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INTERNATIONAL CONFERENCE ON GREEN TECHNOLOGY AND DESIGN 2020

A Smart Deliberation in Green Technology and Design Towards New Normal Mitigation

VIRTUAL CONFERENCE
December 2nd - 3rd, 2020

ISBN: 978-623-7525-35-6

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Vol. 2020: INTERNATIONAL CONFERENCE ON GREEN TECHNOLOGY AND DESIGN (ICGTD)

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Published: 2022-01-10

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IMPORTANT DATE

- Full Paper Deadline: 16 Oktober 2020
- Acceptance Notification: 30 Oktober 2020

- Camera Ready: 6 November 2020
- Payment Deadline: 15 November 2020
- Conference Date: 2 – 3 Desember 2020

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ICGTD 2020 International Conference on Green Technology and Design

Implementation of Wireless Sensor Network In Taekwondo Sport Branch Kyorugi Category

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Abstract— The Wireless Sensor Network (WSN) has been implemented in several ways to improve quality of living in terms of environment sustainability. WSN in sports such as Taekwondo is applied to validate the points especially in competition. WSN system uses a sensor node (Piezoelectric Sensor) to detect a punch or kick on the body protector of a Taekwondo athlete, then sent by a sink node (ESP8266) to the Web Server. WSN architecture uses a Point to Point Topology that connects two nodes through an Access Point. The WSN Delivery Method uses the Message Queue Telemetry Transport (MQTT) Protocol with the publish / subscribe communication type and the Hypertext Transfer Protocol (HTTP) Protocol with the client-server communication type. The results of the MQTT Protocol test using Round Trip Time (RTT) and Quality of Service (QoS) parameters include Delay, Jitter, Throughput, Packet loss and memory condition parameters, resulting in stable RTT, good QoS delay, stable jitter, good throughput. continues to increase, and 0% packet loss. Then, the HTTP protocol tested the delay and transmission range of 2100 times from the sink node with a distance of 50 m to the access point resulting in an accuracy rate of 100%.

Keywords— **Taekwondo,** ***Wireless Sensor Network, Message Queue Telemetry Transport, Hypertext Transfer Protocol*****,** ***Point to Point Topology.***

I. Introduction

Wireless Sensor Network (WSN) brings the compactness, flexibility and ease of use in sports, such as in martial arts Taekwondo that widely used in environmental sustainability. Taekwondo originates from Korea and is headquartered in Kukkiwon Seoul, Korea. The Taekwondo Sports Branch Organization in Indonesia is the Indonesian Taekwondo Executive Board (PBTI). [1]. Wireless Sensor Network (WSN) is a group of sensors, each of which has the ability to sense (sensing), which, if served by one another, becomes a network, then it will be able to carry out monitoring.[2].

Previous research on Taekwondo martial arts related to the calculation of the Wi-Fi-based Taekwondo point system to make it easier for referees to use buttons has been developed. [3]. But in this study, the system still cannot prove the correctness of the points entered.

Based on these problems, technology is utilized which can be a system, namely the Wireless Sensor Network (WSN) using the Message Queue Telemetry Transport (MQTT) Protocol with the type of publish / subscribe communication. RTT parameters are used, QoS parameters include Delay, Jitter, Throughput, Packet loss and memory condition parameters.

II. Method

The system built using the Wemos D1 R2 microcontroller and the ESP8266 Wi-Fi module as a sink node and broker, and Piezoelectric Sensor as a sensor node. The system consists of 1 sink node and 3 sensor nodes for monitoring validation points. The system is connected to the access point wirelessly using the ESP8266 Wi-Fi module.

