Introduction to Computer Networks **Name:** _____
Fall 2018
HW2 with answer (N/A)

This question set is for your reference. Please submit the answer of the other assignment!!

This homework contains 8 questions. The deadline is on Jan. 3 (Thu.) 23:59. Total of points is 100. Please submit your answers to the TA (office: EC-635).

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1. (10 points) **RTT estimation:** Recall that TCP uses *exponential weighted moving average* (EWMA) to estimate RTT between an end-to-end path using the equation

$$\text{RTT} = (1 - \alpha) * \text{RTT} + \alpha * \text{sampleRTT}$$

   (a) (5 points) Assume that α is set to 0.5, and the initial RTT is set to the first sample RTT. What will be the final estimated RTT when the sender collects the following 4 samples (in milliseconds)?

$$10 \quad 30 \quad 10 \quad 20$$

   Solution:

$$\begin{aligned} RTT_2 &= 0.5 * 10 + 0.5 * 30 = 20 \\ RTT_3 &= 0.5 * 20 + 0.5 * 10 = 15 \\ RTT_4 &= 0.5 * 15 + 0.5 * 20 = 17.5 \end{aligned}$$

   (b) (5 points) The following equation can be used to consider the safety margin in timeout estimation:

$$\text{timeout} = \text{RTT} + \beta * \text{DevRTT}$$

   Why do we need the safety margin? What is the intuition behind this equation?

   Solution:
   When the variance of RTT is high, the mean RTT may be smaller than many RTT samples, leading to timeout too often.
   When the standard deviation of RTT is high, add a larger safety margin such that the estimated timeout can be large enough to prevent unnecessary retransmissions.

2. (15 points) **TCP congestion control:** Consider the following figure. Assuming TCP Reno is the protocol.

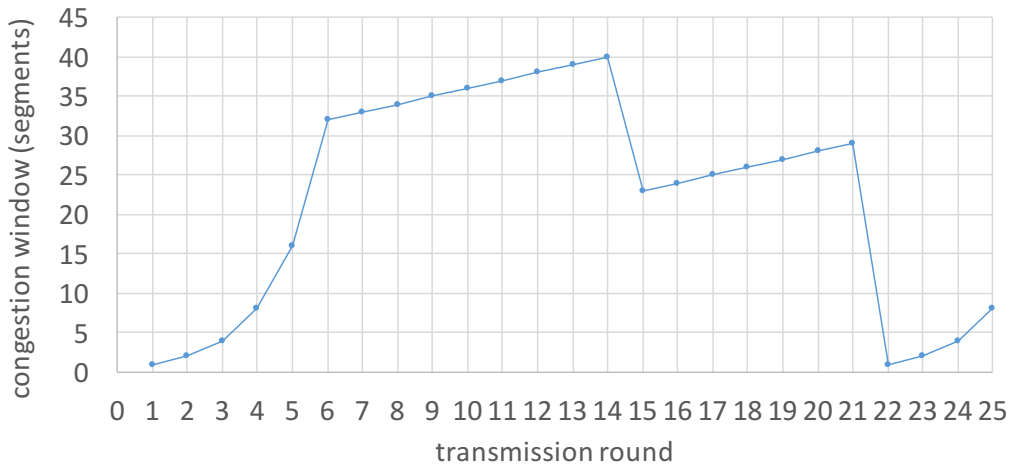


Figure 1: TCP window size as a function of time

(a) (5 points) Identify the intervals of time when TCP slow start is operating.

Solution:
1-6 transmission rounds
22-25 transmission rounds

(b) (5 points) Identify the intervals of time when TCP congestion avoidance is operating.

Solution: 7-21 transmission rounds

(c) (5 points) What is the initial value of `ssthresh` at the first and 16th transmission round, respectively?

Solution: 32, 20

3. (10 points) **Control and data plane.**

(a) (5 points) Briefly explain what is the control plane and the data plane in a router. Describe what are their major tasks.

Solution:
control: calculate the routing paths for node pairs, manage the network
data: forward every packet to the correct output port

(b) (5 points) Briefly explain what is the difference between the per-router control plane and the centralized control plane.

