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Article

Traffic Management Analysis for Video Streaming Service Optimization Using Per Connection Queue (PCQ) Method

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Abstract: Video streaming has become common in everyday life due to its ability to enhance information retrieval and provide an additional dimension to obtaining up-to-date information. However, these benefits are often accompanied by significant bandwidth demands, which can affect network performance. To overcome this challenge, efficient traffic management with separation between browsing and streaming traffic is required. This research addresses network performance issues caused by video streaming services by applying the Per Connection Queue (PCQ) method. This method optimizes streaming video quality while managing network traffic by separating traffic between web browsing and video streaming. The test results show that both types of networks exhibit relatively stable performance over different time intervals. The network without PCQ showed constant values in the measurement parameters, even at 720p video quality with a slight increase in packet loss. Similarly, the network with PCQ showed consistent performance at 240p and 360p video quality, with a slight increase in packet loss in scenario 3 with 720p video quality. The Average Index value of 3.666667 indicates that both have "Good" performance according to TIPHON standardization and can be considered comparable. This conclusion illustrates that the implementation of PCQ does not significantly affect network performance on packet loss, delay, and jitter measurements.

Keywords: PCQ; Action Research; Video Streaming; Jitter; Packet loss; Delay

1. Introduction

The presence of the Internet in corporate environments, campuses, schools, and other agencies is urgently needed, considering that this information technology has provided convenience in supporting the communication process and the infrastructure that will be carried out [1-3]. This can be seen from the internet network users in general and privately; with the many needs for access and communication, the network performance must be in good condition [4-6]. The internet network itself is a network that is connected between computers and can exchange information through hardware devices such as modems, routers, and so on [7-9]. So, the internet network service provider must be able to solve the main problem, namely, providing good service performance to offer comfortable services to users [10-12].

Traffic management in video streaming services is essential to ensure a quality user experience. This involves controlling data traffic during streaming to prevent delays, packet loss, and jitter that can ruin video streaming. With effective traffic management, users can enjoy smooth and quality video streaming without interruption. In addition, it is important to remember that with the rapid growth in the use of video streaming and video conferencing services, efficient traffic management also has a positive impact in reducing the load on the network infrastructure. This can help prevent overloads that disrupt overall network performance and inconvenience users. Therefore, this research also makes important contributions to maintaining the stability and reliability of the network infrastructure in the face of high demands from increasingly popular video services [13-15].

Bandwidth management is essential in computers and computer networks. Apart from managing each individual's needs, it also keeps data traffic running smoothly. The absence of bandwidth management on a network will result in bandwidth control by several users. This bandwidth control will be felt when several users download or stream a file of an immense size so that several users automatically use the allocated bandwidth. And will slow down other computer connections. One way to reduce performance degradation is to adjust the bandwidth [16-18].

Because the data distributed via the internet varies greatly, such as small data packets, multimedia packets such as audio and video are now passed following internet traffic requirements. This can result in an increase in data traffic, leading to a decrease in network users, especially on networks with limited bandwidth [19-21].

Video streaming, both web-based and interactive, and broadcasting, is very popular with the public, which is very appropriate for use in developing information and technology science, which functions to reinforce information and provide different nuances in obtaining that information [22-24].

The use of these video streaming services requires quite a bit of bandwidth but can burden network performance. To overcome these problems, it is necessary to implement traffic management by separating traffic between browsing and streaming This video streaming service requires much bandwidth but can burden network performance. To carry out traffic management by separating browsing and streaming traffic, steps that can be followed include identifying traffic types, tagging packets according to traffic types, creating Queue Trees with proper bandwidth allocation, setting priorities and bandwidth sharing using the PCQ method, and configuring firewall rules. With these steps, you can optimize bandwidth usage, reduce the network load, and improve browsing connections' performance and responsiveness [25-27]. Similar research on video streaming has been done before. Doni Helton Jenus, in his research "Analysis of QOS video streaming on wireless networks using the HTB method," concluded that the available bandwidth capacity also affects QOS [23][25][28].

