Design of Server Room Temperature and Humidity Control System using Fuzzy Logic Based on Microcontroller

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***Abstract*—Server room is a very important asset for a company because in there are servers that contain applications and company databases that are very valuable for the sustainability of a company, therefore the condition of the server room such as temperature, humidity, power and all IT equipment in this room should always be monitored in real time. One way that can be used to control and monitor the temperature and humidity of server room is to use an Internet of Thing (IoT) based system. This research proposed the design of server room temperature and humidity control system using fuzzy logic based on microcontroller Wemos D1 as an infrared transmitter remote control to control temperature and mode setting in Air Conditioner to control temperature and humidity of server room. Fuzzy logic based on microcontroller for control the temperature and humidity of server room was successfully designed and successfully implemented into microcontroller with simulation test results using matlab obtained the value that match with the results on the microcontroller with average AC Temperature Set output deviation 0.03500 and average AC Mode Set output deviation 0.01225. The system is also designed to be able to monitor data temperature, humidity and electricity voltage online using the website and can provide early warning message through social media twitter.**

Keywords—Server Room Monitoring; Fuzzy Logic; Temperature and Humidity Control; IoT; Microcontroller.

I. INTRODUCTION

Server room is a very important asset for a company because in there are servers that contains applications and company databases that are very valuable for the sustainability of a company, therefore the room, server and all network equipment in this room should always be monitored in real time [1]. One of important factors that are needed be monitored is the temperature and humidity of the room, because the computers and networks equipment is very susceptible to high temperatures and humidity. The standard temperature for server room usage in Indonesia is 21-23°C (70-74°F), while the relative humidity of server room is 45% to 60% [2]. Temperatures are too low caused the mechanism to be slow or stop, the temperature is too high make the computers and networks equipment becomes hot and too much use of power for the fan so that eventually shutdown. Humidity too low can cause excessive static electricity and too high humidity causing corrosion [2] and potentially resulting in short circuit [3].

One way that can be used to control and monitor the temperature and humidity of the server room is to use the system based of Internet of Thing (IoT) is a concept where an object that has the ability to transfer data over the network without requiring human to human interaction or human to computer interaction [4]. By using IoT based systems on server room monitoring, data of temperature, humidity and electricity voltage can be automatically monitored using sensors and microcontrollers connected to local and internet networks. Temperature and humidity control can be done by applying artificial intelligence so that the temperature and humidity of the server room can stable at a standard range. One of the most suitable method can be used for control system based on microcontroller is fuzzy logic which is a proper way to map an input space to output space [5]. Fuzzy logic has many advantages that can control complex systems, non-linear, and systems that are difficult to be represented mathematically. Fuzzy logic is easy to understand, flexible, tolerant of improper data, able to build and apply expert experiences directly without training, can work with conventional control techniques, and based on natural language [6]. Fuzzy logic based of microcontroller can be designed to control the air conditioner to control the temperature and use of dry mode to reduce the humidity of the room [7].

Earlier research has discuss about control of room temperature and humidity using fuzzy logic based on microcontroller to control fan and compressor speed of air conditioner [8][9]. Other research using lamp, exhaust-fan, water-pump but without fuzzy logic to control the room temperature and humidity [10]. Research [8][9][10] discuss fuzzy logic for temperature and humidity control of room as

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generaly. Other research has focus to discuss about temperature and humidity control for server room without using fuzzy logic and using relay as actuator to on or off the controlled device [11]. Other research just monitoring the temperature and humidity of server room and send warning notification using email [12].

In this research we proposed the design of temperature and humidity control system of server room using fuzzy logic based on microcontroller Wemos D1 as an infrared transmitter remote control to control temperature and mode setting on air conditioner to control temperature and humidity of server room. The system is also designed to be able to monitor data temperature, humidity and electricity voltage online through the website and can provide early warning message through social media twitter.

II. METHODOLOGY

In this section, we discuss our proposed design of server room temperature and humidity control system using fuzzy logic based on microcontroller Wemos D1. Figure 1 shows the topology for the server room control and monitoring.

