IT-305 Computer Networks

Autumn Semester 2024

Lab05 – TCP Connection Management and Control

Aim: Explore and understand key aspects of TCP (Transmission Control Protocol), focusing on connection management, reliable data transfer, and congestion control.

1. Introduction to TCP Connection Management

Objective: To understand the process of TCP connection management, including the three-way handshake for connection establishment and four-way handshake for termination.

Theory: Transmission Control Protocol (TCP) ensures reliable data transmission. Before transmitting data, a TCP connection must be established using a three-way handshake. The handshake synchronizes both devices, confirming the readiness to transmit and receive data. The session is terminated with a four-step termination process.

Steps:

1. Set up a basic network topology with a client and a server.
2. Configure the client to initiate a TCP connection with the server.
3. Capture packets and observe the SYN, SYN-ACK, and ACK stages of the handshake.
4. Analyze the termination process to see the FIN, ACK, and CLOSE_WAIT states.

Key Insights:

- The three-way handshake ensures a reliable, ordered connection between two nodes.
- The termination handshake gracefully closes the connection without data loss.

Link: https://www.tetcos.com/documentation/NetSim/v13/NetSim-Experiments-Manual/index.htm#rhtocid=_6&t=NetSim_Experiment_Manual.htm%237_Introduction_to_TCPbc-6

2. Reliable Data Transfer with TCP

Objective: To study how TCP ensures reliable data transfer through mechanisms such as sequencing, acknowledgment, and retransmissions.

Theory: TCP provides reliable, in-order delivery of data using acknowledgment (ACK) messages and retransmission of lost packets. Sequence numbers ensure that data is received in the correct order, and a timeout mechanism triggers retransmission if ACKs are not received.

Steps:

1. Set up a network with a client and server using TCP as the transport protocol.
2. Inject packet loss in the network to simulate an unreliable channel.
3. Monitor packet retransmission and acknowledgment mechanisms through the network analyzer.
4. Examine how TCP detects lost packets and recovers from errors.

Key Insights:

- TCP retransmits lost packets using the acknowledgment and timeout mechanism.
- Sequence numbers ensure that out-of-order packets are correctly reassembled.

Link: https://www.tetcos.com/documentation/NetSim/v13/NetSim-Experiments-Manual/index.htm#rhtocid=_7&t=NetSim_Experiment_Manual.htm%238_Reliable_data_transferbc-7

3. TCP Congestion Control Algorithms

Objective: To analyze various TCP congestion control algorithms like Tahoe, Reno, and NewReno, which manage network congestion.

Theory: TCP congestion control helps prevent excessive traffic from overloading a network. Congestion avoidance techniques like slow start, congestion avoidance, fast retransmit, and fast recovery are used to adjust the transmission rate based on network conditions.

Steps:

1. Simulate a network with multiple nodes communicating over TCP.
2. Configure TCP variants like Tahoe, Reno, and NewReno.
3. Inject network congestion and observe the behavior of each algorithm.
4. Analyze the effects of congestion control mechanisms like slow start and fast retransmit on throughput and latency.

Key Insights:

- Tahoe uses slow start and congestion avoidance but lacks fast recovery.
- Reno improves upon Tahoe by introducing fast recovery.
- NewReno further enhances TCP's performance in high-congestion environments.

Link: https://www.tetcos.com/documentation/NetSim/v13/NetSim-Experiments-Manual/index.htm#rhtocid=_12&t=NetSim_Experiment_Manual.htm%2313_TCP_Congestionbc-12

4. Understand the working of TCP BIC Congestion control algorithm, simulate and plot the TCP congestion window (Optional)

Objective: To understand and perform TCP BIC Congestion control algorithm and understand the different parts such as additive increase, slow start, and fast convergence and identify them from the plots.

Theory: In BIC congestion control is viewed as a searching problem in which the system can give yes/no feedback through packet loss as to whether the current sending rate (or window) is larger than the network capacity. The current minimum window can be estimated as the window size at which the flow does not see any packet loss. If the maximum window size is known, we can apply a binary search technique to set the target window size to the midpoint of the maximum and minimum.

