Optimization of Distribution Route Selection based on Combination of Time and Distance

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Abstract. Product distribution plays important role in business activities. One of the important aspects of distribution is how to select best distribution route. This paper emphasizes on developing an approach that can give optimum solution for both time and distance. The approach is developed based on branch and bound technique by considering combination of time and distance. A product distribution in agrocomplex industry is used as case study. Finally, the paper shows that the approach gives better result and it can save both time (1. 7 %) and distance (4.8 %).

Keywords: Optimization, Product distribution, Time and distance

1. INTRODUCTION

Distribution, defined as the process of making a product or service available for use or consumption by a consumer or business user, using direct means, or using indirect means with intermediaries (Wikipedia, 2016), plays very important role to the company success. Weiss and Gershon (2002) states that, "distribution describes all the logistics involved in delivering a company's products or services to the right place, at the right time, for the lowest cost. In the unending efforts to realize these goals, the channel of distribution selected by a business, play a vital role in this process". Products have been manufactured and packaged then will be sent to consumers through the distribution process. Incorrect distribution method will cause to high cost and longer lead time. Therefore, the distribution management must concern to lead time, cost, and service quality.

Transportation has important role in logistic. It becomes one of 4 drivers of supply chain (Chopra and Meindl, 2001). One-third of logistic cost is from transportation cost (Tseng et al, 2005). Based on investigation of National Council of Physical Distribution Management (NCPDM) in 1982, the cost of transportation, on average, accounted for 6.5% of market revenue and 44% of logistics costs (Chang, 1998). Besides, transportation has high impact in logistic performance because it can improve service quality such on reduce lead time.

Travel salesman problem (TSP) is one of important cases in distributing product. Ungureanu (2006) described that TSP as "a travelling salesman has to visit exactly once each of n cities and to return to the start city, but in such order that the respective tour (Hamiltonian cycle) has the minimal total cost (it is supposed that the cost cij of traveling from every city i to every city j is known)". It is related to how to determine an optimal route for a group of vehicles with the number and capacity constraints particular in order to meet demand customer, in this case called outlets, with the location and the number of requests that is known.

In many cases, the best distribution route cannot only be determined based on distance. The shortest distance cannot always give fastest distribution. The traffic density can burden the speed of vehicle so that it can increase distribution time and cost. This means that best route must consider both distance and time distribution.

This paper will discuss how to solve TSP for product distribution by considering both time and distance based on Branch and Bound algorithm.

2. LITERATUR REVIEW

TSP can be described by the task of finding the shortest tour of n cities given the intercity distances (costs).

There are some approaches and methods for solving TSP. Some heuristics. such as constructive heuristics and Christofides algorithm, can solve large problems with a high probability just 2–3% away from the optimal solution (Rego et al, 2011).

Graham, et al (2000) calls E-TSP for TSP when the distances between cities are Euclidean. Some experts state that to produce close-to-optimal solutions to E-TSP problems in time that is (on average) proportional to the number of cities.

Branch and bound (BnB) method was first introduced by A. H Land and A. G Doig in 1960. In marketing, BnB algorithm is often used to find the optimal solutions for combinatorial optimization problems. This method can be easily applied to the TSP, either Asymmetric TSP (ATSP) or Symmetric TSP (STSP). Two tools of BnB are a separation procedures (splitting) and procedures that calculate an upper limit and a lower limit (upper and lower bounds). For a given set S, splitting procedure returns two or more sets of smaller, S1 and S2, which if they are combined would be the same as the S. The minimum value of f (x) in S is min {v1, v2, ... }, which each vi is the minimum value of f (x) in the Si. This step is called branching since the application of recursive defines a tree structure search knots are subsets of S. The second procedure is used to calculate an upper limit and a lower limit value of the minimum of f (x) in the subset S. This step is called bounding (restriction).

The main idea BnB is node A will be ignored if the lower limit of the search for the node A is greater than the lower limit for the node B. This step is called pruning (trimming), and is usually implemented using a global variable m that records the upper limit of the minimum seen between all sub regions that have been tested so far. Each node with the lower limit is greater than m can be ignored. Recursion stops when the set of candidates this time S is reduced to a single element; or when the upper limit to set S

BnB efficiency is dependent on the separation procedure nodes (node-splitting procedure) and the estimator upper limit and lower limit (upper and lower bound estimators). Therefore, you should choose the method of separation (splitting) which provides sets of parts that do not overlap (non-overlapping subsets). When all the nodes in the search tree has been pruned or solved, then ideally the procedure stops. At that point, all the branches of uncropped (non-pruned sub-regions) will have an upper limit and a lower limit equal to the global minimum of the function. But, in practice, this procedure often stops after a certain time limit given. At this point, the upper limit and lower limit of the minimum (among all branches of uncropped) defines a range of values that contains the global minimum. This algorithm may also be stopped when an error criterion, such as (max - min) / (min + max), it is smaller than a certain threshold value defined.

