



## Implementation of sugeno fuzzy method on bandwidth management at STMIK YMI Tegal

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### ARTICLE INFO

#### Article history:

Received Sep 2, 2023  
Revised Sep 12, 2023  
Accepted Sep 20, 2023

#### Keywords:

Bandwidth Management;  
Fuzzy Sugeno;  
Matlab;  
Streaming Limit.

### ABSTRACT

In the lecture process, the Internet becomes very important, and access settings or bandwidth management is needed so that Internet use can run smoothly. Many users can cause the burden of computer access to be high, so internet use will be unbalanced if bandwidth management is not carried out. Bandwidth management aims to allocate bandwidth in an internet network so that the distribution is equal and the comfort between users and one another is not disturbed. The method used is fuzzy Sugeno to implement Sugeno's fuzzy logic into bandwidth management and optimize internet usage. Fuzzy inputs used include download, streaming, and browsing variables. Using three fuzzy sets, namely low, standard, and solid. The output is Download Limit, Streaming Limit, and Browsing Limit. System testing will be conducted using MATLAB. After testing, results were obtained through bandwidth limits from downloading, streaming, and browsing. One of the study's results included a given system input download = 700, streaming = 668, and browsing = 611. Produce output is Download Limit = 700, Streaming Limit = 481, and Browsing Limit = 319.

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## 1. INTRODUCTION

Computer networks are essential because they allow users to share resources and information (Nunes et al., 2014). This network can access data and information from other devices, such as printers, servers, and hard drives, even in different places. It can also make it easier for users to communicate directly through email, messages, or other applications (Alam, 2021).

A computer network is a set of devices connected and functions to share information, resources (such as printers or hard disks), and services between computers through internet media. This network consists of two or more computer devices by cables, radio waves, or other media to transmit data and information to each other (Singh & Singh Tomar, 2019).

Computer networks can be divided into local area networks (LAN) and wide area networks (WAN). LANs are typically used within a single building or a limited area, while WANs are used to connect long distances between different locations (Ray, 2018).

On this network, there are special devices called routers, switches, or hubs that function to manage data traffic and information between devices connected to the network, and there are also protocols and unique technologies used in computer networks such as TCP/IP, Ethernet, Wifi, and others (Zhang et al., 2019)

A computer network is a collection of several computer devices that are mutually exclusive, interacting and exchanging information through a predetermined network structure. The largest network, the network that connects the entire world, is called the Internet. Accessing information can be effortless and fast thanks to the Internet, but to access the Internet requires a connection. The time it takes to access information on the Internet depends mainly on the connection quality (Wahab, 2019).

To provide optimal network services, network quality management is needed precisely following the service needs applied to the network. (Purwodwiyogo & Subardono, 2018). One factor often encountered is the number of users who try to access the Internet through the same connection. The number of users can overload the connection so that internet access becomes slow or often called lagging. This incident will significantly disrupt activities, for example, campus activities (Yayla et al., 2020).

Bandwidth management has theoretical and practical implications that impact network and communication aspects, in theory, such as Network Optimization: bandwidth management will contribute to developing network optimization theories and algorithms. Theoretical models and frameworks are used to analyze and design optimal solutions for bandwidth allocation, congestion control, and quality of service (quality of service) provision. At the same time, the practical implications include improving Network Performance and user experience to save costs by minimizing network over-provisioning and optimizing resource usage. Bandwidth Management can also maintain network security by helping identify and mitigate network attacks.

One solution to the above problem is bandwidth management: Bandwidth is the maximum path capacity data can travel in a few seconds. Bandwidth is often analogous to hose and data as water. The bandwidth affects the amount of data that can be sent quickly. One fatal thing that influences network quality is that users take up most of the bandwidth, so other users will be disturbed because they are faced with slow connections (Bouraqia et al., 2020).

Bandwidth Management must consider each network user's needs and priorities to balance and optimize bandwidth management. Using the proper bandwidth management techniques and strategies can make network usage more efficient and optimal, improving network performance (September 2007).

Fuzzy logic is often used for various studies because it has advantages (LENDARIS, 1994). Fuzzy Sugeno and fuzzy Madani are methods included in the Fuzzy logic. Both are used to solve various problems involving uncertainty in data and linguistic variables.