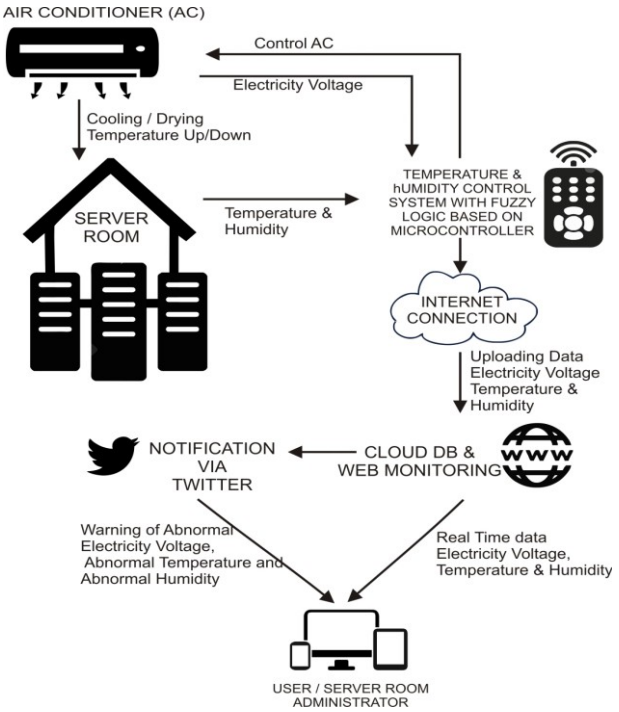

Fig. 1. Proposed system for server room control and monitoring.

In this proposed system, we proposed server room temperature and humidity control system using fuzzy logic as the decision making to mantain server room temperature and humidity by control the setting of air conditioner based on the measurement of sensor data. In this system, we collected sensor data such as temperature, humidity, and electricity voltage from the sensor that implemented using microcontroller. The system read temperature, humidity and electricity voltage then automatically upload the data to cloud server via HTTP protocol, so all users can access sensor data via mobile or web based monitoring applications (PCs, Laptop, Smartphone). To control room temperature and humidity, system read temperature and humidity from sensor as crisp input for fuzzyfication then fuzzy input from fuzzyfication proccessed with inference system (fuzzy rule bases), then fuzzy output processed with defuzyfication and produce crisp output to control the temperature setting and mode setting of air conditioner. Figure 2 shows the proposed fuzzy logic algorithm system, which consists of fuzzification, inference system (decision making with fuzzy rule bases), defuzzification and crisp output to control temperature and humidity of server room.

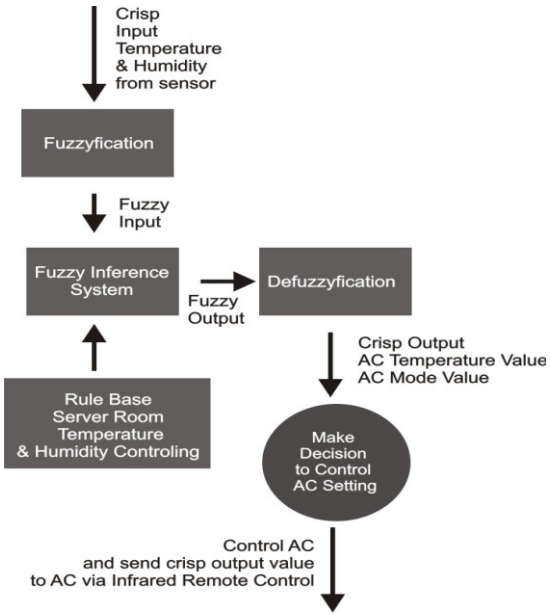

Fig. 2. Proposed fuzzy logic system

This proposed system using Wemos D1 as mikrocontroller, DHT22 as temperature and humidity sensor, ZMPT101B as electricity voltage sensor, lcd 16x2 to display information, and infrared transmitter modul as actuator to controling air conditioner like showed on Figure 3.

