



Performance Analysis of IPv4 and IPv6 in Network Traffic Management Using Various Queuing Mechanism Algorithms

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Abstract

Internet Protocol Address (IP Address) is a crucial element in computer networks that enables communication between devices. As the demand for IP addresses increases, the transition from IPv4 to IPv6 becomes increasingly important. This research analyzes the performance of IPv4 and IPv6 in network traffic management using various queuing mechanism algorithms, such as FIFO, WFQ, PQ, and CBWFQ. The Network Development Life Cycle (NDLC) approach is used to test bandwidth, latency, and packet loss parameters in IPv4 and IPv6-based network scenarios. The results show that IPv4 has higher bandwidth, while IPv6 offers better network stability. The CBWFQ queuing mechanism proved effective in managing data traffic and ensuring quality of service. This study provides recommendations for network managers to choose suitable queuing protocols and algorithms to improve network efficiency.

Keywords: IPv4, IPv6, Queuing Mechanism, NDLC, QoS

1. Background

An Internet Protocol Address (IP Address) is a unique label used to identify devices on a computer network. It enables communication between devices on a network by assigning a specific address to each device. Currently, there are two main versions of IP Address in use, namely IPv4 and IPv6 (Hartono, 2023). IPv4 is an IP protocol that has been used for decades with an established infrastructure and broad compatibility. However, as the number of internet-connected devices increases, the limited capacity of IPv4 addresses is driving the adoption of IPv6 as a long-term solution (Kurniati, 2024).

The transition from IPv4 to IPv6 is important because of the limited number of addresses in IPv4, which is only 4.3 billion (Santoso, 2024). IPv6, with its much larger address capacity of up to 2^{128} addresses, is designed to support the future growth of the internet. It also offers new features such as simpler headers, built-in security (IPsec), and better data processing efficiency. However, IPv6 adoption still faces challenges, such as hardware and software compatibility that previously only supported IPv4 (Mas'ud, 2023).

In the management of network data traffic, the queuing mechanism is one of the important components. Queuing mechanisms regulate data flow to ensure optimal quality of service (QoS), reduce latency, and prevent congestion. Queuing mechanism algorithms such as FIFO (First In First Out), WFQ (Weighted Fair Queuing), PQ (Priority Queuing), and CBWFQ (Class-Based Weighted Fair Queuing) offer different approaches in managing data traffic. Each algorithm has advantages and disadvantages that can affect network performance (Srimuni, 2022).

As IPv6 adoption increases, understanding the impact of IPv4 and IPv6 protocols on queuing mechanisms becomes increasingly relevant. Several studies have shown that the implementation of certain queuing algorithms and mechanisms can improve QoS in IPv6-based networks. For example, the implementation of Never Queue and Destination Hashing algorithms has been shown to improve time per request by adjusting the queuing mechanism in IPv6 network configurations (Deltaviahay, 2019). In addition, a comparison of IPv4 and IPv6 performance with

throughput, delay, jitter, and packet loss parameters shows that IPv6 is superior in data transmission, although it has some disadvantages such as slightly higher delay than IPv4 in ICMP packets (Kristanto, 2021).

Queuing mechanisms also play an important role in improving QoS on the network. Methods such as Low Latency Queue (LLQ) and Class-Based Weighted Fair Queue (CBWFQ) have been proven to reduce delay by 84.95% in FTP service testing (D. A. Salman, M. T. Rendy Munadi, and R. Mayasari). In addition, the CBWFQ method is also effective in managing bandwidth on VoIP networks, ensuring optimal bandwidth sharing when simultaneous calls occur (Ali et al, 2020).

Furthermore, research comparing various queuing mechanism methods such as FIFO, Weighted Fair Queuing (WFQ), and Priority Queuing (PQ) shows that WFQ and PQ have significant advantages in reducing throughput, jitter, and packet loss in video streaming for IPv4 and IPv6 networks (Fayyadh, 2018).

