Measurement performance quality of services (QoS) to optimizing on wireless sensor network topology for water pollution monitoring system

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Abstract. The problem of the need for clean water is very important. The several diseases triggered by poor water quality reach more than 200 cases each year and cause more than 5 million deaths worldwide. Thus, monitoring water quality becomes important for the availability of safe and clean water. Wireless sensor networks have become a promising alternative to adopted for supplementing the conventional monitoring process. This network allows measurements from the remote location in real-time and with little human intervention. Wireless sensor network topology performance will support the stability of real-time data transmission. The difference in network topology between each router-node station affects the disruption of data distribution. Quality of Services (QoS) measurement is based on wireless sensor connectivity in transmit sensor data from several parameters, including temperature, total dissolved solids, and pH in the node station to the website service. The delay in transmitting data affects the performance of the measurement of the water pollution monitoring system.

1. Introduction
Water is the source of life for every living thing. Diseases triggered by poor air quality reach more than 200 cases each year and cause more than 5 million deaths worldwide [1][2]. Water pollution is the presence of chemical, physical, or biological components or factors producing a condition or impairment of a given water body concerning some beneficial use[3]. Water quality can be defined as the suitability of water for certain needs based on chemical, biological, and physical elements. Therefore, water temperature is very important to ensure the sustainability of civilization [2], because temperature is influences on water chemistry. One of the challenges in measuring water quality is collecting large quantities of samples to ensure accurate and reliable analyzes [2]. In this case, it occurs in real-time, precise, and allows early information if there is water contamination [2].

Several parameters as a measure of water pollution, including total dissolved solids (TDS) and water temperature acidity (pH) [1][4]. For example, water quality pollution in rivers and residential areas can be monitored using a wireless sensor network (WSN) [1][5]. Wireless sensor networks have earned their place, as they provide a wide range of control applications in remote, real-time monitoring and minimal...
human intervention [2]. A WSN consists of hundreds to thousands of sensor nodes, which can communicate between them using a radio antenna [6][7]. Each node is usually small with limited processing power, memory, and energy resources [7][8]. Therefore, each node collaborates as a network to achieve a general goal of taking some predetermined parameter values [6].

The data delivery performance of each WSN node is affected by the quality of data traffic via the internet. The efficient configuration of WSN topology, internet, and data traffic quality will provide reliable real-time data accuracy information [9]. The high quality of QoS in real-time applications often leaves users dissatisfied with current network performance [10]. In this research, we purposed measurement performance of QoS with delay data transmission and bandwidth capture to improve QoS for developing WSN topology and routing optimization [9][10].

2. Method

2.1. Wireless sensor networks

WSN is a technology in which sensors and networks work together to enable communication using a wireless transceiver. Each of these networks has sensors. A sensor can detect, retrieve, process data, sense communication referred to as nodes in a WSN. Sensor nodes perform the computation of data that are not analyzed. So, the sensor node can function as the originator of the initial data before the data is processed [11].

2.2. Topology management techniques in WSN

Wired or wireless networks require monitoring and maintenance. This maintenance task service is called network management. According to the International Organization for Standardization (ISO), Network management includes five functional areas, including configuration management, error management, management security, performance management, and management accounting. The need for wireless networks such as WSN has created a new functional area, namely network topology management. The main objective of technical topology management in WSN is to maintain network connectivity and energy efficiency. This technique is used to track the state of communication between nodes, to save energy by shutting down multiple nodes without reducing network coverage and connectivity, to balance the load on existing nodes and links, or for monitoring scalability where each node operates without human intervention[11][12]. Topology management in a WSN can be done through deterministic node placement or done autonomously after deployment [12].

