Introduction to Computer Networks
Fall 2021
Homework 2 (**Due: 12/26/2021**)

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This homework contains 8 questions. The deadline is on Dec. 26 (Sun) at 23:59. Please submit your answers to new E3.

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1. (10 points) **Router:**

   (a) (4 points) List the four components of a router.

   Input ports, high-speed switching fabric, output ports, routing processor.

   (b) (2 points) When will the input queue (or the output queue) of a router overflow, leading to packet losses?

   Buffering required when datagrams arrive from fabric faster than the transmission rate.

   (c) (2 points) Why we prefer *prefix matching*, instead of ID matching, during packet forwarding?

   The look-up table may occupy huge memories to store the flows if we use ID matching.

   (d) (2 points) Explain when will a flow match multiple rules in a forwarding table. Explain WHY we adopt *longest prefix matching* to resolve this issue.

   When there is a small IP range inside a larger one and the flow could match both of them, such as the smaller one is 140.113.10.xx while the larger one is 140.113.xx.xx.
   The reason we adopt longest prefix matching is that if the flow matches the smallest range, it must in the range of the larger ones, and also the smallest range(longest prefix) is the most specific route where the flow will finally go.

2. (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	2	1	2	2	1	2	1
time (second)	0.5	1.0	1.2	2.5	3.0	5.0	5.5	6.3	8.2	8.6

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.)

packet 1: 1.5s
packet 2: 2.5s
packet 3: 3.5s
packet 4: 5.5s
packet 5: 4.5s
packet 6: 6.5s
packet 7: 8.5s
packet 8: 7.5s
packet 9: 9.5s
packet 10: 10.5s

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

packet 1: 1.5s
packet 2: 3.5s
packet 3: 2.5s
packet 4: 4.5s
packet 5: 5.5s
packet 6: 6.5s
packet 7: 8.5s
packet 8: 7.5s
packet 9: 9.5s
packet 10: 10.5s

3. (15 points) **Subnet.**

   (a) (4 points) What is the maximum number of hosts in the subnet 140.113.10.0/22?

   2^10 - 2 = 1022

   (b) (3 points) Following the above question, what is the IP address reserved for broadcasting?

   140.113.11.255

   (c) (4 points) What is the subnet mask of subnet 140.113.10.0/22 in decimal?

   255.255.253.0

   (d) (4 points) If this subnet only includes 2,000 host, what is a more efficient subnet mask? (hint: minimize the number of non-occupied IP addresses)

   255.255.248.0

4. (10 points) **DHCP.**

   (a) (3 points) Explain why DHCP uses link-layer broadcasting to send requests.

   If one requests for DHCP, which means one has no IP address, so he can't use any IP layer service, and since the users of the subnet don't know who you are(since there's no IP address), DHCP must use broadcast to send requests.

   (b) (2 points) Why does a DHCP request require two requests, instead of just one request?

   Because there are many DHCP servers will respond to your first request for DHCP, but only the one you send the second request for that IP will give you the IP address.

(c) (2 points) Explain what is a lease of a dynamic address allocated by DHCP?

When you get your IP address from the DHCP server, you'll also get a lease. When reaching timeout, you have to send another request to renew your lease to get another IP address.

(d) (3 points) Explain why DHCP can address the issue of insufficient IP addresses.

When a user is not using his IP address distributed by the DHCP server, the server will take the IP address back so that the other user can use the IP address, which means an IP address can be used by many people at different time.

5. (10 points) **SDN:**

(a) (2 points) Explain what is the major difference between traditional routers and programmable switches.

programmable switches support that you can write a program to change the way of sending packages anytime you want while traditional routers can only follow the rules that are already written into it.

(b) (4 points) List the fields that can be matched in the OpenFlow protocol.

Switch Port,VLAN ID, MAC src, MAC dst, Eth type, IP Src, IP Dst, IP Prot, TCP sport, TCP dport.

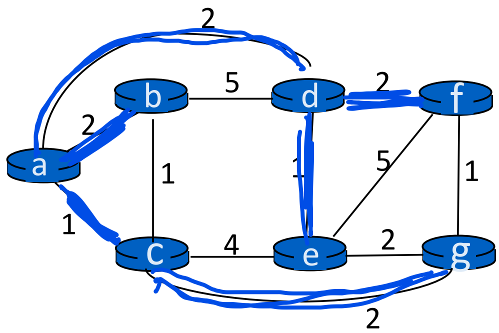
(c) (2 points) List the actions that can be performed in the OpenFlow protocol.

1. Forward packet to port(s)
2. Encapsulate and forward to controller
3. Drop packet
4. Send to normal processing pipeline
5. Modify Fields

(d) (2 points) Define what is the 5-tuple of a flow.

source IP address, source TCP/UDP port, destination IP address, destination TCP/UDP port and IP protocol.