This research aims to compare the performance of IPv4 and IPv6 based on parameters such as bandwidth, latency, and packet loss in a network configured with a specific queuing mechanism algorithm. Using the Network Development Life Cycle (NDLC) approach, this research will cover the stages of analysis, design, simulation, implementation, monitoring, and network management. The results of this research are expected to be a reference for network practitioners in selecting IP protocols and queuing algorithms that suit the specific needs of the network.

Through this research, it is expected that the transition from IPv4 to IPv6 can be carried out more purposefully based on strong empirical data. In addition, the analysis of queuing mechanisms used in both protocols can provide recommendations to improve efficiency and quality of service on computer networks. This research can also open up opportunities for further studies related to the performance of IP protocols in various more complex network scenarios.

2. Research Methods

This research uses the Network Development Life Cycle (NDLC) approach as the main methodology. NDLC was chosen because it provides systematic steps for developing and analyzing computer networks, from the initial planning stage to the evaluation of results. The method consists of six main stages: analysis, design, prototype simulation, implementation, monitoring, and network management. This approach allows the research to be conducted in a structured and in-depth manner, resulting in valid and relevant data to support the research objectives (Sanjaya, 2019).

The first stage is analysis, which includes problem identification, literature review, and formulation of research objectives. In this stage, the research is focused on comparing the performance of IPv4 and IPv6, specifically on the parameters of bandwidth, latency, and packet loss. The queuing mechanisms used, such as Class-Based Weighted Fair Queuing (CBWFQ), are analyzed to determine how they affect network performance. This analysis also includes the identification of hardware and software requirements to support the research, such as routers, switches, simulation applications, and network performance measurement tools.

The next stage is design, where the network topology is designed based on the results of the previous analysis. The designed network consists of several devices such as routers, switches, servers, and clients connected in two separate networks, using IPv4 and IPv6 respectively. Routers in the network are configured with CBWFQ queuing mechanism algorithm, which prioritizes TCP packets as much as 30% of the total bandwidth. This design aims to represent a real network environment that can be tested with various data delivery scenarios.

After the design is complete, the prototype simulation stage is carried out using simulation applications such as Cisco Packet Tracer. At this stage, the network design is implemented in a virtual environment to test the queuing mechanism configuration and IP protocol performance. Simulations are carried out with data transmission scenarios using TCP and ICMP protocols. The data obtained from this simulation is then used to determine the feasibility of physical network implementation. Simulation results include bandwidth, latency, and packet loss measurements, which are analyzed to compare IPv4 and IPv6 performance.

The last stage is implementation, monitoring, and network management. Implementation involves the installation of hardware such as routers, switches, and client/server computers, as well as the configuration of the queuing mechanism algorithm on the router. Monitoring is done using tools such as iperf to measure bandwidth and Ping to measure latency and packet loss. Data from monitoring results are analyzed to assess network performance, while the management stage is used to record and compile reports on test results. The results of all NDLC stages

are expected to provide a clear picture of the comparison of IPv4 and IPv6 performance in network management using queuing mechanisms.

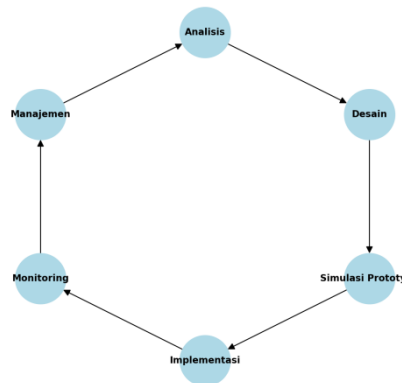
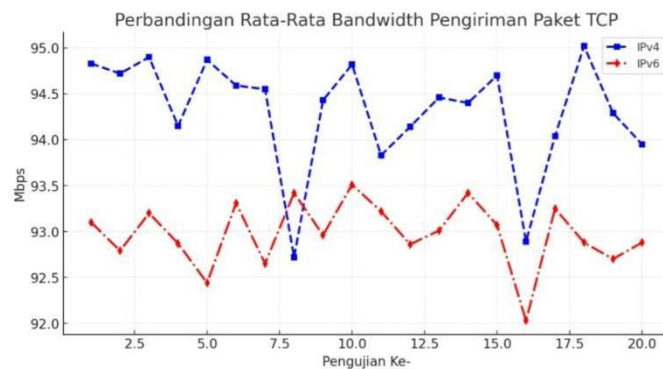


