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Development of Model-Ant Colony Optimization (ACO) in Route Selection Based on Behavioral User was Transport in Semarang, Indonesia

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ABSTRACT: In the selection of transport routes typically use optimization considerations transportation system with aggregative behavior by determining the shortest route or the lowest cost. Determinants of consumer behavior in route selection and decision making dominant (disaggregated). Route selection optimization model based on user behavior can be implemented from the results of model development preference with conjoint analysis. Preferences user behavior seems, is directly proportional to the convenience, the crowd, the facilities, the ease , safety, and inversely proportional to the density. Route selection optimization model with the development of ant - colony optimization substitution formula can be applied with a probability of interaction and preferences as well as the network models incorporate the concept of route selection based on consumer behavior and the physical conditions of the network as the provincial capital of Semarang, Central Java, Indonesia has a lot of road network that connects the origin zone trip up to the trip destination zone, the route selection optimization model based on user behavior can be implemented for the selection of trips in the city of Semarang.

Keywords:- Optimization, Consumer Behavior, Systems Network, Route Options.

I. INTRODUCTION

Selection of land transportation for this route, always using optimization considerations on the network system with aggregative behavior that is based on the determination of the shortest route or the minimum cost. The fact indicates that the consideration of consumer behavior models is very dominant determinant yamg decision. Thus, the selection of design decisions that during the land transport is only considering the shortest route or the lowest cost should consider the concept of consumer behavior as land transportation route selection considerations. Transport route choice models can be developed based on consideration of consumer behavior, the concept of route selection, consideration of psychology and user preference towards the preferred path network. Can be explained that the choice of routes, giving satisfaction to the consumer and the consumer is deemed to have aspects of distance or time and the other is minimal.

The design of transport routes, generally based on the optimization of multiple networks to obtain optimum route. Nowadays, highly developed optimization model and a challenge for researchers and practitioners from multiple disciplines, using some optimization techniques that have been developed. Traditional operations research techniques have evolved, but still a lot of shows calculations and complex problem. The result is a metaheuristic search algorithm such as Simulated Annealing (SA), Tabu Search (TS), Genetic Algorithms (GA) and Ant Colony Optimization (ACO) has been applied to obtain good solutions with a good enough computing time.

This study uses an algorithm Ant Colony Optimisation (ACO) to solve the unique of route problems, and aims to explore possible solutions to develop a good solution and a small computational time. Flexibility of ACO algorithms using basic probability in the selection of the best route, making the ACO is able to involve several parameters in the selection of the best route.

Purpose of this research is the development of transport routes selection model by considering the behavior of the user, using an algorithm Ant Colony Optimisation (ACO), aims to determine consumer preferences based on user behavior is analyzed by conjoint, and determine the model optimization algorithms developed from Ant Colony Optimization (ACO).

This study was applied to the road network of the city of Semarang, Central Java, Indonesia with the hope of giving benefits to transport users in obtaining transportation network that connects the origin zone to the destination zone based on user behavior and characteristics of the road network.

II. LITERATURE REVIEW

2.1 Theory of Consumer Preferences

Heirshleifer and Glazer (1992) suggests that the ideal alternative to the individual preferences of consumer goods can be viewed from two aspects of the law Axiom Law (revealed preferences), namely : 1. Axiom Comparison, and 2. Axiom of Transitivity.

The second axiom when combined will form a proportion of the entire sorting preference that the items are consistently sorted in order of preference somebody, this sorting function is called preference. According to Browning and Zupan (1997) there are three basic assumptions in consumer preferences, namely ;

1. Consumers can rank order of preference in full for all goods in the market . The order of preference indicates the relative degree of pleasure without regard to the price of the goods;
2. Preference is transitivity, this assumption allows people to have a rational and consistent preference; and
3. Consumers will favor the goods in large quantities of the stuff a bit.

2.2 Attribute Theory Approach

Attribute approach is based on the assumption that consumers' attention not to the physical product , but rather addressed to the relevant product attributes (Arsyad, 2008). This approach uses analytical tools merged with the indifference curve analysis. Here are all attributes of services resulting from the use or possession of an item.

Consumer preferences can be described through indifference curve shows the combinations of two goods that provide the same level of satisfaction to the individual. Level of customer satisfaction will be different (higher / lower) when a combination of the two goods are in a different indifference curve (Nicholson, 2002).

