EE673 Assignment 2

Adit Jain, 200038

October 8^{th}, 2023

1 Solution 1

1.1 TCP Lab

1. Source IP: 192.168.1.102:1161
2. Destination IP: 128.119.245.12:80
3. IP: 192.168.1.102:1161
4. 0
5. 0
6. 1
7. Sequence Numbers: 1, 566, 2026, 3486, 4946, 6406

	Sent Time	**ACK Received Time**	**RTT (s)**	**Estimated RTT (s)**
Segment 1	0.026477	0.53937	0.02746	0.02746
Segment 2	0.041737	0.077294	0.035557	0.0285
Segment 3	0.054026	0.124085	0.070059	0.0337
Segment 4	0.054690	0.169118	0.11443	0.0438
Segment 5	0.077405	0.217299	0.13989	0.0558
Segment 6	0.078157	0.267802	0.18964	0.0725

$$EstimatedRTT = 0.875 * EstimatedRTT + 0.125 * SampleRTT \tag{1}$$

8. Length of the first TCP segment (containing the HTTP POST): 565 *bytes*. Length of each of the other five TCP segments: 1460 *bytes* (MSS)
9. The minimum amount of buffer space (receiver window) advertised at gaia.cs.umass.edu for the entire trace is 5840 *bytes*, which shows in the first acknowledgement from the server. This receiver window grows steadily until a maximum receiver buffer size of 62780 *bytes*. The sender is never throttled due to lacking of receiver buffer space by inspecting this trace.

10. There are no retransmitted segments in the trace file. We can verify this by checking the sequence numbers of the TCP segments in the trace file. In the Time-Sequence-Graph (Stevens) of this trace, all sequence numbers from the source (192.168.1.102) to the destination (128.119.245.12) are increasing monotonically with respect to time. If there is a retransmitted segment, the sequence number of this retransmitted segment should be smaller than those of its neighboring segments.

11. The difference between the acknowledged sequence numbers of two consecutive ACKs indicates the data received by the server between these two ACKs.

	ACKd Sequence Number	**ACKd Data**
ACK1	566	566
ACK2	2026	1460
ACK3	3486	1460
ACK4	4946	1460
ACK5	6046	1460
ACK6	7866	1460
ACK7	9013	1460
ACK8	10473	1460
ACK9	11933	1460
ACK10	13393	1460
ACK11	14853	1460
ACK12	16313	1460

12. The computation of TCP throughput largely depends on the selection of averaging time period. As a common throughput computation, in this question, we select the average time period as the whole connection time. Then, the average throughput for this TCP connection is computed as the ratio between the total amount data and the total transmission time. The total amount data transmitted can be computed by the difference between the sequence number of the first TCP segment (i.e. 1 *byte* for No. 4 segment) and the acknowledged sequence number of the last ACK (164091 *bytes* for No. 202 segment). Therefore, the total data are 164091 - 1 = 164090 *bytes*. The whole transmission time is the difference of the time instant of the first TCP segment (i.e., 0.026477 *second* for No.4 segment) and the time instant of the last ACK (i.e., 5.455830 *second* for No. 202 segment). Therefore, the total transmission time is 5.455830 - 0.026477 = 5.4294 *seconds*. Hence, the throughput for the TCP connection is computed as $164090/5.4294 = 30.222\ KByte/sec$.

1.2 UDP Lab

1. The UDP header contains 4 fields: source port, destination port, length, and checksum.

2. Each of the UDP header fields is 2 *bytes* long.

3. The value in the length field is the sum of the 8 header bytes, plus the 42 encapsulated data bytes.

4. The maximum number of bytes that can be included in a UDP payload is 216 – 1 less the header bytes. This gives 65535 – 8 = 65527 *bytes*.
5. The largest possible source port number is 2^{16} – 1 = 65535.
6. The IP protocol number for UDP is 0x11 hex, which is 17 in decimal value.
7. The source port of the UDP packet sent by the host is the same as the destination port of the reply packet, and conversely the destination port of the UDP packet sent by the host is the same as the source port of the reply packet.

2 Solution 2

2.1 Old Tahoe (fig. 1 & 2)

2.2 Reno (fig. 3 & 4)

2.3 Cubic (fig. 5 & 6)

3 Solution 3

3.1 Part A

3.2 Part B

$$\begin{aligned} \mathbb{E}|X| &= p \times (p_a \times a + p_b \times b + p_c \times c + p_d \times d) \\ \mathbb{E}|X^2| &= p \times (p_a \times a^2 + p_b \times b^2 + p_c \times c^2 + p_d \times d^2) \\ Var(X) &= \mathbb{E}|X^2| - \mathbb{E}|X|^2 \end{aligned} \tag{2}$$

3.2.1 Case 1 $[p_a = p_b = p_c = p_d = 0.25]$

- $\mathbb{E}|X| = p(0.25 \times (2 + 4 + 6 + 8))$
- $\mathbb{E}|X| = 5p$
- $\mathbb{E}|X^2| = p(0.25 \times (4 + 16 + 36 + 64))$
- $\mathbb{E}|X^2| = 30p$
- $Var(X) = 30p - 25p^2$

3.2.2 Case 2 $[p_a = p_d = 0, p_b = p_c = 0.5]$

- $\mathbb{E}|X| = p(0.5 \times (4 + 6))$
- $\mathbb{E}|X| = 5p$
- $\mathbb{E}|X^2| = p(0.5 \times (16 + 36))$
- $\mathbb{E}|X^2| = 26p$
- $Var(X) = 26p - 25p^2$