This study was conducted with the aim of filling the research gap that still exists in understanding the influence of delay, throughput, and jitter on video conferencing quality, and providing more effective solutions to improve user experience. Previous research, which is related to this topic, tends not to touch deeply on some key aspects, leaving a number of shortcomings that need to be addressed. One of the weaknesses of previous research is the lack of focus on holistically analyzing the effect of delay, throughput, and jitter together on video conferencing quality. Therefore, this research seeks to address these shortcomings by presenting a more comprehensive analysis and more detailed solutions to improve the quality of video conferencing services. With this approach, it is expected that the results of this research can make a significant contribution in guiding the development of superior and integrated video conferencing technology, especially in the context of increasingly digitally connected businesses.

Based on the description above, the author takes the title "Traffic Management Analysis for Optimizing VLC Streaming Video Services Using the Per Connection Queue (PCQ) Method." This paper aims to determine the traffic management of a video so that it can measure jitter, delay, and packet loss and know the quality of a running video so that it can run properly and get the maximum rate.

2. Methods and Materials

In this research, based on the literature review and observations made, an experiment will be conducted to manage traffic optimization of video streaming services using the Per Connection Queue (PCQ) method with eight scenarios in ten clients and one server. The parameters used are delay, packet loss, and jitter. The objectives of this research are to identify the effect of using the PCQ method on the quality of video streaming services, especially in terms of reducing delay, analyzing the impact of the PCQ method on packet loss rates in video streaming services, measuring changes in jitter in video streaming services after applying the PCQ method, studying the effectiveness of the PCQ method. The results of this study can also be considered for possible future actions in improving the quality of video streaming services and network traffic management in the context of video streaming services. Here is a Research Stages that will be carried out in Figure 1.

The first stage in the Research Stages shown in Figure 1 is to design the network topology. The next stage is to configuration the system including basic configuration and PCQ configuration that will later be applied to the router. After that, testing based on the scenario, namely by performing traffic management by separating the use of browsing traffic and streaming traffic. So, when the client is using video streaming services from YouTube and at the same time the client is also doing browsing activities, then the network traffic activity is then taken using Wireshark software on each client with 8 times determine. The scenario that will be carried out after the implementation of the testing model. Then, as the test scenario is implemented, data is collected in the form of the parameters to be tested, namely delay, packet loss, and jitter. And the last step is to analyze network traffic related to the use of video streaming services and provide conclusions based on the results of the tests that have been carried out.

