DETERMINATION OF FLEET ROUTE IN PT XYZ USING TABU SEARCH ALGORITHM IN HETEROGENEOUS FLEET VEHICLE ROUTING PROBLEM WITH TIME WINDOWS TO MINIMIZE DISTANCE AND TRANSPORTATION COSTS BASED GEOGRAPHIC INFORMATION SYSTEM

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Abstract. *PT XYZ is a joint venture between the synergistic some of Indonesia's largest enterprise groups and international investment group which has one of the services, such as transport and distribution. One of these services is the process of transportation and distribution of both raw materials and finished goods from the warehouse to the customer which is located especially Jabodetabek area. Problems owned by PT XYZ is not having the calculations to determine the shipping route to 43 customers so frequent delays. As a consequence a total distance of route are very expensive and have an impact on expensive transportation costs in addition to the large distances between route and the penalties imposed as a result of delays*
This research designs an application that uses a formulation that has an objective function to minimize the total distance for every route and transportation costs. Tabu Search algorithm is used as a method to find objective function. This study uses customer location data, time windows, each customers demand and availability of fleet. Where the data is used as input to find route proposals to minimize distance and transportation costs so as to reduce the delays in delivery of goods to customers.

Keywords: *Transportation, Distribution Center, Tabu Search Algorithm, Geographic Information System*

1. INTRODUCTION

Transportation is an integral part of all industrial sectors. Transportation is always costly, and therefore affect the production and distribution costs up to 10-20% of the total cost of a product. Therefore, the efficiency in the field of transport is very important and can significantly reduce the total cost of production and distribution. PT. XYZ is a joint venture between the synergistic some of Indonesia's largest enterprise groups and international investment groups. One service that owned by PT. XYZ is the transportation and distribution. Where the service is performing better transport and distribution of raw materials (raw material) and finish good from the distribution center to the customers located especially in Jabodetabek area.

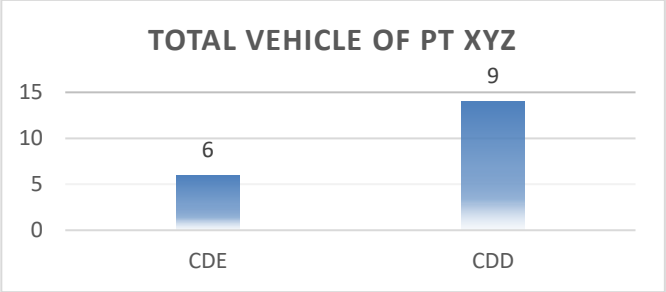

Figure 1.1 Total Fleet of PT XYZ

PT. XYZ have fifteen fleet is divided into two types: CDE (Colt double Engkle) and CDD (Colt Double Diesel). Whe re are CDE type has a capacity of 7.2 m3, while for CDD type has a capacity of 13:21 m3. Transport activity at PT XYZ has several problems including the delay caused the unfavorable stats.

Table 1.1 Delivery Failure 2015

Month	Total Departure	Total Delay	Achievement
June	160	15	91%
July	174	12	93%
August	193	12	94%
September	188	13	93%
October	154	10	94%
November	176	15	91%
		Average	93%

Some of the causes that have been identified, among others because the road or route through which the vehicle is based on frequent or regular route, so often experienced bottlenecks that impact on the delay in the distribution process.
To solve the above problems optimal route planning is needed that takes into account the capacity, distance and time windows as well as the use of Geographic Information Systems (GIS) will be used to help map the location.

2. RESEARCH METHOD

The study begins with the initial data collection such as data delivery request (demand) and the location of each customers to calculate the travel time. The travel time is obtained by taking into account the customer's location and each demand and taking into account the average speed of vehicles on the road. Then the route takes in planning time data services at customer sites, vehicle data, as well as transportation cost data for analysis by the method. Furthermore, the data used as input to do the establishment of appropriate mathematical models on the problem consists of the objective function by taking into account the existing barrier. The data is then analyzed by a heuristic method with Nearest Neighbour algorithm to determine the initial solution of the problem. After that, the data is then performed using Tabu Search algorithm optimization. From the results of the iterative algorithm will obtain optimal results distribution service with delivery times and costs less optimal distribution. The transportation cost is calculated based on several aspects such as the cost of fuel, driver fee, the fees and tolls. Having obtained the results of the optimal distribution of the results of the algorithm iterations of Tabu Search.

