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# Analysis of First In First Out (FIFO) Bandwidth Packet Queuing Technique with Random Early Detection (RED) on WLAN (Wireless LAN)

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A R T I C L E I N F O

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A B S T R A C T

Implementation of bandwidth usage is generally only optimally utilized by some WLAN network users; this is often influenced by the monopoly use of bandwidth capacity for both download and upload. The aim is to determine the optimal packet queuing technique based on QoS parameters in WLAN network implementation. This research method uses QoS FIFO and RED packet queuing techniques with throughput, delay, jitter, and packet loss parameters on WLAN networks. Quality of Service (QoS) results on queuing methods using FIFO parameters (throughput 79.65%, delay 73.43 ms, jitter 82.21 ms, and packet loss 3.39%) RED technique throughput parameters: 79.29% delay (75.35 ms), jitter (71.45 ms), and packet loss (7.17%). QoS, compared to FIFO and RED queuing techniques, both perform well in maintaining the quality of network services. The FIFO queuing technique has an average index value of 3.5 with "Satisfactory" degradation, while the RED queuing technique has an average index value of 3.75 with the same degradation. Although the difference in average index values is not very significant, the RED queuing method provides slightly better results in terms of QoS.

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## INTRODUCTION

The implementation of information technology (IT) is now not only limited to the scope of the business sector but also utilized by the public sector. The existence of a wireless network facilitates access to connect to the internet network. Wireless network technology enables the convenience of wireless network connections, including internet networks (Kusbandono and Syafitri, 2019). The implementation of Wireless LAN (WLAN) technology functions for easy access to the network and connecting to the internet without using cables indoors and outdoors. This WLAN is usually installed at each point to support network connection facilities and the internet. After success, many connections from computers (laptops/notebooks) to the WLAN cannot be adequately used for internet access. It still happens that internet access is stuck, and with a specific time lag, it returns to normal. Things like this often happen, so that activities on internet usage are disrupted.

The use of bandwidth capacity, in general, is often only maximized for some network user clients. This is influenced by clients who monopolize download and upload bandwidth capacity. WLAN implementation is generally carried out using various techniques to maximize bandwidth management. Meanwhile, networks connected to the internet will be affected by the amount of capacity and how effectively the bandwidth can be used for smooth uploads and downloads or other applications. Proper bandwidth management can be one of the methods in providing quality assurance of a network service or what is known as Quality of Services (Libratama & Irmayani, 2018). The parameters that must be considered to determine the Quality of Service are throughput, Delay, Jitter, and Packet Loss (Sukri & Jumiati, 2017). Bandwidth management implements queuing theory; data packets from traffic will be queued and organized. This packet queuing process is crucial for management so that the data reaches its destination without packet loss. The principle of setting the rate limit can be fulfilled if the rate exceeds the limit, then the packet will be queued for the next time. Otherwise, the packet will be dropped.

## THEORETICAL REVIEW

### Queue Types Method

FIFO (First-In First-Out) technique. It is the default method that is active on the network device interface. The FIFO method creates a buffer to hold incoming packets for a while. According to Towidjojo (2016), FIFO has several characteristics that do not perform classification, is a standard solution that is widely used, uses one buffer for various types of packets, congestion is difficult to estimate, allows for longer delays, and frequent packet drop conditions.

RED (Random Early Detection) technique. It uses a mechanism to avoid queue buildup by calculating based on averages. The average queue value will be compared with two limits, namely the lower limit (minimum) and the upper limit (maximum). All packets will be accepted if the average queue exceeds the minimum limit. All incoming packets will be rejected when the queue average exceeds the maximum limit. However, when the average queue is between the

minimum and maximum limits, the packets will be randomized, and then the probability value (Pd) is determined (Pratama et al., 2015).

**Bandwidth Management**

Bandwidth management measures and controls information exchange on a computer network to avoid unwanted things that result in network congestion and decreased network capability (Septiawan, 2013). Good bandwidth management must be able to create and maintain rules about connection availability (in this case, the internet).

