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Decision Support Model for Evaluating the Level of the Implementation Effectiveness of 3in1 or ERP Systems using Fuzzy-Logic Method

Ditdit Nugeraha Utama[1], Alfia Miranti[2], Desintia Dwi Astuti[2], Tuti Astuti[2], Rizki Dharma Ananda[2]
[1]Computer Science Department, BINUS Graduate Program - Master of Computer Science, Bina Nusantara University, Jakarta, Indonesia 11480; ditdit.utama@binus.edu
[2]Information System, Universitas Islam Negeri Syarif Hidayatullah, Jakarta, Indonesia

ABSTRACT
The Indonesian capital Jakarta has a problem in traffic road management. In several main traffic roads, many types of solution have been tried to implement to reduce traffic road congestion; e.g. 3in1, electronic road pricing system (ERP), odd-even strategy, etc. Fuzzy logic based decision support model (fuzzy DSM) was successfully constructed. The model is able to assess the feasibility of two types of such solutions (i.e. 3in1 and ERP). The model suggested that Jakarta should applied ERP systems in several main roads to practically downgrade the road traffic congestion.

Key words: Decision support model, road traffic congestion, ERP system, 3in1 system.

1. INTRODUCTION

Traffic roads are one of the public properties. Their uses are vital in influencing the economic stability of a region or country. Naturally, they are public facilities, where everyone is able to use and enjoy them together. Thus, well-management applied by government should be executed day by day. The wrong management has implication to road traffic. It is going to increase congestion and also decrease the economic stability in one region. In this special case, the government is obliged to balance between the availability of the number of traffic roads and the number of road users in a certain period, as if the number of roads is inadequate, congestion will occur. Particularly in Indonesia, there are several cities with high level of congestion. One of them is Jakarta city as the Capital of Indonesia [1].

Congestion that occurs in Jakarta is increasingly getting worse. Here, the local government, as the manager of public facilities, has actually implemented several efforts to balance the availability of the number of traffic roads with the number of road users (i.e. public vehicles, private vehicles, or motorcycles).
In this study, we developed a decision support model based on fuzzy logic conception to compare the uses of a 3in1 system and electronic road pricing (ERP) system. The 3in1 system is a system applied in one road segment where one private vehicle (only for private vehicle) passing by the road should be with three passengers maximum only. On the other hand, ERP system is a system implemented for every vehicle and motorcycle should pay (with high price) when passing by the specific traffic road.

The constructed model is a novel model to evaluate the implementation effectiveness of “road traffic congestion reducing” system. It is able to be operated to the local government to make a vital decision in order to degrade the level of road traffic congestion.

2. RELATED WORKS

Two previous researches strongly related to this study are coming from [2] and [3]. Those both already operated the same main method fuzzy logic with different cases. Also, for model designing, two such studies operated theoretically object oriented conception. The mindset of the study is similar with this study as well. Case understanding, parameter and decision determining, and model constructing are three big stages similarly functioned.

3. RESEARCH METHODOLOGY

3.1 Data Collecting

The first thing to do is look for data on each parameter that has been listed. The data source that we have obtained is secondary data. Secondary data is a source of research data obtained indirectly through intermediary media (obtained and recorded by other parties) or collected by people conducting research from existing sources. This data is usually obtained from libraries or from previous research reports.

The data that has been obtained, will be useful to make a decision needed. We conducted research for the Jakarta area, therefore we only looked for data from parameters only in that area. The data we get various journals and also the official website of the Ministry of Transportation.

3.1 Research Method

According to [4], fuzzy logic is a method to allow computers to have a better understanding of parameter descriptions. There are three steps to do in the fuzzy logic process; fuzzification, fuzzy rule-base operation, and de-fuzzification. The fuzzification process required to process the crisp value (crisp input) converted to fuzzy value. Then, the fuzzy value is going to be processed based on fuzzy rule-base and finally converted again to become crisp valur (crisp output) via de-fuzzification process. Academically, the method is introduced by [5] and also ever operated by [6]. In its operation, a membership function, linguistic variable, and degree of truth are important element should be functioned.

4. RESULT AND DISCUSSION

4.1 High Level Configuration of Constructed Model

Class diagram, in Figure 1, shows interconnected entities in the constructed model. All parameters talked about in the model are represented here. It is a high level configuration of constructed model. Parts of model clearly represented via one schema, to make us more understand regarding model developed.