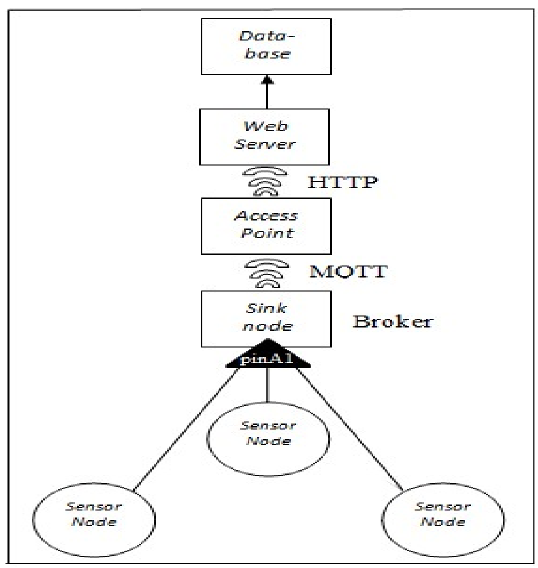

Fig.1. Working Principle Diagam Block

In Figure 1 is a Working Principle Diagam Block which shows that the sensor node sends validation detection data for entry points using the Message Queue Telemetry Transport (MQTT) Protocol on the sensor node to the sink node and Hypertext Transfer Protocol (HTTP) as a Transmission Protocol Sending data to the web server then data is stored in the database. Because there are 3 sensor nodes when sending data, so that the data does not occur. Piezoelectric sensors are connected in series which are connected to the microcontroller on the Analog / A1 input pins as many as 3 Piezoelectric sensors, so the sensor node only issues 1 fastest detection result using the Message Queue Telemetry Protocol Transport (MQTT).

In Figure 2 you can see the sensor node on the body protector which uses a Piezolectric Sensor connected to the Wemos D1 R2 microcontroller as many as 3 Piezoelectric Sensors. Wemos D1 R2 equipped with ESP8266 will send sensor detection data to the broker (sink node). At the initial stage using the publish / subscribe concept where the one that acts as a publisher here is the sensor node, namely Piezoelectric Sensor, sending Publish the topic in the form of "Sensor Indication" then received by the sink node, namely Wemos D1 R2 as a subscriber, sending a Subscribe to the topic in the form of "Sensor Indication" which then received by the Broker, namely the ESP8266 connected to the Access Point so that it can publish from the sensor node to the sink node and subscribe to broker using the Message Queue Telemetry Transport (MQTT) Protocol and forward it to the web server using the Hypertext Transfer Protocol (HTTP) Protocol. Then the results of monitoring the detection of entry points displayed by the web server on the laptop on the monitor are stored on the database server in real-time.

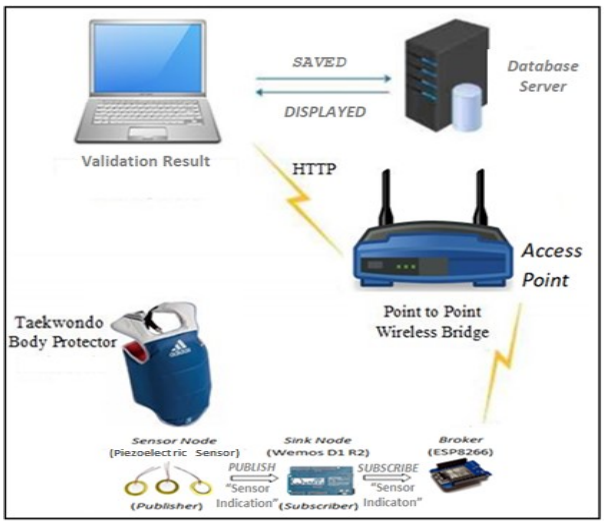

Fig.2. Network Architecture

Give an indication "no point" if the value of the power of the stroke or kick produced is 100 ADC to 699 ADC. Where the punch or kick energy produced by Taekwondo Athletes at 100 ADC to 699 ADC does not cause a loud enough sound to be heard by the referee in the Taekwondo Competition.