Figure 1: *Network Development Life Cycle Research Method*

3. Results and Discussion

In this research, the designed network topology consists of two different networks that use IPv4 and IPv6 protocols respectively. This topology includes several devices such as routers, switches, and interconnected clients. Routers are configured with a queuing mechanism using Class-Based Weighted Fair Queuing (CBWFQ) algorithm to prioritize TCP packets by 30% of the total bandwidth distribution. This configuration aims to analyze how IPv4 and IPv6 protocols affect network performance, especially in terms of bandwidth, latency, and packet loss.

Bandwidth Testing

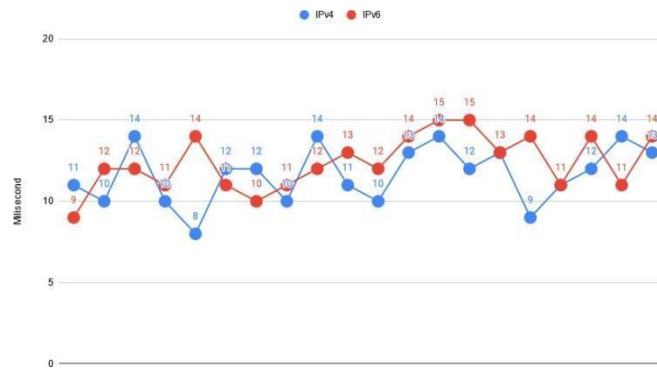


Comparison of Average TCP Packet Delivery Bandwidth

The test results show that the IPv4 protocol has a higher average bandwidth than IPv6. The average IPv4 bandwidth ranges from 92.89 Mbps to 95.02 Mbps, while IPv6 reaches an average between 92.03 Mbps to 93.44 Mbps. The difference in average bandwidth between IPv4 and IPv6 is about 1.35 Mbps. Although IPv4 yields higher bandwidth, IPv6 shows better stability in use, which is a significant advantage for this protocol.

Bandwidth stability in IPv6 is influenced by the simpler header design. IPv6 headers do not have per hop checksums, so routers can process packets more quickly and efficiently. Although the size of the IPv6 header is larger (40 bytes compared to 20-60 bytes in IPv4), its design reduces the processing overhead at the router. This contributes to better stability despite a slight decrease in bandwidth compared to IPv4.

Latency Testing



Comparison of Average ICMP Packet Latency

The latency measurement results using ICMP packets show that IPv4 has a lower average latency than IPv6. The average latency of IPv4 is in the range of 8-14 milliseconds, while IPv6 has a range of 9-15 milliseconds. The difference in average latency between IPv4 and IPv6 is about 0.75 milliseconds. This difference is quite small and may not be very significant in small-scale networks, but it can be a concern in networks that require very low latency, such as real-time networks.

The CBWFQ queuing mechanism used in this study prioritizes TCP packets with a certain bandwidth allocation. This causes a slight increase in latency on ICMP packets due to the queuing of data transmission. However, the impact is relatively small and acceptable in network management.

Packet Loss Testing

In packet loss testing, no packet loss was found in both protocols, both IPv4 and IPv6. This shows that the configuration of the queuing mechanism using CBWFQ is able to manage data transmission well. TCP packet prioritization and efficient queue management help prevent data loss during transmission. With this mechanism in place, the network can maintain optimal quality of service without any significant disruption. In addition, the absence of packet loss also indicates that the network capacity used is sufficient to handle the existing traffic load.

