APPLICATION OF FUZZY SUGENO METHOD AND SAW FOR BANDWIDTH USAGE OPTIMIZATION

[1]Ulfa Tenripada, [2]Mustafid, [3]Oky Dwi Nurhayati

[1]Master Program of Information System of Postgraduate School
[1]Diponegoro University, Semarang, Indonesia.

Abstract : Provide services of internet network quality and user satisfaction become a liability for a university. In the meet it is the most major note is the capacity of the bandwidth used. It is used as a parameter of network quality at the university, from the other side of the bandwidth management is also influential in creating the internet network quality. The calculation of the bandwidth needs require some variable value integer and produce a solution that is worth an integer also. By using a fuzzy logic method that works with the rules linguistic will be obtained a solution with an integer value. SAW method is used because it has several advantages compared with other methods, an excess of the SAW method compared to the models with other decision-makers lies in its ability to perform assessment is more appropriate because it is based the value of criteria weights and preferences already determined, the SAW can also complete the best alternative from a number of alternatives that exist because the process of ranking after determining the weights for each attribute The results obtained from the application of such methods at the university can determine the amount of bandwidth requirements overall and per division. The results obtained from testing the value of the presentation QoS of 93,75% the index is very good. With the method of fuzzy sugeno, SAW help optimize the performance of the use of network bandwidth and streamline network service quality at the university**.**

Keywords: ***Optimization; Bandwidth; Fuzzy Sugeno; Simple Additive Weigthting;***

I. INTRODUCTION

The Internet network used in an organization is not detached from the kinds of problems in the organization, including those relating to the quality of the network service, in addition to the satisfaction of the users of the network service can be a serious problem that can cause network utilization to be less than optimal. Providing quality Internet Network Service and user satisfaction become fulfilled is the obligation of the Organization. In fulfilling that it is more important is bandwidth capacity used. This can be used as a parameter of the network quality in the organization, from the other side of bandwidth management is also influential in realizing a quality Internet network [1].

In an organization or agency, several divisions require network of the internet that will be used for each in a division.But there is organization or agencies that give the bandwidth that does not conform to what is required by the division.This is a causing discharging it network the internet in any division of being unbalanced, there is indeed very fast access to but there are others who arriving, or even there is often also the divisions not gain access at all.To adjust the bandwidth required on each in a division to organizations or agencies said to the methods that can identify the needs of the bandwidth in each the division [2]. Is the bandwidth capacity or capacity of an ethernet or wireless to pass by data packets traversed. Management bandwidth is away in the implementation of the and optimization of in a network by applying service quality of service [3].

In some research of fuzzy method has been widely utilized because of the level of error in this method was relatively little, the fuzzy method can process a lot of data so that you can calculate obtaining the results. Fuzzy logic is also very flexible because it can adapt to change and the value of uncertainty that often accompanies the problem, fuzzy logic can model the function of non-linear very complex and can apply the experience of experts directly without having to go through various processes of training. The fuzzy method is a great way to map an input space into an output that has a continuous value. The continuous value will be expressed in degrees of membership and degrees of truth. In the design of this method does not require the mathematical equation of the object is controlled[4].

The calculation of the bandwidth needs require some variable value integer and produce a solution that is worth an integer also. With the fuzzy logic method that works with the rules of the linguistic solution to the integer value [5].

SAW method is used because it has several advantages compared with other methods. Excess of the SAW method compared to the models with other decision-makers lies in its ability to perform assessment is more appropriate because it is based on the value of criteria weights and preferences already determined, in addition SAW method can also complete the best alternative from a number of alternatives that exist because the process of ranking after determining the weights for each attribute [6]. This research aims to implement the method of fuzzy Sugeno, SAW on the optimization of the bandwidth usage of the network university and to give recommendations on the ideal needs of the overall bandwidth and quality of each division

II. THEORETICAL FRAMEWORK

A. Management Bandwidth

Management bandwidth is a tool that can be used for the management and optimize the different types of tissue by applying a service Quality of Service (QoS) to assign the type of network traffic whereas QoS is the ability to describe a level of achievement in a communication system. Bandwidth management is the process of measuring and controlling the communications (traffic, packets) on a network link to avoid filling the link or overfilling the link, which would result in network congestion and poor performance. The purpose of the bandwidth management this is how we implement the Allocation or the bandwidth settings by using a PC Router Mikrotik [7]