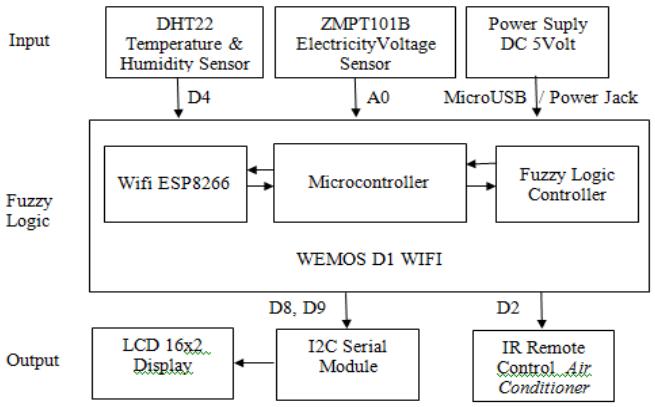

Fig. 3. Block diagram proposed system

A. *Fuzification of Temperature and Humidity Controling*

Fuzzification is a process of translating output in the form of fuzzy. Fuzzification gives a membership degree value ranges between 0 to 1. Figure 4 to 7 shows fuzzy input membership degrees such as temperature and humidity also fuzzy output membership degrees such as ac temperature and ac mode. We use fuzzy mamdani and trapezium for membership function types.

