CSE 123: Computer Networks

Homework 4 (Due 12/03 in class)

Total Points: 30

Student Name:
PID:
UCSD email:

1. Random Early Detection (6 Points)

Consider a RED gateway, where the probability that a packet is dropped when the average queue size is equal to the maximum threshold size of the queue is 12%. Also assume that at the moment the average queue length is 2/3 of the distance between the minimum threshold and the maximum threshold. For each question, **please show your work.**

(a) What is the drop probability if the number of newly arrived packets in the queue is 2? **(1 Point for correct steps; 1 Point for correct answer)**

TempP = MaxP X (AvgLen - MinThreshold) / (MaxThreshold - MinThreshold)
= 0.12 * 2/3 = 0.08
Pcount = TempP / (1-count*TempP)

P2 = 0.08/(1-2*0.08) =0.095 (or 2/21)

(b) What is the drop probability if the number of newly arrived packets in the queue is 10? **(1 Point for correct steps; 1 Point for correct answer)**

P10 = 0.08/(1-10*0.08) = 0.4

(c) Find n such that the probability that none of the first n packets is dropped is 1/23. **(1 Point for correct steps; 1 Point for correct answer)**

let InvP = 1 / TempP = 1 / 0.08 = 12.5
1-Pcount = 1 - TempP / (1 – count * TempP) = (InvP - count -1) / (InvP- count).

(1) Assume count ranges from 0 to n-1 (precise interpretation),
$(1-P_0)(1-P_1)\ldots(1-P_{n-1})$ = (InvP-n)/(InvP) = 1/23
Therefore, n = 12.

(2) Assume count ranges from 1 to n,
$(1-P_0)(1-P_1)\ldots(1-P_{n-1})$ = (InvP-n-1)/(InvP-1) = 1/23
Therefore, n = 11.

Either n = 12 or 11 is a correct answer.

2. Token Bucket (6 Points)

Consider the transmission schedule table for a given flow as shown below. Values in the right column represent the number of bits (in Kb) sent between the time in the left column and the following second. For example, the first row in the table indicates that 3 Kb are transmitted in the first 1 second. Note that a bit can be transmitted only when a token in the bucket is available. The bucket has a depth of b and a replenishment rate of r, which are always positive. Assume the bucket is initially full. For each question, **please show your work.**

Time (seconds)	**Bits Sent (Kb)**
0	3
1	4
2	2
3	5
4	1

(a) What is the minimum bucket depth b (in Kb) if r = 0.8 Kbps?
(1 Point for correct steps; 1 Point for correct answer)

Token cannot be negative, so we have
b-3+r >= 0; b-3-4+2r>=0; b-3-4-2+3r >= 0; b-3-4-2-5+4r >= 0; b-3-4-2-5-1+5r >= 0.
Plug in r = 0.8, we have b(r=0.8) >= 11Kb.

Therefore, b_min(r=0.8) = 11 Kb

(b) What is the minimum bucket depth b (in Kb) if r = 3.2 Kbps?
(1 Point for correct steps; 1 Point for correct answer)

Since the bucket cannot have more than b tokens, to transmit 5 Kb when t = 3, bucket size must be at least 5-3.2 = 1.8 Kb.

Therefore, b_min(r=3.2) = 1.8 Kb

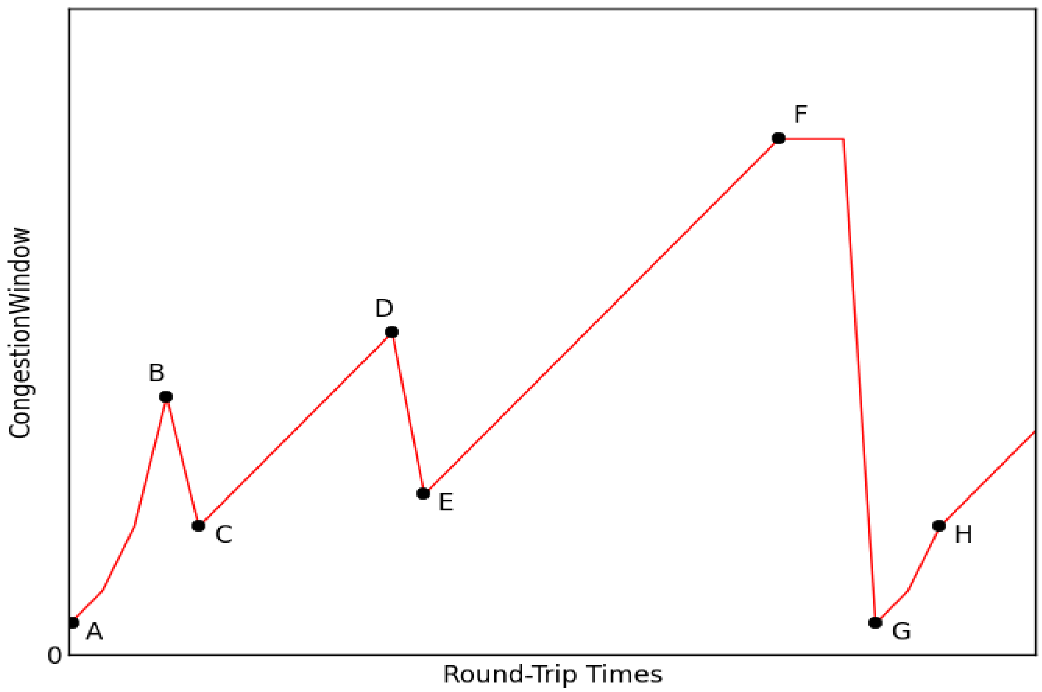
(c) What is the minimum replenishment rate r (in Kbps) if b = 9 Kb?
(1 Point for correct steps; 1 Point for correct answer)