The efficiency of BnB is also dependent on the effectiveness of the algorithm used branching and bounding. Repeated branching, without any pruning, until the sub-regions to be very small, could result from a bad choice. In this case the method would be tantamount to a search of all the possibilities of the existing domains, which are often very large. There is no universal bounding algorithm that can be used for all issues. Therefore, a common paradigm needs to be implemented separately for each application, with branching and bounding algorithms that are specifically designed for it.

3. METHODOLOGY

This research is done in four steps (Figure 2), namely (1) determining the distance and time duration among station/stage. Each station/stage has at least 1 other stations that can be visit directly. The distance and time among station are collected for some station visible combination. (2) Combining time and distance by adding standardized time and distance. (3) Minimizing combined time and distance to visit the whole stations based on Branch and Bound method (4) analyzing the best route by comparing the result of the proposed method to time optimization or distance optimization method.

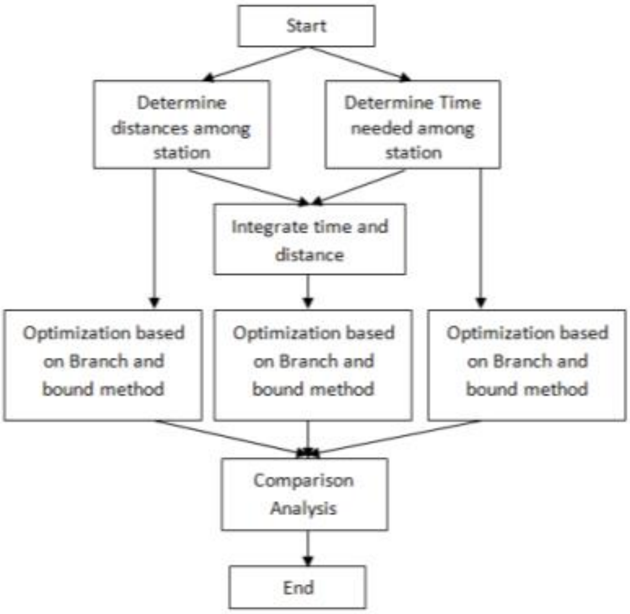


Figure 1: Research Flowchart

A case study in agrocomplex industry is used to evaluate the proposed method. The firm has 44 stations that must be visited.

4. RESULT AND DISCUSSION

4.1 Time and Distance Data collection

Time data among station were collected by directing observation/collection. Researcher joined the firm driver to visit all station in normal condition. Six stations (from 44 stations in this research) were used to describe the case and processes. Table 1 shows time duration matrix of six stations.

	1	2	3	4	5	6
1		13	17,8	21		
2	17,8		5	10,2		
3	17,8	4,6		1		
4	21,2		2,4		2	
5				0,4		1
6					0,8	

Figure 2: Time Duration matrix

Meanwhile, distance data were found by implementing Google Map for all visible combination of 44 stations. One of example is shown in Figure 3.

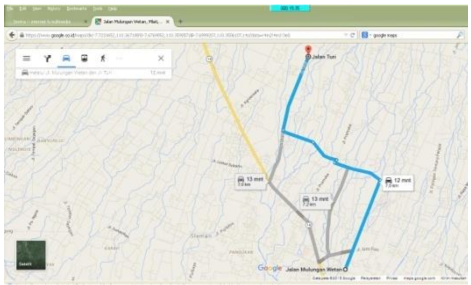


Figure 3: Google Map for identify inter station distance

	1	2	3	4	5	6
1		7	8.9	9.6		
2	7		2,3	4.1		
3	8.9	2,3		1.2		
4	9.6	4.1	1.2		0.2	
5				0.2		0.4
6					0.4	

Figure 4: Distance matrix

Based on Google Map inter station distance, a distance matrix is constructed. Figure 4 shows the matrix distance of six stations.

4.2 Integrating Time And Distance Matrix

Firstly, both time and distance are normalized independently, so all value are in between 0 up to 1. Then both standardized time and distance matrix are integrated into integrated score by adding the standardized time and distance (Figure 5). This is done because both time and distance are assumed having same priority.

	1	2	3	4	5	6
1		0,502	0,658	0,74		
2	0,572		0,176	0,334		
3	0,658	0,17		0,067		
4	0,74		0,089		0,04	
5				0,015		0,033
6					0,03	

Figure 5: Integrated Time and Distance Score Matrix

4.3 Combined Time and Distance Optimization

After all stations visited, the service will then return to the starting point. There are 280 nodes that must be decided before returning to the starting position. The resulting optimum route is 1-44-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-43-17-18-42-41-40-39-38-37-35-34-33-32-31-30-29-28-36-27-24-23-22-21-25-26-19-20-1

The optimum solution gives shorter distance and faster time compared to initial/current distance and time.

