RESEARCH ARTICLE



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# Vehicle Routing Problem Settlement for Supply Chain Network of Batik SMEs in Pamekasan District Area

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Distribution channels of batik material throughout the batik SMEs in Pamekasan District should be optimized because the characteristics of those channels will influence the production cost. These batik SMEs will have their supplier settled in Kolpajung, Pamekasan area, which will be built by the Department of Industry and Commerce (Dinas Perindustrian dan Perdagangan or Disperindag) to reduce the competition between the SMEs and also to improve the competitiveness of Pamekasan District. This problem is called the vehicle routing problem (VRP), which has the aim of minimizing the distance of the route in the distribution network. VRP is a complex combinatorial optimization problem, thus the metaheuristic optimization approach in this situation is excellent to solve the problem. This study uses the Deferential Evolution (DE) method, which is part of metaheuristic approach. DE is well known for its fast optimization characteristics due to its simple optimization strategy. The results of this study showed that the shortest distance obtained to send raw materials to all of the 37 batik SMEs in Pamekasan is 390,16 kilometers. The number of the vehicles needed was as many as 16 vehicles in one-time shipment (16 routes), with the type of the vehicles used was box-trucks with six double wheels and 48 $m^3$ of capacity per truck.



**Keywords:** Theorem Proving, Parallel Algorithm, Extension Rule.

## 1. INTRODUCTION

Based on the World Bank's Logistics Performance Index (LPI), Indonesia was ranked the 5th among the ASEAN countries in year 2014 (World Bank, 2016).[1] According to the Chairman of Indonesian Chamber of Commerce (Kamar Dagang Indonesia or Kadin), logistics cost in Indonesia is about 30% of the minimum production cost (supplychainindonesia.com, 2016). This also applies to batik product, which in year 2013 was nominated as a superior product towards the era of the ASEAN Economic Society (viva.com, 2016).

Generally, batik industries in Indonesia are small and medium industries (SMEs), which are spread mostly across the Java Island.[1] Names and types of the batik products are usually adapted based on the characteristics of the areas' culture. Pamekasan is one of the example of the areas that has its own style and name for its batik products.[2] Dinas Perindustrian dan Perdagangan (Disperindag) will build a supplier store in Kolpajung, Pamekasan. This supplier store will supply batik products to each of the SMEs in order to reduce the competition between the SMEs and also to improve the competitiveness of Pamekasan District. Thus, it is necessary to optimize the distance of the route in the distribution network as well as to minimize the number of the vehicles needed for the distribution transportation. This kind of problem is called the vehicle routing problem (VRP).[3]

Tasan and Gen[4] state that VRP is part of Nondeterministic Polynomial Time Hard Problem. This implies that the time used to solve the problems will be higher in non-deterministic polynomial manner as the problems' size increases. Because the problem's scope is quite large, approaching VRP with an exact method VRP will not generate an efficient solution. Thus, a method called metaheuristic was developed to better resolve the problem.[5] A well-known, easier and simpler metaheuristic method to use is the Differential Evolution (DE) approach. DE belongs to the Evolutionary Algorithm (EA) family, and it is an improved version of the older EA methods' shortcomings. DE optimizes faster than the other EAs, because its optimization strategy is simple and calculates faster with fewer iteration to find global optimal solution.[6] Using DE method, this research explores the best distribution route of the batik raw materials to each of the batik SME in Pamekasan District area.