Give an indication of the "get points" if the value of the power of the punch or kick produced is 700 ADC to 1024 ADC. Where the energy of punches or kicks produced by Taekwondo Athletes at 700 ADC to 1024 ADC causes a fairly loud sound to be heard by the referee at the Taekwondo Competition.

Based on research conducted by [4] the ADC value can be converted into Volts which are usually used to measure electrical voltage units, according to the working principle of the ADC is to convert analog signals into a quantity which is the ratio of the ratio of the input signal to the reference voltage, with the following equation:

$$V = \frac{ADC}{\text{Max Value of ADC}} \text{ x Reference Voltage} \quad (1)$$

Information:

V = Volt, SI (International Standard) unit for measuring the difference in electric voltage. 1 Volt, which means the difference in the voltage required to make a current exactly 1 Ampere in a circuit with a resistance of 1 Ohm.

ADC = Analog To Digital Converter, the unit of value for conversion from digital signals to digital signals.

Max Value Of ADC = The maximal value of the ADC.

Reference Voltage = The reference voltage value is the available power supply, which is in the form of volts. An example of the reference voltage value used in this study is 5 volts, which is obtained from the power supply voltage of the microcontroller used, namely Wemos D1 R2.

Then according to [5] Volts can be converted into units of energy usually used for punches or kicks, namely Joules, with the following equation:

$$J = V \text{ x } C. \quad (2)$$

Information:

J = Joule, the SI (International Standard) unit for measuring energy. 1 Joule is the number of Watts for 1 seconds.

V = Volt, SI (International Standard) unit for measuring the difference in voltage. 1 Volt, which means the difference in the voltage required to make a current exactly 1 Ampere in a circuit with a resistance of 1 Ohm.

C = Coulomb, SI (International Standard) unit for measuring electric charge. 1 Coulomb is the amount of electric charge carried by a current of 1 Ampere flowing for 1 second.

III. RESULT AND IMPLEMENTATION

In this chapter, the results and implementation of sensor nodes, sink nodes and web servers are described as well as the test results for the entry point validation system.

Piezoelectric sensor serves as a sensing / detecting on the body protector in the area targeted by a blow or kick by a taekwondo athlete. The sensor node implementation looks like Figure 3 and Figure 4.

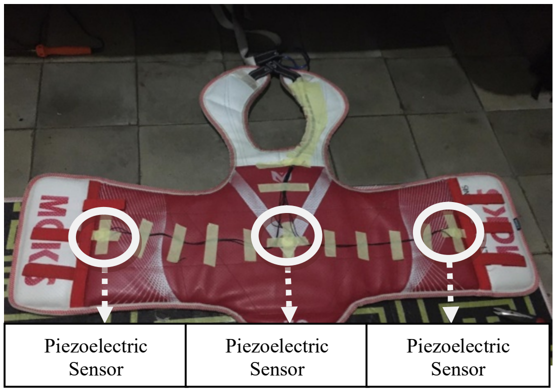

Fig.3. Implementation of Sensor node (in)

Fig.4. Implementation of sensor nodes outside

In Figure 4 there is a body protector that has been used by Taekwondo athletes, where on the inside of the body protector there is a sensor node in the form of a Piezoelectric Sensor which is marked with a white circle with a dotted line arrow.

The sink node implementation consists of a Wemos D1 R2 microcontroller equipped with a Wi-Fi ESP8266 module inside and a power bank as a power supply. The Wemos D1 R2 microcontroller is in charge of receiving hit or kick data from the sensor node and then converted into validation data for the entry of points based on the power value. The ESP8266 Wi-Fi module is in charge of sending validation data for the entry of points from the Wemos D1 R2 Microcontroller to the web server.

The following Figure 5 and Figure 6 are a sink node implementation consisting of a Wemos D1 R2 Microcontroller equipped with a Wi-Fi ESP8266 module.