3.2.3 Case 3 $[p_a = p_d = 0.5, p_b = p_c = 0]$

- $\mathbb{E}|X| = p(0.5 \times (2 + 8))$
- $\mathbb{E}|X| = 5p$
- $\mathbb{E}|X^2| = p(0.5 \times (4 + 64))$
- $\mathbb{E}|X^2| = 34p$
- $Var(X) = 34p - 25p^2$

3.2.4 Case 4 $[p_a = p_b = p_c = 0, p_d = 1]$

- $\mathbb{E}|X| = p(1 \times 10)$
- $\mathbb{E}|X| = 10p$
- $\mathbb{E}|X^2| = p(1 \times (64))$
- $\mathbb{E}|X^2| = 64p$
- $Var(X) = 64p - 100p^2$

As seen from the expectation values, the incoming communication traffic exceeds the network capacity for $p = 1$.

4 Solution 4

The plots as shown in fig.(11) show the convergence behavior for two different cases. The convergence line is observed to have different slopes, which is dependent on the ratio of Round-Trip Times (RTTs) of the clients (1 and 10 in this case). Interestingly, it takes approximately 16,000 timestamps for both cases to converge.

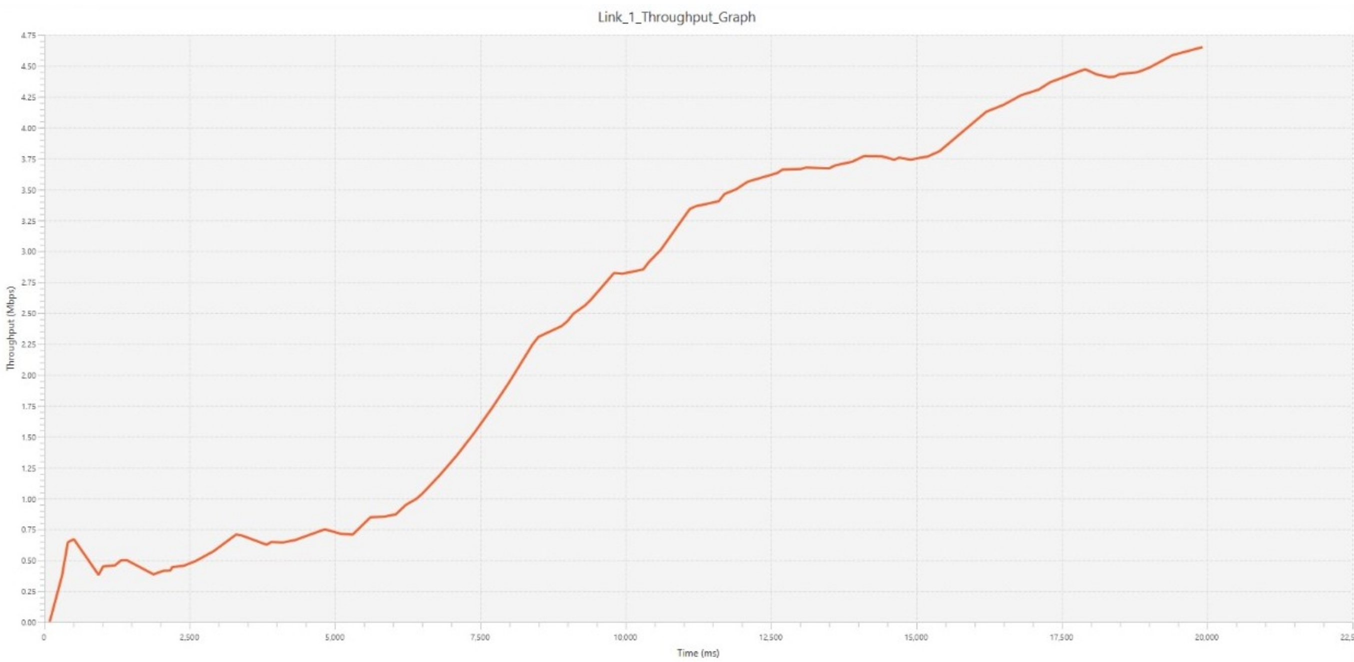

Figure 1: Old Tahoe

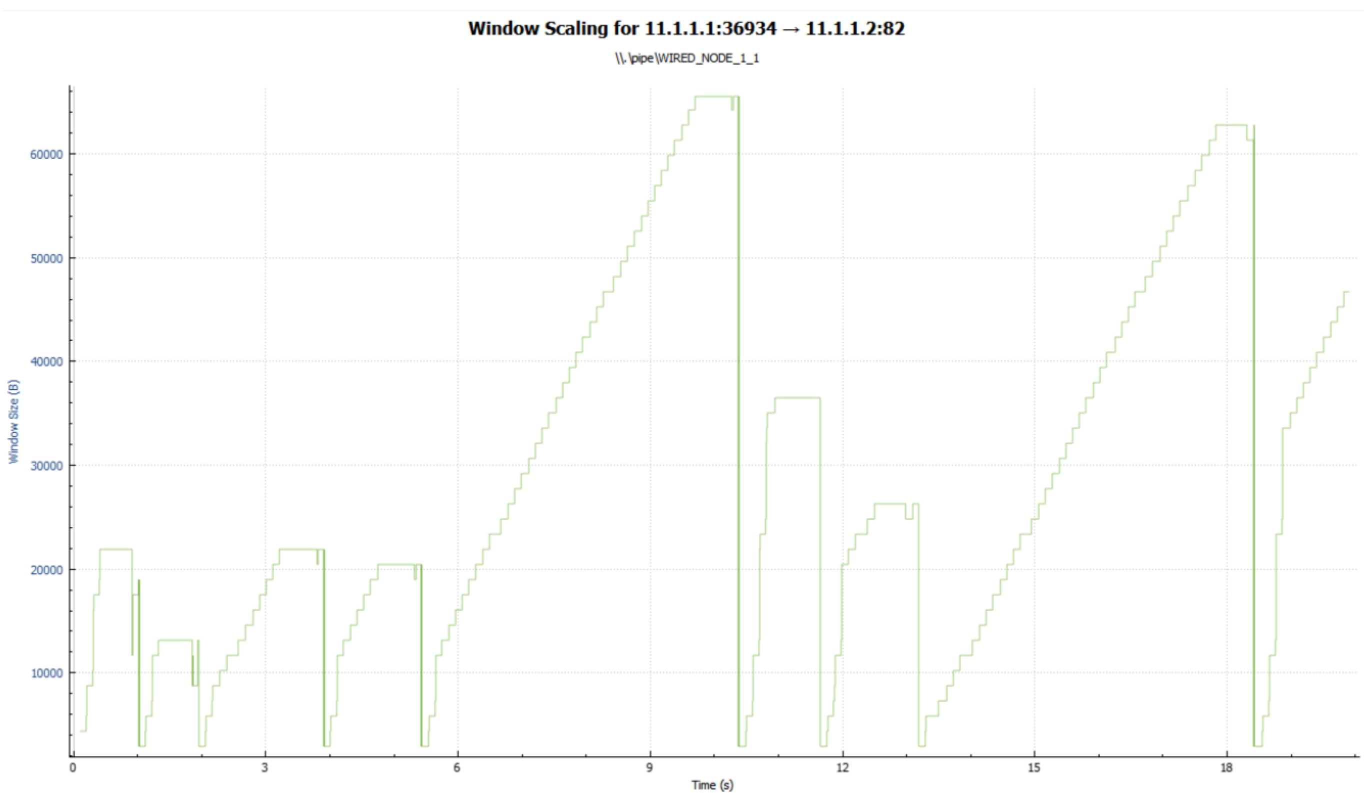

Figure 2: Old Tahoe

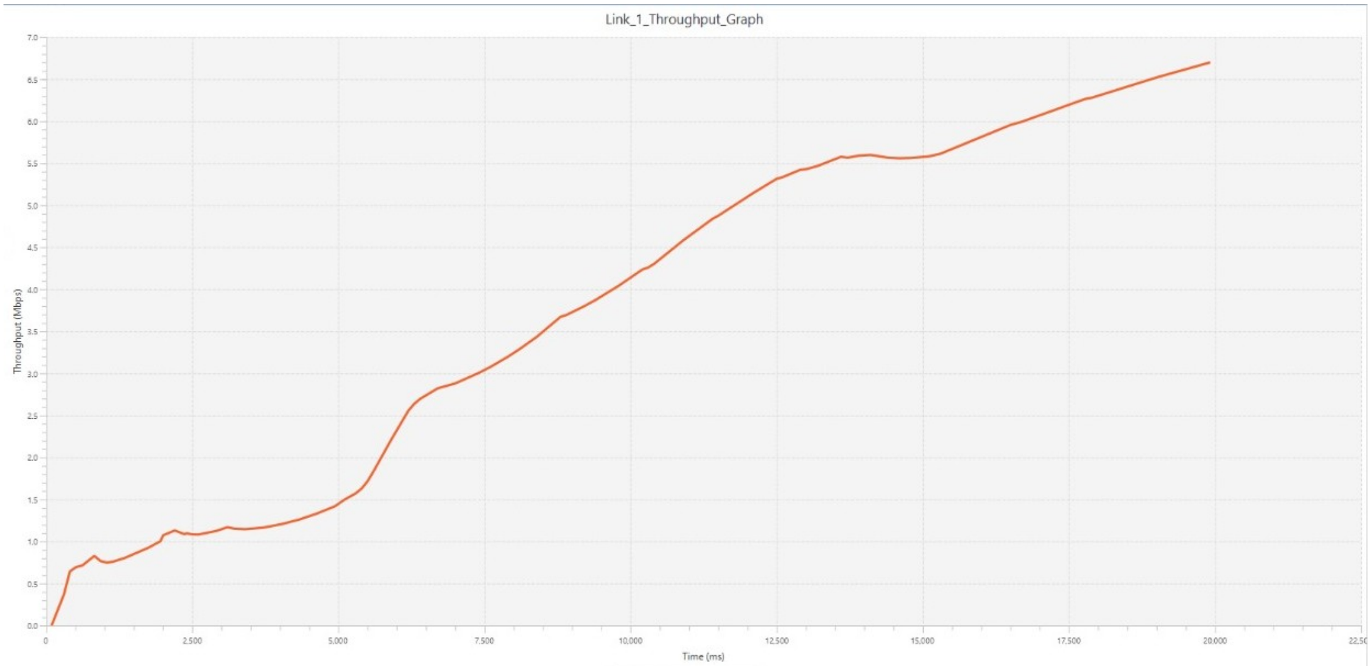

Figure 3: Reno

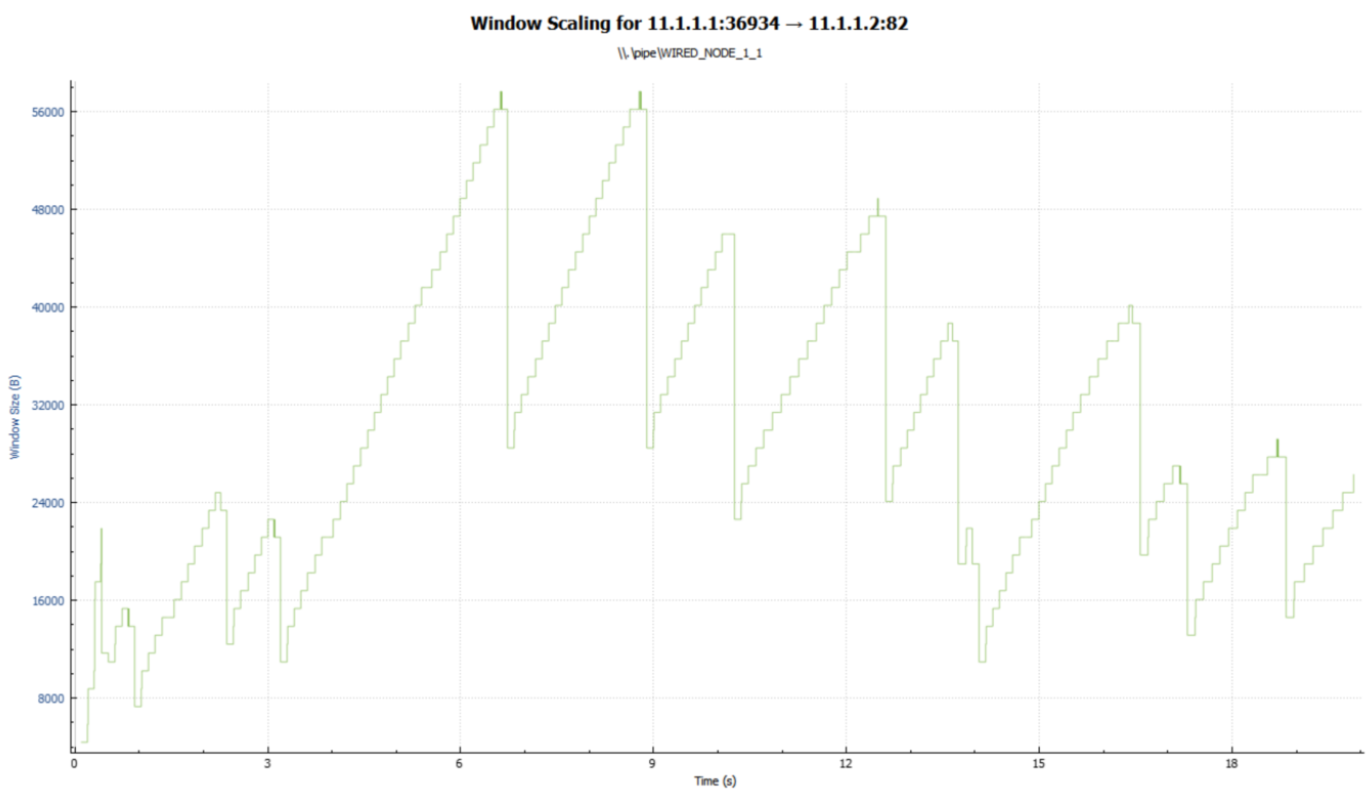

