Determination of Critical Servers by using Fuzzy Mamdani and Fuzzy Sugeno on PT. Samudera Indonesia Tbk

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Abstract

PT Samudera Indonesia Tbk is a company engaged in logistics. As a service company, it prioritizes service especially in providing information services to customers or clients. However, in the case of frequent information system technology problems used in particular what happens is the server is down. This is due to several unpredictable factors. Plus this company still depends on the role of IT personnel to wait for the handling of server events to be down. Efforts to find out the critical level of the server is one of the prevention or mitigation of fatal risks to the company's business processes, so a decision support system is needed. In this study, the authors compared the calculation of the Mamdani fuzzy logic method with the sugeno fuzzy method to measure the critical level of the server used by PT Samudera Indonesia Tbk. This research produced a prototype built with Matlab R2013a. The prototype is used to calculate the critical level on the server. The prototype uses two fuzzy mamdani and fuzzy sugeno methods. Fuzzy Mamdani method has an average accuracy of 85.21%. From the calculation of the two methods, the highest accuracy value will be used as a reference in determining the critical server.

I. INTRODUCTION

In this study, the authors conducted a comparison between fuzzy mamdani logic and fuzzy sugeno to measure server performance in a critical or non-critical state at PT Samudera Indonesia Tbk. Some things that cause the server to enter into the critical zone and need special attention are the increasing number of accessors to increase server workload and require a solution. Comparison of performance on web servers that are able to provide the best service, especially information services with increasing numbers of access to websites requires optimal performance loads [1]. A server is a computer system that provides certain types of services in a computer network. Factors that affect critical servers in PT Samudera Indonesia Tbk that the authors convey are response time, memory usage, CPU usage, storage usage, and network usage. In this case, later the company can make a decision to make an effort to maintain the performance of the server that is used after knowing that the condition or facility of the company against the server is in a critical position or not.

Research Purposes:
1. Helping PT Samudera Indonesia Tbk in making decisions to determine the level of server performance.
2. Determine the selection of server performance levels based on criteria that have been weighted with fuzzy mamdani and fuzzy sugeno methods

II. METHODS

The research used is applied research. Data collection is done by primary and secondary data collection methods. In the primary data collection method that is by collecting data directly to data sources owned by PT Samudera Indonesia Tbk also data collection is done by observation, interviews and questionnaires for secondary data collection methods carried out by reading, observing and studying data from sources related to this research to get a parameter to server

performance. Data that will be used as a parameter to determine server performance in PT Samudera Indonesia Tbk are response time, memory usage, CPU usage, storage usage, and network usage
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2.1. Research Steps
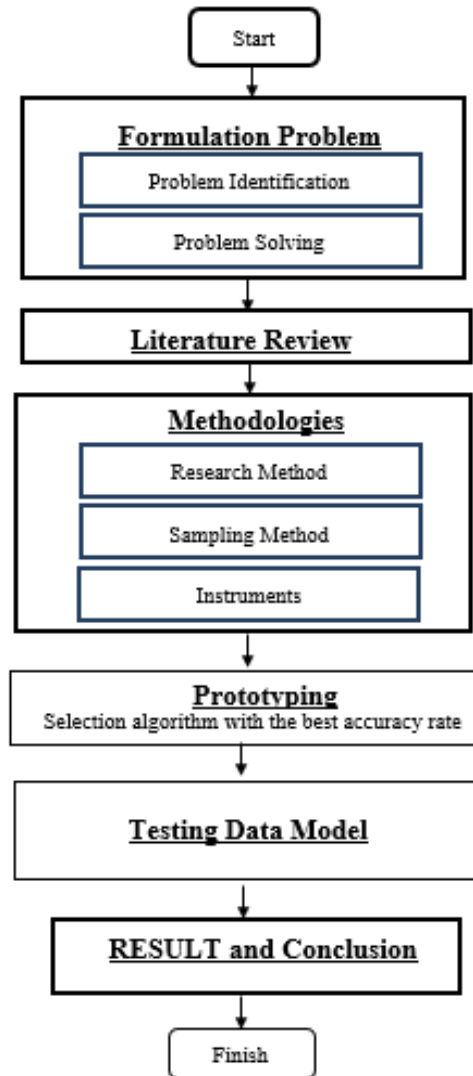
Picture 1. Research Steps

From Picture 1. above described the research steps applied in this study, namely problem identification, problem formulation, review of studies, research methods, review of studies, methods of sample selection, instrumentation, application creation, system testing and research results.

