Optimization of Distribution Channel Vehicle Routing Problem with Time Windows using Differential Evolution Algorithm: A Case Study in Newspaper Industry

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Abstract

The newspaper industry has some distinctive qualification which makes it stands out from other industries especially in the distribution process. The strict is a short delivery deadline that will affect the product price. Because of the demand is defined, with some agencies spread on an area so the problem in the newspaper industry will be the Vehicle Routing Problem with Time Window (VRPTW). Optimal route can be determined using Differential Evolution Algorithm to calculate the shortest route for every agency and maximized the usage of the vehicle using coordinates and demands of the agencies. The result shows that there is an optimal route which have shorter route and shorter travel time than the existing route in the distribution process.

Keywords
Distribution, VRPTW, Differential Evolution, Supply Chain Management

1. Introduction

A successful company distribution are generated from integrated scheduling between production scheduling, transport scheduling and inventory scheduling (Chen, 2010) meanwhile Regarding the printing and distribution of the newspaper industry taking from the actual occurrence that orders of products with high time sensitivity character must send their goods directly to the consumer without using intermediary inventory so that the focus is to coordinate between the inventory and the distribution of the newspaper company (Buer, et al., 1999). The result of a case study in one of the newspaper company in Surakarta town got some problems, one of them is the slowest of distribution process due to the less precise route determination.

Thus the research needs to be done to reduce the mileage by finding the optimal route. For the problem, the suitable model is the Vehicle Routing Problem (Wang, 2015) (Baekers, et al., 2016) and due to time constraints, the model added Time Window elements (Kumar, et al., 2012). VRP itself can serve to solve the problem where the state of delivery has many points and carried out continuously in an area. VRP development itself has been done on various issues, for example VRP is used to determine the distance matrix on completion using a Nearest Neighbour algorithm (Amri, et al., 2014).

Prior to this research there were several studies similar to case studies in newspaper companies, but using other models, including using the Sweep method (Cahyaningsih, et al., 2015). However, in the case study in this article, the algorithm that best matches the data obtained is Differential Evolution which has an advantage in the evolution experienced by every individual in the population where differentiation and crossover occur sequentially in each individual who is randomly selected from the population at any time (Fahmiari and Santosa, 2010). Thus the most appropriate solution to determine the optimal route in the study case in this article is the Differential Evolution algorithm (Mingyong, et al. 2010) (Silva, et al., 2013)

This article is intended to solve the problem of determining the existing route in a newspaper company in Surakarta town so that the best route that has the shortest distance is expected to have a shorter travel time than the current route

2. Method

The method used in this research is the data collection stage, followed by data processing, and the last stage is the implementation of a Differential Evolution algorithm. The data used in this research are primary data and secondary data.

2.1 Data Collection

Data collection methods used are direct observation in the form of data retrieval and interviews with the newspaper industry that before performing the model simulation is required conceptual model of the whole system in the form of identification agency and sequence of relations between agencies (Singgih, et al., 2014) And in the determination of respondents using the concept of respondents selected based on the results of mapping in a particular area (Ubud, 2015), For this case study, agencies located in the town area of Surakarta, as well as determining the path using the Global Positioning System (GPS) and then obtained some data such as the number of agencies, the number of vehicles, the number of demand, the number of returns, routes, delivery time. For the current route has a distance of 38 km with an estimated travel time of 1 hour 41 minutes. In the case study, data used are the demand, number of vehicles, vehicle capacity, agency number, and agency location.

Table 1. Current Distribution Route

The order of distribution routes	
A1-A2-A9-A11-A10-A6-A7-A5-A4-A3-A8-A1	
38 km	1 hour 44 minutes