Figure 4: Reno

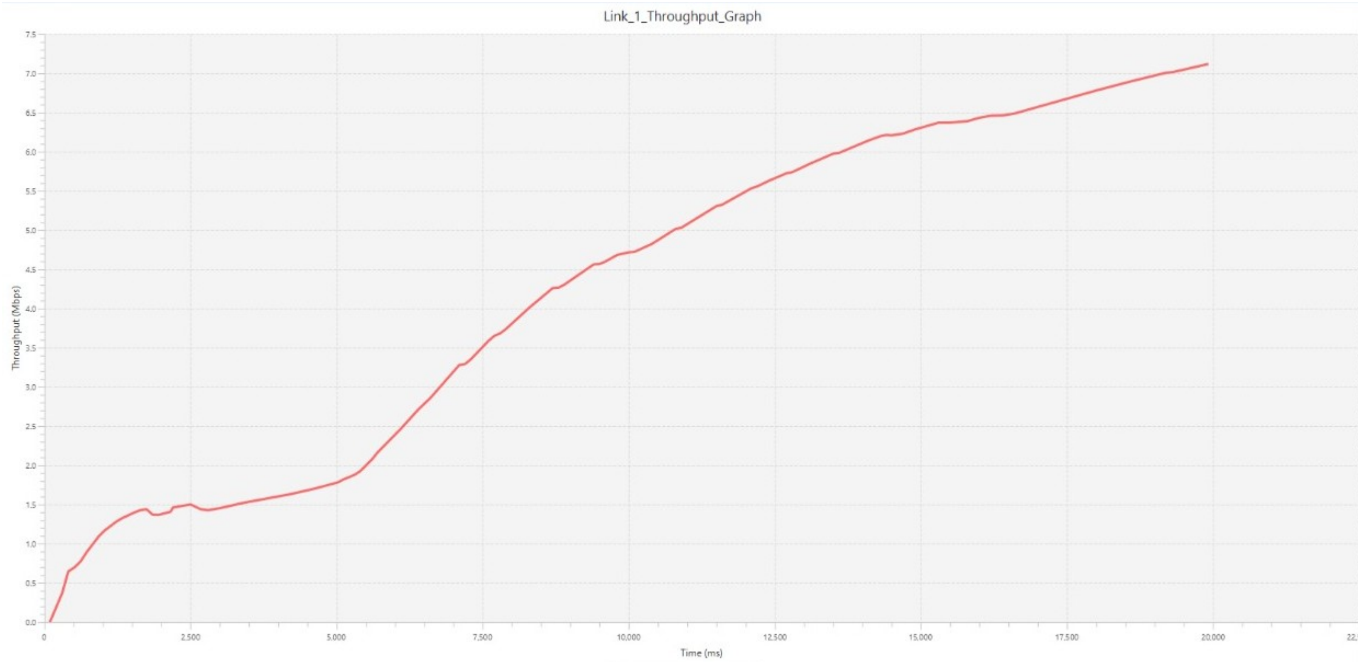

Figure 5: Cubic

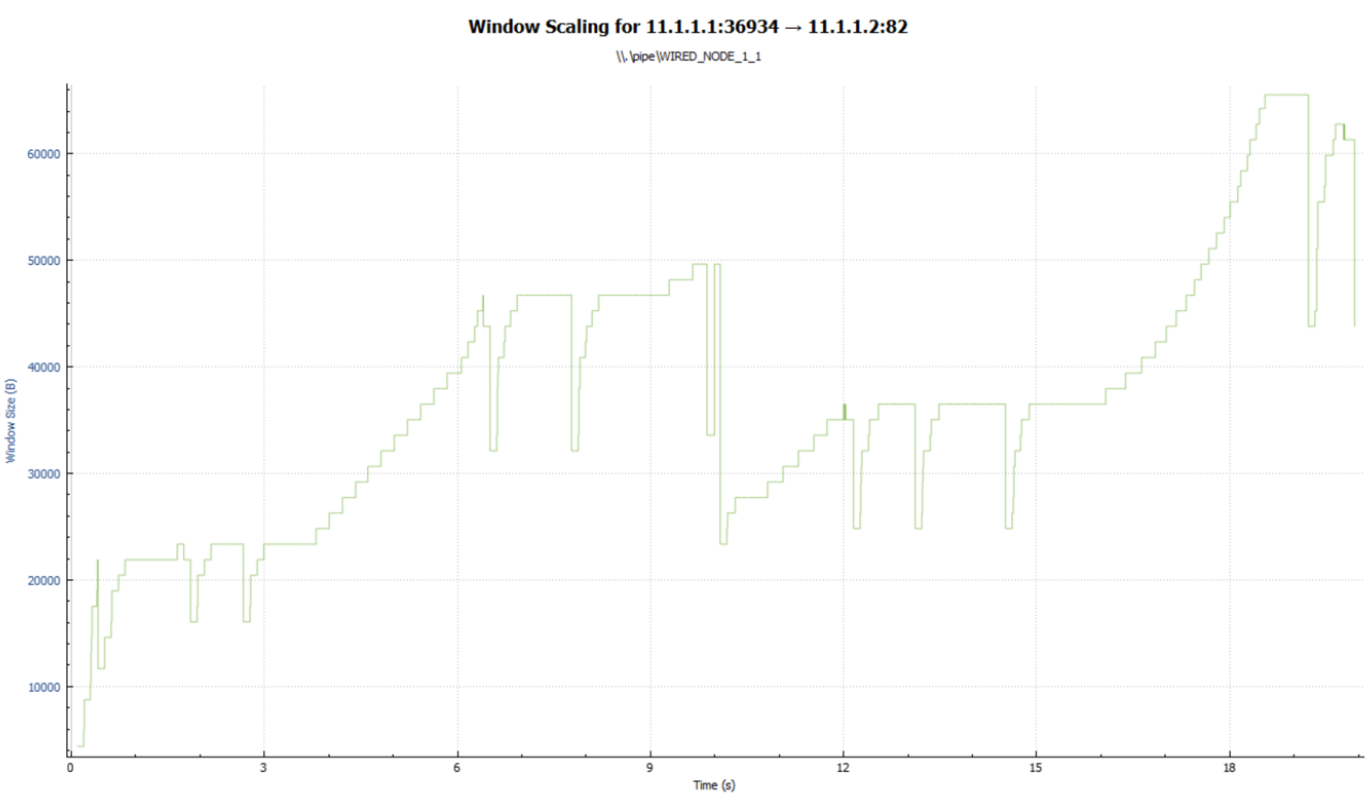

Figure 6: Cubic

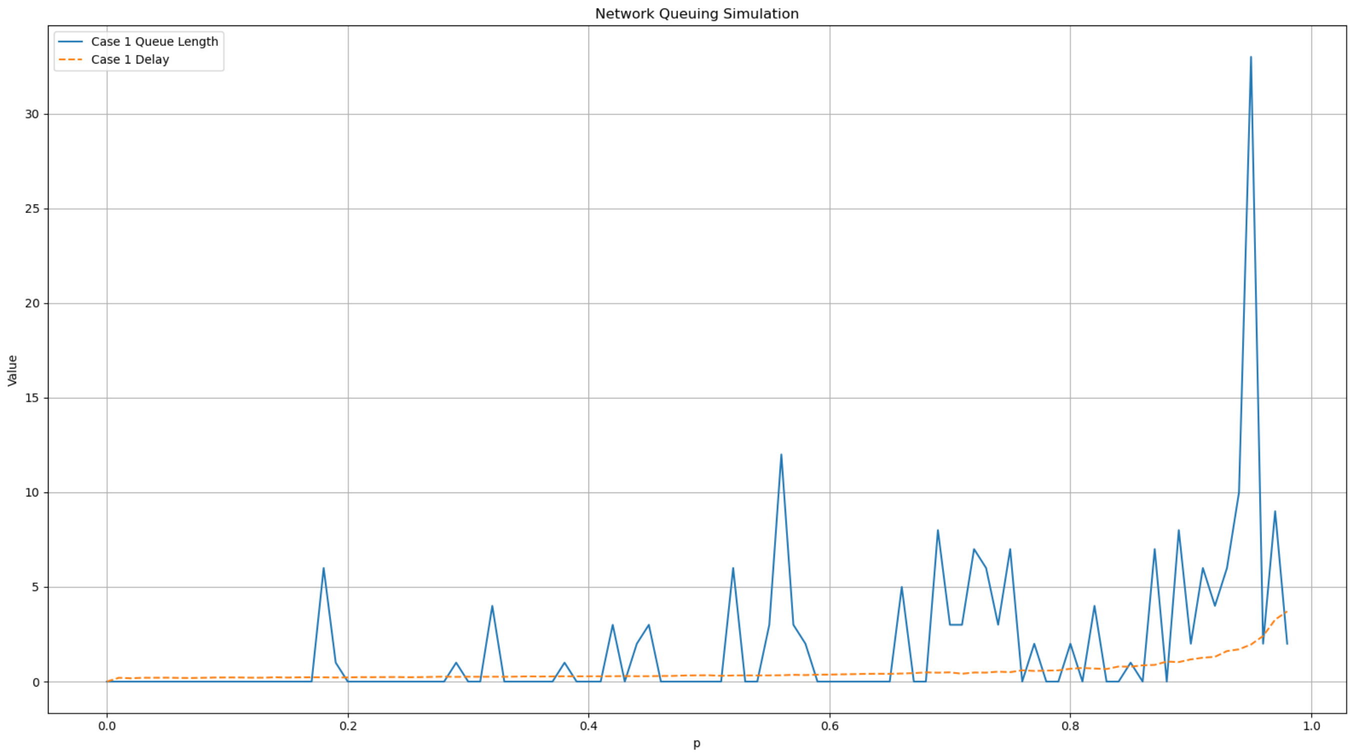

Figure 7: Case 1

