Case study

OPTIMIZATION OF MULTI-PRODUCTS DISTRIBUTION BY TABU SEARCH ALGORITHM (Case Study: Fuel Distribution)

ABSTRACT

Aims: Determine the vehicle s fuel distribution as distribute case of multi-product based on the number of routes and the total mileage optimal manner using a split delivery tabu search algorithm.
Study design: Trial percentage loading capacity of the three types of fuel to determine the percentage which gives optimum results.
Place and Duration of Study: Polytechnic Indonusa to make the application of a tabu search algorithm to determine the route and calculate the total mileage of the vehicle. The time required 1 month.
Methodology: In this study as a central depot supplier number one, the number of consumers who have served are 19, types of products to be distributed is 3, and the type of transport vehicle used is one where vehicles are not restricted. There are 37 scenarios percentage payload capacity tested in this study to find the percentage of transport capacity which gives optimum results.
Results: The results showed that for three types of fuel distribution to 19 customers, scenarios percentage of premium transport capacity of 25%, 18% kerosene, diesel fuel 57% provide optimal results. Optimal results based on the number of routes of distribution and total mileage. The amount of the distribution as much as 5 routes with a total distance are 9.727 nautical miles.
Conclusion: Tabu search algorithm can be used to complete the Split Delivery Vehicle Routing Problem in the case of multi-product distribution by creating a scenario type of fuel carrying capacity of each product.

Keywords: Vehicle Routing Problem, Split Delivery, Multi-Products, Tabu Search

1. INTRODUCTION (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

To support its operations in marketing their products, companies need a distribution system. The distribution system is a system for the distribution of goods/services from producers to consumers by the number of goods and certain delivery time. The problem of the distribution of goods/services can not be separated from the problem of transportation. Transport is one area in supply chain management that determine how and when to send the goods to the consumer. Transportation also plays an important role in the logistics activities [1]. Determination of the distribution effect on transport costs [2]. Transportation costs can contribute up to 40% of total logistics costs [3].

In shipping goods, companies must be able to determine the exact configuration of the distribution channels so that delivery is quick and it does not cost that much. The problem distribution system is an important factor that involves a few key considerations. Some of the major considerations include the route selection of vehicles, fleet vehicles, and vehicle scheduling [4].

Routing Vehicle The Problems(VRP) is a model of the distribution of goods/services from a / some depot (warehouse) to several agents (consumers) using a number of vehicles, which was to determine the optimal distribution of vehicles. VRP problem was first modeled by a homogeneous fleet of trucks serving demand for oil to a couple of gas stations by considering the minimum mileage [5]. The problem then developed into an optimization problem in logistics and transportation[6], In umumVRP defined as the problem of determining a route for a vehicle which aims to minimize the total cost of transportation to meet a number of constraints that reflect the characteristics of the real situation [7]. VRP can also be defined as a problem of distribution route search with a minimum fare from one depot to customers who are dispersed by the number of requests (demand) different [8].

VRP with split deliveries (SDVRP) is a distribution model where consumers can visit more than one service vehicle [9][10]. In contrast to the VRP, where each consumer can only be visited by 1 service vehicle. This is caused by exceeding consumer demand than the capacity of the vehicle [11][12]. SDVRP typically used to reduce the number of routes and a total distance [13]. Interest SDVRP approach is to produce an efficient service [14]. SDVRP also tasked to find a number of these vehicles which begins and ends at the depot to meet customer demand at the lowest possible shipping costs [15].

SDVRP first introduced by [16] then [17]. SDVRP problem is said to be NP-hard, because it is not easy to handle [17]. Several approaches are used to solve the problem SDVRP. Methodological search [16], branch and bound method[18], dynamic programming and shortest path [19], local search with the grouping procedure [20], picking algorithm [21], dynamic program[22], tabu search algorithm [23][13][24][25][26][27][28], a heuristic approach[29], and scatter search algorithm [30][31].

The type of goods carried by a vehicle distribution may consist of one type of goods/products or can be more than one type of goods/products. The type of goods/products of more than one type is called a lot of stuff or multi goods/products. Zhang and Chen [32] and Kabcome & Mouktonglang [33] have made a multi-product distribution model with two types of products.

