Implementation Internet Of Things For Monitoring Water Quality System of Koi Fish Ponds

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Abstract—Koi fish is one of the ornamental fish that is in great demand and has a fairly high price. Water quality plays an important role in the success of keeping koi fish. The quality of koi fish water must be at an ideal temperature of 25-30°C and an acidity level or pH of 7-8 pH. The level of salt contained in water for koi fish must also be considered. A pond with a size of 200 x 50 x 100 cm requires a salt content of 1 to 2 ppm. Giving this salt is done to prevent the growth of bacteria in the koi pond which can come at any time. Ignorance of pond owners about the value and condition of water quality can disrupt the health of koi fish which can cause death. Based on these problems, the authors created a water quality monitoring system in koi fish ponds. The system created consists of a pH sensor, temperature sensor, and salinity sensor, and uses the Message Queuing Telemetry Transport (MQTT) protocol. The process of sending data to the IoT platform using a WiFi network. Based on the temperature sensor test, there is an average error of 1.4% with a sensor accuracy level of 98.6%. Testing the pH sensor and salinity sensor using the linear regression method. As for the pH sensor, the average error is 2% with an accuracy rate of 98%. The results of the salinity sensor test obtained an average error value of 7.6% with an accuracy rate of 92.3%. Then in the MQTT protocol, the parameters for delay and jitter have a bad category, while throughput has a moderate category, and packet loss has a very good category according to the TIPHON standard.

Keywords— Monitoring, Water quality, Koi Fish, MQTT, Internet of Things

1. Introduction

Koi fish is one type of ornamental fish that is in great demand, and has a relatively high price. To ensure koi fish can grow healthily and develop properly, pond water quality plays a very important role. Therefore, maintaining pond water quality in koi fish rearing is an important factor and must be considered [1].

According to the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia (2018), koi ornamental fish production dominated in 2015-2019 even though it had experienced a decline in production in 2018. Koi fish production in 2015 reached 392,372.3 thousand heads then increased in 2016 to reach 404,329.1 thousand heads, in 2017 reached 560,819 thousand heads, and had decreased production in 2018 to 476,345.9 thousand heads. The development of koi fish production has increased again in 2019 reaching 523,775 heads from the production target of 350,000 heads [2].

In the context of fish farming, temperature plays a very important role. If the temperature is too high, the fish will have an increase in respiratory rate, so the need for oxygen will also increase. In addition, the fish will also produce more impurities, which adversely affects the quality of the water in the pond. The ideal temperature for koi fish growth is between 25 to 30°C. If the temperature exceeds these limits, it can weaken the endurance of the fish. In addition to temperature, the pH level in the pond also affects the growth of koi fish, and the ideal pH is between 7 to 8 [3]. In addition, salt levels in koi ponds affect the survival of these fish [4].

The research aims to design, test, and implement an Internet of Things-based koi pond water quality control and monitoring system. This includes testing temperature, pH, and salinity sensors, as well as evaluating parameter values such as delay, jitter, throughput, and packet loss in sending data from the microcontroller to the user.

2. Literature Review

2.1. State of The Art

Research [5] discusses handling water quality in IoT-based koi fish ponds using information in the form of temperature, pH, and salinity values. There is an automatic control system for pH values and temperature values. Sensor reading data from each sensor is accessed via telegram. This research has not used internet service quality measurements to find out whether the quality of internet service from hardware to Telegram is good or not.

Next, Research [6] discusses the IoT-based water quality control and monitoring system in koi ponds using information in the form of temperature and pH values. This research only focuses on the temperature control system in koi ponds for the pH value of the water, there is no control but only monitoring. In this research, we measure the quality of internet services using distance analysis to find out the differences in measurements for each distance. The parameters measured are delay and throughput, but not using a protocol.

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Next Research [7], this research aims to determine the quality of koi fish pond water with temperature and pH parameters. Using an ESP32 microcontroller to send and receive data from pH and water temperature sensors, using a control system to drain and fill water in the pond. There is no control system for temperature and pH values, only monitoring is carried out at Thingspeak and does not measure the quality of internet services for sending data.

