

CSCI4211: Introduction to Computer Networks  
Spring 2020  
HOMEWORK ASSIGNMENT 2

*Due 11:55pm Monday April 13*

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Instructions:

1. Please submit your homework using the on-line electronic submission system (via the class Canvas site).

In case you could not use the on-line electronic submission system, please hand in your homework to the instructors or TAs on the due day. Please email [csci4211-help@googlegroups.com](mailto:csci4211-help@googlegroups.com) to let us know that you have handed in a hard-copy of your homework immediately afterwards. (*Make sure that you also make and retain a copy of your homework!*)

*Please make sure that you include your name and student id in your submission, and retain a copy of your submission!*

2. There are **seven** questions in total. The number of points for each question is given in parentheses. There are 130 points in total. An *estimated* time for answering each question is also given in parentheses. This is just a guideline, you may take less or more time on each problem.
  3. Partial credit is possible for an answer. Please try to be as concise and make your homework as neat as possible. We *must* be able to read your handwriting in order to be able to grade your homework.
  4. Enjoy!
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**1. Short Questions and Answers:** (10 points; 15 minutes)

*(Two or three sentences would generally suffice.)*

a. (2 points) Can we assign any arbitrary IP address to a computer connected to a network? Please briefly explain your answer.

b. (2 points) A network on the Internet has a subnet mask of 255.255.224.0. What is the maximum number of hosts it can handle?

c. (2 points) Can an IP packet loop forever inside an IP network even though there is a cycle in the topology? Briefly explain your answer.

d. (2 points) When an IP host receives two IP datagrams, how can it tell that these two IP datagrams are two IP datagram “fragments” belonging to one *single* original IP datagram?

e. (2 points) Briefly explain why IP datagram re-assembly is done only at the destination host, not by any intermediate IP router.

**2. TCP Flow & Congestion Control** (25 points total. Approx. 25 minutes)

a. (8 points) Briefly describe how TCP congestion control works.

[In answering the following questions, we assume that the TCP Reno version (the most commonly used version in today’s Internet) is used, i.e., with the *Fast Recover/Fast Retransmit* mechanisms implemented.]

b. (5 points) Suppose that the congestion window, **CongWin**, at a TCP sender is currently 4 KB, and **threshold** = 12 KB. After the sender has sent 4 KB of data during the next round trip time and received the acknowledgment for the data sent, what will be the value of **CongWin** and **threshold**? In this and the following questions, please assume that the maximum segment size (MSS) is 1 KB.

c. (4 points) Suppose that the congestion window, **CongWin**, at a TCP sender is currently 16 KB, and **threshold** = 12 KB. After the sender has sent 16 KB of data during the next round trip time and received the acknowledgment for the data sent, what will be the value of **CongWin** and **threshold**?

d. (4 points) Suppose that the congestion window, **CongWin**, at a TCP sender is currently 24 KB, and **threshold** = 12 KB. After the sender has sent 24 KB of data in the next round trip time and a *timeout* event occurs at the sender, what will be the value of **CongWin** and **threshold**?

e. (4 points) Suppose that the congestion window, **CongWin**, at a TCP sender is currently 48 KB, and **threshold** = 24 KB. After the sender has sent 48 KB of data during the next round trip time, it received *three duplicate* acknowledgment packets. Furthermore, in the last acknowledgment packet the receiver has set the receiver advertisement window, *RecvWin*, to 30 KB. What is the maximum amount of data the sender can send in the next round?

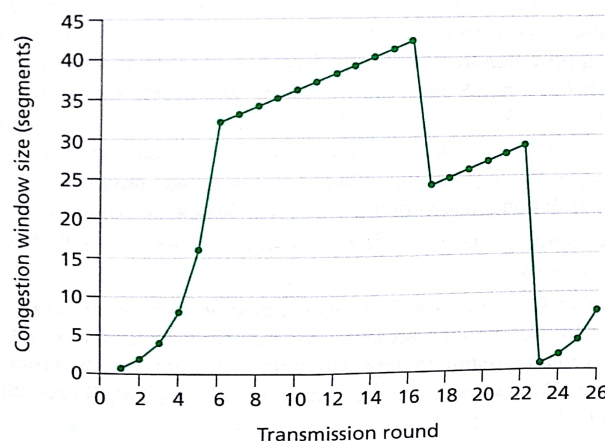
### 3. More on TCP Congestion Control (25 points total. Approx. 25 minutes)

a. (5 points) Briefly describe how TCP flow control works.

