# Planning route distribution of IKM DM using the methods vehicle routing problem (VRP) and shortest-route algorithm

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# PLANNING ROUTE DISTRIBUTION OF IKM DM USING THE METHODS VEHICLE ROUTING PROBLEM (VRP) AND SHORTEST-ROUTE ALGORITHM

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## ABSTRACT

*IKM DM is a company engaged in the business of apparel or garment. Many actors involved in the business of the company, one of them is convection who became a partner of IKM DM in producing a product company especially trousers. Availability of finished goods in storage is the most noted companies, as an effort to improve competitiveness with always meet the needs of customers. The management of the distribution system should be very noticed by IKM DM, because so influential against time until goods in a warehouse. In this case, time is strongly influenced by the distance or route which passed by a conveyance that transports the product IKM DM.*

*Based on it, research conducted on the distribution system of the IKM DM by making design route distribution optimal with two types of route companies that become case study are the location of the distribution routes of convection (Jakarta) to the location of the warehouse finished goods using the approach of VRP (Vehicle Routing Problem) and Route of distribution Jakarta-Pekalongan by approach shortest-route algorithm.*

*The result of the calculation using the VRP indicate savings on regular routes that by passed the IKM DM vehicles 5 routes into 4 routes with combining the location of convection Bambang and Noto. Then sort the results based on the route obtained approximately 6.1 km with an allocation of a vehicle using the truck a wheel 4 and including the location which was also performed by convection allocation other vehicles. While in the calculations using the shortest-route algorithm, show the results of shortest route on the distribution route Jakarta-Pekalongan of 389 km. saving the distance made after using the method by 50 km shorter than the initial routes 1 and 8 miles on route 2 normally skipped. The results of the cost savings transport with make an investment vehicle as much as 51.2 % or worth IDR 1,705,800 based on ratios convection Kusnandi and Bambang.*

***Keywords:*** *Distribution system, routes, distance, the location convection, costs, transportation*

## 1. INTRODUCTION

In improving the quality of an enterprise, a lot of things in the activity of a business firm needs to be noticed, among them are distribution system. The distribution of highly influential against the arrival time of goods or materials and also the cost that must be spent by the company. Therefore, companies should plan things pertaining to distribution like distance, the number of units distributed, and mode of vehicle used. *Vehicle Routing Problem* (VRP) and *Shortest-Route Algorithm* are two methods that can be used in the planning of the optimal routes for the distribution system. VRP used in designing the route with the

planning on a mode of transportation that in have, while shortest-route algorithm used in determining the shortest distance of a route. Both of these methods are used to obtain the optimum route for distribution systems of a company.

Through both this method, IKM DM will plan two routes were chosen based on the results of observation in the distribution system of his trousers to be more optimal. VRP will be used in designing the vehicle allocation and savings for route distribution of convection (Jakarta) location to the location of the warehouse finished goods. While the Shortest-Route Algorithm will be used in designing and choosing the shortest route is the route most optimal distribution

on the route Jakarta-Pekalongan. Then after a calculation done, Researchers are also designing an investment vehicle that costs comparison carried out one of the convection, and can make a proposal for yet another convection using the ways.

## 2. LITERATURE
### 2.1 Distribution System

Distribution is an activity to move product of the suppliers to the consumers in supply chain. The preparation of distribution network proper can be used to achieve multiple purposes of of supply chain, ranging from low cost to high response to a request from the customer (Copra, 2007).

### 2.2 Vehicle Routing Problem (VRP)

VRP is the determination of a number of a route for a bunch of vehicles must be served a number of dismissal (node) of depot the center. Besides that, to solve the problems of VRP can also use methods VRP with the base calculations use saving the matrix. *Saving matrix* is one of the techniques used to schedule a limited number of vehicles from a facility and number of vehicles in the fleet is limited and they have different maximum capacity. The purpose of this method is to select the assignment of vehicles and the best possible routing (Bowersox dkk., 1996).

The following is the completion of a method of VRP with the base calculations of saving matrix:

#### 2.2.1 Identify Matrix Distance

In this measure should be the presence of data over distances between each location of a warehouse to convection and distance among several locations convection. The distance between two locations can be obtained by the use of manhattan distance that is shown on the equation 1.

$$d = \sum_{i=1}^{n} |Xi - Yi| \qquad (1)$$

Where:

d  = The overall distance locations (m)

Xi = The X coordinate (latitude) location of convection to-i

Yi = The Y coordinate (*longitude*) location of convection to-i

#### 2.2.2 Identify Saving Matrix

Saving matrix represents the savings if a vehicle to visit several locations in sequence in a single trip compared to visit one at a location.

