Take-Home Quiz II

Due Sunday April 26 11:55pm

Csci4211: Introduction to Computer Networks
Spring 2020

Last Name: **First Name:**

Student Id.

Instructions:

1. This is an **open-book** and **open-note** quiz.
2. There are **five** questions in total, each of which has several sub-questions, with a total of 100 points. You have roughly **four days** to answer the questions.
3. Please make sure to write down your name and student id. on your answer sheets.
4. Partial credit is possible for an answer; please include intermediate steps as appropriate. Please try to be as concise and make your exam as neat as possible. We *must* be able to read your handwriting in order to be able to grade your exam.
5. **Please work on the quiz *individually, by yourself only!* No discussion among other students or others, is allowed. If you find your answers from the Internet (e.g., via some "cheating" sites or social groups) or from students who have taken the course before, please cite your sources. You CANNOT simply copy the answers! Any violation of the University's *Student Conduct Code* will be reported to both the department and the University, and you may be suspended or expelled! Please note that if you let another student to copy your answers, you are also in violation of the University's *Student Conduct Code.***
6. Good luck. Enjoy!

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1. Short Questions and Answers: (15 points total. approx. 30 minutes)

(a) (3 points) In DHCP, how does a client machine requesting an IP address know whether a DHCP offer message from a DHCP server is meant for it or not? (Note that the client machine does not have an IP address yet!)

(b) (3 points) Given an IP address 123.121.139.21 and a network mask 255.255.192.0, what is its *network prefix*.

(c) (3 points) Suppose that your computer is assigned with the IP address 128.101.225.81 and the network mask 255.255.128.0, and your friend's computer is assigned with the IP address 128.101.81.81. Are the two computers on the same IP subnet? Briefly explain your answer.

(d) (3 points) Suppose that a router has four physical interfaces with active links (see Fig. 1 for an illustration). How many IP addresses will the router have if all the links are active? And how many IP networks ("subnets") does it belong to?

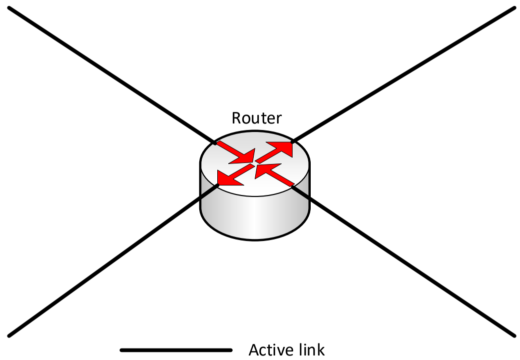

Figure 1: Figure for Question 1d.

(e) (3 points) Given an IP datagram where the "length" field =1000, the "offset" field = 100 and the "more fragment" flag=0. How do you know this datagram is a fragment of an (originally) larger IP datagram? What is the *payload* size (i.e., excluding the 20-byte IP header) of the original IP datagram?

2. TCP Flow and Congestion Control (24 points total. Approx. 30 minutes)

(a) (8 points) Suppose that the current congestion window, `CongWin`, of a TCP connection is currently at 12 KB, and `threshold` = 24 KB. During this round, the sender sends **8** TCP data segments, each of size 1500 bytes. [Here we assume that 1KB = 1000 bytes; and the TCP maximum segment size is 1500 bytes.] The last segment of these 8 data segments sent by the send carries the sequence number 2003000 (in *decimal* representation, not binary representation). The sender then receives four acknowledgments from the receiver, each acknowledging the receipt of *two consecutive* data segments. In particular, the last acknowledgment from the receiver carries the acknowledgment number 2004500. What will the sender set `CongWin` to at the end of this round?

(b) (8 points) Suppose that during the next round of data transmission after **b.**, a *time-out* event occurs at the sender side. What will be the value (in bytes) of `CongWin` after this event? What will be the value (in bytes) of `threshold`?

(c) (8 points) Now consider a *new* scenario where the congestion window, `CongWin`, at the sender side is currently set to 9 KB, and `threshold` = 9 KB. The sender then sends 6 data segments of 1500 bytes each (thus a total of 9 KB data is sent), where the *last* data segment carries a sequence number 3001500 (in decimal representation, not binary representation). After having sent these 6 data segments, the sender receives **3** acknowledgments from the receiver, each acknowledging the receipt of two consecutive data segments. In particular, the *last* acknowledgment from the receiver carries the acknowledgment number 3003000. What will the sender set `CongWin` to at the end? What will be the value (in bytes) of `threshold`?

3. Virtual Circuit (18 points total. Approx. 15 minutes)

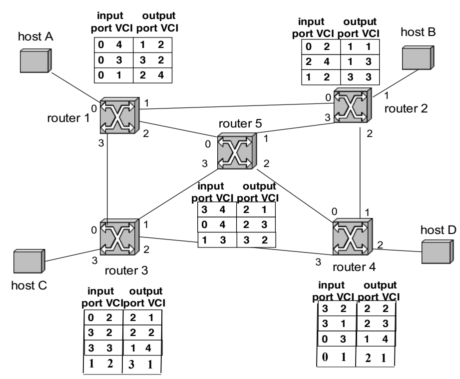

Figure 2: Figure for Question 3.