**Wireless Local Area Network (WLAN)**

Wireless Local Area Network (WLAN) is a computer network that uses radio frequency and infrared as a data transmission medium. Wireless LANs are often called wireless networks or wireless networks. Wireless LAN works by using radio waves (Utomo, 2015).

***Quality of Service (QoS)***

Quality of Service (QoS) is a method of measuring how good a network is and is an attempt to define the characteristics and properties of a service. QoS measures performance attributes specified and associated with a service (Febriyanti et al., 2017). QoS refers to the ability of a network to provide better service to specific network traffic through different technologies. QoS offers the ability to define the attributes of the network services provided, both qualitatively and quantitatively.

Tabel 1. Percentage and Quality Value of Service (QoS)

| Value | Percentage (%) | Index |
|---|---|---|
| 3,8 - 4 | 95 - 100 | Very Satisfactory |
| 3 - 3,79 | 75 - 94,75 | Satisfactory |
| 2 - 2,99 | 50 - 74,75 | Less Satisfactory |
| 1 - 1,99 | 25 - 49,75 | Poor |

(TIPHON, 1999)

QoS aims to meet different service requirements using the same infrastructure. Network performance elements within the scope of QoS often include availability (uptime), bandwidth (throughput), delay (latency/delay), and error rate. Some parameters that can be used for Quality of Service (QoS) assessment are Throughput, Delay (Latency), Jitter (Variation of packet arrival), and Packet Loss (Pratama et al., 2015).

**Throughput**. The speed (rate) of effective data transfer is measured in bps (bits per second). Throughput is the total number of successful packet arrivals observed at the destination during a given time interval divided by the duration of the time interval.

Table 2. Throughput Parameters

| Throughput Category | Throughput | Index |
|---|---|---|
| Very Good | 100 % | 4 |
| Good | 75 % | 3 |
| Medium | 50 % | 2 |
| Poor | < 25 % | 1 |

(TIPHON, 1999)

**Delay (Latency)**. It is the total time that a packet travels from sender to receiver through the network. Delay can be affected by distance, physical media, congestion, or long processing times.

Table 3. Delay (Latency) Parameters

| Delay Category | Delay | Index |
|---|---|---|
| Very Good | < 150 ms | 4 |
| Good | 150 s/d 300 ms | 3 |
| Medium | 300 s/d 450 ms | 2 |
| Poor | > 450 ms | 1 |

(TIPHON, 1999)

**Jitter (Packet arrival variation)**. It is a variation of end-to-end delay. High jitter levels in UDP-based applications are an unacceptable situation where the applications are in real-time. In such cases, the jitter will cause a distorted signal, which can be corrected only by increasing the buffers in the queue.

Table 4. Jitter Parameters

| Jitter Category | Jitter | Index |
|---|---|---|
| Very Good | 0 ms | 4 |
| Good | 0 s/d 75 ms | 3 |
| Medium | 75 s/d 125 ms | 2 |
| Poor | 125 s/d 225 ms | 1 |

(TIPHON, 1999)

**Packet Loss**. This parameter describes a condition indicating the total number of packets lost, which can occur due to collisions and congestion on the network.

Table 5. Packet Loss Parameters

| Packet Loss Category | Packet Loss | Index |
|---|---|---|
| Very Good | 0 % | 4 |
| Good | 3 % | 3 |
| Medium | 15 % | 2 |
| Poor | 25 % | 1 |

TIPHON, 1999)

## METHODOLOGY

This research method uses experimental methods and literature studies investigating the process of each parameter and variable. The method used to measure the quality of service and performance of the Wireless LAN (WLAN) network on the running internet bandwidth is Quality of Service (QoS). The queue types tested were First In, First Out (FIFO) and Random Early Detection (RED) with the parameters Throughput, Delay, Jitter, and Packet Loss. The bandwidth used is 10 Mbps upload and 10 Mbps download with the number of connections to the access point (WLAN) of 10 clients (Laptop/Notebook).

