DESIGN OF LABM2M PLATFORM AS IOT (INTERNET OF THINGS) GATEWAY USING WEB SERVICE

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ABSTRACT

Creating a platform is one of the technological advances and the internet in industrial 4.0. To implement industrial 4.0, one of the main supporting factors is the availability of digital infrastructure. One of them is the Internet of Things (IoT). However, IoT devices have certain limitations on storage load and computing power. Storage refers to how and where data will be stored. In contrast, computing power refers to processing power, memory, and network, and processed in such a way that it is later displayed to end users and can transfer data over the network without requiring human-to-human (P2P) or human-to-computer (P2M) interaction. PaaS (platform as a service) is one of the solutions which utilizes web services as the main foundation of this IoT Gateway. Using Paas, end users can integrate IoT projects that are being developed easily and quickly without thinking about the limitations of storage and computing power. To determine the performance of the system created, an analysis is carried out by monitoring simultaneously and using different devices. And the system is expected to handle every request and response from the client.

Keywords *: Internet of Things, IoT, IoT Gateway, Platform as a Service, LabM2M, Machine to Machine*

1. INTRODUCTION

The development of Internet of Things (IoT) applications has many purposes. Health, disaster management, automation, sports, smart cities, and even security require IoT. On the other hand, when developing IoT applications, 7 out of 10 users are constrained when connecting devices to the applications they are developing for monitoring and controlling processes. The results of the performance and scalability analysis of monitoring and controlling are the average protocol CPU usage of 0.68%, MQTT of 0.60% and the average Memory usage of 5-7%. [1]

While the purpose of IoT itself is to expand the impact of internet connectivity by making a microcontroller device that can be controlled and monitored, collecting data and sending it to end users. The main problem in developing IoT applications is usually in the device, one of which is that IoT devices have limitations on storage load and computing power. That concept makes IoT devices need a relationship with a system where the system has the expected computing power. In performance testing, application performance calculations are carried out, and the results obtained are Subscriber Throughput is 161.55 message/s, Publisher Throughput is 2.13 message/s, the average message latency of Subscriber apps is 1488.28 ms, and the average message latency of Publisher apps is 5208.86 ms. [2]

However, connecting IoT devices to a system with the expected computing power is complicated, such as ease of connectivity and availability of databases so that data can be processed further and display output as a website; moreover, integrating so that IoT devices can be controlled and monitored according to the user's wishes. So, to overcome these limitations, a supporting platform is needed whose services can connect all aspects into a system that includes IoT devices that are connected to the database, controlling and monitoring IoT devices according to the wishes of the user, and displaying the output data that has been processed into a website.

By utilizing the development of the internet, the author initiated the development of applications using PaaS (Platform as a Service) to provide IoT gateway services and also using Web Service with the aim that users are more flexible in integrating services into the system being developed, by utilizing APIs whose output is in the form of JSON object data, users will be straightforward to consume data that has been processed and can be utilized by users to create applications on it.

With this service, researchers hope to facilitate users in integrating IoT projects into the LabM2M IoT Gateway platform to shorten the time in the project development process.

2. LITERATURE REVIEW

2.1. Previous Studies

In research conducted by Rozi, et al in 2017 with the title "Performance and Scalability Analysis on Event-Based IoT Middleware", a storage management design called Internet of Thing movie database (IOTMDB) was built which is based on NoSQL which is used as a way to store large and heterogeneous IoT data. The IOTMDB system is divided into four, namely the master node which functions as a manager for all clusters, the standby node which becomes a replacement when there is an error in the master node, the data reception node

becomes a receiver of sensor data, and the slave node is used to store all data. [1]

