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Research paper

Optimization of Angkot Route Control System Based on Passenger Capacity

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Abstract

Traffic congestion problems is not only problem for big cities but already leading to small towns. It is necessary to provide an application that can help make an assessment quickly, accurately and cheap cost. Such studies can be used to specify a public policy issues related to traffic management. One of transportation mode cause congestion problem of urban areas of Indonesia is angkot. One of the problems that arise in transportation is not optimal route. In Indonesia, angkot is a unique public transportation. The problem relating to transport public transportation is related to improper route and passenger capacity are inadequate. Thus, in this study will establish a control system based on the route of public transportation passengers' optimum capacity. Completion of the issues discussed can be divided into two parts: the first relates to research in the field of prediction system for route weights based on the capacity of passengers in crowded places and the second relates to research in the field of the routing algorithm problem. The results obtained from this study was to perform route optimization breaking at the point route crowd. The test results showed that our system can give new optimal route for all sample routes. These results can also be used to make new route of public transportation in the city of Bandung.

Keywords: *Angkot, route, route weight, capasity, exhaustive search*

1. Introduction

Currently traffic congestion in big cities in Indonesia such as Jakarta, Bandung, Surabaya and others cities become an important issue. One solution to overcome traffic jams ever offered is to reduce the use of private vehicles in cities and increase the amount of public transport one public transportation. The effort to reduce the use of private vehicles will not be effective if it is not accompanied by the policies of the government on the production of private cars and the provision of adequate public transportation. Good public transportation can be measured at least on it's ability to reach a whole urban area and ratio of the passengers number. When the public transport can not reach certain areas, then the use of private vehicles in these places will increase. The number of transportation modes must be calculated precisely in every route. When the number of modes that are too little, then the cost of transportation modes will be lower but the number of passengers that were not served become greater or ratio between modes and passenger becomes very high. In contrast, when there are too many transportation modes, then the ratio between modes and passenger becomes very low. This will cause the costs of transportation public modes will be great and will harm providers of public transportation modes.

Realizing an adequate public transport and could be a solution to traffic congestion is not easy. One of the problems in public transport is not optimal route. Therefore, it is necessary to make the transportation control system of public transportation that can determine an effective public transport route. There are several factors that need to consider in making this control system are: the determination of the points terminal of transportation modes, the determination of the type and capacity of the transportation mode and the estimation of the passengers' distribution on each route and limitation of travel time. In this study, the optimal route determination system for public transportation modes (angkot) is developed based on the input data: terminal nodes (transportation modes) and data passenger occupancy at some locations crowds (supermarkets, schools, offices, etc.). We hope this study will produce an efficient public transport service and an optimal number of transportation modes in each route. The best route and transportation modes optimal amount is measured based on the level of the whole range of these regions, the ratio of the passenger mode according to prevailing standards, and the average cost to passengers traveling from one place to another.

This research is related to the research areas of routing problems, in particular in multiple vehicle routing problems (many to many routing) and also research field in system prediction based on geostatistics. Route optimization process is done by using a modified exhaustive search algorithms based on certain rules. The use of hustle location and prediction of passenger occupancy with spatial analysis in the calculation of route weights is a novelty of this research.

2. Related Work

Studies of information systems related to public transportation, especially angkot, it is generally just focus on displaying the existing route of public transportation, types of modes and locations of transit. There is no research that discusses or propose the optimization of route or breaking of routes. In route optimization, (Chien et al. 2003) discusses the bus route optimization by considering the network link diagonal and minimizing the cost of the bus transit system, operator and user costs. This method transforms the network into a pure grid by constructing a model of a pure grid network that can be applied to the network on a regular grid. Research on public transportation service in Indonesia especially for angkot have been conducted by several researchers. (Yulianto et al. 2012) developed a web application for angkot in Jakarta, which can display the rates and route. Disadvantages of this system are the route of angkot is based on the private vehicles, and route search results is not accurate. The public transportation research for angkot mode was also conducted by (Cahyono & Arna Fariza 2001). They developed a web-based public transportation search system. This public transportation information system can display routes and other public facilities. While Ade et al (2010) focus on optimization of public transportation route. The method for route optimization is Depth First Search algorithm. The focus of the research is to determine the optimal route by using the shortest distance where the results obtained are still not efficient.