The data collection methods used are observation and literature study. *Observation* is a method used to collect data by direct observation or review of the object of research to get an accurate picture of the implementation of internet bandwidth package queue management and determine the Quality of Service (QoS) on WLAN. Meanwhile, the literature study is carried out by collecting data and information used as references related to WLAN, Bandwidth, Quality of Service, and Queue Type implementation.

The tools and materials in this research are hardware consisting of a router (Mikrotik RB1100x4), WLAN (Linksys LAPN300) with Single Band (2.4 Ghz), and a computer (Laptop/Notebook) used for data collection of queue type implementation results and QoS analysis. The software used is the wireshark application (www.wireshark.org) and speed test (speed.cloudflare.com).

## RESULTS

This research is an implementation to determine the quality of service and performance of wireless LAN (WLAN) networks using the Quality of Service (QoS) method with throughput, delay, jitter, and packet loss parameters to test and analyze packet queuing techniques based on FIFO, RED, on wireless LAN (WLAN) networks. The devices used are internet connections from ISP (Internet service provider) in the form of ONT (Optical Network Terminal), Router (the router used is Mikrotik RB1100x4), Access Point (Linksys LAPN300) using a Single Band (2.4 Ghz), for testing the Access Point connection using a Laptop/Notebook.

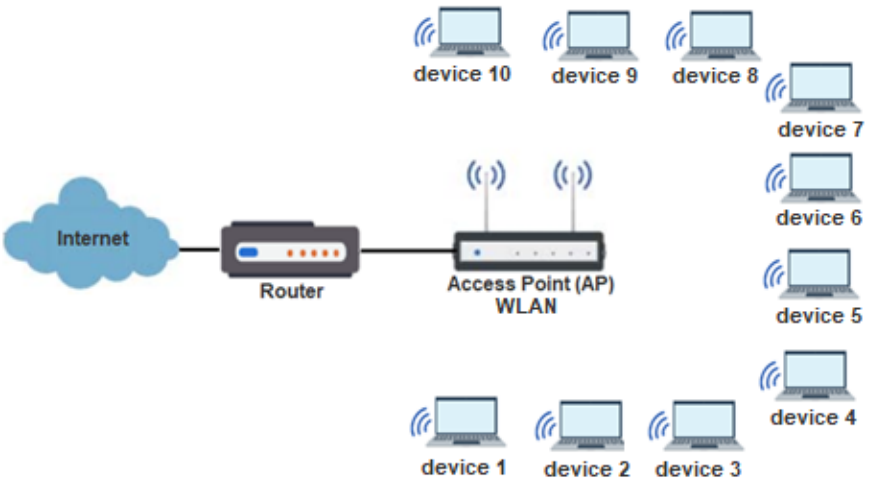


Figure 1. WLAN Network Topology Design

Based on the Quality of Service (QoS) results on the implementation of the First In, First Out (FIFO) method packet queuing technique on the throughput parameter, a throughput value of 75.60% to 100% is obtained on device 1 and device 7 with a degradation category of "Very Good." In comparison, the throughput value is 72.38% to 73.71% on device 8 to device 10, with a degradation category of "Good." The FIFO method has a positive impact on throughput on some devices. Device 1 and 7 show consistent throughput in the range of 75.60% to 100%, indicating that this method successfully optimizes data delivery and supports a quality of service that is "Very Good." However, it is worth noting that devices 8 to 10 show a slight decrease in throughput, although still in the "Good" category. This could be a point to explore further the factors causing the throughput degradation on these devices.

The delay parameter obtained a delay value of 18 ms to 97 ms on devices 1 to device 8 with a degradation category of "Very Good," while a delay value of 150 ms to 260 ms on device 9 and device 10 with a degradation category of "Good." The FIFO method effectively reduces delay on most devices. The fact that devices 1 to device 8 have delays ranging from 18 ms to 97 ms and fall into the category of "Very Good" shows that the FIFO queue helps maintain optimal quality of service. Although device 9 and device 10 have higher delays, they are still in the "Good" category, possibly due to network complexity or different device capacities.