Some distribution of goods/products is sometimes carried out in accordance with the will of the vehicle driver regardless of distance traveled. This can cause the vehicle mileage can be longer and result in cost he costs of traveling vehicles were also great. Based on these issues, this research will provide solutions on set route vehicles that carrying three types of fuel (premium gasoline, kerosene, diesel fuel) by way of a split delivery using tabu search algorithm so as to obtain the vehicle slightly and total mileage minimal.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

The problem in this research is a multi-product distributor by way of a split delivery. The data used are secondary data from Paillin and Wattimena (2015) about the distribution of fuel in eastern Indonesia. Data-related data in this study consisted of:

1. Depot. Depot used only one. This study, which is regarded as the fuel depot is the Transit Terminal in Wayame-Ambon.
2. Vehicle. Vehicles used for fuel distribution is a tanker. The tanker that is assumed to only one type, the type of medium fuel range with a payload capacity of 1,000 KL. Where the tanker has several compartments. The compartment used is a dedicated compartment (compartment that there has been devoted to loading one type of product and can not be used to load a different type of product). Each vehicle can do more than one route.

3. Products are distributed. Products are distributed is the fuel that consists of three types, namely premium, kerosene, and diesel.
4. Agent. In this study is the agent depot which is the goal of fuel distribution from the Transit Terminal. There are 19 depots purpose, namely Biak, Bula, Dobo, the consortium, Jayapura, Kaimana Labuha, Manokwari, Masohi, Merauke, Nabire, Namlea, Sanan, Saumlaki, Serui, Sorong, Ternate, Tobelo, and Tual.
5. Distance. Comprising distance data from the distance between the depot with each agent and spacing agent. The distance is known and assumed to be symmetric.

Multi-product distribution problem with this delivery split respect to the total mileage of at least meet the criteria in accordance with VRP models with split delivery as follows:
The objective function:

$$Min \sum_{i=0}^{n} \sum_{j=0}^{n} \sum_{k=1}^{m} x_{ijk} c_{ij} \quad (1)$$

With restrictions:

1. Each customer can be served more than 1 time by another vehicle
$$\sum_{i=0}^{N} \sum_{k=1}^{K} x_{ijk} \geq 1, \forall j = 1, \ldots, N \quad (2)$$
2. Every vehicle leaving the depot, after arriving in the consumer vehicle took off again and finally back to the depot
$$\sum_{j=0}^{N} x_{i0k} = 1, \quad \forall k = 1, \ldots, K \quad (3)$$
$$\sum_{i=0}^{N} x_{0jk} = 1, \quad \forall k = 1, \ldots, K \quad (4)$$
$$\sum_{i=0}^{N} x_{ihk} - \sum_{j=0}^{N} x_{hjk} = 0, \quad , \forall h = 0, \ldots, N \forall k = 1, \ldots, K \quad (5)$$
3. The charge for each product must be less than or equal to the capacity of the vehicle
$$\sum_{p=1}^{P} B_{pk} \leq Q_k, \quad \forall k = 1, \ldots, K \quad (6)$$
4. The amount of each product load carried by the vehicle must be less than or equal to the number of consumer demand
$$\sum_{p=1}^{P} B_{pk} \leq \sum_{i=1}^{N} \sum_{p=1}^{P} f_{ikp} \,.\, d_{ip}, \forall k = 1, \ldots, K \quad (7)$$
5. Each customer will receive a shipment demand in full
$$\sum_{k=1}^{K} f_{ikp} = 1, \forall i = 1, \ldots, N, \forall p = 1, \ldots, P \quad (8)$$
6. Consumers can only be served by visiting the consumer vehicle
$$\sum_{j=1}^{N} x_{ijk} \geq f_{ikp}, \forall i = 1, \ldots, N \quad (9)$$

Problem-solving multi-product distribution with a split delivery using a tabu search algorithm. Step completion is described in Figure 1 as follows:

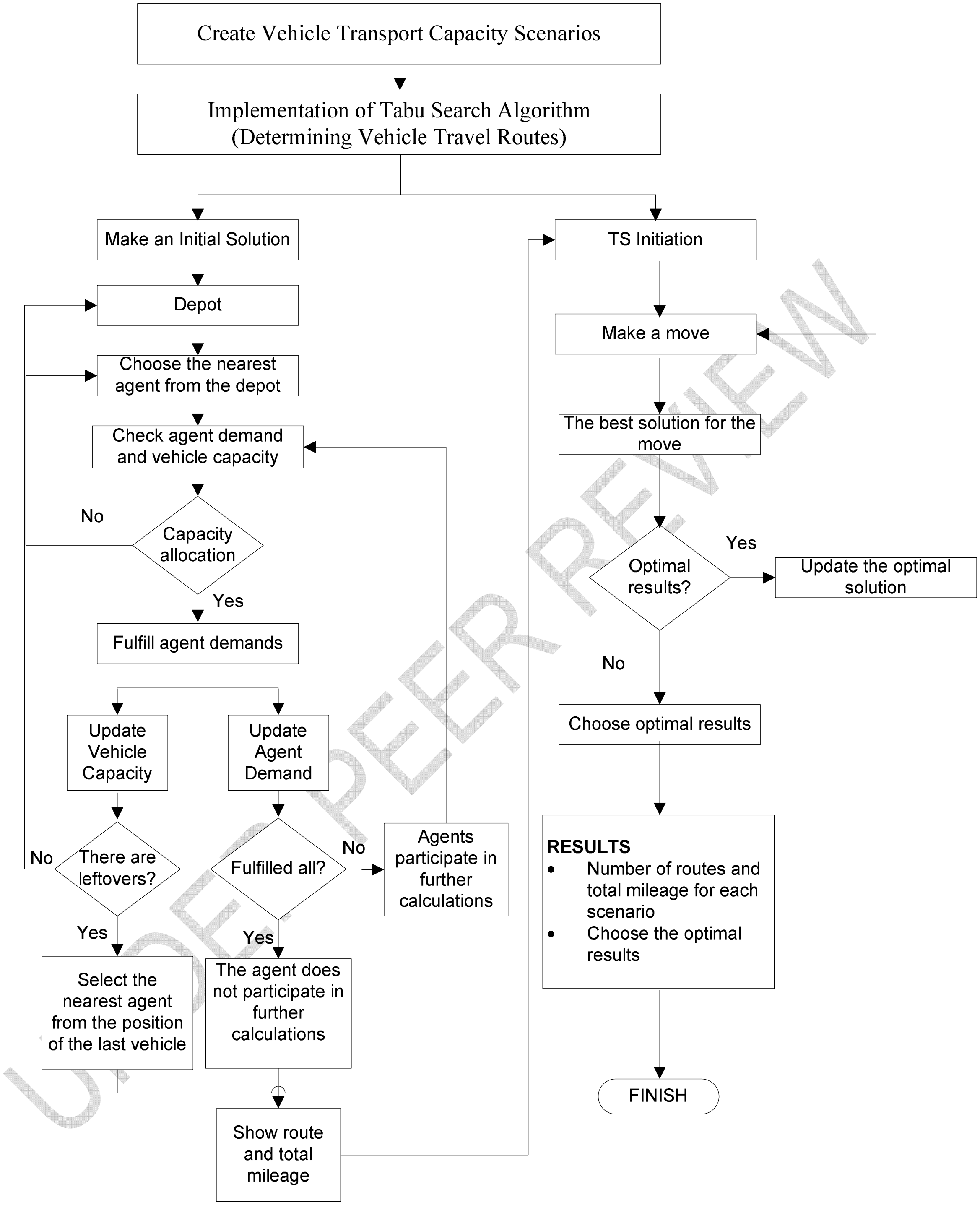

Figure 1. Flow Troubleshooting Multi-Product Distribution

3. RESULTS AND DISCUSSION

The settlement of the case of multi-product distribution with a split delivery using a tabu search algorithm is the case of the distribution of the three types of fuel are transported by one vehicle type. The first step is to create multiple scenarios the percentage of the capacity of each product to be loaded by a vehicle. Then perform these calculations and the calculation of total mileage. The calculation of the number of routes and the total mileage of the vehicle using a software application programming language PHP with MySQL database and web server XAMPP. Demand each agent (consumers) are presented in Table 1, whereas the distance between agents (consumers) are presented in Table 2.

Table 1. Consumer Demand Data

NO	DEPOT (Consumer)	PREMIUM	KEROSENE	SOLAR
1	Masohi	343.5	525.0	397.5
2	Tual	291.0	363.0	1426.5
3	Dobo	118.5	250.5	513.0
4	Kaimana	190.5	82.5	589.5
5	Bula	120.0	187.5	153.0
6	Saumlaki	154.5	285.0	946.5
7	Merauke	949.5	513.0	2467.5
8	Namlea	249.0	195.0	241.5
9	Sanana	151.5	220.5	214.5
10	Labuha	231.5	23.5	307.5
11	Ternate	1245.0	1411.5	3723.0
12	Tobelo	655.5	337.5	976.5
13	Sorong	1414.5	975.0	6978.0
14	Manokwari	808.5	333.0	951.0
15	Serui	370.5	217.5	292.5
16	Nabire	711.0	327.0	715.5
17	FakFak	246.0	234.0	265.5
18	Biak	514.5	301.5	1063.5
19	Jayapura	2749.5	1377.0	4365.0