The difference between fuzzy Sugeno and Mamdani is that fuzzy Sugeno has a faster computational speed than fuzzy Mamdani because it uses a simpler inference model and does not require composition and aggregation operations on fuzzy sets. In addition, fuzzy Sugeno uses an inference model with linear equations to calculate the output value. In contrast, fuzzy Mamdani uses compositional and aggregation methods to produce output in fuzzy sets. The Sugeno method has similarities with the Mamdani method. The Sugeno method produces an output not in the form of fuzzy sets. On fuzzy, decisions use the if-then rule (Tundo et al., 2020).

Research on bandwidth management has been conducted previously in journals (Purwodwiyogo & Subardono, 2018). As a result, fuzzy algorithms are used to control bandwidth on ad hoc wireless networks by adjusting the speed of data transmission between nodes in the network. Dynamically adjusting the transmission speed maximizes bandwidth usage and avoids overlapping data transmitted by different nodes. Another study (Tundo et al., 2020) explained the comparison of fuzzy Tsukamoto and Sugeno in

determining woven fabric production using decision tree results using Tsukamoto, which has a higher accuracy of 83.33%. Another study (Sihotang et al., 2020) states that a fuzzy Mamdani decision support system can solve existing problems at PT Legato International.

Other research to investigate bandwidth management (Prihantoro et al., 2021). The study showed positive results where bandwidth management could divide bandwidth evenly, thus ensuring the client's connection was stable. Bandwidth management becomes essential to improve the efficiency and effectiveness of resource-use networks. The results of this study show that the implementation of bandwidth management can help overcome problems that often occur on the network, such as connection instability and bandwidth throttling. Therefore, further research on bandwidth management with more innovative and effective methods is essential. Bandwidth division is done by calculating bandwidth capacity divided by the number of clients (Doni, 2019).

Another study applied the Fuzzy Sugeno method to analyze estimated tofu production (Nurdini et al., 2021). The results showed that using the Fuzzy Sugeno method yielded a very high level of truth, reaching 97.825%. These results indicate that Sugeno's Fuzzy method can produce highly accurate and reliable output.

Fuzzy Sugeno method in research determining the best path to tourist attractions in Surabaya (Mukaromah, 2019). The Fuzzy method can provide more optimal decisions in choosing the path to tourist sites in Surabaya. Matlab calculations found six optimal paths with a percentage of 33.36% or 12 paths less optimal with a presentation of 66.64%. These findings show the potential of the Fuzzy Sugeno method in providing solutions to problems involving many factors with various possibilities.

From the research that has been carried out above, there have been those who use fuzzy Sugeno in bandwidth management in various fields of work more flexibly. Still, in this research, the title is Implementation of the Fuzzy Sugeno Method in Bandwidth Management using the MATLAB application, which was carried out on the STMIK YMI Tegal campus to make it easier for users to implement internet bandwidth management in internet network management on the STMIK YMI Tegal campus.

## 2. RESEARCH METHOD

Implementing the Fuzzy Sugeno method in bandwidth management is carried out to allocate bandwidth evenly among network users. In this case, several input variables have been defined, including downloading, browsing, and streaming, while the resulting output variable is the maximum limit of each input variable. The research procedure used as a reference is outlined in Figure 1.

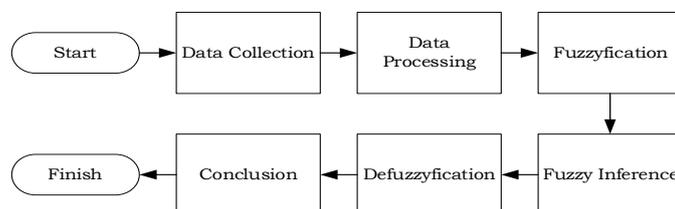


Figure 1. Research Procedure

From Figure 1 above, it appears that this research began by collecting data from the STMIK YMI Tegal campus. The data was processed into data that was ready to be processed through data processing; after that, it was processed using the stages of Fuzzy Logic, namely fuzzy Sugeno, including fuzzy inference, defuzzification, and finding conclusions from the results of Sugeno's fuzzy calculations.

## 2.1. Internet

Interconnected networking, abbreviated as the Internet, is a computer network system that is widely interconnected (Hidayanto & Zidni Ilmi, 2015). Around the decade of 1970, the Internet began to appear and continue to grow as it is today. ARPANET is a network established by the United States Department of Defense and developed into a vast source of information (Walker-Andrews, 1997).

There are several types of internet connections available, such as Connections for Personal Users, Connections for Institutional Users, Analog/Digital Dial-Up (ISDN) Connections, Leased Line Connections (fixed), and VSAT Connections (Very Small Hole Terminals). In addition, the Internet also has addresses, such as an IP address consisting of four 8-bit numbers and a MATT consisting of a domain name. There are also other user addresses.

