CS244 Computer Network Assignment2

Command

1. Change the algorithm

```
sudo vim /etc/sysctl.conf
```

2. Reload the config

```
sudo sysctl -p
```

3. Show the algorithm

```
sysctl net.ipv4.tcp_congestion_control
```

4. Throughput and Delay

```
iperf3 -c 10.68.75.53 -t 20
iperf3 -c 10.68.75.53 -t 20 -J -i 0.1
```

1. TCP congestion control algorithm

1.1 TCP BBR

TCP BBR (Bottleneck Bandwidth and RTT) is a congestion control algorithm developed by Google to improve network transmission efficiency. Unlike traditional TCP congestion control algorithms (e.g., TCP Reno or TCP CUBIC), which rely heavily on packet loss and congestion window adjustment, TCP BBR employs a bandwidth and delay (RTT)-based mechanism to estimate the network's bottleneck bandwidth and the minimum RTT in order to dynamically adjust the sending rate.

TCP BBR works by actively detecting the current network state by continuously monitoring the available bandwidth and RTT of the network links and estimating the optimal transmission rate (i.e., bottleneck bandwidth) and the shortest delay (i.e., RTT when there is no queuing) of the network. It then controls the data sending rate based on these .

1.2 TCP CUBIC

TCP CUBIC is a congestion control algorithm for the Transmission Control Protocol (TCP) designed to optimize TCP transmission performance in high-bandwidth-latency network environments. It is the default TCP congestion control algorithm in the Linux kernel, and is designed to address the lack of performance of traditional TCP congestion control algorithms in high-bandwidth and high-latency networks

When network congestion is detected (e.g., packet loss), CUBIC decreases the congestion window size and then gradually increases the window as a cubic function. Over time, the growth rate accelerates until the maximum bandwidth utilization is reached. When the network stabilizes, CUBIC recovers the pre-packet-loss state more quickly, thus maintaining higher transmission rates in high-bandwidth-latency networks.

1.3 TCP Reno

TCP Reno is a popular congestion control algorithm for the Transmission Control Protocol (TCP) with some improvements over TCP Tahoe.The main goal of TCP Reno is to improve network throughput and efficiently adjust transmission rates when congestion is detected.

TCP Reno controls network traffic through four steps: Slow Start, Congestion Avoidance, Fast Retransmission, and Fast Recovery. TCP Reno controls network traffic through four steps, “Slow Start,” “Congestion Avoidance,” “Fast Retransmission,” and “Fast Recovery,” and adjusts the sending rate to minimize packet loss when congestion is detected.

1.4 TCP Vegas

TCP Vegas is a delay-based TCP congestion control algorithm proposed by Brakmo and Peterson in 1994. Unlike the classic TCP Tahoe and TCP Reno, TCP Vegas does not rely on packet loss to detect network congestion, but rather measures delay to predict network congestion. Its core idea is to pre-adjust the sending rate before congestion occurs in order to reduce packet loss and improve network utilization.