In prediction system research on the field of transportation, several studies have been conducted and generally these studies are carried out by researchers from civil engineering. In number prediction of passengers on a flight route, (agus muldiyanto 2001) used linear regression analysis based on several factors that are considered to have an important influence. (Trimukti 2010) used a model of trend analysis to predict growth patterns of passengers and luggage at an airport. Trend analysis consists of methods of linear regression, exponential regression, and polynomial regression method. Other studies generally also used regression models as a method of prediction.

In some studies, the predicted of passengers' number and passengers' movement of the modes are still predicted by using regression analysis without consider the spatial characteristics of the data. But actually, the region characteristics like existence of residential, offices, industrial and educational institution will give affect to the distribution and the number of passenger movements. The movement location points of passengers in public transportation is a spatial data. In Statistic, this problem can be predicted by using the kriging method with semivariogram models approach that contained in geostatistical analysis.

The use of spatial models in transportation has been conducted by some researchers but spatial data information is not used in predicting of passengers' number. (Chatterjee & Venigalla n.d.) use spatial data to create urban trip transportation planning. (Golledge & Gärling 2001) conducted a study to see the effect of spatial information for a person in making transportation plan. (Anderson & Wilson 2005) proposed a Full Spatial Model in the trains and ship. This model required location shippers, geography transport networks and the options available from shippers. Angkot public transportation is not discussed in these all studies.

The research in determining the optimal transport route can not be separated with the shortest path algorithm. Russell and Norvig (2002) classified the shortest path search algorithm as a searching strategy. In this strategy, searching algorithms are divided into two categories, namely un-informed (blind) search and informed (heuristic) search. Heuristic search strategies have a better performance compare to blind search. In heuristic search strategy, there are several algorithms that can be used like the Best-first search, Greedy Best-first search, A* and variant of A*. A * algorithm has better performance than the Best-first search algorithm and Greedy Best-first search. Variant of A * is selected when memory is limited or speed factor is concerned. In another study, Chabini and Lan (2003) implements the A* algorithm in dynamic networks (DAA*) in determining the shortest route. Compared to Djikstra algorithm, DAA * have fewer number of nodes and have faster computing time.

On the issue of public transportation that involves many vehicles then the determination of transportation route can be narrowed into multiple vehicle routing problems. In the case of multi-vehicle tour covering problem, (Hachicha et al. 2000) propose a solution as a set of most minimum route of vehicles at a vertices W by m vehicles. In this research, Hachicha proposes three heuristics solutions: modified savings, modified sweep and route-first / second cluster. The experimental results show that the proposed heuristics can solve real problems with a reasonable computation time. Modified had the fastest time, but related to the quality of the solution, modified sweep and route-first / second cluster is superior to approximately 10%.

(Sanders & Schultes 2007) classified Multiple vehicle routing problems as Many-to-Many Routing. Several algorithms that can be used to resolve such cases are the adaptation of some algorithm in the case of one source node and one target node. The algorithm is Highway hierarchies (HHS) with 2 stages: node reduction and edge reduction. In another study, Vidal et al (2011) proposed an algoritmic framework to resolve three issues in Vehicle Routing Problem (VRP) : multy depot VRP, VRP Periodic and multy depot Periodic VRP with certain vehicles capacity and the time duration. The proposed algoritmic framework is excellent based on computational efficiency and quality of solutions.

Based on the above, none of the studies above, which examines the optimization of public transportation service, by establishing a control system based on the capacity of the passenger, and yet there is also a determination of the capacity of passengers carried by the kriging method. Therefore, in this study, will make the design of the optimization of public transportation routes with a control system based on passenger capacity. Where route optimization process is done by using a modified exhaustive search algorithms based on certain rules. The use of hustle location and prediction of passenger occupancy with spatial analysis in the calculation of route weights is a novelty of this research.

3. Design of route system

Currently, the process of determining the route is still done manually by the government. Route optimization automatically by researchers are still performed based on the shortest distance. The question is: " Is the shortest distance has considered a public transportation passenger capacity regulated by government regulations and be able to reach all areas optimally? ". Therefore, we need a method of determining an accurate and optimal route, which is supported by an acceptable reason and have a scientific explanation. The government is the user of this system. They need to control number of transportation mode and need to determine the optimal route of public transportation.