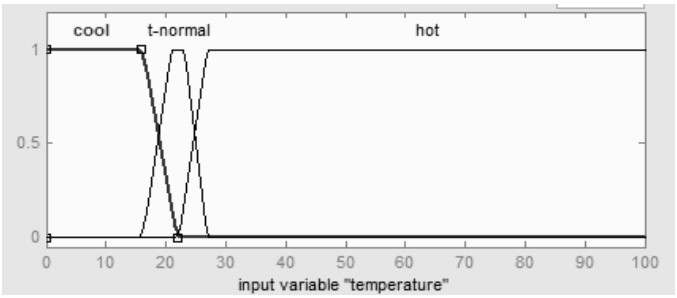

Fig. 4. Membership of input variable temperature

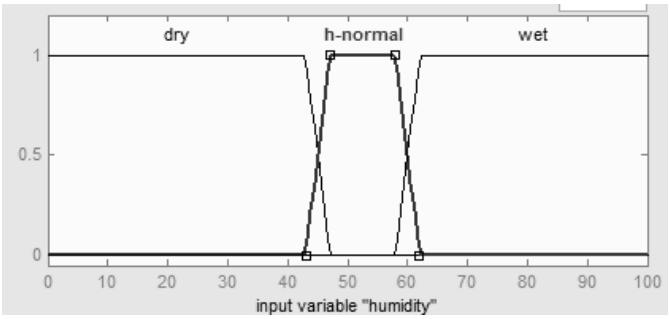

Fig. 5. Membership of input variable humidity

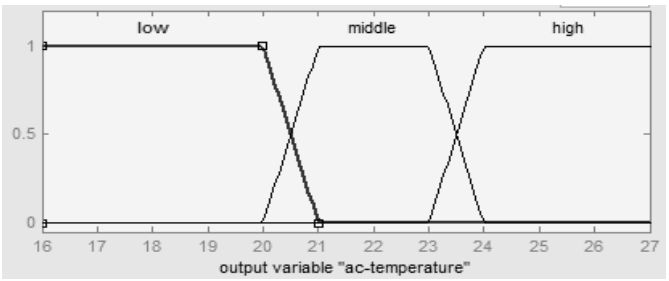

Fig. 6. Membership of output variable ac temperature

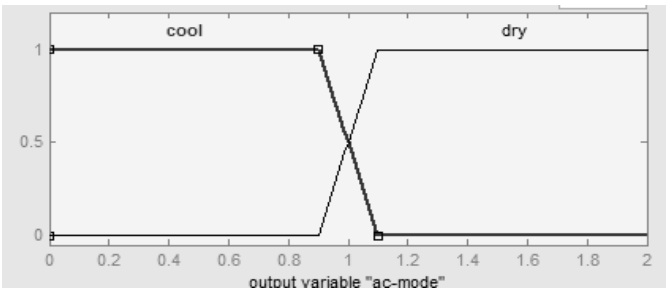

Fig. 7. Membership of output variable ac mode

B. *Rule Based*

This system analysis using fuzzy input and fuzzy rules which have been determined earlier to produce fuzzy output. In this proposed inference system, we have 2 input variables and each comprise 3 fuzzy membership. Variable temperature comprise to fuzzy membership COOL, NORMAL, HOT. Variable humidity comprise to fuzzy membership DRY, NORMAL, WET. Total of 9 rules were used to make decisions to produce output AC Temperature in 3 membership degree i.e LOW, MIDDLE, HIGH, and AC Mode in 2 membership degree i.e COOL and DRY. In this case, we calculated 2 output at a time with 2 input. The used rules are as follows :

IF Temperature COOL AND Humidity DRY
THEN Temperature AC HIGH AND AC Mode COOL

IF Temperature COOL AND Humidity NORMAL
THEN Temperature AC HIGH AND AC Mode COOL

IF Temperature COOL AND Humidity WET
THEN Temperature AC HIGH AND AC Mode DRY

IF Temperature NORMAL AND Humidity DRY
THEN Temperature AC MIDDLE AND AC Mode COOL

IF Temperature NORMAL AND Humidity NORMAL
THEN Temperature AC MIDDLE AND AC Mode COOL

IF Temperature NORMAL AND Humidity WET
THEN Temperature AC MIDDLE AND AC Mode DRY

IF Temperature HOT AND Humidity DRY
THEN Temperature AC LOW AND AC Mode COOL

IF Temperature HOT AND Humidity NORMAL
THEN Temperature AC LOW AND AC Mode COOL

IF Temperature HOT AND Humidity WET
THEN Temperature AC LOW AND AC Mode DRY

C. *Fuzzy Logic Based on Microcontroller*

In order for this fuzzy logic to work to control the Air Conditioner, the hardware designed as in figure 3 to be inserted with fuzzy logic algorithm program code. Fuzzy algorithm implemented on microcontroller Wemos D1 using eFLL Library (Embedded Fuzzy Logic Library) v1.0.10 that support fuzzy mamdani type in C programming language through Arduino IDE aplication.

D. *Web Based Monitoring Aplication*

Web-based monitoring applications are created using PHP, Bootstrap, JQuery and MySql as databases. This application can store and display the temperature, humidity and voltage data generated by the sensor in real time also and can provide early warning message through social media twitter using PHP TwitterOAuth library for use with Twitter API as shown in Figure 8.

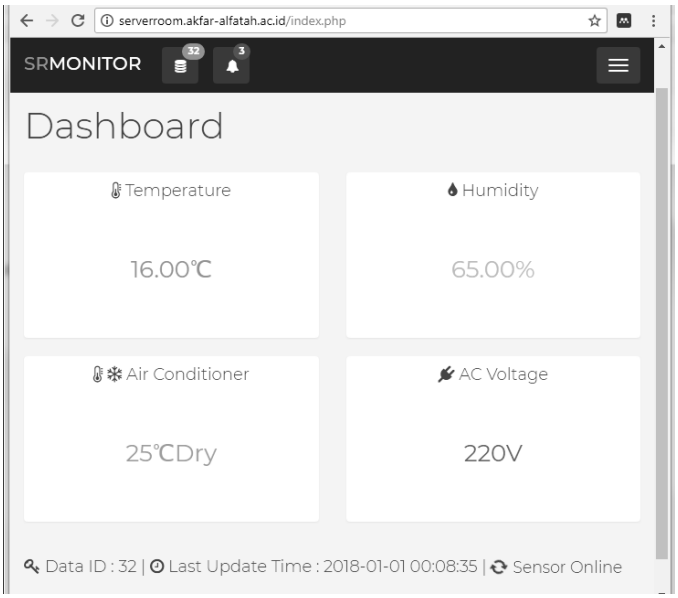

Fig. 8. Web based monitoring aplication dashboard

III. RESULT AND DISCUSSION

In this research we test fuzzy logic which we have designed using FIS Editor Matlab and we get simulation result as in Table I and Table II.