(a) (6 points) Consider the network shown in Figure 2, where the numbers beside the links connecting hosts and routers represents the port numbers of the routers. The table beside the routers represent the VCI translation table at the routers. When a packet carrying VCI no. 1 arrives at port 0 of router 1, what will be the VCI no. it carries after it passes through router 1? Write down the path this packet takes from its source to the final destination as well as the VCI no. that the packet carries as it leaves each router along the path of the VC.

(b) (12 points) Please write down the virtual circuit translation tables for all of the routers after the following four new virtual circuit (VC) connections are established in the order given below.

(1) Host A connects to host B via router 1, router 5 and router 2.

(2) Host B connects to host C via router 2, router 4 and router 3.

(3) Host C connects to host A via router 3 and router 1.

(4) Host D connects to host A via router 4, router 5 and router 1.

4. Subnets, Routers and Longest Prefix Matching (15 points total. Approx. 20 minutes)

Suppose a router has built up the following routing table as shown in Table 1.

Table 1: Routing Table.

Network Prefix	Network Mask	Next-Hop (Interface)
91.25.87.0	255.255.240.0	eth0
127.18.128.0	255.255.192.0	eth1
127.18.128.0	255.255.224.0	ppp
17.125.0.0	255.255.0.0	wifi
0.0.0.0	0.0.0.0	ppp

Where will the router send packets addressed to each of the following destinations? Please write down the next-hop (interface) after each IP address (e.g., eth0, ppp, etc.).

i. 127.18.127.11

ii. 127.18.165.11

iii. 127.18.243.11

iv. 91.25.89.07

v. 17.125.110.110

5. MAC Addresses, ARP, Switches and Routers (28 points total. Approx. 40 minutes)

Consider a campus network as shown in Figure 3, where there are two IP routers $R1$ (the border gateway router) and $R2$ and four Ethernet switches, $S1$, $S2$, $S3$ and $S4$. The numbers (1, 2, 3 or 4) beside the routers/switches indicate their interface numbers. As you can see from the figure, the campus network is segmented into three IP *subnets*: IP subnet 1 with the IP address block 128.101.0.0/18, IP subnet 2 with the IP address block 128.101.164.0/22, and IP subnet 3 with the IP address block 128.101.100.0/20. (For your convenience, we have shaded the links and switch(es) belonging to each IP subnet in Figure 3: IP subnet 1 with light blue color, IP subnet 2 with light orange, and IP subnet 3 with light green, when viewed in color print or on screen.) Note that host H is *multi-homed*, with its interface 1 connected to IP subnet 1, and its interface 2 connected to IP subnet 3. As a result, host H are assigned two IP addresses: 128.101.0.15 and 128.101.100.21.

The forwarding tables at routers $R1$ and $R2$ as well as their ARP caches at *the current moment* are given in Figure 4; a snapshot of the forwarding (or switch) table of the switch $S3$ at the *current moment* is also shown in the figure. Answer the following questions *briefly*. (A few sentences would be sufficient!)

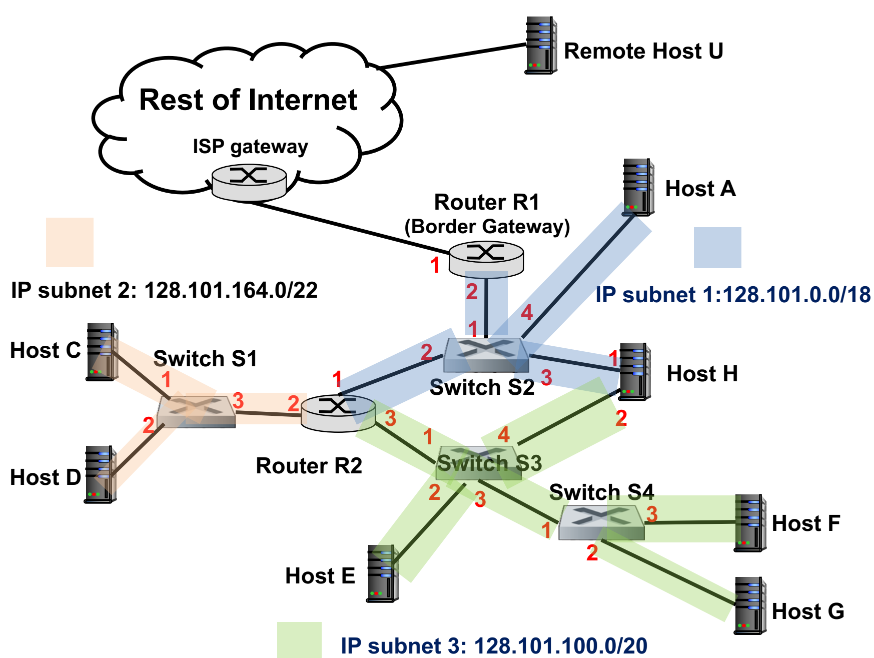

Figure 3: Figure for Question 4.: a Campus Network with three IP subnets

a. (11 points) Consider a scenario where host E wants to send an IP datagram packet to host G. Suppose host E's ARP cache is empty, so it *broadcasts* an *ARP request* message with G's IP address as the target address, and encapsulates the ARP message into an Ethernet