2.3. Quality of service (QoS)

QoS is the measure of service quality that the network offers to the end-user or application[8]. Several QoS parameters include fault tolerance, energy efficiency, bandwidth, packet loss, delay and jitter, throughput[8][10]. A reliable QoS guarantee is very important. However, the QoS quality of a wireless network will fluctuate due to interference from other transmission devices [10]. In general, the QoS that is considered is [13]:

1. Latency, is defined as the delay experienced by a packet until it reaches the destination.
2. Reliability, defined as the network's ability to send real-time information to a destination with minimal packet loss.
3. Throughput, defined as the rate at which packets are successfully sent through the transmission medium. Increasing network throughput will minimize the impact of disruption on transmission.
4. Bandwidth is defined as the capacity for a given data transmission speed.

| Table 1. Quality Standards ITU-T G.114 for Delay |
| Category | Delay (Latency) Standard |
|----------|-------------------------|
| Good     | 0 - 150 ms              |
| Medium   | 150 - 400 ms            |
2.4. Routing topology networks
Efficient routing in network topology will speed up the process of sending data packets in the network. Smooth communication between sensor nodes in each topology will reduce the data transfer lag that occurs at the node to the terminal. If there is continuous data transmission, Bandwidth may be a limitation in routing, resulting in increased network delays and loss of packet transmission. Where data packets will be resent during the next routing process. So the routing process that occurs in each topology must focus on all parameters to choose the shortest path that is efficient [8]. In this section, the most common topologies used in sensor networks are considered. Also, another topology type is analyzed in which the behavior of the nodes affects network performance. Furthermore, several metrics are presented as emergency properties of this behavior; such metrics are reliability, energy consumption, and latency [14].

2.5. Network topology infrastructure for wireless sensor implementation
Network Topology Infrastructure for Wireless Sensor Implementation show in figure 1. Each topology cluster has a coordinator and gateway, the coordinator functions as the head node of each end node. The gateway functions as a routing topology between clusters for transmitting packet data from the sensor acquisition results. In a topology cluster consisting of several sensor end nodes, coordinators, and gateway nodes which are connected. The data packet delivery stage from each topology cluster will be forwarded to the base station for data acquisition data from each node in each cluster. Furthermore, the sensor acquisition data will be processed at the base station, the information from the data processing is then sent to the web service using the Hypertext Transfer Protocol (HTTP). Information is presented by the web service at web services.

Figure 1. Network topology infrastructure for wireless sensor

3. Result and discussion

3.1. Implementasi network topology infrastructure
The end Node is equipped with pH and Total Dissolve Solids (TDS) sensors as well as wireless devices to connect to the node coordinator. From the coordinator node connected to the topology cluster gateway, proceed to the base station. Each base station can process data from several topological clusters. Figure 2 shows the results of packet data on the Base Station received from the gateway router.
topology cluster, which consists of 8 end nodes with a distance between the topological cluster and the base station as far as 10 km. In Figure 3 used 12 end nodes with a distance of 10 km.

3.2. QoS network topology

The results of the QoS network topology measurement show in Figure 1 and Figure 2 that the delay during data transmission is influenced by differences in the distance and number of end nodes for each topology cluster. Where the farther the distance the greater the delay, and vice versa [15]. Meanwhile, a large number of end nodes require a larger bandwidth than the topological cluster, which has fewer end nodes. These two things affect the performance level of the Network Topology Infrastructure for Wireless Sensor Design. By recording the delay in each cluster when sending data to the each base station shown in Table 2, it can be measured performance of QoS is in a good or poor condition.

| Source               | Destination    | Delay |
|----------------------|----------------|-------|
| Cluster 1 and Cluster 2 | Base Station 1  | 90 ms |
| Cluster 2 and Cluster 3 | Base Station 2  | 160 ms|
| Cluster 4 and Cluster 5 | Base Station 2  | 170 ms|
| Cluster 5 and Cluster 6 | Base Station 3  | 90 ms |

4. Conclusion

Based on QoS measurements on data distribution delay and used bandwidth in Table 2. Shows delay of the wireless sensor's connectivity in sending data acquisition Temperature, pH, and TDS from each cluster to base station in the data distribution. Cluster with multiple connections of the base station has a higher delay and poor QoS. Otherwise, Cluster with single connection to the base station has a lower
delay and indicated a better QoS. With this method of QoS, measurements can be used for the development of WSN infrastructure with better performance.

Acknowledgment
The research is funded by the Ministry of Research and Technology / National Research and Innovation Agency Under the letter of the contract Research Number: 109/LPPM.UMK/J.15.06/V/2020.

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