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Optimization for routing vehicles of seafood product transportation

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Abstract. Recently, increasing usage of marine products is creating new challenges for businesses of marine products in terms of transportation that used to carry the marine products like seafood to the main warehouse. This can be a problem if the carrier fleet is limited, and there are time constraints in terms of the freshness of the marine product. There are many ways to solve this problem, including the optimization of routing vehicles. In this study, this strategy is to implement in the marine product business in Indonesia with such an expected arrangement of the company to optimize routing problem in transportation with time and capacity windows. Until now, the company has not used the scientific method to manage the routing of their vehicle from warehouse to the location of marine products source. This study will solve a stochastic Vehicle Routing Problems (VRP) with time and capacity windows by using the comparison of six methods and looking the best results for the optimization, in this situation the company could choose the best method, in accordance with the existing condition. In this research, we compared the optimization with another method such as branch and bound, dynamic programming and Ant Colony Optimization (ACO). Finally, we get the best result after running ACO algorithm with existing travel time data. With ACO algorithm was able to reduce vehicle travel time by 3189.65 minutes, which is about 23% less than existing and based on consideration of the constraints of time within 2 days (including rest time for the driver) using 28 tons capacity of truck and the companies need two units of vehicles for transportation.
Keywords: Optimization, Indonesia Marine product, Stochastic Vehicle Routing Problem with Time Windows and Capacity Windows, Ant Colony Optimization.

1. Introduction

Based on a news article written by Deny in 2015[1], President Joko Widodo has goals to restore Indonesia's maritime heyday. It is becoming a reference for the various parties to participate in achieving goals. To achieve these goals has a lot of ideas that was blasted out. The idea of the toll of the sea, such as building improvements to regulation, legal affirmation, to attract investors to participate build a sector maritime Indonesia begins to look. This is evident with the start of the work of the project with a fantastic nominal [2].

Minister of marine and the fisheries from Indonesia, Susi Pudjiastuti has several times issued its policy regarding fishing and fish were able to reduce the theft of up to 50 percent it will increase the productivity of the fishermen and this situation needed the transportation to send the products to customer such as fresh market. In fact, the catch increased indirect impact on improving the welfare of fishermen. This can occur if the selling price of the catch from the fishermen to the dealer/company is still low, while the selling price of the catch to consumers. Increased costs occurring during the process of distribution of the catches. As expressed by the Chairman of the Association of Logistics

and Forwarders Indonesia (ALFI), the increase in food prices caused by the high cost of distribution. Increasing in price that is too high can also affect the purchasing power of consumers will be the products of the sea. An increase in the harvest of the sea also spawned new obstacles for the company engaged in the export of seafood products. The company may experience constraints in terms of transporting the catch. This can happen if the constraints almost all locations experienced a harvest [3], but the transport resources owned by a limited company.

The easiest solution that can be offered is the purchase of a vehicle to transport as well as the recruitment of drivers. However, this requires more costs [4]. More costs are for the purchase of the vehicle and the driver's salary (even though the vehicle is not used if the sea after harvest). This is the problem that we want to solve in this research. During this time the company has not used the scientific method in determining the route of the transport vehicle. The company still uses the conventional way in determining the route of the vehicle transport, namely by looking at the distance on the map. As the vehicle routing is a multi-objective decision that not simple to solve [5]. Thus, companies require finding the optimum route results with methods that can be used to complete the VRP based research from Golden in 2008 [6]. In this research, to solve this VRP problem [7] for the seafood products, we want to compare the optimization with several algorithms as previous research with time uncertainty [8] and stochastic demands [9]. In this research, we compared the optimization of this VRP problem in seafood products on another metaheuristic methods such as Ant Colony Optimization [10], compared to methods modeling in WinQSB software as Branch and Bound, Dynamic Programming, Two-Way Exchange Improvement, Cheapest Insertion, Nearest Neighbor[11] to find which one could get the best result for optimization.

2. Research methodology

The stages of research briefings can be seen in figure 1.