The next research [8] discusses monitoring temperature and water levels in IoT-based ornamental fish aquariums. There is a control and monitoring system for temperature and ultrasonic sensors, monitoring the data obtained is in the telegram bot. Using ESP8266 for the microcontroller, WiFi is used for the data transmission network. However, this research has not yet measured the quality of internet services for sending data.

2.2. Koi (Cyprinus Carpio)

Koi is an ornamental fish from Japan, which has now become one of the fish that is widely cultivated in Indonesia. This fish is very popular because of its beauty and variety of attractive colors. Apart from that, in some Indonesian communities, koi fish are also believed to bring good luck[9]. The ideal temperature for growing koi fish is between 25 to 30°C. If the temperature exceeds this limit, it can weaken the fish's resistance. Apart from temperature, the pH level in the pond also influences the growth of koi fish, and the ideal pH is between 7 and 8 [3].

The characteristics of koi fish that are in healthy condition can be seen from their agile and active movements when responding to food. On the other hand, koi fish that are not in good health will show slow movements and be less responsive to food[10]. The benefit of adding fish salt to koi fish ponds is that it prevents the growth of bacteria in koi ponds which can come at any time. Providing salt affects koi fish being attacked by bacteria, the higher the salt content in the water, the fewer parasites will attack the fish [6].

Fig. 1. Koi (Cyprinus Carpio) [11]

2.3. Internet Of Things

IoT is the latest technological innovation that allows internet access to intelligently recognize objects regarding their behavior. In general, IoT reflects the concept of network devices that can collect data from around the world, and then share that data over the internet for processing and use for various purposes. With IoT, objects can be connected via an internet connection, allowing them to share information and run automated processes[12].

IoT architecture consists of 4 aspects, the first aspect is devices consisting of IoT devices, such as sensors, smart devices, and devices that can be connected to the internet[12]. This device can communicate with networks and communication protocol services. Then the second aspect, namely the network, consists of a network of devices and technology that allows tools to communicate with the internet. Some of the network protocols used in IoT include WiFi, Bluetooth, ZigBee, and LoRaWAN[13]. Then the third aspect is that the platform consists of software and services that function to manage data that has been collected by IoT devices and provide services. Then the fourth aspect, namely the application, consists of services that are used to process and analyze data on IoT devices, thereby enabling users to monitor, control, and automate IoT devices[14].

Fig. 2. IoT Architecture[14]

3. Research Method

3.1. System Design

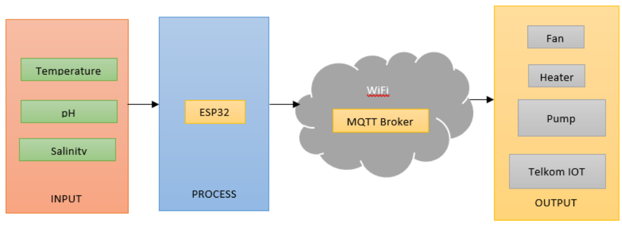

Fig. 3. System Design

In Fig 3. the system design contains 3 stages, namely the input stage, process stage, and output stage. Each stage has a different function and different components too. The input stage consists of 3 components, namely a temperature sensor, pH sensor, and salinity sensor.

In this research, a temperature sensor, namely DS18B20, was used. This sensor has a temperature measurement range of -55-150°C. With this range, the DS18B20 sensor is suitable for research purposes, namely as a water temperature meter in koi fish ponds, where the optimal temperature value is in the range of 25-30°C.

The salinity sensor used in this research is to measure the salt content in koi pond water. Next, there is a pH sensor which is used to measure the degree of acidity in koi pond water. This sensor has a pH measurement range of 0-14. With this range, the pH sensor is suitable for research needs, namely as a pH meter in koi pond water, where the optimal pH is in the range 7-8.

The temperature sensor is used to measure the temperature of the koi pond water which will later provide a temperature output that will affect the on and off of the heater and fan used. The salinity sensor is used to measure the salt content in the koi pond water and output the salinity value which will affect the on and off of the fish salt pump.

