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Research paper



Determination of liquid product distribution route using clark and wright saving and tabu seacrh algorithm for a milk industry in indonesia

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Abstract

Distribution system is a bridge between producers and consumers where the level of importance is very high and the need for calculation of time and capacity of the determination of the route to be made. Therefore, it is necessary to propose effective and efficient distribution route determination by using Clarke & Wright and Tabu Search method and application proposal which must be in company. Based on the proposed distribution determination can determine the route of the achieved distribution channels, the efficiency of time and distance by taking into account the capacity, speed, route, and others. The Clarke & Wright and Tabu Search methods are used to determine the route of distribution routes and improvements on the routes route of distribution of ultra-liquid dairy products by considering the capacity aspect, vehicle speed, loading and unloading time, time matrix, distance matrix, distance saving, and iterations Contained in the method. Based on the calculation results can be concluded that the proposed determination of distribution feasible applied to the company because the comparison of time and distance performance resulting savings and improvements in time and distance by reducing the amount of time achieved on each route and tour contained in the applicable time horizon.

Keywords: *Distribution Route;Liquid Milk;Clarke & Wright;Tabu Search*

1. Introduction

This introduction contains about the background of product distribution in Indonesia.

1.1. Introduction

Distribution channels in Indonesia, especially in the city of Bandung into the spotlight is important because access fleet, etc(1). is an important matter in building a bridge between producers with consumers so it needs a definite distribution route based on quantitative method in order to become the driver's reference in doing his duty in delivering goods.
Although currently the company has a special application contained in every gadget that is given to the fleet driver distribution but the application does not have a special route to do the distribution so it needs an access that allows the driver in doing his duties because the current conditions only the address of the customer or retailer only Contained in the application. On tours that have been done for the clarke & wirght method, there is no time limit outside the work just to avoid the overtime of course need for supervision and prevention in order not to happen overtime at the time set. Based on the results of interviews, due to fluctuations in demand at the company a milk industry in a week minimum overtime in the distribution of ultra-liquid milk in the package is as much as 3-5 hours. Seeing the current state of the company that there is no standard route maps only address list is located in the smartphone connection held by each driver can result in overtime. The Clarke & Wright method is used to create an initial distribution route, but not yet optimal enough because in one tour it will pass the working hours limit so as to cause overtime.

2. Literature Review

Literature study means used to collect data or sources related to the topics raised in a study.

2.1. Vehicle Routing Problem

Vehicle Routing Problem is a common term used by many parties. Some other experts use different names, with the same problem. Vehicle Routing Problem was first studied by Dantzig and Ramser (1959) in the form of route and truck scheduling(2). This VRP plays an important role in distribution management and has become one of the problems in optimizing the combination that is widely studied. The solution of a VRP is a number of customer delivery route routes where the vehicle departs from the depot then goes to the customer and returns to the depot. Clarke and Wright (1964) then continued this research by introducing the term depot as a place of departure and return of the vehicle. Clarke and Wright use Saving algotihm(3).
Problem formulation (4) :
We enumerate in what follows the main symbols used in the mathematical model (1)–(8):
Parameters

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n set of customers and the depot (0)
m number of vehicles
C capacity of each vehicle
Di demand of customer i
d_{ij}^{k} distance of a direct travel from customer i to customer j by vehicle k
Decision Variables
$x_{ij}^{k} = \begin{cases} 1 \; if \; vehicle \; k \; travels \; from \; customer \; i \; to \; j \\ 0 \; elsewhere \end{cases}$
K number of used vehicles

$$Minimizef(\mathrm{x}) = \sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{m} dijx_{ij}^{k} \quad (1)$$

S.t.

