Comparison of Sweep and Tabu Search Methods in Searching for Item Delivery Routes based on Volume

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Abstract*— One example of a rental business that is currently developing is the children's toys rental business. Many factors that affect the success of the children's toy rental business in addition to the variety of toys that can be rented and time delivery must also be considered. The main problem in the delivery of children's toys is because children's toys have different volumes or sizes, so delivery routes are needed that not only pay attention to distance but also the volume of toys. This research was conducted to compare two methods, namely Sweep method and Tabu Search method to determine the route of delivery of toys that based on volume. The best method from these comparisons is used for developing applications that produce delivery routes. The results of the comparison of the two methods indicate that the tabu search method produces shorter delivery distances compared to the sweep method with a distance difference of 1595 for the case the delivery volume does not exceed the maximum vehicle capacity and 3532 for the case the delivery volume exceeds the maximum vehicle capacity.

Keywords—delivery items, routes delivery, volume, sweep method and tabu search method.

I. INTRODUCTION

In this modern era, business opportunities are increasing and wide. One business opportunity that is currently developing is the rental business. One example of a rental business that is currently developing is the children's toys rental business. The rental business of children's toys is much in demand by parents because it feels more efficient in renting children's toys than buying. Children's toys that are also rented are not only toys in small size but with large size. Many factors that affect the success of the children's toy rental business in addition to the variety of toys that can be rented and also time delivery must also be considered. Therefore, a strategy is needed to deliver the toys.

The main problem in the delivery of children's toys is because children's toys have different volumes or sizes, so delivery routes are needed that not only pay attention to distance but also the volume of toys. This caused that toys being delivered can exceed or less than the maximum volume capacity of the vehicle. Another problem is the inappropriate delivery route. This caused in more delivery distance and of course the greater cost for fuel. For this reason, a good strategy is needed so that the delivery process of toys can run effectively and efficiently.

Research related to route search have been done by [8] to find delivery routes using the Tabu Search method and [4] using the Sweep method. The previous research indicate that the route produced using Tabu Search better than the manually route. And also indicate that the Sweep method produced a better route than the route designed by the company, besides that the Sweep method was considered suitable for route based on reality in the field. Referring to the previous research, this research made a comparison of the two methods, namely the sweep method and the tabu search method. Comparison of this method is done to find the best method in producing item delivery routes by paying attention to the maximum volume capacity of the vehicle. The best method produced is then applied in the development of applications to produce delivery routes.

II. LITERATURE REVIEW AND RELATED SEARCH

A. Related Research

Related research to this research is that the use of the Sweep method. The research conducted by [10] use sweep method to develop applications that can determine the distribution routes of newspapers. The sweep method consists of two stages, first stage is clustering customers by region and available vehicles and second stage is make the route each cluster. The calculation results obtained by two routes with a total travel time of 5 hours 55 minutes. Other research conducted by [3] used the sweep method to determine the delivery route of the newspaper. The application of route determination using the sweep method results in a total vehicle mileage of 142.9 km with a travel time of 210 minutes. This result is better 32 km in terms of distance and 23 minutes is better in terms of time than the company currently used. The percentage of mileage savings that has been calculated is 18.29%. Research by [4] conducted a comparison of heuristic methods and metaheuristic methods to resolve CVRP. The sweep method is included in the heuristic method. The sweep method was chosen because the sweep method produced a solution that was in accordance with the real conditions in the field for the optimization of sugar distribution problems.