III. RESULTS AND DISCUSSION

In this study, the authors compared the accuracy of the calculation of Sugeno fuzzy method and fuzzy Mamdani to measure server performance used by PT Samudera Indonesia Tbk

3.1. Variables and indicators
In this study there are 5 input variables and 15 indicators that are used, namely: Response Time, Memory Usage, CPU Usage, Storage Use and Network Use. 15 indicators will be analyzed and used as variables to determine the critical

server at PT Samudera Indonesia Tbk, then the variables will be calculated using the Prototype that has been designed using the Fuzzy Mamdani method and the Fuzzy Sugeno method.

Table 1. Assessment Variable Against Server Determination

| No.	Variables	Indicators
1	Response Time	3
2	Use of Memory	3
3	Use of CPU	3
4	Use of Storage	3
5	Network use	3
	Total	**15**

3.2. Fuzzy Variable Input

In order for server performance to be measured, critical server variables are needed (3). Therefore, the author conducted interviews with experts or server experts at PT Samudera Indonesia Tbk regarding any variables used to determine critical servers. The results obtained from the interview are the establishment of five variables in fuzzy functions to determine the critical server, namely the variable Response Time, Memory Usage, CPU Usage, Storage Use and Network Usage and the output variables that are critical servers and uncritical servers. The five inputs are then calculated using the Mamdani and Fuzzy Sugeno fuzzy methods, to determine server rating output at PT Samudera Indonesia Tbk.

a. Respon Time

$$\mu Cepat = \begin{cases} 1 & ; \quad 0 \leq x \leq 150 \\ (500 - x)/(500 - 150); & 150 \leq x \leq 500 \\ 0 & ; \quad x \geq 500 \end{cases}$$
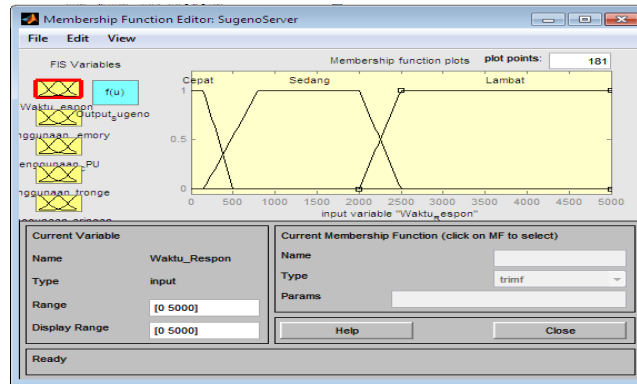
$$\mu Sedang = \begin{cases} (x - 150)/(800 - 150) & ; \quad 150 \leq x \leq 800 \\ 1 & ; \quad 800 \leq x \leq 2000 \\ (2500 - x)/(2500 - 2000) & ; 2000 \leq x \leq 2500 \end{cases}$$

$$\mu Lambat = \begin{cases} 0 & ; \quad x \leq 2000 \\ (x - 2000)/(2500 - 2000) & ; 2000 \leq x \leq 2500 \\ 1 & ; 2500 \leq x \leq 5000 \end{cases}$$
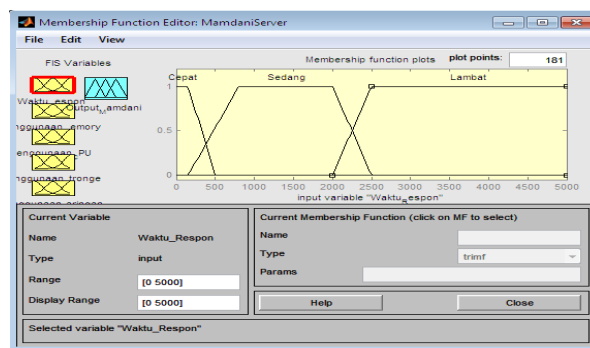
Picture 2. Mamdani Fuzzy Input Set Response Time