The saving matrix can be calculated in the equation 2 as follows:

$$S(a,b) = J(G,a) + (J(G,b) - J(a,b) \qquad (2)$$

Where:

S(a,b) = The value of saving the matrix of locations convection a to location convection b (Km)

J(G,a) = The distance between the warehouse to the location of convection a (Km)

J(G,b) = The distance between the warehouse to the location of convection b (Km)

J(a,b) = The distance between the location of a and b (Km)

#### 2.2.3 Allocating Convection Location or Route to a Vehicle

Based on the results of saving have been obtained, then the allocation can be done from any location of the convection to the vehicle or route. In the previous step, the allocation of each convection performed on different routes. So there will be a number of routes which are obtained at the beginning, but in this step the convection locations can be combined based on location and position also limits the capacity of the vehicle used. The merger will be started based on the value of the largest savings, because it is expected to obtain maximum savings

#### 2.2.4 Sort the Location of Convection (Goal) in the Routes that are Already Defined

The next step which is the final step in this method is to determine the route visits. There are some method can be used method is nearest insert nearest neighbor and methods. Both methods were used to minimize distance travelled truck. The following explanations regarding the use of these two methods:

a. Nearest Insert method

This method begins by selecting the location of the convection which at the time incorporated into the existing route generates additional minimum distances. In the beginning, there were only trip from warehouse to warehouse with a

distance of zero. Next will be seen in how the distance will happen by adding each of the stores to the existing route.

b. *Nearest Neighbor* method

This procedure started route his vehicle convection by its distance from the closest to the locations visited by the last convection. Then the next route is approximately the location of convection is closest to the warehouse. This procedure will be repeated until all consumers continue to get into travel routes.

### 2.3 Shortest-Route Algorithm

*Sourtest-rute problem* usually found to the case of the determination of the shortest route between source and destination in transportation network. To solve problems in the determination of the shortest route can spend two the algorithms that derived from shortest-route algorithm namely acyclic and cyclic network (Taha, 1992).

Where known $u_1 = 0$. Then the value of $u_j$, $j = 1, 2, …, n$, in calculated using the equation 3.

$$u_j = \min_i \{ \text{shortest distance } u_i \text{ to an immediately preceding node } i \text{ plus distance } d_{ij} \text{ between present node } j \text{ and its predecessor } i \}$$
$$= \min_i \{u_i + d_{ij}\} \qquad (3)$$

The formula on to explain that the shortest distance of $u_j$ for node j obtained after having the calculation result of $u_i$ for each node i from the predecessor activity related to j according to a specified direction. on the final solution of shortest-route model, The result it is not enough to explain the nodes $u_j$ from *node* j. Concurrently, must also identification on each node that has passed along the route. To accomplish a purpose of this algorithm, o be done labeling procedure which it will combine a label to a node j, as an equation 4 following:

$$\text{node j label} = [u_j, n] \qquad (4)$$

Where n is the node immediately preceding the j which leads to the shortest distance from $u_j$. The equation of 5 is accounting for gain in value $U_j$ when node having more than one node a predecessor.

$$U_j = \min_i \{u_i + d_{ij}\}$$
$$= u_n + d_{nj} \qquad (5)$$

With the determination of 1 is that node [0,-], assuming 1 node as the source or starting point of travel network.

## 3. METHOD OF RESEARCH

The Research start with formulating the problem while conducting observations, then the determination of the limits, assumptions, goals, and the benefits of research. After that, Performed the collection of necessary data in processing then proceed with the processing of data, this process was conducted in parallel with two different problem namely processing using methods VRP and processing using methods Shortest-Route Algorithm. Attachment 1 showing the sequence of the work in this study.

## 4. RESULTS AND DISCUSSION
### 4.1 Data Collection

Data is collected data for research in the form of primary and secondary data. Primary in which data obtained directly namely based on observation and an interview with the company that deals with distribution system of companies such as data lead time for distribution of a product trousers, transportation costs data, and others. Then for data secondary obtained based on their existing at companies like data address convection and data history the sale of products trousers every convection. Then, there is the secondary data from outside the company but remain with regard to the data needed for this study as an example of the data distribution region each coordinate IKM DM derived from Google Maps application.

### 4.2 Data Processing

At this stage, there are two data processing process undertaken in parallel, namely the processing method using a distribution route for the VRP site attempts convection in Jakarta with finished goods warehouses belonging to the IKM DM and method of shortest-route algorithm for route distribution of finished goods Pekalongan-Jakarta with a case study on convection Kusnandi. But, the researcher first describes the calculation method using VRP.

### 4.2.1. Vehicle Routing Problem (VRP)

The researcher using this method to route from finished goods warehouse to the

location IKM DM convection in Jakarta or vice versa by using this method Researchers want to a saving perform the merger against several locations by looking size and location every convection order. This is a step that is carried out in the VRP with base calculation using the saving matrix.

### 4.2.1.1 Determining the location of the objective and the size of the order

On the initial process of this method, Researchers in advance determine the coordinates of each location of convection and the size of the order every effort of convection. The Researchers first searched for and set a route that passed by each location of convection towards the warehouse finished goods or vice versa. Next, designating the size of the order based on the data history sales every convection by first done forecasting to the size of the order a period of next, that will be the input of DRP (Distribution Resource Planning). The forecasting results obtained using software minitab 16.

Besides data forecasting that becomes enter to DRP, also required components of *safety stock*. A component is needed to maintain the stock in a warehouse always available or anticipation when demand exceeds stock that is available. All the data is inserted into the table and after the calculation of the DRP is done order results obtained for each location as in show table 1.