Research related to this study is that the use of the Tabu Search method has been carried out in previous studies. Research by [2] uses the Tabu Search method to produce the item delivery route. The 1 week test results show that applications that use the method produce delivery routes with a better delivery time than the current company route. The difference in total delivery time obtained is 2196 minutes or 36.6 hours and the difference in the total delivery costs is Rp. 540,984 compared to the company's route for the current 1 week. The percentage of total delivery costs that can use the Tabu Search method is 17.71% and the total delivery time savings reaches 8.39%. Other research by [11] used the Tabu Search method with 16 customer data and 300 liter maximum vehicle capacity. Tabu search method calculation consists of five steps, namely determining the initial solution, searching for neighborhood solutions, selecting the best neighborhood solution in each iteration, updating the tabu list and selecting the optimum solution from the tabulist. The calculation results obtained the

shortest and optimal route with a total distance of 101.1 km. Research by [8] applied the Tabu Search method to determine the delivery route of 30 customers. The application produces two shipping routes for each vehicle with a total distance for vehicle 1 of 27125 and for vehicle 2 of 27990.

B. *Sweep Method*

Sweep Method is an algorithm using the two-phase method with the first phase in the form of customer clustering based on the region and available vehicles, and phase two consists of make the routes for each cluster. To resolve CVRP model using the Sweep Method, it takes two stages or phases, namely the clustering phase and the route formation phase. The clustering phase is done by sorting the polar angle of each agent to the depot then grouping it by taking into the volume of the vehicle [10]. The steps taken at the grouping stage are to determine all the polar coordinates of each agent with the initial depot using the formula below.

$$r=\sqrt{x^2+y^2} \quad (1)$$

$$\theta=\arctan\frac{x}{y} \quad (2)$$

The phase of distribution route formation from each cluster is completed using the Nearest Neighbor method, so delivery routes for each cluster formed. The steps of forming a delivery route are determining the starting point of the delivery, then adding the next point with the minimum distance and so on until all points included in the delivery route [6].

C. *Tabu Search Method*

The tabu search method is one method that is within the scope of the heuristic method. This method uses short-term memory to keep the search process from being trapped at the local optimum value. This method uses a tabulist to store a set of solutions that have just been evaluated. The optimization process in each iteration, the evaluated solution is matched first with the contents of the tabu list to see if the solution is already in the tabulist. If the solution is already in the tabu list, then the solution is not evaluated again in the next iteration. New solutions are not formed to become members of the tabulist, the best value just obtained is the real solution [1].

The steps of calculation in Tabu Search method explained as follows [7].

- Select the initial solution i in the set S. Set i*=i dan k=0 where i* is the best solution and k is the number of repetitions that occur when searching the best solution i*.
- Set k=k+1 and produce the subset V* if the solution in the set solution N(i,k) therefore the tabu conditions doesn't meet aspirations conditions
- Select the best solution j in the sub set V* set i=j.
- If f(i) ≤ f(i*) then set i*=i.
- *Update tabu*list and *aspirations conditions*.
- If the stopping conditions are met, then the search stop. If not, do step 2.

III. RESEARCH METHODOLOGY

This part also explain about the stages of the research that manage as follow in Figure 1.

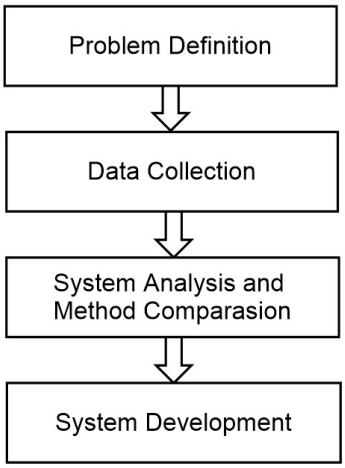

Fig 1. Research Methodology

Figure 1 is a research methodology where the research step is defining the problem of the system to be built, namely the problem of the route of delivering items. Data collection is done by collecting for various literature studies related to sweep and tabu search methods which then search for route search applications that have previously been developed. Defining the problem of the built system, to increase knowledge and understanding about it. Methods of data collection observation stages, interviews and literature review methods. Systems analysis is done by identifying problems that occur in delivering item and comparing of two methods, namely Sweep and Tabu Search method using manual calculations. Development of systems is based on the results of system analysis and manual calculation of two method. The system built using the best method is the Tabu Search method to form the best delivery routes. Development system using PHP programming language and MySQL database.