Steps:

1. Network scenario designed in the NetSim GUI Library
2. In general properties of wires node, Windows scaling is set TRUE
3. For all devices, the Congestion Algorithm is set to BIC and plot is set to true
4. Link Properties are set
5. CBR Application is used in this experiment
6. Enable plots and simulation time is set to 100 seconds

Key Insights:

- BIC implements a unique congestion window (cwnd) algorithm.
- It uses the Binary Search Increase method.
- When a network failure occurs, the BIC uses a multiplicative decrease in correcting the cwnd.

Link: https://www.tetcos.com/documentation/NetSim/v13/NetSim-Experiments-Manual/index.htm#t=NetSim_Experiment_Manual.htm%2333_Understand_thebc-32&rhtocid=_32

Exercise :

1) Understanding the communication between server and client via TCP. Plotting the congestion plot. Write up a full explanation describing why the plot has certain movements at certain points in all the exercises.
2) Briefly discuss the TCP Tahoe, Reno and New Reno Algorithms. In what characteristics they differ from each other?
3) Understand the plots with lossy network and lossless network and explain their behaviour throughout the plot.

Groups Specific Questions:

1) **For Group 1-2 : Based on the Netsim Manual Experiment 7, Write your observations of the below packet capture file.**

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	0.0.0.0	0.0.0.0	IPv4	20	
2	0.000000	11.1.1.2	11.1.1.1	TCP	44	82 → 36934 [SYN] Seq=0 Win=65535 Len=0 MSS=1460
3	0.100335	11.3.1.2	11.1.1.2	TCP	44	36934 → 82 [SYN, ACK] Seq=0 Ack=1 Win=4380 Len=0 MSS=1460
4	0.100335	11.1.1.2	11.1.1.1	TCP	40	82 → 36934 [ACK] Seq=1 Ack=1 Win=4380 Len=0
5	0.100335	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=1 Win=4380 Len=1460
6	0.100335	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=1461 Win=4380 Len=1460
7	0.100335	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=2921 Win=4380 Len=1460
8	0.204208	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=1461 Win=4381 Len=0
9	0.204208	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=4381 Win=5840 Len=1460
10	0.204208	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=5841 Win=5840 Len=1460
11	0.205430	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=2921 Win=4381 Len=0
12	0.205430	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=7301 Win=7300 Len=1460
13	0.205430	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=8761 Win=7300 Len=1460
14	0.206651	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=4381 Win=4381 Len=0
15	0.206651	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=10221 Win=8760 Len=1460
16	0.206651	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=11681 Win=8760 Len=1460
17	0.308027	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=5841 Win=4381 Len=0
18	0.308027	11.1.1.2	11.1.1.1	TCP	1500	82 → 36934 [<None>] Seq=13141 Win=10220 Len=1460
19	0.309249	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=7301 Win=4381 Len=0
20	0.310471	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=8761 Win=4381 Len=0
21	0.311692	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=10221 Win=4381 Len=0
22	0.312914	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=11681 Win=4381 Len=0
23	0.314136	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=13141 Win=4381 Len=0
24	0.411846	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=14601 Win=4381 Len=0
25	0.411846	11.1.1.2	11.1.1.1	TCP	40	82 → 36934 [FIN] Seq=14601 Win=18980 Len=0
26	0.512161	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [FIN, ACK] Seq=1 Ack=14601 Win=4381 Len=0
27	0.512215	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [FIN] Seq=2 Win=4381 Len=0
28	0.512215	11.1.1.2	11.1.1.1	TCP	40	82 → 36934 [ACK] Seq=14602 Ack=3 Win=18980 Len=0

2) **For Group 3-4 : Based on tha Netsim Manual Experiment 8, Write your obervations of the below packet capture file.**