2.1 Initial Vehicle Route Planning

At the stage of determining the initial or the initial solution, the algorithm used is Nearest Neighbour algorithm. The concept of the algorithm is looking for a customer from a nearby vehicle with the last position of limitations time window and also the capacity of the vehicle. After visiting the customer first, the next customer is a customer that is located closest to the first customer, this step is repeated until one or both limits are violated, the time window and vehicle capacity. Here are the steps to search the route by using the nearest neighbor algorithm:

1. The first step is to determine the vehicles that will be used, vehicles are selected according to the needs or objectives, if the function of the purpose is to minimize costs, the chosen vehicle is a vehicle that has the lowest cost.
2. Determine the hour of departure from the depot, the determination is performed in order to determine the right time to leave the vehicle so that all customers can be served
3. Once a vehicle is selected, then the customer find the nearest location of the position of the vehicle, if the vehicle is just starting service from the depot, then began to find customers closest to the depot.
4. Check the customer demand, the demand of customers who visit must not exceed the capacity of the vehicle or add capacity so that goods carried exceeds the capacity of the vehicles, each vehicle will visit customers to -i, always checking cargo vehicles, these customers can be served by vehicle k if the demand of the customers can still be transported, so that customers can be served.
5. Then check time window, where customers will be visited yet in the span of time window, then the customer can not be visited. oti <= sik <= CTI
6. If the customer violates one or both of these limitations, other customers find the nearest afterwards, then do a double check.
7. After finding the nearest customer and can be visited, do the same by finding the nearest customer following from the location of the customer first. This step is done continuously hinggan no Spelanggan that can be visited again.
8. End the entire route by adding depot at each end of the route

2.2 Calculation Routes Using Tabu Search Algorithm

Having obtained the order of the initial solution using the nearest neighbor algorithm further Tabu Search algorithm is used to find the best solution because the solution of the initial determination of the solution may be trapped in a solution that is not wholly or partly (local optimum). With the help of MATLAB software version 2014 solution that has been obtained in advance as the initial solution reprocessed to find the best solutions available on the overall solution (Global optimum). In the manufacturing processes required data attributes on Attributive memory that will be used as an early initiation of treatment. The memory attributive of which is the initial solution such as sequence distribution service performed per day ..

The number of iterations to be determined after entering data delivery service because the program can not decide alone. These factors also affect the processing time run the program and output.

The output of this data processing is the order of these new delivery every day different to the order of the initial solution. The sequence of this new service will produce a more optimal mileage. Then the program will choose uniformly to do a combination of the customer on the route. This combination involves a process known as a move between the customer on the route. In this case it is assumed that the same move with one iteration. In each iteration. checking whether the attribute used move into the taboo list or not. If there are. then the move should not proceed further. whereas if the move is used are not included in the list of taboo. then the resulting solution should be checked on demand capacity. whether or not exceed the capacity of the truck. If it does not meet. then the move can not proceed to the next process. but if it meets. then the solution is a solution selected. Next is to rearrange the order of the customer in the service to obtain a more optimal result. If the chosen solution has a better distance than the best solution at the current iteration. then the solution is the best solution that is new and will be a solution this time will be processed on the next iteration of-iteration. Attribute move that results in the best solution newly recorded in the taboo list that within the next iteration.

Output data processing results with the Tabu Search algorithm is a sequence of new customers on each route with a total mileage is more optimal than the total mileage of the initial solution. Output can be seen in these

The resulting service will be directly converted into Ms.Excel distance along each route. Further analysis of transportation costs. This cost analysis calculation is the same as in the calculation of the current transportation costs.

