

Solving the Travelling Salesman Problem (TSP) Using Branch and Bound Method (Case Study at Company of XYZ)

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This method is implemented in the Company of XYZ. Company of XYZ is a distributor company of mineral water in Bandung with a gallon package. The distributor must deliver gallons to four mini-markets every day with different locations and must travel back to the distributor point. The objective function of this study is to know the best route with the shortest distance delivery, using Branch and Bound Method in solving the Travelling Salesman Problem; from distributor to retailer and back to the distributor. Each retailer can be passed just once. The advantage of the Branch and Bound Method is the small error level, but this requires quite a long calculation. The results are two routes, route 1 O-A-C-B-D-O and route 2 O-D-B-C-A-O, where the total of the shortest distance is 38.5km.

Key words: *Travelling salesman problem, branch and bound method, distributor.*

Introduction

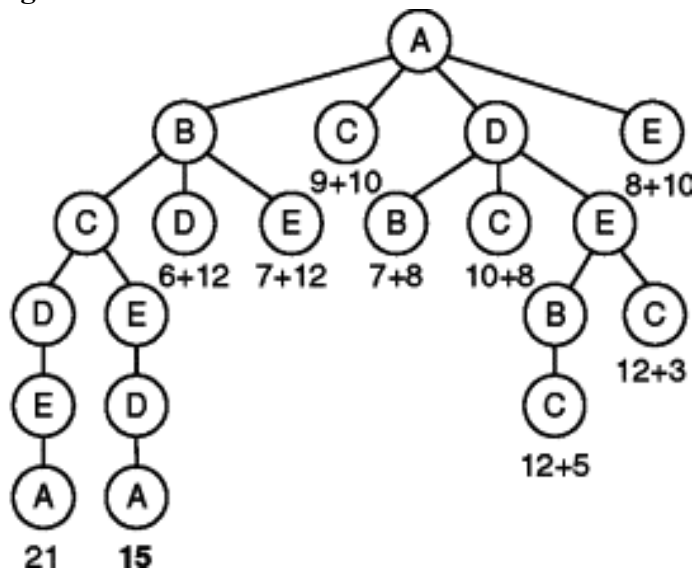
The Travelling Salesman Problem (TSP) is about finding the best route method with the shortest distance. One of the problems concerns the delivery from the origin to destination and back to the origin. Mostly the distance of TSP is symmetrical; it means that the distance from O (origin) to A (destination) is the same with from A (as origin) to O (as destination). Many algorithms can be used to solve the TSP, among them the Branch and Bound Method, Complete Enumeration Method, Nearest Neighbour Method, and others. The following are the rules for using the TSP:

1. The trip starts and ends at the same point of origin;
2. All destinations must be visited without any destinations being missed;

3. Salesman (transporter) must not return to the origin before all destinations are visited; and
4. The purpose of solving this problem is to find the optimum value by minimizing the total distance of the route.

This study uses the Branch and Bound Method because it has the smallest error level. The Branch and Bound Method is an algorithm method for finding the optimal solution to various optimization problems, especially in discrete and combinatorial optimizations. The Branch and Bound Method is a general technique for improving the searching process by systematically enumerating all candidate solutions and disposing of obviously impossible solutions (Wang et al., 2009). In this method, the solution space is organized as a treelike structure. Figure 1. Shows an instance of the Branch and Bound Method.

Figure 1. Instance of Branch and Bound tree solution



Source: Wang, L. T. et al., 2009

The main concept of the Branch and Bound Method is to divide the big original problem into sub-problems. These problems then become smaller groups until all sub-problems can be resolved (Hillier et al, 2001). Alternative number algorithm on the Branch and Bound Method is (n-1). One alternative is the best route. Study in the research by Bangun et al. (2015) discusses the issue of assigning goods at a Post Office. The goods transported from all Branch Post Office are collected at the Examining Post Office (Post Office Centre). The transportation of goods is performed by using a car that starts from the Examining Post Office and then moves to each Branch Post Office. The transportation of goods must have a systematic route and use the shortest distance from Examining Post Office to each Branch Post Office and back to the Examining Post Office. This method is implemented on the Company of XYZ. Company of XYZ is a distributor company of mineral water in Bandung,

with gallon package. The distributor must deliver gallons to four mini-markets every day with different locations and then head back to the distributor point.

