**Fall 2023 CS120 Homework Assignment #3**

**Due Date: Dec. 16, 2023**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_ ID: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Please read the following instructions carefully before answering the questions:**

* This assignment is to be completed by each student **individually**.
* There are a total of **8** questions.
* When you write your answers, please try to be precise and concise.
* Fill your name and student ID at the first page.
* Please typeset the file name and format of your submission to the following one: YourID\_CS120\_HW3.pdf (Replace “YourID” with your student ID). Submissions with wrong file name or format will **NOT** be graded.
* Submit your homework through Blackboard.

1. (5 points) When closing a TCP connection, why is the two-segment-lifetime timeout not necessary on the transition from LAST\_ACK to CLOSED?
2. (10 points) You are hired to design a reliable byte-stream protocol that uses a sliding window (like TCP). This protocol will run over a 1-Gbps network. The RTT of the network is 100 ms, and the maximum segment lifetime is 30 seconds. How many bits would you include in the **AdvertisedWindow** and **SequenceNum** fields of your protocol header?
3. (10 points) The Nagle algorithm, built into most TCP implementations, requires the sender to hold a partial segment’s worth of data (even if PUSHed) until either a full segment accumulates or the most recent outstanding ACK arrives.
4. Suppose the letters **abcdefghi** are sent, one per second, over a TCP connection with an RTT of 4.1 seconds. Draw a timeline indicating when each packet is sent and what it contains. (5 points)
5. Suppose that mouse position changes are being sent over the connection. Assuming that multiple position changes are sent each RTT, how would a user perceive the mouse motion with and without the Nagle algorithm? (5 points)
6. (10 points) Suppose, in TCP's adaptive retransmission mechanism, that EstimatedRTT is 4.0 seconds at some point and subsequent measured RTT's all are 1.0 second. How long does it take before the TimeOut value, as calculated by the Jacobson/Karels algorithm, falls below 4.0 seconds? Use . Use initial deviation value of 1.0 (Hint: You can use Excel to calculate).
7. (10 points) Suppose a congestion-control scheme results in a collection of competing flows that achieve the following throughput rates: 200 KBps, 160 KBps, 110 KBps, 95 KBps, and 150 KBps.
8. Calculate the fairness index for this scheme. (5 points)
9. Now add a flow with a throughput rate of 1000 KBps to the above, and recalculate the fairness index. (5 points)
10. (20 points) Suppose a router has three input flows and one output. It receives the packets listed in Table 1 all at about the same time, in the order listed, during a period in which the output port is busy but all queues are otherwise empty. Give the order in which the packets are transmitted, assuming:
11. Bit-Level fair queuing. (10 points)
12. Weighted bit-level fair queuing, with flow 2 having weight 4, and the other two flows having weight 1. (Hint: when calculating finishing time, transmission time = actual transmission time/weight) (10 points)

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| Table 1 Packets for Exercise 7 | | |
| Packet | Size | Flow |
| 1 | 100 | 1 |
| 2 | 100 | 1 |
| 3 | 100 | 1 |
| 4 | 100 | 1 |
| 5 | 190 | 2 |
| 6 | 200 | 2 |
| 7 | 110 | 3 |
| 8 | 50 | 3 |

1. (20 points) Assume that TCP implements an extension that allows window sizes much larger than 64 KB. Suppose that you are using this extended TCP over a 1-Gbps link with a latency of 50 ms to transfer a 10-MB file, and the TCP receive window is 1 MB. If TCP sends 1-KB packets (assuming no congestion and no lost packets):
2. How many RTTs does it take until slow start opens the send window to 1 MB? (5 points)
3. How many RTTs does it take to send the file? (5 points)
4. If the time to send the file is given by the number of required RTTs multiplied by the link latency, what is the effective throughput for the transfer? What percentage of the link bandwidth is utilized? (10 points)
5. (15 points) Consider a RED gateway with, and with an average queue length halfway between the two thresholds.
6. Find the drop probability for and . (5 points)
7. Calculate the probability that none of the first 50 packets is dropped. Note that this is . (10 points)