Table 1. Calculation Order Results

| The location of convection | Order for each convection (unit) |
|---|---|
| Alan | 81,438 |
| Bambang | 18,625 |
| Kusnandi | 89,265 |
| Noto | 48,768 |
| Rani | 60,099 |

### 4.2.1.2 Identify Matrix Distance

A matrix distance is obtained based on the results of the calculation of the coordinates of each location using Equation 1. Table 2 showing the results of calculations of distance matrix of location of convection. A value on a matrix distance will be used in the calculation of saving matrix in the next

stage. Because the route every locations in calculating of the real condition and spots of the meeting (node) before to the destination. Then unknown coordinate the latitude of $x$ and $y$ coordinate longitude every nodes. Next, these coordinates are included in Equation 1. Example calculation use equation 1 are on calculations matrix distance between convection Alan to the finished goods warehouse, There are 6 meeting point or node before reaching the destination. The distance both obtained by means[4]

$$d = | (X_1 + X_1 + X_1 + X_1 + X_1 + X_1) - (Y_1 + Y_1 + Y_1 + Y_1 + Y_1 + Y_1 +) |$$
$$d = 1.13 \text{ km}$$

The results obtained of 1.13 km, that comes from a reduction in the number of coordinates X and coordinates Y of each node. Then like it anyway calculation matrix distance other locations. In obtaining real results at a distance, after the results obtained in the calculation then the results compared with the results of distance based on the google map application and value acquired for 1.5 km. There is the difference in value between reckoning with the data the application of google maps but its value not so far. The results derived from calculations of strongly influenced by the values of the coordinates so that when a search value, in fear, with some minor errors when accessing the site or less accurately the real location of the position. Therefore, Researchers are using the distance derived from the application for the next calculation. This is to lead to results more approach distance on condition of real. But for the calculation of the distance of others the location continue to take into account the distance using the comparison of calculation results in equation 1 as well as data from the google map application. Table 2 showing the results of calculations of distance matrix of the entire site.

Table 2. Results calculation of the matrix of Distances (in km)

| | Warehouse | KA | KB | KK | KN | KR |
|---|---|---|---|---|---|---|
| KA | 1.5 | 0 | 0.4 | 1.8 | 1.4 | 4.8 |
| KB | 1.9 | 0.4 | 0 | 4.5 | 1.1 | 5.1 |
| KK | 3 | 4.9 | 1.4 | 0 | 0.35 | 5 |
| KN | 3.1 | 4.1 | 3.7 | 0.35 | 0 | 6 |
| KR | 3.8 | 4.8 | 5.1 | 6 | 5.8 | 0 |

### 4.2.1.3 Identify Saving Matrix

The savings matrix obtained by equation 2. Table 3 showing the results of calculations of the savings matrix from each site. Examples of the calculation in this process, namely the saving matrix between the node KA and the node KB by using equation 2, the values of distance matrix node KA (The convection of Alan) against finished goods warehouse location is 1.5 km and the distance matrix node value KB (The convection of Bambang) against finished goods warehouse location is 1.9 km. Both of those values in total and then reduced by the value of the matrix of distances between nodes KA and node KB which amounted to 0.4 km so that the obtained results of 3 km.

Table 3. Results Calculation of the Saving Matrix (in km)

|    | KA  | KB  | KK   | KN   | KR  |
|----|-----|-----|------|------|-----|
| KA | 0   | 3   | 2.7  | 3.2  | 0.5 |
| KB | 3   | 0   | 0.4  | 3.9  | 0.6 |
| KK | 1.8 | 3.5 | 0    | 5.75 | 1.8 |
| KN | 0.5 | 1.3 | 5.75 | 0    | 0.9 |
| KR | 0.5 | 0.6 | 0.8  | 1.1  | 0   |

### 4.2.1.4 Allocating Convection Location or Route to a Vehicle

At this stage, researchers conduct allocation route or based on the location on a vehicle order set. The Data is derived from the value of saving matrix. Each location will have a convection attempt different routes, so there are 5 route before allocation. A table 3 showing the distribution of the route every location by the result of saving matrix and also the order. Order obtained based on the table 1.

After the route done, the next step is sort value of saving matrix from the largest to the smallest. Attachment 3 showed the results sorting of the value of saving matrix every location. It is conducted to determine the location that can be combined in 1 routes, with also paying attention to the capacity of mode that exist.

The location of greatest value may be combined into one route in advance and can be allocated on a mode of existence. Table 4 showing specifications of mode, owned by IKM DM.

Table 4. Specifications Mode of IKM DM

| The mode of transportation | Maximum capacity | | |
|---|---|---|---|
|  | Capacity per sack | Capacity per bunch | Capacity per unit |
| Truck box of a wheel 4 | 23 | 115 | 6,900 |
| Truk Box of double wheel | 25 | 125 | 7,500 |
| Truck box of a wheel 4 | 22 | 110 | 6,600 |
| Truck box of a wheel 4 (large size) | 22 | 110 | 6,600 |
| Truck box of a wheel 4 (medium size) | - | 74 | 4,440 |
| APV | - | 43 | 2,580 |

From the order of an existing location in attachment 3 and the merger that results can be obtained with customized matrices for each location as well as the number of orders that will be transported vehicle. Can be seen in attachment 3, there is one combined order routing between locations KK and location KN with a total order 9.859 units. Both route that cannot join in having no mode having capacity for transporting order that those two locations have. Different with the location on third namely the location of KB and KN to the size of the order of 4.814 units, Can be combined because both locations hasn't in allocation and the number of order meet capacity mode owned is on vehicle truck box wheel 4. While based on the other cannot be combined since the number of order that do not meet the capacity of a maximum of modes and there is also one of the locations have an allocation. Table 5 showed the results of the route after doing allocation route and also is the vehicle.