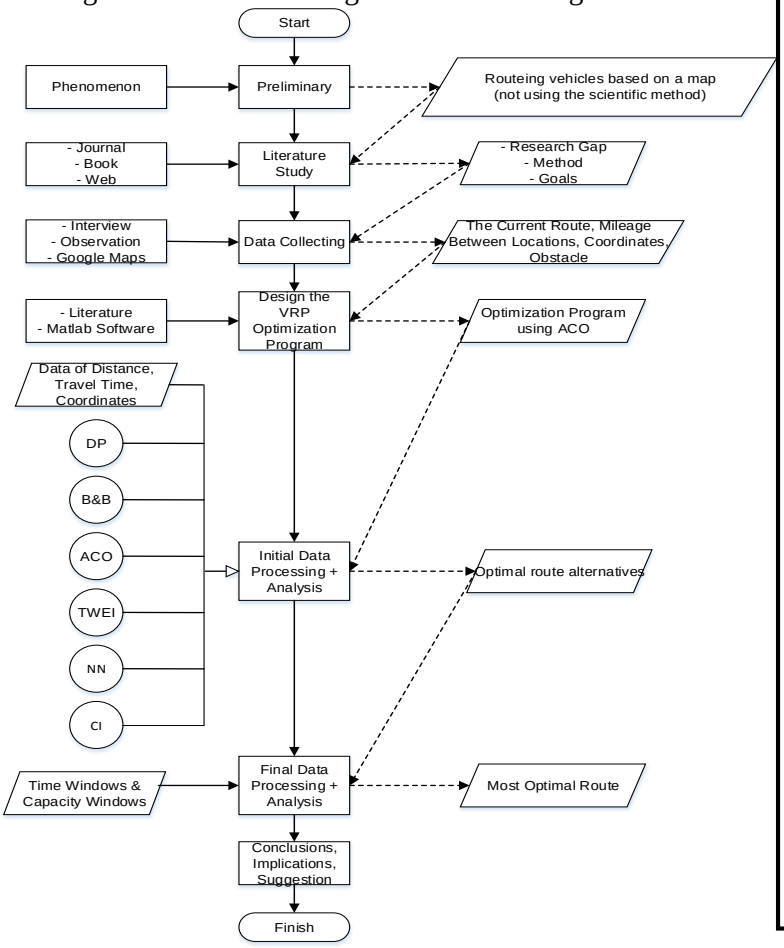

Figure 1. Research methodology

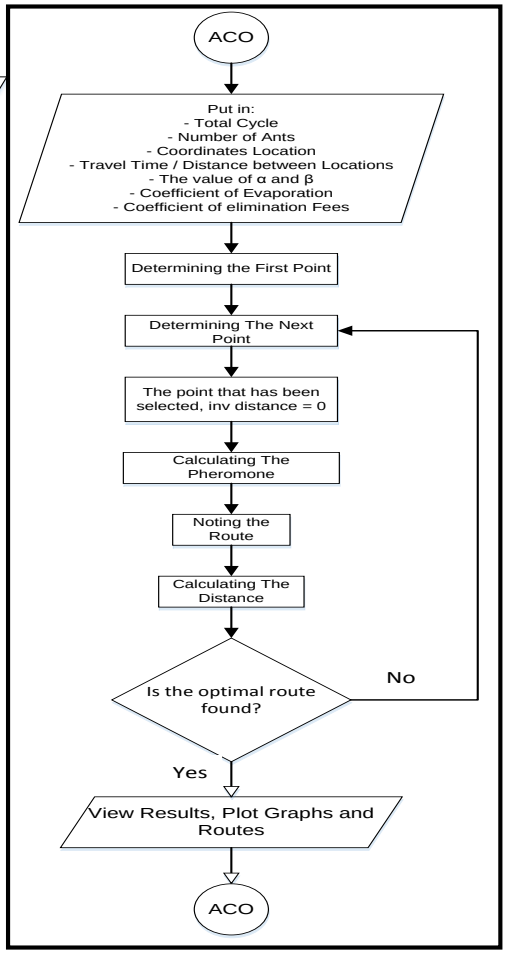

Figure 2. ACO Algorithm used in MATLAB

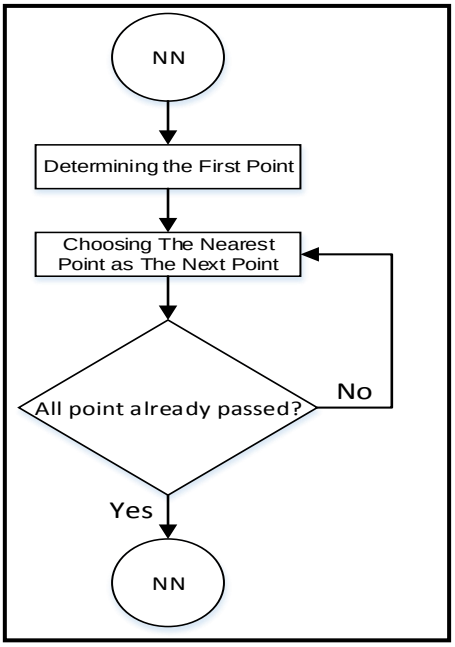

Figure 3. Nearest Neighbor Algorithm used in Software WinQSB

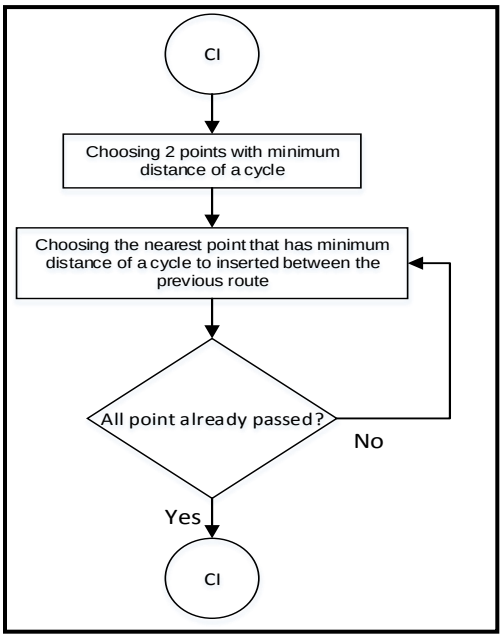

Figure 4. Cheapest Insertion Algorithm used in WinQSB

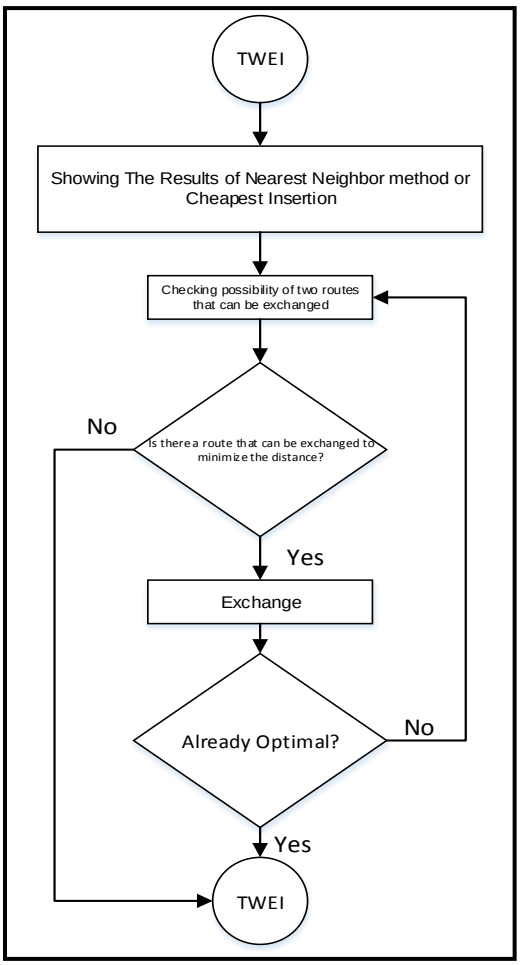

Figure 5. Two-Way Exchange improvement used in WinQSB

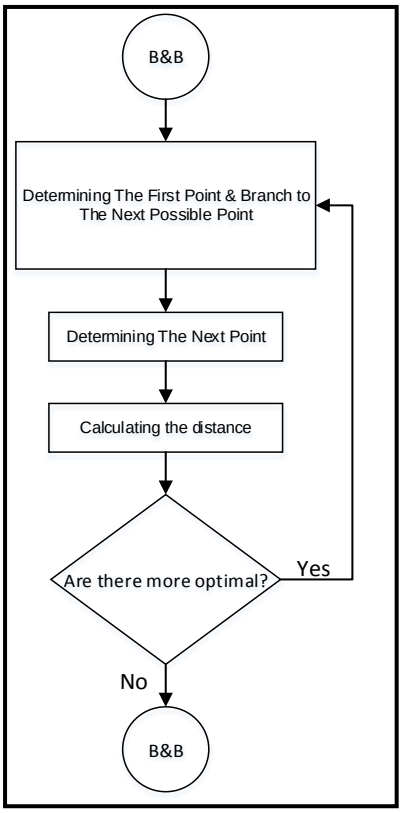

Figure 6. Branch and bound algorithm used in WinQSB

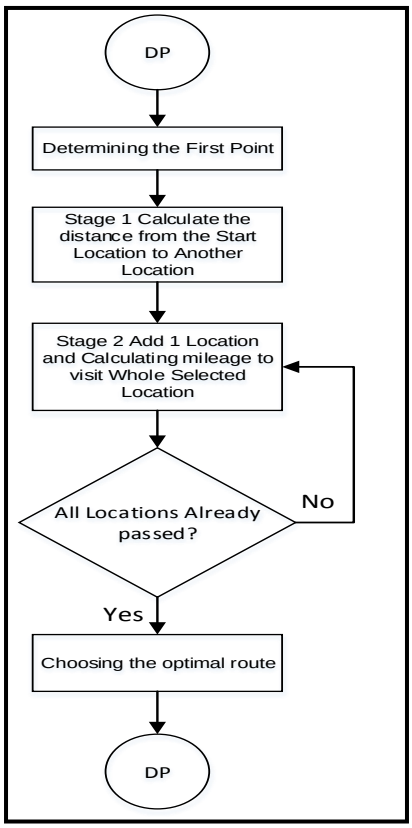

Figure 7. Dynamic programming algorithm

A flow diagram can be seen on the research methodology starting from the discovery of the phenomenon, to getting the results and conclusions of the research. For the step of the algorithm we described in figure 2 as the flow diagram of ACO algorithms according to our reference[12] that we run the algorithm using MATLAB data processing