Figure 1. Research stages

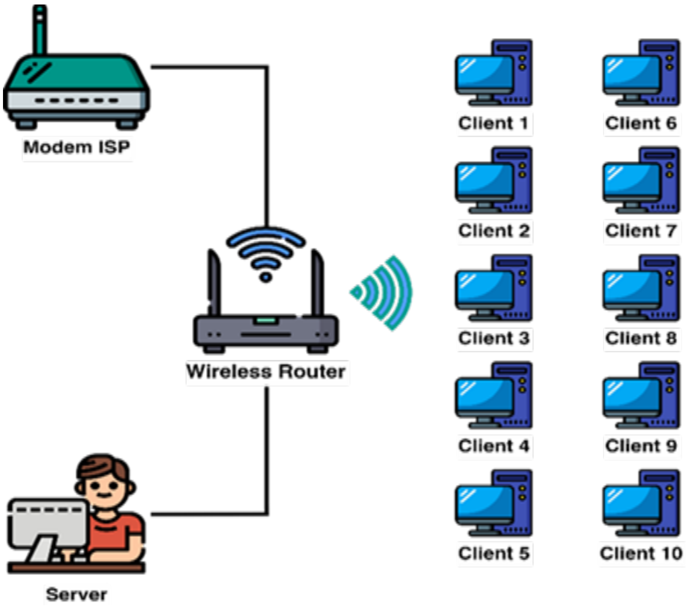

Figure 2. Topology design

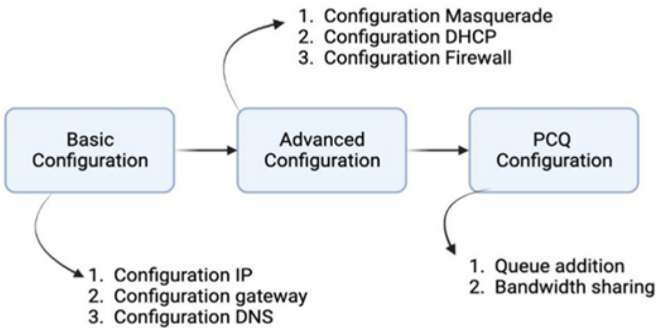

Figure 3. System configuration flow

2.1. Design Topology

Figure 2 shows the network topology design used, which is a combination of 10 clients connected via wireless to the router. The server acts as a regulator and provider of bandwidth which will then be distributed to the clients using the PCQ method.

2.2. System Configuration

The next step is to configure the system. System configuration includes basic configuration, advance configuration, PCQ configuration. Basic configuration includes IP, gateway and DNS configuration which will be done on the client side. Advanced configuration includes configuration of masquerading, DHCP, and firewall, which will be done on the server side. Then PCQ configuration includes queue addition and bandwidth sharing to share bandwidth on each client [29-31]. Figure 3 shows the flow of the configuration system.

In Figure 3, detail system configuration stages in this study include:

- In the basic configuration, an IP address will be given to the router, and an IP address will later be given to network users to connect the router to the internet network. The IP Address Configuration on the Bridge Interface for the ether2 interface is the IP address that connects the router to the internet. In contrast, the ether3 interface IP address will be connected to the local network for configuration display using Winbox, Gateway Configuration for the process of managing devices that connect different networks, ensuring connectivity and proper data transfer so that the DNS server serves to map the hostname or domain of sites on the internet. For that, the router needs to be configured to access the internet to give DNS configuration commands on the router.
- Masquerade Router configuration is between the internet network and the local network, therefore based on the network design scheme in this study, NAT is made on the firewall so that all clients can connect to the internet; in the masquerade configuration, there is a chain srcnat option which means that data packet transfer will be carried out for data packets going to the internet, outinterface 1tel option which will create the IP address of the data packet sender using public IP, while DHCP Server Configuration Making a DHCP server so that the client gets IP automatically from the router so that the next stage Firewall (Mangle) is used to mark or mark data packets and a connection that can be applied to other proxy features. Or better known to make it easier to do traffic management. Here's how to create a mangle to mark the browsing path and run Streaming in VLC.
- PCQ configuration for queue creation uses PCQ for both download and upload traffic. In this configuration, you can set speed limits (bandwidth) for each connection, prioritize more important traffic, and resolve network congestion. The process involves identifying the traffic criteria the PCQ will apply, determining the bandwidth allocation for each, and configuring the router or gateway device to apply those PCQ rules.

2.3. Testing

After designing the network topology and configuring the system, the next step was to conduct tests with a series of scenarios. In the first to fourth scenarios, tests were conducted without using PCQ traffic management, where all clients accessed VLC from the server with resolution variations ranging from 240p to 720p for five minutes of streaming. Evaluation is done by measuring the QoS parameters of delay, packet loss, and jitter for each scenario. While in the fifth to eighth scenarios, testing is done by applying PCQ traffic management. In this scenario, clients access VLC from the server with the same resolution as before for five minutes of streaming, and QoS measurements of delay, packet loss, and jitter are taken to evaluate overall network performance. All scenarios will be monitored using Wireshark software for data collection.