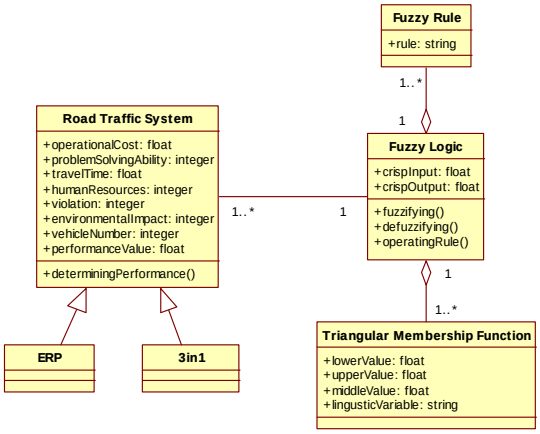

Figure 1: High Level Configuration of Constructed Model

Scientifically, model consists of six classes, with two classes as main classes. Classes Road Traffic System and Fuzzy Logic are main classes of model. All operations in the model defined in both classes. All parameters taken into consideration in the model are determined in class Road Traffic System, where it has two types: ERP and 3in1 systems. Then, all operations of fuzzy logics operated in the model defined in class Fuzzy Logic with interconnecting to classes Fuzzy Rule and Triangular Membership Function.

4.2 Model's Parameters

Table 1 presents the parameters operated in the model. The first parameter of determining a 3in1 or ERP system is operational cost (OC). OC referred to in this parameter is funds that must be spent by the government to create ERP and 3in1 systems both in terms of development and the provision of human resources. Based on data, the cost of making an ERP system amounted to 283.2 million and for the 3in1 system, the required cost is 83.2 million [7].

Table 1: Parameters Operated in Model

No.	Parameter
1.	Operational cost (OC)
2.	Problem solving ability (PSA)
3.	Travel time (TT)
4.	Human resource (HR)
5.	Violation (V)
6.	Environmental impact (EI)
7.	Vehicle number (VN)

Table 2: Parameters' Linguistic Variable, Fuzzy Membership Function Form, and Range

Linguistic Variable	Range	Unit
OC		
Low (L)	0, 150, 250	Million Rupiah
Medium (M)	150, 250, 350	Million Rupiah
High (H)	250, 350, 450	Million Rupiah
PSA		
Solved (S)	0, 1.5, 3	Unit problems
Little New Problems (LNP)	1, 3.5, 6	Unit problems
Many New Problems (MNP)	3, 5, 7	Unit problems
TT		
Fast (F)	0, 30, 60	Minute
Medium (M)	40, 80, 120	Minute
Slow (SL)	80, 110, 140	Minute
HR		
Not Available (NA)	0, 250, 450	Person
Less Available (LA)	250, 475, 750	Person
Available (A)	550, 750, 950	Person
V		
Not Consistent (NC)	0, 20, 40	%
Quite Consistent (QC)	20, 50, 80	%
Consistent (C)	60, 80, 100	%
EI		
Low (L)	0, 100, 120	kg CO2 / ha
Medium (M)	100, 120, 140	kg CO2 / ha
High (H)	120, 140, 160	kg CO2 / ha
VN		
Low (L)	0, 2, 4	Million
Medium (M)	2, 4, 6	Million
High (H)	4, 6, 8	Million
Decision (output)		
Not Applied (NAPP)	0, 0.25, 0.6	Point
Applied (APP)	0.4, 0.75, 1.00	Point

The next parameter is problem solving ability (PSA). The solution to the problem is how many problems will arise from the implementation of the ERP system and 3in1. The author takes information from a number of existing articles. From the information that authors got, the problems that arise from the implementation of the ERP system are as many as two problems, which means few problems arise as a result of implementing an ERP system. Whereas for 3in1 problems that arise as many as four problems which means that many problems arise as a result of implementing the 3in1 system.

The next parameter is travel time (TT). TT describes the length of travel time taken by users of the ERP system and 3in1. The information coming from [8]. Based on the information we got, the travel time on the ERP system is 56.5 minutes; whereas 3in1 consumes 90 minutes.

Furthermore, it is parameter human resources (HR). HR here means that employees who are available to manage and supervise when the system will run, both ERP and 3in1 systems. Based on data, the availability of human resources to manage and oversee the ERP system as many as 659 people, and for the 3in1 system as many as 740 people [9].