Based-on-demand data in Table 1 descriptively known that depot (consumers) the greatest use premium gasoline is Jayapura 2,749.5 usage amount; or approximately 27.495%. Depot greatest use kerosene fuel is Ternate 1,411.5 usage amount; or approximately 14.11%. And the biggest depot using Solar Fuel is Sorong with a total of 6978 or around 68.78%.. While the average use of BBM for premium is 6.06%, for the average Kerosin fuel is 4.29% and for the average diesel is 13.99%. So the biggest demand is diesel fuel when compared to kerosene and premium.

Table 2. Mileage

	Ambon	Masohi	Tual	Dobo	Kaimana	Bula	Saumlaki	Merauke	Namlea	Sanana	Labuha	Ternate	Tobelo	Sorong	Manokwari	Serui	Nabire	FakFak	Biak
Masohi	78																		
Tual	325	285																	
Dobo	410	365	115																
Kaimana	400	347	130	135															
Bula	285	230	202	280	255														
Saumlaki	380	384	215	250	326	360													
Merauke	860	803	532	490	560	710	547												
Namlea	80	122	417	465	460	225	428	900											
Sanana	180	230	483	542	563	300	547	984	115										
Labuha	230	300	458	518	478	238	561	1017	203	180									
Ternate	320	335	582	677	625	370	688	1098	265	210	90								
Tobelo	445	480	598	659	618	383	824	1247	385	360	245	150							
Sorong	332	390	379	470	445	216	521	833	274	357	223	303	308						
Manokwari	545	570	575	620	585	340	807	1067	465	541	399	489	420	185					
Serui	660	690	710	722	700	490	812	1112	625	618	540	619	570	330	150				
Nabire	700	720	690	725	724	554	82	1107	652	621	497	686	600	375	170	103			
FakFak	282	245	160	212	180	106	403	678	329	400	330	420	450	218	501	553	503		
Biak	631	660	695	680	665	454	780	1132	594	667	533	692	530	310	116	110	148	626	
Jayapura	940	996	992	1060	1020	770	1193	1440	890	1017	883	1015	828	660	425	320	391	858	291

The optimized capacity of each product to be loaded by a vehicle impact also on mileage so that the distribution of each product through multiple routes will affect the total mileage. Several scenarios load the capacity of each products to be carried out are created by making combinations of 3 types of products. The results are presented in Table 3.

Table 3. Distribution with Multiple Scenarios

Scenario	Premium (%)	Kerosene (%)	Solar (%)	Number of Routes	Total Mileage (Nautical miles)
1	10	10	80	12	24,459
2	10	20	70	12	24,355
3	10	30	60	12	25,622
4	10	40	50	12	28,358
5	10	50	40	12	25 ,695
6	10	60	30	12	23,427
7	10	70	20	14	29,876
8	10	80	10	27	50,404
9	20	10	70	9	21,561
10	20	20	60	6	13,179
11	20	30	50	6	14,083
12	20	40	40	6	13,179
13	20	50	30	9	21,036
14	20	60	20	14	29,044
15	20	70	10	27	47,060
16	30	10	60	9	20,909
17	30	20	50	6	14,020
18	30	30	40	7	17,453
19	30	40	30	9	21,818
20	30	50	20	14	27,368
21	30	60	10	27	43,454
22	40	10	50	9	23,275
23	40	20	40	7	19,935
24	40	30	30	9	18,003
25	40	40	20	14	26,362
26	40	50	10	27	41,909
27	50	10	40	9	20,304
28	50	20	30	9	21,751
29	50	30	20	14	24,950
30	50	40	10	27	41,079
31	60	10	30	9	17,835
32	60	20	20	14	27,883

33	60	30	10	27	42,147
34	70	10	20	14	27,963
35	70	20	10	27	44,950
36	80	10	10	27	47,355

From several scenarios percentage of each product by vehicle transport, optimum results indicated by the scenario transports 20% premium cotton, 20% kerosene, 60% diesel and 20% premium, 40% kerosene, 40% diesel. Both scenarios produce a number of distribution routes 6 vehicles with a total mileage of 13 179 nautical miles. A new scenario on the percentage of each product transportation by vehicles made based on the calculation of the total demand for each product using the following formula:

$$\text{Percentage of the capacity of each product in the vehicle} = \frac{\text{number of requests for each type of product}}{\text{the total number of requests}} \text{ x } 100\%$$

Then it would earn a percentage of each product being transported by vehicle is a 25% premium, 18% kerosene, and 57% diesel. By using the percentage of freight vehicles for each of the products tested to calculate many routes and total mileage. The result was 5 routes with a total distance of 9727 nautical miles. Comparison of results from several scenarios percentage payload capacity can be seen in Figure 2.