The entity providing Internet access is called an ISP (Internet Service Provider). The server or Host is the device that is responsible for handling all internet activities. Login or user ID is the identity of a person's email address.

The security system on the Internet is called a password. Facilities contained on the Internet are remote computer access (remote login), communication with other users both offline (electronic mail, mailing list, newsgroup) and online (chat netmeeting), Telnet, information access (WWW, Search, download), File Transfer and to find out the collation of a file (Archive).

## 2.2. Bandwidth

Bandwidth is a concept of measurement in the network. The shortcomings of this concept are that it does not care about how to send information, so it results in a maximum speed limit (Yupapin et al., 2012).

Bandwidth management is a way to determine the amount of bandwidth to each user on the network, which impacts transmission speed. The provider provides this bandwidth with the amount according to the rental from the customer. QOS can be set so that bandwidth does not run out. In essence, this bandwidth describes the capacity of the connection followed by good performance despite another factor, namely latency or time delay, between the life of a device and access permission to transmit (Hekmat & Van Mieghem, 2005).

## 2.3. Fuzzy Logic

This Fuzzy logic method is often considered a black box connecting input to output (Komariyah et al., 2016). This box contains ways to process input data into output results in the form of information.

Fuzzy sets have two attributes: numerical and linguistic. Linguistic characteristics are used to name a group representing a state or condition, such as young, adult, and old. Meanwhile, numerical characteristics refer to values that indicate the size of a variable. (Yulianto et al., 2017). Things to note in this fuzzy logic are (a) Fuzzy variables are variables that are discussed in fuzzy systems, (b) Fuzzy set is a collection that represents a specific situation or condition on a particular fuzzy variable, (c) The Talking Universe is all the values allowed for the operation of fuzzy variables that always increase monotonously; the values can be negative or positive, (d) Domain is a whole value in a speech unit operated on a fuzzy set that constantly increases monotonously and can be both negative and positive.

## 2.4. Fuzzy Membership and Operator Functions

It is a function that maps input points into its membership value or degree of membership that falls between 0 and 1. Standard procedures include linear representation, triangular representation, trapezoidal representation, S-curve

representation, V-shape representation with shoulders, and bell shape representation (Nur Azizah et al., 2015). Several operations can be interpreted to modify and combine fuzzy sets, the value of which results from the process of two sets or the so-called fire streng (Khademi et al., 2017). There are three fuzzy operators: the AND operator, the OR operator, and the NOT operator.

## 2.5. Fuzzy Inference

It is a computational framework based on fuzzy set theory, and the rules are if-then and reasoning. It is often applied to automatic control, classification, analysis, and expert systems. There are several main components, including input variable data and the fuzzification functions, of which there are two types, namely the function to determine the membership function and the operator use function. This function will remap fuzzy into CRIPS values which are the output of problem solutions (Rozie et al., 2021).

## 2.6. Defuzzyfikasi

Defuzzification equation using weighting average method

$$Z = \frac{\alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3}{\alpha_1 + \alpha_2 + \dots + \alpha_{27}} \quad (1)$$

The Z value is the z-browsing, z-download, and z-streaming values.

## 2.7. Sugeno method

In 1985, Takagi-Sugeno Kang introduced this method, which proposed using Singleton as a membership function of the consequent Singleton, a fuzzy set with a membership function at a given point valued at 0 beyond that point. In the Sugeno method, the first two parts of the fuzzy conclusion-drawing process, namely input fuzzification and the application of fuzzy operators, are the same as the Mamdani method. However, the difference is that the function membership output of the Sugeno method is linear or constant. The rules of the Sugeno Method are seen in Equation 2.

$$\text{If input 1} = x \text{ and input 2} = y \text{ then output is } z = ax + by + c \quad (2)$$

For zero-order Sugeno models, the z-level output is constant ( $a=b=0$ ). The z output level of each rule is the weight of  $w_i$  (firing strength). For example, in the AND rule with input 1 = x and input 2 = y, firing strength:  $w_i = \text{And Method } (F1(X), F2(Y))$  where F1.2 membership function input 1 and 2. (Ayuningtias et al., 2017)

There are two kinds of fuzzy models in the Sugeno method, namely:

### a. Fuzzy Sugeno Model Order 0

The general form of the fuzzy Sugeno model:

$$\text{IF } (x_1 \text{ is } A_1) \dots (x_N \text{ is } A_N) \text{ THEN } z = f(x, y) \quad (3)$$

Where  $A_i$  is fuzzy to I as antecedent and k is constant as consequent.

