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IoT-Based Infusion Fluid Monitoring System Using the MQTT Protocol

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ABSTRACT — One of the medical equipment that is often used in hospitals is infusion; however, the infusion monitoring system is generally still manual so that medical staff must constantly monitor the infusion device condition, which is requiring more effort and time. In this study, a 500 ml Ringer's lactate infusion fluid monitoring system was developed based on the internet of things (IoT) using the message queuing telemetry transport (MQTT) communication protocol and an IoT cloud server system using the MQTT Dash. This infusion fluid was chosen as it is the most widely used infusion fluid. The HX711 load cell was used as a sensor to determine the weight of the infusion fluid. In addition, the NodeMCU ESP8266 microcontroller was used since it is equipped with a WiFi module called the ESP8266 module, hence it can support the implementation of IoT systems. The MQTT protocol was used to send the data to users. It was then connected to the MQTT Dash application as a monitoring medium for medical personnel. The system's performance based on the performance of the HX711 load cell sensor in terms of the accuracy of reading the weight of infusion fluids was very good. It is evidenced by the average error percentage value of 0.08% to 0.64%, meaning that load cell sensor works well as it remains within the error tolerance limit of 5%. Meanwhile, the quality of service (QoS) test revealed that the results of the average delay on all systems ranged from 0.014 ms to 0.023 ms. According to the telecommunications and internet protocol harmonization over networks (TIPHON) standards, these values are considered very good. After that, the average of packet loss testing results on all systems were 0% to 0.01%. According to the TIPHON standards, these values are likewise classified as very good.

KEYWORDS — Infusion Fluid Monitoring, IoT, HX711 Load Cell, MQTT.

I. INTRODUCTION

The world of medicine has experienced significant developments in term of science and technology used, leading to the advancement of medical devices, and making it easier for medical personnel to diagnose disease, treat patients, or carry out healing procedures. One of the medical equipment that is frequently used in hospitals is infusion. As a medical device, infusion, under certain conditions, is used to replace body fluids and balance electrolytes, besides functioning as a medium for treatment through fluids channeled directly into blood vessels. Currently, infusion devices are generally still used manually, requiring medical workers to constantly monitor the condition of these devices, which certainly consumes more energy and time [1].

Digital and information technology have a significant impact on many aspects of human activities, resulting in an improvement in the quality of our lives. The healthcare system is undergoing a real technological revolution, with the widespread usage of IoT platforms supporting enhanced monitoring services and intelligent inference systems totally transforming the way medical services are provided [2]. As human beings currently live in complex times in the health, social, political and energy sectors, new trends in intelligent social health systems powered by IoT must be recognized and implemented [3].

The current infusion monitoring system has several drawbacks, one of which is that infusion fluids are manually monitored. This problem is quite serious as intravenous fluids can run out at any time if medical personnel do not supervise them. Running out of intravenous fluids may threaten the patient's life since the intake of fluids to replace electrolyte fluids in the body and the intake of medicinal fluids into the blood vessels stop. Therefore, there is a need of technology to monitor infusion fluids remotely and in real time [1], [4].

Existing technological advances make many medical activities and devices can be monitored in real time by utilizing the internet, making the work more effective, efficient, and accurate. The internet of things (IoT) is a version of a conventional network that is developed with the aim of connecting various connected devices. The IoT concept is further strengthened by advanced technologies such as wireless sensor networks and machine to machine communication [5]. Previous study created a wireless microcontroller-based infusion fluid replacement alarm system using photodiode and infrared sensors placed on infusion fluid bottles. The data were processed by the microcontroller, then medical staff would receive notifications of infusion conditions through an alarm in the nurse station [1]. In another study, a medical infusion system monitoring tool was created using ZigBee, which is one of the communication protocols on a wireless sensor network, with photodiode and infrared sensors to monitor several volumes of infusion fluids. The data from each sensor node were sent to the doctor's computer [6]. Another study is a prototype of an IoT-based infusion monitoring system. In this study, the weight of infusion fluids was monitored via the ThingSpeak website [4].