Table 1: Initial and proposed solution comparison

Combined time and distance Data					
Initial			Proposed		
Route	Distance (Km)	Time (Minutes)	Route	Distance (Km)	Time (Minutes)
6-7	1,5	3	5-6	0,4	1
7-8	0,9	2	6-7	1,5	3
8-9	0,6	1	7-8	0,9	2
9-10	0,3	1	8-9	0,6	1
..	..	..	..	..	..
..	..	..	..	..	..
..		..	..	..	..
41-42	0,2	4	25-26	1	1
42-43	8,6	16	26-19	5,3	10,6
43-44	4,2	8	19-20	0,2	1
44-1	4,5	17	20-1	12,7	29,4
Total	75,1	169	Total	73,8	155,2
		t(s) 125			t(s) 125
		294			280

4.4 Comparison Analysis

Figure 6 shows proposed routes based on distance, time and combined distance and time optimization. The results give different routes. The optimum route of distance and time are relative similar but not for the route of combined distance and time optimum. Table 2 shows difference between initial and optimization performance for the three data. The combined time and distance (proposed) optimization can save both distance and time. It can save 1.3 km for distance and 14 minutes for time duration. In distance based comparison, the proposed optimization gives better distance saving than distance optimization. Distance optimization can save only 0.8 km in one trip. Meanwhile, the proposed optimization can save 1.3 km for one trip.

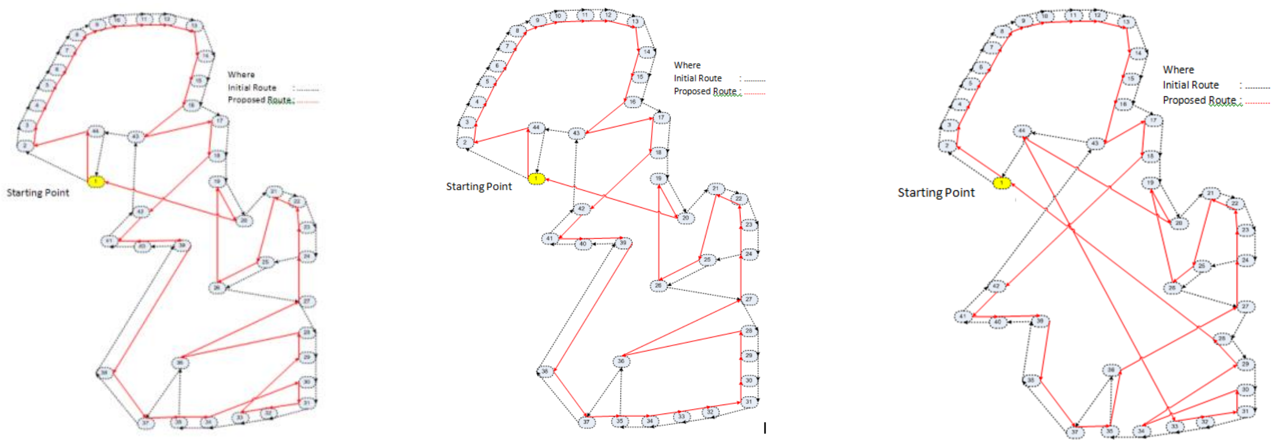
In time duration analysis, the combined time and distance optimization saving is better than time duration optimization saving. The proposed optimization can save only 14 minutes. Meanwhile, the time optimization cannot reduce the time for one trip.

From the time of congestion, initial route pass 7 traffic light, while the proposed route passes only 4 traffic light. It certainly will save time and fuel because of the congestion in the traffic light. Every traffic light mostly needs 2 minutes for waiting.

There is no linear relation between distance and time, so the traffic condition must be considered as important aspect to determine the distribution route. So, there is single best route for all case distribution. Officer judgment will play important role in getting the best route to save both time and distance.

Conclusion

The combined time and distance optimization method can save both distance and time by 1.3 km for distance and 14 minutes for time duration. The proposed route gives better distance and time saving than distance optimization route and time optimization route.



(a) (b) (c)

Figure 6: Optimal Distribution Route based on (a) Distance (b) Time and (c) combined Distance and Time

Table 2: Comparison among Type Based Optimization

Comparison	Distance based optimization process		Time based optimization process		Combined Time and Distance based optimization process (proposed)	
	Initial	BnB	Initial	BnB	Awal	BnB
	75.1 km	74.3 km	294 minutes	347.9 minutes	• 75,1 km • 294 minutes	• 73,8 km • 280 minutes
Saving	0.8 km		53.9 minutes		• 1.3 km • 14 minutes	

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