QOS is a method for measuring network quality to guarantee a certain level of performance to network data. Quality of service is a technique or mechanism that allows applications to run or operate properly or as expected. Analyzing network parameters such as Delay, packet loss, and jitter involves critical steps. First, measurements of these parameters are taken with network monitoring tools or specialized software to obtain accurate data. After that, the causes of each parameter are analyzed, ranging from network hardware to inefficient configuration. The final step is to take action to optimize the network, including updating hardware, redesigning the network topology, or applying traffic prioritization to reduce delay, packet loss, and jitter issues. Analysis of these parameters is important to ensure good network quality, especially in applications that require reliable connections, such as VoIP and video conferencing. The following are the parameters of quality of service: Delay is the time needed to send packages, from the time the package arrives at the system until it is finished transmitting; the delay is usually influenced by the length of the queue process needed for the package to queue or wait for the queue to be processed; this delay is commonly called the queue delay. The equation that can be used to show the calculation of standardization delay in Table 1 is:

$$delay\ mean = \frac{total\ delay}{total\ packet\ receivd} \times 100\% \quad (1)$$

Equation 1 calculates the average delay by dividing the total delay in the system by the number of successfully received packets. The total delay is the delay time in each packet sent, while the number of packets arrived is the number of packets successfully received. Table 1 shows the category of index values determining the delay value.

Table 1 shows the delay standards that serve as standardization for package delivery. This standard has four categories: excellent, good, medium, and poor. An excellent category is obtained if the delay value is <150 ms; a good category is obtained if the delay value is 150-300 ms; a medium category is obtained if the delay value is 300-450 ms; and a bad category is obtained if the delay value is >450 ms.

Jitter is a variation in data arrival time or signals from the expected time. This can cause issues in delay sensitive apps, such as bad voice and video calls. The use of buffering, better protocols, and proper synchronization can solve the jitter problem. Understanding these Jitter indices has become very important in evaluating and managing the quality of communication services in the context of increasingly complex digital networks. With quality data on timing variations, users and service providers can take appropriate actions to improve service quality, reduce disruptions in communication, and provide a better experience for end users. To find the jitter value, you can use equation 2.

$$Jitter = \frac{total\ delay\ variations}{total\ data\ packets\ received} \times 100\% \quad (2)$$

Equation 2 shows the jitter from dividing the total delay variation by the total data packets received. At the same time, the total delay variation is obtained by subtracting the delay value from the average delay, as in Equation 1.

Jitter can be calculated using Equation 2, which includes the total Delay variation and the total received data packets. The total Delay variation is calculated by subtracting the Delay on each data packet using Delay as in Formula 1. This explains the difference between the expected packet arrival time and the actual arrival time. Table 2 shows the category of index values to determine the jitter quality.

Table 2 represents the standards that classify jitter levels in the context of communication network performance. This standard has four categories, which play an important role in understanding and assessing the stability and quality of data delivery in the network. The first category is "excellent," defined by a jitter value equal to 0 ms. This indicates a very high level of stability, where the difference between the expected packet arrival time and the actual arrival time is minimal.

Packet Loss is a parameter that indicates the total number of packets lost. Packets can be lost due to conflicts and congestion on the network that affect applications and reduce network efficiency. The following equation for packet loss and degradation categories in packet loss and degradation categories in packet loss are shown in equation 3.

Packet loss in Equation 3 involves subtracting the number of data packets received and the number of data packets sent, then dividing by the number of data packets sent, and multiplying by 100% to get a percentage. Table 3 shows the index values for the packet loss.

Table 3 shows packet loss standards that function as a condition for the total number of packets lost. This standard has four categories: very good, good, medium, and bad. The good category is obtained if very good is obtained if the packet loss value is equal to 0%; the good category is obtained if the packet loss value is > 0% and <= 3% ms; The category is obtained if the package loss value is > 3% and <= 15%; And the bad category is obtained if the package loss value > 15% and <=25%.

3. Results and Discussion

After successfully testing the next stage is to analyze the test results based on QoS parameters.

3.1. Process Analysis

The analysis process in this study involves collecting experimental data related to delay, packet loss, and jitter in eight different scenarios, followed by statistical analysis to identify significant differences due to the use of the PCQ method. The data will be visualized in graphical form while considering external factors that affect the results. This analysis aims to evaluate the effectiveness of the PCQ method in improving video streaming service quality and provide relevant recommendations for future network traffic management.

3.2. Results and Scenario Testing

After successfully testing the next stage is to analyze the test results based on QoS parameters. test results and data collection process using Wireshark software. Testing was carried out with four scenarios, each of which was tested ten times. Table 4 shows the test results without PCQ and by using PCQ for the delay parameter.