From Picture 2. above the fuzzy mamdani input set is described for three response times, fast, medium and slow.
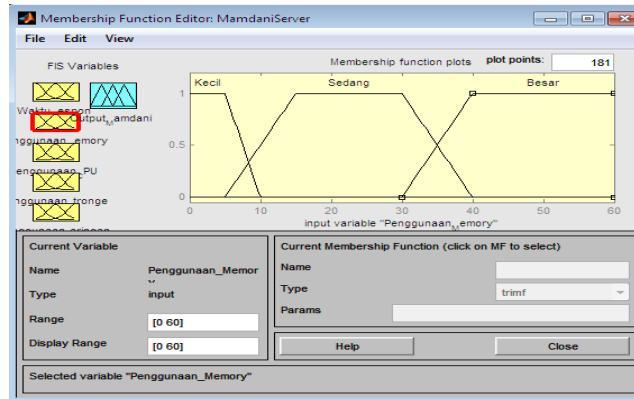
Picture 3. Sugeno Fuzzy Input Set Response Time

From Picture 3. above illustrated the sugeno fuzzy input set for the response time there are three, namely fast, medium and slow.

b. Use of Memory

$$\mu Kecil = \begin{cases} 1 & ;\ \ 0 \leq x \leq 5 \\ (10-x)/(10-5) & ;\ 5 \leq x \leq 10 \\ 0 & ;\ \ \ \ \ x \geq 10 \end{cases}$$
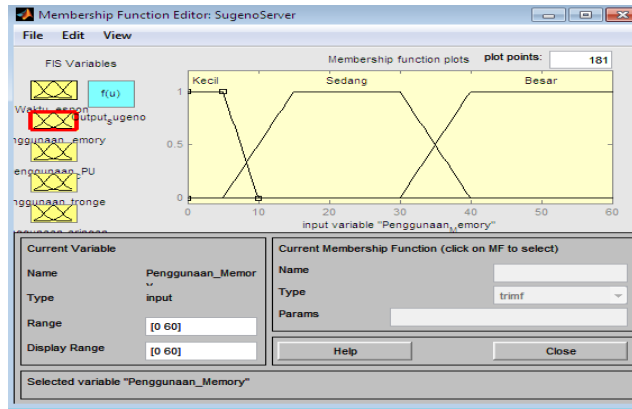
$$\mu\ Sedang = \begin{cases} (x-5)/(15-5) & ;\ 5 \leq x \leq 15 \\ 1 & ;\ \ 15 \leq x \leq 30 \\ (40-x)/(40-30) & ;\ 30 \leq x \leq 40 \end{cases}$$

$$\mu\ Besar = \begin{cases} 0 & ;\ \ \ \ x \leq 30 \\ (x-30)/(40-30) & ;30 \leq x \leq 40 \\ 1 & ;40 \leq x \leq 60 \end{cases}$$

Picture 4. Mamdani Fuzzy Input Set Using Memory

From Picture 4. above illustrated fuzzy mamdani input sets for memory usage there are three, namely small, medium and large.
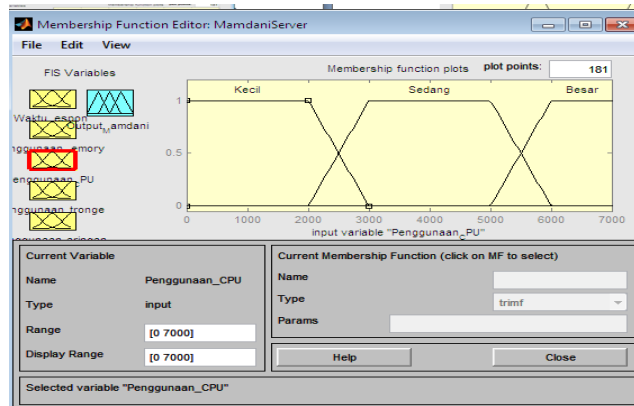
Picture 5.Sugeno Fuzzy Input Set Using Memory

From Picture 5. above illustrated sugeno fuzzy input sets for memory usage there are three, namely small, medium and large.