Next, at this stage of the research process, an ESP32 microcontroller is used to carry out data processing functions and to create an internet connection. Then after all the blocks are connected and running according to their function, before the last block there is the MQTT protocol which is an application layer network protocol that works on top of the TCP/IP stack.

In the output block, there is a fan, heater, fish salt pump, and Telkom IoT. Heaters and fans are used to increase and decrease the temperature of the koi fish pond water according to predetermined parameters. Fish salt pumps are used as pumps to add fish salt to koi pond water. The measurement data results will be stored on the platform, namely Telkom IoT.

System testing is carried out by taking data from readings of temperature, pH, and salt levels in the koi fish pond. Testing the temperature sensor, if the temperature value is >30°C then the fan will work but if the water temperature is <25°C then the heater will work. Testing the salinity sensor, if the salt level is less than the specified limit then the fish salt pump will work.

3.2. Temperature Sensor Testing Scenario

Testing the accuracy level of the DS18B20 sensor was carried out to find out how accurate the DS18B20 sensor was that the author would use in developing an IoT-based koi pond water quality monitoring tool. The test consists of comparing the temperature value and the value read by the DS18B20 sensor with a measuring instrument, namely a thermometer, as a reference. Temperature data collection for testing the DS18B20 sensor was carried out using 3 conditions, namely water with temperatures of 8°C, 28°C, and 35°C. The first treatment was to place the DS18B20 sensor with a thermometer in a glass containing cold water with a temperature of 8°C, then the test was carried out by placing it in water with a temperature of 28°C, and water with a temperature of 35°C.

3.3 PH Sensor Testing Scenario

PH sensor testing is carried out by knowing the ADC value first, then the ADC value is entered into the linear regression equation to get the appropriate PH value. After the linear regression operation has been carried out, the linear regression equation above is entered into the program, and tests are carried out on the sensor and pH meter measuring instrument. Tests were carried out with different pH values, namely 3.5, 4.7, and 7 with 30 data being carried out for each test. The first treatment is to place the pH sensor with a pH meter in a glass containing water with a pH of 3.5, then the test is carried out by placing it in water with a pH of 4.7, and water with a pH of 7.

3.4 Salinity Sensor Testing Scenario

Testing the accuracy level of the salinity sensor was carried out to find out how suitable the salinity sensor was to be used in developing an IoT-based koi pond water quality monitoring tool. Where in this test we use data before using the linear regression method and data that has already used linear regression. The test consists of comparing the concentration value and the value read by the salinity sensor with a measuring instrument, namely a refractometer as a reference with salinity values of 0.1, 1, and 5 ppm

3.5 QoS Testing Scenario

Testing service quality for sending data from ESP32 to Telkom IoT using parameters including delay, jitter, throughput, and packet loss[15]. The size of the data package from the temperature sensor, pH sensor, and salt content sensor has different sizes. QoS testing on the publish method used to send data to the MQTT Broker. Fig 4 is a description of the publish method test scenario. Using Wireshark software to measure the quality of service on the network used by the system in the koi fish pond, the laptop was used as an access point.

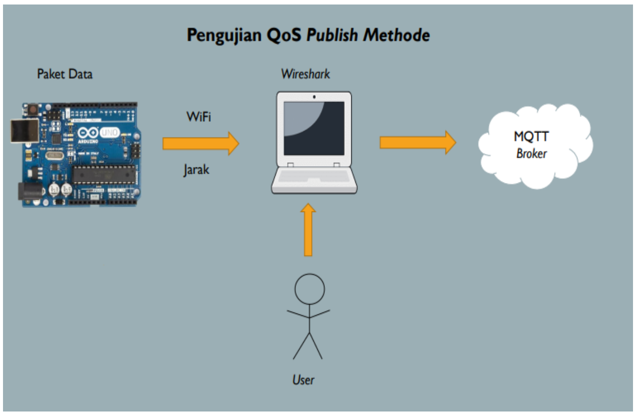

Fig. 4. QoS Testing Scenario

4. Result And Analysis

4.1. System Design Result

Fig 5. is the result of system design including hardware design and software design, including the IoT platform, namely Telkom IoT.