### b. First-order Sugeno Fuzzy Model

$$\text{IF } (x_1 \text{ is } A_1) \dots (x_N \text{ is } A_N) \text{ THEN } z = P_1 x X_1 + q \quad (4)$$

With  $A_i$  as the fuzzy set as the antecedent and  $p_i$  a constant in consequent. Defuzzification is done by calculating the average (Wuragil, 2015).

Fuzzy Sugeno has the advantage of fixing the weaknesses of pure fuzzy to add simple mathematical calculations as part of THEN. Fuzzy systems have a weighted average value in the fuzzy rules section of IF-THEN. The weakness is the power of mathematical calculations, so it cannot provide a natural framework to present

fundamental human knowledge and cannot perform different principles in fuzzy logic so that the uncertainty of fuzzy systems cannot be presented (Saputri et al., 2019).

The shoulder curve describes gradual variation in a concept or variable without sudden transition or high uncertainty.

Membership function for left shoulder curve:

$$\mu[x] = \begin{cases} 0, & x \leq a; \\ \frac{b-x}{b-a}, & a \leq x \leq b; \\ 1, & x \geq b. \end{cases} \quad (5)$$

Membership function for right shoulder curve:

$$\mu[x] = \begin{cases} 0, & x \leq b; \\ \frac{x-b}{c-b}, & b \leq x \leq c; \\ 1, & x \geq c. \end{cases} \quad (6)$$

This curve is often used to describe a gradual change in membership level as input values move from one side of the set to its central value and then return gradually as the input value moves from its center value to the other side of the set. An example of its use is in velocity variables with slow, medium, and fast fuzzy sets. The shoulder curve describes a gradual change in the membership level of a medium set as the velocity value moves from slow to fast. Shoulder curves provide a flexible representation of fuzzy systems' relationship between input and membership levels. They are often used in various applications such as systems control, decision-making, and fuzzy data analysis.

### 3. RESULTS AND DISCUSSIONS

The initial step carried out in this study was to collect data conducted at STMIK YMI Tegal. Data obtained as many as 27 data. The data obtained includes input data and output data. The input variables include download, browsing, and streaming traffic. Similarly, the output is divided into download, browsing, and traffic, as in Table 1.

Table 1. Data Download, Streaming, and Browsing STMIK Tegal

No	Input			Output		
	Download	Streaming	Browsing	Download	Streaming	Browsing
1	low	low	low	700	500	300
2	low	low	normal	700	300	500
3	low	low	high	500	300	700
4	low	normal	low	500	700	300
5	low	normal	normal	300	700	500
⋮	⋮	⋮	⋮	⋮	⋮	⋮
23	high	normal	normal	700	300	500
24	high	normal	high	700	300	500
25	high	high	low	700	500	300
26	high	high	normal	700	500	300
27	high	high	high	700	500	300

Table 1 shows that the fuzzy rule that will be used is if the input download, input streaming, and input browsing, then the value of output download and output streaming and output browsing. For example, at number 12, if the regular download input is 500, the streaming input is low at 300. The browsing input is 700, which is a relatively solid a value: the predicate of each fuzzy uses the minimum value (AND operator)  $z$  value; there are three, namely  $z$ -download,  $z$ -streaming, and  $z$ -browsing, to produce accurate output.

The next step is to create a fuzzy rule as a link between input and output variables. Fuzzy rule forms include IF traffic IS  $x$ , THEN bandwidth limit IS  $y$ . The  $x$  value represents the user's internet traffic input, divided into downloading, streaming, and browsing. In comparison, the  $y$  value represents the output value to determine the bandwidth limit, including download, streaming, and browsing limits. The bandwidth

limit determined will be based on how many downloads, streaming, and browsing traffic are inputted.

The input variables must be converted into fuzzy sets for calculations in forming fuzzy systems. Then, the degree of membership is determined from each fuzzy set. The degree of membership indicates how far an input value belongs to the corresponding fuzzy set. This value is expressed in the range of values 0 to 1. If the value is outside of the values 0 to 1, it is declared not to include members of the set. The closer the input value is to 0, the less the value fully indicates membership. Conversely, if the input value is close to 1, then the value indicates full membership.

Each variable contains the value of download traffic, browsing, and streaming traffic. The traffic value will be low if it is in the range between 300 to 500. The traffic value will be moderate if it ranges between 300 to 500 and 500 to 300. Finally, the traffic value is densely membered if it is in the range of 500 to 700 values.