with licensed version 2013b from Mathworks. In figure 3 until figure 6 we showed the four algorithm flowchart shows the methods contained in the software i.e. WinQSB as Nearest Neighbor, Cheapest Insertion, Two-Way Exchange Improvement, and Branch and Bound as a comparison of ACO algorithm. Also for comparing the result of optimization in figure 7, we showed the algorithm of the Dynamic Programming using analytic method.

3. Data collection

The object of the research is a national company exporter of marine products such as fish, prawn, and seaweed was located at West Nusa Tenggara. We have collected data from January 2015 till March 2015 such as the location of source marine products as seaports or fishing village, the travel time between location and capacity of the vehicle are obtained from the interview with the company. The location of the selected capture is not the entirety of the location of the fishing area in Indonesia but represented by area that was rated to do research on the determination of transport vehicle lines. The area is selected with consideration of the following:

1) The distance between locations is not the same. The distance between the location of more or less the same, even the same votes is not too important to do the research because the route of the vehicle can smother them or pick up the catch is sorted from most locations do end up to the most approaching the main warehouse (location 1) as described in figure 8.

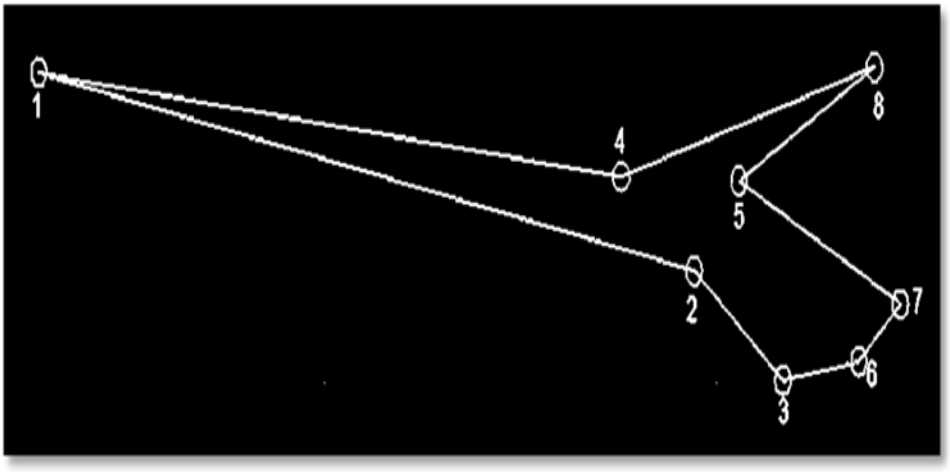

Figure 8. The current route

2) The region is one of the regions with a total harvest per day, more and the number of the location of the fishing area more than other regions. Location data obtained, in the plot into the map coordinates. The coordinates of a location can be seen in table 1. The first location was the main warehouse, whereas the other location is the location of the source of marine products.