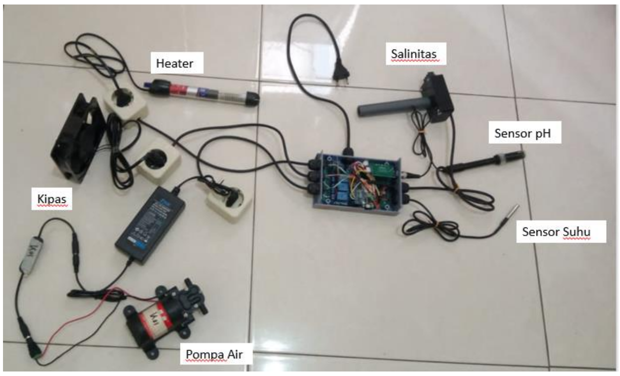

Fig. 5. System Design Result

The flow of this monitoring system starts from the hardware where the DS18B20 sensor will read the pool water temperature value in degrees Celsius, the salinity sensor reads the salt content value in the pool water and the pH sensor reads the pH value in the pool water. The value that has been read by the sensor will be processed by the NodeMCU ESP 32 which will then determine whether the heater, fan, and fish salt pump are on or not. Furthermore, the information provided by the sensors will be sent via the platform, namely Telkom IoT, in real-time. Apart from that, salinity sensor and pH sensor data are also calculated using the linear regression method.

Fig 6. is a test of data to Telkom IoT. The aim is to ensure that the data read on the temperature sensor, pH sensor, and salinity sensor can be sent to Telkom IoT. The data sent is pH value, temperature value, salinity value, heater, fan, and pump status.

Fig. 6. Data on IoT Platform

4.2. Temperature Sensor Testing Result

Based on the results of test data for water with a temperature of 8°C, the average error result was 2.7% and the accuracy level was 97.3%, then for water with a temperature of 28°C, the average error result was 0.4%. and the accuracy level was 99.6% for water with a temperature of 35°C, the average error result was 1.1% and the accuracy level was 98.9%. Furthermore, the total error result was 1.4% and the accuracy level was 98.6%. With the results obtained, it can be said that the DS18B20 sensor can read temperature values well. Graph of accuracy and error temperature sensor can be seen in Fig 7. and Fig 8