Table 5. Results of the Route after the Allocation

| Route | Route | The location of convection | The number of orders that are transported | Utility (%) |
|---|---|---|---|---|
| Rute 1 | Truck box of a wheel 4 | KB,KN | 4,814 | 69.8 |
| Rute 2 | Truk Box of double wheel | KA | 5,817 | 77.6 |
| Rute 3 | Truck box of a wheel 4 | KK | 6,376 | 96.6 |
| Rute 4 | Truck box of a wheel 4 (large size) | KR | 4,293 | 65.0 |
|  | Truck box of a wheel 4 (medium size) | - | - | - |
|  | APV | - | - | - |

Based on the results in table 5, only to see that the location of the convection Bambang and Noto can do the merger route. The location convection other continue to use the same route but coupled with allocated based on a vehicle owned companies. In addition to the location which can be combined, based on the results were obtained the allocation route from distribution system that is owned by IKM DM namely route from 5 to 4 route and also the utilization of transportation mode exist. There are two modes that are not used on the distribution office trousers from every convection into the GBJ, namely box truck wheels 4 (medium size) and APV. Both types of this mode doesn't mean not at all used by IKM DM, rather it is used for operational business activities such as the distribution of products other than the product office trousers and also to deliver the product to the store. But both these activities outside the scope of the research conducted so not explain in detail in this paper.

4.2.1.5 Sort the Location of Convection (Goal) in the Routes that are Already Defined

The route to be sorted is derived from convection Bambang and Noto which became two sites convection can do the merge. While for others continue to use the same route. The next process is to sort the routes that have been in the merge by using two sorting method routes namely method nearest insert and nearest neighbor.

1.  Nearest Insert

This method of sorting done on routes with the most minimum distance viewing of each location on the GBJ, from the early departure of GBJ until returning to GBJ anyway. Acquisition sequence based on the value of the smallest to the largest distance distance. A table 6 showing a result of calculation method nearest insert.

Table 6. The Sorting Results of Each Location

| No | The sequence of location | Distance (Km) |
|---|---|---|
| 1 | GBJ-KB-GBJ | 3.8 |
| 2 | GBJ-KN-GBJ | 6.2 |

On a table 6 there are results sorting of the location convection Bambang and Noto by using the method nearest insert. Then the sorting results both locations can be seen in table 7.

Table 7. The Result Sequence of Locations after the Using Nearest Insert Method

| The Result Sequence of Locations | Total Distance (Km) |
|---|---|
| GBJ-KB-KN-GBJ | 6.1 |

2.  Nearest Neighbor

This method of sorting done on the route by looking at a distance closest to the warehouse of finished goods. Then the next sequence acquisition was the location of the nearest distance with the distance that was previously selected. Table 8 showing the results of calculations for each location of convection with nearest neighbor method.

Table 8. The Sorting Results of Each Location

| No | The sequence of location | Distance (Km) |
|---|---|---|
| 1 | GBJ-KB | 1.9 |
| 2 | GBJ-KN | 3.1 |

Then the sorting results both locations can be seen in table 9.

Table 9. The Result Sequence of Locations after Using the Nearest Neighbor Method

| The Result Sequence of Locations | Total Distance (Km) |
|---|---|
| GBJ-KB-KN-GBJ | 6.1 |

From the results of sequencing of routes on both methods, large distance obtained both is the same, worth of 6.1 km. So, based on the sequence of the process of distribution routes on the site of Bambang and Noto convection can be done with a single transport and through the same route one. Table 10 showing the results and then sorting the entire route

from the location of the convection and also total distance after sorting.

Table 10. Results Sorting the Whole Location Convection

| No | The Result Sequence of Locations | Total Distance (Km) |
|----|----------------------------------|---------------------|
| 1  | GBJ-KB-KN-GBJ                    | 6.1                 |
| 2  | GBJ-KA-GBJ                       | 3                   |
| 3  | GBJ-KK-GBJ                       | 6                   |
| 4  | GBJ-KR-GBJ                       | 7.6                 |

### 4.2.2. *Shortest-Route Algorithm*

The second method is to use Shortest-route algorithm. This method is used to obtain the shortest route from the route Jakarta-Pekalongan. At the time of observation, Researchers saw that there was an interesting thing for route distribution convection that almost all convection perform the process of distribution to the region of Pekalongan because of a production process they done there.

To get to the location, there are several routes that Pekalongan traveled, and based on the results of interviews to some of the driver, there are two alternative paths that can be followed in the middle lane of route or routes through Bandung. Based on it, Researchers would like to make a proposal to the company in determining the best route for route distribution product trousers IKM DM. Before the Researchers using the calculation of the Shortest-route algorithm, Researchers are looking for some nodes or points of distribution routes impassable meeting Jakarta-Pekalongan. In this research, case study done at convection Kusnandi. That location was chosen because of the convection has the largest number of stitches than all convection, workers on this amount of convection as well at most and only this convection are investing in transportation modes namely procurement of trucks, while others use the services of convection expedition.

From the shortest route obtained based on calculations of the shortest route-algorithm, Researchers also want to compare the results of the calculation of costs when using its own mode of transportation with the use of the service of the expedition. Attachment 4 showing

calculation uses the method *Shortest-route algorithm*. The calculations in this method by using equation 3 to equation 5. After having the shortest route to route obtained distribution Jakarta-Pekalongan, as showed in attachment 5. Next, the Researchers compare transport costs incurred two convection using different strategies in terms of providing vehicle distribution. Convection Kusnandi making investments on a vehicle while other convection only using services expedition to the process of distribution of goods. Data about the components of transportation costs on data collection, Used for comparing two convection who became case study researchers are used by convection Kusnandi and convection Bambang. The assumptions that are used in usage mode, both used mode of truck with the wheel of a double with products that are transported 25 sack. And of distance used based on the shortest route is 389 km. Attachment 6 showing calculation transportation costs to convection Bambang. Based on the results of the calculation of the total cost on convection Bambang is Rp. 3,495,800. Attachment 7 showing calculation convection kusnandi transportation costs.