$$\sum_{k=1}^{m}\sum_{i=0}^{n} x_{ij}^{k} = 1 \;\; j = 0, \dots, i-1, i+1, \dots, n \quad (2)$$

$$\sum_{k-1}^{m}\sum_{j=0}^{n} x_{ij}^{k} = 1 \;\; i = 0, \dots, j-1, j+1, \dots, n \quad (3)$$

$$\sum_{i=0}^{n} x_{it}^{k} - \sum_{j=0}^{n} x_{ij}^{k} = 0 \;\; k = 1, \dots, m, i \neq j \;\; t = 0, \dots, n \quad (4)$$

$$\sum_{j=0}^{n} Dj\left(\sum_{i=0}^{n} x_{ij}^{k}\right) \leq C \;\; k = 1, \dots . m, i \neq j \quad (5)$$

$$\sum_{j=0}^{n} x_{oj}^{k} \leq 1 \; k = 1, \dots . m \quad (6)$$

$$\sum_{i=0}^{n} x_{io}^{k} \leq 1 \;\; k = 1, \dots . m \quad (7)$$

$$\sum_{i,j \in S} x_{ij}^{k} \leq |S| - 1 \;\; S \subseteq \{2, \dots . n\}, k = 1 \dots . , m \quad (8)$$

– Objective function: Eq. (1) designates the total traveled distance to be minimized in accordance with the set of system constraints.
– System constraints: Constraints (2) and (3) impose that each node is visited only once by one vehicle. Constraints
(4) ensure the continuity of vehicles' pathways. Constraints
(5) enforce the capacity constraint of the vehicles.
Constraints (6) and (7) ensure that each used vehicle starts and ends at the depot. Constraints (8) discard vehicles' sub-tours.

2.2. Clarke and Wright

One method that can be used to solve VRP problems is the Clarke & Wright method, this method includes the heuristic algorithm(5), where the heuristic algorithm is a technique designed to solve a problem that ignores whether the solution can be proved true, but usually results in a good solution or problem solving Simpler ones that contain or bypass with more complex problem solving(6).

2.3. Tabu Search

Tabu Search is one of the algorithms within the scope of the heuristic method(7). The basic concept of Tabu Search is an algorithm that guides each stage in order to produce the most optimum goal function without being trapped into the initial solution found during this stage(8). The purpose of this algorithm is to prevent the occurrence of looping and the discovery of the same solution on an iteration that will be used again in the next iteration. Tabu Search algorithm has Five main elements used to complete VRP [2] namely:

1. Solution Representation The solution representation used Tabu Search algorithm is a sequence of points (nodes), where each point (node) is seen only once in a sequence. The node represents depots and customers.
2. Initial Solution (Initial Solution) The initial solution is formed using a random method or heuristic method that will be fixed on the next iteration.
3. Neighborhood Solution
   Neighborhood Solution is an alternative solution obtained by making a move node (move). Each node move (move) will result in a Neighborhood solution.
4. Tabu List
   The tabu list contains movable attributes that have been found previously. Tabu List size will increase as the size of the problem increases. Tabu List List that is too long will not produce a good quality solution because it can cause too many node displacements (move) is prohibited (Glover and Kochenberger, 2003).
5. Aspiration Criteria
   The criterion of aspiration is a method to cancel tabu status (Glover and Kochenberger, 2003).
6. Criteria for Dismissal.
   The termination criteria used after all the iterations determined fulfilled.

Tabu search has been used to solve the VRP and its produced excellent results. The following are some paper that uses Tabu search for solving real-life VRP. Proposed a Tabu Search algorithm named DETABA to solve the VRP on a distribution company in Turkey. The algorithm is first tested upon the benchmark problems in the literature before it was used to solve the VRP for each plant of this distribution company. A considerable improvement in operational performance is achieved(9). Developed a Tabu Search approach to tackle the livestock collection problem in the Norwegian meat industry. The problem is viewed as a vehicle routing problem extended with inventory constraints to ensure a smooth production flow at the slaughter house(10). Applied Tabu Search for a commercial company that serves food products in the region of Jendouba in the north west of Tunisia(11).

3. Methodology/Materials

The data used in this study are customer demand data, distance between customers, distance depot to the customer and vehicle capacity as one of the producers.