IV. RESULT AND DISCUSSION

In this part, we discuss the comparison of Sweep and the Tabu Search method in forming delivery routes. There are two cases resolved, namely if the delivering volume does not exceed the maximum capacity of the vehicle and the delivering volume exceeds the maximum capacity of the vehicle. Both of these cases are used to find out which method is best used to search for delivery routes for children's toys. Parameters used to determine which method is the most suitable is the total distance generated from the shipping route.

A. *Forming Route Using Sweep Method*

The forming route with the sweep method starts with searching for the distance matrix for each delivery point then looking for the closest route between points. In the case below the clustering process is not carried out because the shipping volume does not exceed the maximum volume capacity of the vehicle.

TABLE I. DELIVERING DATA

ID	Latitude	Longitude	Volume (m^3)
1	-8.673808	115.217078	0.2
2	-8.66753	115.22167	0.6

3	-8.666681	115.215147	0.3
4	-8.672576	115.209593	0.1
5	-8.672809	115.221202	0.5
6	-8.6609547	115.203015	0.3
7	-8.6735125	115.192475	0.2
8	-8.6779247	115.204389	0.2
9	-8.6758883	115.201402	0.1
10	-8.67011860	115.200715	0.5

Table I show the delivery data that must be done. It can be seen that the total volume of delivery is 3 m^3so it does not exceed the maximum capacity of the vehicle which is 3 m^3. The next step is to find a distance matrix from each delivery point with the help of Google Maps. The distance matrix can be seen in Table II.

TABLE II. DISTENCE MATRIX

	0	10 62	13 67	75 3	94 6	14 52	26 10	31 01	19 36	19 70	20 87
	97 6	 0	12 18	20 94	13 28	12 89	42 56	46 34	23 26	26 13	22 56
	17 57	11 92	 0	21 56	23 25	64 1	43 17	44 80	33 15	33 50	34 67
	77 8	10 23	84 0	 0	13 46	14 03	23 26	35 01	23 37	23 71	21 28
	94 6	16 30	19 35	13 21	 0	20 20	25 44	25 32	11 82	12 16	13 00
	15 83	85 2	22 62	21 79	21 51	 0	43 40	43 07	31 07	31 76	32 93
	27 52	35 01	33 17	25 51	26 86	38 80	 0	32 37	34 14	27 53	24 53
	31 01	37 86	40 90	38 32	25 32	41 76	32 30	 0	23 04	18 62	20 07
	18 26	23 31	28 16	22 02	10 72	29 01	30 54	26 71	 0	98 9	15 15
	19 70	26 65	29 60	27 25	12 16	30 49	26 12	18 62	98 9	 0	10 72
	20 87	27 72	30 77	24 95	13 00	31 62	24 53	20 07	15 15	10 72	 0

Table II shows the distance matrix between each delivery point. The sweep method works by finding the lowest distance from each point starting from the depot or the shipping center (point 0). Forming the delivery routes using Sweep method can see below.

TABLE III. DELIVERY ROUTES

Route	Point Distance	Route Distance
0-3	778	778
0-3-4	1321	2099
0-3-4-8	1072	3171
0-3-4-8-9	989	4160
0-3-4-8-9-10	1072	5232
0-3-4-8-9-10-7	2007	7239
0-3-4-8-9-10-7-6	3237	10476
0-3-4-8-9-10-7-6-1	4256	14732
0-3-4-8-9-10-7-6-1-5	852	15584
0-3-4-8-9-10-7-6-1-5-2	641	16225
0-3-4-8-9-10-7-6-1-5-2-0	1367	17592
Total Distances		17592

Table III show the delivery route formed using the Sweep method, where the starting point and end point of delivery are point 0 or depot. From this point 0, choose the next point with lowest distance, which is point 3. From point 3, choose again the next point with the lowest distance and so on until all delivery points are fulfilled. The delivery route formed using the Sweep method is 0-3-4-8-9-10-7-6-1-5-2-0 with a total distance of 17592 meters.

