CS118 Quiz 3, Spring 2020

Name: _____

Student ID: Solution

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	

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

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

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

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

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

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

   - 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.

5. C 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)?

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

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

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

7. DE 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?

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

8. B 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?

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

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 the Options field in the IP header has variable length. The header needs to specify the length of header to get the position of data payload.

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?

   Solution: No. Use the TTL field to decrement by 1 over each traversed hop; and drop the packet when TTL=0.

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

   Solution: No. It is for inter-domain routing, so only AS numbers are included.

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

   Solution: Yes. If a BGP peer receives a route that contains its own AS number in the AS path, then using that route would result in a loop.

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.

Solution: use IP protocol (constructing IP packets), ICMP protocol (so that the destination responds). Others are also used: ARP, IP routing (RIP/OSPF, BGP), DNS.

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. Longest prefix matching

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

Tunneling. At the entry of the tunnel, create a new IPv4 header; at the exit, remove the IPv4 header.

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.

src: 10.1.1.2:5000 dest: 128.78.49.7:80
src: 10.1.1.3:5000 dest: 128.78.49.7:80

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

WAN: 158.46.39.3:5001 LAN: 10.1.1.2:5000

WAN: 158.46.39.3:5002 LAN: 10.1.1.3:5000

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

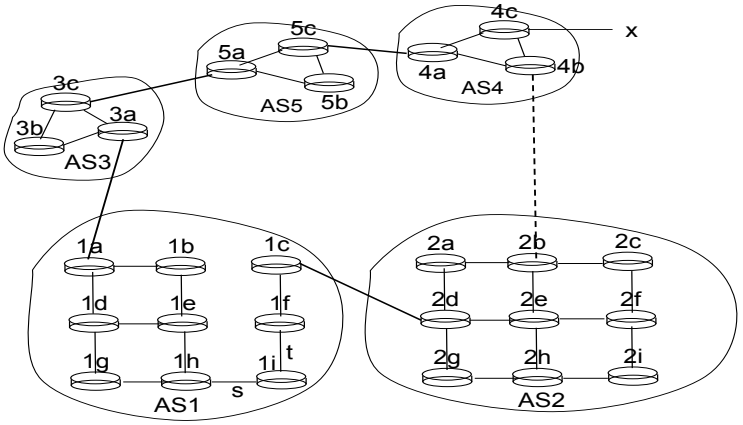
src: 158.46.39.3:5001 dest: 128.78.49.7:80
src: 158.46.39.3:5002 dest: 128.78.49.7:80

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

Outside:
src: 128.78.49.7:80 dest: 158.46.39.3:5001
src: 128.78.49.7:80 dest: 158.46.39.3:5002
Inside:
src: 128.78.49.7:80 dest: 10.1.1.2:5000
src: 128.78.49.7:80 dest: 10.1.1.3:5000

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?

   Solution: eBGP

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

   Solution: iBGP

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

   Solution: iBGP

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

   Solution: AS3 AS5 AS4. The reverse order (AS4 AS5 AS3) is also fine.

   (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.

   Solution: link s. Since that leads to the only path.

(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.

Solution: 2 (messages per min) x 3 (neighbors) = 6 routing messages per minute.

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?

Solution: AS2 AS4. The reverse order (AS4 AS2) is also fine.

(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.

Solution: link t. This is based on hot potato routing/shortest AS path.

(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.

Solution: 2 (routing messages per min) x 8 (other nodes in AS2) = 16 routing messages per min

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

Solution: No. $3c$ uses eBGP, but $3a$ uses iBGP.

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

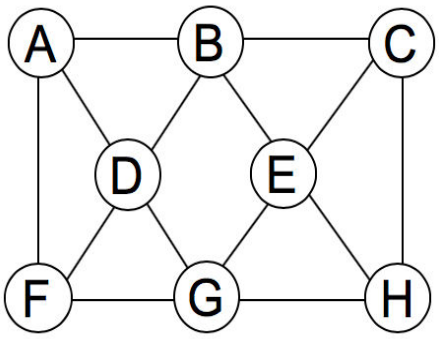
Solution: AS1 AS2 AS4. The reverse order is also fine.

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

Solution: AS3, AS1, AS2, AS4. The reverse order is also fine.

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.



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.

   Solution: 100ms because all updates can arrive at E after 100ms.

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	E
D	D
E	E
F	F
H	H

Table 2: Forwarding table after failure

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