3.1. Diagram of process

In this study, a system that can determine a new optimal route public transportation by considering the passenger capacity is proposed. In this system, the user can know the existing public transportation route for each route or for overall route. The user can also determine a new optimize route based on the prediction of public transportation passengers' capacity for each route. Prediction passenger capacity for each route is conducted by using kriging method. The diagram of the system in level 1 is illustrated in the Fig 1.

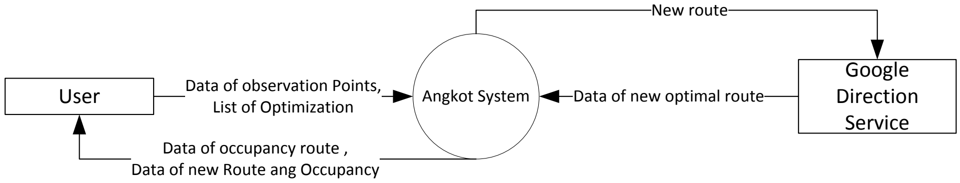

Fig. 1: Context Diagram of Public Transportation Routing System

Fig. 1 shows that the system will interact with the user and google service. Users will provide input to the system: passenger occupancy data, location data and optimization methods. The system then will predict weight of route based on passenger occupancy in all region and provide recommendations of a new optimal route which supported by google service. Prediction of passenger occupancy is conducted by using the Kriging method as seen in equation (1).

$$\hat{Z}(S_0) = \sum_{i=1}^{n} \lambda_i Z(S_i) \dots\dots\dots\dots\dots\dots\dots\dots. (1)$$

Determination of the optimal route is done by using modified exhaustive search algorithms. The route weights prediction system diagram can be seen at Fig. 2.

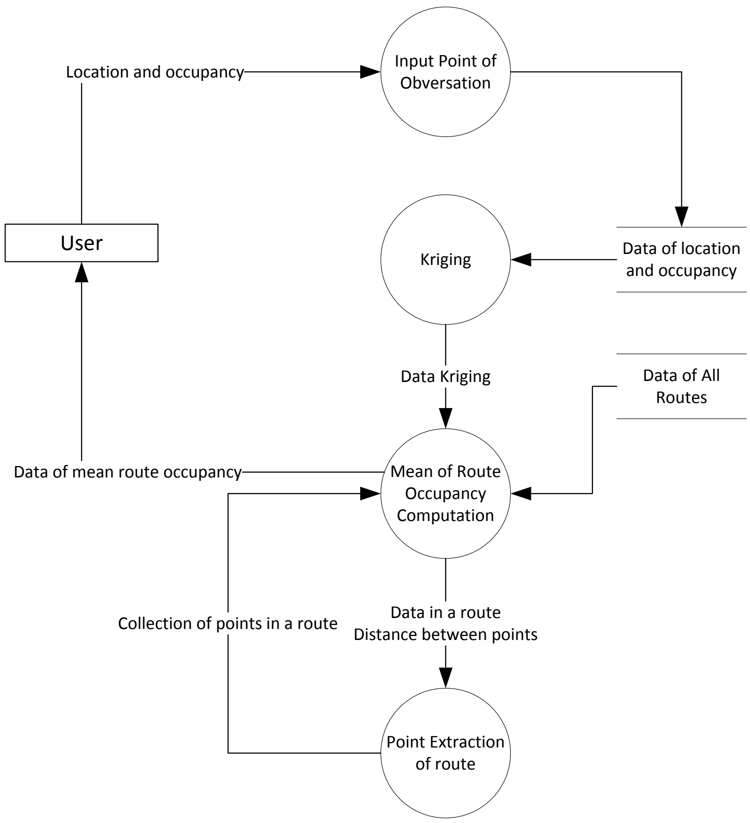

Fig. 2: DFD Prediction of Route Weights

In Angkot Route Weight Prediction process, calculation of the routes weight that connect terminal to other terminals is conducted. Weight route calculation is conducted based on location, occupancy data and route data. There are three sub-processes contained in this process i.e.: kriging process, route occupancy computation process and the extraction process of route points. The final result of these processes is the average occupancy for each route. Where design of kriging process above using a design created by (Suryani, 2016). Detailed of route weigh prediction process can be seen in Fig. 2.

