CS118 Quiz 3, Spring 2020

Name: ____________________________

Student ID: ________________________

Notes:

1. This is an open-book, open-notes quiz. You have two hours to work on your quiz, scan or photo your paper copy, and upload to the Gradescope.
2. You need to upload your scanned copy or the photoed picture of your answer sheet to the Gradescope before the deadline.
3. You are allowed to use your calculator. You are advised **not** to use the Internet to search for hints during the quiz. By submitting your quiz, you declare that **your work is solely done by yourself and you have not interacted with anyone else other than the instructor and proctors during the test**.
4. If you have any issues with the quiz, you can tune in the regular Lecture Zoom link and use the Chatroom there during the quiz time. We will provide clarifications there during the quiz.
5. Be **brief** and **concise** in your answers. Answer only within the space provided. If you need additional work sheets, use them but do NOT submit these sheets.
6. If you wish to be considered for partial credit, show all your work.
7. **Show your steps to receive partial credit**.
8. You have 5 problems in 6 pages plus this page.

PROBLEM	MAX SCORE	YOUR SCORE
1	24	
2	21	
3	10	
4	22	
5	13	
TOTAL	90	

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Problem 1: Multiple choices (24 points; 3 points each). Select *all* (i.e., possibly more than one) correct answers.

1. Which of the Internet design principle(s) do network address translation (NAT) **violate**?

A

- Your answer ____ (A) End-to-end argument where the design complexity is mostly implemented and operated at the end systems. (B) Packets with private IP addresses should not be delivered in the public Internet. (C) Port numbers are used for addressing hosts. (D) The network-layer device should process packets at the network layer only.

2. DHCP can be used to obtain network configuration information. Which of the following information **cannot** be found using DHCP?

D

- Your answer ____ (A) IP address of the new host. (B) IP address of the DNS server. (C) IP address of the default first-hop router. (D) MAC address of the first-hop router. (E) network mask.

3. Which field is deleted in the IPv6 header but appeared in the IPv4 header?

BD

- Your answer ____ (A) Source and destination IP addresses. (B) Header checksum. (C) Flow label. (D) Options. (E) Version.

4. Which of the following statement on distance vector routing is true?

CD

- Your answer ____ (A) Every node exchanges route information with all other nodes in the network topology graph. (B) Both good news and bad news would travel very fast. (C) It could suffer from count-to-infinity problem when link cost increases. (D) Each node computes routes by only using the topology information propagated from neighbors.

C

5. Consider sending a 3000-byte datagram into a link that has an MTU of 700 bytes. What is the size (in bytes) of the last fragment (including 20-byte IP header)?

$680/8 = 85$ 2720 2980

$680 \times \frac{5}{4} = \cancel{3400}$ 600

- Your answer ____ (A) 35; (B) 200; (C) 280; (D) 300; (E) 360.

6. Which protocol(s) is/are **not** using soft state (i.e., certain protocol states are deleted after timeout)?

BD

- Your answer ____ (A) DNS; (B) DHCP; (C) IP; (D) UDP.

7. Which protocol(s) is(are) **never** used during the process a newly arriving device to a subnet (constructed by Ethernet) gets its IP address assigned?

DE

- Your answer ____ (A) DHCP; (B) UDP; (C) IP; (D) HTTP; (E) POP3.

8. A host must receive four pieces of necessary configuration information from DHCP for it to be connected to the Internet. If a host moves from one subnet 223.1.2.0/24 to another subnet 223.1.3.0/24, how many configurations among the four **must** be changed?

B

- Your answer ____ (A) 1; (B) 2; (C) 3; (D) 4.

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Problem 2 (21 points; 3 points each): Answer the following questions. Be brief and concise.

1. Why does the IP header need a Header Length field? Briefly explain why.

   Because there is an option field in the IPv4 header in the datagram that will change the size of the length of header. Without a 4-bit Header Length field, it cannot be determined where in the IP datagram the payload begins. Thus, if there's no option field, the header length indicates 20 bytes, and it will indicates 20 bytes plus length of option field if option field exists.