B. Forming Route Using Tabu Search Method

The forming steps of a delivery route with the tabu search method starts with making the initial route solution. The initial solution formed was 0-3-4-8-9-10-7-6-1-5-2-0 with a total distance of 17592 meters. The next step is doing the iteration to find alternative route solutions. Iteration is done by moving two points so that a new route is formed, then compared with the initial solution if the distance formed is shorter than the new route is included in the tabulist.

TABLE IV. TABULIST

Iteration	Route	Distance
1	0-3-6-8-9-10-7-4-1-5-2-0	17171
2	0-3-6-7-9-10-8-4-1-5-2-0	16378
3	0-3-6-7-10-9-8-4-1-5-2-0	15997
4	0-3-6-10-7-9-8-4-1-5-2-0	16010
5	0-3-6-7-10-9-8-4-1-5-2-0	15997

Table IV show the tabulist. Tabulist stores the results of alternative routes that have the shortest distance in each iteration. All routes in the tabulist are then compared and selected with the shortest distance. The route generated by the Tabu Search method is 0-3-6-7-10-9-8-4-1-5-2-0 with a total mileage of 15997 meters.

Based on the results of the calculation, the comparison of routes formed by the Sweep method and Tabu Search are as follows.

TABLE V. RESULT COMPARATION FOR CASE 1

Method	Route	Distance
Sweep	0-3-4-8-9-10-7-6-1-5-2-0	17592
Tabu Search	0-3-6-7-10-9-8-4-1-5-2-0	15997

Table V show the comparisons of route formed using the Sweep method and Tabu Search method. Based on distance, it can be seen that the Tabu Search method has a shorter distance than the Sweep method with total distance 15997 meters with a distance difference 1595 meters. Based on the calculations performed in case the volume does not exceed capacity, it can be proved that the route produced by the tabu search method is better than the sweep method because it has a shorter of total distance.

Another cases in delivering item where the delivery volume is exceed the maximum vehicle volume, so more than one delivery is required. This case is used to find a better method of producing a delivery route that must be done more than once. This case can also be used as proof of whether the tabu search method still produces a better delivery route as in the first case. The parameter used is the total distance from each route produced.

C. Forming Routes Using Sweep Method

Forming route using Sweep method for this case begins with the clustering stage by sorting the polar angle and then grouping it according to its volume. After the clustering process, its form the routes for each cluster by looking for the distance matrix for each point and looking for the closest route between points. Examples of delivery data shown in Table VI.

TABLE VI. DELIVERY DATA

ID	Latitude	Longitude	Volume (m^3)
1	-8.673808	115.217078	0.5
2	-8.66753	115.22167	0.6
3	-8.666681	115.215147	0.3
4	-8.672576	115.209593	0.5
5	-8.672809	115.221202	0.5
6	-8.6609547	115.203015	0.3
7	-8.6735125	115.192475	0.4
8	-8.6779247	115.204389	0.4
9	-8.6758883	115.201402	0.3
10	-8.67011860	115.200715	0.6

This case is solved first by doing clustering or grouping of items. Clustering in the sweep method is done by finding the polar degree of each delivery point against the depot with formulas (1) and (2) then sorted.

TABLE VII. DELIVERY DATA WITH POLAR DEGREE

ID	Latitude	Longitude	Volume	Degree
1	-8.6609547	115.203015	0.3	36
2	-8.67011860	115.200715	0.6	87
3	-8.6735125	115.192475	0.4	101
4	-8.6758883	115.201402	0.3	123
5	-8.672576	115.209593	0.5	133
6	-8.6779247	115.204389	0.4	140
7	-8.673808	115.217078	0.5	224
8	-8.672809	115.221202	0.5	249
9	-8.66753	115.22167	0.6	294
10	-8.666681	115.215147	0.3	334

Table VII show the delivery that has been sorted by the smallest polar degree. The sorted delivery data is then cluster by volume to meet the maximum vehicle volume, data that does not meet will enter the second cluster. The cluster data can be seen in Table VIII.