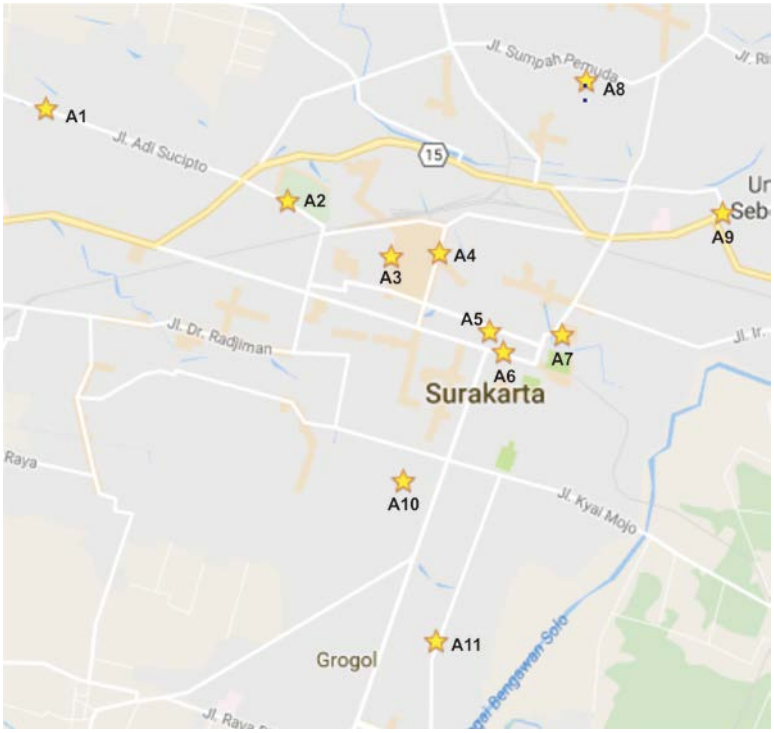

Figure 1. Location of Agencies

2.2 Data Process

Data processing obtained using the help of google maps application to know the travel time and mileage and assumed when in delivering and picking up the daily newspapers without including the road congestion or traffic jam.

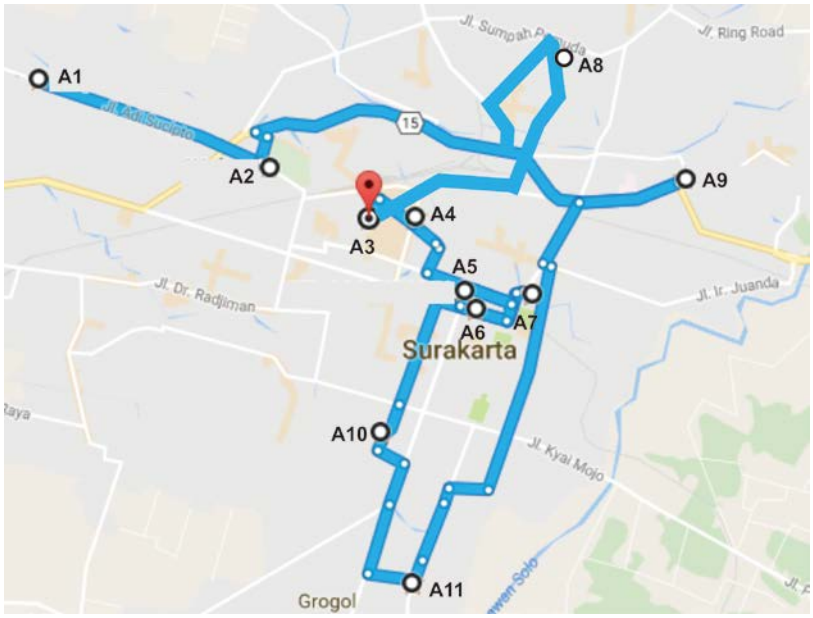

Figure 2. Current Distribution Route

2.3 Implementation of VRPTW models using Differential Evolution algorithm

Vehicle Routing Problem Time Windows (VRPTW) is the problem of determining the route with the limited capacity of the vehicle. The vehicle is expected to visit requested place and fulfil it from the depot.
Characteristics of VRPTW problems as follows:

- The vehicle route begins and ends from and to the original depot.
- Each place must be visited and completed the requirement once exactly.
- If the capacity of the vehicle is used and cannot serve the next place, the vehicle can return to the depot to meet the capacity of the vehicle and serve the next place.
- The goal is to minimize the total distance travelled by arranging the sequence of places to visit and when the vehicle returns to fill its capacity again.

There are basic mathematical model of VRP that has constraints on the vehicle's carrying capacity. If there are other constraints, then this model can be developed as needed.
N = Depot and agencies nodes, N = (0, 1, . .n)
N = 0 Depot node
N ≠ 0 Agencies node
K = Number of vehicles, K = (0, 1,. . . ., k)
Vk = Maximum capacity of vehicle, k
dj = Total customer demand, j
cijk = Cost / distance to travel agency i to agency j using vehicle k