c. Use of CPU

$$\mu Kecil = \begin{cases} 1 & ; \quad 0 \leq x \leq 2000 \\ (3000 - x)/(3000 - 2000) & ; \quad 2000 \leq x \leq 3000 \\ 0 & ; \quad x \geq 3000 \end{cases}$$
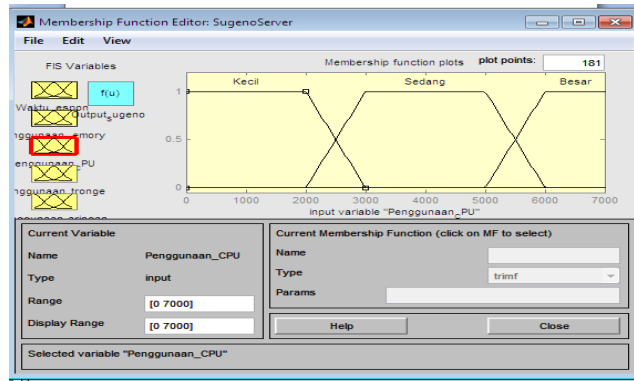
$$\mu\ Sedang = \begin{cases} (x - 2000)/(3000 - 2000) & ; \quad 2000 \leq x \leq 3000 \\ 1 & ; \quad 3000 \leq x \leq 5000 \\ (6000 - x)/(6000 - 5000) & ; 5000 \leq x \leq 6000 \end{cases}$$

$$\mu\ Besar = \begin{cases} 0 & ; \quad x \leq 5000 \\ (x - 5000)/(6000 - 5000) & ; 5000 \leq x \leq 6000 \\ 1 & ; 6000 \leq x \leq 7000 \end{cases}$$

Picture 6. Mamdani Fuzzy Input Set Using CPU

From Picture 6 above the fuzzy mamdani input set is described for three cpu uses, namely small, medium and large.
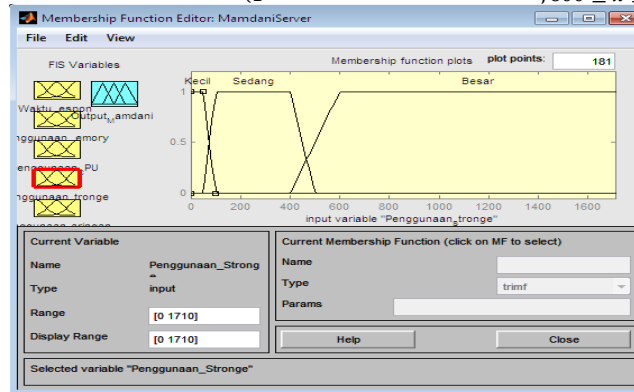
Picture 7. Sugeno Using the CPU Fuzzy Input Set

From Figure 7 above illustrated the set of sugeno fuzzy inputs for cpu usage there are three, namely small, medium and large.

d. Use of Storage

$$\mu Kecil = \begin{cases} 1 & ;\ 0 \le x \le 50 \\ (100-x)/(100-50) & ;\ 50 \le x \le 100 \\ 0 & ;\ x \ge 100 \end{cases}$$
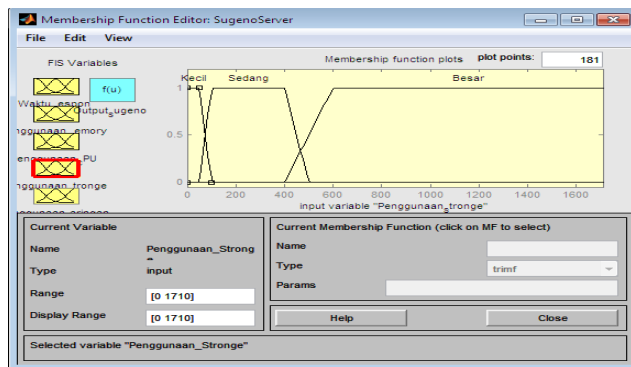
$$\mu\ Sedang = \begin{cases} (x-50)/(100-50) & ;\ 50 \le x \le 100 \\ 1 & ;\ 100 \le x \le 400 \\ (500-x)/(500-400) & ;\ 400 \le x \le 500 \end{cases}$$

$$\mu\ Besar = \begin{cases} 0 & ;\ x \le 400 \\ (x-400)/(600-400) & ;400 \le x \le 600 \\ 1 & ;600 \le x \le 1710 \end{cases}$$

Picture 8. Mamdani Fuzzy Input Set Using Storage

From Picture 8 above illustrated fuzzy mamdani input sets for storage use there are three, namely small, medium and large.