Furthermore Nicholson (2002) explains that for arise maximixed utility, the combination of items selected by consumers is limited by budget constraints. This constraint indicates where the combination of these items can be obtained and determine how an individual 's ability to select any combination of categories that provide the highest utility.

2.3 Ant Colony Optimization

Ant-based techniques were first proposed by Dorigo et. al (1996) using the ACO to solve the Traveling Salesman Problem (TSP). In ACO, each ant in a herd that runs will leave pheromone (a kind of chemical substances) on the path which it passes. This pheromone, be a signal to fellow ants. Shortest path will leave a stronger signal. The next ant, when deciding which path to choose, tend to choose to follow the path with the strongest signal, so that the shortest path will be found as more ants will pass through the lane. The more ants through a pathway, the stronger the signal in the lane.

2.4 Behavior of Ants

An ant k at node i will choose the destination node j in herd next ant with probability equation as follows;

$$p_{i,j} = \begin{cases} \dfrac{\tau_{i,j}^{\alpha}}{\sum_{j \in N_i^{(k)}} \tau_{i,j}^{\alpha}}, & \text{jika } j \in N_i^{(k)} \\ 0, & \text{jika } j \notin N_i^{(k)} \end{cases} \qquad \text{...........................(1)}$$

where, α indicates the degree of interest of pheromone and Ni (k) is an alternative option ant k (neighborhood) at the time of being at node i. Neighborhood of ant k in node i will contain all the vertices that can be addressed directly connected to the node i, except node previously visited.

2.5 Addition and Pheromone Evaporation

An ant k when passing will leave a pheromone segment. Number pheromone contained in the bypassed segment after ant k ij is given by the following formula;

$$\tau_{i,j} \leftarrow \tau_{i,j} + \Delta\tau^{k} \qquad \text{...........................(2)}$$

Increasing the value of pheromone on segment i-j, gives great opportunities of this segment will be selected in the next iteration. After evaluating a number of vertices. Thus, pheromone evaporation will occur according to the following rules;

$$\tau_{i,j} \leftarrow (1 - \rho)\tau_{i,j}, j \; ; \; \forall (i,j) \in A \qquad \text{.........................(3)}$$

where $\rho \in (0, 1)$ is the evaporation rate parameter, A represents a segment or segments that have been passed ant k as part of the trajectory of the nest toward food sources. The decrease in the amount of pheromone enables ants to explore a different path during the search process. This will eliminate the possibility of choosing the path that is less good and help limit the maximum value achieved by a pheromone path. The amount of pheromone is added to the segment i - j by ant k is given as

$$\Delta\tau_{i,j}^{(k)} = \frac{Q}{L_k} \qquad \text{.........................(4)}$$

where Q is a constant and L_k is the shortest path through which the ant k. Q value is usually determined by the user, or can be implemented with the following equation: If (i, j) ∈ global best path for others

$$\Delta\tau_{i,j}^{(k)} \begin{cases} \frac{Q}{L_k}, \\ 0, \end{cases} \qquad \text{.........................(5)}$$

ACO model was initially applied by the inventor Marco Dorigo [Dorigo et al., 1996] to solve the problem Traveling Salesman Problem (TSP). In the TSP, if there are n cities there will be a (γ) segment, and have (γ - 1) ½ a possible route. Distance used in the standard TSP is symmetric distance is the distance between city r to city s equal to the distance between the city s to city r where d (s, r) = d (r, s).

The primary role of pheromone evaporation is to prevent stagnation, ie a situation in which all the ants ended up doing the same route. The above process is then repeated until the routes that do reach the maximum number of iterations specified by the user) or does not happen again change solutions. Status transition rules used by Ant system called random proportional rule, which is shown by the following equation;

$$p_k(r,s) = \begin{cases} \tau(r,s)\eta(r,s)^\beta \Big/ \sum_{u \in M_k} \tau(r,u)\eta(r,u)^\beta, & \text{jika } s \notin M_k \\ 0, & \text{another} \end{cases} \qquad \text{.........................(6)}$$