The jitter parameter obtained a jitter value of 2 ms to 20 ms on device 1 to device 5 with a degradation category of "Good," while the jitter value of 75 ms to 80 ms on device 6 and device 7 with a degradation category of "Medium," while the jitter value of 166 ms to 221 ms on device 8 to device 10 with a degradation category of "Bad." It can be argued that the variation in jitter values across devices indicates a challenge in maintaining consistency in data transmission. Although some devices (device 1 to device 5) have low jitter and fall into the category of "Good," devices with higher jitter values indicate the need for more attention in jitter management.

The packet loss parameter, with a packet loss value of 0% on device 1 and device 2 with a degradation category of "Excellent," while packet loss values of 0.97% to 2.56% on device 3 to device 5 with a degradation category of "Good," while packet loss values of 3.42% to 7.62% on device 6 to device 10 with a degradation category of "Medium." The FIFO queuing method manages packet loss. It seems that device 1 and device 2 have a "Very Good" performance in this regard, while some devices (device 6 to device 10) have a higher packet loss rate and fall into the "Medium" category.

The average value of Quality of Service (QoS) of the First In, First Out (FIFO) method is in Table 6 with the throughput parameter of the "Very Good" degradation category with an average throughput value of 79.65%. For the degradation category delay parameter "Very Good" with an average delay value of 73.43 ms. The jitter parameter of the "Medium" degradation category with an average jitter value of 82.21 ms. At the same time, the packet loss parameter degradation category is "Good" with an average packet loss value of 3.39%.

Table 6. FIFO Test Average

| Parameters | Average | Index | Description |
|---|---|---|---|
| *Throughput* | 79.65 % | 4 | Very Good |
| *Delay* | 73.43 ms | 4 | Very Good |
| *Jitter* | 82.21 ms | 2 | Medium |
| *Packet loss* | 3.39 % | 3 | Good |

The First In, First Out (FIFO) method effectively manages the network's Quality of Service (QoS). In the "Excellent" category, the FIFO method achieved an average throughput of 79.65%, signaling its ability to cope with enormous data traffic. In addition, the average delay value of 73.43 ms shows that FIFO can maintain the delay in data transmission well. Although the average jitter value reaches 82.21 ms in the "Medium" category, the FIFO method still adequately manages to cope with fluctuations in data transmission time. With an average packet loss rate of only 3.39% in the "Good" category, FIFO also effectively reduces data packet loss during transmission.

Based on the results of Quality of Service (QoS) on the implementation of the Random Early Detection (RED) method packet queuing technique on the throughput parameter, the throughput value is 75.81% to 100% on device 1 to device 5 with the degradation category "Very Good." While the throughput value is 71.46% to 74.77% on devices 6 to device 10 with the degradation category "Good." Implementing the packet queuing technique with the RED method produces significant throughput values, reaching 75.81% to 100% on devices 1 to 5. In this context, the results show that the RED technique can effectively increase the data transfer rate on several devices in the network, supporting faster and more efficient data delivery.

The delay parameter obtained delay values of 41.70 ms to 95.90 ms on devices 1 to 10 with a degradation category of "Very Good." This relatively low range of delay values indicates that implementing the RED technique can reduce data waiting time in transmission, potentially resulting in a faster response.

The jitter parameter, 10.50 ms to 72.20 ms, is obtained on devices 1 to 6 with the degradation category "Good." In comparison, the jitter value is 84 ms to 121.34 ms on devices 7 to 9 with the degradation category "Medium," while the jitter value is 154.87 ms on device 10 with the degradation category "Bad." Lower jitter values on some devices (device 1 to device 6) indicate good data delivery, while higher jitter values on other devices indicate a more significant variation in delivery time.

As for the packet loss parameter, packet loss values of 1.10% to 2.02% were obtained on device 1 and device 2 with a degradation category of "Very Good," while packet loss values of 4.23% to 11.54% on device 3 to device 10 with a degradation category of "Medium." The low packet loss values (device 1 and device 2) indicate that the RED implementation reduced significant data loss. In contrast, the higher values on the other devices indicate that more effort is needed to address this issue.