##2. Algorithm comparison

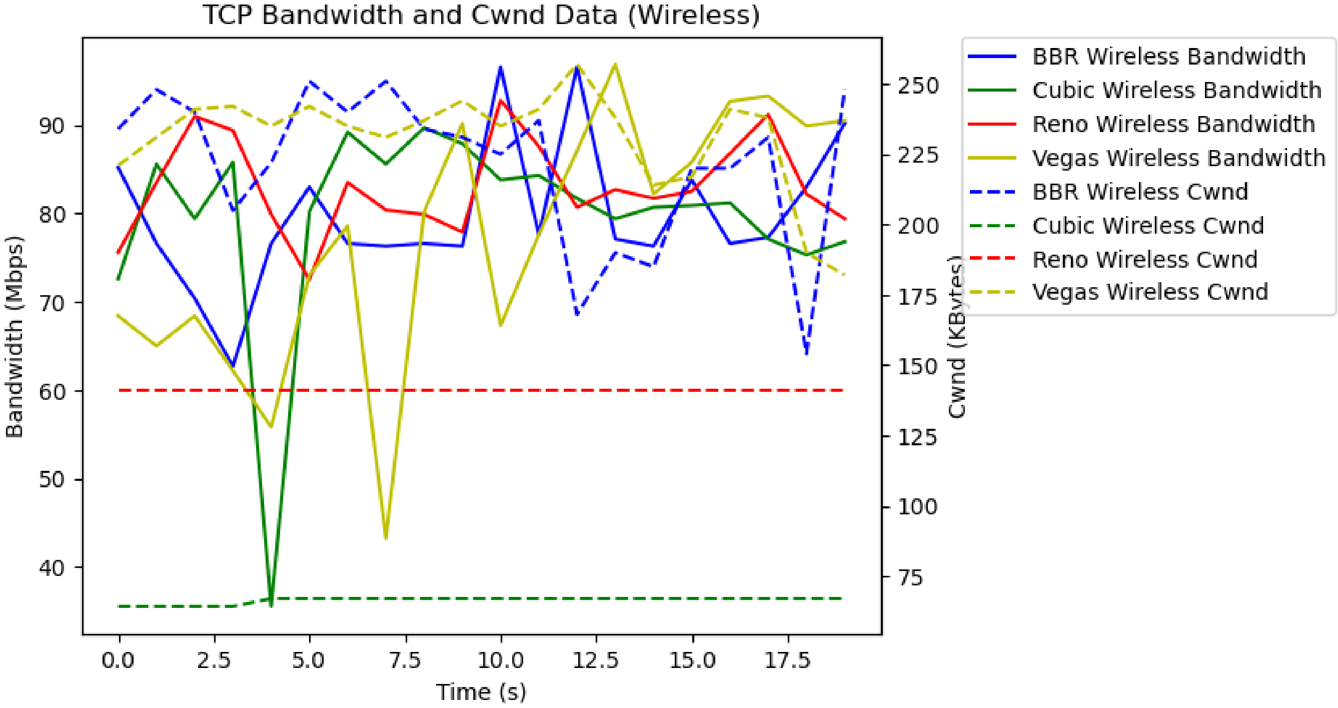
2.1 Throughput

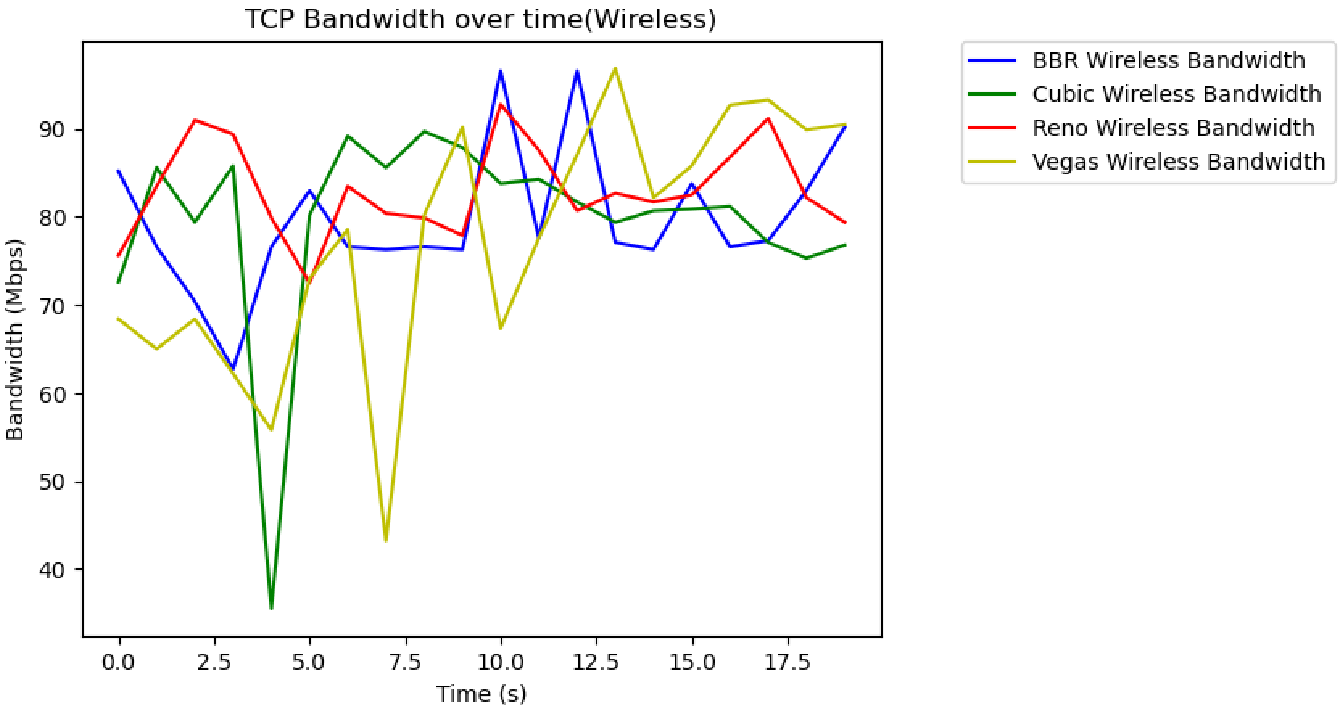
2.1.1 Wireless

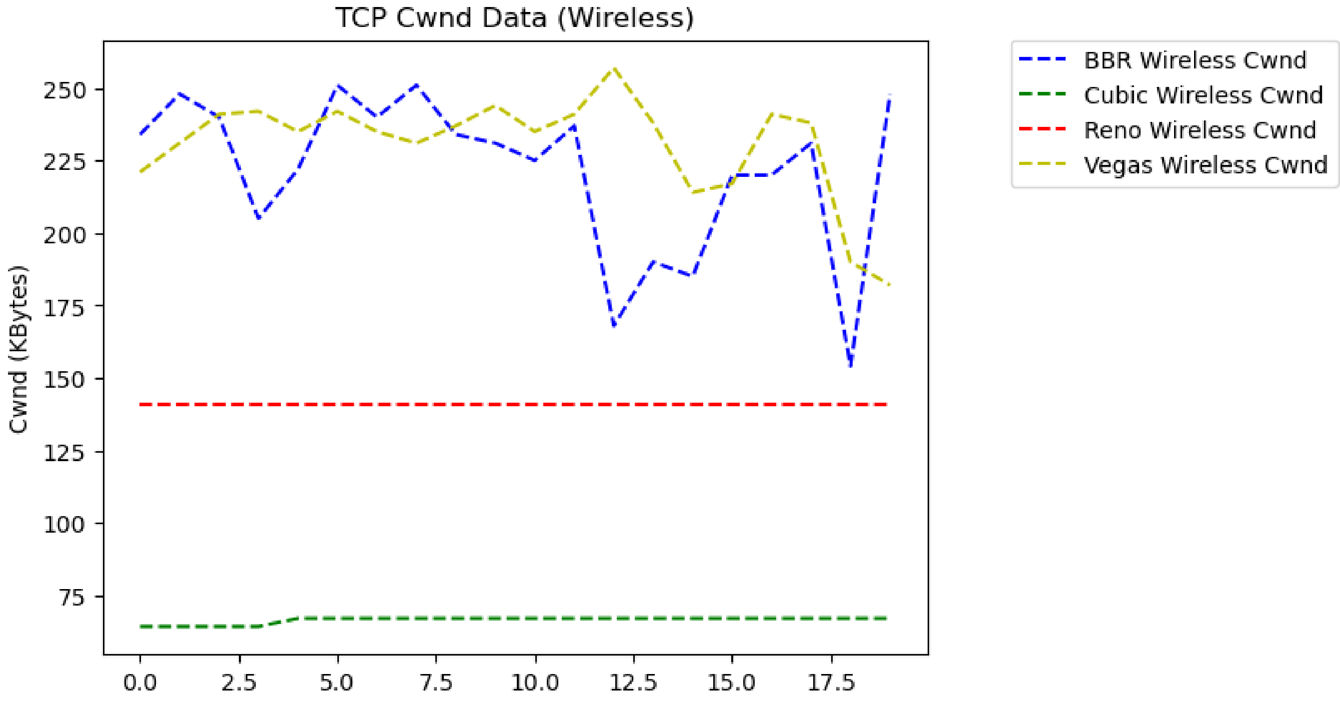
	1s	3s	5s	7s	9s	12s	15s	20s	AVG
Bandwidth-BBR	85.2 Mbits/s	70.4 Mbits/s	76.6 Mbits/s	76.6 Mbits/s	76.6 Mbits/s	96.6 Mbits/s	76.3 Mbits/s	90.2 Mbits/s	79.8 Mbits/s
Bandwidth-CUBIC	72.6 Mbits/s	79.4 Mbits/s	35.5 Mbits/s	89.2 Mbits/s	89.7 Mbits/s	83.8 Mbits/s	80.7 Mbits/s	76.8 Mbits/s	79.6 Mbits/s
Bandwidth-Reno	75.6 Mbits/s	91.0 Mbits/s	79.9 Mbits/s	83.5 Mbits/s	79.9 Mbits/s	92.8 Mbits/s	81.7 Mbits/s	79.4 Mbits/s	83.1 Mbits/s
Bandwidth-Vegas	68.4 Mbits/s	68.4 Mbits/s	55.8 Mbits/s	78.6 Mbits/s	80.2 Mbits/s	67.3 Mbits/s	82.2 Mbits/s	90.5 Mbits/s	77.4 Mbits/s

	1s	3s	5s	7s	9s	12s	15s	20s
Cwnd-BBR	234.0 KBytes	240.0 KBytes	222.0 KBytes	240.0 KBytes	234.0 KBytes	225.0 KBytes	185.0 KBytes	248.0 KBytes

	1s	3s	5s	7s	9s	12s	15s	20s
Cwnd-CUBIC	64.2 KBytes	64.2 KBytes	67.0 KBytes	67.0 KBytes	67.0 KBytes	67.0 KBytes	67.0 KBytes	67.0 KBytes
Cwnd-Reno	141.0 KBytes	141.0 KBytes	141.0 KBytes	141.0 KBytes	141.0 KBytes	141.0 KBytes	141.0 KBytes	141.0 KBytes
Cwnd-Vegas	221.0 KBytes	241.0 KBytes	235.0 KBytes	235.0 KBytes	237.0 KBytes	235.0 KBytes	214.0 KBytes	182.0 KBytes