The results show that IPv4 has an advantage in terms of bandwidth usage efficiency, while IPv6 excels in data delivery stability. Although there is a small difference in latency, both protocols show similar performance in preventing packet loss. This performance can serve as a reference for determining the use of protocols based on the specific needs of the network. In resource-constrained environments, IPv4 may be more reliable due to its more bandwidth-efficient use. In contrast, IPv6 is more suitable for systems that require high stability in data transmission without significant fluctuations.

The stability of IPv6 is one of the main advantages that makes it suitable for use in networks that are sensitive to performance changes. It is more reliable in maintaining quality of service (QoS) in environments that have unpredictable data traffic. With more advanced routing algorithms, IPv6 can handle more complex network scenarios than IPv4. In addition, the auto-configuration and enhanced security features of IPv6 provide additional benefits for users who want a more flexible and secure network.

The increased number of addresses provided by IPv6 also allows more devices to connect without experiencing the limitations of IPv4. These advantages are important factors for the development of modern network infrastructures that continue to grow. Thus, the use of IPv6 is increasingly relevant as the need for more reliable and secure networks increases. IPv4 remains a good choice for small-scale networks or local networks (LANs).

The CBWFQ algorithm used in this study proved to be effective in managing data traffic. By prioritizing packets based on specific categories, the algorithm is able to reduce latency and prevent congestion in the network. This makes it a good choice for modern network management. CBWFQ ensures that each type of traffic gets the bandwidth allocation it needs, thus optimizing data transmission efficiency.

The transition from IPv4 to IPv6 is becoming increasingly important as the need for more IP addresses increases. The results of this research can guide network managers in preparing for IPv6 adoption, especially in configuring queuing mechanisms to maintain network performance. IPv6 not only offers greater address capacity, but also has better security features than IPv4.

In addition, the protocol is designed to improve efficiency in routing and managing data traffic, which contributes to improved network quality of service. Although IPv6 adoption still faces some challenges, such as compatibility

with older devices, the long-term benefits are significant. Therefore, careful planning and phased implementation are necessary for a smooth transition from IPv4 to IPv6.

This research provides a strong foundation for further exploration. Future studies could include testing IPv4 and IPv6 performance on more complex network scenarios, such as office or data center networks. In addition, the use of additional performance measurement tools and more varied testing methods could provide more comprehensive results. Another factor that could be explored is the effect of different queuing mechanisms on quality of service in IPv6-based networks.

4. Conclusion

This research has analyzed and compared the performance of IPv4 and IPv6 protocols in network management using the Class-Based Weighted Fair Queuing (CBWFQ) queuing mechanism algorithm. Based on the test results, the IPv4 protocol shows an advantage in terms of bandwidth with a higher average than IPv6. However, IPv6 provides an advantage in terms of stability in bandwidth utilization, which is an important advantage for networks that require consistency in performance. In terms of latency, IPv4 has a slightly lower value than IPv6, although the difference is not significant. Packet loss testing shows that both protocols do not experience data loss in network configurations that have been optimized using the CBWFQ algorithm. IPv6's advantages in stability and header design efficiency make it an ideal choice for more complex or large-scale networks, such as enterprise networks or data centers, which require high reliability and greater address capacity. On the other hand, IPv4 is still relevant for small-scale or local networks (LANs), mainly because the infrastructure and hardware supporting it are well-established. The CBWFQ queuing mechanism is proven to be effective in prioritizing data packets and ensuring good quality of service, so it can be used in both protocols to improve network performance. As a practical recommendation, the transition from IPv4 to IPv6 should be done in a phased manner considering the specific needs of the network. Network managers are advised to adopt appropriate queuing mechanisms, such as CBWFQ, to optimize network performance during the transition process. This research is expected to be a reference for network practitioners and researchers in understanding the advantages and disadvantages of each protocol and the importance of efficient data traffic management.

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