Several studies on infusion monitoring systems that have been conducted have advantages and disadvantages. In the study on the wireless microcontroller-based infusion fluid replacement alarm system by using a notification from a buzzer placed in the nurse station has succeeded in monitoring the presence or absence of infusion droplets and volume using photodiode and infrared sensors [1]. Unfortunately, IoT was not implemented in this system since it used the nRF2401L module so that the monitoring distance was limited to the range of 4 m - 6 m. In addition, the notification of infusion conditions still used the buzzer so that the staff could not observe the remaining infusion volume. Then, in other studies a medical infusion monitoring system was also developed using ZigBe using a wireless sensor network [6]. This system succeeded in monitoring infusion fluids remotely using a wireless sensor network, but it was not implemented IoT so that wireless network coverage was limited to the local hospital network. In addition, the use of photodiode and infrared sensors was easily affected by the electromagnetic wave interference, causing delays in the data delivery [7]. Subsequent research on the IoT-based infusion monitoring system prototype implemented an IoT system in monitoring the weight of the infusion in real time, but the monitoring was only applied to one infusion and the system was not equipped with a liquid crystal display (LCD) [4].

Based on some of these shortcomings, this research developed an IoT-based monitoring system for Ringer's lactate infusion fluids for patients using the MQTT communication protocol and an IoT cloud server system using the MQTT broker. IoT ecosystems involve web-enabled smart devices that use integrated systems, such as processors, sensors, and communication hardware, to assemble, transmit, and act on the data they acquire. IoT devices disclose sensor data collected by engaging IoT entries or other edge devices where the data are sent to the cloud for analysis or on-site analysis. These devices communicate with other connected devices and act on the information they get from each other. They do most of the work without human intervention, although people can interact with them, for example to configure, instruct, or access the data [8]. Cloud-enabled IoT applications grow and communicate across networks. The cloud enables cloud-based services for hosting, deploying, and introducing the IoT applications. In addition, cloud computing is a suitable internet platform for storing and processing smart device data, such as connected cars, smart networks, smart cities, WiFi, sensors, and actuator networks [9]. This research is a solution to the shortcomings of previous research on infusion monitoring, namely by using the MQTT communication protocol which is suitable for IoT-based systems with multiple infusion objects being monitored. The infusion volume consists of several types, including 1000 ml, 500 ml, and 100 ml. According to a user from the Bungah health center, Gresik, East Java, Ringer's lactate infusion with a volume of 500 ml is the most used intravenous fluid in hospitals. Therefore, 500 ml Ringer's lactate was used in this study. The HX711 load cell sensor was chosen as the sensor because this sensor is more flexible it is more flexible to changing infusions and therefore easier to use; the medical staff only need to connect the infusion bottle to the load cell sensor. This sensor was used to determine the weight of the infusion fluid. The system developed in this study consisted of several main hardware and software, the first of which was the NodeMCU ESP8266 microcontroller. This microcontroller was chosen since it is equipped with the ESP8266 module which is a WiFi module and therefore it supports the implementation of IoT systems. The data transmission was carried out using the MQTT protocol [10], with the NodeMCU ESP8266 microcontroller and the HX711 load cell as a Publisher that sent the data and then forwarded them to the MQTT Broker as a cloud server. This cloud server was responsible for receiving the data from the Publisher before distributing them to the subscribers with certain topics. In this study, the MQTT Broker used was the HiveMQ, while on the subscriber side, the MQTT Dash application served as a user interface for an infusion fluid monitoring system.

II. THE 500 ML RINGER'S LACTATE INFUSION

Ringer's lactate is a sterile solution consisting of water, sodium chloride (salt), sodium lactate, potassium chloride, and calcium chloride. This infusion fluid is often used as a substitute for saline solution (water and 0.9% sodium chloride). In addition, it is frequently used to replace lost fluids and to assist with certain intravenous procedures. Ringer's lactate is considered more beneficial than saline solution since it does not last long in the body and therefore it is less likely to cause fluid overload. The addition of lactate reduces acidity as it is converted by the body into bicarbonate which is a basic element that helps regulate the body's pH balance. Hance, the Ringer's lactate infusion is not recommended for people who have a body pH of more than 7.5, have liver disease that cannot metabolize lactate, and are in conditions of lactic acidosis [11].