where p_k (r, s) is the opportunity to move from city to city r s of ant k, τ is the pheromone level, η (r, s) the proximity of the town r and s and β are weights that control the visibility of the pheromone level τ. The first needs to be done is to compute the proximity matrix between city states (visibility), η (r, s), where each entry is 1/distance from r to s. For each ant needs to be done early in the placement where the city will begin the route. For TSP, each ant will start from city 1. From this equation, the segment that is shorter and has a larger amount of pheromone will be greater probability to be selected in the route. The level of pheromone (pheromone trail) change both locally and globally. Global pheromone update is intended to give sections are to be found in the shortest route. After one iteration, all ants complete one route, after all the ants back to the nest will happen with the pheromone updating rules

$$\tau_{r,s} \leftarrow (1-\rho)\tau_{r,s} + \sum_{k=1}^{N} \Delta\tau_{r,s}^{k} \qquad \text{.........................(7)}$$

where ρ (0 , 1] is the rate of evaporation or often also called the decay factor and Δτ (k) i , j is the amount of pheromone is added to the segment r-s by the best ant k. goal of the update increases the pheromone is the pheromone value associated with promising path or trajectory that good. artificial ants After completing one route, then it will add the best ant pheromone on sections that have been visited, ie segments are included in the route . while other sections do not change the level of pheromonenya. Amount pheromone Δτ (r, s) is added to each link you visit (r,s) by the best ant is inversely proportional to the total distance of the route, the shorter the higher the amount of pheromone is added to the segment - ruasnya. way is meant to mimic how pheromones These events are accumulated in the real , which is affected by the path length and continuity of the trajectory of live ant time. Global update is formulated as follows;

$$\tau(r,s) \leftarrow (1-\rho)\tau(r,s) + \Delta\tau(r,s), \qquad \text{............................(8)}$$

where Δ (r, s) = (shortest route)-1a or $1/L_k$, where L_k is the shortest path taken by ant k. Local pheromone update rule is useful to prevent the good sections are not selected by all ants. Each time a segment chosen by an ant number pheromonena changed by applying the local update rules:

$$\tau(r,s) \leftarrow (1-\rho)\tau(r,s) + \Delta\tau(r,s) \qquad \text{............................(9)}$$

where τ is a parameter. Local update is also influenced by evaporation as happens in real ants. In other words, the influence of local renewal is to make the level of attractiveness of the existing sections are dynamically changing. Every time an ant uses a segment , then this segment will immediately reduced interest rate (due to the amount of pheromone segment decreased due to evaporation). It will indirectly create another ant will choose the other sections that have not been visited. So the ants will not have a tendency to choose the same path. By creating a different route then there is a higher likelihood of getting one better route than if they all take the same route.

2.6 Model Study Area

Modelling for the study area road network and the network structure of the city made with the initial step is the division of the study area into zones and defines the road network.

1. Area Studies

The study area is determined as an area which is considered to represent all the information necessary to estimate trip models travel needs in accordance with the objectives of the study. The area bounded by a line cordon study (Figure 2.1).

2. Zones For Small Spatial Analysis Unit

Study area is divided into N zones. Each zone is the smallest spatial unit as observation or towing power and movement. Each zone is represented by the center of the zone, as the generation and or pull start of the movement. The main criteria in the zoning in the study area include:

a. zone must be able to present as a unit generation and movement or towing

b. zone must be smaller than that required to handle traffic on a sub- area study

c . zone has a characteristic homogeneity, such as the type of activities, land use and population density of others.

d . To facilitate data collection and modeling for the study of transport, zone boundaries usually follow administrative boundaries .

The size of zone depends on the size of the study area, to study the transport system of State different size it will be necessary to study the zone unit urban transport. Basically the smaller the broad zone made, the more thorough the research results obtained.