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	0.0.0.0	0.0.0.0	IPv4	20	
2	0.000000	11.1.1.2	11.1.1.1	TCP	44	82 → 36934 [SYN] Seq=0 Win=65535 Len=0 MSS=1460
3	0.100695	11.3.1.2	11.1.1.2	TCP	44	36934 → 82 [SYN, ACK] Seq=0 Ack=1 Win=4380 Len=0 MSS=1460
4	0.100695	11.1.1.2	11.1.1.1	TCP	40	82 → 36934 [ACK] Seq=1 Ack=1 Win=4380 Len=0
5	0.100695	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=1 Win=4380 Len=1480
6	0.100695	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=1481 Win=4380 Len=1480
7	0.204976	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=1481 Win=4381 Len=0
8	0.204976	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=2961 Win=5840 Len=1480
9	0.204976	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=4441 Win=5840 Len=1480
10	0.206214	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=2961 Win=4381 Len=0
11	0.206214	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=5921 Win=7300 Len=1480
12	0.206214	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=7401 Win=7300 Len=1480
13	0.310441	11.3.1.2	11.1.1.2	TCP	40	[TCP Dup ACK 10#1] 36934 → 82 [ACK] Seq=1 Ack=2961 Win=4381 Len=0
14	0.312916	11.3.1.2	11.1.1.2	TCP	40	[TCP Dup ACK 10#2] 36934 → 82 [ACK] Seq=1 Ack=2961 Win=4381 Len=0
15	0.809257	11.1.1.2	11.1.1.1	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=2961 Win=5840 Len=1480
16	0.809257	11.1.1.2	11.1.1.1	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=4441 Win=5840 Len=1480
17	0.810649	11.1.1.2	11.1.1.1	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=5921 Win=7300 Len=1480
18	0.810649	11.1.1.2	11.1.1.1	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=7401 Win=7300 Len=1480
19	0.913484	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=5921 Win=4381 Len=0
20	0.914722	11.3.1.2	11.1.1.2	TCP	40	[TCP Dup ACK 19#1] 36934 → 82 [ACK] Seq=1 Ack=5921 Win=4381 Len=0
21	5.646135	11.1.1.2	11.1.1.1	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=5921 Win=7300 Len=1480
22	6.854954	11.1.1.2	11.1.1.1	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=5921 Win=7300 Len=1480
23	9.272592	11.1.1.2	11.1.1.1	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=5921 Win=7300 Len=1480
24	9.376820	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=8881 Win=4381 Len=0
25	9.376820	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=8881 Win=2920 Len=1480
26	19.089550	11.1.1.2	11.1.1.1	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=8881 Win=2920 Len=1480
27	19.193777	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=10361 Win=4381 Len=0
28	19.193777	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=10361 Win=2920 Len=1480
29	19.298004	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=11841 Win=4381 Len=0
30	19.298004	11.1.1.2	11.1.1.1	TCP	1520	82 → 36934 [<None>] Seq=11841 Win=4380 Len=1480
31	19.298004	11.1.1.2	11.1.1.1	TCP	1320	82 → 36934 [<None>] Seq=13321 Win=4380 Len=1280
32	19.402231	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=13321 Win=4381 Len=0
33	19.403309	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [ACK] Seq=1 Ack=14601 Win=4381 Len=0
34	19.403309	11.1.1.2	11.1.1.1	TCP	40	82 → 36934 [FIN] Seq=14601 Win=5840 Len=0
35	19.503984	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [FIN, ACK] Seq=1 Ack=14601 Win=4381 Len=0
36	19.504038	11.3.1.2	11.1.1.2	TCP	40	36934 → 82 [FIN] Seq=2 Win=4381 Len=0
37	19.504038	11.1.1.2	11.1.1.1	TCP	40	82 → 36934 [ACK] Seq=14602 Ack=3 Win=7300 Len=0