Research conducted by Budianto, et al in 2019 with the title "Application of Mobile Publisher Subscriber Devices as an Intermediary for Sensor Data Delivery from the Field to the Data Center", that Gateway can connect different communication rules. Gateway can have a function as a protocol converter and be used as a connector for various types of communication protocols. Gateways and data centers can be connected to each other, which means that one of the communication rules is needed in order to exchange information. One protocol that can be used for communication is the MQTT protocol. The Message Queuing Telemetry Transport protocol is used because of the ability to send data and has characteristics that support the reliability that IoT has such as being able to work in terms of low power and low bandwidth usage. [2]

In the research of Taufiqurrohman, et al in 2020 entitled "Application of IoT (Internet Of Things) for Monitoring the Use of Infusion Levels and the Condition of Patients Who Are in Need of Care", with the development of this technology, hospitals can monitor patient conditions. The condition is only seen through the nurse's room on a website-based monitor screen that lists all data including the patient's name, room, and patient condition. This development has features that can help ordinary users and website tables that can change color according to the patient's condition, namely red, yellow, and green. The red color means that the patient's condition must be treated immediately to replace the infusion or check the patient's condition, the yellow color means that the patient's infusion will soon be completed because the infusion volume is less than 100 grams, and the green color means that the patient's condition is fine. [3]

According to research by Mebiyantara, et al in 2021 with the title "Development of Remote Laboratory Management Applications Using the Mobile-Based Restful Web Service Method", that the development of this mobile-based management application supports remote practicum activities, where users who are at a distance are enabled to interact with measurement devices and real laboratory equipment. Where during the pandemic almost all educational institutions, especially in universities and schools, carried out an online learning system to reduce the number of infections from the corona virus that was endemic throughout the world. This application was developed to remote red pitaya's oscilloscope and signal generate tools using RESTful Web Service technology so that data transfer is faster and takes up relatively small data sizes [4].

2.2. *Internet of Things* (IoT)

The Internet of Things is a technology that allows us to connect machines, equipment, and other physical objects with networked sensors and actuators to obtain data and manage their own performance, thus allowing machines to collaborate and even act on new information obtained independently. The purpose of the Internet of Things is to make it easier for humans to interact with the objects around them [5].

2.3. *Lab Machine to Machine* (LabM2M)

Lab Machine to Machine or LabM2M is a service product being developed by researchers. This service is an Internet of Things platform in the cloud where clients can send or receive data with the HTTP communication protocol and can also display data values through the free dashboard provided. The LabM2M service itself functions as a data collector that comes from node devices in the form of sensors that are connected to the internet and also allows data retrieval from software for visualization and control purposes.

2.4. *Machine to Machine* (M2M)

M2M (Machine to Machine)/IoT (Internet of Things) is a solution built to digitize work processes with the aim of resource efficiency and effectiveness. M2M/IoT technology connects devices through IP networks so that they can be monitored and controlled by the company so that more information can be utilized from these interconnected devices. This technology allows companies to obtain information in real time and ensure that all devices are running properly [6].

2.5. IoT *Gateway*

Gateway is a network connecting device that can be used to connect two devices in two different networks. Basically, the function of the gateway is as a "gate" between two networks. It can be a server, firewall, router, or any other device that uses traffic to flow through the network. Gateways serve as exit and entry points for networks because all data must go through a communication gateway before it is routed [7].

2.6. *Web Service*

Web Service is a defined communication mechanism between different computer systems. Without web services, custom peer-to-peer communication becomes complicated and platform-specific. It's like hundreds of different types of things that need to be understood and interpreted by the web [8].

2.7. Metode *RESTful* API

REST (Representational State Transfer) is the de-facto standard for software architecture for interactive applications that typically use multiple

Web services. To be used in a REST-based application, Web Services must meet certain restrictions; such Web Services are called RESTful. RESTful Web Services are required to provide an application access to its Web resources in a textual representation and support their reading and modification with a stateless protocol and a predefined set of operations. With RESTful, Web Services provide interoperability between computer systems on the internet that provide these services. REST offers alternatives. For example SOAP as a method of access to Web Services [9].