3.1. Current Distribution System

A milk industry has marketing office or representative district located in Bandung city. Such offices or districts serve as depots where starting and ending the work of the distribution vehicle. This depot is the starting point of the distribution vehicle before heading to the retailers located in every area of Bandung municipality.
In every retailer, the distribution vehicle will transport a homogeneous product of 200 ml size to 750 Cars which will be replaced with filled and filled amount still available, then the distribution vehicle will go to other retailers. However, if the available time is still sufficient for the distribution process but the quantity sent is exhausted or the capacity unfilled to suffice the retailer's demand, then the distribution vehicle will return to the depot for charging. After the charging then will go back to other retailers. This will continue until the time available during the horizon planning

3.2. Troubleshooting

In this research, distribution system of a milk industry consists of one representative district located in the middle of Bandung or one depot (single depot) and a number of n places visited (retailers) with demand on each retailer that varies and the point of spread of retailers spread across The city of Bandung. In one business day the company distributed milk products with erratic because the company

does not have a route maps. This is a characteristic of VRP, ie multiple trips. This problem can be solved using the heuristic method as the initial solution and the exact method as an improvement solution, in this method there are several VRP troubleshooting techniques that can be used to solve the problem(12).
In this research the method used is Clarke & Wright method as the initial solution. The Clarke & Wright method is used because the calculation is based on the distance saving value, judging from the largest saving value to the smallest, it is expected to form a route or path with the smallest total distance. The improvement method used in this research is by using Tabu Search method. The use of Tabu Search method is used in this research because it can give improvements to the route of visit from the chosen method so as to get the route of the near-optimal traffic and the existence of such problems required a design of vehicle distribution routes better than existing ones. It is expected that with the new route design can improve the efficiency of vehicle distribution usage which will be done by a milk industry.

4. Results and Findings

This data processing is used for calculation as the steps of both methods.

4.1. Saving Matrix Distance

Saving matrix is a saving that can be implemented by combining two customers into one route. If customer 1 and customer 2 are visited separately then the distance traveled is the distance from depot to customer 1 and from customer 1 to depot is cultivated with distance from depot to customer 2 and from customer 2 back to depot.

4.2. Current company routes

Currently the company does not have a fixed or standard distribution route, line or line of distribution known based on interviews. The company does not have a route of maps so that the daily distribution is only based on the order of the address list addressed to the driver only. Therefore the researchers will create a route maps first by using clarke & wright method and then repaired by Tabu Search method.

4.3. Routing formation using clarke & wright method

Using Clarke & Wright Savings method, the calculation is based on the distance saving value, and can be seen from the saving value or the biggest savings up to the smallest. In this case there is a maximum time limit in the delivery and the capacity of the vehicle, ie in one tour the completion time should not be more than 8 hours or 480 minutes and 700 carton. The results of the Clarke & Wright Saving method can be seen in Table 1.

4.4. Route repair using tabu search method

The Tabu Search method is used to improve results obtained from the initial method (Clarke & Wright). The results is given in Table 2.

Table 1: Corporate Route Method Clarke & Wright

ROUTE OF CLARKE & WRIGHT COMPANY				
Tour	Route	Order Delivery System	Distance (Km)	Completion Time (Hours)
1	1	depot-P119-P12-P36-P25-P73-P23-P103-P57-P87-P81-P1-P141-P29-P34-depot	210,90	7,97
	2	depot-P111-P68-P35-P48-P72-P115-depot		
2	1	depot-P5-P21-P14-P33-P55-P56-P86-P130-P66-depot	177,70	8,00
	2	depot-P8-P42-P27-P85-P62-P127-P148-depot		
3	1	depot-P45-P59-P118-P145-P3-P46-P65-P64-P52-P44-P38-P77-depot	166,10	7,91
	2	depot-P98-P109-P54-depot		
4	1	depot-P61-P123-P146-P16-P18-P58-P70-P71-P75-P80-P84-P83-P60-P50-P89-P91-P100-P101-P102-P1226-P137-P138-P2-P4-P7-P88-P113-P134-P143-depot	250,13	7,11
5	1	depot-P6-P15-P98-P90-P150-P11-P95-P9-P106-P99-P108-P110-P10-P13-P17-P19-P24-P20-P32-P30-P135-depot	201,18	7,99
	2	Depot-P147-P97-P91-P149-P28-P139-P140-P142-P37-P136-P31-P26-P144-depot		
6	1	depot-P112-P43-P41-P63-P22-P136-P40-P145-P117-P131-P133-P39-P47-P53-P49-P47-P53-P49-P51-P129-P132-P128-P124-P65-P69-P125-P121-P67-P76-P122-P116-P104-P74-P118-P120-P114-P107-P78-P93-depot	171,17	7,33
	2	depot-P28-P96-P79-P105-P94-depot		