B. Sugeno Fuzzy Inferencing Model

Sugeno Fuzzy Inference model popularly known as TSK modelwas introduced by Takagi, Sugeno and Kang. Fuzzy Inference Systems (FIS) are based on three components namely rule base, data-base and reasoning mechanism. The rule base consists of theantecedents and consequents of the following form: If A is antece-dentthen B is consequent.The database defines the membershipfunction which represents the degree to which an object belongsto a set. Reasoning uses the antecedent information, the rulesand the membership degrees to find the output [8]

In Sugeno model a fuzzy rule is represented as

If x is A and y is B then z – f(x,y) (1)

where the consequent 'z' is a crisp function of the antecedents. Theoutput function is a polynomial whose order depends on the num-ber of inputs. If there are two inputs 'x' & 'y' the output polynomialwill be of the form z = px + qy + r. The overall output is computedusing the weighted average of the 'z' values [8].

Below we present a brief comparison between Sugeno model and its contemporary Mamdani model, which explains our rationale behind the choice of Sugeno model [9–11].

1. There is more flexibility in the design of FIS based on Sugeno as the consequents can have as many parameters per rule as the number of input values.
2. Though Mamdani model is considered to be more interpretable, Sugeno scores in computational efficiency and accuracy because a simple weighted average technique is used instead of complex defuzzification.
3. It is considered more accurate for Multiple Input Single Output Systems.
4. Can be well integrated with neural networks and genetic algorithms for sample data based fuzzy modeling.
5. The only problem is there is no concrete method to determine the coefficients p, q, r which play an important role in the effectiveness of the model.

Since the problem under consideration in our study is a Multiple Input Single Output system and we have the flexibility to have as many parameters in the consequent as the number of rules, Sugeno model is the most appropriate model to apply to our problem [8].

C. Simple Additive Weighting

Simple Additive Weighting (SAW) is a multi-attribute procedure is based on the concept of a weighted summation. Looking for a weighted summation of rating the performance of each alternative on all alternative criteria which the highest score overall is the best alternative and will be taken. This method can be used to support Geographic Information System with overlay operations [6].Completion step is [6] :

1. Determine alternative, namely Ai.
2. Determine the criteria that will be used as reference in the decision, namely Cj. Subsequently identified the types of criteria, whether the criteria advantage (benefit criteria) or cost criteria (cost criteria). If Cj is the criteria benefit the greater the value, the better the criteria for the determination of alternatives. If Cj is the cost attribute the smaller the value, the better the criteria for the determination of alternatives. 3.
3. Provide rating matches the value of each alternative on each criterion.
4. Determine the weight of preference or importance level (W) of each criterion. W = [W1, W2, W3, ..., Wj]
5. Create a table rating the suitability of each alternative on each criterion. 6.
6. Making a decision matrix (X), which is formed from a table rating the suitability of each alternative on each criterion. Value (X) each alternative (Ai) on each criterion (Cj) that have been determined, wherein, i = 1,2, ... m and j = 1,2, ... n.

$$X = \begin{bmatrix} X_{11}X_{12} & \cdots & X_{1j} \\ \vdots & & \vdots \\ X_{i1}X_{i2} & \cdots & X_{ij} \end{bmatrix} \quad (2)$$

7. Normalizing the decision matrix by calculating values ternomalisasi performance rating (rij) of alternative Ai on the criteria Cj.

$$r_{ij} = \begin{cases} \frac{X_{ij}}{Max_i\,(X_{ij})} & if\ j\ is\ benefit\ criteria \\ \frac{Min_i\,(X_{ij})}{X_{ij}} & if\ j\ is\ cost\ criteria \end{cases} \quad (3)$$

8. The results of the performance rating value ternomalisasi (rij) form a matrix of normalized (R).
9. The final result preference value (Vi) obtained from the sum of the multiplication element row normalized matrix (R) weighs the preferences (W) corresponding element column matrix (W).

$$V_i = \sum_{j=1}^{n} W_j\, r_{ij} \quad (4)$$

III. RESULT AND DISCUSSION

3.1 System Optimization Bandwidth

On this system, the application of fuzzy Sugeno inference of his use of several stages of the process fuzzification where the data input value that is firm (crisp input) into the input of the fuzzy. this research used several variables used in the optimization of bandwidth usage with the parameters of the amount of bandwidth, number of users and the quality of the network. This variable was formed based on the classification data bandwidth usage daily.