2.8. PaaS (*Platform as a Service)*

Platform as a Service (PaaS) is one type of service from Cloud computing. PaaS is an intermediary software service in a cloud environment to facilitate the running of other application programs. This service is for building, testing and deploying applications that are in the development stage. To run the application that has been created, the analogy is that the user can rent a "house" along with the environment. The user does not need to bother to prepare the "house" and maintain the "house", the important thing is that the application created can run well. The maintenance of this "house" (operating system, network, database, application framework, etc.) is the provider's business [10].

3. RESEARCH METHOD

3.1. Functional Requirement Analysis

There are several functional requirements in the LabM2M Design system as an IoT (Internet of Things) Gateway:

1. The developed service can be accessed for 24 hours.
2. The developed service is able to connect to the IoT device used by the user.
3. The developed service is able to display monitoring data into the dashboard of each user.
4. The developed service is able to control the IoT project that has been developed by the user.
5. The developed service can create individual project channels in each different account.
6. Data that has been entered into the LabM2M IoT Gateway can be integrated back into the system that the user has developed through API consumption.
7. Sensor and actuator devices used as important parameters for monitoring and controlling data can be integrated with system services.
8. Communication devices can access the services developed as a means of monitoring IoT projects through HTTP protocol transfer.

3.2. Analisa Kebutuhan Non-Fugsional

The designed service requires minimum specifications for the system including:

1. The service can be run by several web browser software including Internet Explorer, Google Chrome, and Mozilla Firefox.
2. The developed service can only run if there is an internet connection.
3. User service security and monitoring data security are integrated with access tokens and API keys.
4. The service has an easy-to-understand UI display.

3.3. Schematic of the Connection Flow into the Gateway

The IoT device design scheme and the flow of device connections to the LabM2M IoT Gateway Platform, illustrates that there are sensors and actuators as important parameters in the monitoring and controlling process, communication devices as a means of connecting to the IoT Gateway by carrying monitoring and controlling data. After going through the process of sending data to the IoT Gateway, the data will be forwarded to the LabM2M service which is cloud-based where the data will be processed and displayed in the form of a dashboard. In addition to being displayed in the form of a dashboard, data can also be integrated into applications that are being developed by users. The flow scheme can be seen in Figure 1.

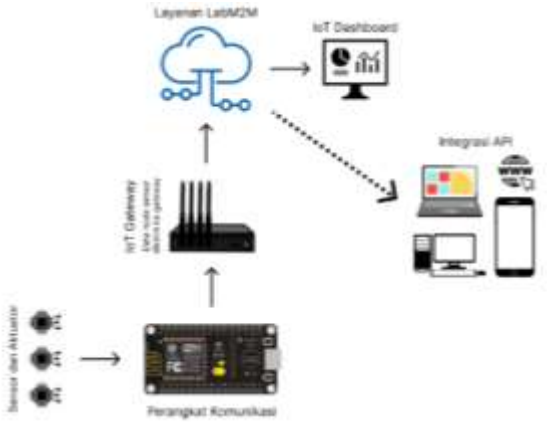

Figure 1. Gateway Connection Flow Schematic

3.4. Use Case Diagram

Use Case Diagram of LabM2M Platform Design as IoT (Internet of Things) Gateway Using Web Service can be seen in Figure 2.

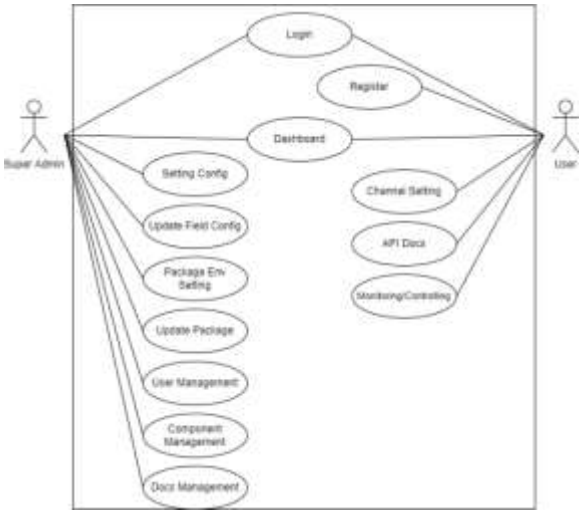

Figure 2. *Use Case Diagram*

3.5. Website Sitemap

Sitemap of LabM2M Platform Design as IoT (Internet of Things) Gateway Using Web Service can be seen in Figure 3.