2. Can the Internet always guarantee loop-free routing? If yes, justify your answer; If no, how does the Internet handle those packet that traverse over looped routes?

   No. Because for Distance-vector algorithm, when there is an increase in a link cost, there is poison reverse that if z routes through y to get to dest x, then z will advertise that its distance to x is infinity. However, when there are more than two nodes involved in the loop, the poison reverse will not prevent the infinite looping.

3. Does the path vector in BGP include any router's IP address? Briefly explain why.

   No, because the path vector is based on originated prefix, and the path is involving each AS, which does not include any specific IP address, but prefix that representing the ASes.

4. Is BGP able to detect loops during path advertisement? Briefly explain why.

   Yes, because eBGP would prepend the AS to AS PATH when travel through each AS, and BGP router can check the existence of loop by checking the attribute of AS Path such that if a router sees its own AS number in the AS Path list, it determines that there is a loop and the route will be dropped.

5. Ping allows us to probe a destination host on the Internet. Can you identify at least two protocols we have learned from the class, which will be used when we run the *ping* program? For each used protocol, explain why ping needs to use it.

   IP and ICMP.
   IP is needed in ICMP such that it is implemented on top of IP protocol, since ping is a computer network administration software utility used to test the reachability of a host on an Internet Protocol(IP) network.
   ICMP is needed because Ping is operated by sending ICMP echo request packets to a host and waiting for an ICMP echo reply.

6. In destination-based IP forwarding, can the destination address match multiple entries in the forwarding table of the IP router? If so, which entry will be used? If not, briefly justify why.

   Yes, it can match multiple entries. The longest prefix that can be matched will be used, because longest prefix matching will direct to the destination with the correct AS.

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7. Describe a solution that allows us to incrementally/gradually upgrade the Internet with IPv6 over time to replace the current IPv4.

   Tunneling is a solution such that IPv6 datagram is carried as payload in IPv4 datagram among IPv4 routers. Then, IPv4 tunnel connects IPv6 routers, in which IPv4 datagram containing IPv6 datagram will be transmitted.

Problem 3 (10 points): NAT. Assume two hosts on a private network behind an NAT router with private IP addresses 10.1.1.2 and 10.1.1.3, respectively. Each host initiates a separate TCP connection on port 5000 at the same time to an external Web server with the public IP address 128.78.49.7 and port 80. The NAT router has the public IP address 158.46.39.3. Assume the NAT router assigns port 5001 to the host with private IP address 10.1.1.2 and port 5002 to the host with private IP address 10.1.1.3.

1. (2 points) Show the four tuples (source/destination IP address and port number) of the two TCP SYN segments on the private network received by the NAT.

   From the host with private IP 10.1.1.2:
   Source IP: 10.1.1.2 Source port: 5000
   Destination IP: 128.78.49.7 Dest port: 80
   From the host with private IP 10.1.1.3:
   Source IP: 10.1.1.3 Source port: 5000
   Destination IP: 128.78.49.7 Dest port: 80

2. (2 points) What is the NAT table content after the NAT router has forwarded the two TCP segments to the Web server?

IP: port within private network	IP: port outside private network
10.1.1.2:5000	158.46.39.3:5001
10.1.1.3:5000	158.46.39.3:5002

3. (2 points) Show the four tuples of the two TCP SYN segments on the public Internet sent by the NAT.

   Segment from the host with private IP 10.1.1.2:
   Source IP: 158.46.39.3 Source port: 5001
   Destination IP: 128.78.49.7 Dest port: 80
   Segment From the host with private IP 10.1.1.3:
   Source IP: 158.46.39.3 Source port: 5002
   Destination IP: 128.78.49.7 Dest port: 80

4. (4 points) Show the four tuples of the two TCP SYN-ACK segments received and sent by the NAT.