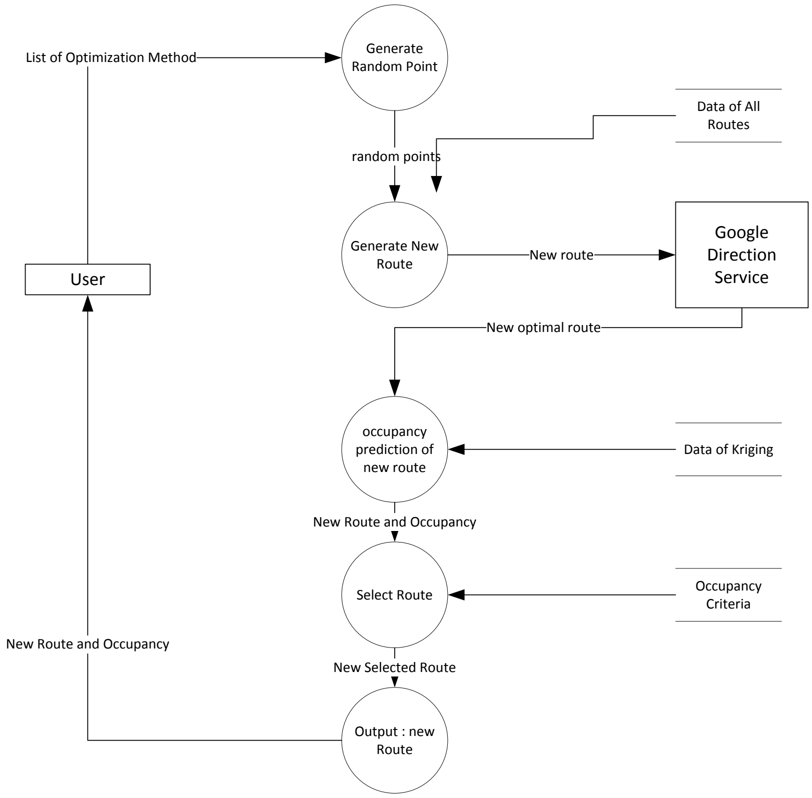

Fig. 3: DFD Optimal Route Recommendation

The second process is the Determination of optimal route. There are five sub-processes within this process: generate new points, generate new route, occupancy calculation of the new route, route selection and display route. In this process, the user specifies the parameters in optimization methods. Then the system will generate some random point within a certain range. By combining these points to route data, system will produce a new route. Occupancy calculations then conducted on this new route by using Kriging prediction of the previous process. Selection of new optimal route is conducted by comparing the occupancy of a new route and occupancy of existing route. The new route will have a more optimal if the new route has better occupancy criteria. Detailed of Optimal Route Recommendation process can be seen in Fig. 3. While the detailed algorithm of optimal route recommendation can be seen in Fig.4 (procedure Optimize).

```
route:  array of points // form a route.
AngkotRouteList: array of all route.
PROCEDURE optimize(AngkotRouteList)
       FOREACH route in AngkotRouteList
              Create Thread(exhaustiveSearch(route)
       ENDFOR
ENDPROCEDURE
FUNCTION exhaustiveSearch(route): routeType
  RandomPointsDistancefromOriginalPoints = 200
  RandomPointNumber = 8
  occupancyAverage = countOccupancyAverage(route)
  i = 0
FOREACH point in route
    AfterPoint = downloadAfterPoints(point, route)
WHILE i < RandomPointsNumber
     RandomPoint = generateRandomPoint(Point, RandomPointsDistancefromOriginalPoints)
     insertedRoute = generateShortestRoute (point, RandomPoint, afterPoint)
     occupancyAverageInsert = countingOccupancyAverage(insertroute)
 IF (occupancyAverageInsert > occupancyAverage) THEN
 RETURN insertPointToRoute(route, RandomPoint , afterPoint)
       //stop searching
 ELSE
       i = i + 1  //next searching
 ENDIF
   ENDWHILE
   RETURN route
  ENDFOR
ENDPROCEDURE
```

Fig. 4: Algorithm of optimal route recommendation

Procedure optimize (AngkotRouteList) is a procedure to create a thread for each route, so that optimization can be performed in parallel for each route. Procedure CreateThread create a new thread that will perform optimization on a single route. Function exhaustiveSearch

(s) is an optimization function that uses exhaustive search, where the function will return the new route, which more optimal, or return the original route if the better route is not founded. The measurement of these are based on the average occupancy.