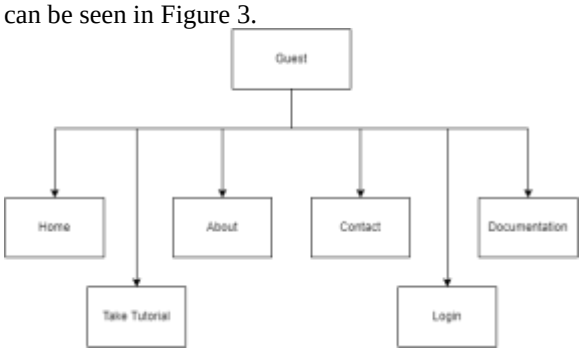

Figure 3. Website Sitemap

3.6. Admin Menu Structure

The admin menu structure of the LabM2M Platform Design as an IoT (Internet of Things) Gateway Using Web Service can be seen in Figure 4.

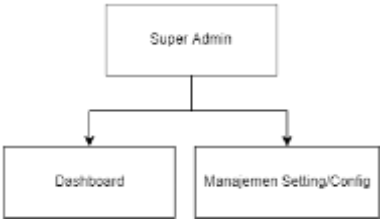

Figure 4. The admin menu structure

3.7. User Menu Structure

The user menu structure of the LabM2M Platform Design as an IoT (Internet of Things) Gateway Using Web Service can be seen in Figure 5.

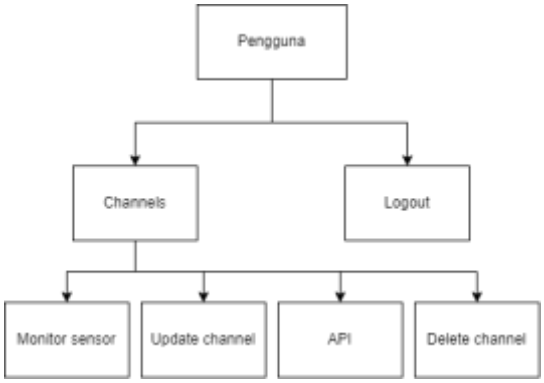

Figure 5. User Menu Structure

3.8. IoT Hardware Flowchart

Flowchart of IoT device hardware LabM2M Platform Design as IoT (Internet of Things) Gateway Using Web Service can be seen in Figure 6.

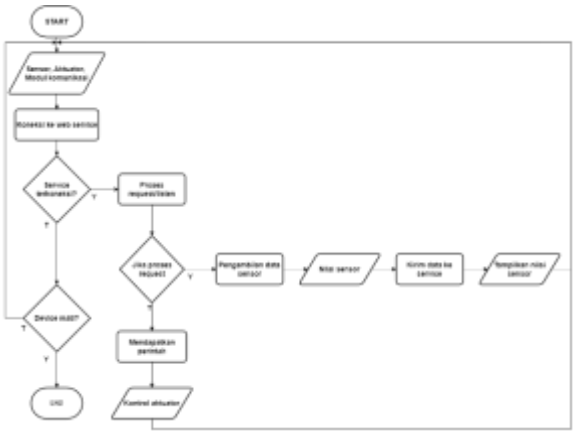

Figure 6. IoT Hardware Flowchart

3.9. Website System Flowchart

The flowchart of the website system for the LabM2M Platform Design as an IoT (Internet of Things) Gateway Using Web Service can be seen in Figure 7.

