PADERBORN UNIVERSITY

Advanced Networked Systems SS24

Exercise 2: Network Transport

1 Basic Concepts

Question 1: Explain the core idea of TCP slow-start.

Question 2: How does TCP use AIMD to control the congestion window?

Question 3: Given a simple link model with a queue, explain how the RTT and the delivery rate behave in the three queue states (i.e., no queue, queue formation, and queue saturation).

Question 4: Explain how BBR differs from congestion-based TCP variants like TCP Reno and CUBIC.

Question 5: How does MPTCP address issues caused by middleboxes (that check/rewrite TCP sequence/ACK numbers) on the network?

Question 6: What goals does MPTCP achieve with respect to congestion control?

2 The Mystery of Network Transfer Time

Assume we are given a symmetric network link between two hosts with 40 Mbps bandwidth and 5 ms one way delay. The link is running Ethernet with an MTU of 1500 bytes. For the calculation below, we ignore the overhead brought by the socket interface implementation.

Question 1: Suppose we transfer a file of 150 KB on the link with a TCP connection. The announced receive window is 46,720 bytes throughout the file transfer. How long does it take for the file transfer to finish?

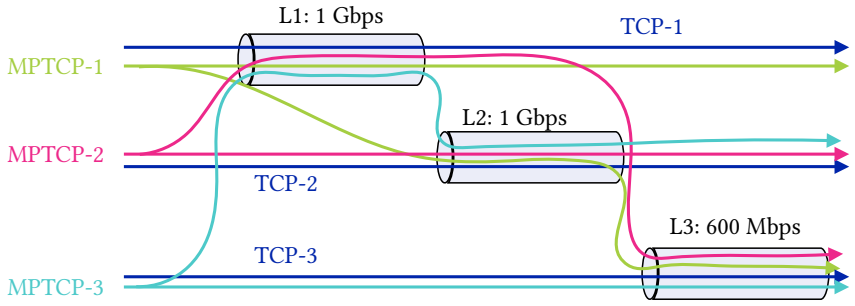
Question 2: Instead of TCP now we use UDP to send the same file. How long does it take for the file transfer to finish?

3 TCP Congestion Control

Question 1: Assume we are running a TCP Reno connection and the following three events occur to the connection sequentially: (1) three duplicate ACKs when the congestion window reaches 20 the first time, (2) timeout when the congestion window reaches 22, and (3) three duplicate ACKs when the congestion window reaches 20 again. Please draw the change of the congestion window.

4 MPTCP Congestion Control

Given a network with three links shared by multiple MPTCP and TCP flows, as depicted in the following figure. The capacities of these links are also given in the figure. Assume all other links are not shared between any of these flows and are not bottlenecks.



Question 1: What are the expected throughput of each of these flows?