Plug in b = 9, we have r(9=b) >= 1.25 Kbps

Therefore, r_min(b=9) = 1.25 Kbps

3. TCP Congestion Control (8 Points)

Consider the graph of TCP congestion window below, where the x-axis represents round-trip times and the y-axis represents the size of TCP congestion window (maximum number of unacknowledged frames allow). Assume that the timeout of each packet is three times of the round trip time. At t = 0, the size of TCP congestion window is 1, and at t = 3, congestion window size is 8. Therefore, the coordinates of A and B are (0, 1) and (3, 8), respectively. Also known is that the y-coordinate of D is 10 and the x-coordinate of F is 22.



a) What are the coordinates of point C, D, E, F, G and H, respectively? **(6 Points; -1 for each wrong answer)**

C: (4, 4)	D: (10, **10**)	E: (11, 5)
F: (**22**, 16)	G: (25, 1)	H: (27, 4)

b) How many times did fast retransmit happen in the above graph? **(1 Point)**

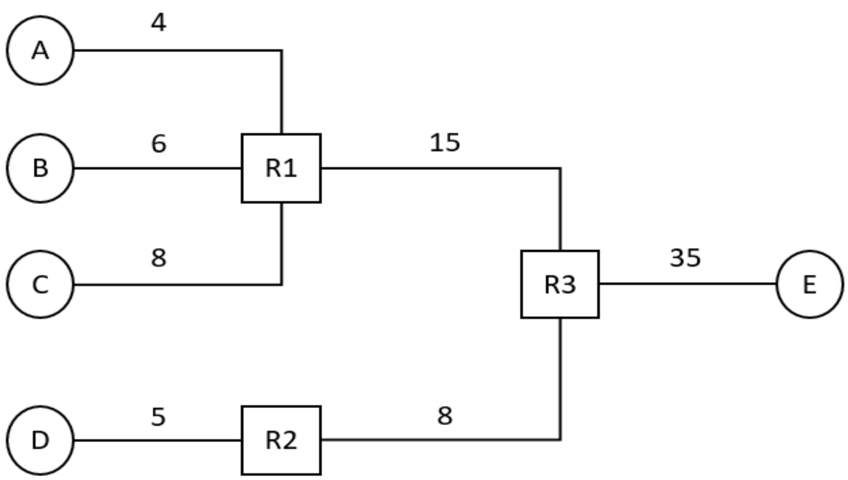
2

c) How many times did slow start happen in the above graph? **(1 Point)**

2

4. QUEUING DISCIPLINES (6 Points)

Consider the network shown below. R1, R2 and R3 are routers and A, B, C, D and E are hosts. The capacity (bandwidth) of each link (in Mbps) is numbered. Suppose A, B, C and D only send packets to E while E does not send any packets.



(a) Based on this topology, what is the maximum throughput (in Mbps) that can be achieved for the link between R3 and E? **(2 Points)**

20

(b) Suppose R1 receives the following packets in the order listed at about the same time. Assume all queues are empty and large enough to keep all receiving packets. The output port is busy.

Packet	Size (bytes)	Flow	Weight
1	200	A	1
2	150	B	2
3	150	B	2
4	180	C	4
5	180	C	4
6	180	C	4
7	180	C	4

(i) Give the order in which these packets leave R1 if fair queuing is applied. **(2 Points; No partial credits)**

<2, 4, 1, 3, 5, 6, 7>

(ii) Give the order in which these packets leave R1 if weighted fair queuing is applied. **(2 Points; No partial credits)**

<4, 2, 5, 6, 3, 7, 1>

5. Signaling constraints (4 Points)

Suppose a channel has a bandwidth of 13 MHz. For each question, **please show your work**.

a. What is the minimum required signal-to-noise ratio (in dB) that could deliver an effective bandwidth of at least 117 Mbps?

Applying Shannon's Law,
$SNR = 2^{C/B} - 1 = 511$
$SNR(dB) = 10\log_{10}SNR = 27.1$ dB

b. Now presume the channel is perfect—i.e., introduces no noise so the SNR is infinite. Is it possible to achieve 125 Mbps using a digital encoding scheme with only 32 levels?

Applying Nyquist Theorem,
$2B\log_2 M = 130 > 125$.
Therefore, the channel can transmit 125 Mbps information.