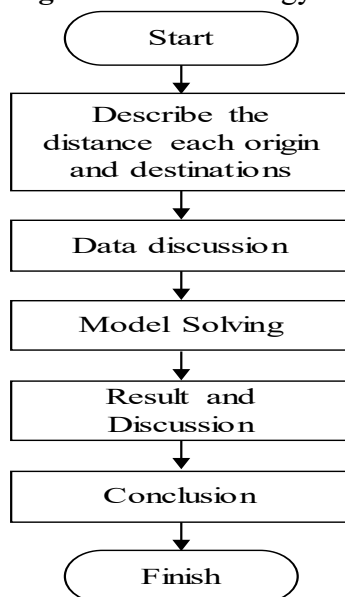
Formulation of the Problem

The problem is a driver does not know the sequence of delivery to customer to produce the minimum mileage. A driver just delivers based on his thoughts and not based on the actual distance. Company of XYZ wants to know the best route to get the shortest distance on the distribution route from point of origin to four destinations. These destinations are Indomaret Point Braga 52, Indomaret Point Ciumbuleuit, Indomaret Point Dipati Ukur 85, and Indomaret Point Stasiun Selatan.

Methodology

The steps in this study are:

Figure 2. Methodology Flow



The following is an explanation from Figure 2:

1. Describe the distance data from each origin to the destination and each destination to the next destination;
 - a. This study has one origin and four destinations. Origin name is Company of XYZ. Destinations names are Indomaret Point Braga 52, Indomaret Point Ciumbuleuit, Indomaret Point Dipati Ukur 85, and Indomaret Point Stasiun Selatan.
 - b. Distance O to A or A to O is symmetrical.
 - c. Number of alternative route is $(n-1)!$. This study has 24 alternatives.
2. Data discussion

- a. Make a matrix of distance $n \times n$. n is total number of origin and destination. This study 5×5 .
- b. Make a diagram of alternative routes.
3. Model solving with Branch and Bound Method
 - a. Showing the distance in the matrix
 - b. Drawing a tree diagram for all alternative routes.
4. Result and Discussion
 - a. Calculating all alternative routes.
 - b. Comparing all alternative routes.
 - c. Selecting the route that produces the shortest distance.
5. Conclusion

Result and Discussion

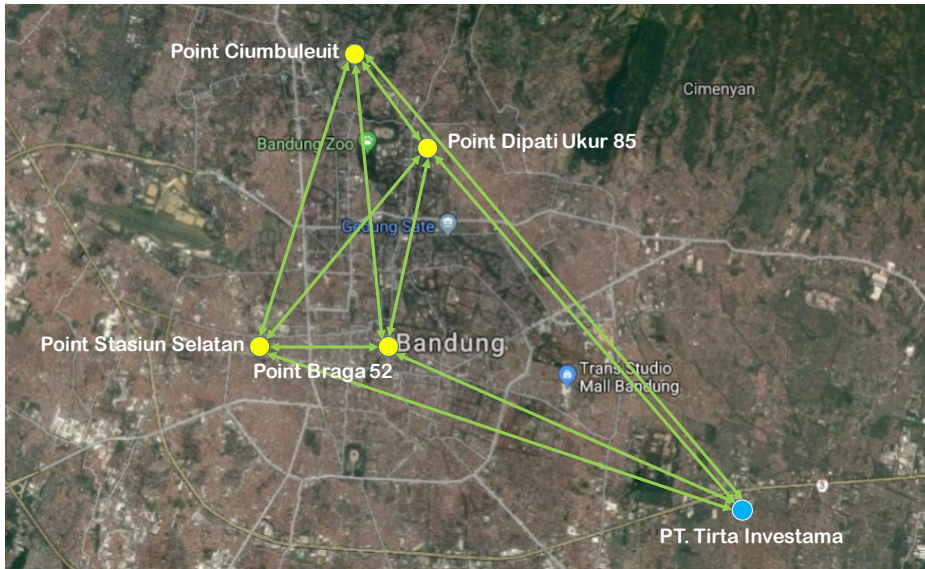
Data in this study is each location and the distance of origin and destinations. Company of XYZ is the point of origin and is located at Jln. Soekarno Hatta No. 608E Bandung. The location of each destination is shown in Table 1.