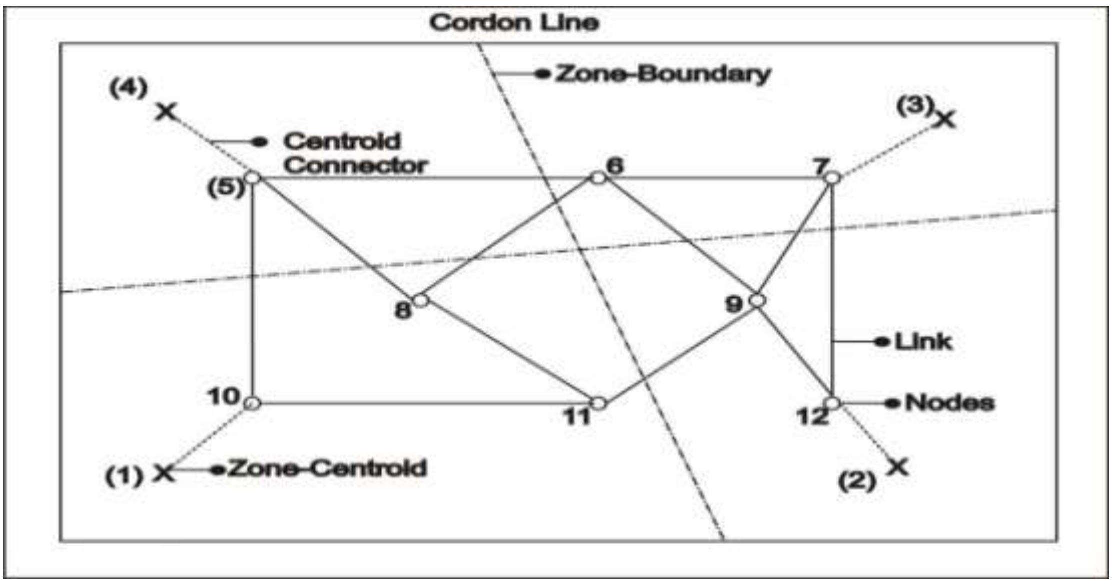


Figure 2.1 Regional Model Study
(Tamin, O.Z, 2000)

Description:

Cordon Line	: boundary of the study area
Zone Boundary	: the boundary zone
Centroid zones	: the central zone
Centroid connector	: connecting the center of the zone
Link	: roads
Nodes	: the point of intersection and the station

A road segment (link) is defined as a liaison between the stain with a stain next.

III. RESEARCH METHOD

In this study, consumer preferences in choosing the route is done by building stimuli that is combination of several attributes which are based on the concept of the transport behavior, namely:

1. The road traffic density
2. Perceptions road comfort
3. Crowds roadside
4. Perceptions on roads facility
5. Ease reaching freight feeder lines from home / office
6. Roads Security