Based on the calculation total cost on convection Kusnandi is worth Rp.1,790,000. It appears that a total cost of the distribution of belonging to Kusnandi more small in comparison with convection Bambang. It is also because it is affected by the absence of expenses for each sack carried on business, while the convection Bambang cost per sack due to the efforts of this convection using the services of an expedition by calculating the number of units that are transported. The savings can be seen performed in the Kusnandi convection transport costs for product distribution trousers Rp.1,705,800 or approximately 51.2% smaller than spending undertaken convection Bambang. This can also be applied by other convection but with further economic calculation, by considering other cost components such as maintenance costs, availability of capital, and others. It's just that these calculations can be accounted for by any convection due to very influential towards the cost savings have.
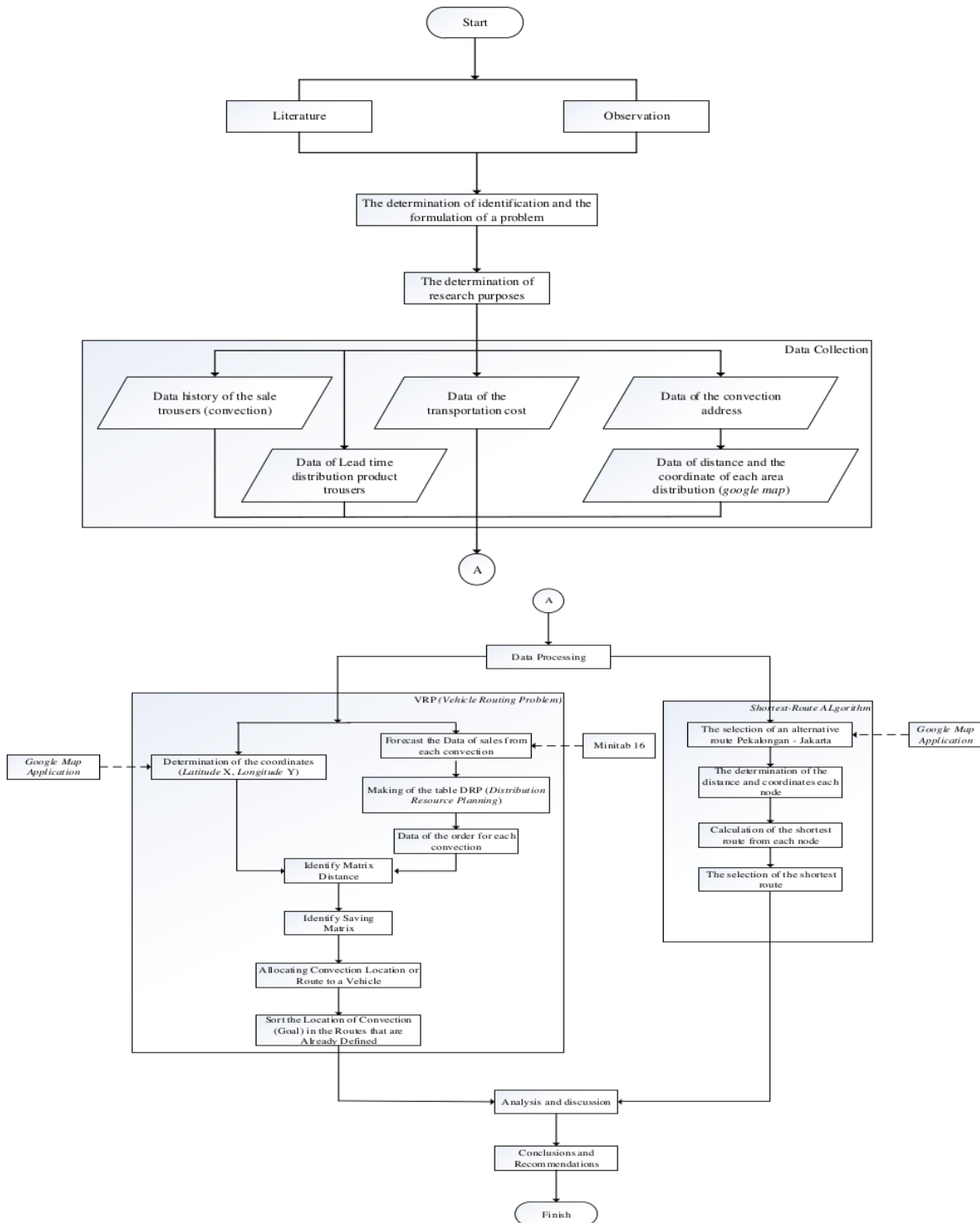
## 5. CONCLUSION

Based on the results of analysis and discussion in the previous chapter, the conclusion can be obtained as follows:

1. Based on a result of calculation Vehicle Routing Problem (VRP) method. Obtained the result of the merger route between convection Bambang and Noto by the number of order of 4.814 a unit with value utility of 69,8 %. While in convection other there is no change or be considered continue to use the route it was before. In addition, there are the savings on a route traversed mode of transportation that is the route from 5 to 4 route. The result of sorting the location of using methods nearest insert and nearest neighbor on a route combined, were both yielding of value and the same order namely by the result of reckoning the distances obtained from both this method of 6.1 km.