[In answering the following questions, we assume that the TCP Reno version (the most commonly used version in today's Internet) is used, i.e., with the *Fast Recover*/*Fast Retransmit* mechanisms implemented.]

(20 points) Do Problem P40 a. b. c. d., Chapter 3 (page 297) in the textbook (*Kurose & Ross*, 7th edition). In case you do not have the current version of the textbook, the problem is reproduced below for you.

- p40. Consider Figure 3.58. Assuming TCP Reno is the protocol experiencing the behavior shown above, answer the following questions. In all cases, you should provide a short discussion justifying your answer.
- Identify the intervals of time when TCP slow start is operating.
  - Identify the intervals of time when TCP congestion avoidance is operating.
  - After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?
  - After the 22nd transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?



**Figure 3.58** ♦ TCP window size as a function of time

#### 4. Longest Prefix matching (10 points total. Approx. 15 minutes)

Do Problem P5, Chapter 4 (page 366) in the textbook (the 7th edition). In case you do not have the current version of the textbook, the problem is reproduced below for you.

Consider a datagram network using 32-bit host addresses. Suppose a router has four links, numbered 0 through 3, and packets are to be forwarded to the link interfaces as follows:

Destination Address Range	Link Interface
11100000 00000000 00000000 00000000 through 11100000 00111111 11111111 11111111	0
11100000 01000000 00000000 00000000 through 11100000 01000000 11111111 11111111	1
11100000 01000001 00000000 00000000 through 11100001 01111111 11111111 11111111	2
otherwise	3

- Provide a forwarding table that has five entries, uses longest prefix matching, and forwards packets to the correct link interfaces.
- Describe how your forwarding table determines the appropriate link interface for datagrams with destination addresses:

11001000 10010001 01010001 01010101  
11100001 01000000 11000011 00111100  
11100001 10000000 00010001 01110111

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**5. Virtual Circuits** (15 points total. Approx. 15 minutes)

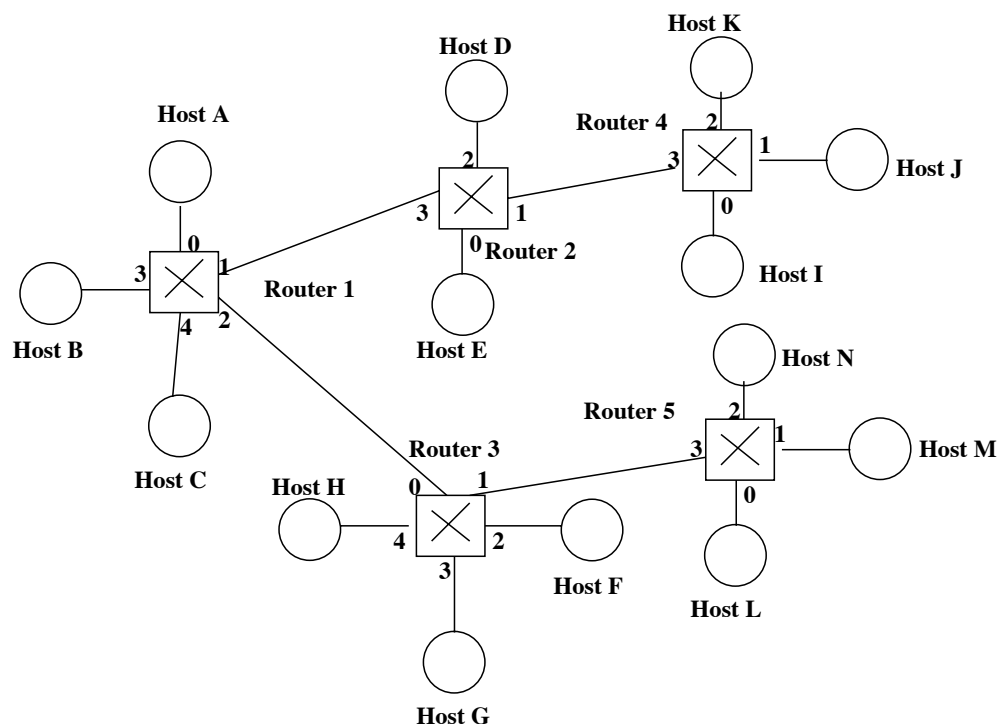


Figure 1: Figure for Question 5.