Differential Evolution Algorithm
The objective function is to minimize the total distribution cost:

$$Z = \sum_{i}\sum_{j}\sum_{k} c_{ijk}x_{ijk}$$

One node is only visited by one vehicle:

$$\sum_i \sum_k x_{ijk} = 1$$

Only one vehicle out of one node:

$$\sum_j \sum_k x_{ijk} = 1$$

There are k vehicles coming out of the depot / warehouse:

$$\sum_j \sum_k x_{0jk} = K$$

There are k vehicles that enter the depot / warehouse:

$$\sum_i \sum_k x_{i0k} = 1$$

Total goods transported by one vehicle do not exceed its carrying capacity:

$$\sum_i \sum_j \sum_k d_j x_{ijk} \leq V_k$$

The data needed to fulfil this algorithm include:

1. The maximum iteration, the maximum number of iterations in the DE algorithm
2. Iteration fails maximum, maximum number of iterations that do not provide the best solution
3. Maximum time, Maximum amount of distribution time
4. Population, Number of vector population
5. Number of nodes, Number of destinations (including depot / initial node)
6. Maximum Capacity, Maximum capacity of vehicles
7. Maximum distance, the longest distance travelled by vehicle in one trip

The next step is to enter the data that has been obtained to be calculated by using iteration of 10,000 times and the maximum time of 1 hour.

3. Result and Discussion

The data used in this study used a list of agencies in the town of Surakarta with daily demand in February 2017. There are 1 point as a depot (A1) and 10 distribution points in the form of agency (A2-A11) scattered with different demand for each agency. Vehicle that overcome the demand in the town of Surakarta there is one car with a capacity of 3550 copies of newspapers. In this study using Differential Evolution (DE) algorithm, the distribution points raised in the map are then drawn with the x and y axes so that the position and coordinates of those points of distribution are known.

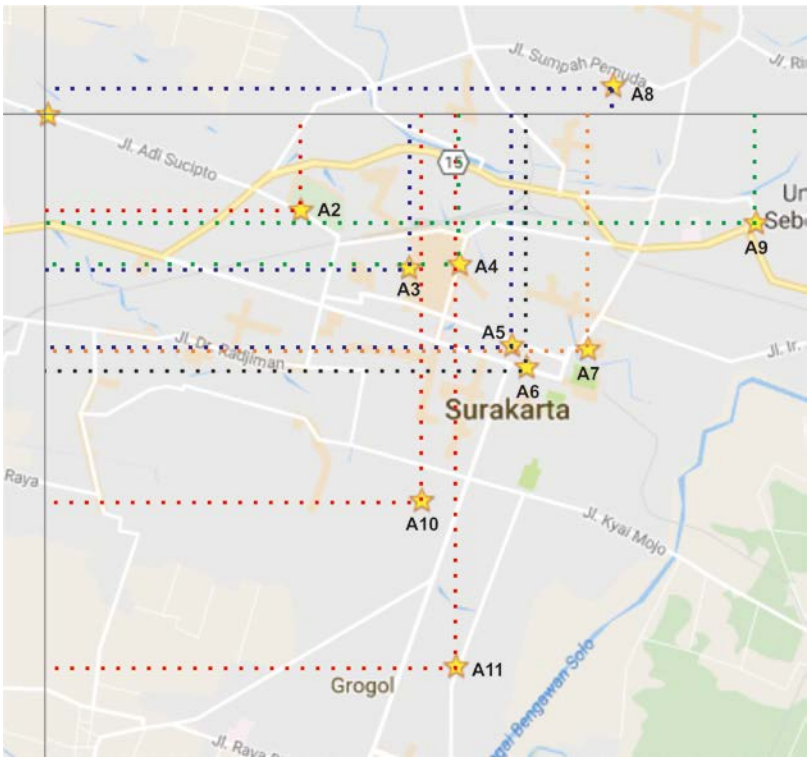

Figure 3. Distribution nodes coordinate

Table 2. Distribution nodes information

No	Coordinates		Demand
	x	y	
A1	0	0	0
A2	49,92	-18,87	120
A3	71,26	-30,52	210
A4	80,19	-29,46	250
A5	91,13	-45,71	150
A6	93,95	-50,29	220
A7	105,94	-46,41	180
A8	110,77	4,94	105
A9	138,64	-21,34	210
A10	73,49	-76,05	200
A11	80,19	-108,50	215

The amount of daily demand of each agency varies between 105 and 250 in February 2017 according to the table above. After the calculation by entering the data according to the table above, we obtained the results of the most optimal of a new route that is generated by the algorithm Differential Evolution (DE)