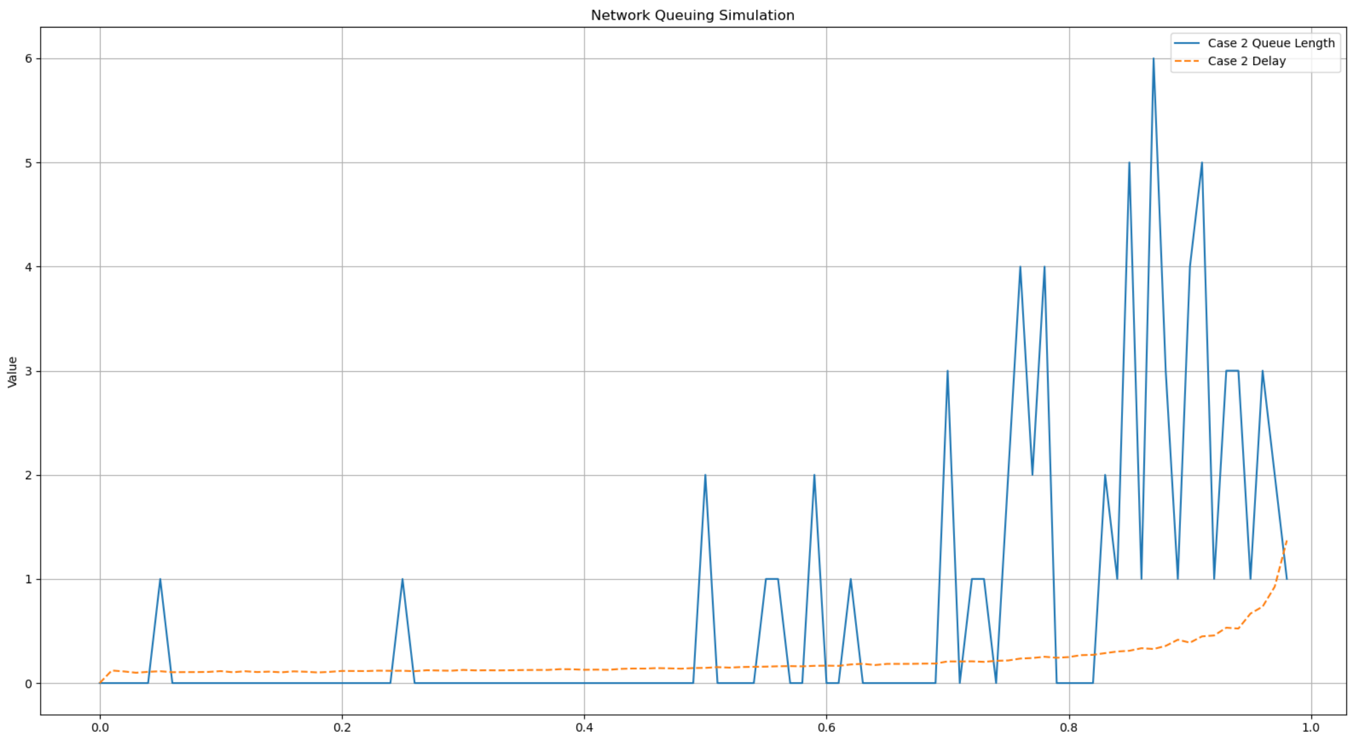

Figure 8: Case 2

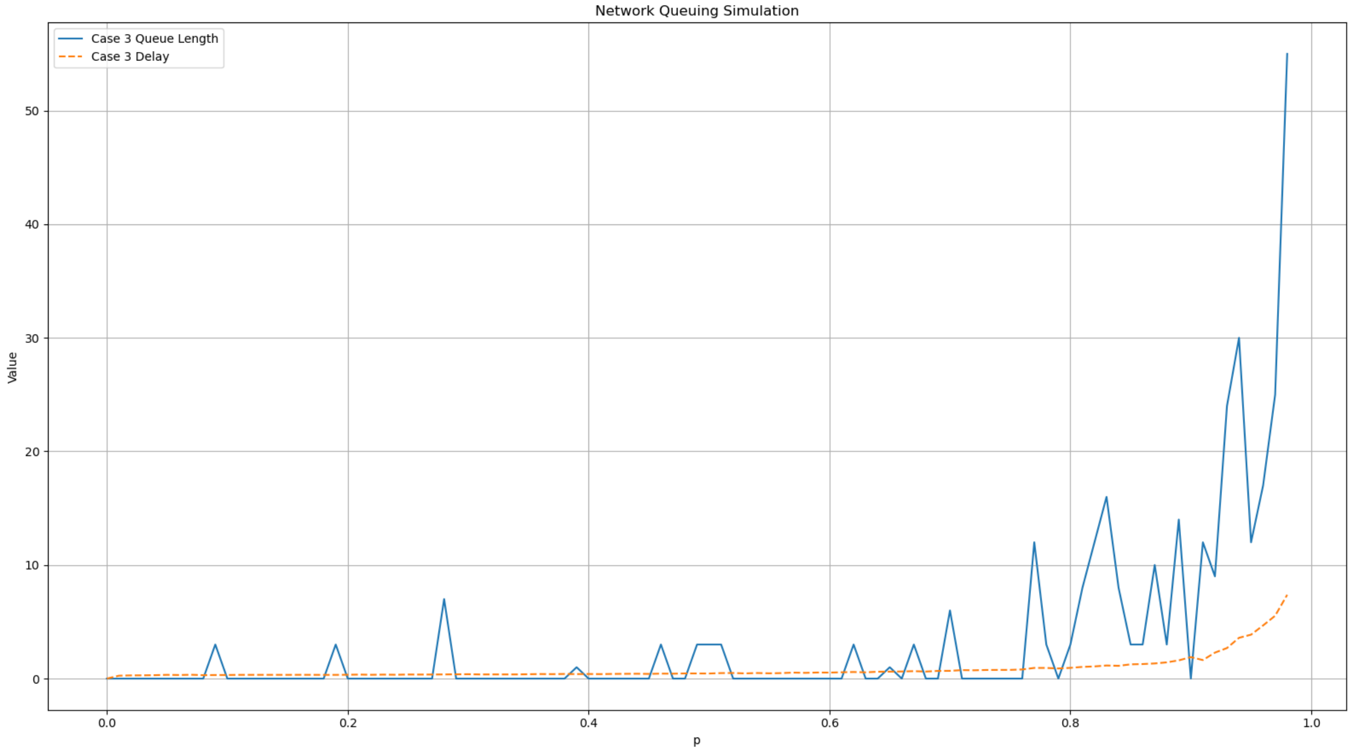

Figure 9: Case 3

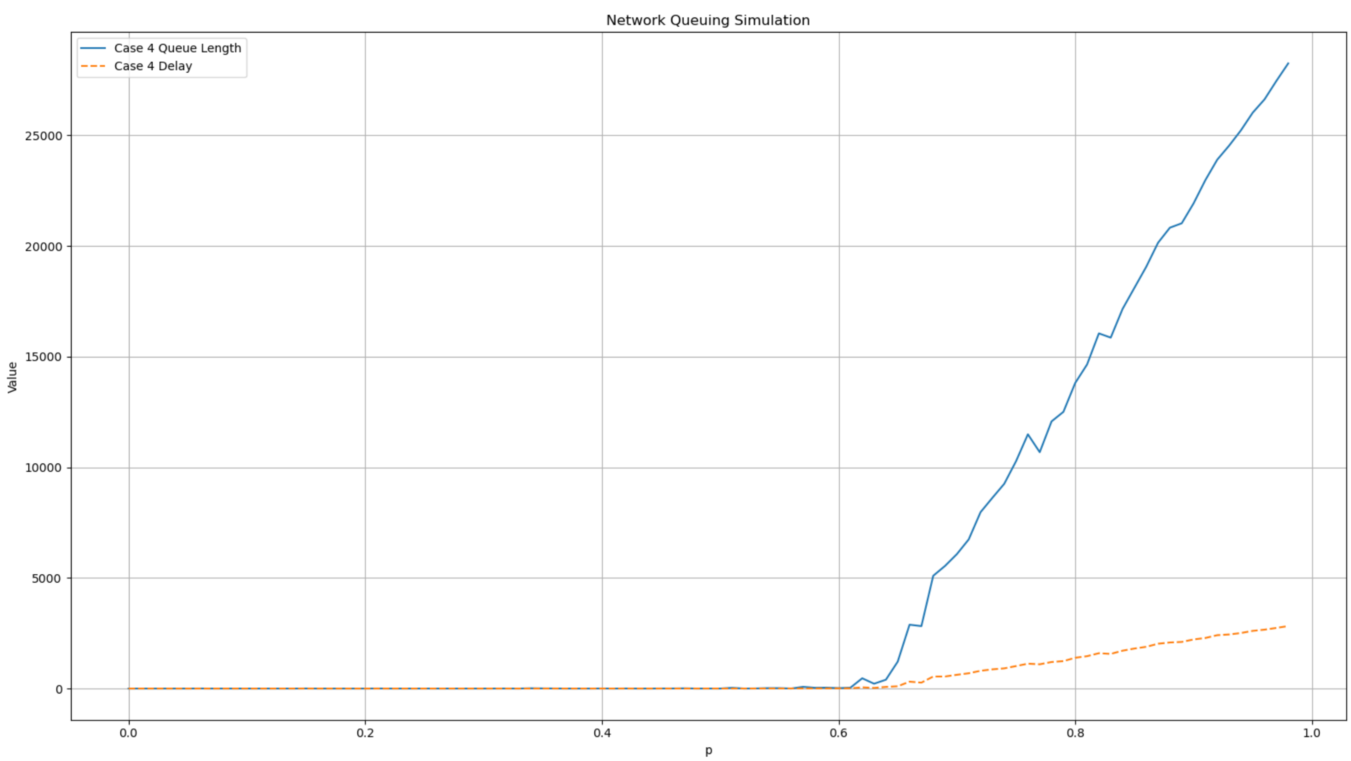

Figure 10: Case 4

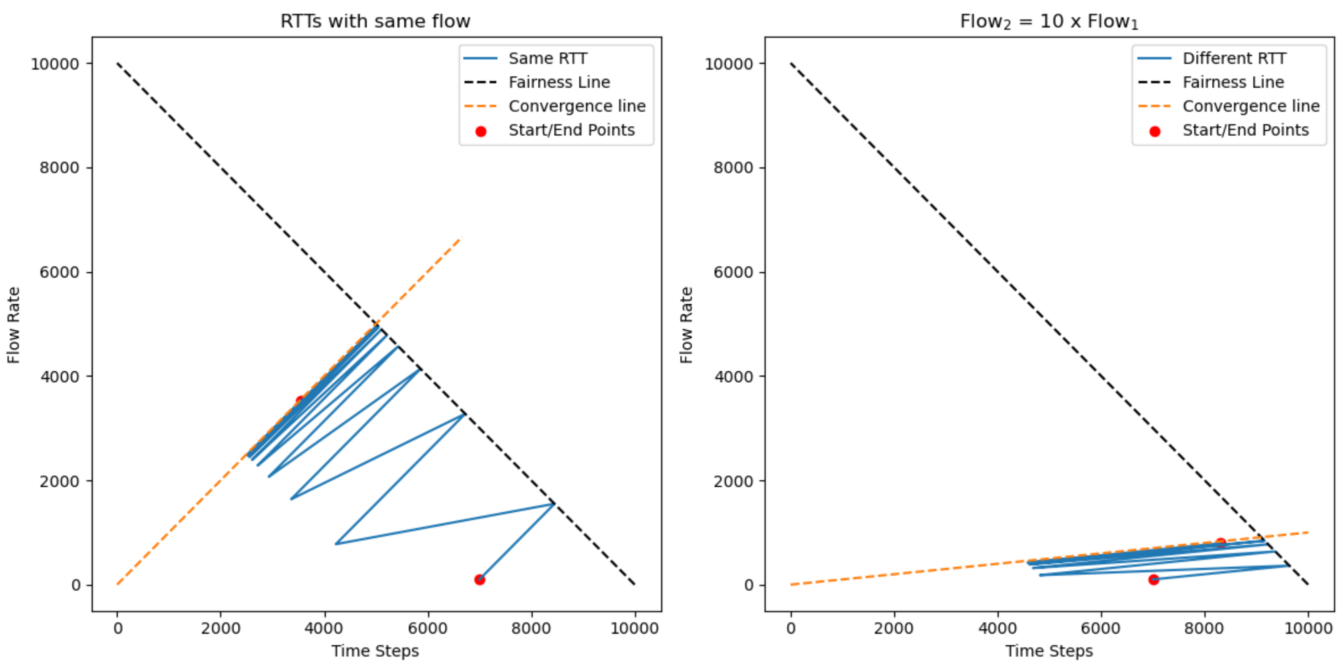

Figure 11: Flow