## 2. METHODOLOGY

This research is categorizes as quantitative research whereas the data to be used can be measured mathematically. The data in this study were the requirements of raw materials and the distance between batik SMEs in Pamekasan. The primary data used in this study is the batik's raw material demand of every batik SME. The secondary data used in this study is the address of each

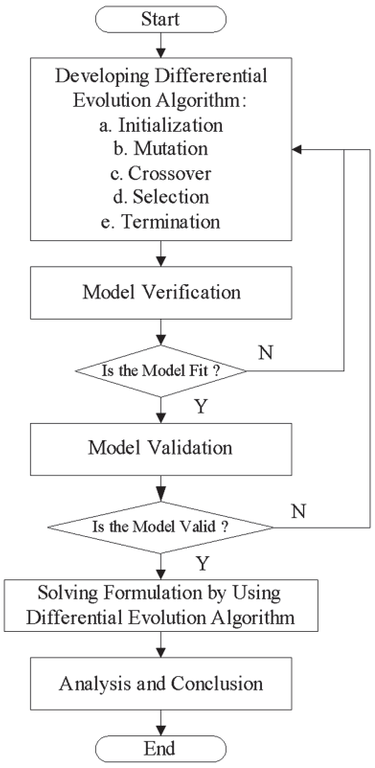


**Fig. 1.** Research flowchart.



batik SME in Pamekasan obtained from Disperindag Pamekasan that will be used for route determination among SMEs using the Google Map.

This research applied mathematical modelling by using:

Index(es):

$i, y =$ index to describe node (SME and supplier)

$k =$ index to describe vehicle

Parameter(s):

$j_{iy} =$ distance from node ($i$) to node ($y$)

$d_i =$ order of SME ($i$)

$q_k =$ capacity of vehicle ($k$)

Decision variable

$x_{iyk} = 1;$ if customer is visited by vehicle $k$ from node $i$ to node $y$

$0;$ if customer is not visited by vehicle $k$ from node $i$ to node $y$

This research was conducted by following these steps;

1. Constructing mathematical model by defining objective function and constrains.

The objective function is to minimize distance:

$$\min \sum_{i=0}^{N} \sum_{y=0}^{N} \sum_{r=1}^{N} j_{iy} x_{iyk} \tag{1}$$

While the constrains are developed as:

a. Customers are served once only

$$\sum_{i=0}^{N} \sum_{r=1}^{N} x_{iyk} = 1 \quad \text{for} \quad y = 0, 1, \ldots, N \tag{2}$$

$$\sum_{y=0}^{N} \sum_{r=1}^{N} x_{iyk} = 1 \quad \text{for} \quad i = 0, 1, \ldots, N \tag{3}$$

b. The vehicle must deliver and pick up at the same customer

$$\sum_{i=0 i \neq y}^{N} x_{iyk} = \sum_{i=0 i \neq y}^{N} x_{iyk} \quad y = 1, 2 \ldots, N \; k = 1, 2 \ldots, N \tag{4}$$

c. Number of customer order on a such route is not allowed to exceed the vehicle route capacity

$$\sum_{i=0}^{N} d_i \sum_{y=0 y \neq i}^{N} x_{iyk} \leq q_k \quad k = 1, 2 \ldots, N \tag{5}$$

2. Developing differential evolution algorithm.

Before developing differential evolution algorithm, it must be considering created formula. The steps to develop differential evolution algorithm are:

a. Initialization
b. Mutation
c. Crossover
d. Selection
e. Termination

3. Solving the formula by using developed differential evolution algorithm.

## 3. RESULTS AND DISCUSSION

Batik producers in Indonesia are generally small and medium industries (SME), which are spread over several areas in Java. The names and types of batik are usually customized according to the name of each region, mainly because each region has different characteristics.[7] Batik industry in Madura was established by history. Batik center in Madura is not too far from the palace, because based on the history, people who make batik in Madura is a community among the palace. There are several centers of batik Madura. Among others are in Pakandangan Sumenep, Batu Biru Pamekasan, and Banyu Mas.