Table 4 shows the results of testing the delay parameter for networks with and without PCQ. In scenario 1 with video quality (240p), the network without PCQ has a lower average delay (0.47 ms) than the network with PCQ (0.62 ms). However, in scenario 2 with video quality (360p), there is no significant difference between the two, with an average delay of about 0.49 seconds. In scenario 3 with video quality (480p) and scenario 4 with video quality (720p), both show similar average delays, around 0.47-0.48 ms. Table 5 test results without PCQ and by using PCQ for Packet loss parameters.

Table 5 shows the results of packet loss testing on networks with and without the use of PCQ. In scenario 1 with video quality (240p), the network without PCQ has an average packet loss of 0.49%, while the network with PCQ has increased with an average of 0.52%. In scenario 2 with video quality (360p), there is a change in dynamics where the network without PCQ has an increase in packet loss to 0.39%, while the network with PCQ shows a lower average of 0.28%. In scenario 3 with video quality (480p) and scenario 4 with video quality (720p), the network without PCQ again shows a higher packet loss value compared to the network with PCQ, with an average of 0.53% and 0.57% respectively. Table 6 test results without PCQ and by using PCQ for Packet loss parameters.

Table 6 shows the results of testing the jitter parameter on networks that use and do not use PCQ show variations in the level of response time fluctuations at each delay time. In scenario 1 with video quality time (240p), the network without PCQ has an average jitter of 0.48 ms, while the network with PCQ shows a slightly higher value with an average of 0.49 ms. In scenario 2 with video quality (360p), it can be seen that the network without PCQ has the same average jitter of 0.49 ms, while the network with PCQ has decreased the average jitter to 0.39ms, indicating better performance in managing response time fluctuations in the network with PCQ.

Table 1. Standardization delay.

Category	Big delay	Index
Very Good	<150 ms	4
Good	150 s/d 300ms	3
Medium	300 s/d 450 ms	2
Bad	>450 ms	1

Table 2. Jitter Standardization.

Category	Big Jitter	Index
Very Good	Jitter == 0 ms	4
Good	0 ms <Jitter <=75 ms	3
Medium	75 ms <Jitter <= 125 ms	2
Bad	125 ms <Jitter <= 225 ms	1

Table 3. Packet loss standardization.

Category	Packet loss	Index
Very Good	Loss == 0%	4
Good	0% < loss <= 3%	3
Medium	3% < loss <= 15%	2
Bad	15% < loss <= 25%	1

$$packet\ loss = \frac{data\ packets\ send - data\ packet\ received}{data\ packet\ send} \times 100\% \tag{3}$$

Table 4. Test results for delay parameters.

Delay (ms)								
Client	**Scenario 1 (240p)**		**Scenario 2 (630p)**		**Scenario 3 (480p)**		**Scenario 4 (720p)**	
	No PCQ	**PCQ**	**No PCQ**	**PCQ**	**No PCQ**	**PCQ**	**No PCQ**	**PCQ**
1	0.47	0.45	0.61	0.47	0.47	0.57	0.47	0.47
2	0.51	0.49	0.46	0.46	0.46	0.49	0.47	0.47
3	0.46	0.51	0.47	0.47	0.49	0.47	0.47	0.47
4	0.47	0.44	0.47	0.46	0.48	0.46	0.47	0.47
5	0.48	0.61	0.47	0.47	0.47	0.47	0.46	0.47
6	0.48	0.46	0.48	0.47	0.47	0.46	0.46	0.47
7	0.47	1.76	0.48	0.47	0.47	0.47	0.47	0.47
8	0.46	0.58	0.47	0.67	0.47	0.47	0.47	0.47
9	0.45	0.46	0.47	0.49	0.46	0.49	0.47	0.47
10	0.46	0.48	0.47	0.46	0.46	0.47	0.47	0.47
Average	**0.47**	**0.62**	**0.49**	**0.49**	**0.47**	**0.48**	**0.47**	**0.47**

Table 5. Test results for Packet Loss parameters.