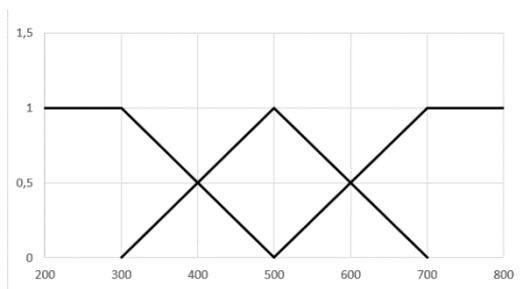


Figure 1. Shoulder curve

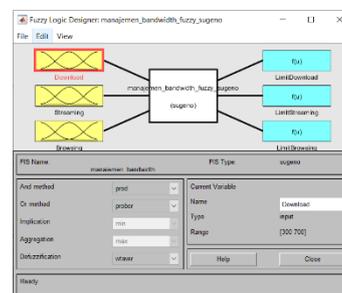


Figure 2. Fuzzy logic system design

Membership functions of low, standard, and solid sets:

$$\mu[x]_{\text{low}} = \begin{cases} 1, & x \leq 300; \\ \frac{x - 300}{500 - 300}, & 300 \leq x \leq 500; \\ 0, & x \geq 500. \end{cases} \quad \mu[x]_{\text{normal}} = \begin{cases} 0, & x \leq 300 \text{ atau } x \geq 700; \\ \frac{x - 500}{500 - 300}, & 300 \leq x \leq 500; \\ \frac{700 - x}{700 - 500}, & 500 \leq x \leq 700. \end{cases} \quad \mu[x]_{\text{high}} = \begin{cases} 0, & x \leq 300; \\ \frac{700 - x}{700 - 500}, & 500 \geq x \geq 700; \\ 1, & x \geq 700 \end{cases}$$

The next stage is the implementation of the program. This Matlab program research aims to simulate bandwidth management with the fuzzy sugeno method.

In Figure 3, you can see the design of Sugeno's fuzzy logic system using MATLAB. The menu displays three inputs, namely Download, Streaming, and Browsing. These inputs will be processed through Sugeno fuzzy logic to produce the desired output. The menu has three outputs: Download Limit, Streaming Limit, and Browsing Limit.

Figure 4, Figure 5, and Figure 6 are the views of the three membership function inputs. Each membership has three sets, namely low, standard, and dense, with a range of [300-700]. The low set has parameters [-500 300 500]. Standard sets have parameters [300 500 700]. A solid set has parameters [500 700 900].

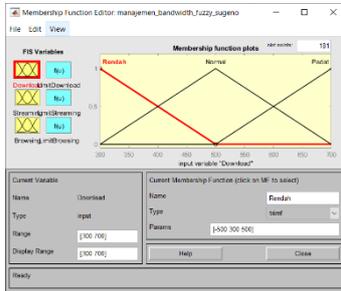


Figure 3. Input membership download function

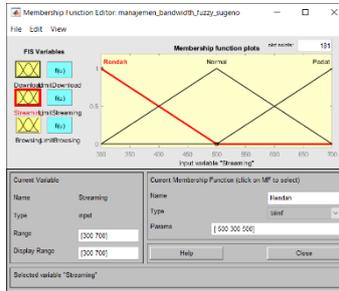


Figure 4. Streaming membership function input

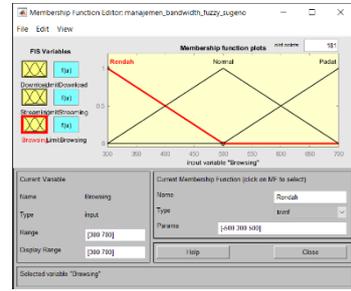


Figure 5. Input membership browsing function

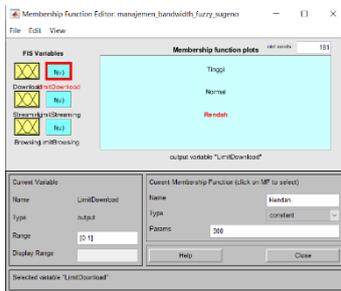


Figure 6. Output membership function download limit

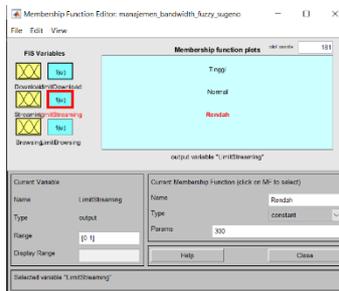


Figure 7. Streaming limit membership function output

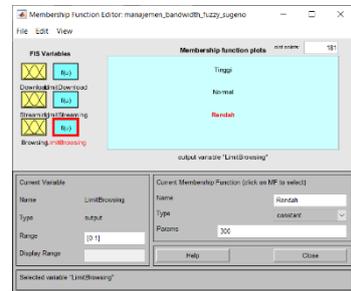


Figure 8. Membership function output limits browsing

Figure 7, Figure 8, and Figure 9 are output displays of the membership function. All three have the same set of low, standard, and high. Low sets have parameters [300], standard sets have parameters [500], and high sets have parameters [700].