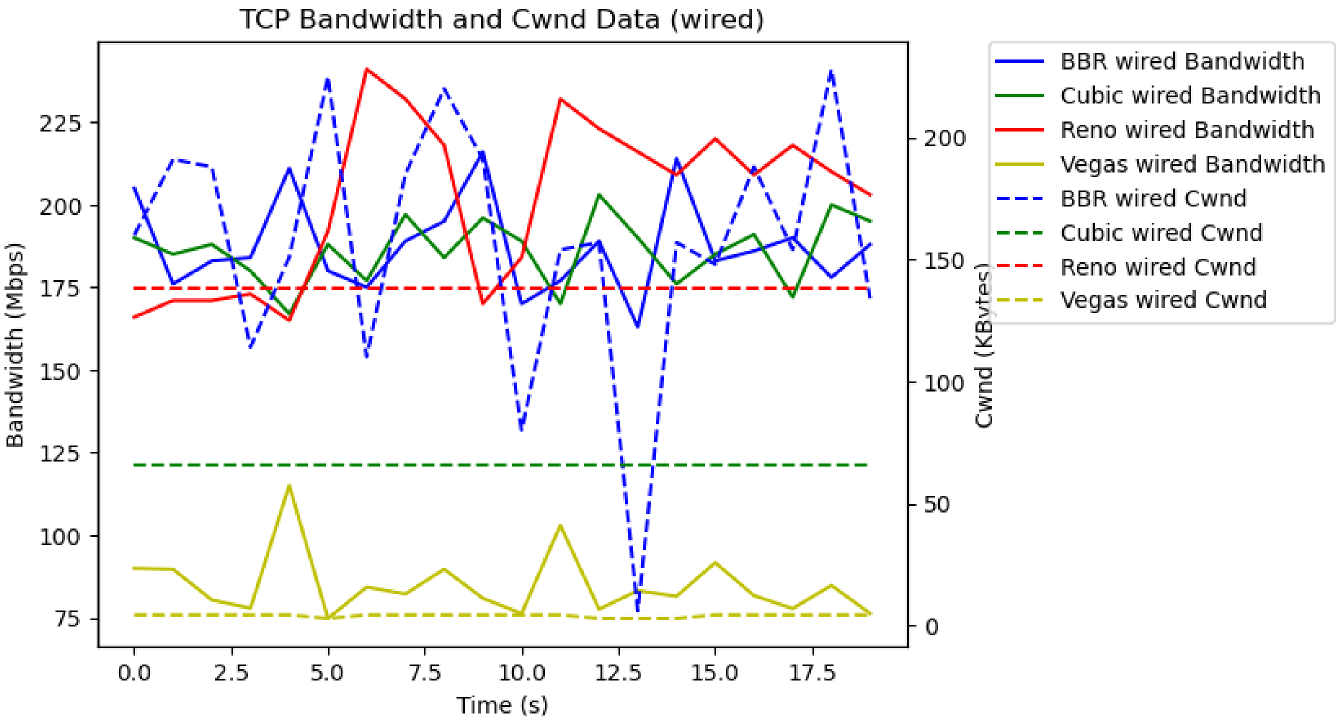
> Analysis: In the wireless network test we can see that the BBR and Reno have the best performance but in terms of average bandwidth the Reno performs better.Vegas consistently performs the worst as it chooses to slow down before congestion occurs. From the graph we can also see Cubic's ability to quickly return to the original network situation after experiencing congestion.