The average Quality of Service (QoS) value using the Random Early Detection (RED) method in Table 7 shows that the network performance in terms of throughput is in the "Very Good" degradation category with an average throughput value of 79.29%. This indicates that implementing the RED method successfully improved the network's ability to transfer data efficiently, creating a good user experience. In addition, regarding delay parameters, the network also received a degradation category of "Excellent," with an average delay value of 75.35ms. This means that implementing the RED method has successfully reduced the delay time of data transmission, maintaining a fast and consistent response. However, the jitter parameter showed a "Good" degradation category with an average jitter value of 71.45 ms. Although the value is in the "Good" category, the variation in data delivery time can still be further improved to achieve better stability. Finally, the packet loss parameter is also in the "Good" degradation category, with an average packet loss value of 7.17%. Although the packet loss value is relatively low, there is still potential to optimize network performance further to reduce data loss.

Table 7. RED test average

| **Parameters** | **Average** | **Index** | Description |
|---|---|---|---|
| Throughput | 79.29 % | 4 | Very Good |
| Delay | 75.35 ms | 4 | Very Good |
| Jitter | 71.45 ms | 3 | Good |
| Packet loss | 7.17 % | 3 | Good |

It is based on Quality of Service (QoS) with percentages and values on comparing queuing techniques using FIFO with RED with QoS parameters shown in Table 8.

Table 8. Percentage and Quality of Service (QoS) values

| **QoS Parameters** | **FIFO Index Value** | **RED Index Value** |
|---|---|---|
| Throughput | 4 | 4 |
| Delay | 4 | 4 |
| Jitter | 3 | 4 |
| Packet loss | 3 | 3 |
| **Average value** | 3.5 | 3.75 |
| **QoS Index** | Satisfactory | Satisfactory |

Quality of Service (QoS) comparison of queuing techniques using the FIFO method throughput parameters with an index value of 4, delay with a value of 4, jitter with a value of 3, and packet loss with a value of 3. The average index value of the FIFO method is 3.5 with "Satisfactory" degradation. While the RED method parameters throughput with index value 4, delay with value 4, jitter with value 4, and packet loss with value 3. The average value of the RED method index is 3.75 with a degradation of "Satisfactory." Based on the QoS analysis results on comparing the FIFO queuing technique and the RED queuing technique, both have pretty good performance in maintaining the quality of network services. The FIFO queuing technique has an average index value of 3.5 with "Satisfactory" degradation, while the RED queuing technique has an average index value of

3.75 with the same degradation. Although the difference in average index values is not very significant, the RED queuing technique provides slightly better results in terms of QoS.

## DISCUSSION

The First In, First Out (FIFO) queuing technique can handle packets according to their order of arrival into the queue. The first incoming packet will be picked up and transmitted first, then the second packet, and so on. No special priority is given to certain types of packets. Meanwhile, the Random Early Detection (RED) queuing technique can control the number of packets in the queue to avoid congestion in the network. RED deletes some packets randomly before the queue reaches the maximum limit, thus reducing the possibility of congestion.

## CONCLUSIONS AND RECOMMENDATIONS

Quality of Service (QoS) results on the FIFO queuing technique have an average index value of 3.5 with degradation of "Satisfactory". In contrast, the RED queuing technique has an average index value of 3.75 with a degradation of "Satisfactory". Although the difference in the average index value is insignificant, the RED queuing technique tends to provide slightly better results in providing QoS.

## FURTHER STUDY

The researcher is fully aware that this article is still imperfect. Therefore, the researcher apologizes for any errors contained in this research article. This research article can provide the best possible benefits for those who make references.

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Alhamdulillahi Robbil `Alamin, all praise belongs only to Allah SWT, the Lord of the universe. We can complete this article only with the abundance of His Grace, Favors, and Gifts. Sholawat and salam may remain devoted to the Prophet Muhammad SAW and his family, friends, and people who always follow him.

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