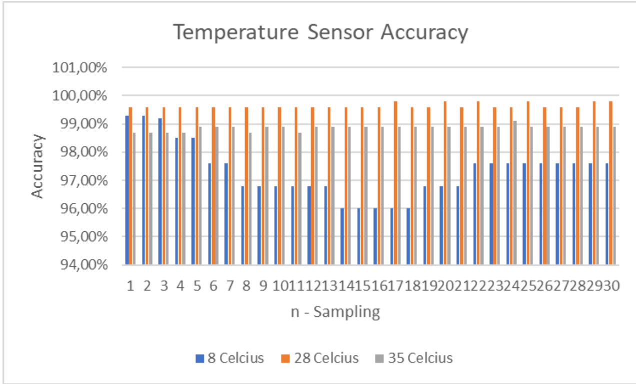

Fig. 7. Temperature Sensor Accuracy Result

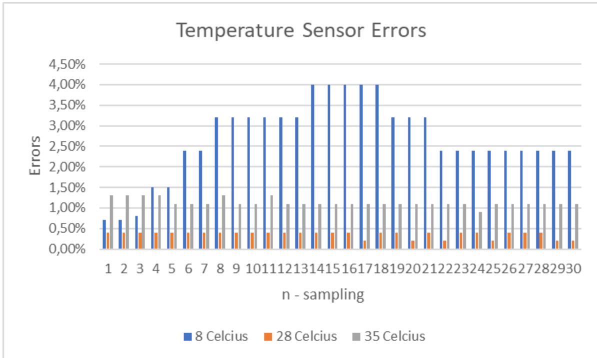

Fig. 8. Temperature Sensor Error Result

4.3. PH Sensor Testing Result

Based on the pH sensor test results, it is known that the pH value is 7 with an average error of 1.7% and an accuracy of 98.3%. The results obtained can be said to be good because the error is less than 5%. Based on the results of test data for water with a pH of 3.5, the average error result was 2.4% and the accuracy level was 97.6%, then for water with a pH of 4.7, the average error result was 1.9%. and the accuracy level was 98.1% for water with a pH of 7 the average error result was 1.7% and the accuracy level was 98.3%. Furthermore, the total error result was 2% and the accuracy level was 98%. With the results obtained, it can be said that the pH sensor can read pH values well. Graph of accuracy and error PH sensor can be seen in Fig 9. and Fig. 10.

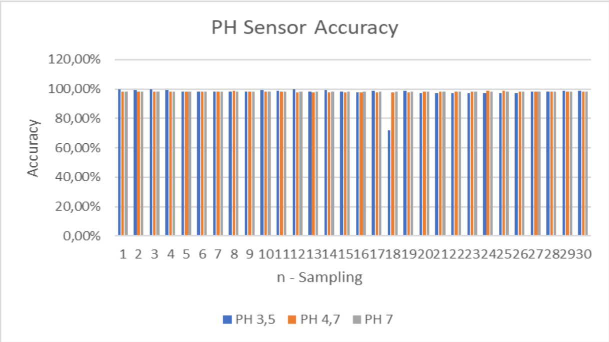

Fig. 9. PH Sensor Accuracy Result

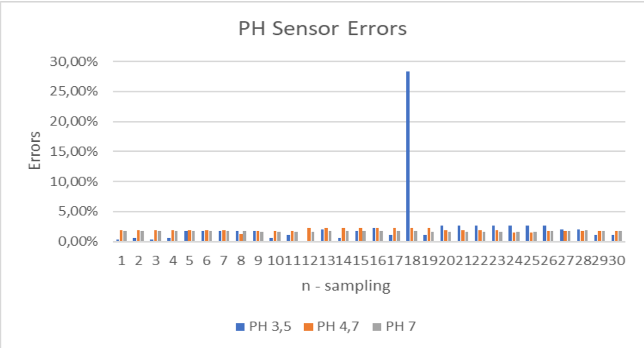

Fig. 10. PH Sensor Error Result

4.4 Salinity Sensor Testing Result

Based on the test results of the salinity sensor with a salinity value of 0.1 ppm with an average error of 2.8% and an accuracy of 97.2%. With the results obtained, it can be said to be good because the error is no more than 5%. Based on the results of test data for water with a salt content of 0.1 ppm, the average error result is 20% and the accuracy level is 80%, then for water with a salt content of 1 ppm, the average error result was 2.8% and the accuracy level was 97.2%, and for water with a salt content of 5 ppm, the average error result was 0.2% and the accuracy level was 99. 8%. Furthermore, the total error results obtained were 7.6 and the accuracy level was 92.3%. Graph of accuracy and error Salinity sensor can be seen in Fig 11. and Fig. 12