TABLE VIII. CLUSTERED DATA

Delivery Number	ID	Volume
Delivery 1	6	0.3
	10	0.6
	7	0.4
	9	0.3
	4	0.5
	8	0.4
	1	0.5
	3	0.3
Delivery 2	5	0.5
	2	0.6

The results of cluster data can be seen in Table VIII, where delivery 1 consists of ID 6-10-7-9-4-8-1-3 and delivery 2 consists of ID 5-2. The next step after the delivery data has been successfully clustered is to determine the delivering route for each cluster in the same way looking for the lowest distance from the starting point to the destination point.

TABLE IX. DELIVERY ROUTE 1 AND 2

Route	Distance	Route Distance
0-3	778	778
0-3-4	1321	2099
0-3-4-8	1072	3171
0-3-4-8-9	989	4160
0-3-4-8-9-10	1072	5232
0-3-4-8-9-10-7	2007	7239
0-3-4-8-9-10-7-6	3237	10476
0-3-4-8-9-10-7-6-1	4256	14732
0-3-4-8-9-10-7-6-1-0	2772	17504
Total Distance for Delivery 1		17504
0-5	1583	1583
0-5-2	641	2224
0-5-2-0	1367	3591
Total Distance for Delivery 2		3591
Total Distance		21095

Table IX show delivery routes for delivery 1 and 2. The delivery routes for delivery 1 are 0-3-4-8-9-10-7-6-1-0 with a total distance of 17504 meters, while the delivery routes for delivery 2 are 0- 5-2-0 with a total distance of 3591 meters. The total distance of two delivery is 21095 meters.

D. Forming Routes Using Tabu Search Method

The process of forming a delivery route using the Tabu Search method for cases where the volume exceeds the maximum vehicle volume is same as the sweep method, if the data is first clustered. The initial solution for delivery 1 was 0-3-4-8-9-10-7-6-1-0 with a total mileage of 17504 meters and for delivery 2 0-5-2-0 with a total distance of 3591 meters. The next step is iteration to find a solution for the alternative routes of each delivery.

TABLE X. TABULIST

Delivery Number	Iteration	Route	Distance
Delivery 1	1	0-1-4-6-9-10-7-6-3-0	14062
	2	0-1-4-8-9-7-10-6-3-0	14068
	3	0-1-4-8-9-10-7-6-3-0	10462
Delivery 1	1	0-2-5-0	5471
	2	0-5-2-0	3591
	3	0-2-5-0	5471

Table X show the tabulist for delivery 1 and delivery 2. The best route produced for delivery 1 is 0-1-4-8-9-10-7-6-3-0 with a total distance of 14062 meter and for delivery 2 is 0-5-2-0 with a total distance of 3591 metesr. The total distance generated for the two delivery using the Tabu Search method is 17653 meters.

Based on the results of the calculation, the comparison of routes formed by the Sweep and Tabu Search method are as follows.

TABLE XI. RESULT COMPARATON FOR CASE 2

Method	Delivery Route 1	Delivery Route 2	Distance
Sweep	0-3-4-8-9-10-7-6-1-0	0-5-2-0	21095
Tabu Search	0-1-4-8-9-10-7-6-3-0	0-5-2-0	17563

Table XI show the comparison of the routes formed using the Sweep and the Tabu Search method for cases where the volume exceeds the maximum vehicle volume so that two delivery must be done. Based on delivery distance, it can be seen that the Tabu Search method has a shorter distance than the Sweep method with total distance 17563 meters and with a distance difference 3532 meters. Based on the results of the calculation it can be seen that the tabu search method produces better delivery routes even though delivery must be done more than once with a shorter total delivery distance.