3. RESULT AND DISCUSSION

3.1 Result of Nearest Neighbour Algorithm Routes

After figuring the input data such as demand each customers, fleet capacity, time window, then nearest algorithm has been generate routes sequence as follow;

Table 3.1 Route Iteration Using Nearest Neighbour Algorithm

Trip 1						
CDD Type Vehicle (13200 lt)						
Routes	D	C18	C014	C001	C011	D
Time Window		08.00	08.00	08.00	08.00	
		16.00	16.00	16.00	16.00	
Demand (cm3)	0	3049	3049	3254	3049	
Loading Accumulation (Cm3)	12401	9352	6303	3049	0	
Departure time	08.00	08.45	09.54	11.09	13.49	
Travel Time		15	149	101	46	46
Service Time (Minutes)		39	39	41	39	
Arrived Time		08.15	09.15	10.41	13.10	14.35

In table 3.1 is the result of iterations using the Nearest Neighbour algorithm, which were obtained by the route of the D-C019-C001-C011-D with a total demand of 12 401 cm3, which departed starting time of 08:00 am and returned to the depot at 14:35 noon. It can be concluded that the delivery of the customer with the total demand does not exceed the capacity of the fleet in the amount of 13 210 cm3, and do not pass the time window or time C011 customer service.

Table 3.2 Initial Solutions Using Nearest Neighbour Algorithm

No	Vehicle	Routes				
1	CDE1	D	C018	C023	D	
2	CDE2	D	C006	C017	D	
3	CDE3	D	C035	D		
4	CDE4	D	C020	C021	D	
5	CDE5	D	C030	C010	D	
6	CDE6	D	C009	C008	D	
7	CDD1	D	C038	C036	C004	D
8	CDD2	D	C037	C024	C007	D
9	CDD3	D	C028	C026	C002	D
10	CDD4	D	C032	C012	C011	D
11	CDD5	D	C001	C031	C003	D
12	CDD6	D	C039	C025	D	

13	CDD7	D	C005	C034	C016	D
14	CDD8	D	C027	C033	C019	D
15	CDD9	D	C014	C013	D	

Table 3.2 is the result of the total of Tabu Search algorithm, where there are assign 15 routes using 6 CDE typevehic le and 9 CDD type vehicle to serve demand for 43customers with 1827 km as total distance and 38.8 hours as travel time.

3.1 Result of Determining Tabu Search Routes

After generate initial routes from nearest neighbour algorithm, then these routes will be used as input to tabu search a lgorithm to avoid generate local solutions (local optimum).

Table 3.3 Delivery Failure 2015

No	Vehicle	Routes				
1	CDE1	D	C018	C023	D	
2	CDE2	D	C006	C017	D	
3	CDE3	D	C035	D		
4	CDE4	D	C020	C021	D	
5	CDE5	D	C030	C010	D	
6	CDE6	D	C009	C008	D	
7	CDD1	D	C038	C036	C004	D
8	CDD2	D	C037	C024	C007	D
9	CDD3	D	C028	C026	C002	D
10	CDD4	D	C032	C012	C011	D
11	CDD5	D	C001	C031	C003	D
12	CDD6	D	C039	C025	D	
13	CDD7	D	C005	C034	C016	D
14	CDD8	D	C027	C033	C019	D
15	CDD9	D	C014	C013	D	

Table 3.3 is the result of the total of Tabu Search algorithm, where there are assign 15 routes using 6 CDE typevehic le and 9 CDD type vehicle to serve demand for 43customers with 1501 km as total distance and 34.98 hours as trave l time.

2.2 Result of Geographic Information System Application

In the application of geographic information system applications tested to input data such as number of customers and demand each customers.

Time window, service time and distance matrix becomes the data input and has been incorporated in the application's database so that users do not need to input the data on the application.

In the first phase for the user to log into the application, then users place an order on the part of new orders and input the data in

each column that already exist in the application. To input data in applications such as those described in the following table.

Table 3.4 Examples of Input Data on Application

No	Customers Name	Demand
1	Kreasi Indi Cikarang	3000 lt
2	Prima Makmur Bekasi	3500 lt
3	Carrefour Bekasi	4500 lt

After the user input the data as shown in Table 3.4, the application will display the data that has been entered in advance so that the user can check the data that has been entered. As seen in Figure 3.1.

Figure 3.1 Order List Display on Application

After that the user able to planning vehicle route through the Tabu Search Generate button to see which vehicles are assigned and the order in compliance with the request based on time windows, capacity and mileage as well as the most cost optimized in order to minimize the distance and transportation costs, as seen in the figure I .4.