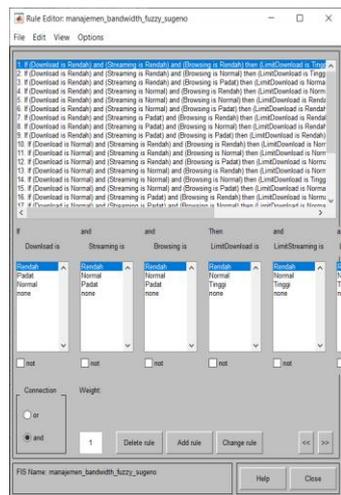


Figure 9. Rule editor

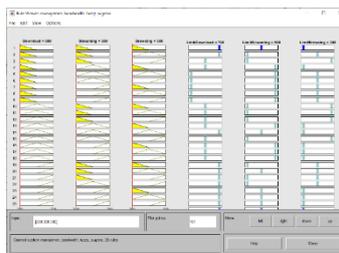


Figure 10. Rule view input 1

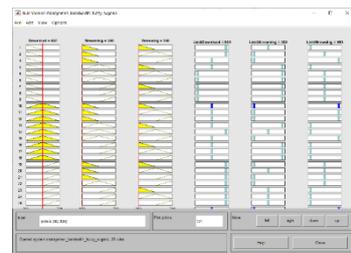


Figure 11. Rule view input 2

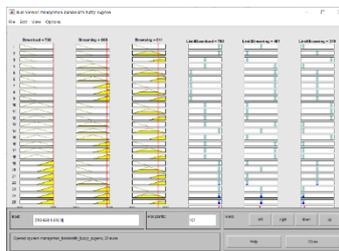


Figure 12. Rule view input 3



Figure 13. Rule view input 4

The next step is to enter the fuzzy rule into the system. Rules are inputted one by one based on the data in Table 1. The menus shown in Figure 11 through Figure 14 result from a bandwidth management process with sugeno fuzzy logic. As a result, the system was given input download = 700, streaming = 668, and browsing = 611. Then the

output results are LimitDownload = 700, LimitStreaming = 481, and LimitBrowsing = 319. This output result is obtained from the input value, which is then processed through fuzzy Sugeno inference based on the rules in Table 1 to produce the appropriate output. This applies also to other input results.

#### 4. CONCLUSION

Based on the results and discussion, the following conclusions are drawn. The Sugeno fuzzy method is very suitable for designing bandwidth management systems because it can process data efficiently. The Sugeno fuzzy method can provide flexible solutions for uncertain problems such as traffic movement. As a result, the system is given input download = 700, streaming = 668, and browsing = 611. Then the output results are LimitDownload = 700, LimitStreaming = 481, and LimitBrowsing = 319. So, it can be concluded that the Sugeno fuzzy Matlab application can facilitate and help prioritize bandwidth needs using Matlab application based on user needs and help reduce cost and network waste in maximizing resource use efficiency on the STMIK YMI Tegal campus. From the results of this research, it is recommended for further study, namely to use data obtained directly in the field with a more significant amount of data so as to get an even more extensive data range, to develop this bandwidth application system using other Fuzzy logic and different applications so as to get results in better bandwidth management.