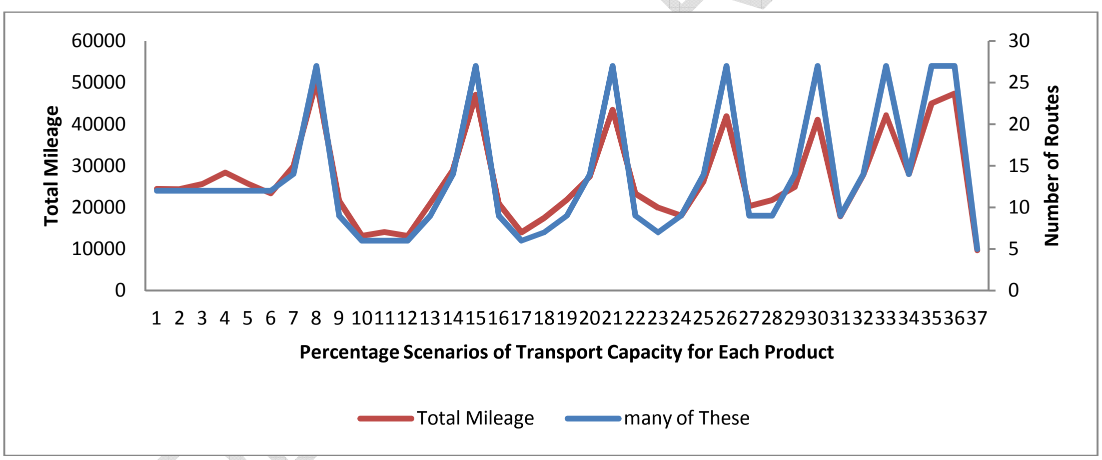

Figure 2. Results Distribution with Multiple Scenarios

Based on the results of multiple scenarios the percentage of freight vehicles based on a combination of three types of products and the results of calculation of the percentage of conveyance total demand of each product, optimum results shown by calculating the percentage of freight based on the total demand of each product that is 25% premium, 18% kerosene, and 57% diesel. These routes distributions resulting from the optimal percentage of freight vehicles are presented in Table 4.

Table 4. This Based Distribution by Percentage Transports Calculation of Total Demand

Route	Trip	Distance (nautical miles)
1	Ambon - Masohi - Namlea - Sanana - Tobelo - Ternate - Labuha - Ambon	1,145
2	Ambon - the consortium - Bula - Tual - Kimana - Dobo - Saumlaki - Nabire - Serui - Biak - Ambon	2,031
3	Ambon - Ternate - Tobelo - Manokwari - Sorong - Ambon	1,407
4	Ambon - Sorong - Manokwari - Biak - Jayapura - Serui - Ambon	1,904
5	Ambon - Merauke - Jayapura - Ambon	3,240
Total Distance		9727

Based on the results in Table 4 it appears there are some consumers who are served by more than one service vehicle distribution. Tobelo and Ternate are served by two routes of the vehicle, Route 1 and Route 3, Manokwari and Sorong served by these vehicles 3 and 4, Jayapura served by Route 4 and 5. So the optimization of distribution carried out by vehicles with multi-product loading can be done by dividing consumer demand for vehicles serviced by a different route. The optimization can also be done by making the percentage of each product transport capacity.

4. CONCLUSION

Tabu search algorithm can be implemented in the case of determining the multi-product distribution vehicles in order to obtain optimal results. Optimization of the results is done by dividing the number of requests (depot) so that consumers can be served by multiple vehicles. Optimal results are seen by the number of vehicles and the total mileage of the vehicle. The percentage of freight each product by each vehicle also has an effect on the outcome. The percentage of transports any product that can meet the optimal results calculated based on the ratio between the number of requests for each product of all consumers by the number of overall demand for all products.

This research can be developed by using another method as a comparison of the results of the tabu search algorithm. This type of vehicle also affects the distribution of product distribution optimization. For further research can make a combination of several different types of distribution vehicles.

CONSENT (WHERE EVER APPLICABLE)

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

Here is the Definitions section. This is an optional section.
Term: Definition for the term