Table 2: Company Route Method Tabu Search

ROUTE OF TABU SEARCH COMPANY				
Tour	Route	Order Delivery System	Distance (Km)	Completion Time (Hours)
1	1	depot-P119-P12-P36-P25-P73-P23-P103-P57-P87-P81-P1-P141-P29-P34-depot	180,50	7,68
	2	depot-P111-P35-P48-P72-P115-P68-depot		
2	1	depot-P5-P21-P14-P55-P33-P66-P56-P130-P86-depot	165,24	7,54
	2	depot-P8-P42-P27-P62-P148-P127-P85-depot		
3	1	depot-P45-P59-P118-P145-P3-P46-P65-P38-P52-P64-P44-P77-depot	165,92	7,72
	2	depot-P98-P109-P54-depot		
4	1	depot-P61-P123-P146-P16-P18-P58-P70-P71-P75-P80-P84-P83-P60-	236,48	6,76

		P50-P89-P91-P100-P101-P102-P1226-P137-P138-P2-P4-P88-P7-P113-P134-P143-depot		
5	1	depot-P6-P15-P98-P90-P150-P11-P95-P9-P106-P99-P108-P110-P10-P13-P17-P30-P24-P19-P20-P32-P135-depot	191,36	6,90
	2	depot-P147-P97-P91-P149-P28-P139-P140-P142-P37-P26-P31-P136-P144-depot		
6	1	depot-P112-P43-P41-P63-P22-P136-P40-P145-P117-P131-P133-P39-P47-P53-P49-P47-P53-P49-P51-P129-P132-P128-P124-P65-P69-P125-P121-P67-P76-P122-P116-P104-P118-P107-P120-P114-P74-P78-P93-depot	170,83	7,25
	2	depot-P28-P79-P94-P105-P96-depot		

5. Conclusion

Table 3 shows that the Tabu Search can improve the total distance obtained using Clarke and Wright.

Table 3: Total Distance Comparison

Total Distance (Km)				
Tour	*Clarke & Wright*	*Tabu Search*	Percentage	Total Saving Distance (Km)
1	210,9	180,5	16,842	30,40
2	177,7	165,24	7,542	12,46
3	166,1	165,92	0,110	0,18
4	250,13	236,48	5,771	13,65
5	201,175	191,36	5,132	9,82
6	171,17	170,83	0,195	0,33
Amount	1177,17	1110,32	6,020	66,85

In Table 4 we can see the improvement percentage in terms of the Completion Time.

Table 4: Comparison of Completion Time

Completion Time (Hours)				
Tour	*Clarke & Wright*	*Tabu Search*	Percentage	Total Saving Time (Hours)
1	7,97	7,68	3,776	0,29
2	8	7,54	6,101	0,46
3	7,91	7,72	2,461	0,19
4	7,11	6,76	5,178	0,35
5	7,99	6,90	15,797	1,09
6	7,33	7,25	1,103	0,08
Amount	46,31	43,85	5,610	2,46

Company selects six tours a week to distribute ultra-liquid milk in packs and number of vehicles used by a milk industry in distributing ultra-liquid milk in packs of 150 customers is as much as one medium box car. The total distance traveled for six tours a week based on the clarke & wright method is 1177.17 kilometers. The total distance traveled for six tours a week based on the tabu search method is 1110.32 kilometers. And the result completion time for six tours per week based on clarke & wright method is 46.31 hours. Total completion time for six tours per week based on tabu search method is 43.85 hours. The tabu search method gives a near-optimal result by considering the various iterations of distance on each route. The clarke & wright method considers only the saving of distance, while the tabu search method looks at the shortest distance and the order of visits based on the shortest iteration distance on each route. The tabu search method minimizes overtime in the distribution of ultra-liquid milk in the package. Before the research there was one depot with 150 customers, using clarke & wright method obtained six tours with total mileage of 1177.17 kilometers and completion time of 46.31 hours. After obtaining the initial route of liquid milk distribution in the packaging, it was performed by using tabu search method which resulted in six tours with a total distance of 1110.32 kilometers and completion time of 43.85 hours. Shouting that, it can be concluded that the company is able to meet all the requests of 150 customers without passing overtime or working hours

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