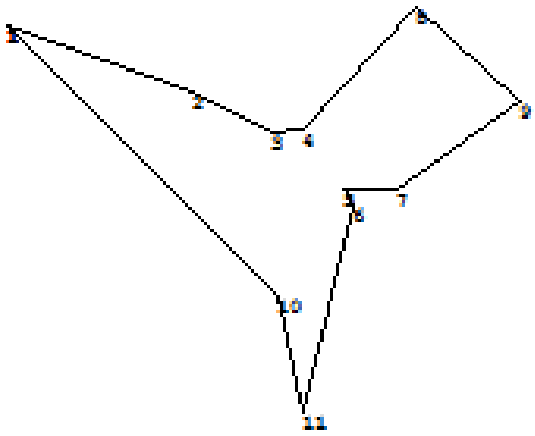

Figure 4. Iterated Results Layout

Table 3. Proposed distribution route

The order of distribution routes	
A1-A10-A11-A6-A5-A7-A9-A8-A4-A3-A2-A1	
32,6 km	1 hour 28 minutes

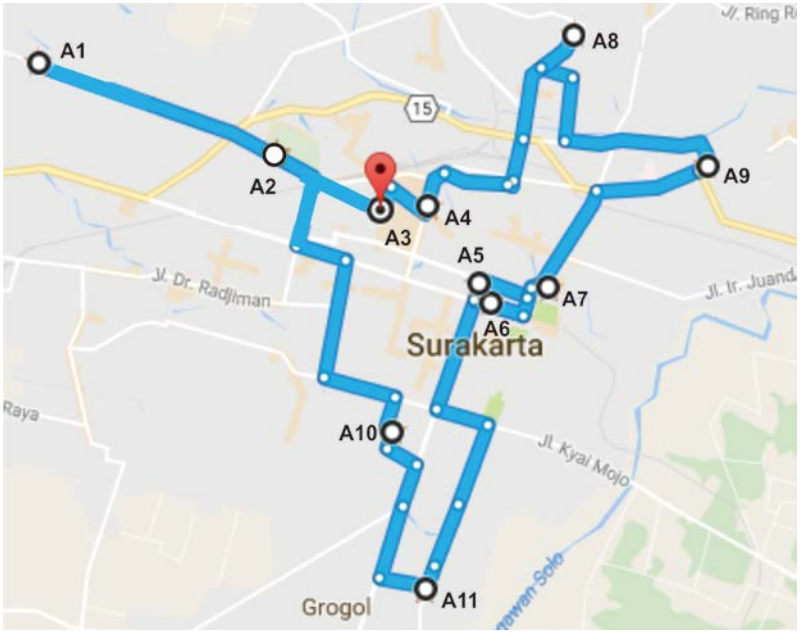

Figure 5. Proposed Distribution route

The route implementation can be implemented in the absence of any change of agency or change of the current traffic beacon. And the results obtained only cover one area of the town of Surakarta

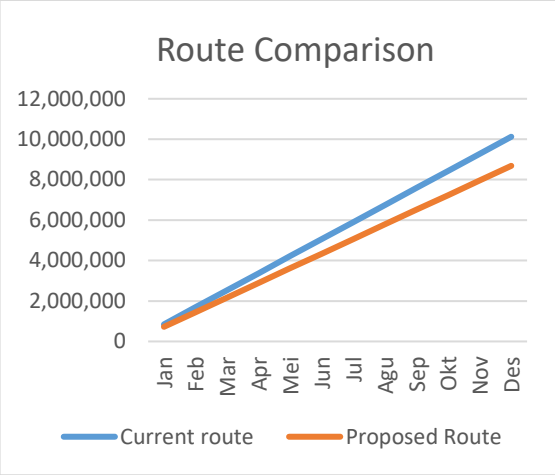

Figure 6. Route Comparison

Due to the distribution process in this area takes place every day, then in a month can be calculated that the company experience saving distance of 162 km or if calculated cost savings of vehicle fuel with assumption a litre of Pertalite can go for 10 kilometres and the price of Pertalite is IDR 7,400.00 per litre then it will save 119,880.00 per day. For one year it can save IDR 41,958,000.00, with the assumption of 350 work days per year. Of course, it is a considerable saving because of no investment should be made.

4. Conclusion

From result of data processing that have been done can be concluded that result of determination of VRPTW model by using Differential Evolution (DE) algorithm get optimal proposed route with total distance of 32.6 km with estimated time of 1 hour 28 minutes compared to existing route with 38 km distance and estimated time of 1 hour 44 minutes. So the new route produced is better because it has a shorter time and a shorter distance that can result in savings of IDR 41,958,000.00 with no investment is made. Further research can be conducted by combining using qualitative methods that will enrich the model and can reflect the real condition more closely.

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