- (a) (5 points) What is the key difference between virtual circuit and circuit switching? (one or two sentences should suffice!)
- (b) (10 points) Consider the network shown in Figure 1, where the numbers beside the links connecting hosts and routers represents the port numbers of the routers. Please write down the virtual circuit translation tables for *all the routers* after the following connections are established in the order given below. You can assume that the VCI assignment always picks the lowest unused VCI on an outgoing link.
  - (1) Host A connects to host E.
  - (2) Host C connects to host J.
  - (3) Host C connects to host D.
  - (4) Host D connects to host G.
  - (5) Host E connects to host M.

## 6. MAC Address, ARP, Switching and IP Forwarding(25 points. Approx. 30 minutes)

Consider the following switched network (Figure 2), where we have one Ethernet switch S, connecting three hosts, host H on port 1, host X on port 2 and host Z on port 3, as well as an IP router R (default router for the hosts) on port 0. These hosts lie on an IP network with the network prefix 127.64.1.0/24. The IP address for the interface of router R that is connected to switch S is 127.64.1.254. The IP addresses for hosts H, X and Z are shown in the figure. Furthermore, the *current* switch (forwarding) table at switch S and the ARP caches at host X and router R are also shown in the figure.

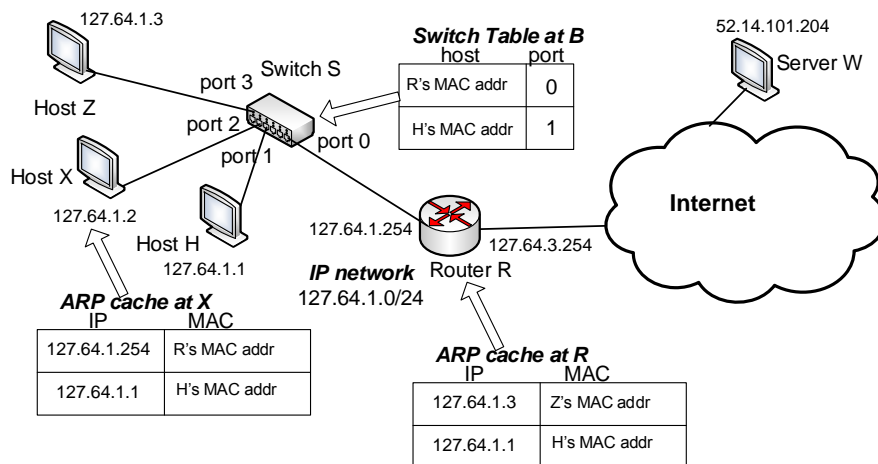


Figure 2: Figure for Question 6.

- (a) (9 points) Suppose host X wants to send an IP datagram to host Z, and assume that host X knows the IP address of host Z (e.g., via DNS lookup).
- (3 points) Briefly explain how host X obtains the MAC address of host Z. Describe how switch S handles the ARP request and response messages, and builds its switch table.
  - (3 points) Will router R also receive the ARP request? If your answer is affirmative, what action does router R take? What about the ARP response message from host Z?
  - (3 points) After host X learns the MAC address of host Z. Briefly describe how the IP datagram is delivered from host X to host Z, paying particular attention to the actions taken by switch S, and router R *if any*.
- (b) (7 points) Suppose host X sends an IP datagram to host H instead of host Z. Repeat the above questions.

(c) (9 points) Suppose now that host X wants to send an IP datagram to a remote server W outside the network. The IP address of sever W is 52.14.101.204. Answer the following questions.

- (3 points) Since sever W's MAC address is not currently in its ARP cache, will host X issue an ARP request for server W? Briefly explain your answer.
- (3 points) How does X know that it should forward the IP datagram to router R so that it can be delivered (via the Internet) to server W?
- (3 points) Briefly describe how the IP datagram is delivered from host X to router R, paying in particular attention to the actions taken by switch S and router R. Moreover, please explicitly describe the source and destination IP and MAC addresses contained in the IP datagram and the encapsulating Ethernet frame.