TABLE I. RESULT OF FUZZY LOGIC CONTROLLER USING MATLAB FIS EDITOR WITH VARIATION OF TEMPERATURE INPUT

Input		Output			
Temp	***Humid***	***AC Temp***	***AC Temp Set***	***AC Mode***	***AC Mode Set***
30	50	18.2	18	0.497	Cool
29	50	18.2	18	0.497	Cool
28	50	18.2	18	0.497	Cool
27	50	18.2	18	0.497	Cool
26	50	19	19	0.506	Cool
25	50	19.7	19	0.516	Cool
24	50	20.4	20	0.508	Cool
23	50	21.1	21	0.497	Cool
22	50	22	22	0.497	Cool
21	50	22.5	22	0.497	Cool
20	50	23	23	0.506	Cool
19	50	23.5	23	0.516	Cool
18	50	24.1	24	0.512	Cool
17	50	24.6	24	0.504	Cool
16	50	25.3	25	0.497	Cool

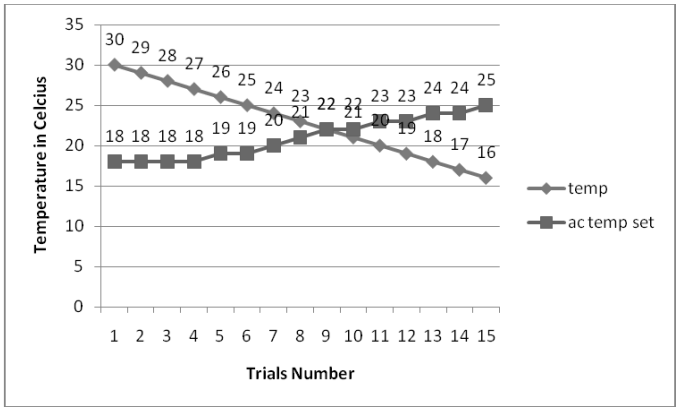

Fig. 9. Result graph of fuzzy logic controller using Matlab FIS editor with variation of temperature input

The graph in Figure 9 shows when the temperature of the server room inputted with value 30C (above the normal temperature of the server room), then the fuzzy logic will produce an output of 18C, when the input of the server room temperature is 24C then the fuzzy output is 20C, when the temperature of server room is 16C then the output fuzzy is 25C. From the graph is known that the output result is in accordance with the desired. When temperature of the server room is above normal then the fuzzy logic controller will try to normalize the server room temperature by setting the temperature of Air Conditioner to a number below the normal temperature range, so that the air conditioner will produce more cold to reach the desired normal temperature. Similarly vice versa when the temperature of the server room is below the normal temperature, fuzzy logic controller will try for normalize the temperature by setting the temperature of the air conditioner to a number above the normal temperature range, so that the conditioner will reduce the cold produced to achieve the desired normal temperature. When the server room temperature is in normal condition then the fuzzy logic controller will return the air conditioner setting value to normal temperature range.

To control the humidity, proposed system try to adjust the mode setting on air conditioner ie if the humidity is too high then the fuzzy logic controller will set air conditioner mode into DRY mode, so air conditioner will operated with fan on low speed and compressor is on short duration in large cycles just to remove extra humidity, so it can reduce humidity. When humidity is back to normal range then fuzzy logic controller will set the air conditioner back into COOL mode so that the air conditioner still dehumidifier and will keep humidity in normal range. From the results of the experiments as showed on graph in Figure 10, it is known that the fuzzy logic produce the output in accordance with the desired. When the humidity is normal between 45%-60% then the fuzzy produces output with a value is <=1 which means normal humidity and so air conditioner will be set to COOL mode, but when humidity is above the 60% then fuzzy produce output value > 1 which means high humidity so that the air conditioner will be set to DRY mode.