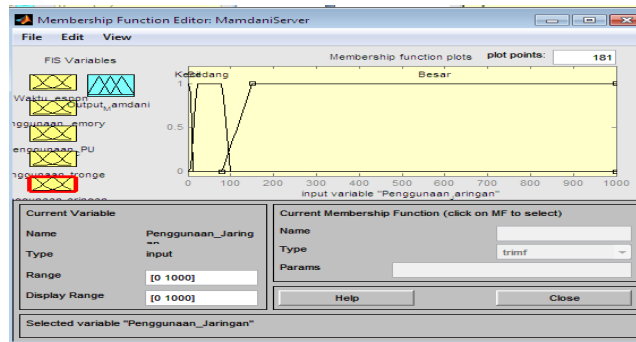Picture 9. Sugeno Usage Storage Fuzzy Input Set

From Picture 9 above, it is illustrated that there are three sets of fuzzy sugeno inputs for storage use, namely small, medium and large.

e. Network Use

$$\mu Kecil = \begin{cases} 1 & ; \ 0 \le x \le 5 \\ (10-x)/(10-5) & ; \ 5 \le x \le 10 \\ 0 & ; \quad x \ge 10 \end{cases}$$
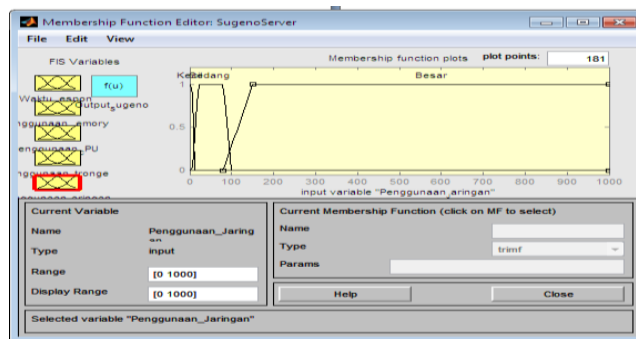
$$\mu\ Sedang = \begin{cases} (x-5)/(20-5) & ; \ 5 \le x \le 20 \\ 1 & ; \ 20 \le x \le 80 \\ (100-x)/(100-80) & ; \ 80 \le x \le 100 \end{cases}$$

$$\mu\ Besar = \begin{cases} 0 & ; \quad x \le 80 \\ (x-80)/(150-80) & ; \ 80 \le x \le 150 \\ 1 & ; 150 \le x \le 1000 \end{cases}$$

Picture 10. Mamdani Fuzzy Input Set Using Network

From Picture 10 above illustrated fuzzy mamdani input sets for network usage there are three, namely small, medium and large.

Picture 11. Sugeno Fuzzy Input Set Using Network

From Figure 11 above, there are three sets of fuzzy sugeno inputs for network use, namely small, medium and large.

3.3. Output Fuzzy

In this study there are no dominant input variables so that all have the same effect in determining server performance output. The range used at this output (0-100) and server performance variables are divided into 2 fuzzy sets, which are critical at intervals (0-60) and not critical at intervals (40-100), as follows:
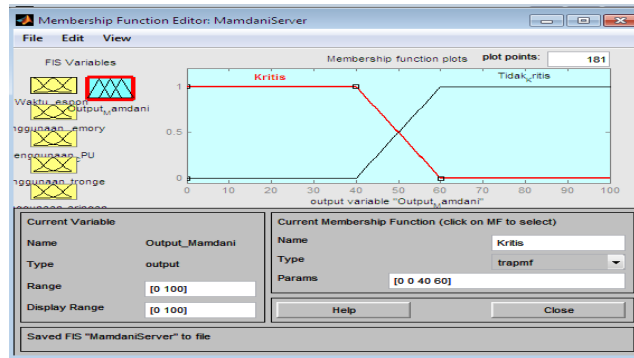
Tabel 2. Server Performance Output Variable

Variable	Fuzzy Input Set	Range	Domain	Parameter
Server Perform	Critical	0-100	0-60	[0 0 40 60]
	Non-Critical		40-100	[40 60 100 100]

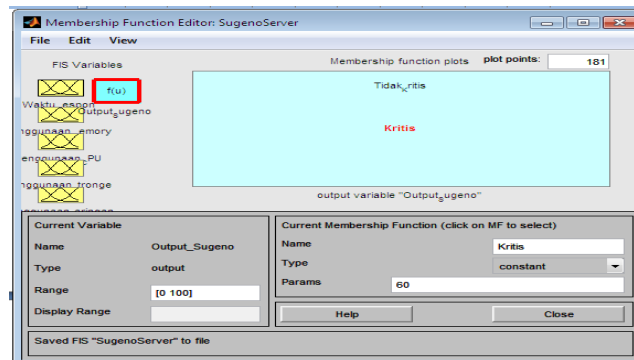Then it is stated using the equation as follows:

$$\mu Kritis = \begin{cases} 1 & ; \quad 0 \leq x \leq 40 \\ (60-x)/(60-40) & ; \quad 40 \leq x \leq 60 \\ 0 & ; \qquad x \geq 60 \end{cases}$$

$$\mu\,Tidak\,Kritis = \begin{cases} 0 & ; \qquad x \leq 40 \\ (x-40)/(60-40) & ; \quad 40 \leq x \leq 60 \\ 1 & ; \quad 60 \leq x \leq 100 \end{cases}$$