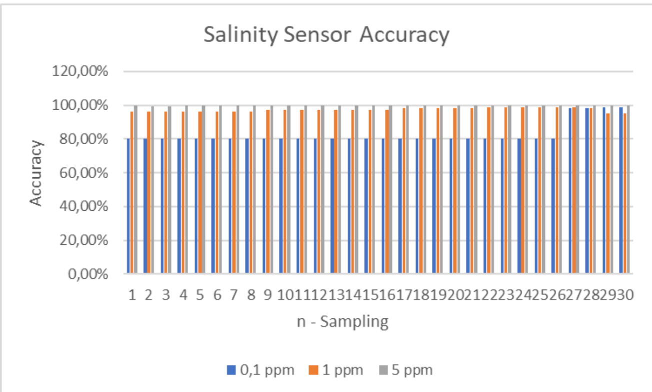

Fig. 11. Salinity Sensor Accuracy Result

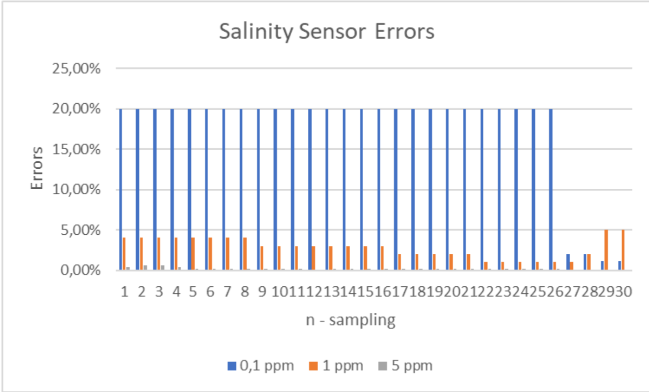

Fig. 12. Salinity Sensor Error Result

4.5 QoS Testing Result

The results of network service quality testing data were obtained using the Wireshark analyzer application using the MQTT protocol. They were using a distance variation testing scheme of 1.5 meters, 6 meters, and 13 meters. The parameters analyzed are delay, packet loss, throughput, and jitter.

4.5.1. Delay Result

Delay is the time required to send data from the sender to the recipient. The delay results from the Wireshark application are exported in CSV format. They were tested at varying distances, namely 1.5 meters, 6 meters, and 13 meters. Using 81 data packets sent with a total delay for a distance of 1.5 meters the results were 106.899776 seconds, for a distance of 6 meters the results were 93.991357 seconds and for a distance of 13 meters the results were 100.715566 seconds. Table 2.23 is the result of delay measurements with distance information of 1.5 meters, 6 meters, and 13 meters.

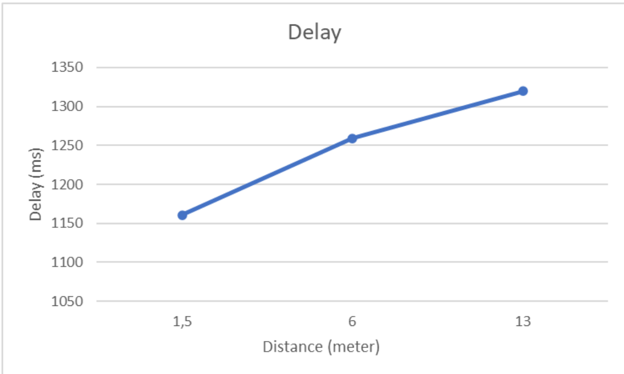

Fig. 12. Delay Testing Result

4.5.2. Troughtput Result

Throughput is the amount of data that can be sent or received in one unit of time. Based on the measurement results, a distance of 1.5 meters shows results of 1,110 kilo bit/s, a distance of 6 meters shows results of 1,090-kilo bit/s and a distance of 13 meters shows results of 1,061-kilo bit/s, seen from throughput measurements with different distance results throughput also did not experience much change. This shows that distance does not affect this test. Based on the TIPHON standardization at distances of 1.5 meters, 6 meters, and 13 meters, it gets the "Enough" category.