	Packet Loss (%)							
Client	**Scenario 1 (240p)**		**Scenario 2 (630p)**		**Scenario 3 (480p)**		**Scenario 4 (720p)**	
	No PCQ	**PCQ**	**No PCQ**	**PCQ**	**No PCQ**	**PCQ**	**No PCQ**	**PCQ**
1	0.49	0.75	0.63	0.46	0.49	0.11	0.41	0.59
2	0.09	0.99	0.86	0.94	0.62	0.43	0.73	0.71
3	0.39	0.37	0.36	0.01	0.47	0.22	0.95	0.62
4	0.53	0.11	0.59	0.01	0.37	0.64	0.65	0.36
5	0.78	0.89	0.41	0.17	0.95	0.82	0.97	0.67
6	0.78	0.27	0.44	0.08	0.13	0.72	0.39	0.09
7	0.58	0.23	0.03	0.41	0.96	0.91	0.33	0.02
8	0.97	0.34	0.01	0.04	0.82	0.63	0.03	0.69
9	0.07	0.42	0.11	0.11	0.42	0.68	0.31	0.24
10	0.24	0.79	0.41	0.58	0.07	0.57	0.92	0.53
Average	**0.49**	**0.52**	**0.39**	**0.28**	**0.53**	**0.57**	**0.57**	**0.45**

Table 6. Test results for Jitter parameters.

	Jitter (ms)							
	Scenario 1 (240p)		**Scenario 2 (630p)**		**Scenario 3 (480p)**		**Scenario 4 (720p)**	
Client	**No PCQ**	**PCQ**	**No PCQ**	**PCQ**	**No PCQ**	**PCQ**	**No PCQ**	**PCQ**
1	0.48	0.62	0.62	0.47	0.47	0.57	0.47	0.47
2	0.52	0.46	0.46	0.47	0.46	0.50	0.47	0.47
3	0.46	0.48	0.48	0.47	0.49	0.47	0.47	0.47
4	0.48	0.47	0.47	0.46	0.49	0.46	0.47	0.47
5	0.48	0.48	0.48	0.47	0.47	0.48	0.46	0.47
6	0.49	0.48	0.48	0.47	0.47	0.46	0.46	0.47
7	0.47	0.48	0.48	0.47	0.47	0.47	0.47	0.47
8	0.46	0.47	0.47	0.68	0.47	0.47	0.47	0.47
9	0.46	0.48	0.48	0.49	0.47	0.49	0.47	0.47
10	0.46	0.47	0.47	0.47	0.46	0.48	0.47	0.48
Average	**0.48**	**0.49**	**0.49**	**0.49**	**0.47**	**0.39**	**0.47**	**0.47**

Table 7. Index QoS No PCQ.

	No PCQ							
	Scenario 1		**Scenario 2**		**Scenario 3**		**Scenario 3**	
Parameter	**value**	**Index**	**value**	**Index**	**value**	**Index**	**value**	**Index**
Packet loss	0.49	4	0.39	4	0.53	4	0.57	4
Delay	0.47	4	0.49	4	0.47	4	0.47	4
Jitter	0.48	3	0.49	3	0.47	3	0.47	3
Average		**3.666667**		**3.666667**		**3.666667**		**3.666667**

Table 8. Index QoS PCQ.

	PCQ							
	Scenario 1		**Scenario 2**		**Scenario 3**		**Scenario 3**	
Parameter	**value**	**Index**	**value**	**Index**	**value**	**Index**	**value**	**Index**
Packet loss	0.52	4	0.28	4	0.57	4	0.45	4
Delay	0.62	4	0.49	4	0.48	4	0.47	4
Jitter	0.49	3	0.49	3	0.39	3	0.47	3
Average		**3.666667**		**3.666667**		**3.666667**		**3.666667**