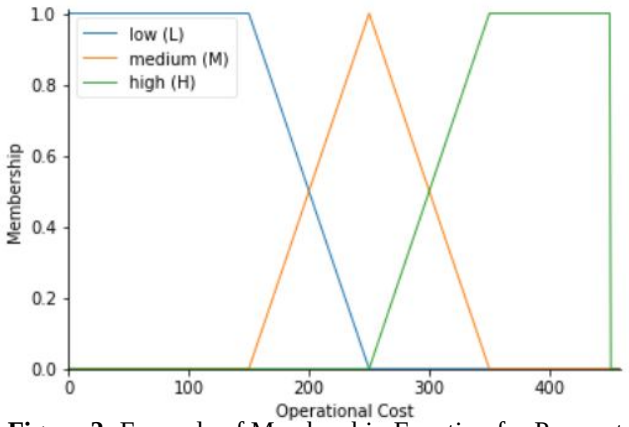

Figure 2: Example of Membership Function for Parameter Operational Cost

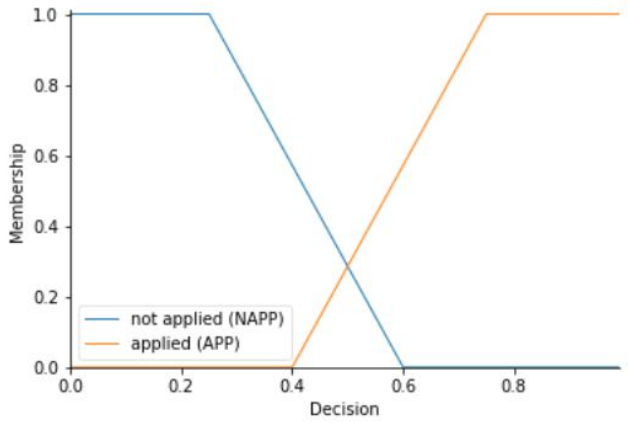

Figure 3: Example of Membership Function for Decision Parameter

Moreover, the next parameter is violation enforcement (V). V actions referred to in this parameter are the consistency of violations that occur in both the ERP and 3in1 systems. In this case, the greater the percentage of numbers that exist, the more consistent the actions of violations applied and conversely the smaller the percentage of numbers that exist, the more inconsistencies in the actions of the violations that are applied. Based on data, the consistency of violations to the ERP system is 75%, and for the 3in1 system by 25%.

The next parameter is the environmental impact (EI). EI means that is how much carbon dioxide emissions are generated from the implementation of ERP and 3in1 systems. Based on data, EI resulting from the ERP system is 118,641.7 kg * CO2 / (ha). While the environmental impact produced by the 3in1 system is 130.000 kg * CO2 / (ha) [8].

Finally, it is the vehicle number (VN) parameter. It is talking about the number of vehicle passing by the systems ERP and 3in1. Based on data, the number of vehicles that cross the location is 3,266,609 units; whereas for 3in1, there were 3,010,403 units [7].

All value of parameters are as crisp input of model for further processing. Thru benefiting the fuzzy rules bases (with also membership function defined before), the model is able to produce the performance value of both road traffic system. Performance value indicated methodically via crisp value.

Table 3: Result of Decision Alternatives Justification

Parameter	ERP	3in1
OC	0.67 L 0.33 H	0.55 L
PSA	0.67 S 0.40 LNP	0.50 MNP 0.40 LNP
TT	0.55 M 0.12 F	0.75 M 0.55 M
HR	0.75 A 0.25 LA	0.95 LA 0.04 A
V	0.55 QC 0.50 C	0.50 NC 0.33 QC
EI	0.93 M 0.06 L	0.60 H 0.40 M
VN	0.63 L 0.36 M	0.50 L 0.49 M

Table 4: The Example of Fuzzy Rules

Decision Type	Fuzzy Rules
ERP	If MEDIUM Cost, and MEDIUM Environmental Impact, and AVAILABLE Human Resources, and LOW Vehicle Number, and MEDIUM Travel Time, and SOLVED Problem Solving Ability, and CONSISTENT Violation then the ERP System IS APPLIED.