2. The results of the distance route jakarta-pekalongan obtained shorter than distance before using approach shortest-route algorithm is as much as 389 km and proved to be a distance obtained better than before using this method is by savings of 50 km on a route 1 and 8 km on a route 2. The results of the cost savings transport with make an investment vehicle as much as 51,2 % or worth Rp.1,705,800 through comparison convection Kusnandi and Bambang.

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## Attachment 1. Flow Chart of Research Methodology

```
                          ┌──────────┐
                          │  Start   │
                          └──────────┘
                               │
              ┌────────────────┴────────────────┐
        ┌───────────┐                      ┌──────────────┐
        │ Literature│                      │ Observation  │
        └───────────┘                      └──────────────┘
              └────────────────┬────────────────┘
                    ┌────────────────────────────────┐
                    │ The determination of            │
                    │ identification and the          │
                    │ formulation of a problem        │
                    └────────────────────────────────┘
                                 │
                    ┌────────────────────────┐
                    │ The determination of    │
                    │ research purposes       │
                    └────────────────────────┘
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**Data Collection**

- Data history of the sale trousers (convection)
- Data of the transportation cost
- Data of the convection address
- Data of Lead time distribution product trousers
- Data of distance and the coordinate of each area distribution (*google map*)

( A )

( A )

**Data Processing**

**VRP (*Vehicle Routing Problem*)**

- *Google Map Application*
- Determination of the coordinates (*Latitude X, Longitude Y*)
- Forecast the Data of sales from each convection
- Minitab 16
- Making of the table DRP (*Distribution Resource Planning*)
- Data of the order for each convection
- Identify Matrix Distance
- Identify Saving Matrix
- Allocating Convection Location or Route to a Vehicle
- Sort the Location of Convection (Goal) in the Routes that are Already Defined

**Shortest-Route ALgorithm**

- The selection of an alternative route Pekalongan - Jakarta
- *Google Map Application*
- The determination of the distance and coordinates each node
- Calculation of the shortest route from each node
- The selection of the shortest route

- Analysis and discussion
- Conclusions and Recommendations

( Finish )

Attachment 2. The Division of a Route Every Location Convection

|      | Warehouse   | KA   | KB   | KK   | KN   | KR   |
|------|-------------|------|------|------|------|------|
| KA   | Route 1     | 0    | 3    | 2.7  | 3.2  | 0.5  |
| KB   | Route 2     | 3    | 0    | 0.4  | 3.9  | 0.6  |
| KK   | Route 3     | 1.8  | 3.5  | 0    | 5.75 | 1.8  |
| KN   | Route 4     | 0.5  | 1.3  | 5.75 | 0    | 0.9  |
| KR   | Route 5     | 0.5  | 0.6  | 0.8  | 1.1  | 0    |
|      | Order (unit)| 5817 | 1330 | 6376 | 3483 | 4293 |

Attachment 3. The Sorting Results of Saving Matrix Value

| No | Saving Matrix | From | To | Total Order | No | Saving Matrix | From | To | Total Order |
|----|---------------|------|-----|-------------|----|---------------|------|-----|-------------|
| 1  | 5.75 | KN | KK | 9,859  | 11 | 1.3 | KN | KB | 4,814  |
| 2  | 5.75 | KK | KN | 9,859  | 12 | 1.1 | KR | KN | 7,776  |
| 3  | 3.9  | KB | KN | 4,814  | 13 | 0.9 | KN | KR | 4,814  |
| 4  | 3.5  | KK | KB | 7,706  | 14 | 0.8 | KR | KK | 10,669 |
| 5  | 3.2  | KA | KN | 9,300  | 15 | 0.6 | KR | KB | 5,623  |