**7. (Optional Bonus Question) IP Forwarding, Default Router and ICMP Redirect**  
(20 points. Approx. 30 minutes)

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Refer to Figure 3 and answer the following questions as concisely as you can. In answering these questions, you'll need to google and look up relevant information on *ICMP Redirect*, e.g., on *wikipedia*.

a. (4 points) Consider the following scenario: host C in LAN2 wants to send an IP packet to host B, which is connected to LAN1 (IP network prefix: 128.105.0.0/16). Since host B is *not* on the same IP network as host C. Hence host C will send it to its default gateway router R1. Describe the actions taken by router R1 (and subsequently at router R2) at *both* the network layer and data link layer for sending this IP packet to host B. You can assume that R1 has the MAC address of R2, and R2 has the MAC address of host B.

b. (4 points) Continue the scenario in problem 7.a: suppose host C wants to send *another* IP packet to host B. Will host C still send it to router R1? Or will it send it to router R2? (Hint: if you did not mention ICMP Redirect message in your answer to problem 7.a, your answer is *not complete*.) Since host C does not have router R2's MAC address. Describe how host C obtains R2's MAC address using the ARP protocol.

c. (4 points) Consider yet another scenario: suppose host C now wants to send an IP packet to host A, which is connected to LAN3 (IP network prefix: 131.16.143.0/20). Host C will send it to its default gateway router R1, which will send it to router R2, based on its current routing table. Now let's assume that, based on the routing table at router R2 (not shown), it will send the packet to router R3 via its interface 2, namely, back to the same interface where it comes from. Will router R2 send an ICMP Redirect message to *router R1*, telling it to use R3 for destination network prefix 131.16.143.0/20? (Hint: ICMP messages are *always* sent to the source IP address of an IP packet.) More basically, can the *network layer* at router R2 tell whether router R1 or host C sends the packet to it? Briefly explain your answer.

d. (4 points) Continue the scenario in problem 7.c: how will router R1 eventually know that it can reach destination network prefix 131.16.143.0/20 directly via router R3 instead of router R2? Namely, changing the next hop from R2 to R3?

e. (4 points) What might have happened that caused R1 to have a “non-optimal” route entry that has router R2 as the next-hop to the destination network prefix 131.16.143.0/20 instead of router R3 in the first place?

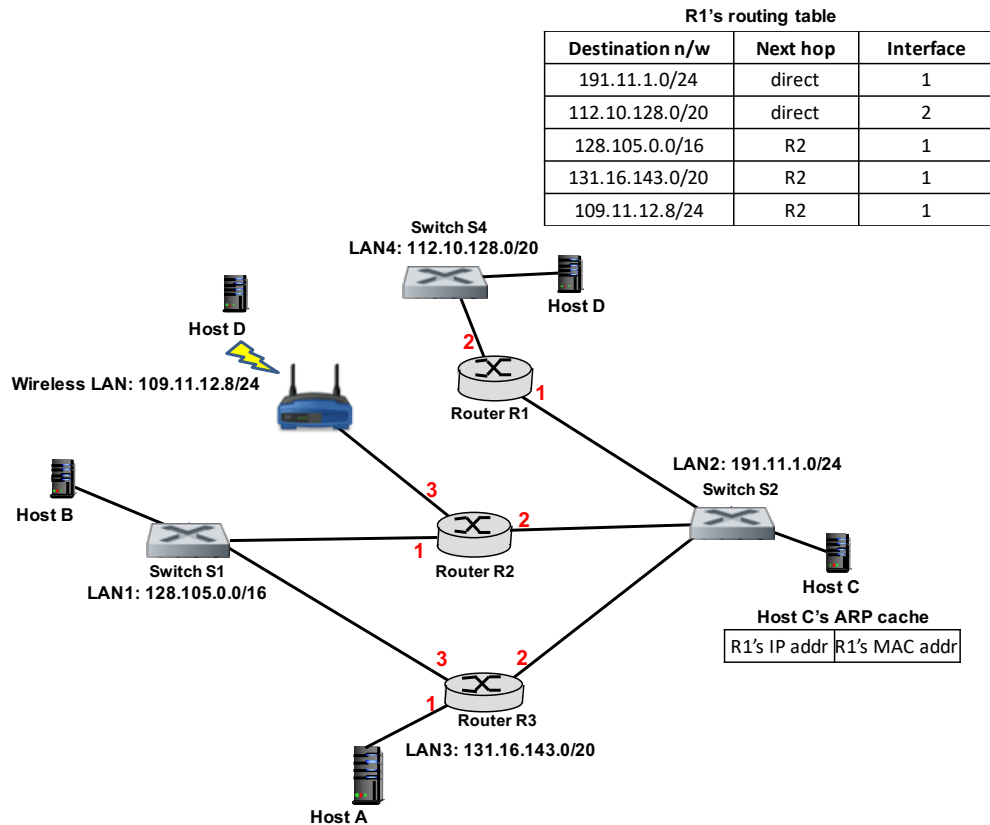


Figure 3: Figure for Question 7.