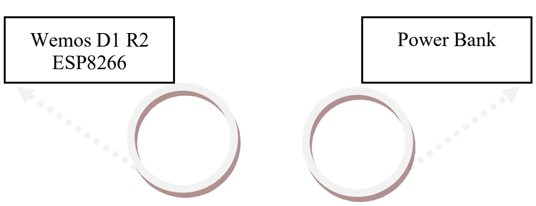

Fig.5. Implementation of a sink node

Fig.6. Implementation of Sink node

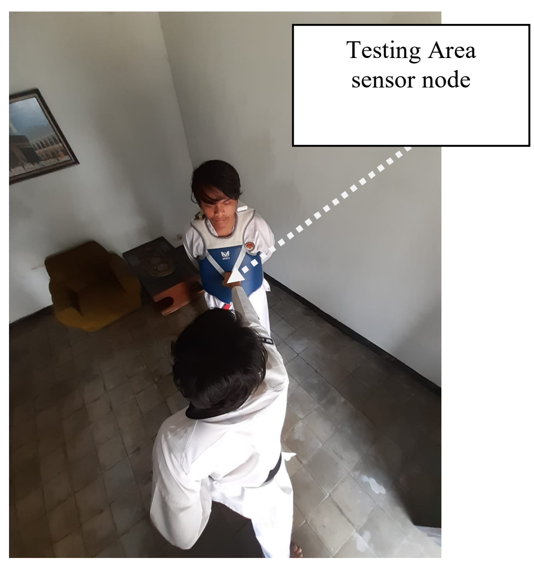

Fig.7. Front-punched sensor node test

In Figure 6, there is a body protector that has been used by Taekwondo athletes, where at the top left of the body protector there is a sink node in the form of Wemos D1 R2 and ESP8266 and at the top right of the body protector there is a Powerbank as a power supply which is marked with a white circle with a dotted line arrow.

Sensor node testing is an experiment on the sensor node when sensing and sending data to the sink node. The sensor node testing looks like Figure 7 and Figure 8.

Fig.8. Front Kicked sensor node test

In Figure 7 and Figure 8, it can be seen that the test area (see white arrow with dotted line) is a detected punch or kick. If the sensor node is tested using a punch or kick produced by a Taekwondo athlete, the data is sent to the sink node.

Fig.9. Sink node test

Based on Figure 9, to get a valid test, the test was carried out 2 times, with the result 1 times "Get Points" and 1 times "No Points". It can be seen in Figure 4 that the code "200" describes "OK" which means successfully sent. Where the delivery implements the Hypertext Transfer Protocol (HTTP), there are 2 times "acknowledge" or answers from the server which previously received requests and responses from the client, so the total packet delivery in the Hypertext Transfer Protocol (HTTP) Protocol is 4 times delivery. If the power value is 100 ADC to 699 ADC then it says "No Point" and if the power value is 700 ADC to 1024 ADC then it says "Get Point", and if the power value is below 100 ADC then it is not considered a hit or kick. The ADC value is converted into Volts which are usually used to measure the unit of electric voltage using equation (1) then converted again into units of energy usually used for punches or kicks, namely Joule using equation (2).

Fig.10. Web Sever Test

Based on Figure 10, to get a valid test, the test was carried out 7 times, with the result being 1 times "Get Point" and 6 times "No Point". It can be seen on the web server testing web page, it is found that the monitoring data results from the validation of the inclusion of sensors based on the power value are successfully sent to the web server completely.

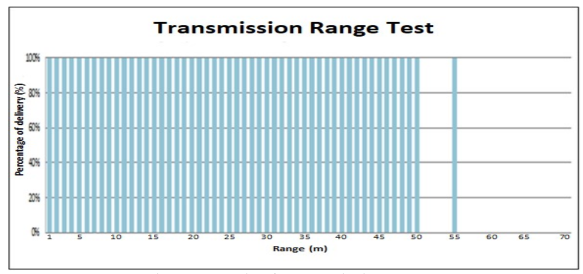

Fig.11. Graph of Transmission Range Test

Based on Figure 11 is the result of testing the transmission range, to get a valid test, the transmission range test is carried out 30 times at 70 distance points using units of meters, so that the total test is 2100 times. If the percentage value of sending shows 100% then the data is sent otherwise if it shows 0% then the data is not sent. At a test distance above 50 m to 70 m, it is only sent once at a distance of 55 m with a 100% percentage of delivery and most of it is not sent, this is because the distance is too far and the network is inadequate for the Wemos D1 R2 microcontroller with an access point.