The next process is the process of determining the fuzzy rule which is created based on conditions that have occurred in the past which is known from the time data of the lamp and to further the process of implication functions used is AND (Function MIN) it is because of all the variables is done by finding the fire strength is the value of membership as a result of the operation of the association and the value of Z for each rule than do the prose defuzzification /affirmation is to convert the set of fuzzy output into the form of numbers firmly (crisp) using the method of defuzzy weighted average. In the next process, namely the process of SAW method which is made based on the results of the data fuzzy Sugeno, the data will be normalized will then be made to the process of ranking that will produce the priority bandwidth to the faculty. The implementation of a system that has three stages : input, process and output.

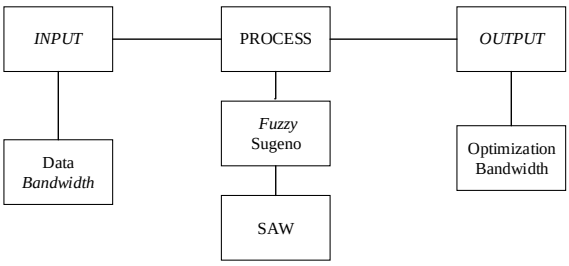

Fig. 1. Phases of system optimize bandwidth .

The stages of the early methods of fuzzy sugeno is the formation of the repertoire of fuzzy. On the system that will be made has been determined 3 criteria for optimization as a fuzzy rule. For the obtained optimization needs bandwidth it takes a variable input to be able to optimize bandwidth as in the table below :

Table 1. Variable input

Criteria	Parameter
BW	Bandwidth
CMT	Users
CK	Quality of Service

The membership functions of each input variables where μ is the degree of membership and α is the value of the input that would be converted into a set of fuzzy described as follows :

The membership fuction *bandwidth*

$\mu[\alpha]$ *bandwidth medium* $= \frac{100-98}{100-92,5} = \frac{2}{7,5} = 0,26$

$\mu[\alpha]$ *jumlah bandwidth high* $= \frac{98-92,5}{100-92,5} = \frac{5,5}{7,5} = 0,73$

The result of the process of calculating the value of the fuzzy membership then in inference on fuzzy rules . On the method of fuzzy Sugeno, implication functions used are MIN. The following example rule that has been created which consists of 27 rules.

[R1] IF *bandwidth* low And *users* low And *quality* Bad Then *Upgrade* ;

[R2] IF *bandwidth* low And *users* low And *quality* sufficient Then *Upgrade* ; until….

[R27]IF *bandwidth* high And *users* high And *quality* good Then *Normal;*

the formation rules are described with the following formula as in equation (1) :

If x is A and y is B then z – f(x,y)

Further search for α-predicate (fire strength), namely the value of membership as a result of the operation of the association and the value of Z for each rule. Following the search of α-predicate based on the rules :

$\alpha Predikat_1$ = MIN(0.30,1.50,1.00)
= 0.30
Z_1 = Upgrade = 100
$\alpha Predikat_2$ = MIN(0.30,1.50,1.00)
= 0.30
Z_2 = Upgrade = 100

next, the process of defuzzification using the method of the weighted average (defuzzy weighted average)

Weight Average

$$FO = \frac{(30)+(30)}{(0.30)+(0.30)}$$

FO = 60/0.6
FO = 100

Of the overall process of the obtained results of the fuzzy sugeno *UPGRADE*

Table. 2 Result Fuzzy Sugeno

NetID	Faculty	Node	Bandwidth	Users	Quality	FuzzyOutput
1	Ekonomi	1	10	50	33,3	Upgrade
2	Ilmu Komp	2	10	100	100	Normal
3	Kes.Masyrakat	4	10	100	100	Normal
4	Farmasi	1	10	50	66,6	Upgrade
5	Teknik	2	10	50	66,6	Upgrade

After getting the value of the fuzzy Sugeno and find out the results of the status of the bandwidth for the status of the results of the general faculty the next will be done with the SAW method to determine the priority bandwidth on the faculty. In the process of the method of SAW users in this case the head of IT or IT Staff can access the menu method on the initial view and then select the menu SAW method. After the user enters in the menu of the SAW method will perform the process menu the process SAW. The following menu display process SAW

On the process method of the SAW there are several stages to get the bandwidth priority ranking results in the early stages of the faculty, i.e. determining the criteria serve as decision-making, namely c. on this system there are three criteria that used to perform process priority bandwidth usage, namely:

C1 = bandwidth,

C2 = users

C3 = quality of service.