| 6  | 3    | KB | KA | 7,147  | 16 | 0.6 | KB | KR | 5,623  |
| 7  | 3    | KA | KB | 7,147  | 17 | 0.5 | KA | KR | 10,110 |
| 8  | 2.7  | KA | KK | 12,193 | 18 | 0.5 | KN | KA | 9,300  |
| 9  | 1.8  | KK | KA | 12,193 | 19 | 0.5 | KR | KA | 10,110 |
| 10 | 1.8  | KK | KR | 10,669 | 20 | 0.4 | KB | KK | 7,706  |

Attachment 4. The Calculation of Shortest-Route Algorithm

| Node j | Computation of Uj | Uj | Label |
|--------|-------------------|------|-------|
| 1  | U1 | 0 | [0,-] |
| 2  | $U2 = U1+d12$ | 0.26 | [0.26,1] |
| 3  | $U3 = U2+d23$ | 0.96 | [0.96,2] |
| 4  | $U4 = U3+d34$ | 1.13 | [1.13,3] |
| 5  | $U5 = U4+d45$ | 2.83 | [2.83,4] |
| 6  | $U6 = U5+d56$ | 3.11 | [3.11,5] |
| 7  | $U7 = U6+d67$ | 3.46 | [3.46,6] |
| 8  | $U8 = U7+d78$ | 3.518 | [3.52,7] |
| 9  | $U9 = U8+d89$ | 4.418 | [4.42,8] |
| 10 | $U10 = U9+d910$ | 4.868 | [4.87,9] |
| 11 | $U11 = U10+d1011$ | 5.168 | [5.17,10] |
| 12 | $U12 = U11+d1112$ | 5.568 | [5.57,11] |
| 13 | $U13 = U12+d1213$ | 6.018 | [6.02,12] |
| 14 | $U14 = U13+d1314$ | 7.818 | [7.82,13] |
| 15 | $U15 = U14+d1415$ | 11.518 | [11.52,14] |
| 16 | $U16 = U3+d316$ | 1.13 | [1.13,3] |
| 17 | $U17 = U16+d1617$ | 2.13 | [2.13,16] |
| 18 | $U18= U17+d1718$ | 2.165 | [2.17,17] |
| 19 | $U19= U18+d1819$ | 2.225 | [2.23,18] |
| 20 | $U20= U19+d1920$ | 2.302 | [2.30,19] |
| 21 | $U21 = \min \{U15,U20\}$ <br> $= \min \{U15+d1521, U20+d2021\}$ <br> $= \min \{11.52+0.26, 2.30+0.17\}$ <br> $\min \{11.78, 2.47\}$ | 2.47 | [2.47, 20] |
| 22 | $U22 = U21+d2122$ | 9.57 | [9.57, 21] |
| 23 | $U23 = U22+d2223$ | 62.67 | [62.67, 22] |
| 24 | $U24 = U23+d2324$ | 63.07 | [63.07, 23] |
| 25 | $U25 = U24+d2425$ | 63.62 | [63.62, 24] |
| 26 | $U26= U25+d2526$ | 64.72 | [64.72, 25] |
| 27 | $U27= U26+d2627$ | 66.62 | [66.62, 26] |
| 28 | $U28= U27+d2728$ | 72.12 | [72.12, 27] |
| 29 | $U29= U28+d2829$ | 79.02 | [79.02, 28] |

| Node j | Computation of Uj | Uj | Label |
|---|---|---|---|
| 30 | U30= U29+d2930 | 79.37 | [79.37, 29] |
| 31 | U31= U30+d3031 | 81.87 | [81.87, 30] |
| 32 | U32= U31+d3132 | 86.07 | [86.07, 31] |
| 33 | U33= U32+d3233 | 89.37 | [89.37, 32] |
| 34 | U34= U33+d3334 | 89.97 | [89.97, 33] |
| 35 | U35= U34+d3435 | 217.97 | [217.97, 34] |
| 36 | U36= U35+d3536 | 218.12 | [218.12, 35] |
| 37 | U37= U36+d3637 | 244.02 | [244.02, 36] |
| 38 | U38= U37+d3738 | 244.57 | [244.57, 37] |
| 39 | U39 = U23+d2339 | 128.57 | [128.57, 23] |
| 40 | U40 = U39+d3940 | 130.77 | [130.77, 39] |
| 41 | U41 = U40+d4041 | 216.67 | [216.67, 40] |
| 42 | U42 = U41+d4142 | 222.47 | [222.47, 41] |
| 43 | U43 = U42+d4243 | 239.77 | [239.77, 42] |
| 44 | U44 = U43+d4344 | 244.57 | [244.57, 43] |
| 45 | U45 = U44+d4445 | 282.57 | [282.57, 44] |
| 46 | U46 = U45+d4546 | 282.79 | [282.79, 45] |
| 47 | U47 = U46+d4647 | 285.59 | [282.59, 46] |
| 48 | U48 = U47+d4748 | 286.89 | [286.89, 47] |
| 49 | U49 = U48+d4849 | 287.64 | [287.64, 48] |
| 50 | U50 = U49+d4950 | 289.54 | [289.54, 49] |
| 51 | U51 = U50+d5051 | 289.63 | [289.63, 50] |
| 52 | U52 = U51+d5152 | 290.93 | [290.93, 51] |
| 53 | U53 = U52+d5253 | 291.09 | [291.09, 52] |
| 54 | U54 = U53+d5354 | 292.289 | [292.29, 53] |
| 55 | U55 = U54+d5455 | 292.412 | [292.42, 54] |
| 56 | U56 = U55+d5556 | 293.02 | [293.02, 55] |
| 57 | U57 = U56+d5657 | 293.52 | [293.52, 56] |
| 58 | U58 = U57+d5758 | 295.82 | [295.82, 57] |
| 59 | U59 = U58+d5859 | 296.37 | [296.37, 58] |
| 60 | U60 = U59+d5960 | 299.17 | [299.17, 59] |
| 61 | U61 = U60+d6061 | 299.97 | [299.97, 60] |
| 62 | U62 = U61+d6162 | 320.97 | [320.97, 61] |
| 63 | U63 = U62+d6263 | 321.18 | [321.18, 62] |
| 64 | U64 = U63+d6364 | 323.88 | [323.88, 63] |
| 65 | U65 = U64+d6465 | 326.28 | [326.28, 64] |
| 66 | U66 = U65+d6566 | 328.98 | [328.98, 65] |
| 67 | U67 = U66+d6667 | 339,38 | [339.38, 66] |
| 68 | U68 = U67+d6768 | 342,88 | [342.88, 67] |