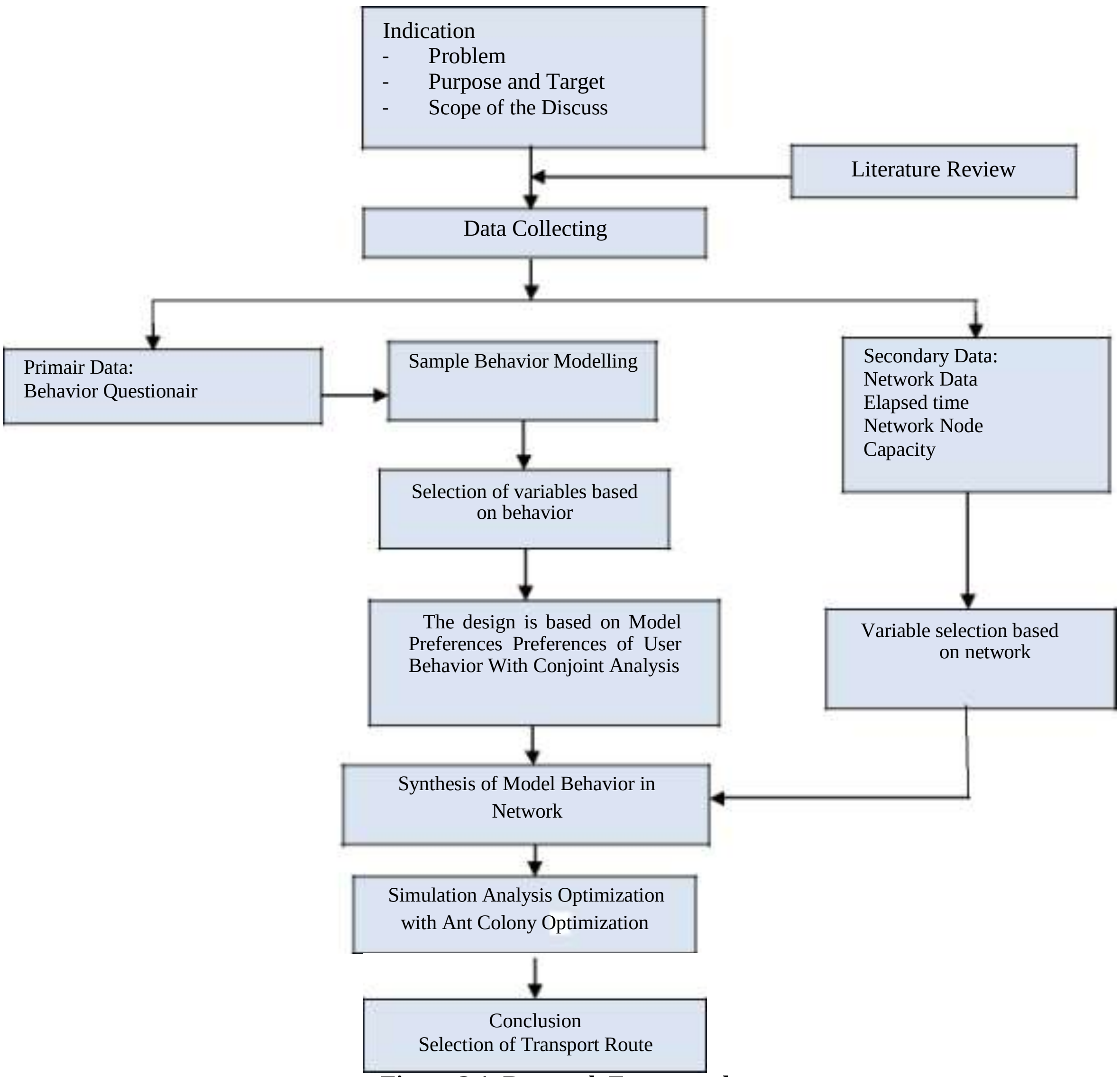


Figure 3.1. Research Framework

3.1 Conjoint Analysis

Conjoint analysis is used to determine the relative interests, associated attributes important to customers and utilities they attach to the level or levels of attributes (Supranto, 2004). The steps that must be done in using conjoint analysis is (Supranto, 2004).

1. Formation of the stimulus is done by using the full profile (full - profile procedure), which took six attributes are safe, comfortable, crowded, facilities, easy, and solid.
2. Number of stimuli to be generated is as much as $2^6 = 64$ stimuli were obtained from the multiplication between the number of levels for each attribute .
3. Amount of the stimuli is too much that it would confuse the respondents in the sort . To reduce the number of stimuli that is too much , then the reduction is done by using orthogonal array with statistical formula combinations permutations $n = 2^6/2^2 = 16$ stimuli. This design assumes that all interactions are not important can be ignored.
4. Stimuli are then used in the questionnaire for sorted by respondents.
5. Subsequently the study subjects were asked to fill in their preference ranking of the 16 combinations of these attributes with values ranking which shows very unpopular highest value and the lowest value indicates the least favored.
6. From the data results to the preference of the 16 stimuli were presented conjoin analysis procedure is then performed with the basic model as follows :

$$\mu(X) = \sum_{i=1}^{m} \sum_{j=1}^{k_i} a_{ij} x_{ij} \qquad ....(10)$$

where:
μ (X) is the entire utility of an alternative
aij is the coefficient of parth-worth or utility of the i-th attribute and level j
k_i is the number of levels of attribute i
m is the number of attributes
Xij is a dummy variable i-th attribute level j

From the analysis of the coefficients obtained will conjoin parth worth of each attribute level. Part coefficient worth is the value of each attribute level were observed. The order of preference ranking is the sum total of the value of each coefficient of each attribute level in all combinations of attributes, with the following formula;