	…
	If MEDIUM Cost, and LOW Environmental Impact, and AVAILABLE Human Resources, and HIGH Vehicle Number, and MEDIUM Travel Time, and LITTLE New Problem, and CONSISTENT Violation then the ERP System IS APPLIED.
3 in 1	If LOW Cost, and MEDIUM Environmental Impact, and VAILABLE Human Resources, and HIGH Vehicle Number, and MEDIUM Travel Time, and LITTLE new problem, and CONSISTENT Violation then the 3in1 System IS NOT APPLIED.
	…
	If LOW Cost, and HIGH Environmental Impacts, and LESS Human Resources, and the HIGH Vehicle Number, and SLOW Travel Time, and MANY New Problem, and CONSISTENT Violations Enforcement then the 3in1 System IS NOT APPLIED.

4.3 Fuzzy Logic based Model

This Membership Function is a representation of language variables mapped to degrees of the truth (DoT) [4]. The Table 2 lists the linguistic variable and membership function of each parameter that we use in this study. And the examples of configuration for membership function are represented in Figure 2 and 3; respectively for membership function of parameter operational cost and decision.

Each parameter valued based on several literatures analysis. The result of justification is able to be showed in Table 3. After getting the value of each parameter, the value is entered into the predetermined rule base. Fuzzy rule base (fuzzy rule base) is another element needed to solve a classical problem by using the concept of fuzzy logic intact [4]. Table 4 shows the results of the values entered into the rule base.

4.4 Evaluation of ERP and 3in1 Systems

Maximum
IF (OC = 0.67L) ^ (TT = 0.55M) ^ (PSA = 0.67S) ^
(EI = 0.93M) ^ (HR = 0.75A) ^ (V = 0.55QC) ^
(VN = 0.63L)
THEN (Decision = 0.55APP).

Minimum
IF (OC = 0.33H) ^ (TT = 0.12F) ^ (PSA = 0.40 LNP) ^
(EI = 0.06L) ^ (HR = 0.25LA) ^ (V = 0.50C) ^
(VN = 0.36M)
THEN (Decision = 0.06APP).

By using weighted average, decision is 0.42APP. It means that the ERP system is probably able to be implemented by points 0.42.
Maximum
IF (OC = 0.55L) ^ (TT = 0.75M) ^ (PSA = 0.50MNP) ^
(EI = 0.60H) ^ (HR = 0.95LA) ^ (V = 0.50NC) ^
(VN = 0.50L)
THEN (Decision = 0.95NAPP).

Minimum
IF (OC = 0.55L) ^ (TT = 0.55M) ^ (PSA = 0.40LNP) ^
(EI = 0.40M) ^ (HR = 0.04A) ^ (V = 0.33QC) ^
(VN =0.49M)
THEN (Decision = 0.04 NAPP).

Based on average calculation, the decision for 3in1 system implementation is 0.45 NAPP. It means that the system in not good to be implemented by points 0.45.

4.5 Model's Dashboard

The dashboard of the constructed model was developed as well. It is presented in Figure 4. Here, all information operated and produced by model are able to be presented in one-page dashboard. It can be easier used by decision maker. Also, the dashboard is able to show the proposed decision clearly.

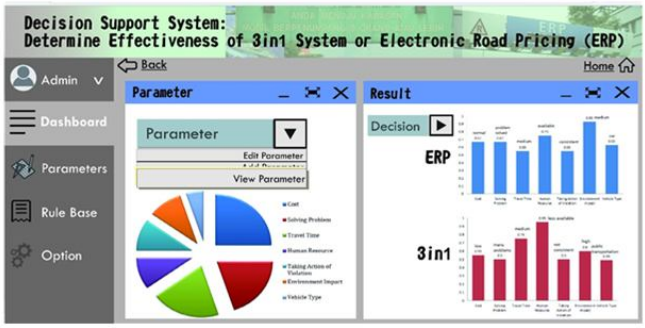

Figure 4: Dashboard of the Constructed Model

5. CONCLUSION AND FURTHER WORKS

A decision support model for evaluating two types of road congestion reduction strategies was academically constructed. It was developed based on main method fuzzy logic. The result showed that ERP system is better than 3in1 system. It was rationally applied to reduce traffic road congestion in Jakarta.

Consideration for other parameters is open to study (e.g. implementation cost, traffic road condition in one area, etc.). It is going to enrich the model constructed. It is also able to make the decision proposed more objective and scientific.

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