III. MEASUREMENT OF PERCENTAGE ERROR VALUE

The percentage error value is obtained from comparing the weight of the infusion fluid resulting from system readings made with the weight of the infusion fluid resulting from manual measurements using a digital scale. The limit of the percentage error value cannot be more than 5% [12]. Equation (1) was used to determine the percentage of error [13].

$$\text{error value } (\%) = \frac{\text{original weights} - \text{system weight}}{\text{original weights}} \times 100\% \quad (1)$$

with *original weight* signifies the weight of infusion fluid when measured with a digital balance, while the *system weight* signifies the weight of the infusion fluid when measured with the system that has been made

IV. MEASUREMENT OF QUALITY OF SERVICE (QoS)

The quality of service (QoS) is a measurement method of how good the network is and is an attempt to define the characteristics and nature of a service. The QoS is used to measure a set of performance attributes that have been specified and are usually associated with a service. It is designed to help end users (clients) become more practical by ensuring that users obtain good performance from network-based applications. In this study, two parameters were tested with reference standards set by telecommunications and internet protocol harmonization over networks (TIPHON) standards [14], [15].

A. DELAY

The delay is the time required to travel the distance of sending data to the destination. Table I shows the delay category and index based on the TIPHON standards.

B. PACKET LOSS

The packet loss is the number of data carrier packets lost in the transit. Table II presents the packet loss categories and indexes based on the TIPHON standards.

The calculation of delay and packet loss parameters were carried out using (2), (3) and (4) [16], [17].

$$\text{delay } (\%) = \text{delay } 2 - \text{delay } 1 \quad (2)$$

$$\text{delay average} = \frac{\sum \text{delay}}{\text{number of packages}} \quad (3)$$

where *delay 1* is the first delivery delay, *delay 2* is the second delivery delay, and $\sum$*delay* is the amount of the delay difference.

TABLE I
TIPHON STANDARD DELAYS

Delay Category	Delay (ms)	Index
Very good	<150	4
Good	150 – 300	3
Currently	300 – 450	2
Bad	>450	1

TABLE II
TIPHON STANDARD PACKET LOSS

Packet Loss Category	Packet Loss (%)	Index
Very good	0	4
Good	3	3
Currently	15	2
Bad	25	1

$$\text{packet loss} = \frac{\text{packages sent} - \text{packages received}}{\text{package sent}} \times 100\% \quad (4)$$

where, *packages sent* denotes number of packets sent, *packages received* denotes number of packets successfully received.

V. SYSTEM DESIGN

The design of an IoT-based patient infusion monitoring system using the MQTT protocol comprised of three Publisher subsystems, each of which sent monitoring data to the MQTT Broker and then distributed them to the subscribers or clients as users. The parts of the designed system are as follows:

1) POWER SUPPLY

Power supply was used to provide a voltage source to NodeMCU, HX711 load cell weight sensor, and 16 × 2 LCD.

2) HX711 LOAD CELL WEIGHT SENSOR

HX711 load cell weight sensor was used to measure the patient’s infusion weight. The HX711 load cell sensor was connected to the NodeMCU as a data processor that was obtained from sensor readings.

3) NODEMCU

NodeMCU was used as a microcontroller that already has a WiFi module that can be connected to the internet network. NodeMCU receives data from the weight sensor, processes the data and executes commands to display text on the 16 × 2 LCD, in addition it also sends the data to the MQTT Dash application.

4) LCD

LCD was used as a data viewer in the form of text or images. In this study, the LCD displayed the text “Weight of Infusion ... Grams”.