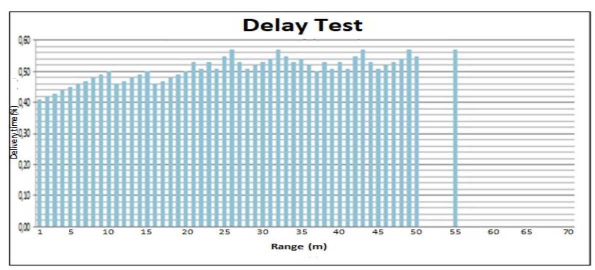

Fig.12. Graph of Delay Test

In Figure 12 Graph of Delay Test Results, it can be seen that at a distance of 1 m to 10 m and 11 m to 15 m, the farther the node is, the longer the server receives data from the sink node and vice versa the closer the sink node and the server are, the faster it is. Also sending data and delay seen regularly increasing with an average interval of 0.2 s. Then it can be seen that at a further distance the delay increases and decreases irregularly, this is due to a bad network factor caused at the test site being carried out in the home page being disturbed by surrounding objects such as passing vehicles. For test distances above 50 m to 70 m, it is only sent once at a distance of 55 m with a delivery time of 0.57 s and most of it is not sent, this is because the distance is too far on the Wemos D1 R2 microcontroller with an access point. the delay test is carried out 30 times at 70 distance points using units of meters, so that the total test is 2100 times.

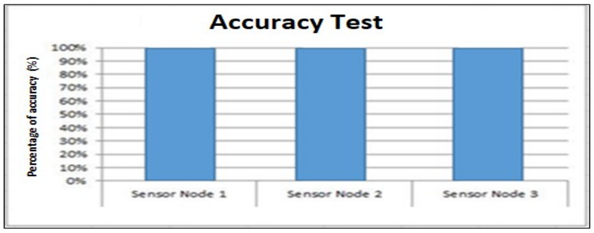

Fig.13. Graph of Accuracy Test

Based on research that has been conducted by [6] to measure the percentage of accuracy of the results of sending and receiving data on each overall test using the following equation:

$$Accuracy = \frac{\text{Character entered and correct}}{\text{Total character}} \text{ x } 100\% \tag{3}$$

$$= \frac{120}{120} \text{ x } 100\% \tag{4}$$

$$= 100\% \tag{5}$$

In Figure 13, the accuracy level test is carried out 120 times, which uses 3 sensor nodes, each of which is 40 times tested. If the number of characters that are entered and correct (data received by the web server) is 120 divided by the total data, which is 120 then multiplied by 100%, then the test results are 100% accuracy. From the results of this level of accuracy testing, it was found that the system in detecting punches or kicks from Taekwondo athletes used test data on 3 piezoelectric sensors as sensor nodes, to obtain valid test results, each sensor node was tested 40 times, with a sink node distance to access point 30 m. So that for the total test, the accuracy level is 120 times.