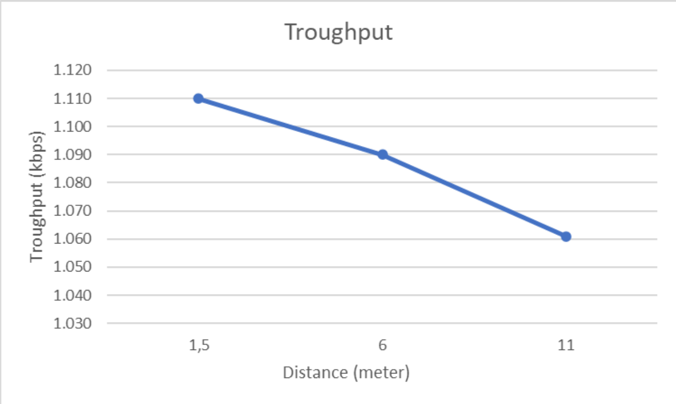

Fig. 13. Throughput Testing Result

4.5.3. Jitter Result

Jitter shows variations in delay in sending data on a network. Based on the results of measurements at a distance of 1.5 meters, it shows a result of 618.6 ms, for a distance of 6 meters it shows a result of 755.1 ms and for a distance of 13 meters it shows a result of 876.4 ms, judging from jitter measurements at different distances, the jitter results also do not experience much change. This shows that distance does not affect this test. Based on the TIPHON standardization at distances of 1.5 meters, 6 meters, and 13 meters it gets the "Bad" category.

Fig. 14. Jitter Testing Result

4.5.4. Packet Loss Result

Packet loss is the percentage of packets lost during data transmission. Based on the measurement results at a distance of 1.5 meters, no packet loss occurred with results reaching 0%. The same thing happened at distances of 6 meters and 13 meters, where the test results also showed packet loss of 0%. Interestingly, this packet loss measurement does not change even with different distance variations. Viewed from the perspective of TIPHON standardization, the measurement results at distances of 1.5 meters, 6 meters, and 13 meters are included in the "Very Good" category. This indicates that performance

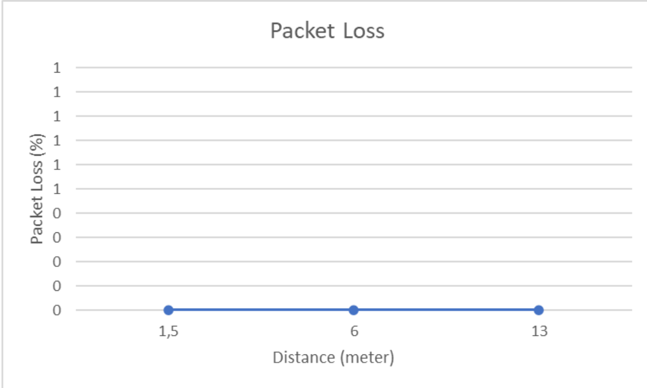

Fig. 15. Packet Loss Testing Result

5. Conclusion

The implementation of a koi pond water quality monitoring and control tool, utilizing Internet of Things (IoT) technology, has yielded positive outcomes. The results indicate the successful design and testing of the system. In the evaluation of individual sensors, the temperature sensor demonstrated an average error of 1.4%, accompanied by a commendable sensor accuracy rate of 98.6%. Similarly, the pH sensor, employing the linear regression method, exhibited an average error of 2% and an accuracy level of 98%. Meanwhile, the salinity sensor showcased an average error of 7.6%, with a respectable accuracy level of 92.3%. Furthermore, the quality of service assessment, conducted through the MQTT protocol, revealed varying performance across parameters. In evaluating the quality of service using the MQTT protocol, parameters such as delay and jitter are assessed as low, while throughput reaches the medium category, and packet loss is in the very good category according to the TIPHON standard. Therefore, to increase system effectiveness, improvements to sensor accuracy and protocol service quality need to be prioritized in an effort to optimize overall monitoring and control of koi pond water quality.

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References

[1] R. Fakhriza, B. Rahmat, and S. Astuti, "Perancangan Dan Implementasi Alat Monitoring Dan Controlling Kualitas Air Pada

Kolam Ikan Koi," *e-Proceeding Eng.*, vol. 8, no. 5, pp. 5274–5289, 2021.

[2] D. J. P. Budidaya, "Laporan Kinerja Direktorat Jenderal Perikanan Budidaya Kementrerian Kelautan dan Perikanan 2018," 2018.

[3] A. M. S. Danang Haryo Sulaksono, "Sistem Monitoring dan Kontrol Otomatis Untuk Budidaya Ikan Koi Dengan Parameter Suhu dan pH Berbasis Internet of Things (IoT)," *J. Semin. Nas. Tek. Elektro, Sist. Inf. dan Tek. Inform.*, pp. 91–96, 2021.