TABLE II. RESULT OF FUZZY LOGIC CONTROLLER USING MATLAB FIS EDITOR WITH VARIATION OF HUMIDITY INPUT

Input		Output			
Temp	*Humid*	*AC Temp*	*AC Temp Set*	*AC Mode*	*AC Mode Set*
22	80	22	22	1.5	dry
22	70	22	22	1.5	dry
22	61	22	22	1.25	dry
22	60	22	22	1	cool
22	59	22	22	0.748	cool
22	58	22	22	0.497	cool
22	57	22	22	0.497	cool
22	50	22	22	0.497	cool
22	48	22	22	0.497	cool
22	47	22	22	0.497	cool
22	46	22	22	0.508	cool
22	45	22	22	0.52	cool
22	44	22	22	0.508	cool
22	43	22	22	0.497	cool
22	30	22	22	0.497	cool

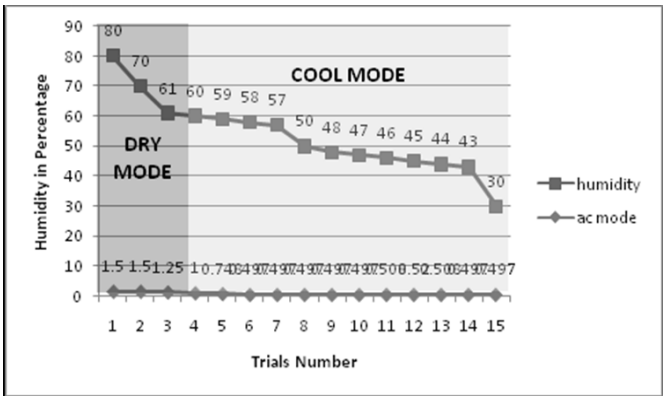

Fig. 10. Result of fuzzy logic controller using Matlab FIS Editor with variation of humidity input.

In this research we compare simulation result of fuzzy logic control that was simulated using FIS Editor Matlab with result of fuzzy logic control that implemented on microcontroller Wemos D1 with hardware and software used specified in table III. The result showed that the output of fuzzy logic that implemented on microcontroller Wemos D1 is match with output simulation of fuzzy logic that designed using FIS Editor Matlab with average AC Temperature Set output deviation 0.03500 and average AC Mode Set output deviation 0.01225 as showed in figure 11 and table IV. although there is a difference in several output value, but the function to control the air conditioner is successfully designed in accordance with the desired.

TABLE III. HARDWARE AND SOFTWARE SPECIFICATION DETAILS

Hardware Specification	
Microcontroller	***Sensor DHT22***
Wemos D1 Wifi ESP-8266EX Operating Voltage 3.3V Digital I/O Pins 11 Analog Input Pins 1 Clock Speed 80MHz/160MHz Flash 4M bytes Length 68.6mm Width 53.4mm Weight 25g	Power Suply : 3.3-6V DC Output Signal : digital via single bus Sensing Element : Polymer capacitor Operating Range : 0-100%RH -40~80Celcius Accuracy : Humidity +-2%RH(Max+-5%RH) Temperature <+-0.5Celcius Sensing period : +-2s Dimensions 14*18*5.5mm
Software Specification	
Matlab	***Arduino IDE***
Version : 8.1.0.604 (R2013a) FIS Editor Fuzzy Type : Mamdani And method : min Or method : max Implication : min Aggregation :max Defuzification centroid	Version :1.6.7 Programming Language : C Fuzzy Library : eFLL Library v 1.0.10 Fuzzy Type : Mamdani And method : min Or method : max Implication : min Aggregation :max Defuzification centroid

