COUPLING OF GEOGRAPHIC INFORMATION SYSTEM
AND OPTIMIZATION METHOD WITH CONGESTION CONSIDERATION
TO SUPPORT URBAN FREIGHT TRANSPORT

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Abstract
The study aimed to evaluate focus and quality of Indonesian e-government website. All 456 websites of
districts/cities throughout the country are taken into account. The study revealed that 66.9% of districts/cities
had their own website and were in operations, while other were either still embedded into website of province,
not found, or inaccessible. In general, the websites focused on promoting linkage between government and
business, while efficiency and effectiveness in the delivery of frontline services were less prioritized. The quality
of the website in general was in medium level, both in terms of the quality of content and the level of ease-of-use.

Keywords: e-government website, website focus, website quality, Indonesia.

INTRODUCTION

1.1 Role of Congestion in Urban Freight Transport
Demand for access and mobility for both passenger
and goods within a city are arising parallel to
population growth. In addition, each year the
number of vehicles running on city streets is
increasing. This situation raises consequences on
traffic, thus, congestion becomes a common or even
an inevitable issue for many cities. On the other
hand, the population growth had foster businesses
to enlarge, which also pushed logistics businesses,
in particular, the urban freight businesses to thrive.

The situation above creates a dilemma for the urban
freight businesses. They are required to provide a
better level of service to customers, but at the same
time, they also have to keep their costs as low as
possible, because competition is fierce. In order to
survive the competition, efficiency is a very
important issue. Congestion is one contributing
factor to this dilemma [10]. It discourages
efficiency by delaying deliveries and prolonged
travel time.

Looking at the situation above, therefore, urban
freight transporters need to consider congestion in
their operational planning to make sure that
congestion interference is minimal.

1.2 Use of GIS in Urban Freight Transport
It is logically viable to use GIS in this context as
the urban freight operation is part of logistics
system which is very much spatial in nature (e.g,

2. GIS APPROACH TO CONGESTION

2.2 Congestion Representation within GIS
There are various works related to congestion
representation within GIS, for example; [12], relate
congestion to delay time. While, [8] used links-
speed with dynamic segmentation in their
congestion studies. Both are using colour coded
lines to visualize congestion.

Congestion in this paper is represented in GIS as
follow; a road network layer is consisted of road
segments links, each segment has certain congestion situation which is represented by an index. An index is a value which shows the percentage of speed reduced if a vehicle travels on a certain road segment. Congestion situation in a day is divided into two timeframes of AM (morning) and PM (afternoon). A multi-layered approach [3] is adapted to represent the timeframes in GIS. Therefore, there are fourteen layers of road network that represent congestion situation in a week. Colour coded lines is used to represent the congestion index value.

An example of congestion index data of a road segment for each timeframes is presented in Table 1. In Monday, for example, Jalan Pasirkaliki has congestion index of 0% in the AM peak hours and 83% in the PM peak hours. Figure 2, shows the visualization of the congestions index in each timeframe as layers in GIS.

<table>
<thead>
<tr>
<th>Day</th>
<th>Session 1</th>
<th>Session 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>0%</td>
<td>83%</td>
</tr>
<tr>
<td>Tuesday</td>
<td>25%</td>
<td>58%</td>
</tr>
<tr>
<td>Wednesday</td>
<td>58%</td>
<td>92%</td>
</tr>
<tr>
<td>Thursday</td>
<td>25%</td>
<td>42%</td>
</tr>
<tr>
<td>Friday</td>
<td>42%</td>
<td>33%</td>
</tr>
<tr>
<td>Saturday</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Sunday</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 1 Summary of Congestion Index of Jalan Pasirkaliki

The congestion index is changing over time, depending on the pace of data updating. The best data updating would come from a real-time data provider such as Intelligent Transportation System or ITS sensors [7] [10]. The faster the data updating process, the faster the index will change, thus, the better the planning will be. However, due to lack of resources, it is not possible for this paper to update the data in real-time. The data provided for this paper is a survey data, therefore congestion index updating is very limited.

3. URBAN FREIGHT OPTIMIZATION

3.1 Optimization Methods

In this paper the optimization is conducted in two steps. The first step is the preparation step, which is to find initial shortest paths between a pair of point of origin and destination. This is done by using the Dijkstra’s shortest path algorithm [9]. The output from this step then refined in the optimization step. Optimization of freight transport within urban setting can be approached from Vehicle Routing Problem (VRP) standpoint [10]. There are mainly three types of VRP approach to routing optimization, namely; Exact approach, Meta-Heuristics, and Heuristics [6]. The approach used in the optimization step is from the latter type, namely the Clarke-Wright Saving heuristic. This heuristic emphasized on the saving of costs that can be achieved by modifying sequences of routes [1], thus the optimal condition would be the best or highest saving route. An implementation of Clarke-Wright Saving heuristic called Logware: Router [2] is used for this paper.

3.2. Data, GIS and Optimization Engine

The relations between data provider, GIS and optimization engine are depicted in Figure 1. Data provider such as; ITS, survey or any other data gathering activities supply the congestion-data per timeframe to GIS layers, which are recorded in a road segment database. Thus, it will eventually construct layers which hold road network congestion indexes.

Identified origins-destinations (OD) are supplied to the optimization engine. Along with it, are the road network average travelling-speed and average loading-unloading time. The OD than settled in a table of OD pairs. In order to run the Clarke-Wright Saving heuristics algorithm, the OD pairs need to have impedance; in this case, distance is the default impedance of the optimization engine.