Vehicle Routing Problem (VRP) is a problem of determining the route of several independent vehicle to travel to different consumers in many different locations. Transport capacity of each vehicle are identical and the product's demand is generated by the customers. Customers are visited one time and the total demand of each route may not exceed the carrying capacity of the vehicle. Points of departure and returns of each vehicle, usually called

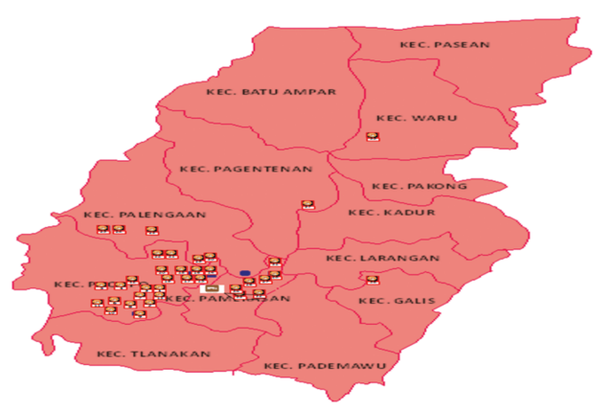


**Fig. 2.** Map Pamekasan's Batik SMEs.

depot, are the same each time. According to Osvald and Stirn,[8] the purpose of VRP is "minimizing total mileage and the number of vehicles used to meet the demand in each location."

Deferential Evolution (DE) algorithm is defined as part of metaheuristic methods, which is included in the family of evolutionary algorithm (EA) and employed stochastic search methods based on population, population-based search. The difference between the DE algorithm and the other EA methods is the distance and direction information that is used for indicating the process of finding a better solution.[9] According to Rahnamayan et al.,[9] there are several steps in DE, which are described as followings.

### 3.1. Initialization

(a) $Np$ (The population) is the number of individuals who will be raised in a generation or iteration, using Eq. (3) $N$ where $N$ is the number of points which is 37 SMEs, thus the number $Np = 3 \times 37 = 111$.[10]

(b) Number of $F$ and CR. CR is a control parameter used in performing the crossover process, while $F$ is a multiplier factor used in mutation. According to Teoh et al.,[10] the best value for crossover is 0.4 while the value of $F$ is between 0.5–1.

**Table I. Number of route.**

| No | Route | | | | | | Number |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 10 | 21 | 1 | | | 1 |
| 2 | 1 | 33 | 32 | 1 | | | 1 |
| 3 | 1 | 36 | 38 | 1 | | | 1 |
| 4 | 1 | 20 | 15 | 1 | | | 1 |
| 5 | 1 | 30 | 31 | 23 | 1 | | 1 |
| 6 | 1 | 7 | 26 | 1 | | | 1 |
| 7 | 1 | 2 | 5 | 27 | 1 | | 1 |
| 8 | 1 | 16 | 25 | 14 | 19 | 1 | 1 |
| 9 | 1 | 6 | 9 | 1 | | | 1 |
| 10 | 1 | 9 | 1 | | | | 1 |
| 11 | 1 | 12 | 1 | | | | 1 |
| 12 | 1 | 29 | 24 | 35 | 37 | 1 | 1 |
| 13 | 1 | 37 | 1 | | | | 1 |
| 14 | 1 | 13 | 11 | 18 | 17 | 1 | 1 |
| 15 | 1 | 34 | 8 | 4 | 1 | | 1 |
| 16 | 1 | 22 | 3 | 28 | 1 | | 1 |
| | | | Total | | | | 16 |

Mutation is done through 3 individuals randomization, followed by subtraction of individual number 2 by individual number 3 times $F$ and then added to individual number 1.

Crossover process is conducted through comparing the control parameter (CR) with numbers, which are generated randomly. If CR is less than or equal to the random numbers, then the gene of target vector becomes trial vector. If CR is higher than the random numbers, then the gene of mutation vector becomes trial vector.

The selection process is done by comparing the evaluation values between the target vector to trial vector. If the evaluation value of trial vector is better than the evaluation value of target vector, then the target.

## 4. CONCLUSION

The best distance obtained is 390160 meters with total routes of 16 routes and capacity of 48 $m^3$. The following Table I shows the routes.

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