5) USB MODEMS

This device was used as an access point functioning as a liaison between NodeMCU to the internet so that data could be sent to the Broker and therefore they could be accessed by MQTT Dash on the smartphone.

6) INTERNET

The internet was used to connect smartphones and NodeMCU to access infusion monitoring systems, both on the MQTT Dash application on smartphones and brokers.

7) MQTT DASH APPLICATION

MQTT Dash application was used to receive and transmit system data via the internet network.

8) SMARTPHONE

It was used as a medium for monitoring the weight of the infusion and is displayed on the MQTT Dash application that had been installed on an Android smartphone.

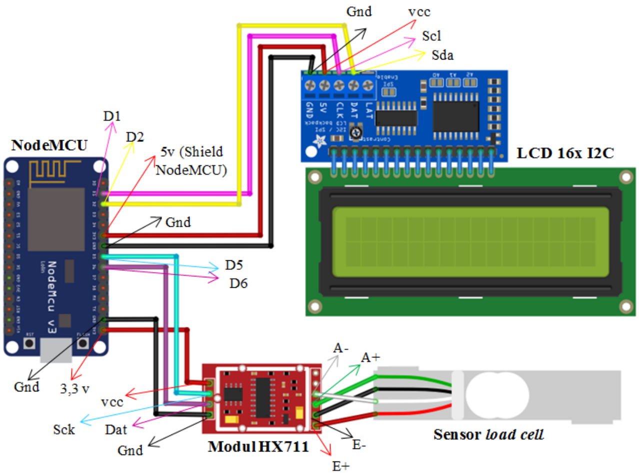

Figure 1. Electrical system wiring.

A. MECHANICAL SYSTEM DESIGN

The intravenous pole was designed in this stage. The design was carried out by modifying the infusion’s bottle hooks of the conventional pole. The height of the intravenous pole was between 1.3 m and 3 m. The pole was also modified by adding a panel box to place the system hardware. The 16 × 2 LCD screen was placed on the front of the box panel, while the HX711 load cell sensor was placed at the top of the intravenous pole.

B. ELECTRICAL SYSTEM DESIGN

The electrical system was developed using the NodeMCU ESP8266 as a data processing microcontroller, which was equipped with a WiFi communication feature at 2.4 GHz for data transmission to the IoT system. Then the HX711 load cell sensor was used as the input device; meanwhile, on the output, a 16 × 2 LCD was used to display monitoring results directly on the device. Figure 1 is the wiring of the electrical system used in the system.

In detail, the wiring and pin connections used between the microcontroller board and the input output devices in the electrical system are as follows:

- Pin D1 of the NodeMCU shield was connected to the SCL pin of the I2C LCD 16 × 2 module.
- The NodeMCU shield’s D2 pin was connected to the SDA pin of the 16 × 2 LCD I2C module.
- Pin D5 of the NodeMCU shield was connected to the SCK pin of the HX711 load cell sensor.
- Pin D6 of the NodeMCU shield was connected to the DAT pin of the HX711 load cell sensor.
- Jack DC Power 3.3 Volt DC shield NodeMCU was connected to the VIN pin on NodeMCU, Vcc sensor load cell HX711, Vcc I2C Module.
- 3.3 Volt DC Shield NodeMCU Power Jack was connected to the I2C Module Vcc.
- DC Gnd jack was connected to NodeMCU G pin, HX711 load cell sensor Gnd, I2C Module Gnd.

C. TOPOLOGY USED

The network topology used in the IoT-based patient infusion monitoring system using the MQTT protocol was the infrastructure topology. Infrastructure topology is a wireless network. Communication that occurs can involve between two or more computer systems using an intermediary in the form of an access point [18]. A USB WiFi modem as an access point acted like a hub or switch on a wired network and became the

Figure 2. Results of the overall system design.

center a wireless network. In the infrastructure topology, the wireless adapter on the NodeMCU ESP8266 microcontroller communicated via a USB WiFi modem and then communicated with the broker from MQTT, and the MQTT Dash application [19], [20].