The next stage is the average results of all scenarios for each parameter adjusted to the QoS index. Table 7 shows the QoS index value for the network without PCQ. Table 7 shows that the average results of network testing without PCQ show consistent performance with a low packet loss rate with the packet loss value index always at level 4 on the index scale, indicating that the packet loss rate can be considered low in all tested scenario conditions. The delay parameter is stable with the delay value index always at level 4 on the index scale, indicating that the delay level can be considered low in all tested scenario conditions. The jitter level on the network without PCQ also shows consistency, the jitter value index is always at level 3 on the index scale, indicating that response time fluctuations (jitter) can be considered quite stable in all tested delay conditions. The average index that remains at 3.666667 indicates that this network has good performance in maintaining its availability, stability, and responsiveness. Table 8 shows the QoS index values for the PCQ network.

Table 8 shows the average results of network testing with the use of PCQ in all four scenarios showing a relatively stable index value with an average of 3.666667. Although the packet loss values varied among the scenarios, the index value remained at level 4, indicating that the packet loss rate was acceptable in the context of the tests. The use of PCQ in the network shows consistency in delay handling, with index values at level 4 in all scenarios, indicating network performance that can be considered stable with acceptable levels of delay. The jitter parameter also shows consistency, with index values at level 3 for all scenarios, indicating that fluctuations in network response time remain within acceptable limits. The results of network testing using PCQ and without PCQ for each scenario when viewed graphically can be seen in Figure 4.

Figure 4 shows the test results of the network without PCQ has a relatively stable performance on each measurement parameter during different times. Specifically, in scenario 1 with 240p video quality, the average value of packet loss in Figure 4(a) is 0.49%, the average value of delay in Figure 4(b) is 0.47 ms, and jitter in Figure 4(c) is 0.48 ms. Likewise, in scenario 2 with 360p video quality, the average value of packet loss in Figure 4(a) is 0.39%, delay in Figure 4(b) is 0.49 ms, and jitter in Figure 4(c) is 0.49 ms. In scenario 3 with 360p video quality and scenario 4 with 720p video quality, the average values of packet loss in Figure 4(a) are 0.53% and 0.57%, delay in Figure 4(b) remains at 0.47 ms, and jitter in Figure 4(c) is 0.47 ms, respectively. Thus, the overall results show that the network without PCQ has a stable performance with relatively constant average values on each parameter during the time tested. The Average Index of 3.666667 indicates that the network without PCQ has comparable performance on all three measurement parameters. While network testing using PCQ shows consistent and relatively stable performance on each measurement parameter during different times.