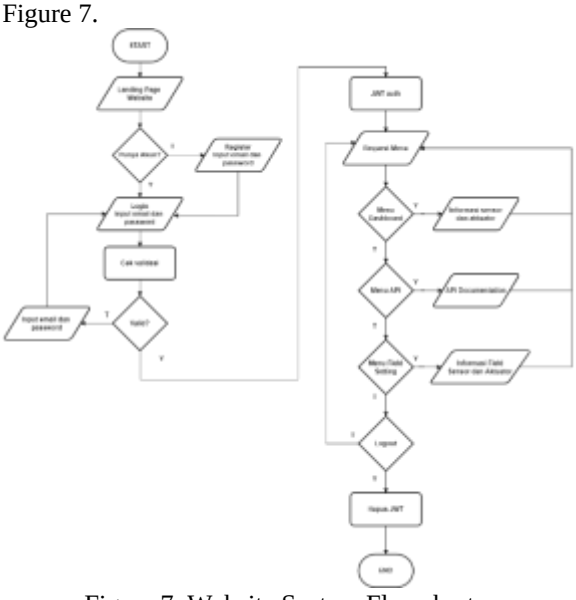

Figure 7. Website System Flowchart

4. RESULT AND DISCUSSION

The results obtained from this research are in the form of a service platform and monitoring or controlling devices that have installed sensors or actuators for monitoring or controlling IoT projects and a service platform that functions as a client interface to access monitoring devices or even controlling from anywhere and anytime using an internet connection.

This research discusses system testing in terms of monitoring hardware, controlling, multi-user, and also the function of the IoT gateway service platform. The monitoring hardware of Tester A is shown in Figure 8. While the controlling hardware of Tester B is shown in Figure 9.

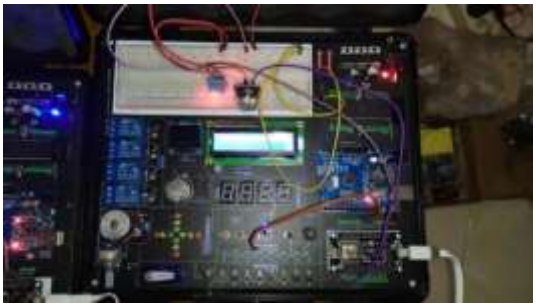

Figure 8. Hardware Display of Tester A

Figure 9. Hardware Display of Tester B

4.1. Hardware Testing

Hardware testing is the activity of reading supporting sensors, actuator control, sending data from communication devices until the data is received by the LabM2M gateway platform. The scenario of this hardware test is to use several different users and use different sensors and actuators.

4.2. Tester A Client Testing Using Wi-Fi Network and Smartphone Hotspot

The specifications of the components used are as ESP8266 NodeMCU as a communication device, DHT11 and MQ2 sensors, and Led actuators. The connection status via Wi-Fi will be shown in Figure 10. While the connection via Hotspot will be shown in Figure 11.

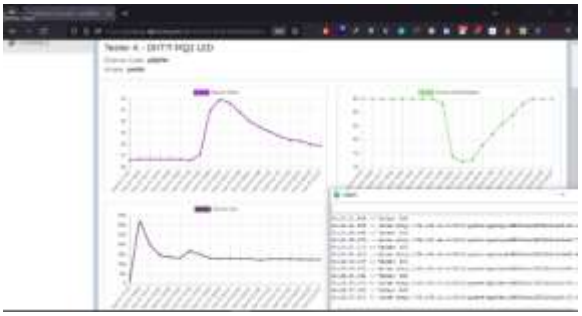

Figure 10. Monitoring Connection via Wi-Fi

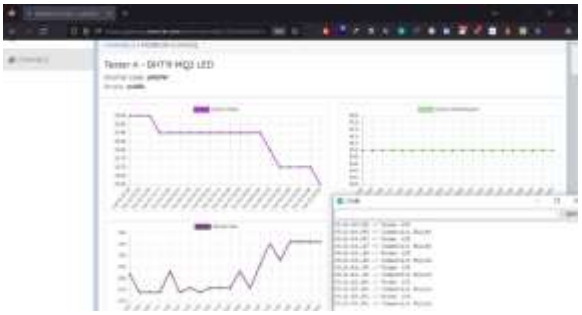

Figure 11. Monitoring Connection via Hotspot

Monitoring connections using smartphone hotspots are not recommended because of the 5 trials can only be connected once. Researchers also recommend using Wi-Fi or ethernet networks because they are more stable.