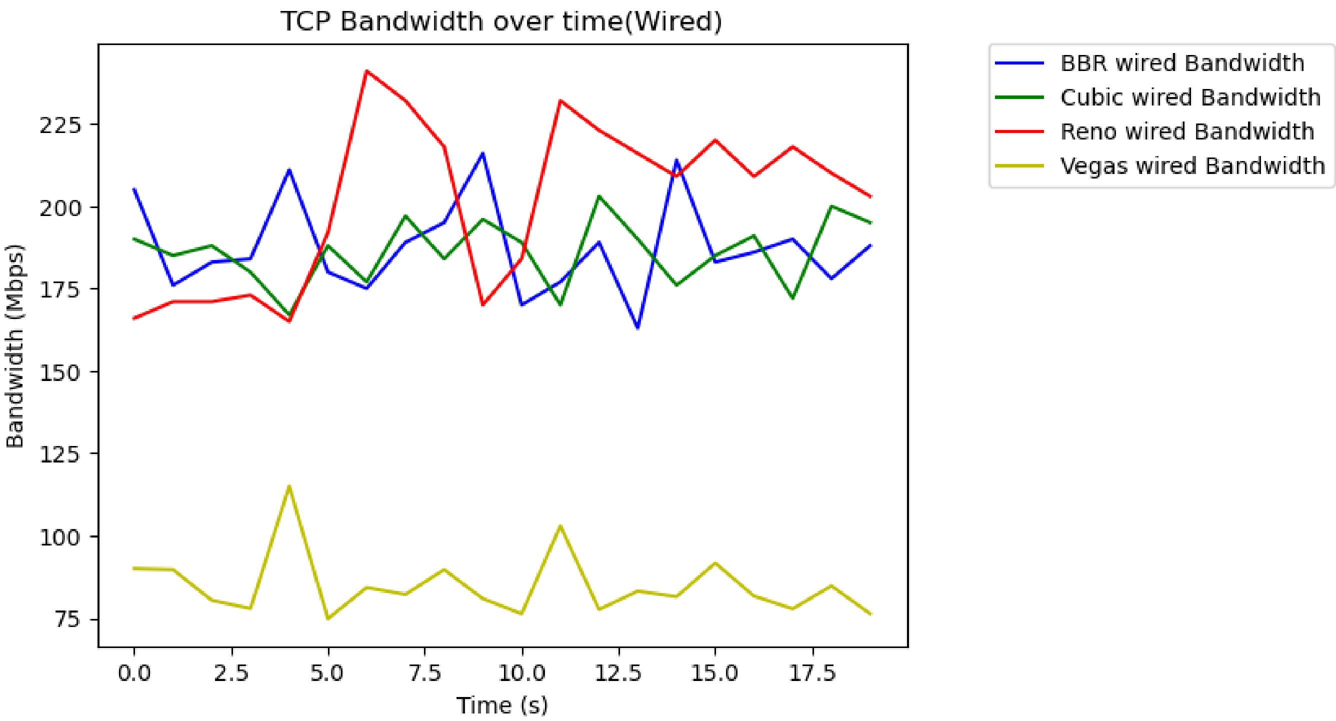
2.1.2 Wired

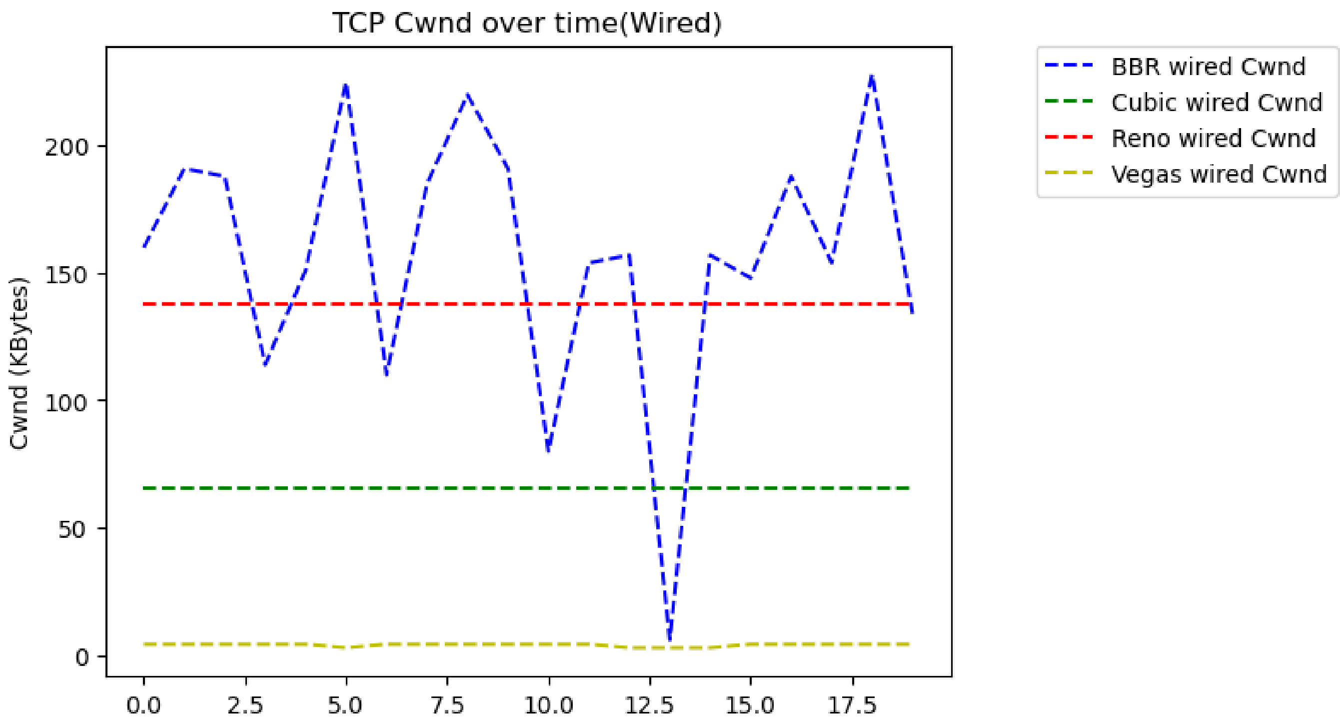
	1s	3s	5s	7s	9s	12s	15s	20s	AVG
Bandwidth-BBR	205.0 Mbits/s	183.0 Mbits/s	211.0 Mbits/s	175.0 Mbits/s	195.0 Mbits/s	170.0 Mbits/s	214.0 Mbits/s	188.0 Mbits/s	188.0 Mbits/s
Bandwidth-CUBIC	190.0 Mbits/s	188.0 Mbits/s	167.0 Mbits/s	177.0 Mbits/s	184.0 Mbits/s	189.0 Mbits/s	176.0 Mbits/s	195.0 Mbits/s	186.0 Mbits/s
Bandwidth-RENO	166.0 Mbits/s	171.0 Mbits/s	165.0 Mbits/s	241.0 Mbits/s	218.0 Mbits/s	184.0 Mbits/s	209.0 Mbits/s	203.0 Mbits/s	201.0 Mbits/s
Bandwidth-VEGAS	90.0 Mbits/s	80.4 Mbits/s	115.0 Mbits/s	84.3 Mbits/s	89.7 Mbits/s	76.3 Mbits/s	81.5 Mbits/s	76.3 Mbits/s	84.9 Mbits/s

