of routes is reduced. In the distribution process, if the company uses the Sweeb Algorithm, the company can minimize distribution costs. In this problem, the research focuses on solving methods using the sweeb algorithm only by comparing the route from the company and the route that can be obtained after doing the calculation using the sweeb algorithm.

D. Conclusions And Suggestions

1. Conclusion:

1. The optimal route was obtained in the process of distributing goods from the Depot to each agent (base), where there were 24 agent location points and as many as 3 groups of distribution routes with a total distance traveled by vehicles of 118.85 km.
2. The total vehicle mileage for the process of distributing goods using the Sweep Algorithm can be reduced by 14.35 km or 10.7732733% of the total vehicle mileage with the route used by the company.
3. The number of vehicles needed in the distribution process remains at 3 vehicles.
4. The use of the Sweeb Algorithm is efficient in this case example because the results of the study show that there is a reduction in the mileage route in the distribution process in this case only reduced by 14.35 km.

2. Suggestion

Based on the results of the studies conducted, the authors suggest that:

1. Companies may consider the use of the CVRP method by using the Sweeb Algorithm to determine the Route of distribution.
2. For the next study, the author suggests conducting research by paying attention to the time of the distribution process and the congestion of the route to be traveled by the vehicle so that a more optimal distribution process is obtained.

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