Picture 12. Output set of the Mamdani Method Server Performance

From Picture 12 above, the fuzzy mamdani output set is described for two server performance, critical server and uncritical server.


Picture 13. Output set of the Sugeno Method Server Performance

From Picture 13 above, the set of sugeno fuzzy outputs is described for two server performance, namely critical servers and non-critical servers.

3.4. Fuzzy Rule Base

After the formation of a fuzzy set, fuzzy rules are formed. Rules are formed to express the relation between input and output. Each rule is an implication. The operator used to connect between two inputs is AND operator and the one that maps between input-output is IF-THEN. Propositions that follow IF are called antecedents, while propositions that follow THEN are called consequent. After the membership function is done, the next step is to make rules (rule base). This rule base consists of several sets of rules to detect server performance with fuzzy mamdani and fuzzy sugeno methods to indicate server conditions are critical or not critical.
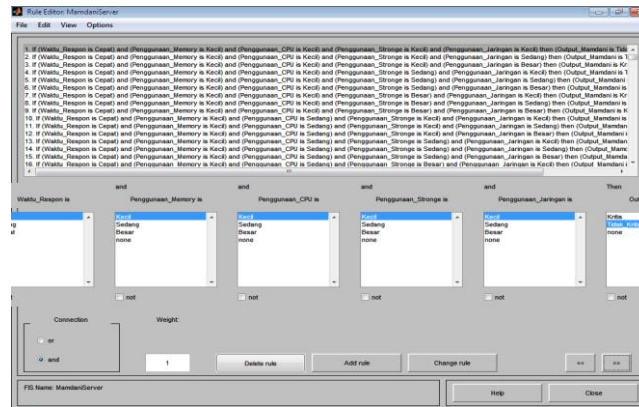
Picture 14. Rules for Determining Server Performance

From Figure 14 above, it is illustrated that this Rule base consists of a collection of rules for detection of server performance with fuzzy mamdani and fuzzy sugeno methods to state the condition of the server is critical or not critical.

Rule base example:

[R1] IF(Waktu_Respon is Cepat) **AND (Penggunaan_Memory is** Kecil) **AND (Penggunan_CPU is** Kecil) **AND (Penggunaan_Storage is** Kecil) **AND (Penggunaan_Jaringan is** Kecil) **THEN** penentuan performa server, Tidak Kritis.

[R2] IF(Waktu_Respon is Cepat) **AND (Penggunaan_Memory is** Kecil) **AND (Penggunaan_CPU is** Kecil) **AND (Penggunaan_Storage is** Kecil) **AND (Penggunaan_Jaringan is** Sedang) **THEN** penentuan performa server, Tidak Kritis.

[R3] IF(Waktu_Respon is Cepat) **AND (Penggunaan_Memory is** Kecil) **AND (Penggunan_CPU is** Kecil) **AND (Penggunaan_Storage is** Kecil) **AND (Penggunaan_Jaringan is** Besar) **THEN** penentuan performa server, Kritis.

3.5. Compositition of Rules

The Max method is used to determine the composition of the rules. Output variable:

The degree of truth set is not critical = Max (α1; α5;)

= Max (0,3; 0,667;)

= 0,667

The degree of truth set is critical s= Max (α9; α12;)

= Max (0,25; 0,667;)

= 0,667

The membership function of the non-critical set output variable at the time α5 is obtained as 0.667d (5) as follows:

$$MR\ (d5) = a5\ \leftrightarrow \frac{d(5) - 40}{50 - 40} = 0,667$$
$$d(5) - 40 = 13,34$$
$$d(5) = 53,34$$

The membership function of the critical set output variable at α12 is obtained by the value 0.667 d (12) as follows:

$$MR\ (d12) = a12\ \leftrightarrow \frac{d(12) - 50}{500 - 40} = 0,667$$
$$60 - d(12) = 13,34$$
$$d(12) = 46,66$$