#### REFERENCES

- Alam, T. (2021). A Survey on Blockchain and Internet of Things. SSRN Electronic Journal. <https://doi.org/10.2139/ssrn.3837964>
- Ayuningtias, L. P., Irfan, M., & Jumadi, J. (2017). Analisa Perbandingan Logik Fuzzy Metode Tsukamoto, Sugeno, Dan Mamdani. *Jurnal Teknik Informatika*, 10(1), 9–16.
- Bouraqia, K., Sabir, E., Sadik, M., & Ladid, L. (2020). Quality of Experience for Streaming Services: Measurements, Challenges and Insights. *IEEE Access*, 8, 13341–13361. <https://doi.org/10.1109/ACCESS.2020.2965099>
- Cranford, S. W. (2020). Seven Seconds or Less: Buzzworthy Titles in the Era of MOFs and Tinder. *Matter*, 3(4), 965–967.
- Cronje, J. C. (2020). Designing Questions for Research Design and Design Research in e-Learning. *Electronic Journal of E-Learning*, 18(1), pp13-24.
- Doni, F. R. (2019). IMPLEMENTASI MANAJEMEN BANDWIDTH PADA JARINGAN KOMPUTER DENGAN ROUTER MIKROTIK. *Jurnal Sains Dan Manajemen*, 7, 52–57.
- Fryer, L. K., & Dinsmore, D. L. (2020). The Promise and Pitfalls of Self-report: Development, research design and analysis issues, and multiple methods. *Frontline Learning Research*, 8(3), 1–9.
- Grieshaber, S. (2020). Equity and research design. In *Doing early childhood research* (pp. 177–191). Routledge.
- Hekmat, R., & Van Mieghem, P. (2005). Interference power sum with log-normal components in ad-hoc and sensor networks. *Proceedings - WiOpt 2005: Third International Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks*, 2005, 174–182. <https://doi.org/10.1109/WIOPT.2005.23>
- Hidayanto, F., & Zidni Ilmi, M. (2015). Pentingnya Internet Sehat. *Jurnal Inovasi Dan Kewirausahaan*, 4(1), 21–24.
- Khademi, F., Akbari, M., Jamal, S. M., & Nikoo, M. (2017). Multiple linear regression, artificial neural network, and fuzzy logic prediction of 28 days compressive strength of concrete. *Frontiers of Structural and Civil Engineering*, 11(1), 90–99. <https://doi.org/10.1007/s11709-016-0363-9>
- Komariyah, S., Yunus, R. M., & Rodiansyah, S. F. (2016). Logika Fuzzy Dalam Sistem Pengambilan Keputusan Penerimaan Beasiswa. *Proceeding Stima 2.0*, 62.
- LENDARIS, G. G. (1994). A review of: "FUZZY THINKING:" The New Science of Fuzzy Logic, by Bart Kosko, Hyperion, 1993. *International Journal of General Systems*, 22(3), 330–332.