While the rules for random point distance from the original point of at least 200 meters. When the distance between point random from original point (reference) is smaller, then the random point will be closer to the original point. This will give affect to searching process. The smaller distance cause the inserted route will have small probability to obtain better occupancy criteria compared to original route, but the positive thing is the process time is faster.

3.2. Formula of optimal route

The public transportation system of angkot in Indonesia has legal protection that is SK Director General of Land Transportation No. 687 / AJ.206 / DrJD / 2002 on technical guidelines for the organization of public passenger transport in urban areas in the route and regularly. The regulation states that passengers sitting capacity for this public transport is 8 for each vehicle and the number of standing passengers is zero. Referring to the regulation, the ideal conditions for passenger occupancy is 8. The new route is said to be more optimal than the existing route, when Occupancy_Critera in equation (2) has a smaller value.

$$Occupancy\_Criteria(route) = |Occupancy(route) - 8| \quad \text{.....................(2)}$$

Too little occupancy from the ideal value will make passengers more comfortable but cost of modes will be high, otherwise too large occupancy will make the cost of modes is low but the index mode of passenger comfort to be low.
Consideration manufacture of the formula is based on three things: 1) government regulations above, 2) when the number of passengers exceeds 8, the comfort of the passengers will be disrupted, 3) when the number of passengers is less than 8, then the operating costs of public transportation is less, so the quality of the feasibility of public transportation reduced. Therefore, the difference of the route which is considered optimal occupancy with required capacity is close to zero.

4. Implementation, result and discussion

4.1. Prediction of Occupancy

Proposed new route is based on the results of public transportation passenger occupancy predictions that most of the capacity is still less than 8 before the new route is proposed, predictions passenger occupancy public transportation across of the road by public transportation must be done first. The page of passenger occupancy prediction by using kriging method can be seen in Fig. 5.

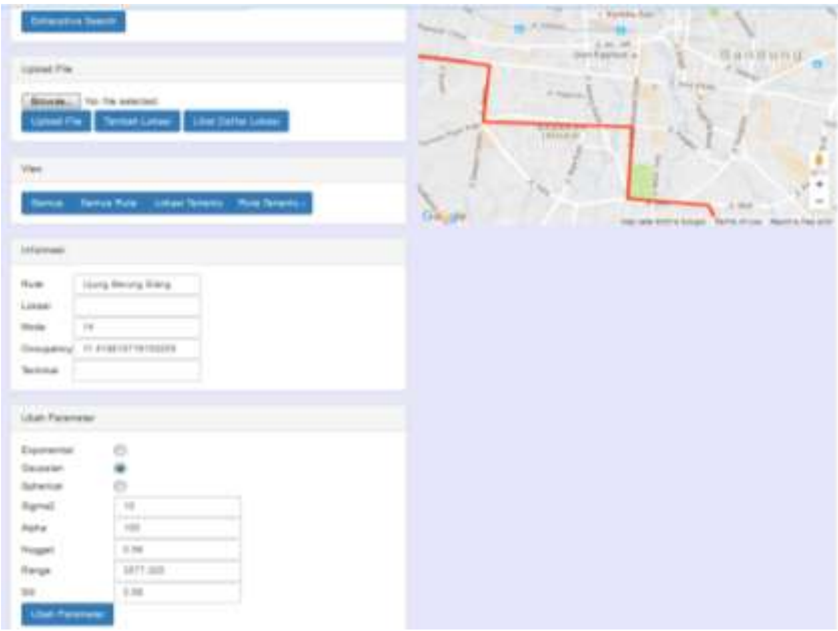

Fig. 5:.Weight Route Prediction Page

4.2. Generate New Optimal Route

For each route, generating and occupancy computation of new route is conducted. This process only give output as new optimal route. We can also analysis optimality of existing angkot based on result of this process. When our system can give new optimal route, it's mean that the existing route is optimal. The page of these processes can be seen in Fig.6.