6. (15 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 a to the remaining nodes using the link-state algorithm.



(a) (8 points) Write down the step-by-step procedure of the link-state algorithm as building the distance/predecessor table from node a to all the remaining nodes.

		d(b)	d(c)	d(d)	d(e)	d(f)	d(g)
0	a	2,a	1,a	2,a	∞	∞	∞
1	ac	2,a		2,a	5,c	∞	3,c
2	acb			2,a	5,c	∞	3,c
3	acbd				3,d	4,d	3,c
4	acbde					4,d	3,c
5	acbdeg					4,d	
6	acbdegf						

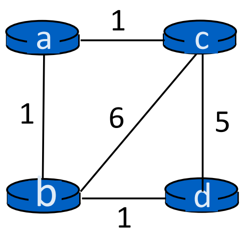
(b) (3 points) What is the routing path from a to g?

a → c → g

(c) (4 points) What is the forwarding table at node c?

dst	link
a	(c,a)
b	(c,a)
d	(c,a)
e	(c,a)
f	(c,a)
g	(c,g)

7. (20 points) **Distance-vector routing.** Consider the following network topology with 4 nodes. Let the number associated with each link be the cost of the link. Try to find the shortest path from each node to the remaining nodes using the distance-vector algorithm.



(a) (4 points) What is the initial distance vector of each of the four nodes?

a's table

	a	b	c	d
a	0	1	1	∞
b	∞	∞	∞	∞
c	∞	∞	∞	∞
d	∞	∞	∞	∞

b's table

	a	b	c	d
a	∞	∞	∞	∞
b	1	0	6	1
c	∞	∞	∞	∞
d	∞	∞	∞	∞

c's table

	a	b	c	d
a	∞	∞	∞	∞
b	∞	∞	∞	∞
c	1	6	0	5
d	∞	∞	∞	∞

d's table

	a	b	c	d
a	∞	∞	∞	∞
b	∞	∞	∞	∞
c	∞	∞	∞	∞
d	∞	1	5	0

(b) (4 points) Assume that all the nodes broadcast their distance vectors $\mathbf{D}_i$ at the same time. What will be the distance vector of each of the four nodes after receiving the initial distance vector from the neighbors (i.e., the distance vector of all nodes after the first information exchange)?

	a	b	c	d
a	0	1	1	∞
b	1	0	6	1
c	1	6	0	5
d	∞	1	5	0

the four table are the same.

(c) (8 points) Assume that all the nodes broadcast their updated distance vectors at the same time. Write down the detailed information exchange and distance vector update procedure until convergence.

iter 1:

a's vector:

	a	b	c	d
a	0	1	1	2
b	1	0	6	1
c	1	6	0	5
d	∞	1	5	0

b's

	a	b	c	d
a	0	1	1	∞
b	1	0	2	1
c	1	6	0	5
d	∞	1	5	0

c's

	a	b	c	d
a	0	1	1	∞
b	1	0	6	1
c	1	2	0	5
d	∞	1	5	0

d's

	a	b	c	d
a	0	1	1	∞
b	1	0	6	1
c	1	6	0	5
d	2	1	5	0

broadcast:

	a	b	c	d
a	0	1	1	2
b	1	0	2	1
c	1	2	0	5
d	2	1	5	0

iter 2:

a, b not changed,

c's

	a	b	c	d
a	0	1	1	2
b	1	0	2	1
c	1	2	0	3
d	2	1	5	0

d's

	a	b	c	d
a	0	1	1	2
b	1	0	2	1
c	1	2	0	5
d	2	1	3	0

broadcast:

	a	b	c	d
a	0	1	1	2
b	1	0	2	1
c	1	2	0	3
d	2	1	3	0

. iter 3 is the same → convergence

(d) (2 points) How many iterations are required to achieve convergence? (Note that the last iteration, which is duplicated with the previous iteration, should also be counted.

3

(e) (2 points) What is the shortest path from node c to node d?

c → a → b → d

8. (10 points) **MAC.** Medium access control protocols.

(a) (2 points) Give two key shortages of channel partitioning.

First, Utilization may be low as slots are already allocated.
Second, we need to synchronize the clock to get the starting time of every slots.

(b) (3 points) Explain what is *collision avoidance* in a random access protocol. Why could random access be better than channel partitioning?

Collision avoidance means waiting for other packets finish their transmission, then deliver your packet on the medium.
Random access allows higher utilization then channel partitioning as it allows transmmision all the time and it need'nt to reserve the slots for other users.

(c) (5 points) Explain the difference between *collision detection* and *collision avoidance*. Why does 802.3 exploit collision detection, but 802.11 exploit collision avoidance?

Collision detection is an approach to reduce wastage of transmission.
Collision avoidance is the way to try to avoid collision before sending the packet.
802.3 is used in ethernet while 802.11 is used in wired LANs.