Solution:
per-router: control unit of routing configuration is performed at each router
centralized: control unit of routing configuration of all the routers is installed in a remote server

4. (15 points) **Prefix matching.** Consider the following routing table at a router.

prefix	output port
`11000110 10111101 101****** ********`	1
`11000110 10111101 1111010* ********`	2
`11000110 10111101 111***** ********`	3
otherwise	4

   (a) (5 points) What is the output port is the destination address is `11000110 10111101 11110101 00101101`?

Solution: 2

   (b) (5 points) What is the output port is the destination address is `11000110 10111101 11100011 11101101`?

Solution: 3

   (c) (5 points) What is the output port is the destination address is `10000110 10111101 11100011 11101101`?

Solution: 4

5. (10 points) **Queueing.** Consider a router that help forward packets classified into two classes. Say that ten packets arrive the router with the following class and arrival time:

sequence	1	2	3	4	5	6	7	8	9	10
class	1	1	2	1	2	1	1	2	2	1
time (second)	0	2	2.5	2.8	3.5	4.5	6	7	7.2	7.8

   Assume that the transmission time of each packet is *one second*.

   (a) (5 points) Assume that class 1 has a high priority, while class 2 has a low priority. When will each packet be sent if the router forwards packets using priority queueing? (Note that there is no preemptive.)

Solution:

time (second)	0	2	3	4	5	6	7	8	9	10
sequence	1	2	4	3	6	7	5	10	8	9

(b) (5 points) When will each packet be sent if the router forwards packets using round robin queueing?

Solution:

time (second)	0	2	3	4	5	6	7	8	9	10
sequence	1	2	3	4	5	6	8	7	9	10

6. (10 points) **Subnet.**

(a) (5 points) What is the maximum number of hosts in the subnet 140.113.178.0/22?

Solution: $2^{10} - 2 = 1022$

(b) (5 points) What is the subnet mask of subnet 140.113.178.0/22 in decimal?

Solution: 255.255.252.0

7. (10 points) **DHCP.**

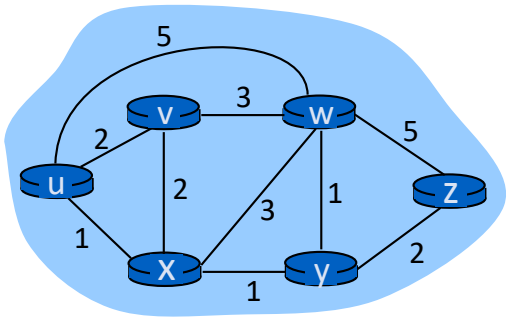
(a) (5 points) Why in DHCP the first two message is sent via link-layer broadcasting?

Solution: A requesting node does not the IP address of DHCP server(s).

(b) (5 points) Why in DHCP we need four messages to confirm the retrieval of an IP address, instead of just two messages?

Solution: A subnet might have multiple DHCP servers that all offer IP address for the requesting node. The requesting node needs pick on and sends confirmation via messages 3 and 4.

8. (20 points) **Link-state routing.** Consider the following network topology with 6 nodes. Let the number associated with each link be the cost of the link. Try to find the shortest path from node v to the remaining nodes using the link-state algorithm.



(a) (10 points) Write down the step-by-step procedure of the link-state algorithm as building the distance/predecessor table from node v to all the remaining nodes.

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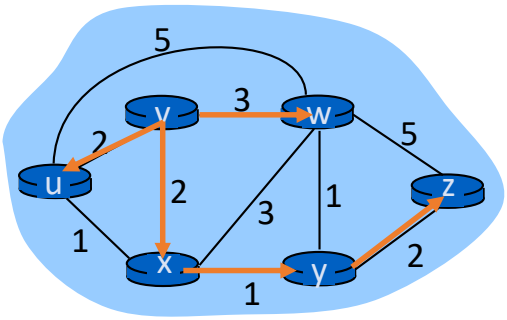
Step	N'	D(u) p(u)	D(w) p(w)	D(x) p(x)	D(y) p(y)	D(z) p(z)
0	v	2,v	3,v	2,v	∞	∞
1	vx	2,v	3,v		3,x	∞
2	vxu		3,v		3,x	∞
3	vxuw				3,x	8,w
4	vxuwy					5,y
5	vxuwyz					



(b) (5 points) What is the routing path from v to z?

Solution: (v, x, y, z)

(c) (5 points) What is the forwarding table at node v?

Solution:

destination	next hop
u	u
w	w
x	x
y	x
z	x