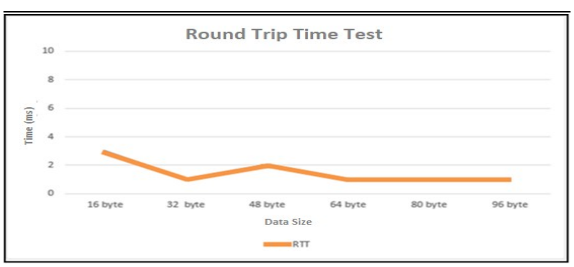

Fig.14. Graph of RTT Test

Based on Figure 14, it can be seen that the time required by the broker and sensor node when conducting the request-response process using the MQTT protocol is quite stable. Because, even though there is a difference in the time needed during the request-response process, the time difference that occurs is not that large. The results show that there are 4 variations in the size of the data which only take 1 ms, while the other 2 take 3ms and 2ms. The test results also prove that the size of the data affects the time taken during the request-response process.

QoS (Quality of Service) testing is carried out in order to determine the quality of the MQTT protocol in providing data communication services, which include parameters of jitter, delay, throughput and packet loss. In QoS (Quality of Service) testing to obtain the results, the calculation of delay, jitter, throughput and packet loss is calculated manually. In the parameter calculation of the delay in data transmission, the sensor node publishes the data to the broker with a time delay of 1 second 10 times. Tests are carried out using different data size variations, namely, 16 bytes, 32 bytes, 48 bytes, 64 bytes, 80 bytes and 96 bytes, this is done to determine the time (seconds) of each incoming data. After getting the results of the time lag shift from the delay test, the next step is to test the jitter or delay variation. In the throughput test, the sensor node sends data packets to the broker for 10 seconds with different data size variations, namely, 16 bytes, 32 bytes, 48 bytes, 64 bytes, 80 bytes and 96 bytes. Then after the throughput test, the next test is packet loss using the MQTT protocol which is carried out 20 times the data publishing process with the sensor node.

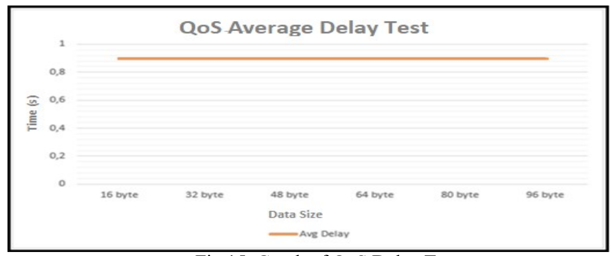

Fig.15. Graph of QoS Delay Test

Based on Figure 15, it can be seen that the delay that occurs is very stable. The delay test is carried out using the MQTT protocol when the sensor node publishes the data to the broker. The test results prove that the MQTT Protocol can maintain data transmission delay that has been given to the sensor node very well, namely 0.9 which indicates that there is no delay shift that occurs when data transmission is carried out using the MQTT protocol and is obtained using equation:

$$Delay = \frac{Packet\ Lenght}{Bandwith} \tag{6}$$

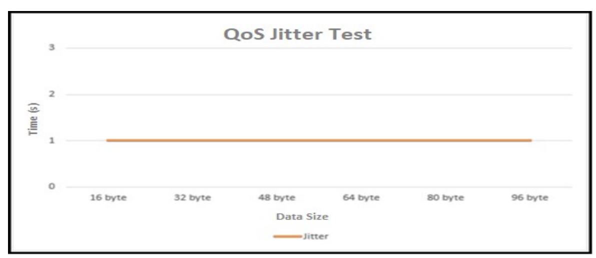

Fig.16. Graph of QoS Jitter Test

Based on Figure 16, it can be seen that the jitter test is very good using the MQTT protocol, which produces a time of 10 seconds with different data sizes (16, 32,48, 64, 80, and 96 bytes). This test is carried out with the same total data transmission time for each data size, which is 10 seconds. The amount of data that can be transmitted by the sensor node at the broker using the MQTT Protocol is very stable. This is evidenced from Figure 17 throughput test results which show, the increasing amount of data that can be sent by the sensor node at the broker using the MQTT protocol is obtained using equation:

$$Troughput = \frac{\text{Data received}}{\text{Lenght Observation}} \tag{7}$$

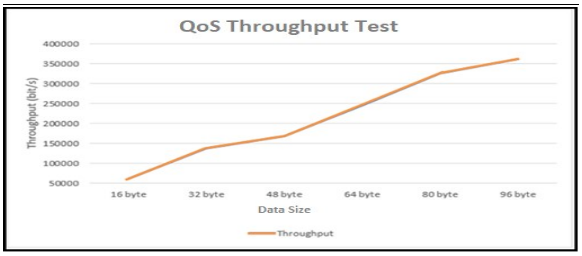

Fig.17. Graph of QoS Throughput Test

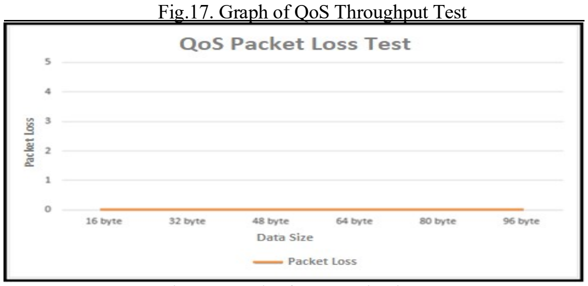

Fig.18. Graph of QoS Packet loss Test

Based on Figure 18, packet loss can be seen that the MQTT protocol can handle data packet transmission very well, which results in not a single packet loss or packet loss during the data transmission process based on different data sizes (16, 32, 48 , 64, 80, 96 bytes) using the MQTT Protocol and obtained using equation:

$$\text{Packet loss} = \frac{\text{Data sent} - \text{Data received}}{\text{Data sent}} \text{ x } 100\%. \quad (8)$$

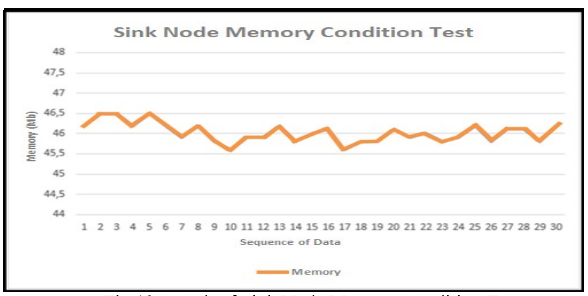

Fig.19. Graph of Sink Node Memory Condition Test

From the test results in Figure 19, it can be seen that the remaining memory condition of the sink node when using the MQTT protocol with unstable results. Even so, this does not cause the data transmission process to be slow and does not cause loss of data sent. Because the sink node can still send 30 data when sending data, the memory condition remains at the broker for one minute with a time lag of 2 seconds. Data transmission is carried out for 1 minute with a time lag of 2 seconds, which is sent to the broker 30 times on testing the remaining memory condition of the sink node.

IV. Conclusion

This research has successfully designed and realized Wireless Sensor Network (WSN) system on validating the entry of points using communication transmission protocol Hypertext Transfer Protocol (HTTP) and Message Queue Telemetry Transport (MQTT). Based on the test results 2100 times, it is known that a sink node with a distance of 50 m from the access point has an accuracy rate of 100% and successfully sends data every 0.5 seconds to the web server and then stored in the database. In QoS testing with parameters of delay, jitter, throughput and packet loss it can provide good network services, shown by the results of very stable delay and jitter parameters, increasing throughput indicates that more data can be sent, and there is no packet loss. . Then the memory condition parameter affects the faster and more stable data transmission from the sensor node to the broker, so that the validation of the entry of points results in less delay and more stability. In the WSN system, the sending process from the sensor node to the sink node / broker uses the MQTT Protocol, then the sending process continues from the sink node to the web server using the HTTP protocol. This is because the MQTT Protocol excels at sending data detected by sensor nodes, while the HTTP protocol excels at sending documents received by the sink node and then sending it to the web server. Therefore, WSN makes it possible to obtain validation information for the entry of points at Taekwondo competitions.

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