Distances for the OD pairs are provided from GIS, by calculating distances of road segments between OD pairs, with an assumption that the road segments are all two ways and driver can only make turn on intersections, turns or stops, which are modelled as nodes. Thus, the assumption implied that each origin and destination should be
modelled as a node as well. An elaboration of
distances calculation is provided in section 3.3.

Road segments relations with OD from the database
standpoint are described as follow; an OD pair must
have one or many road segments and a road
segment belong to none OD pair or

![Image](Insert Image)

Figure 2 Colour coded congestion status of Pasirkaliki as visualized in GIS
(Left: Monday 08.30–10.30 congestion index=0;
Right: Monday 16.00-18.00 congestion index=0.8333)

![Image](Insert Image)

Figure 1 Entity Relationship between OD and Road Segment
within GIS and its topological model.

3.3. Influence of Congestion to Distance
The distances in the road segment table are
originally obtained from the topology measure of
each road segment within GIS. However, at the
moment, the optimization engine does not consider
congestion and it assume that travel speed is
constant, thus it is not able to handle dynamic travel
speed. Therefore, in order to give way to incorporate
congestion influence in the optimization, the road
segment distances need to be adjusted. Moreover,
the data collection method assumes that congestion
is an obstacle to travel speed while the impedance
viable for the OD pair in the optimization engine is
distance; therefore, the distance need to be adjusted
according to congestion index. The adjustment is
done within the GIS, using some database query and
operations.

The congestion incorporation to the optimization is
explained as follow; if a road segment congestion
index is 100% this is classified as a non-operational
road segment, this means that the travelling speed on
this road would be reduced down to 0 Km/h [11]
from the average travelling speed obtained, which is
40 km/h.

The decrease of speed gives the impression that the
distance travelled is longer than it actually is,
because the travelling time would increase as well.
In the following, the adjustment of distance is
elaborated in a mathematical modelling.

The relationship between an adjusted travelling
speed, travelling speed average and congestion index
is formulated as follow; (an example of Jalan
Pasirkaliki on Monday (Ci=83) afternoon is
provided for clearer understanding).
\[ V_{Ci} = Vo - 0.4Ci \quad \text{in example;} \]
\[ V_{Ci} = 40 - 0.4 \times (0.83) \]
\[ = 6.8 \]
\[ Vo = \text{Average Travelling Speed (Km/h)} \]
\[ V_{Ci} = \text{Travelling Speed Influenced by Congestion} \]

After the adjusted traveling speed is obtained, 6.8 Km/H, then, to obtain the travel time, the measured distance of the road segment (Jalan Pasirkaliki) of 2.56 Km, is incorporated in a formula as follow;

\[ To = \frac{RSo}{Vo} \]
\[ = \frac{2.56}{40} = 0.064 \]

and,

\[ T_{Ci} = \frac{RSo}{V_{Ci}} \]
\[ = \frac{2.56}{6.8} = 0.376 \]

\[ To = \text{Travelling Time in Normal Condition (Hours)} \]
\[ T_{Ci} = \text{Travelling Time influenced by Congestion (Hours)} \]
\[ RSo = \text{Road Segment Distance in Normal Condition (Km)} \]

therefore, to find the value for the impression of lengthen distance, a direct comparison of traveling time is conducted;

\[ \frac{To}{T_{Ci}} = \frac{RSo}{RS_{Ci}} \]

Thus,

\[ RS_{Ci} = \frac{RSo \times T_{Ci}}{To} \]
\[ = \frac{2.56 \times 0.376}{0.064} \]
\[ = 15.04 \]

\[ RS_{Ci} = \text{Road Segment Distance Influenced by Congestion (Km)} \]

The calculation shows that the congestion index of 83% on Jalan Pasirkaliki alter the travel time from 0.064 hours to 0.376 hours. This gives the impression that the traveling distance is 15.04 Km instead of 2.56 Km of the actual distance. However, if the congestion index is 100% it will produce a zero travelling speed, thus travel time will become infinite, thus an infinitive distance will also be produced. This is not feasible for the optimization process, therefore if Ci = 100%, then distance is predetermined to 999 Km. This is to make sure that in the optimization process, the road segment will be considered at the last.

3.4. Visualization of Optimized Routes

The optimization engine produces a list of optimized OD pairs as a route. In order to visualize the route in GIS, the result is queried using the OD# of optimized routes from OD#.RS# primary key in the OD_RS table.

The query will produce a set of OD#.RS# which is visualized immediately as selected topologies of nodes and links.

4. CONCLUSION

A coupling of GIS and an optimization engine within the context of urban freight transport is presented. Due to intense requirements to integrate optimization methods within GIS, the loose coupling method is still favourable. However, the combining of two different tools with different standpoint is not without challenges. It was revealed that the value and format of data need to be adjusted.

GIS role in this paper can be summarized as a distance-data provider and visualization tool, while the optimization engine role is to calculate optimized routes.

It is very plausible to lessen the dilemma of urban freight transporters by incorporating congestion in their planning and with the support from a combination of GIS and optimization engine.

5. FURTHER RESEARCH

This paper is created out of an ongoing research; therefore further development may be conducted as follow; an interface or middleware may be built between GIS and optimization engine to make the operation easier. The interface should be able to make the optimization engine automatically read the adjusted distances produces by GIS and it also should be able to automatically query the road segments which are selected as part of the optimized route.

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