CS244 Computer Network: Assignment 3

1 Introduction

In this experiment, the task is to observe how changes in queue length within a Linux system affect network throughput and delay. In the Linux queuing structure, two types of queue lengths can be adjusted: the operating system queue length (using the `ip link dev` command) and the hardware queue length of the network device (using the `ethtool` command). The adjustable queue range for the network adapter on my hardware is [48, 4096], which is too small to observe significant experimental phenomena. Therefore, based on the assignment requirements, the `ip link` command was used to adjust the operating system queue length.

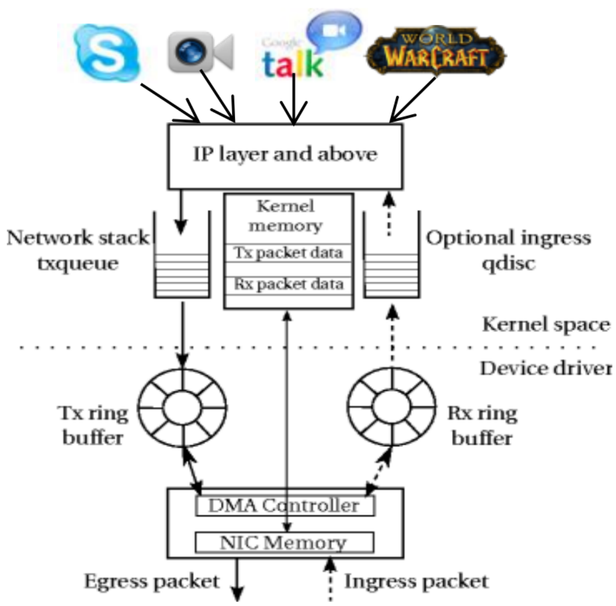

Figure 1: Linux Queue Structure

2 Experiment Setup

To measure the effect of queue length on throughput and delay, I applied a fine-to-coarse classification rule. Each queue configuration was tested five times, with each test lasting 50 seconds. The final data was obtained by averaging the results. For both throughput and delay measurements, I used iPerf with JSON output and parsed the bandwidth and RTT data from the JSON files. For UDP tests, as UDP is a connectionless protocol without RTT measurements, I focused on throughput only.

3 Throughput Over Queue Length

3.1 TCP Throughput

TCP has inherent congestion control mechanisms. Hence, it is predicted that adjusting queue length will have some effect on TCP throughput, but the impact will be minimal since TCP aims to ensure the network remains in a high-performance state through congestion control.

3.1.1 Wired Network Throughput (TCP)

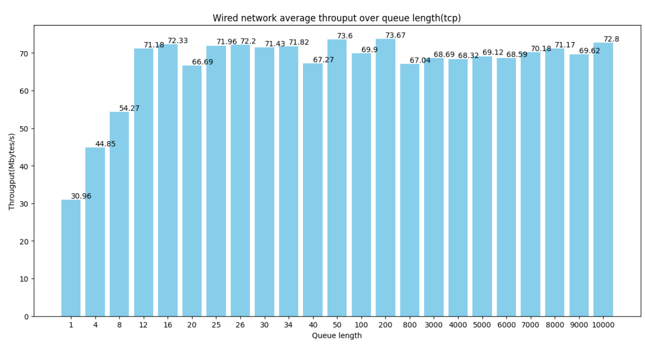

Figure 2: Wired Network TCP Throughput

3.1.2 Wireless Network Throughput (TCP)

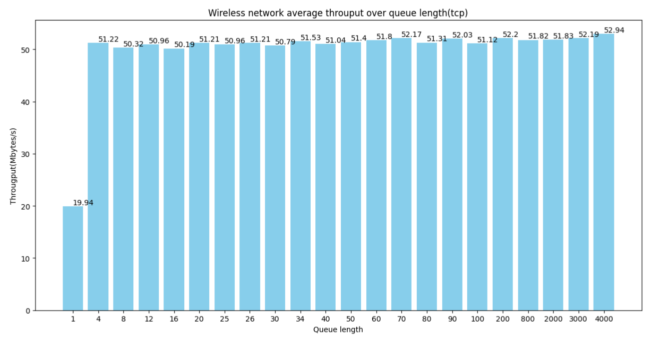

Figure 3: Wireless Network TCP Throughput

Analysis: Increasing queue length positively affects bandwidth, particularly in wired networks. However, beyond a certain point, the effect becomes negligible, likely due to device processing limitations and network conditions. In wireless networks, bandwidth improvement is constrained, likely due to the instability of wireless signals. Hence, appropriate queue length settings must account for specific network environments and device conditions.