| 69 | U69 = U68+d6869 | 367.38 | [367.38, 68] |
| 70 | U70 = U69+d6970 | 444.38 | [444.38, 69] |
| 71 | U71 = U70+d7071 | 464.58 | [464.58, 70] |
| 72 | U72 = min {U38, U71}<br>= min {U38+d3872, U71+d7172}<br>= min {244.57+34.1, 464.58+2.5}<br>min {278.67, 467.08} | 278.87 | [278.87, 38] |
| 73 | U73 = U72+d7273 | 297.87 | [297.87, 72] |
| 74 | U74 = U73+d7374 | 299.27 | [299.27, 73] |
| 75 | U75 = U74+d7475 | 306.97 | [306.97, 74] |
| 76 | U76 = U75+d7576 | 308.17 | [308.17, 75] |
| 77 | U77 = U76+d7677 | 308.52 | [308.52, 76] |
| 78 | U78 = U77+d7778 | 308.68 | [308.68, 77] |
| 79 | U79 = U78+d7879 | 309.48 | [309.48, 78] |
| 80 | U80 = U79+d7980 | 311.28 | [311.28, 79] |
| 81 | U81 = U80+d8081 | 311.78 | [311.78, 80] |
| 82 | U82 = U81+d8182 | 315.68 | [315.68, 81] |

| Node j | Computation of Uj | Uj | Label |
|---|---|---|---|
| 83 | U83 = U82+d8283 | 317.78 | [317.78, 82] |
| 84 | U84 = U83+d8384 | 343.08 | [343.08, 83] |
| 85 | U85 = U84+d8485 | 350.28 | [350.28, 84] |
| 86 | U86 = U85+d8586 | 354.28 | [354.28, 85] |
| 87 | U87 = U86+d8687 | 356.28 | [356.28, 86] |
| 88 | U88 = U87+d8788 | 357.68 | [357.68, 87] |
| 89 | U89 = U88+d8889 | 358.68 | [358.68, 88] |
| 90 | U90 = U89+d8990 | 359.53 | [359.53, 89] |
| 91 | U91 = U90+d9091 | 360.38 | [360.38, 90] |
| 92 | U92 = U91+d9192 | 363.38 | [363.38, 91] |
| 93 | U93 = U92+d9293 | 363.78 | [363.78, 92] |
| 94 | U94 = U93+d9394 | 363.98 | [363.98, 93] |
| 95 | U95 = U94+d9495 | 364.27 | [364.27, 94] |
| 96 | U96 = U95+d9596 | 364.82 | [364.82, 95] |
| 97 | U97 = U96+d9697 | 365.08 | [365.08, 96] |
| 98 | U98 = U97+d9798 | 365.43 | [365.43, 97] |
| 99 | U99 = U98+d9899 | 365.93 | [365.93, 98] |
| 100 | U100 = U99+d99100 | 380.63 | [380.63, 99] |
| 101 | U101 = U100+d100101 | 382.73 | [382.73, 100] |
| 102 | U102 = U101+d101102 | 384.73 | [384.73, 101] |
| 103 | U103 = U102+d102103 | 384.85 | [384.85, 102] |
| 104 | U104 = U103+d103104 | 386.45 | [386.45, 103] |
| 105 | U105 = U104+d104105 | 386.85 | [386.85, 104] |
| 106 | U106 = U105+d105106 | 388.85 | [388.85, 105] |

Attachment 5. The Calculation Results of the Shortest Route

| Shortest Route (Km) | | |
|---|---|---|
| The sequence of route | Total distance (Km) | Rounding the total distance (Km) |
| 1-2-3-16-17-18-19-20-21-22-23-24,25,26,27,28,29,30,31,32,33,34,35,36,37,38.72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100,101,102,103,104,105,106 | 388.85 Km | 389 |

Attachment 6. The Transportation Cost of Convection Bambang

| Bambang | | | | Total (Rp) |
|---|---|---|---|---|
| assumptionsi : 25 suck,  Mode : Truk Box of double wheel, 389 km | | | | |
| Cost of fuel  (Rp) | Solar | 855,800 | PP | |
| The cost of tolls (Rp) | Cawang | 10,000 | 20,000 | 3,495,800 |
| | Jakarta-Cikampek | 30,000 | 60,000 | |
| | Palimanan-Kanci | 30,000 | 60,000 | |
| Driver+Ass.driver @ 250,000 (Rp) | | 500,000 | | |
| The cost per sack (Rp) | | 80,000 | 2,000,000 | |

Attachment 7. The Transportation Cost of Convection Kusnandi

| Kusnandi | Rp.1,650,000 (driver, eat, fuel, etc) | | | Total (Rp) | Saving |
|---|---|---|---|---|---|
| assumptionsi : 25 suck,  Mode : Truk Box of double wheel, 389 km | | | | | |
| Cost of fuel  (Rp) | Solar (Rp. 5,500/liter) | 855,800 | PP | | |
| The cost of tolls (Rp) | Cawang | 10,000 | 20,000 | 1,790,000 | 1,705,800 |
| | Jakarta-Cikampek | 30,000 | 60,000 | | |
| | Palimanan-Kanci | 30,000 | 60,000 | | |
| Driver+Ass.driver  (Rp) | | 400,000 | | | |
| Eat, etc (Rp) | | 1,249,144 | | | |

# Planning route distribution of IKM DM using the methods vehicle routing problem (VRP) and shortest-route algorithm

# Planning route distribution of IKM DM using the methods vehicle routing problem (VRP) and shortest-route algorithm

FINAL GRADE

## /0

GENERAL COMMENTS

**Instructor**