[4] H. Winarno, R. Wiliyanto, V. Nurhayuni, and E. Isnawati, "Pemberdayaan Masyarakat Melalui Pengembangan Budidaya Ikan Air Tawar di Sekitar Aliran Sungai Yang Rentan Terjadi Banjir," vol. 1, no. 2, pp. 89–97, 2023.

[5] R. K. Putra Asmara, "Rancang Bangun Alat Monitoring Dan Penanganan Kualitas Ait Pada Akuarium Ikan Hias Berbasis Internet Of Things (IOT)," *J. Tek. Elektro dan Komput. TRIAC*, vol. 7, no. 2, pp. 69–74, 2020, doi: 10.21107/triac.v7i2.8148.

[6] A. H. G. Akbar, A. T. Hanuranto, and U. U. Kurniawan, "SISTEM PINTAR BERBASIS INTERNET OF THINGS (IoT) UNTUK KOLAM IKAN KOI," *e-Proceeding Eng.*, vol. 7, no. 2, pp. 4235–4243, 2020.

[7] S. Y. Damayanti, T. Andriyanto, and A. Ristiyawan, "Sistem Monitoring Kualitas Air Tambak Ikan Koi (Cyprinus carpio) Berbasis Teknologi of Things (IOT)," *Semin. Nas. Inov. Teknol.*, pp. 141–147, 2021.

[8] P. Wijaya and T. Wellem, "Perancangan dan Implementasi Sistem Pemantauan Suhu dan Ketinggian Air pada Akuarium Ikan Hias berbasis IoT," *J. Sist. Komput. dan Inform.*, vol. 4, no. 1, p. 225, 2022, doi: 10.30865/json.v4i1.4539.

[9] A. Iskandar, D. Amalia, H. S. Aji, A. Hendriana, and G. M. Darmawangsa, "Optimalisasi Pembenihan Ikan Koi Cyprinus rubrofuscus di Mina Karya Koi, Sleman, Yogyakarta," *SIGANUS J. Fish. Mar. Sci.*, vol. 3, no. 1, pp. 154–159, 2021, doi: 10.31605/siganus.v3i1.1029.

[10] A. Hendriana, F. Ridwansyah, A. Iskandar, A. S. Munawar, and D. Lugina, "Metode Pembenihan Ikan koi Cyprinus carpio dalam menghasilkan benih berkualitas di Mizumi Koi Farm, Kabupaten Sukabumi, Jawa Barat. Method," *J. Penelit. Pertan. Terap.*, vol. 2, no. 1, pp. 17–26, 2023, doi: 10.25181/peranan.v2i1.2203.

[11] Minapoli, "Cara merawat Ikan Koi." https://api.minapoli.com/media/infomina (accessed Feb. 02, 2024).

[12] A. E. I Ketut, M. A. Afandi, H. Pujiharsono, F. N. Gustiyana, H. Krishna, and F. H. Juwono, "Implementation and Analysis of the Internet of Things System for Electrical Energy Monitoring At Institut Teknologi Telkom Purwokerto," *J. Tek. Inform.*, vol. 4, no. 3, pp. 627–638, 2023, doi: 10.52436/1.jutif.2023.4.3.1027.

[13] M. Mansour *et al.*, "Internet of Things: A Comprehensive Overview on Protocols, Architectures, Technologies, Simulation Tools, and Future Directions," *Energies*, vol. 16, no. 8, pp. 1–39, 2023, doi: 10.3390/en16083465.

[14] I. K. A. Enriko, M. K. Dewi, S. Indriyanto, and F. N. Gustiyana, "Control and Monitoring System of Growing Media for Cucumber Plants Based on the Internet of Things," vol. 8, pp. 195–202, 2024, doi: 10.30865/mib.v8i1.7072.

[15] ITU-T, "G.1010: End-user multimedia QoS categories," *Int. Telecommun. Union*, vol. 1010, 2001, [Online]. Available: http://scholar.google.com.au/scholar?hl=en&q=ITU-T+Recommendation+G.1010&btnG=&as_sdt=1,5&as_sdtp=#7