Next, do the determination of suitability rating on every alternate on each criterion. The decision-maker in this case head IT university give weights on each criteria i.e.,

C1 = 35%,

C2 = 35%,

C3 = 30%.

After the determination of the criteria of the system will display a matrix of decisions based on criteria that have been created, then the system will perform normalization of matrix. After the stages of normalization in equation (3) the system will display the final results obtained from the process of ranking i.e. the number of multiplication of the normalized R with vector weighted so that it obtained the largest value is selected as the best alternative or the priority use of the bandwidth of the faculty. The results obtained are as follows :

Result normalisation

$$\begin{vmatrix} 1 & 0.81 & 0.98 \\ 0.8 & 1 & 0.95 \\ 0.63 & 1 & 0.89 \\ 0.23 & 1 & 0.88 \end{vmatrix} \mathbf{x} \begin{vmatrix} 35\% \\ 35\% \\ 30\% \end{vmatrix}$$

The process of ranking using the weights given by decision maker based on the equation (4)

W = [0,35 0,35 0,30]

V1 =(0.35)(1)+(0.35)(0.81)+(0.30)(0.98)
=0.35+0.28+0.29
=0.92

V2 =(0.35)(0.8)+(0.35)(1.00)+(0.30)(0.95)
=0.28+0.35+0.28
=0.91

V3 =(0.35)(0.63)+(0.35)(1.00)+(0.30)(0.89)
=0.22+0.35+0.26
=0.83

V4 =(0.35)(0.23)+(0.35)(1.00)+(0.30)(0.88)
=0.08+0.35+0.26
=0.69

The conclusion is V1 or Building 1 has the highest priority so that the bandwidth that is high in priority for Building 1. next, Building 2, Building 3, and Building 4

IV. CONCLUSION

System optimization of bandwidth usage using the fuzzy sugeno, Simple Additive Weighting (SAW) is able to perform the optimization of the use of or bandwidth management in accordance with the needs of each faculty and the university. Access rights in full are held by the ICT of the university in this case the head of IT. The use of this system can provide recommendations to the needs of the ideal bandwidth in whole or in faculty.

REFERENCES

[1]. C. Sethi, P.K Behera, *Networking Traffic Management using Dynamic Bandwidth on Demand,* International Journal of Computer Science and Information Security (IJCSIS), Vol 15, No.6, June 2017

[2]. Vikas Sharma, Vikram Kumar, Balvir Sigh Thakur, *Need of Bandwidth Managment and Formulation of Policy Framework For Effective Utilisation of Internet Service Within a University Campus,*International Journal of Computer Science Science and Communication, Vol 2, No.1, January-June 2011,pp 173-178

[3]. Luigi T. De Luca, *Propulsion physics* (EDP Sciences, Les Ulis, 2009)
[4]. Zafer Civelek, *Optimization of Fuzzy Logic (Takagi-Sugeno) blade pitch angle controller in wind turbines by genetic algorithm,* Engineering Science and Technology, an International Journal, 2019.
[5]. Quarda Lamrabet, Ahmed Ech-charqy, El Houssaine Tissir, Fatima El Haoussi, *Sampled data Control for Takagi-Sugeno Fuzzy Systems with Actuator Saturation,* International Conference on Intelligent Compting in Data Sciences (ICDS 2018)
[6]. Rizka Ella Setyani, Ragil Saputra, *Flood-prone Areas Mapping at Semarang City By Using Simple Additive Weighting Method,* International Conference Intelligent Palnning Toward Cities 2015
[7]. Cuiping Ni, Chaoqin Gan, Wei Li, Heibin Chen, *Bandwidth Allocation based on Priority and excess-bandidth utilized algorithm in WDM/TDM PON,* International Journal of Electronics and Communications, 2015
[8]. Sushsri Samita Rout, Bijan Bihari Misra, Sasmita Samanta, *Competency Mapping with Sugeno Fuzzy Inference Sytem for Variable pay determination : A Case study,* Ain Shams Engineering Journal, 2017
[9]. Chaudhari S, Patil M. Study and review of fuzzy inference systems for decision making and control. Am Int J Res Sci, Technol, Eng Math 2014;5(1):88–92.
[10]. Kansal V, Kaur A. Comparison of mamdani-type and sugenotype FIS for water flow rate control in a rawmill. Int J Sci Eng Res 2013;4(6)
[11]. Wang Y, Chen Y. A comparison of Mamdani and Sugeno fuzzy inference systems for traffic flow prediction. J Comput 2014;9(1):12–21.