Based on the results of calculations for the two cases used, namely from two shipping cases, both the volume not

exceeding and exceeding capacity, it can be proved that the tabu search method produces a better delivery route than the sweep method in terms of total distance parameters. So that in its practice, applications that are built to produce delivery routes can use the tabu search method. With the construction of applications to search shipping routes with the appropriate method, namely the tabu search method, it can benefit the toy rental company. The benefits include delivery to be more effective and efficient, in addition to reducing the amount of shipping costs that must be incurred.

E. Delivery Route on Application

This part shows the results of the route generated by the application. The application that was built utilizes a goggle maps api, making it easier for drivers to make deliveries. In the application the driver can see the entire delivery route, delivery order and delivery route for each point.

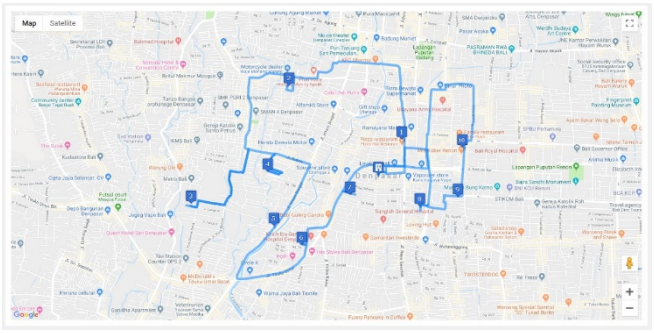

Fig. 2 Delivery Route for Case 1

Figure 2 shows the results of the delivery route for the case the delivery volume does not exceed the maximum vehicle volume so that the delivery is done once. The route formed is 0-3-6-7-10-9-8-4-1-5-2-0.

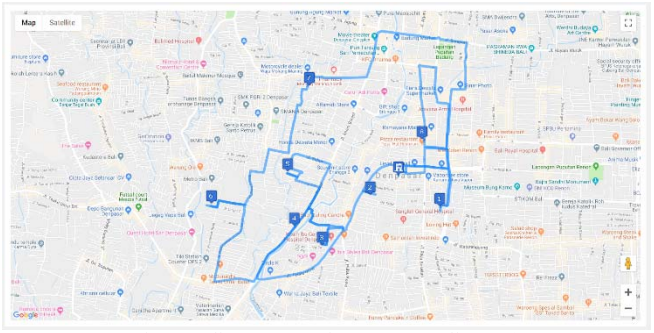

Fig. 3 Delivery Route for Case 2 (Delivery 1)

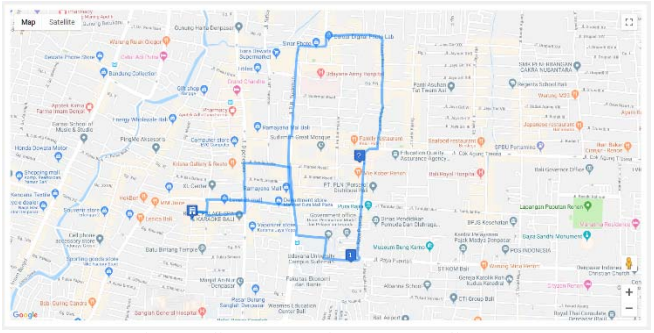

Fig 4. Delivery Route for Case 2 (Delivery 2)

Figures 3 and 4 shows the results of delivery routes for case 2 where the volume of delivery exceeds the maximum vehicle volume so that delivery are done twice. The route formed for delivery 1 is 0-1-4-8-9-10-7-6-3-0 and for delivery 2 is 0-5-2-0.

V. CONCLUSION

Conclusions obtained based on the results of calculations for two different case, namely one delivery and two delivery using the Sweep and Tabu Search method is the Tabu Search method form a better and shorter delivery route compared to the Sweep method with a difference delivery distances are 1595 meters for case 1 and 3532 meters for case 2.

VI. FUTURE WORK

Suggestions that can be given for further development are the applications developed not only based on volume but also on the operational time so that no driver works beyond his working hours and also the route search process using other methods.

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