D. SOFTWARE DEVELOPMENT

Software development for the monitoring system of several IoT-based Ringer's lactate infusion fluids was the MQTT communication protocol and an IoT cloud server system using the MQTT Dash application platform. Applications used for software development on the infusion fluid monitoring system using the MQTT protocol were Arduino IDE and Wireshark. The Arduino IDE was used to program the NodeMCU hardware, while the Wireshark was responsible for the measurement of data transmission delay parameters and data transmission packet loss. On the other hand, the MQTT Dash application on an Android-based smartphone was used to configure the cloud database and served as an interface for users. This application displayed a text in a clear, minimalist, and easy-to-read design, which facilitated the reading of the weight of the infusion fluids.

The stages of system work as a basis for software development are as follows:

1) DATA READING BY LOAD CELL SENSOR HX711

This stage began with the HX711 load cell sensor reading the weight of the infusion fluid, then retrieving data and sending them to NodeMCU.

2) *NODEMCU PROCESSS DATA FROM HX711 LOAD CELL SENSOR*

At this stage, the NodeMCU processed the results of data reading from the HX711 load cell sensor.

3) *READ THE INFUSION WEIGHT*

This stage was the output of the infusion weight which was read after the NodeMCU processed data from the HX711 load cell sensor.

4) *NODEMCU AND BROKER CONNECTIVITY PROCESS*

At this stage, the NodeMCU and the HiveMQ broker were connected to the internet network. If connection was successful, then the data was sent to the HiveMQ broker, and the infusion weight was displayed on the 16 × 2 LCD. If not, the stage returned to NodeMCU and HiveMq broker connectivity.

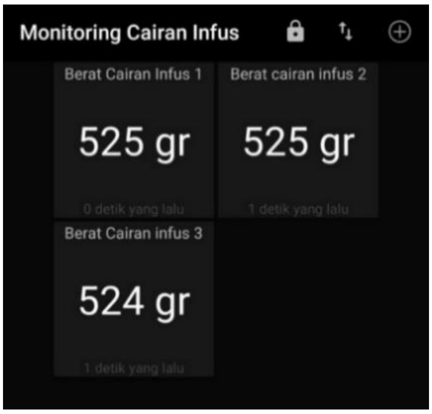

Figure 3. System displays on the MQTT Dash application.

5) 16 × 2 LCD DISPLAYS THE WEIGHT OF THE INFUSION

After the successful connection, the LCD displayed the weight of the infusion.

6) DATA TRANSFER FROM PUBLISHER TO BROKER

In this process, the NodeMCU as a publisher sent data to the broker with a certain topic.

7) COLLECTION OF DATA BY THE BROKER ACCORDING TO THE TOPIC FROM THE PUBLISHER

At this stage, the broker as a liaison between the publisher and the subscriber collected data according to the topics inputted.

8) MQTT DASH AS A SUBCRIBER

At this stage, the MQTT Dash as a subscriber displayed the weight of the infusion on the smartphone by entering a topic matching the publisher's topic.

VI. RESULT AND ANALYSIS

The results of the system design include mechanical system design, electrical system design, and software development. The results of the overall system design are shown in Figure 2.

A. MECHANICAL SYSTEM DESIGN RESULTS

The results of the system's mechanical design were the intravenous pole with height of up to 3 m. The HX711 load cell sensor was placed at the top of the pole from which the infusion bottle hung. The electrical system circuit panel box was placed in the center of the pole, equipped with cables connected to the power supply and to the HX711 load cell sensor. In the trial, the intravenous poles were placed at 2 m from each other. At the same time, all the intravenous poles were placed at approximately 5 m from the access point.

B. RESULTS OF ELECTRIC SYSTEM DESIGN

The results of the electrical system design consisted of several components that were integrated into an electrical circuit that functioned to run an infusion fluid monitoring system. The components used included the load cell sensor to measure the weight of Ringer's lactate infusion fluids; the HX711 module as the serial peripheral interface (SPI) of the HX711 load cell sensor; a 16 × 2 I2C LCD to display the weight of infusion fluids on the box panel; and the NodeMCU ESP8266 microcontroller as a data processor obtained from sensors, as well as a publisher in the MQTT protocol. In this study, three electrical system designs were produced.