Router R1's Forwarding Table

Destination network	Next-hop	Interface
128.101.0.0/18	Direct	2
128.101.100.0/20	R2	2
128.101.164.0/22	R2	2
0.0.0.0/0	ISP's gateway	1

Router R1's ARP Cache

IP address	MAC address
R2's IP address	R2's MAC address
A's IP address	A's MAC address

Router R2's ARP Cache

IP address	MAC address
R1's IP address	R1's MAC address
C's IP address	C's MAC address
128.101.0.15	H's MAC address1
128.101.100.21	H's MAC address2

Router R2's Forwarding Table

Destination network	Next-hop	Interface
128.101.0.0/18	R1	1
128.101.100.0/20	Direct	3
128.101.164.0/22	Direct	2
0.0.0.0/0	R1	1

Switch S3's Forwarding Table

MAC address	Interface
R2's MAC address	1
F's MAC address	3
H's MAC address	4

Host C's ARP Cache

IP address	MAC address
R2's IP address	R2's MAC address
D's IP address	D's MAC address

Figure 4: Figure for Question 5.: Routing Tables at $R1$ and $R2$, Snapshots of $S3$'s Switch Forwarding Table and ARP Caches at $R1$, $R2$ and Host C

frame with its own MAC address and the MAC broadcast address `FF:FF:FF:FF:FF:FF` as the source and destination MAC addresses, respectively.

i) (3 points) What will Switch $S3$ do when it receives this broadcast frame from host E? What will its forwardin (switch) table look like afterward?

ii) (2 points) Will switch $S4$ also receive this ARP request message? If yes, what will Switch $S4$ do when it receives this broadcast frame from host E? What will its forwarding (switch) table look like afterward?

iii) (2 points) Will router $R2$ also receive this ARP request message? If yes, will it forward to IP subnet 1 (via its interface 1) and IP subnet 2 (via its interface 2)? Why or Why not?

iv) (2 points) When host G receives this *ARP request* message, it will reply back with an *ARP response* message to host E, encapsulating this ARP response message in a *unicast* Ethernet frame with its own MAC address and host E's MAC address as the source and destination MAC addresses, respectively. Does host G need to perform an ARP query in order to find out host E's MAC address? Why or why not?

v) (2 points) When Switch $S3$ receives this Ethernet frame containing the ARP response message from host G, what will it do with this frame?

b. (3 points) Consider another scenario where host C wants to send an IP datagram packet to host D. How does host C know that it can directly forward the packet to host D instead of asking for its default router $R2$ to help deliver it? Given the current ARP cache of host C as shown in Figure 4, what source and destination IP addresses and MAC addresses will be used in the corresponding IP datagram and Ethernet frame headers for delivering this packet to host D?

c. (8 points) Now suppose host C wants to send an IP datagram packet to host H using H's IP address, 128.101.100.21 (one of host H's two IP addresses).

i) (2 points) Since H's MAC address is currently *not* in its ARP cache, would host C perform an ARP query to find out H's MAC address? Why or why not?

ii) (2 points) If host C would forward the packet to its default router $R2$ to have it delivered to host H, what source and destination IP addresses should be used in the IP datagram header *and* what source and destination MAC addresses should be used in the encapsulating Ethernet frame in order to deliver this packet to router $R2$?

iii) (2 points) When router $R2$ receives this IP datagram from host C, can it use any of the two outgoing interfaces (1 or 3) to deliver the IP datagram from host C to host H? Why or why not? If your answer is negative, which outgoing interface (1 or 3) should $R2$ use to forward the packet?

iv) (2 points) In order to deliver the IP datagram from host C to host H, $R2$ will encapsulate it in a new Ethernet frame. What source and destination MAC addresses will $R2$ use in this Ethernet frame?

d. (2 points) Consider a scenario where host H wants to send an IP datagram to the remote host U, and router $R1$ is its default router. Will switch $S3$ receive the Ethernet frame containing the IP datagram sent by host H to the remote host U? Briefly explain your answer.

e. (4 points) Consider yet another scenario where host E is sending an IP datagram packet to host H, where the *destination* IP address in the IP datagram is 128.101.0.15 (one of host H's two IP addresses). This datagram is encapsulated in an Ethernet frame with $R2$'s MAC address as the *destination* MAC address.

i) (2 points) When Switch $S3$ receives this Ethernet frame, which outgoing interface (1 or 4) will it use to forward this Ethernet frame?

ii) (2 points) When host H eventually receives the IP datagram from host E, it sends an IP datagram back to E. Which interface will host H likely use to deliver this IP datagram to host E? What determines which interface host H will be using to deliver this IP datagram to host E?