	1s	3s	5s	7s	9s	12s	15s	20s
Cwnd-BBR	160.0 KBytes	188.0 KBytes	151.0 KBytes	110.0 KBytes	220.0 KBytes	80.0 KBytes	157.0 KBytes	134.0 KBytes
Cwnd-CUBIC	65.6 KBytes	65.6 KBytes	65.6 KBytes	65.6 KBytes	65.6 KBytes	65.6 KBytes	65.6 KBytes	65.6 KBytes
Cwnd-RENO	138.0 KBytes	138.0 KBytes	138.0 KBytes	138.0 KBytes	138.0 KBytes	138.0 KBytes	138.0 KBytes	138.0 KBytes

	1s	3s	5s	7s	9s	12s	15s	20s
Cwnd-VEGAS	4.28 KBytes	4.28 KBytes	4.28 KBytes	4.28 KBytes	4.28 KBytes	4.28 KBytes	2.85 KBytes	4.28 KBytes



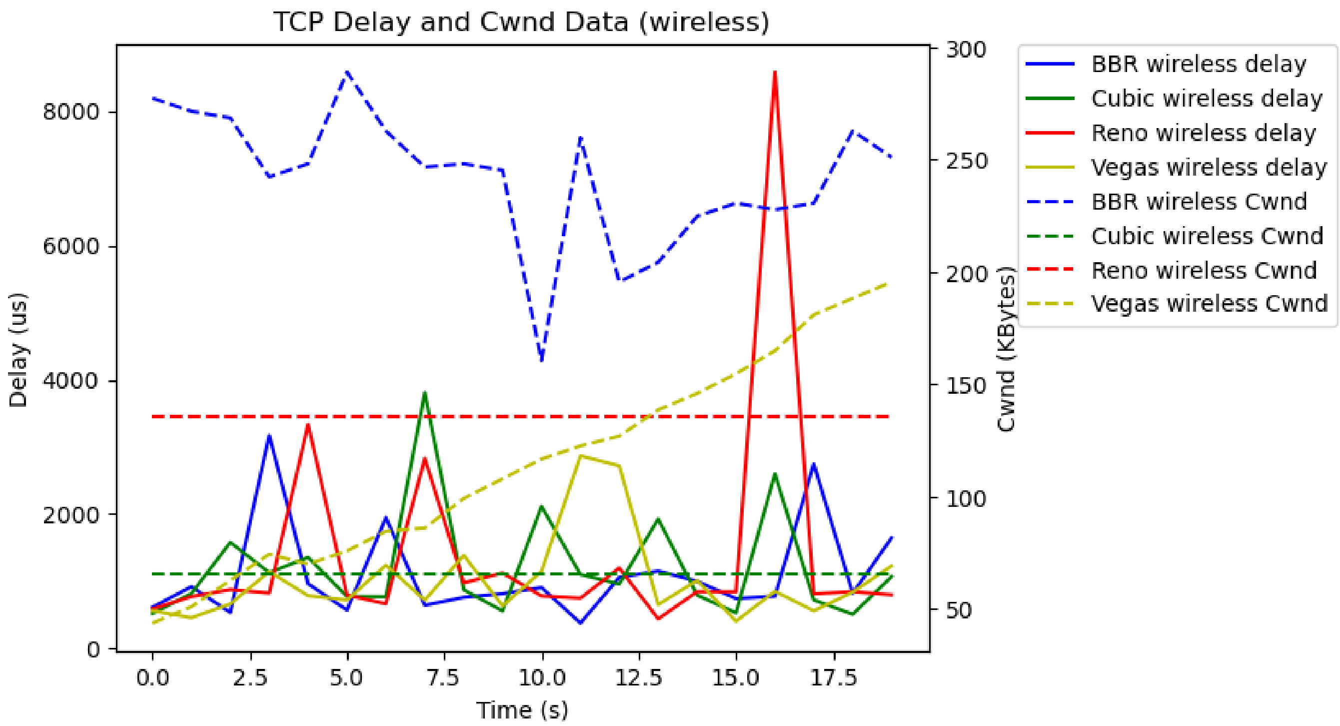




> Analysis: In the wired network test, the network is not in as good a state as it was in the wireless network test because of the objective conditions of the time the experiment was conducted, and we can see that Vegas still performs the worst in bandwidth, while BBR and Reno still perform the best. Similarly, Reno still performs better than BBR on average bandwidth, while Cubic performs the smoothest.

