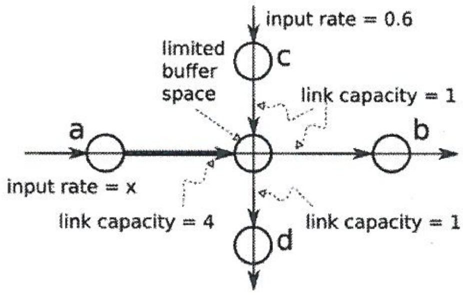
Solution attached

CSC0056 Homework 7

- Submit your work to Moodle before **9PM, Jan. 15th, Friday**.
- This is a bonus homework assignment - we will count the six highest scores out of your seven homework submissions. Also, consider this as a review for the final exam.

1. **(15 points)** Review Sec. 6.1.2 in the textbook. Following Example 6.1 and consider the following configuration instead:

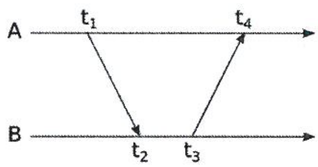


Explain why the total throughput will converge toward 1.25 as x increases.

2. **(15 points)** Review Sec. 6.2.1. For the end-to-end window flow control, where the transmission time of a single packet is 0.1ms. Suppose that we want to send packets from a sensor to our server, using the window size of 20 packets. If the round-trip delay is no larger than 1.7ms, will the flow control throttle the transmission rate of the sensor? Explain.

3. **(20 points)** Consider the leaky bucket scheme, where permits are generated on a per packet basis. With bucket size W=2, what is the average delay for a packet to obtain a permit? Suppose that packets arrive according to a Poisson process with rate λ=2 packets/second and that a permit arrives with rate r=3 permits/second.

4. **(20 points)** Consider the following time-lines, with t_1=80, t_2=100, t_3=115, and t_4=140, and compute the mean time offset between hosts A and B using the NTP protocol:



5. **(15 points)** Consider the CAN protocol (lecture 10), with a *wired-AND* implementation of the bus. For the following three encoding for the IDENTIFIER field (from MSB to LSB), rank their priority levels according to the multiaccess arbitration of the CAN bus:

   IDENTIFIER field of message A: 0 0 0 1 0 1 0 1 1 1 1

   IDENTIFIER field of message B: 0 1 0 1 0 1 0 1 1 0 0

   IDENTIFIER field of message C: 0 0 0 1 1 0 0 1 0 1 1

6. **(15 points)** In the slotted multiaccess model (Sec. 4.2.1), we have two alternative assumptions: (1) *no-buffering assumption*, and (2) *infinite set of nodes assumption*. Explain why using the first assumption the analysis provides a lower bound to the delay, and why using the second assumption the analysis provides an upper bound to the delay.

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(1) The link from the center to node b has less capacity than the link from node a has, and that will cause retransmissions from nodes a and c. Now, the link from a has four times the capacity than the link from c has. Therefore, the throughput to b and c will be $1 + 1 \times \frac{1}{4} = 1.25$ *

(2) No. It will take $0.1 \times 20 = 2$ ms to use up the window of 20 packets, while the acknowledgement of the first packet will return in 1.7 ms. This implies that we will never have to wait.

(3) $T = \frac{1}{3}(P_3 + 2P_4 + 3P_5 + 4P_6 + \cdots)$

$a_0 = \frac{e^{(-2/3)}(\frac{2}{3})^0}{0!} = e^{(-2/3)} = 0.513$, $a_1 = 0.342$, $a_2 = 0.114$, $a_3 = 0.025$, $a_4 = 0.002$, $a_5 = 0.0001$, $a_6 = 0.00006$

$P_0 = \frac{r - \lambda}{r a_0} = 0.65$

$P_1 = \frac{(1 - a_0 - a_1)P_0}{a_0} = 0.183$

$P_2 = \frac{1}{a_0}(P_1 - P_0 a_2 - P_1 a_1) = 0.09$

$P_3 = \frac{1}{a_0}(P_2 - P_0 a_3 - P_1 a_2 - P_2 a_1) = 0.043$

$P_4 = \frac{1}{a_0}(P_3 - P_0 a_4 - P_1 a_3 - P_2 a_2 - P_3 a_1) = 0.02$

$P_5 = \frac{1}{a_0}(P_4 - P_0 a_5 - P_1 a_4 - P_2 a_3 - P_3 a_2 - P_4 a_1) = 0.0108$

$P_6 = \frac{1}{a_0}(P_5 - P_0 a_6 - P_1 a_5 - P_2 a_4 - P_3 a_3 - P_4 a_2 - P_5 a_1) = 0.0068$

$T \approx \frac{1}{3}(0.043 + 2 \times 0.02 + 3 \times 0.0108 + 4 \times 0.0068) = \underline{0.047}$ *

Note that this is only a lower bound of the real average delay. In fact, T may be much larger.

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④ $\frac{1}{2}(100-80+115-140) = \underline{-2.5}$ #

⑤ $A > C > B$

⑥ With the no-buffering assumption, the backlogged nodes are not accepting new arrivals, and thus the total traffic load is lighter than the real load.

With the infinite-set-of-nodes assumption, a retransmission and a new transmission of the same real node can happen simutaneously, and thus the level of traffic congestion is heavier than the real traffic congestion. #