Table 1: Data location of destination

No	Name of Destination	Location of Destination	Location Code
1	Point Braga 52	Jln. Braga No. 52	A
2	Point Ciumbuleuit	Jln. Ciumbuleuit No. 153 Hegarmanah	B
3	Point Dipati Ukur 85	Jln. Dipati Ukur No. 85	C
4	Point Stasiun Selatan	Jln. Stasiun Selatan	D

Map of all location shows in Figure 3.

Figure 3. Origin and destinations location



Source: Google Maps

Mileage data matrix shows in Table 2.

Table 2: Mileage data matrix

		Destination (km)				
		O	A	B	C	D
Origin (km)	O	0	9,9	15,1	13,3	12,6
	A	9,9	0	6,4	4,7	5,2
	B	15,1	6,4	0	2,5	8,8
	C	13,3	4,7	2,5	0	9,6
	D	12,6	5,2	8,8	9,6	0

Source: google.maps

Alternative routes are:

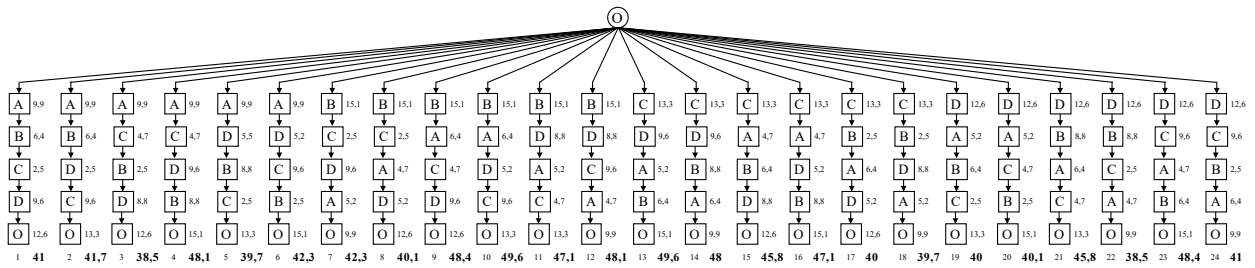
$$(n - 1)!$$

$$(5 - 1)!$$

$$4 \times 3 \times 2 \times 1 = 24 \text{ alternative routes}$$

24 alternative routes are shown in Figure 4.

Figure 4. Alternative routes



Based on Figure 4. the best routes are O-A-C-B-D-O and O-D-B-C-A-O with total distance 38,5 km.

Conclusions

Based on the analysis and discussion on implementing the Branch and Bound Method, it can be concluded that the best route with the shortest distance is (Jabarullah, 2019):

1. Route 1: O-A-C-B-D-O

Jln. Soekarno Hatta No. 608E (origin) → Jln. Braga No. 52 → Jln. Dipati Ukur No. 85 → Jln. Ciumbuleuit No. 153 Hegarmanah → Jln. Stasiun Selatan → Jln. Soekarno Hatta No. 608E (origin), total distance is 38.5 km.

2. Route 2: O-D-B-C-A-O

Jln. Soekarno Hatta No. 608E (origin) → Jln. Stasiun Selatan → Jln. Ciumbuleuit No. 153 Hegarmanah → Jln. Dipati Ukur No. 85 → Jln. Braga No. 52 → Jln. Soekarno Hatta No. 608E (origin), total distance 38.5 km.

Suggestion

Suggestion for this study are:

1. Calculate the total cost of transportation of each alternative route.
2. Consider each order retailer and capacity of transportation modes.



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