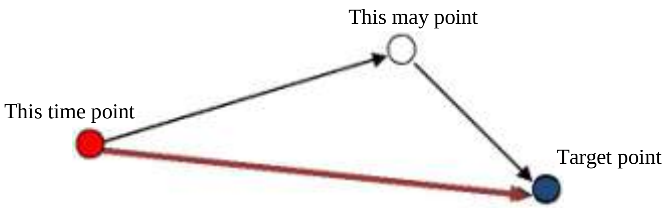
Yb = XP1 + XP2 + Xp3 + Xp4 + XP5 + XP6........................ (11)
where:
Yb = preference behavior
Xp1 = partworth attribute level 1, XP2 = partworth attribute level 2,
Xp3 = partworth attribute level 3, Xp4 = partworth attribute level 4,
XP5 = partworth attribute level 5, XP6 = partworth attribute level 6

The relative value factor shows the percentage of each attribute to the preference. To find out the most important attribute for consumers, the interest rate can be calculated attributes. Attribute the difference in the level of interest is the highest and lowest utility.

3.2 Ant Colony Optimisation

ACO optimization models modified from the beginning of the Ant System model used by Dorigo et. al (1996). Some modifications were made are as follows:
1. Parameters shortest route

The probability of selecting the shortest route is done by using the value of the visibility, which is a measure intended to give effect to each ant in the move towards the next target point with a straight line distance. Because the purpose of ant has been determined, then it is different from the TSP models just getting visibility of the shortest distance alone. The determination of the visibility of a point relative to the target point is as follows:



$$\text{Visibility} = \frac{\text{Distance of the current point to the target point}}{\text{Distances are likely point to the target point}} \quad \text{............................ (12)}$$

Values greater visibility will give a greater probability 2.
Parameters of behavior perception with 6 preference.

The probability of route selection based on the behavior of the six preference secure form, convenient, crowded, facilities, easy, solid values based on the scores obtained from the Conjoint models for each road segment. Value of Conjoint preference scores relative to the maximum score possible. This aspect is called acceptance and value is obtained as follows:
Conjoint preference = preference scores

3. Pheromones Parameter

Pheromones is a trail left by other ants that previously passed through the segment. Pheromones value greater probability greater route choice.
By using all three of these parameters then the acceptance probability is obtained as follows:

$$\text{Prob}(i,j,k) = \frac{(\text{fer})^{\alpha} + (\text{vis})^{\beta} + (\text{pref p})^{\gamma} + (1\text{-DS})}{\Sigma((\text{fer})^{\alpha} + (\text{vis})^{\beta} + (\text{pref p})^{\gamma} + (1 \text{-DS}))} \quad \text{...........................(13)}$$

Description:

- i : index origin node
- j : index node alternative routes
- k : index of the target node (end node)
- α : coefficient multiplier pheromones
- β : coefficient multiplier visibility
- γ : coefficient multiplier preferences

IV. RESULTS AND DISCUSS

4.1 Analysis of Preferences

Preference analysis carried out by the results of a survey of 100 respondents transportation users. Conjoint analysis produces utility value (utility) of each level of each attribute and the value of interest (average importance score is how important an attribute to the overall preference. Utility value and the value of the interest generated by the conjoint analysis are shown in the following table:

Table 1 Results of conjoint analysis

No	Atributes	Customer Value (%)
1	Comfort (Xp1)	19.581
2	Crowded (Xp2)	13.153
3	Facility (Xp3)	16.947
4	Easy (Xp4)	18.433
5	Safe (Xp5)	15.796
6	Solid (Xp6)	16.090

Table 1 shows that the most important attribute considered is the convenience attribute that to the percentage interest of 19.581%, while most attributes are considered important attribute that is equal to 13.153% crowd. This means that users feeder transport services in the first intermodal service is to pay attention to the comfort of the road into a route.

In linear mathematical model of network transport route selection preferences can be obtained as follows:

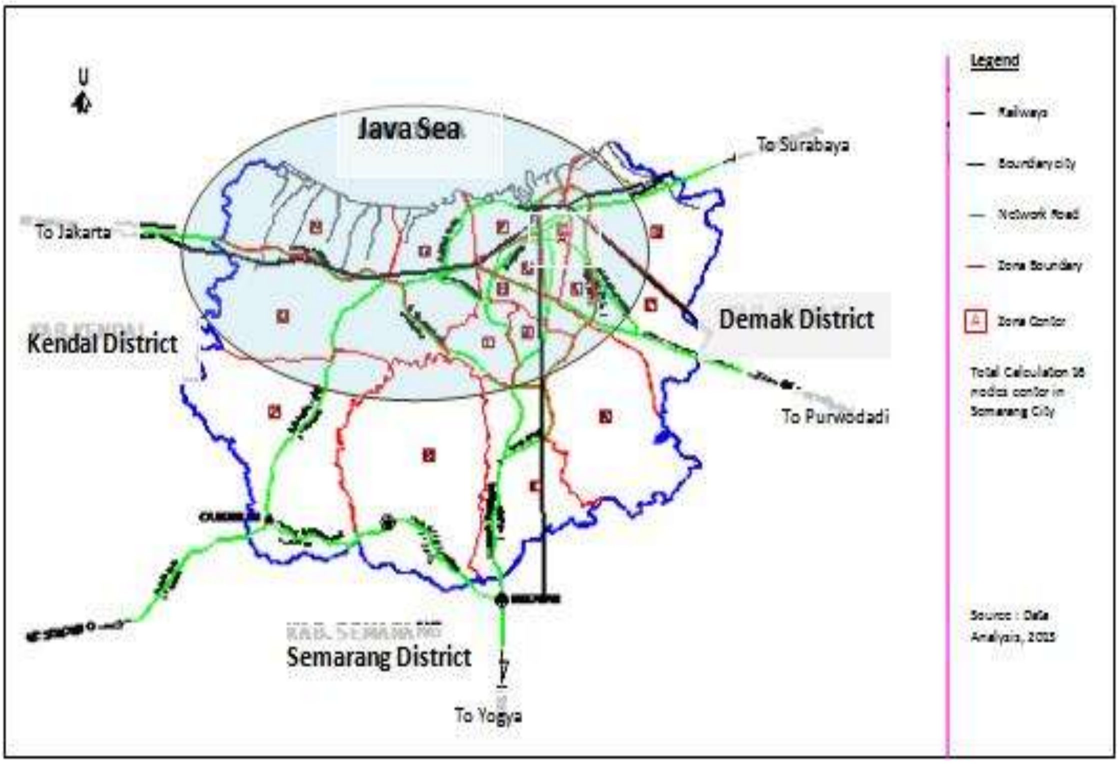
$Y_b = K^1Xp_1 + K^2Xp_2 + K^3Xp_3 + K^4 Xp_4 + K^5Xp_5 – K^6Xp_6$

Description (Source: Dissertation Unpublish Joko Siswanto 2013):