Table 1. Comparison of Connection via Wi-Fi and Hotspot

Test	Wi-Fi	*Smartphone Hotspot*
1	5 seconds	5 seconds
2	5 seconds	9 seconds (connection failed)
3	5 seconds	9 seconds (connection failed)
4	5 seconds	9 seconds (connection failed)
5	5 seconds	9 seconds (connection failed)

4.3. Tester B Client Testing Using Wi-Fi Network and Smartphone Hotspot

The specifications of the components used are as ESP8266 NodeMCU as a communication device, Buzzer and Led actuators. The connection status via Wi-Fi will be shown in Figure 12. While the connection via Hotspot will be shown in Figure 13.

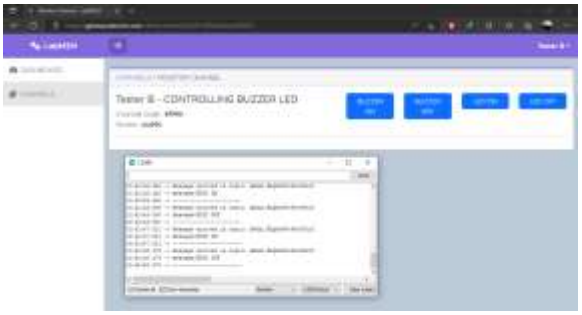

Figure 12. MQTT Connection Over Wi-Fi

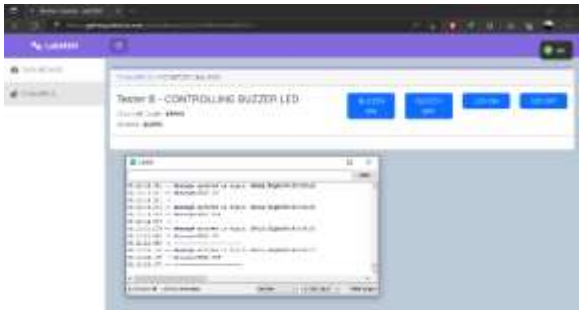

Figure 13. MQTT Connection via Hotspot

MQTT connection using a smartphone hotspot is safe to implement. The value of the connection comparison between using Wi-Fi and using Hotspot is not too different. Each device connection was tried for 5 times and there were no errors in the connection process.

Table 2. Comparison of MQTT Connection via Hotspot and Wi-Fi

Test	Wi-Fi	*Smartphone Hotspot*
1	5 seconds	5 seconds
2	5 seconds	8 seconds
3	4 seconds	8 seconds
4	7 seconds	8 seconds
5	5 seconds	8 seconds

4.4. Software Testing

Analysis is carried out from the results of system testing to the output of the LabM2M IoT Gateway Service Platform. The results of this analysis determine the accuracy of the program in providing information to users and admins. The things that will be tested are as follows

4.5. Web Browser Compatibility Web Test

This test aims to determine whether the web page created can display all data according to the design using several web browsers that are often used by users in general. The results of the web compatibility test against web browsers are shown in Table 3.