Table 1. The coordinates of each location

Coordinates / Location	X	Y	Capacity (tons/day)
1 (Warehouse)	1,7	6,9	-
2	23,4	2,7	5
3	26,8	0,4	10
4	20,6	4,7	6
5	25,1	4,6	4
6	29,7	0,8	5
7	31,3	2	4
8	30,3	7	6

The distance between the locations as we get from Google Maps and shown in table 2 in units of kilometers.

Table 2. The distance between locations (kilometers)

Distance	1	2	3	4	5	6	7	8
1	0	1551.8	1576.4	1538.9	1564.64	1601	1612	1708
2	1551.8	0	40.33	34.35	15.6	62.36	72.32	165.54
3	1576.4	40.33	0	57.43	24.03	22.03	31.99	125.21
4	1538.9	34.35	57.43	0	20.94	45.74	54	48.4
5	1564.64	15.6	24.03	20.94	0	33.42	33.01	32.46
6	1601	62.36	22.03	45.74	33.42	0	9.96	103.18
7	1612	72.32	31.99	54	33.01	9.96	0	93.22
8	1708	165.54	125.21	48.4	32.46	103.18	93.22	0

Travel time between locations which are obtained from the results of the interview is shown in table 3. in units of minutes. In fact, it takes is not always the same in each time travel, but the travel history recorded by the company showed that the difference between each trip not too large. Thus to simplify this, we used average travel time to complete the matrix.

Table 3. Travel time between locations (minutes)

Travel time	1	2	3	4	5	6	7	8
1	0	1446	1448	1445	1559	1450	1451	1464
2	1446	0	90	180	90	120	180	240
3	1448	90	0	45	35	20	30	75
4	1445	180	45	0	20	40	20	19.65
5	1559	90	35	20	0	30	40	10
6	1450	120	20	40	30	0	25	300
7	1451	180	30	20	40	25	0	240
8	1464	240	75	19.65	10	300	240	0

4. Results and discussion

From this research, we obtained the three approach of positioning the search space has several advantages and disadvantages. The advantage of the optimization based on the Cartesian coordinate is can be the route that does not tangle. The shortcoming of this optimization is to ignore the condition of the road should turn/rotate, the difficulty of the terrain, and traffic congestion. This condition resulted in the route gained can require relatively high travel time. Approach distance with coordinates should not be done in the process of optimization of the VRP as shown in table 4 with the capacity of vehicle set for 28 tons. That approach distance was assessed quite reasonable because will consider aspects of the terrain of the road but has a weakness that is ignoring the aspect of time.

Table 4. Comparison of the optimization result without constraint

The optimization results	Approach		
	Coordinate	Distance	Time
Distance(km)	3309.64	3276.89	3323.62
Travel time (minutes)	29357	29182	3189.65

Approach distance was judged well done if the condition of the distance with the travel time is directly proportional. The short distance that would not necessarily require less travel time compared to long distances. Therefore, the best approach is to consider the travel time that figured the situation of traffic, rest time for the driver and loading time. As additional reason, the approach it takes is rated very fit with the case because of a few things. First, the route gained will absolutely optimal. This can be seen by comparing the time it takes between the three approaches. In addition, the product, in this case, products that get from the sea was required special handling such as cooling and will quickly damage if not quickly deposited in special warehouses. One of the obstacles faced is time constraints. With the same unit, will facilitate the optimization is done.

Table 5. Result Comparison of Six Method that Used in This Study

Methods	Branch and bound	Dynamic programming (Analytic)	Ant Colony (Metaheuristic)	Two-way exchange improvement (Heuristic)	Cheapest insertion (Heuristic)	Nearest neighbor (Heuristic)
Travel time (minutes)	3189.65	3189.65	3189.65	3189.65	3380.65	3293.65

The optimize route obtained a results with data in the form of distance in units of length are the same as the route that carried the company at this time. Through research with data usage and ACO algorithms in the form of a time that has been done at this stage, the travel time, travel can be pressed up to about 23% of the time it takes the current (routes obtained from a distance on a map). In this research we run the algorithm using various alpha value and beta value for testing the optimization result. In the ACO algorithm, the alpha value is the rank value for the ant's sight. The value of the ant's

sight is describing the ability of ants to see the trace or pheromone and the beta value is the value of rank for tracers effect, this phenomena was used to find the optimization. By using this algorithm the optimum travel time can be seen in table 5. It has indicated a reduced time of 4147 minutes into 3189.65 minutes. This result has more efficient in time and supported the factor of capacity and time windows as objective in this transportation system of marine products.