TABLE III
TESTING OF THE INFUSION MONITORING SYSTEM 1

Trial	Infusion Fluid Weight Reading (g)			Delay (ms)	Packet Loss (%)
	System	*Manual Measurement*	*Error*		
1	524	524	0. 00	21.28	0
2	480	482	0.41	53.41	0
3	442	444	0.45	1.63	0
4	403	401	0.49	19.35	0
5	377	379	0.52	26.90	0
6	346	349	0.85	2.78	0
7	327	330	0.90	1.45	0
8	311	313	0.95	6.20	0
9	264	267	0.74	10.15	0
10	235	238	0.12	8.40	0

TABLE IV
TESTING OF THE INFUSION MONITORING SYSTEM 2

Trial	Infusion Fluid Weight Reading (g)			Delay (ms)	Packet Loss (%)
	System	*Manual Measurement*	*Error*		
1	525	525	0.00	10.71	0.0
2	486	485	0.20	5.22	0.0
3	413	412	0.24	21.61	0.1
4	346	345	0.28	33.07	0.0
5	305	301	0.13	3.21	0.0
6	259	259	0.00	21.68	0.0
7	212	213	0.46	18.49	0.0
8	204	200	2.00	21.68	0.0
9	182	180	1.11	27.78	0.0
10	153	150	2.00	43.68	0.0

C. SOFTWARE DEVELOPMENT RESULTS

Software developed using the Arduino IDE for infusion monitoring was installed on the NodeMCU microcontroller. Then, the integration and configuration of the MQTT protocol on the MQTT Dash application were carried out. Hence, the infusion fluid monitoring system worked according to the desired design results. Figure 3 exhibits the MQTT Dash application interface that displays data on the weight of infusion fluids in text format.

The broker used was the HiveMQ. The port of the HiveMQ broker was 1883, which is the port for the transmission control protocol (TCP). By activating the “keep screen on when connected to this broker” feature, the screen will remain on when connected to the HiveMQ broker. The “allow metric management” feature also needs to be activated so that users can change the interface configuration on the monitoring system as desired. Power supply failures on the IoT equipment or internet connection failures could be detected on the display of the MQTT Dash application interface, which does not change for more than 1 s. It occurs since the system is designed to detect changes in the weight of infusion fluids every second or real time, and the application interface of the MQTT Dash displays data at the last second prior the failures.

D. TEST RESULT AND ANALYSIS

The trial was carried out using several test parameters, namely the weight of the infusion in the system, the weight of the infusion that was measured manually, the delay, packet loss, and the percentage of error in reading the weight of the infusion.

TABLE V
TESTING OF THE INFUSION MONITORING SYSTEM 3

Trial	Infusion Fluid Weight Reading (g)			Delay (ms)	Packet Loss (%)
	System	*Manual Measurement*	*Error*		
1	525	525	0.00	10.55	0
2	470	470	0.00	37.92	0
3	411	411	0.00	6.25	0
4	365	366	0.27	51.68	0
5	337	336	0.29	8.36	0
6	302	301	0.33	36.91	0
7	242	242	0.00	58.18	0
8	223	223	0.00	9.75	0
9	194	194	0.00	6.38	0
10	147	147	0.00	7.18	0

The smartphone used in the trial had an Octa-core Central Processing Unit (CPU) (4×2.3 GHz Cortex-A73 and 4×1.7 GHz Cortex-A53), random access memory (RAM) of 4 GB, and internal memory of 64 GB. Data sampling was carried out ten times for each testing parameter. The trial was carried out inside the building using the internet network via a WiFi modem installed with a Simpati card from the cellular operator Telkomsel during peak hours. Testing with the same treatment were carried out on the three resulting monitoring systems. The results of each test on the three infusion monitoring systems are presented in Table III, Table IV, and Table V.

