CS 494/594 Homework 3 (Fall 2022)
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Instructor: Dr. Nirupama Bulusu
Due Date: 11/10/2022 11:59 pm PST

For 594 students only: Transport Layer Reviews

Review **only one** of the following three papers:

- Dina Katabi, Mark Handley, and Charlie Rohrs, "Congestion control for high bandwidth-delay product networks", ACM SIGCOMM 2002.

  http://conferences.sigcomm.org/sigcomm/2002/papers/xcp.pdf

- Keith Winstein and Hari Balakrishnan, "TCP ex machina: computer-generated congestion control", ACM SIGCOMM 2013.

  https://dl.acm.org/doi/10.1145/2486001.2486020

1. (10 points) Pipelining
Consider an idealized case of two hosts, one located in the United States and the other located in Japan. The speed of light round-trip propagation delay between the two end systems, RTT, is approximately 100 milliseconds. Suppose that they are connected by a channel with a transmission rate of R, of 100 Gbps (10^9 bits per second). Given a pipelined protocol with a pipeline of N packets, assuming no packet loss, how big would the window size have to be for the channel utilization to be greater than 95 percent? Assume that the size of the data packet is 4096 *bytes*, including both header fields and data.

Answer :
RTT = 100 ms
Transmission rate = R = $100 * 10^9$ bits/sec
Packet size = P = 4096 bytes

Bandwidth delay product of 2 hosts United States to Japan = J(Delay) = R * RTT
$= 100 * 10^9 * 100 / 10^3$
$= 1 * 10^{10}$

For 95% utilization = 95% of $1*10^{10}$
$= 95/100 * 1*10^{10}$
$= 0.95 * 10^{10}$

Minimum Number of packets = $(0.95 * 10^{10}) / (8 * 4096)$
= 289916.99 packets = **289917 packets**

2. (20 points) TCP Congestion and Flow Control

Suppose a TCP Reno sender (congestion avoidance, fast retransmit, fast recovery) has an *ssthresh = 16* and a *cwnd = 2*. The sender has no outstanding unacknowledged segments and 200 more segments left to transmit. In addition, the receiver it is sending to currently has an empty socket buffer that can hold up to 20 segments.

Excluding the TCP FIN handshake at the end of the transfer, how many more roundtrips does it take for the transfer to finish? Assume there is no packet loss. For each round-trip, show how many segments are transmitted.

Answer:

If Cwnd >= ssthresh = then it is congestion avoidance

TCP window size = minimum (cwnd, rwnd)

Round Trip	**TCP Phase**	**cwnd**	**rwnd**	**#Segments transmitted**	**Transmitted Segments**
1	Slow start	2	20	2	1-2
2	Slow start	4	20	4	3-6
3	Slow start	8	20	8	7-14
4	Slow start	16	20	16	15-30
5	Probing for congestion avoidance	17	20	17	31-47
6	Probing for congestion avoidance	18	20	18	48-65
7	Probing for congestion avoidance	19	20	19	66-84
8	Probing for congestion avoidance	20	20	20	85-104
9	Probing for congestion avoidance	21	20	20	105-124
10	Probing for congestion avoidance	22	20	20	125-144
11	Probing for congestion avoidance	23	20	20	145-164
12	Probing for congestion avoidance	24	20	20	165-184
13	Probing for congestion avoidance	25	20	20	185-200

3. (20 points) Wireshark Lab: TCP

Answer: Uploaded another file for wireshark lab