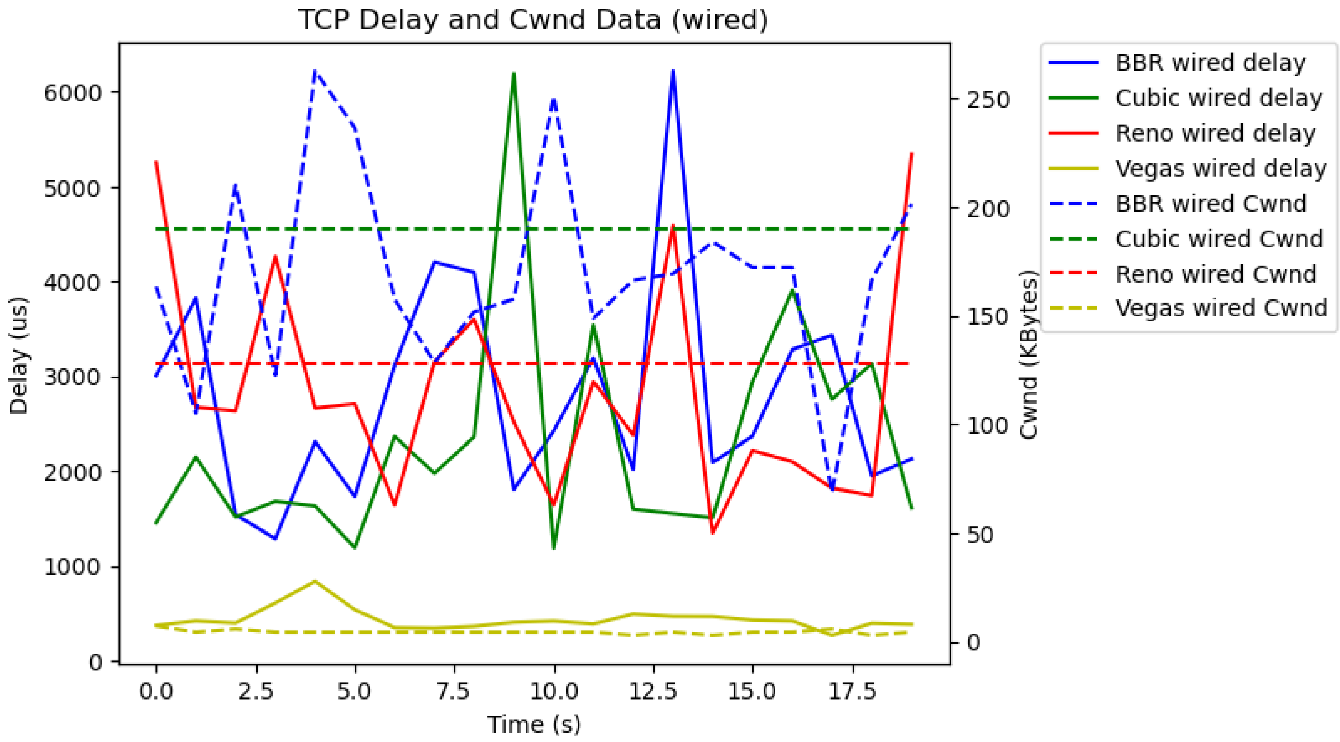
2.2 delay

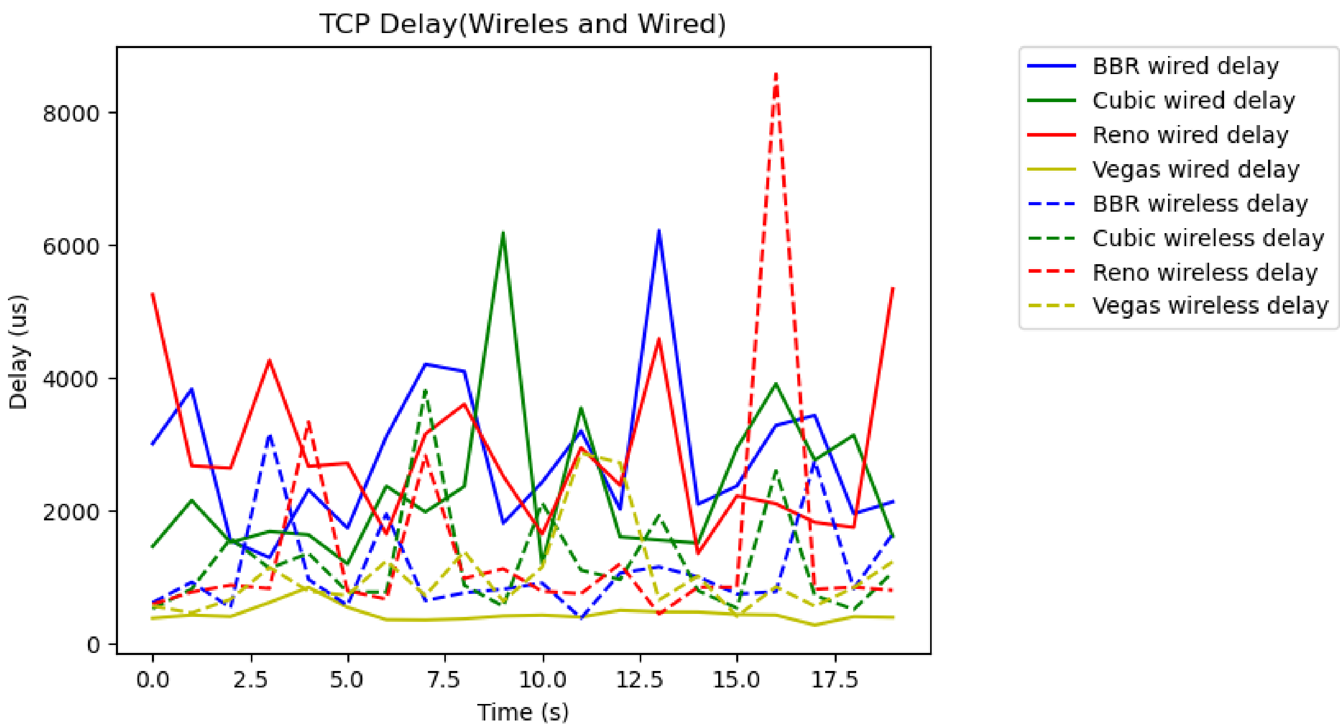
2.2.1 Wireless



> Analysis: Although in bandwidth, Vegas does not perform as well as the other three algorithms, but in terms of latency, Vegas is the best, which is related to the congestion prediction mechanism of Vegas, which reduces the rate when there is a high latency, so that it can always keep the latency low. And BBR, Cubic, and Reno perform close to each other.

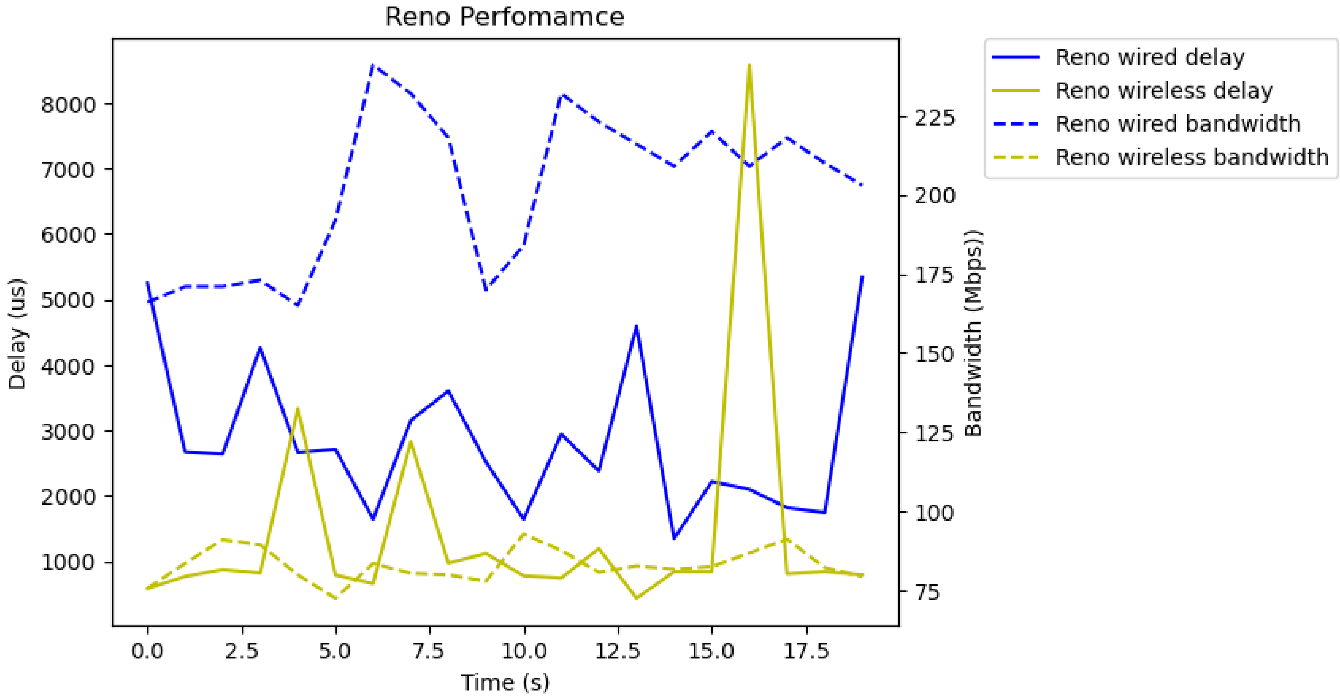
2.2.2 Wired





> Analysis: Comparing wired and wireless networks, we can see that Vegas maintains low latency in both network conditions, whereas BBR, Cubic and Reno all show higher latency fluctuations, but on average, Reno performs better in wired networks.

2.3 Best Award



> Analysis:In fact, all four algorithms have aspects where they perform better, for example Vegas consistently performs best in the latency approach, while BBR and Reno, they tend to come closer in performance. Cubic, on the other hand, is a little behind them, but Cubic is consistently more stable in terms of network performance. Taking both wired and wireless networks into account, the Reno achieves the best performance in terms of average bandwidth, and is just behind the Vegas in terms of latency, so I think the Reno is the winner in my network tests. Base on my understanding, Reno is suitable for the low bandwidth and low latency networks, so I guess the network is low bandwidth(Multi user) and low latency(Short distance) state when I conducted the experiment.