Received by NAT:
Segment to the host with private IP 10.1.1.2:
Source IP: 128.78.49.7 Source port: 80
Destination IP: 158.46.39.3 Dest port: 5001
Segment to the host with private IP 10.1.1.3:
Source IP: 128.78.49.7 Source port: 80
Destination IP: 158.46.39.3 Dest port: 5002

Sent by NAT:
Segment to the host with private IP 10.1.1.2:
Source IP: 128.78.49.7 Source port: 80
Destination IP: 10.1.1.2 Dest port: 5000
Segment to the host with private IP 10.1.1.3:
Source IP: 128.78.49.7 Source port: 80
Destination IP: 10.1.1.3 Dest port: 5000

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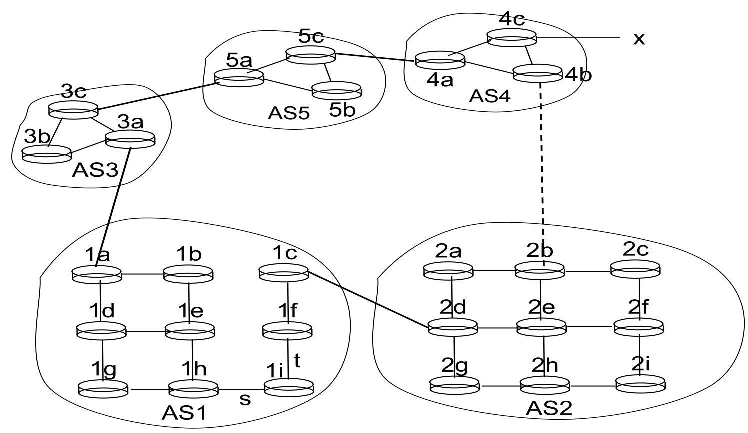
Problem 4 (22 points): Internet Routing. In the figure shown below, suppose AS2, AS3 and AS5 are running OSPF for their intra-AS routing protocol. Suppose AS1 and AS4 are running RIP for their intra-AS routing protocol. Note that RIP implements the distance-vector routing algorithm, whereas OSPF implements the link-state routing algorithm. eBGP and iBGP are used for the inter-AS routing protocols. s and t are two communication links at router $1i$.

Note: we assume there are no special policies applied among ASes and all links inside an AS have the same cost.



1. (9 points) Initially suppose there is no physical link between AS2 and AS4.

   (a) (1 point) Router $1a$ learns about x from which protocol, RIP, OSPF, eBGP, or iBGP?

   eBGP

   (b) (1 point) Router $1c$ learns about x from which protocol, RIP, OSPF, eBGP, or iBGP?

   iBGP

   (c) (1 point) Router $1i$ learns about x from which protocol, RIP, OSPF, eBGP, or iBGP?

   iBGP

   (d) (2 point) What is the path vector that Router $1i$ learns to reach x?

   The path vector is AS3 AS5 AS4 x

   (e) (2 point) Once Router $1i$ learns about x, it will create an entry (x, I) in its forwarding table. Will I be equal to s or t for this entry? Explain why.

   I is equal to s, because the BGP will first try with the shortest AS-PATH before trying hop potato routing, which is going from s to gateway router 1a.

   (f) (2 points) Note RIP is used for intra-domain routing within AS1. Assume that each router sends out routing updates every 30 seconds. On average how many routing update messages does Router $1h$ receive per minute? Show your calculation steps.

   3*2=6 messages. For 1h, it has 3 neighboring routers, and each time it only receive update messages from its neighbors. So, there are 60s/30s=2 times of update, so 3*2 = 6 messages.

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2. (13 points) Now suppose that there is a physical link between AS2 and AS4, shown by the dotted line. Suppose router $1i$ learns that x is accessible via AS2 as well as via AS3.

   (a) (2 point) What is the path vector that Router $1i$ will use to reach x?