3.2 UDP Throughput

For UDP, lacking congestion control, we expect throughput to increase with queue length. However, around queue length 50, bandwidth drops unexpectedly in both wired and wireless networks.

3.2.1 Wired Network Throughput (UDP)

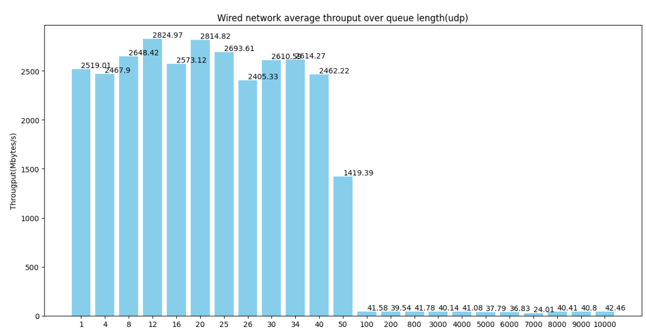

Figure 4: Wired Network UDP Throughput

3.2.2 Wireless Network Throughput (UDP)

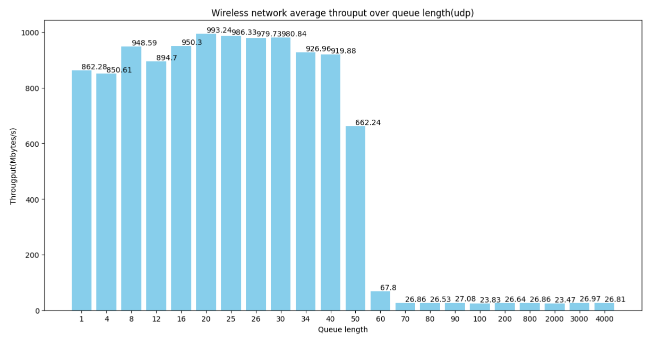

Figure 5: Wireless Network UDP Throughput

Analysis: The unexpected bandwidth drop for UDP likely arises from limitations in network interface processing capabilities, particularly when queue length grows. Virtual machine NAT forwarding also constrains throughput due to host system limitations.

4 TCP Delay Over Queue Length

4.1 Wired Network Delay

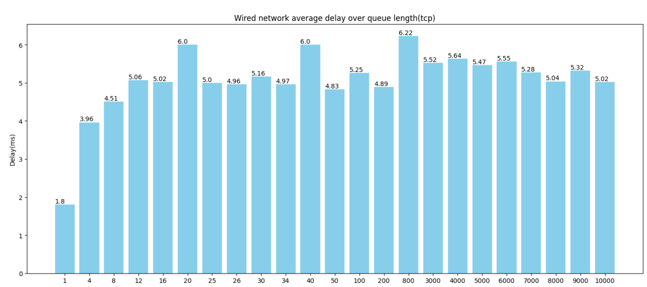

Figure 6: Wired Network TCP Delay

4.2 Wireless Network Delay

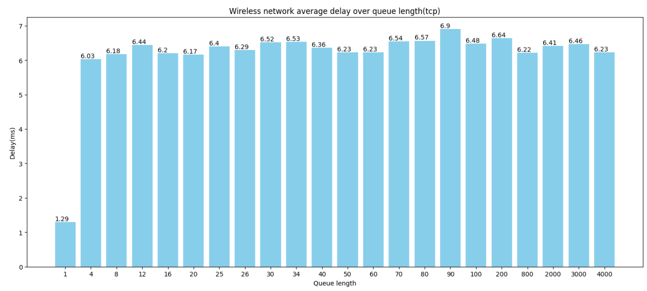

Figure 7: Wireless Network TCP Delay

Analysis: Increasing queue length generally leads to increased delay, reflecting the buffer size and processing limitations of network devices. Wireless networks typically exhibit higher latency due to inherent instability. In the wired network, RTT rises from 1.8 ms to about 6 ms as the queue length increases from 1 to 40, and fluctuates around 5.22 ms thereafter. In the wireless network, delay rises sharply above 6 ms and remains high as queue length increases.

5 Conclusion

Considering both bandwidth and delay, setting the queue length to 50 provides optimal network performance in my setup. At this point, the wired network throughput reaches 73.67 MBytes/s, and the wireless network throughput reaches 51.4 MBytes/s. These values are close to peak performance, while latency remains relatively low.