- <https://doi.org/10.1080/03081079408928570>
- Mukaromah, M. (2019). Penerapan Metode Fuzzy Sugeno Untuk Menentukan Jalur Terbaik Menuju Lokasi Wisata Di Surabaya. *Jurnal Matematika Sains Dan Teknologi*, 20(2), 95–101. <https://doi.org/10.33830/jmst.v20i2.187.2019>
- Nunes, B. A. A., Mendonca, M., Nguyen, X. N., Obraczka, K., & Turlitti, T. (2014). A survey of software-defined networking: Past, present, and future of programmable networks. *IEEE Communications Surveys and Tutorials*, 16(3), 1617–1634. <https://doi.org/10.1109/SURV.2014.012214.00180>
- Nur Azizah, E., Cholissodin, I., & Firdaus Mahmudy, W. (2015). Optimasi Fungsi Keanggotaan Fuzzy Tsukamoto Menggunakan Algoritma Genetika Untuk Penentuan Harga Jual Rumah. *Journal of Enviromental Engineering and Sustainable Technology*, 2(2), 79–82. <https://doi.org/10.21776/ub.jeest.2015.002.02.3>
- Nurdini, S., Nurcahyo, G. widi, & Santony, J. (2021). Analisis Perkiraan Jumlah Produksi Tahu Menggunakan Metode Fuzzy Sugeno. *Jurnal Sistim Informasi Dan Teknologi*, 3(3), 18–23. <https://doi.org/10.35134/jsisfotek.v1i3.4>
- Prihantoro, C., Hidayah, A. K., & Fernandez, S. (2021). Analisis Manajemen Bandwidth Menggunakan Metode Queue Tree pada Jaringan Internet Universitas Muhammadiyah Bengkulu. *Just TI (Jurnal Sains Terapan Teknologi Informasi)*, 13(2), 81. <https://doi.org/10.46964/justti.v13i2.750>
- Purwodwiyogo, Y., & Subardono, A. (2018). Kontrol Bandwidth Dinamis Berbasis Algoritma Logika Fuzzy pada Jaringan Wireless Ad-Hoc. *Jurnal RESTI (Rekayasa Sistem Dan Teknologi Informasi)*, 2(3), 728–735. <https://doi.org/10.29207/resti.v2i3.577>
- Ray, P. P. (2018). A survey on Internet of Things architectures. *Journal of King Saud University - Computer and Information Sciences*, 30(3), 291–319. <https://doi.org/10.1016/j.jksuci.2016.10.003>
- Rozie, F., Syarif, I., Al Rasyid, M. U. H., & Satriyanto, E. (2021). Sistem Akuaponik untuk Peternakan Lele dan Tanaman Kangkung Hidroponik Berbasis IoT dan Sistem Inferensi Fuzzy. *Jurnal Teknologi Informasi Dan Ilmu Komputer*, 8(1), 157. <https://doi.org/10.25126/jtiik.0814025>
- Saputri, A. D., Ramadhani, R. D., & Adhitama, R. (2019). Logika Fuzzy Sugeno Untuk Pengambilan Keputusan Dalam Penjadwalan Dan Peningkat Service Sepeda Motor. *Journal of Informatics, Information System, Software Engineering and Applications (INISTA)*, 2(1), 49–55. <https://doi.org/10.20895/inista.v2i1.95>
- Saragih, M., & Novimariono, N. (2020). An Experimental Study of The Effectiveness PEOW MODEL Through Applying Quartet Card in Teaching English Writing. *Indonesian Journal of Education, Social Sciences and Research (IJESSR)*, 1(1), 32–40.
- September, W. (2007). St at e, In St at e, In. 1–10.
- Shu, K., Mahudeswaran, D., Wang, S., Lee, D., & Liu, H. (2020). Fakenewsnet: A data repository with news content, social context, and spatiotemporal information for studying fake news on social media. *Big Data*, 8(3), 171–188.
- Sihotang, J., Hadi Nasyuha, A., StudiSistemInformasi, P., & Triguna Dharma, S. (2020). Sistem Pendukung Keputusan Menentukan Jumlah Permintaan Alat Musik Menggunakan Metode Fuzzy Mamdani Pada PT. Legato Internasional. *Cyber Tech*.
- Singh, K., & Singh Tomar, D. D. (2019). Architecture, enabling technologies, security and privacy, and applications of Internet of things: A survey. *Proceedings of the International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud), I-SMAC 2018*, 642–646. <https://doi.org/10.1109/I-SMAC.2018.8653708>
- Stewart, E. (2021). Detecting Fake News: Two Problems for Content Moderation. *Philosophy & Technology*, 1–18.
- Tundo, T., Akbar, R., & Sela, E. I. (2020). Analisis Perbandingan Fuzzy Tsukamoto dan Sugeno dalam Menentukan Jumlah Produksi Kain Tenun Menggunakan Base Rule Decision Tree. In *Jurnal Teknologi Informasi dan Ilmu Komputer (Vol. 7, Issue 1, p. 171)*. <https://doi.org/10.25126/jtiik.2020701751>
- van der Giesen, C., Cucurachi, S., Guinée, J., Kramer, G. J., & Tukker, A. (2020). A critical view on the current application of LCA for new technologies and recommendations for improved practice. *Journal of Cleaner Production*, 259, 120904.
- Wahab, R. A. (2019). Comparative Analysis of Broadband Internet Development for Digital Economy in China and Indonesia. *Jurnal Penelitian Pos Dan Informatika*, 9(1), 63. <https://doi.org/10.17933/jppi.2019.090106>

- Walker-Andrews, A. S. (1997). Infants' perception of expressive behaviors: Differentiation of multimodal information. *Psychological Bulletin*, 121(3), 437–456. <https://doi.org/10.1037/0033-2909.121.3.437>
- Wuragil, A. (2015). Alat Bantu Sistem Inferensi Fuzzy Dengan Menggunakan. 11(2), 163–168.
- Yayla, M., Technologies, H., & Madi, M. (2020). A Comparative Study on Internet Performance Measurement Platforms. October.
- Yulianto, T., Komariyah, S., & Ulfaniyah, N. (2017). Application of fuzzy inference system by Sugeno method on estimating of salt production. *AIP Conference Proceedings*, 1867. <https://doi.org/10.1063/1.4994442>
- Yupapin, P. P., Mitatha, S., Ali, J., & Teeka, C. (2012). Nanocommunication networks. *Nanocommunication Networks*, 1–193. [https://doi.org/10.1007/978-3-319-78262-1\\_300430](https://doi.org/10.1007/978-3-319-78262-1_300430)
- Zhang, C., Patras, P., & Haddadi, H. (2019). Deep Learning in Mobile and Wireless Networking: A Survey. *IEEE Communications Surveys and Tutorials*, 21(3), 2224–2287. <https://doi.org/10.1109/COMST.2019.2904897>