Modification The high membership function of the output variable after being applied αcut is:

$$\mu(x) = \begin{cases} (0{,}1x - 1); & 10 \leq d_5 \leq 13{,}34 \\ 0{,}667; & 13{,}34 < d_5 \leq 53{,}34 \\ (0{,}1x - 4); & 53{,}34 < d_5, d_{12} \leq 13{,}64 \\ 0{,}667; & 13{,}34 < d_{12} \leq 46{,}66 \end{cases}$$

3.6. Defuzzifikasi

In the defuzzification stage, there is a difference between Fuzzy Mamdani and Fuzzy Sugeno. For Fuzzy Mamdani, the defuzzification calculation process is done by the cetroid method:

$$Z *= \frac{\int_z z\mu(z)dz}{\int_z \mu(z)dz}$$

$$Z * = \frac{M1\,M1 + M2}{L1 + L2}$$

$$M1 = \int_{10}^{13,34} (0{,}1.x - 1).x\,dx = 6{,}77$$

$$M2 = \int_{13,34}^{53,34} (0{,}333.x)dx = 283{,}0167$$

$$L1 = \int_{10}^{13,34} (0{,}1.x - 1)\,dx = 0{,}55$$

$$L2 = \int_{13,34}^{53,34} (0{,}33\,dx = 9{,}99$$

Crisp Output:

$$Z *= \frac{6{,}77 + 283{,}0167 + 75{,}47 + 2608{,}61}{0{,}55 + 9{,}99 + 1{,}67 + 35{,}57}$$
$$= \frac{2973{,}867}{47{,}78}$$
$$= 62{,}24$$

The output value limit is:
a. Assesment "Not Critical": output value limit > 50
b. Assesment "Critical": output value limit < 50

So it can be concluded with the existing data and after being analyzed, the data used as samples are categorized giving an assessment of server performance with a value of 62.24. While for fuzzy Sugeno, the defuzzification calculation process is done by the formula:

$$Z = \frac{\sum_{i=1}^{n} Wizi}{\sum_{i=1}^{n} Wi}$$

where:
Wi is the result of a fuzzy operation process logic antecedent
Zi is output of rule number one:

$$Z = \frac{(0{,}3x100) + (0{,}667x100) + (0{,}25x50) + (0{,}667x50)}{0{,}3 + 0{,}667 + 0{,}25 + 0{,}667}$$
$$= \frac{142{,}55}{1{,}88} = 77{,}48$$

So it can be concluded with the existing data and after being analyzed, the data used as samples are categorized giving an assessment of server performance with a value of 77.48.

3.7. Hasil Metode Fuzzy Pada Matlab
a. Result of the Fuzzy Mamdani Method

```
>> fis=readfis('MamdaniServer.fis')
    fis =
```

```
            name: 'MamdaniServer'
            type: 'mamdani'
       andMethod: 'min'
        orMethod: 'max'
     defuzzMethod: 'centroid'
       impMethod: 'min'
       aggMethod: 'max'
           input: [1x5 struct]
          output: [1x1 struct]
            rule: [1x243 struct]
>> out=evalfis([2374 18 5026 196 32],fis)
out =    37,516
```

b. Result of the Fuzzy Sugeno Method
```
>> fis=readfis('SugenoServer.fis')
fis =
       name: 'SugenoServer'
       type: 'sugeno'
  andMethod: 'prod'
   orMethod: 'probor'
defuzzMethod: 'wtaver'
  impMethod: 'prod'
  aggMethod: 'sum'
      input: [1x5 struct]
     output: [1x1 struct]
       rule: [1x243 struct]
>> out=evalfis([2374 18 5026 196 32],fis)
out =    62,2724
```

IV. CONCLUSIONS

Based on the results of research and analysis, it was concluded that the performance of the fuzzy method was able to determine server performance and can be applied to an information system to determine the critical level of the server at PT Samudera Indonesia Tbk correctly. This has been proven in a comparison of the two methods included in the fuzzy category, the Mamdani method and the Sugeno method. From the results of the comparison of the two methods, the Mamdani method is the best method with an average accuracy value of 85.21%. Then compared with the opinion of the server experts at PT Samudera Indonesia Tbk. From the results of the comparison it can be concluded that the approach of decision support systems with the Mamdani fuzzy method is good performance to be applied to PT Samudera Indoensia Tbk determine the critical level of the server correctly.

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