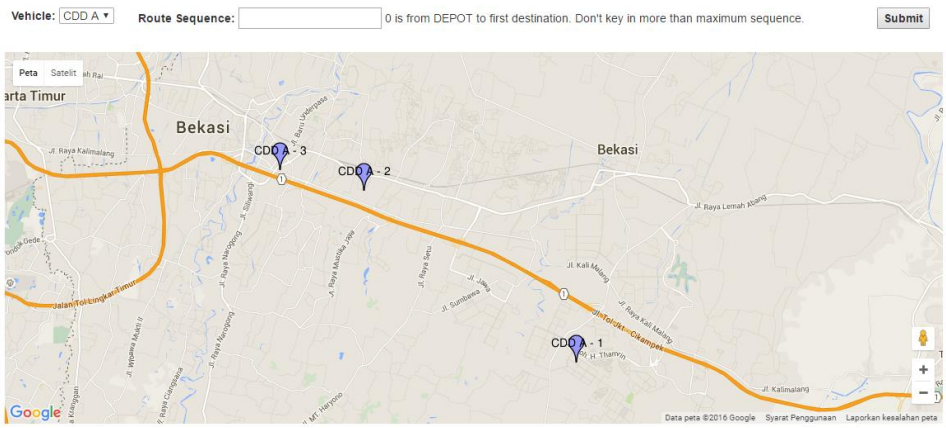

Figure 3.2 Generate Route and Assigned Vehicle Display

As seen in Figure I.4, the application can perform route planning and vehicle that perform activities transportationbase d on data that has been entered by the user. For result of vehicle calculation to assign CDD type vehicle because it h as larger capacity than CDE type vehicle. Because it is needed two vehicles when assign 2 CDE type vehicle and if CDD type vehicle assigned it only need one vehicle to serve the customers. Thus application is valid for routes and v

ehicle plannning.

4. Conclusion

From the research of distribution route planning using Tabu Search algorithm, there are several conclusions, such as:
1. Proposal routes of Tabu Search Algorithm can generate routes with the closer distance. Based on this proposal can generate the total reduction in the distance of 484 km or 20.4% of cost in previous conditions from one day horizon. These changes can occur because there is a better route planning, so the minimum distances can perform to all customers. In addition reduction in distance proposal can also impact on the total transportation cost.
2. The total costs generated by Tabu Search algorithm Rp 2,890,588 and decreased cost of Rp 441,685.7 or 13.25% when compared to the total existing cost. The decline in the total cost of the proposal due to the difference in variable costs that happen, it can happen because of a difference in the distance of these existing and proposed service.
3. Design of Application based Geographic Information System can perform departure fleet planning and can determine the optimal route from Distribution Center to the customer site in accordance with the objective function is the minimum distance. This is evidenced by input system that can determine the use of the fleet based on the data examined, ie using three different customer demand and is determined using the CDD vehicles with larger capacity than the CDE type. So with assign one CDD vehicle can reduce transportation costs compared than using two CDE vehicles.

REFERENCES

Faisal, Firman. 2012. Penentuan Alokasi Dan Rute Transportasi Yang Optimal Di PT. Sumber Alfaria Trijaya Menggunakan Metode ABC Dan Algoritma Tabu Search. Sarjana.Bandung: Institut Teknologi Telkom

Gogatama. 2013. Perancangan Rute dan Penjadwalan Pendistribusian Produk FMCG Di PT. XYZ Bandung Menggunakan Metode Algoritma *Tabu Search*. Bandung: Institut Teknologi Telkom

Hugos, M & Thomas, C. 2006. *Supply chain management in the retail industry.* HD38.5 .H85

I Nyoman Sutapa, et al, 2003. Studi Tentang *Travelling Salesman dan Vehicle Routing Problem dengan time windows*, Petra, 5 (22), pp. 81-89

M. Fisher. *Vehicle routing*. 1995. *Handbooks of Operations Research and Management Science, chapter 1*.

Prahasta, Eddy. 2009. Sistem Informasi Geografis Konsep-Konsep Dasar. Bandung:Informatika Bandung.

Pujawan, Nyoman. 2005. *Supply Chain Management. Surabaya* : Gunawidya

Toth, P. Vigo, D. 2002. *The Vehicle Routing Problem. Philadelpia*: SIAM