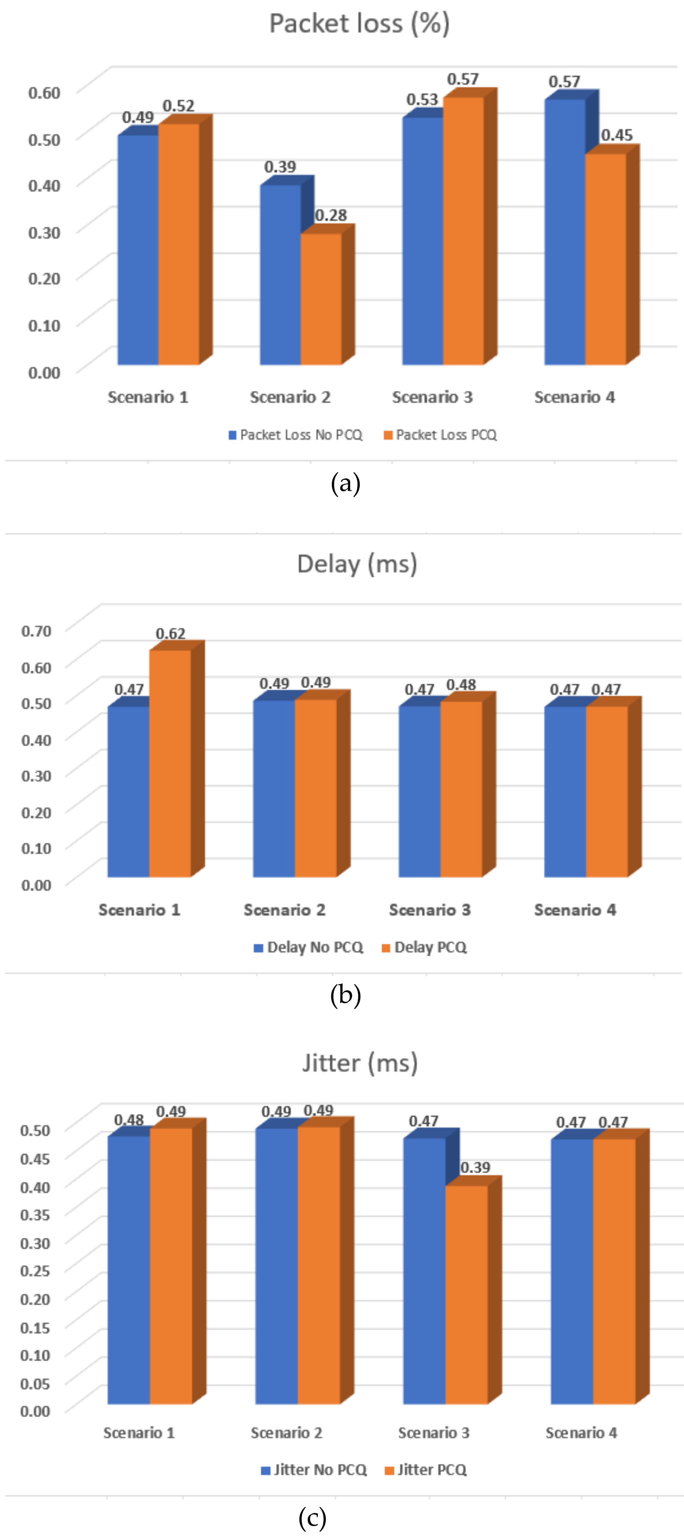

Figure 4. PCQ and no PCQ graphic comparison, with (a). packet loss (%) parameter comparison, (b). delay (ms) comparison, and (c). jitter (ms) comparison

In scenario 1 with 240p video quality, the average value of packet loss in Figure 4(a) is 0.52%, delay in Figure 4(b) is 0.62 ms, and jitter in Figure 4(c) is 0.49 ms. Likewise, in scenario 2 with 360p video quality, the average value of packet loss in Figure 4(a) is 0.28%, delay in Figure 4(b) is 0.49 ms, and jitter in Figure 4(c) is 0.49 ms. In Scenario 3 with 360p video quality and Scenario 4 with 720p video quality, the average values of packet loss in Figure 4(a) are 0.57% and 0.45%, delay in Figure 4(b) remains at 0.48 ms, and jitter in Figure 4(c) is 0.39 ms and 0.47 ms, respectively. Thus, the overall results show that the network with PCQ has a stable performance with relatively constant average values on each parameter during the time interval tested. The Average Index of 3.666667 indicates that the network with PCQ has comparable performance on all three measurement parameters.

4. Conclusion

From the above paragraphs, it can be concluded that the test results of networks without PCQ and networks with PCQ show relatively stable performance on each measurement parameter during different time intervals. In the network without PCQ, 240p and 360p video quality show relatively constant average values of packet loss, delay, and jitter. The same is true for 720p video quality in scenarios 3 and 4, although there is a slight increase in packet loss. Meanwhile, network testing using PCQ also shows consistent and relatively stable performance. At 240p and 360p video quality, the values of packet loss, delay, and jitter tend to remain stable, even with some decrease in some parameters. At 720p video quality, there is an increase in packet loss values in scenario 3, but overall performance remains relatively stable. The Average Index which reaches a value of 3.666667 for network types without PCQ and with PCQ shows that both have "Good" category performance according to TIPHON standardization which is comparable in all three measurement parameters. Although there are differences in numerical values, the performance of networks with and without PCQ can be considered comparable. This conclusion illustrates that the implementation of PCQ does not significantly affect network performance on packet loss, delay, and jitter measurements.

5. Conflicts of Interest

The author (s) declare no conflict of interest.

6. References

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