Table 3. Testing Web Compatibility with Web Browsers

No.	Test Aspects	*Web Browser*		
		Mozilla Firefox	*Edge*	*Google Chrome*
1	Display the register page	✓	✓	✓
2	Input username, email, password, and company	✓	✓	✓
3	Display the login page	✓	✓	✓
4	Input username and password	✓	✓	✓
5	Displays the client dashboard page	✓	✓	✓
6	Displays the channels page	✓	✓	✓
7	Displays the add channels page	✓	✓	✓
8	Displays the monitor or data logger page	✓	✓	✓
9	Displays the channel edit page	✓	✓	✓
10	Displays the channel settings page	✓	✓	✓
11	Displays the user page	✓	✓	✓
12	Displays the add user page	✓	✓	✓
13	Display the edit user page	✓	✓	✓
14	Displays the page, add, edit packages	✓	✓	✓
15	Create a new API Key	✓	✓	✓
16	Delete channel	✓	✓	✓
17	Perform logout process	✓	✓	✓

Information:
✓ = Running
X = Not Running

4.6. Blackbox testing of LabM2M service platform

Black-box testing is a software testing method that checks the functionality of an application without peeking into its structure or internal workings. Blackbox testing results are shown in Table 4.

Table 4. Blackbox testing of LabM2M service platform

Testing Activity	Expected relationship	Test Result	Conclusion
Leave the login data blank and click login	*Email*=”” *Password* = “”	System denies access and sends toaster notification	Valid
Entering the wrong password	*Email* =”tester@mail.com” *Password*=”11”	System denies access and sends toaster notification	Valid
Entering the wrong user	*Email* =”11” *Password*=”test123”	The system denies access and sends a toaster notification	Valid

Enter correct password and user	*Email* =”tester@mail.com” *Password*=”test123”	System denies access to view role and sends toaster notification	Valid
Visualization of device monitoring graph	Connect to LabM2M API	Data graph figure appears	Valid
Channel add testing (Add Channel)	Enter channel name, description, fields as needed, button.	Data can be added	Valid
Deleting channel data	Tap the trash can icon	Data deleted	Valid
Editing channel data	Tap the pen icon	Redirect to the edit page and the value of the form in accordance with the selected id.	Valid
Testing to generate a new API Key	Press the generate new write/read key button	API Key data for system needs will be replaced with a new one	Valid

4.7. User Testing

This test is intended to determine whether the system built is in accordance with the formulation of the problems raised in this study. User testing is done by giving questionnaires to respondents.

Table 5. *User testing*

No	Question	Answer			
		SS	S	TS	STS
1	Is the LabM2M service easy to use?	7	2	-	1
2	The interface of the LabM2M service looks attractive?	6	3	-	1
3	Can this service help you in the integration of IoT projects?	7	3	-	-
4	Does this service make it easy for you to integrate IoT projects?	6	4	-	-
5	I have no difficulty in using this LabM2M service.	3	1	4	2
6	I find interesting features in using this LabM2M service.	6	4	-	-
7	I will recommend my colleagues to use this LabM2M service in the IoT project development process.	8	2	-	-

Answer Description:
SS = Strongly Agree
S = Agree
TS = Disagree
STS = Strongly Disagree

The results of testing the system to 10 respondents shown in Table 5 obtained the total average answer:
Strongly Agree (43 / 70) x 100 = 61,42%
Agree (19 / 70) x 100 = 27,1%
Disagree (4 / 70) x 100 = 5,71%
Strongly Disagree (4 / 70) x 100 = 5,71%

Therefore, it can be concluded that 61.42% of respondents said they strongly agreed with the design of the LabM2M platform as an IoT gateway using this web service..

5. CONCLUSION AND SUGGESTION

From the functional testing of the website in Table 3, it can be concluded that this service runs smoothly on three different browsers. The ESP8266 wifi module can connect to the surrounding wifi to get an internet connection, and sending data to the web server is strongly influenced by the internet connection. The ESP8266 Wi-Fi module must be connected to the 5 Ghz frequency. The monitoring system runs well on several web browsers tested, namely Mozilla Firefox, Microsoft Edge and Google Chrome. User testing follows the formulation of the problem. From the questionnaire results, ten respondents stated that this system could help integrate IoT projects. Data that has been entered into the IoT gateway can be reintegrated using JSON data format.

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