According to the infusion monitoring system’s test results in Table III, Table IV, and Table V, the system successfully monitored the weight of infusion fluids and obtained data on predetermined testing parameters. The percentage error value in the system was the error value for reading the weight of infusion fluids from the system compared to the manual measurement results using digital scales. In some trial samples there was a spike in the error value but remained within the error tolerance limit of 5%. The error percentage value in the infusion fluid monitoring system 1 ranged from 0% to 0.95% for ten trials, with an average error percentage of 0.54%. Meanwhile, the error percentage value in the infusion fluid monitoring system 2 ranged from 0% to 2 % for ten trials, with an average error percentage of 0.64%. The error percentage value in the infusion fluid monitoring system 3 ranged from 0% to 0.33% for ten trials, with an average error percentage of 0.08 %. According to these results, the load cell sensor still works well because it remains within the measurement tolerance limit of 5%. Errors that occur in reading the weight of infusion fluids from the system were related to the accuracy of the load cell sensor.

QoS measurement results for the delay parameter in the infusion fluid monitoring system 1 obtained a value of 1.45 ms to 53.41 ms with an average delay of 15.15 ms. The delay parameter in the infusion fluid monitoring system 2 obtained a value of 3.21 ms up to 43.68 ms with an average delay of 20.71 ms. Then, in the infusion fluid monitoring system 3, the delay parameters obtained a value of 6.25 ms to 58.18 ms with an average delay of 23.31 ms. According to TIPHON standards, all delay values obtained are in the very good category because they are less than 150 ms.

The packet loss parameter in the infusion fluid monitoring system 1 and 3 was 0% in ten trials, with an average packet loss percentage value of 0%. Meanwhile, the obtained packet loss parameter in the infusion fluid monitoring system 2 ranged from 0% to 0.1% in ten trials, with an average value of 0.01%. Since the packet loss is 0%, this value is classified as very good according to TIPHON standards.

VII. CONCLUSION

The IoT-based monitoring system for the Ringer's lactate infusion fluids using the MQTT protocol integrated several hardware, namely NodeMCU, HX711 load cell sensors, and LCD16 × 2; meanwhile, the software used to monitor the weight of infusion fluids was the MQTT Dash. Three developed systems could run well. The system test results showed that the accuracy of the HX711 load cell sensor in reading the weight of infusion fluids was very good. It is evidenced by the average error percentage for reading the weight of infusion fluids, which was 0.08% to 0.64%, the performance of the load cell sensor is in a good category because it remains within the tolerance limit for the load cell sensor reading error, which was 5%. The QoS test results showed that the average delay on all systems was 15.15 ms to 23.31 ms. This value is classified as very good based on TIPHON standards. Then, for packet loss on all systems the average is 0% to 0.01%. This value is classified as very good based on TIPHON standards.

CONFLICT OF INTEREST

The authors declare that the article entitled "IoT-Based Infusion Fluid Monitoring System Using the MQTT Protocol" has never been published and is not in the process of being published in another journal. In conducting research, the authors independently in both scientific and ethical aspects. The results of the research are based on an objective analysis by developing the authors' abilities. In addition, in reviewing research protocols, the authors always use the highest ethical standards. The authors declare that they will not abuse the article for other purposes or for the interests of third parties.

AUTHOR CONTRIBUTION

Conceptualization, Nur Afiyat; methodology, Nur Afiyat; software, Raizly Helmi Navilla; validation, Raizly Helmi Navilla, Nur Afiyat, and Mohamad Hariyadi; formal analysis, Nur Afiyat; investigation, Nur Afiyat; resources, Raizly Helmi Navilla; data curation, Raizly Helmi Navilla; writing—original drafting, Raizly Helmi Navilla; writing—review and editing, Nur Afiyat; visualization, Raizly Helmi Navilla; supervision, Nur Afiyat; project administration, Raizly Helmi Navilla.

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