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	0.0.0.0	0.0.0.0	IPv4	20	
2	0.050348	11.1.1.2	11.3.1.2	TCP	44	82 → 36934 [SYN] Seq=0 Win=65535 Len=0 MSS=1460
3	0.050348	11.3.1.2	11.3.1.1	TCP	44	36934 → 82 [SYN, ACK] Seq=0 Ack=1 Win=4380 Len=0 MSS=1460
4	0.151032	11.1.1.2	11.3.1.2	TCP	40	82 → 36934 [ACK] Seq=1 Ack=1 Win=4380 Len=0
5	0.154638	11.1.1.2	11.3.1.2	TCP	1520	82 → 36934 [<None>] Seq=1 Win=4380 Len=1480
6	0.154638	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [ACK] Seq=1 Ack=1481 Win=4381 Len=0
7	0.155876	11.1.1.2	11.3.1.2	TCP	1520	82 → 36934 [<None>] Seq=1481 Win=4380 Len=1480
8	0.155876	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [ACK] Seq=1 Ack=2961 Win=4381 Len=0
9	0.260103	11.1.1.2	11.3.1.2	TCP	1520	[TCP Previous segment not captured] 82 → 36934 [<None>] Seq=4441 Win=5840 Len=1480
10	0.260103	11.3.1.2	11.3.1.1	TCP	40	[TCP Dup ACK 8#1] 36934 → 82 [ACK] Seq=1 Ack=2961 Win=4381 Len=0
11	0.262579	11.1.1.2	11.3.1.2	TCP	1520	[TCP Previous segment not captured] 82 → 36934 [<None>] Seq=7401 Win=7300 Len=1480
12	0.262579	11.3.1.2	11.3.1.1	TCP	40	[TCP Dup ACK 8#2] 36934 → 82 [ACK] Seq=1 Ack=2961 Win=4381 Len=0
13	0.863146	11.1.1.2	11.3.1.2	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=2961 Win=5840 Len=1480
14	0.863146	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [ACK] Seq=1 Ack=5921 Win=4381 Len=0
15	0.864384	11.1.1.2	11.3.1.2	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=4441 Win=5840 Len=1480
16	0.864384	11.3.1.2	11.3.1.1	TCP	40	[TCP Dup ACK 14#1] 36934 → 82 [ACK] Seq=1 Ack=5921 Win=4381 Len=0
17	0.866860	11.1.1.2	11.3.1.2	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=7401 Win=7300 Len=1480
18	0.866860	11.3.1.2	11.3.1.1	TCP	40	[TCP Dup ACK 14#2] 36934 → 82 [ACK] Seq=1 Ack=5921 Win=4381 Len=0
19	9.326482	11.1.1.2	11.3.1.2	TCP	1520	[TCP Retransmission] 82 → 36934 [<None>] Seq=5921 Win=7300 Len=1480
20	9.326482	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [ACK] Seq=1 Ack=8881 Win=4381 Len=0
21	19.143439	11.1.1.2	11.3.1.2	TCP	1520	82 → 36934 [<None>] Seq=8881 Win=2920 Len=1480
22	19.143439	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [ACK] Seq=1 Ack=10361 Win=4381 Len=0
23	19.247667	11.1.1.2	11.3.1.2	TCP	1520	82 → 36934 [<None>] Seq=10361 Win=2920 Len=1480
24	19.247667	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [ACK] Seq=1 Ack=11841 Win=4381 Len=0
25	19.351894	11.1.1.2	11.3.1.2	TCP	1520	82 → 36934 [<None>] Seq=11841 Win=4380 Len=1480
26	19.351894	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [ACK] Seq=1 Ack=13321 Win=4381 Len=0
27	19.352971	11.1.1.2	11.3.1.2	TCP	1320	82 → 36934 [<None>] Seq=13321 Win=4380 Len=1280
28	19.352971	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [ACK] Seq=1 Ack=14601 Win=4381 Len=0
29	19.453647	11.1.1.2	11.3.1.2	TCP	40	82 → 36934 [FIN] Seq=14601 Win=5840 Len=0
30	19.453647	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [FIN, ACK] Seq=1 Ack=14601 Win=4381 Len=0
31	19.453647	11.3.1.2	11.3.1.1	TCP	40	36934 → 82 [FIN] Seq=2 Win=4381 Len=0
32	19.554376	11.1.1.2	11.3.1.2	TCP	40	82 → 36934 [ACK] Seq=14602 Ack=3 Win=7300 Len=0

3) **For Group 5-6 : Based on the Netsim Manual experiment 9, Write your observations from the plot of Congestion window evolution with TCP New Reno over a lossy link.**