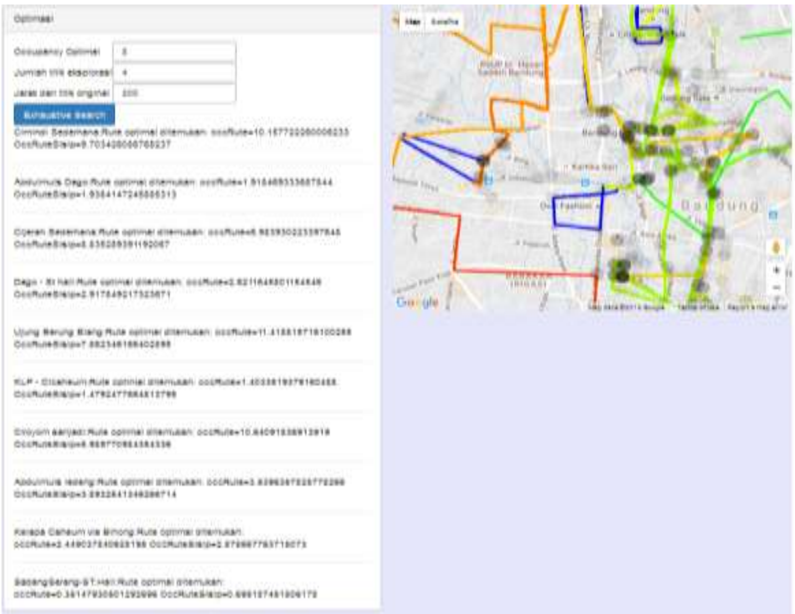

Fig. 6:.Optimal Route Recommendation Page

Detailed of new optimal routes recommendation can be seen in Table 1. The data that used in this experiment is 10 routes which consist more than 400 location points. The experiment show that our system can give new optimal route for all routes. This result can also be used to make breaking of route for some high occupancy routes, like Cimindi-Sederhana, ujung berung-Elang and Ciroyom-Sarijadi.

Table 1: Optimal Routes Recommendation

Number	Trayek	Original Occupancy	New Occupancy	Optimal Route
1	Cimindi-Sederhana	10.16	10.02	New Route
2	Abdul Muis-Dago	1.9	2.06	New Route
3	Cijerah-Sederhana	6.98	8.84	New Route
4	Dago – St Hall	2.62	6.18	New Route
5	Ujung Berung-Elang	11.42	8.79	New Route
6	Kalapa – Cicaheum	1.4	1.66	New Route
7	Ciroyom- Sarijadi	10.64	5.89	New Route
8	Abdul Muis-Ledeng	3.54	8.39	New Route
9	Kelapa-Caheum via Binong	2.45	3.4	New Route
10	Sadang Serang - St Hall	0.35	0.69	New Route

If the tables are expressed by a graph representing the performance comparison between the occupancy of the new route with the original route, the capacity of the standard, it appears that the performance of the new route is better for some routes. Where the passenger occupancy obtained from the new route optimization is closer to standard capacity. The graph is presented can be seen in Fig 7.

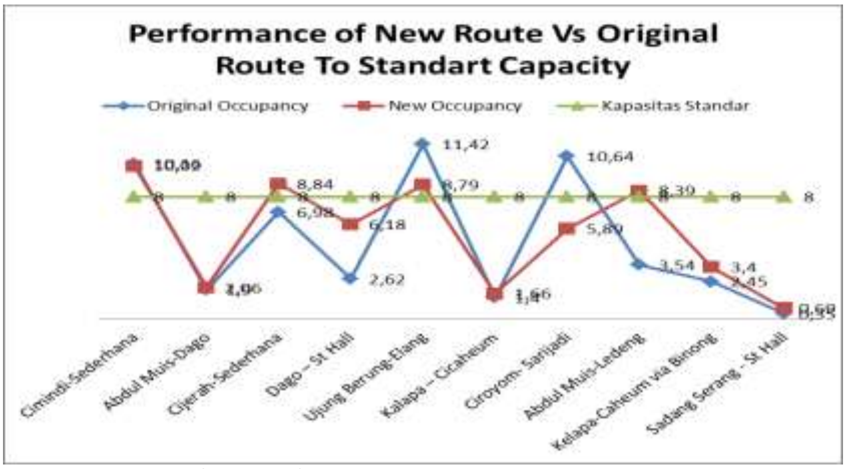

Fig. 7: Performance of New Route vs Original Route to Standart Capacity

5. Conclusion

Based on the results and discussions that have been mentioned above, can be given some conclusions and suggestions as follows

1. Our application is successful in making prediction of passenger occupancy in all location points of routes.
2. Our application can give recommendation new optimal routes for all tested routes.

3. The proposed policy that could be made, among others, related to the splitting route on routes with very high capacity level and reduction modes on routes with very low capacity levels.

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