The value of the trace's effect describes the ability of ant leaves a trace or pheromone. In accordance with the logic of the algorithm, if the value of alpha and beta to be promoted, should affect the most optimal results quickly found. It also fits with the findings of the authors during the process of research. Comparison of method by using the WinQSB software optimization with calculation and Dynamic Programming is used on the condition without any constraints of time and capacity. Optimization results by using the methods of the ACO to be compared with the results of the four methods that are there are WinQSB software and methods on Dynamic Programming. As said by our literature [13], an analytic method is able to get the most optimal though takes a long computation but based on comparisons of methods of testing, which is done, do not cover the possibility of other methods (heuristic and metaheuristic) can find the optimum results and speed in obtaining the results of each method, the analytic method takes more time needed.

Another case with a heuristic method result is not always a global optimum [14]. The theory is evident from the length of time to run the program. The pace looks not so different when the program starts, but if we study each software used will we find differences that affect the speed of the process. The difference is the ability in the core utilization on the processor of the computer. In this research by using WinQSB utilized the entire core of processor, which is different with MATLAB that are only utilized one core to compute the algorithm. In practice, we compared WinQSB and MATLAB is installed on a computer with a number of four-processor core.

Application of stochastic on this issue, not very influential on the value of optimization, it is apparent from the discovery global optimal route at the output of the program MATLAB to ACO. This can occur because the algorithm is designed to obtain routes intact (the beginning and end of the route at one point). If the identification is done more in taking into account the time constraints and capacity, then schedule the assignment of optimal transport vehicles can be obtained.

Table 6. Optimal Route Generated by Six Methods

Methods	Branch and bound	Dynamic programming (Analytic)	Ant Colony (Metaheuristic)	Two-way exchange improvement (Heuristic)	Cheapest insertion (Heuristic)	Nearest neighbor (Heuristic)
Travel time (minutes)	3189.65	3189.65	3189.65	3189.65	3380.65	3293.65
Optimal route	1-2-3-6-7-4-8-5-1 1-2-3-7-6-4-8-5-1 1-5-8-4-7-6-3-2-1 1-5-8-4-6-7-3-2-1	1-2-3-6-7-4-8-5-1 1-2-3-7-6-4-8-5-1 1-5-8-4-7-6-3-2-1 1-5-8-4-6-7-3-2-1	1-2-3-6-7-4-8-5-1 1-2-3-7-6-4-8-5-1 1-5-8-4-7-6-3-2-1 1-5-8-4-6-7-3-2-1	1-2-3-7-6-4-8-5-1	1-5-7-6-2-3-8-4-1	1-5-4-6-3-7-2-8-1

Companies are advised to use analytical methods or methods of metaheuristic optimization results because its global optimum value found as the result shown in table 6. Based on our computational result, we do not recommend the company to use heuristic methods. In addition to the results of the analytical method and optimization of the metaheuristic better than the heuristic methods.

5. Conclusion

In this research, we have considered the seafood product delivery routing problem in Indonesia as transportation with time and capacity windows and we confirmed that some algorithms are proved to solve these problems effectively and at reasonably running times. In accordance with the research objectives, the results of the research can be listed as follows: The company has 4 alternative routes with a total minimum travel time i.e. 3189.65 minutes and with the constraints of time within 2 days and 28 tons capacity for each vehicle we get solution that needed at least two trucks as route 1-2-3-6-7-1 and route 1-4-8-5-1. And for the optimum alternative, the first alternative vehicle utility level is very good because every vehicle transporting corresponds to minimum time and maximum capacity.

From the results calculated by using the method of the ACO, the presence of stochastic, not too influential in the global optimum value, this is shown by the discovery of the remains of a global optimum. Stochastic has had an impact on the priority of the location in terms of transport. Changes in priorities will certainly have an impact on the issue of optimization results are not optimal based on travel time. Next, by doing experimental computation from six methods. Therefore, the proposed method such as ACO can be considered as an effective method for the seafood product delivery routing problem.

We hope this presented research can offer another researcher different insights into the issue of VRP, and promote the exploration of new algorithm to solve the VRP problem in more efficient computational time needed.

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