$K^1 = 0{,}260$; $K^2 = 0{,}596$; $K^3 = 0{,}182$; $K^4 = 0{,}154$; $K^5 = 0{,}535$; $K^6 = 0{,}213$

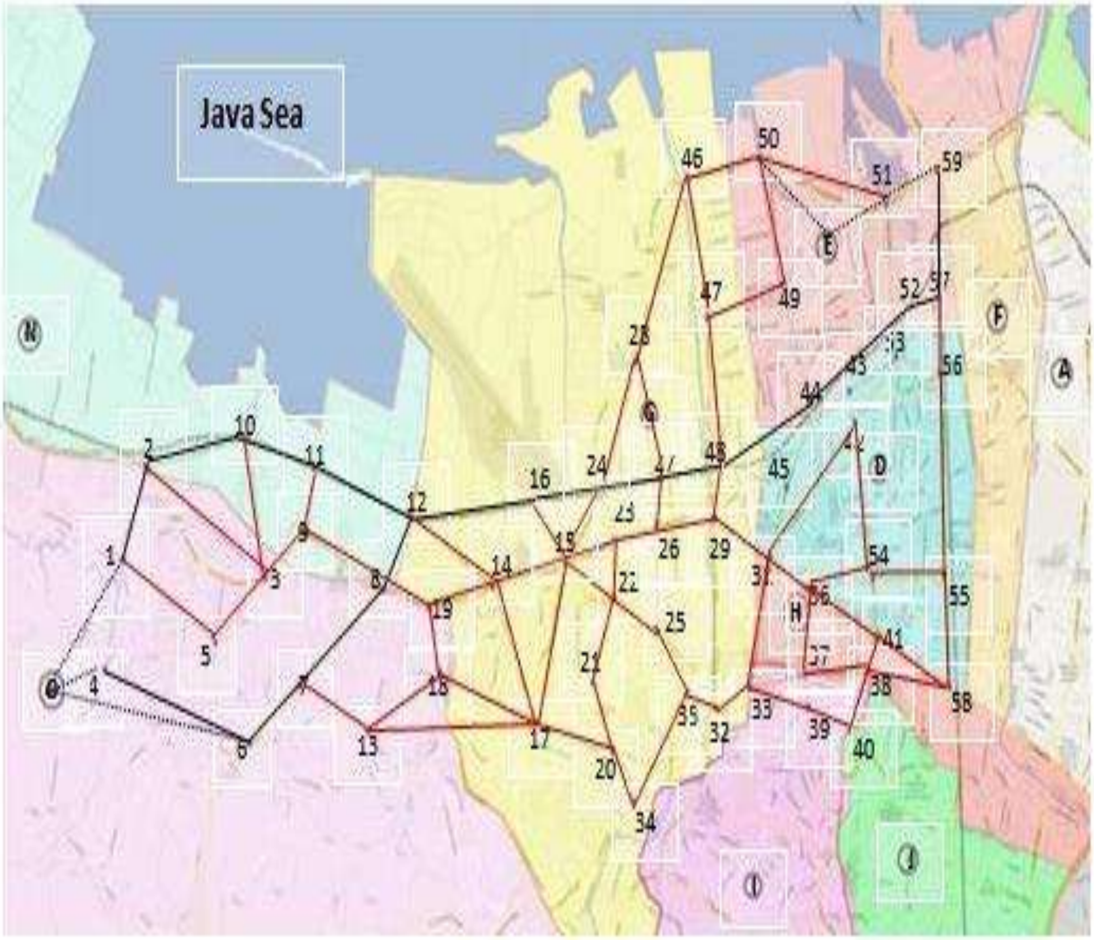
4.2 Optimization

Optimization is used to implement a model of perception-preference and network model to determine the best network models. Implementation of route determination in this case is done at Semarang Central Java Indonesia on the road network connecting the O zone to zone E in Figure 4.1 and Figure 4.2 rail and road network data highway with 59 nodes and figure 4.3 optimization results



Picture 4.1 Map of Semarang City

Picture 4.2 Network Rail Roads and Highways



Picture 4.3 Optimization results Rail and Highways

The parameters used in the following optimization:
$\alpha = 2$ $\beta = 5$ $\gamma = 5$

Black line shows the preferred route optimization based on intermodal route choice models, as figure 4.3

The preferred route from the starting zone to the node O 1-2-10-11-12-16-24-27-48-44-43-52-57-59 toward the end zone E or other choice of starting zone towards O 4 -6-7-8-12-16-24-27-48-44-43-52-57-59 toward the end zone E.

V. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Route selection optimization model based on behavior can be applied by first get Conjoint analysis modeling of preference. Preference of the user's behavior is directly proportional to the convenience, the crowd, the facilities, the ease, safety, and inversely proportional to the density. Optimization of route choice models with ant colony optimization can be applied by using the formula of probability of interaction between the preference network model.

5.2 Recommendation

This model can be used to the concept of route selection based on consumer behavior and the physical condition of tissue that can be applied in Semarang Central Java Indonesia.

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Appendix:
The algorithm used

For each point (i, j) **do**
    pheromone = to specify the value
end
For k = 1 to m **do**
    Put Ants (k) at any point at random
    Determine the value for the distance Lk tempuk Ants (k) and Tk to the set of points visited by ants (k)
end
---- repeat ----
For iteration = 1 to iterasi maximum
  do For k = 1 to m **do**
    Calculate point visited Ants (k) by applying the formula of

$$\text{Prob}(i, j, k) = \frac{\text{probability } (fer)^{\alpha} + (vis)^{\beta} + (pref\ p)^{\gamma} + (1\text{-}DS)}{\Sigma\left((fer)^{\alpha} + (vis)^{\beta} + (pref\ p)^{\gamma} + (1\text{-}DS)\right)}$$

Greatest value is the probability that a point chosen ants
Add ants point visited Ant K to the set T_k
  End for k
  For k = 1 to m **do**
    Calculate the length of each track Lk visited Ants (k)
  End for k
  For k = 1 each point (i, j) do
    Update the pheromone values
  End for k
End for iteration

Show route on the ants of the set origin to set goals