   The path vector is AS2 AS4 x

   (b) (2 point) Once Router $1i$ learns about x, it will create an entry (x, I) in its forwarding table. Will I be set to s or t? Explain why.

   I will be equal to t. Because the shortest AS PATH between 1i and x is 1i AS2 AS4 x, so choose link t to gateway router 1c.

   (c) (3 points) Note OSPF is used for intra-domain routing within AS2. Assume that each router sends out routing updates every 30 seconds. On average how many routing update messages does Router $2h$ receive per minute? Show your calculation steps.

   8*2 = 16 messages. There are 8 other routers in the AS 1, and every time OSPF updates messages from all the other routers, and there are 2*8 =16 messages.

   (d) (2 point) Will Routers $3a$ and $3c$ use the same routing protocol to learn each's shortest path vector to reach x?

   Yes, because all the ASes use the same intra-AS routining protocol OSPF.

   (e) (2 point) What is the path vector Router $3a$ in AS3 uses to reach x if hot potato routing is used?

   The path vector is AS5 AS4 x

   (f) (2 point) What is the path vector Router $5a$ in AS5 uses to reach x if hot potato routing is used?

   The path vector is AS5, x

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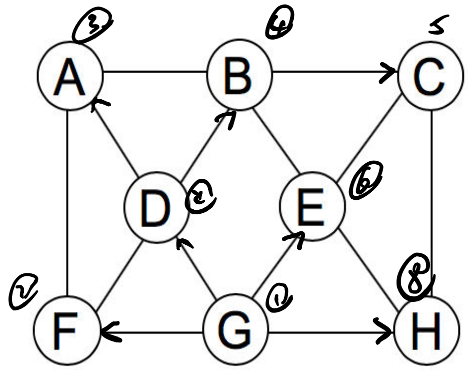
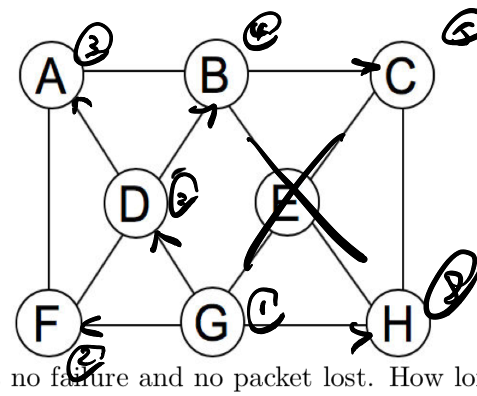
Problem 5 (13 points): Routing protocol Consider a network with 8 routers in the figure below. The routers run OSPF routing protocol. All links have a cost of 1. When a router has to choose between two or more equal-cost paths to a given destination, it breaks the tie by picking the next hop with the lowest node ID (in alphabetic order). Assume that,

- Initially (T=0) the routing tables of all routers are empty.
- Propagation delay across each link is 50 msec.
- All routers send their first routing update message to its neighbors at time T=0.
- Ignore processing, queuing, and transmission delays.





is no failure and no packet lost. How long

1. (3 points) Assume there is no failure and no packet lost. How long does it take for router E to build and finalize its routing table? Please explain your answer.

   It takes (8-1)*50 msec = 350 msec for there are 8 routers. It is because the OSPF uses Dijkstra algorithm, and each step propagates to neighboring routers and finalizes one more router, so it takes (8-1) steps of propagation, each takes 50 msec, so 350 msec in all.

2. (10 points) After all routers have finalized their routing tables, router E fails. Fill the forwarding tables of router G before the failure and after the failure. Leave the next hop filed blank if the destination is no long reachable. Assume that router G received all the update messages from all the other routers.

Table 1: Forwarding table after initial convergence

Destination	Next hop
A	D
B	D
C	B
D	G
E	G
F	G
H	G

Table 2: Forwarding table after failure

Destination	Next hop
A	D
B	D
C	B
D	G
E	
F	G
H	G