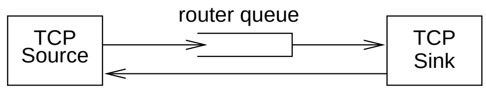
cmsc 417 S05 Exam 1 name: ____________________

• Total points 30. Total time 70 mins. 3 problems over 3 pages. **No book, no notes, no calculator.**

• Sign here ____________________ to have your exam scores listed on web by last five digits of your UID.

1. [10 pts]



This problem deals with TCP congestion control in the scenario shown above. The router queue has a maximum buffer capacity of 2 packets. Overflow at this queue is the only cause of packet loss. If a packet completes transmission at the same time as another packet arrives, the transmission is completed just before the packet arrives. No other traffic uses the link. The link buffer is initially empty.

- The source sends a very large file of size F KB. Packet payload is 1 KB. Source has initial cw (congestion window size) of 1 packet. The source implements *additive-increase multiplicative-decrease* (no slow-start) congestion control: cw is increased by 1 when a window is acked, and set to ceiling(cw/2) upon timeout.
- Rtt and rto are constant at T seconds (rto is just slightly higher rtt).
- The sink sends an ack for every packet received. It can buffer an unlimited number of packets.

Use the *window-level* model in Note 5 (not the packet-level model) and obtain the following as a function of F and T (the skeleton table below is for your convenience):

a. Transfer time (from start until everything is acked).

b. Goodput: number of packets delivered to sink user per second.

b. TxRate: number of packets transmitted by TCP source per second.

SOLUTION

time	nr	na	cw	chunks sent	queue
0T	0	0	1	0	0
1T	1	1	2	1,2	1,2
2T	3	3	3	3,4,5	3,4 (5 lost)
3T	5	5	2	5,6	5,6
4T	7	7	3	7,8,9	7,8 (9 lost)
5T	9	9	2	9,10	9,10

Rows 4T and 5T repeat. So every 2T seconds, 5 blocks sent and 4 received.

a. Transfer time $= \frac{F * T}{2}$ seconds

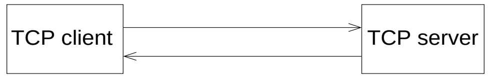
b. Goodput $= \frac{2}{T}$ packets/second

b. TxRate $= \frac{5}{2 * T}$ packets/second

Grading:

- 6 points for evolution. 1 point for transfer time. 1 point for goodput. 2 points for TxRate.
- 0 points for using packet-level model. Approx −5 points for mixing packet-level and window-level models. −3 points for spacing packets in a window by T (instead of spacing windows by T).
- 0 points for using slow-start.
- −2 points for treating ceiling as floor.
- −2 points for wrong cw evolution.
- −2 points for mismatch between cw, na, and chunks sent.

2. [10 pts]



The TCP client establishes a connection to the server, sends a 4KB file, and then closes the connection. Assume the following:

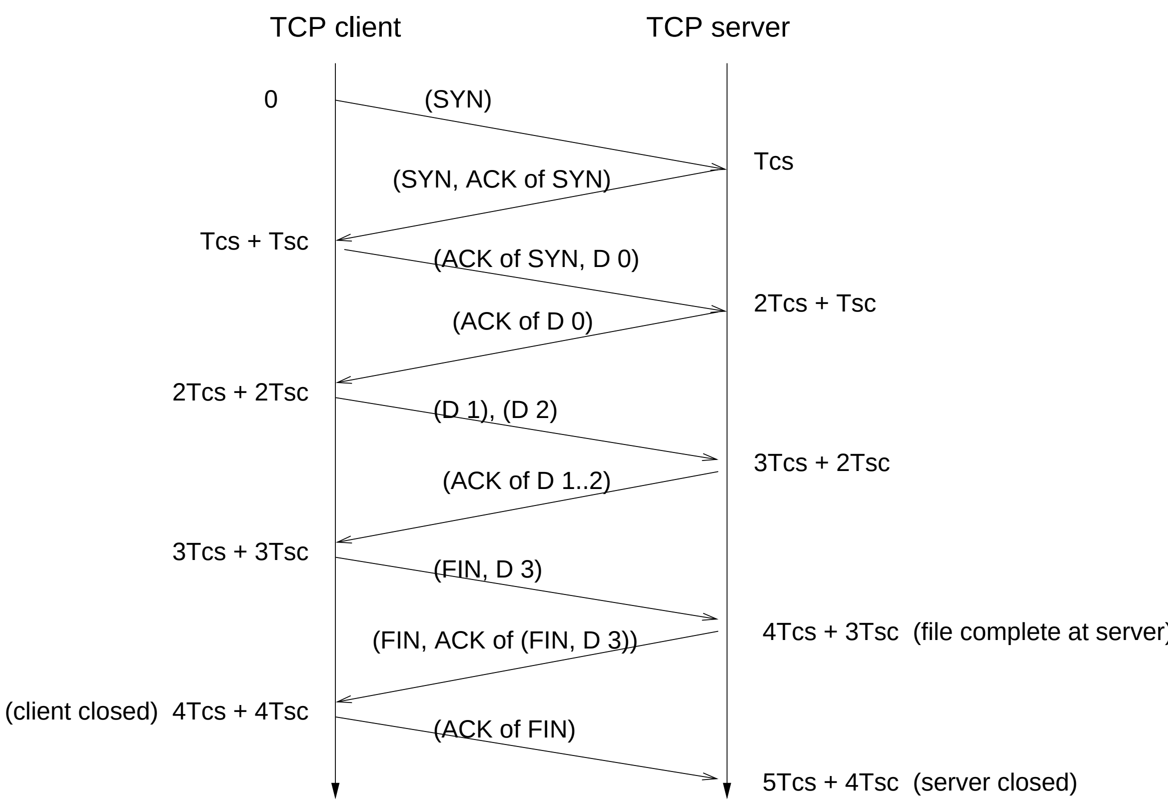
- The channels between the client and server are perfect, with constant delays $\mathsf{T_{CS}}$ from client to server and $\mathsf{T_{SC}}$ from server to client (no other delays).
- The client implements TCP Tahoe congestion control (slow-start, additive increase, multiplicative decrease), Packet payload is 1 KB. Initial cw (congestion window size) is 1 packet, and initial sst (slow-start threshold) is 6 packets.
- The sink sends an ack for every packet received. It can buffer an unlimited number of packets.