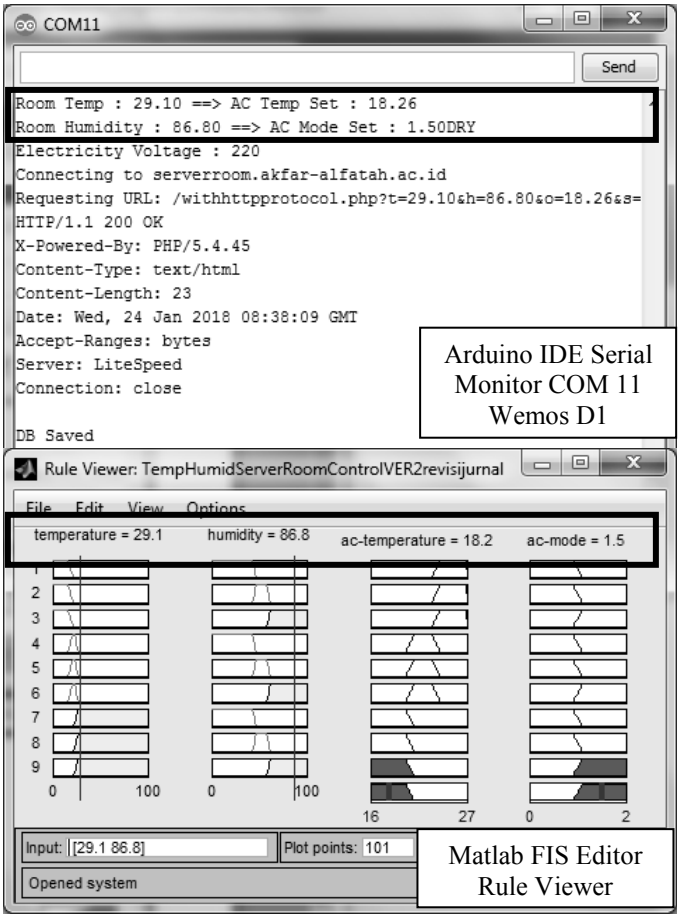

Fig. 11. Result of fuzzy logic controller using Matlab FIS Editor vs fuzzy logic implemented on microcontroller.

TABLE IV. RESULT OF FUZZY LOGIC CONTROLLER USING MATLAB FIS EDITOR VS FUZZY LOGIC IMPLEMENTED ON MICROCONTROLLER

Room Temp	Room Humi Dity	AC Temp Set		Result Deviation	AC Mode Set		Result Deviation
		Mat lab	*We mos*		*Mat lab*	*We Mos*	
16	35	25.2	25.24	0.04	0.497	0.5	0.003
17	40	24.6	24.59	0.01	0.504	0.51	0.006
18	43.5	24	24.02	0.02	0.512	0.52	0.008
20	44	23	23.06	0.06	0.508	0.51	0.002
20	44.5	23.1	23.16	0.06	0.514	0.52	0.006
21	45	22.8	22.83	0.03	0.52	0.53	0.01
22.5	46.5	21.5	21.47	0.03	0.502	0.51	0.008
22	50	22	22	0	0.497	0.5	0.003
22	60	22	22	0	1	0.87	0.13
23	60.5	20.9	20.89	0.01	1.13	1.12	0.01
24	60.5	20.2	20.27	0.07	1.13	1.12	0.01
24	65.5	20.4	20.41	0.01	1.49	1.49	0
24	72	20.4	20.41	0.01	1.49	1.49	0
25	78	19.7	19.79	0.09	1.48	1.48	0
29	80.5	18.2	18.26	0.06	1.5	1.5	0
29.1	86.8	18.2	18.26	0.06	1.5	1.5	0
Average AC Temp Deviation				0.03500	Average AC Mode Deviation		0.01225

IV. CONCLUSSION

Based on comparison test results on Figure 11 and table IV it can be concluded that fuzzy logic based on microcontroller for control the temperature and humidity of server room was successfully designed and successfully implemented into microcontroller with simulation test results using matlab obtained the match value with the results on the microcontroller with average AC Temperature Set output deviation is 0.03500 and average AC Mode Set output deviation is 0.01225. This system also capable to displaying temperature, humidity and voltage information in real time in web based monitoring application and can provide early warning message through social media twitter.

V. FUTURE WORK

In this proposed system, designed fuzzy logic for humidity control has been successfully performed by controlling the mode on the air conditioner, which is to change the air conditioner mode to DRY when the humidity is too high. but when the humidity is too low the system still uses the COOL mode same as when humidity is normal, for the further work, need to research and find for other modes on the air conditioner that can increase the humidity.

In the further research also needs to measure the effectiveness and speed of fuzzy logic that was designed by testing the performance of fuzzy logic based on microcontroller on the server room directly.

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