Complete the chart below showing the sequence of messages sent and received in this connection, starting at time 0 (when the client sends the SYN message) and ending when the server and client are both closed (each closes upon receiving a FIN-ACK).

Obtain (in terms of $\mathsf{T_{CS}}$ and $\mathsf{T_{SC}}$) the time when the file is completely transferred to the server.

Obtain (in terms of $\mathsf{T_{CS}}$ and $\mathsf{T_{SC}}$) the time when the server becomes closed.

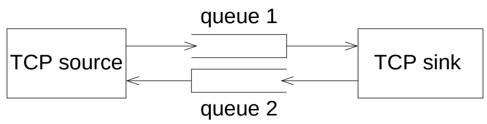
SOLUTION



Grading:

- 3 points for connection establishment (3-way handshake). 3 points for congestion window doubling. 3 points for closing (the two FIN handshakes). 1 point for server closing time.
- -1 point for sending FIN only after receiving ack for data 3. -2 points for not having the FIN handshake initiated by server. -2 points for sending responses to "secondary" messages (e.g., server ack to the client's ack to the server's syn-ack).
- "Multi-function" messages (e.g., (FIN, D3)) can be split into "single-function" messages (e.g., (D3) and (FIN)). The timing is not affected because there are no delays other than $\mathsf{T_{CS}}$ and $\mathsf{T_{SC}}$.

3. [10 pts]



This problem deals with TCP congestion control using the *packet-level* model in Note 5 (not the window-level model) and the scenario shown above. Assume the following:

- Each router link shown above takes D seconds to transmit a packet and has a maximum buffer capacity of 2 packets (regardless of packet size). There are no other delays (i.e., no propogation delay, no delays at the nodes). Overflow at a link buffer is the only cause of packet loss. If a packet completes transmission at the same time as another packet arrives, assume the transmission completes just before the packet arrives. No other traffic uses the links. The link buffers are initially empty.
- The source implements TCP Tahoe congestion control (slow-start, additive increase, multiplicative decrease), except that rto is constant at 5D seconds. It uses a single rto timer that restarts whenever it sends a packet. Packet payload is 1 KB. Source has initial cw (congestion window size) of 1 packet and initial sst (slow-start threshold) of 4 packets.
- The sink sends an ack for every packet received. It can buffer an unlimited number of packets.

Complete the table below for the transfer of a file of size 10 KB. The row at time jD, for $j = 0, 1, \cdots$, should indicate just after this time the values of na, cw, sst, the 1KB chunks sent, the chunks in queue 1, nr, and the contents of queue 2. The first few rows are filled in for your convenience. Also indicate the time when the transfer is completed (fully acked at the source).

SOLUTION

time	na	cw	sst	chunks sent	queue 1	nr (buffered)	queue 2
0D	0	1	4	0	0	0	-
1D	0	1	4	-	-	1	1
2D	1	2	4	1,2	1,2	1	-
3D	1	2	4	-	2	2	2
4D	2	3	4	3,4	3,4	3	3
5D	3	4	4	5,6	4,5 (6 lost)	4	4
6D	4	4+1/4	4	7	5,7	5	5
7D	5	4+2/4*	4	8	7,8	6	6
8D	6	4+3/4*	4	9	8,9	6 (7 bffrd)	6
9D	6	4+3/4*	4	-	9	6 (7,8)	6
10D	6	4+3/4*	4	-	-	6 (7,8,9)	6
11D	6	4+3/4*	4	-	-	6 (7,8,9)	-
12D	6	4+3/4*	4	-	-	6 (7,8,9)	-
13D	6	1	3	6	6	6 (7,8,9)	-
14D	6	1	3	-	-	10	10
15D	10	2	3	-	-	10	-

Grading:

- 3 points for slow start part (0D to 5D). 2 points for congestion avoidance "active" part (6D to 8D). 2 points for congestion avoidance "idle" part (9D to 12D). 3 points for timeout and post-timeout (13D to 15D). At most 1 point for a part if the part was present but the entries were mostly wrong.
- 0 points for using window-level model. Approx -5 points for mixing window-level and packet-level models.
- Some common problems: ending with na and/or nr not equal to 10; chunks sent not consistent with na and cw