Duke University
CS 356 Midterm
Spring 2018

Name (Print): ______________________________ , ______________________________
(Family name) (Given name)

Student ID Number: ______________________________

Date of Exam:	*March 8, 2018*
Time Period:	1:25pm-2:40pm
Number of Exam Pages: (including this cover sheet)	17
Exam Type:	*closed book/notes*
Additional Materials Allowed:	*One sheet of your own notes*

Marking Scheme:

Question	Score
1	/25
2	/39
3	/15
4	/16
Survey	/5
Total	/100

For your convenience, this page includes figures that describe packet formats for Ethernet, ARP, IP, and ICMP.

<table>
<tr><td colspan="2">Hardware type (2 bytes)</td><td colspan="2">Protocol type (2 bytes)</td></tr>
<tr><td>Hardware address length (1 byte)</td><td>Protocol address length (1 byte)</td><td colspan="2">Operation code (2 bytes)</td></tr>
<tr><td colspan="4">Source hardware address*</td></tr>
<tr><td colspan="4">Source protocol address*</td></tr>
<tr><td colspan="4">Target hardware address*</td></tr>
<tr><td colspan="4">Target protocol address*</td></tr>
</table>

(a) ARP request or reply format.

Destination address	Source address	Type	Payload
6 bytes	6 bytes	2 bytes	46−1500 bytes

(b) Ethernet packet format.

bit # 0 7 8 15 16 23 24 31

<table>
<tr><td>version</td><td>header length</td><td>DS</td><td>ECN</td><td colspan="4">total length (in bytes)</td></tr>
<tr><td colspan="4">Identification</td><td>0</td><td>DF</td><td>MF</td><td>Fragment offset</td></tr>
<tr><td colspan="2">time-to-live (TTL)</td><td colspan="2">protocol</td><td colspan="4">header checksum</td></tr>
<tr><td colspan="8">source IP address</td></tr>
<tr><td colspan="8">destination IP address</td></tr>
<tr><td colspan="8">options (0 to 40 bytes)</td></tr>
<tr><td colspan="8">payload</td></tr>
</table>

4 bytes

(c) IP packet format.

bit # 0 7 8 15 16 23 24 31

<table>
<tr><td>type</td><td>code</td><td>checksum</td></tr>
<tr><td colspan="3">additional information
or
0x00000000</td></tr>
</table>

(d) ICMP header format.

1. (25pts) Short answers.

   (a) (5pts) The Internet Protocol (IP) is said to provide "best effort" service. Please explain what "best effort" service is and the pros and cons of this service model.

   (b) (5pts) What problems does the 4B/5B encoding mechanism aim to solve? Explain how 4B/5B works and why it can solve these problems.

(c) (5pts) Ben Bitdiddle developed a sliding window protocol where he set the SWS=RWS=10, and used a 4-bit sequence number. What problem may his protocol run into? Please provide an example where his protocol fails to deliver packets in-order and reliably.

(d) (5pts) Can the count-to-infinity problem occur in a link-state routing protocol? Explain why.

(e) (5pts) A router with the following forwarding table receives a packet with destination 18.0.0.18. Which will be the outgoing interface of the packet?

Network	NextHop	Interface
18.0.0.0/8	192.2.0.1	eth2
18.0.0.0/16	192.0.0.1	eth0
18.0.0.0/24	192.1.0.1	eth1
0.0.0.0/0	192.3.0.1	eth3

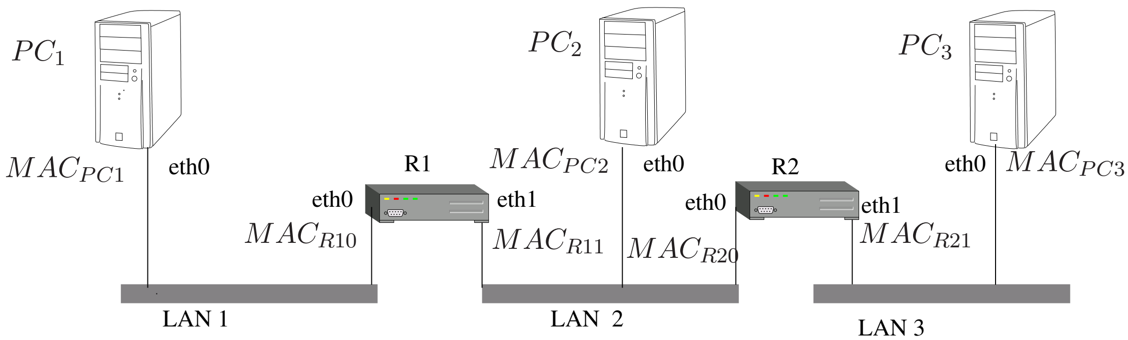

Figure 1: A simple network.

2. (39pts) Figure 1 shows a simple network. Your task is to configure this network. You are given a network prefix 10.1.1.0/24.

   (a) (3pts) The first step is to assign network prefixes to each Local Area Network (LAN). Each LAN is an Ethernet. LAN1 has at most 100 hosts, and LAN2 and LAN3 each has at most 50 hosts. Assign a network prefix to each LAN such that each LAN has enough IP addresses to uniquely identify each host on the LAN. (Hint: the range of IP addresses for each LAN cannot overlap to ensure uniqueness.)

Network	Prefix
LAN1	
LAN2	
LAN3	

   (b) (7pts) The 2nd step is to assign IP addresses and network masks to each PC and routers. Your address assignment must be consistent with your network prefix assignment.

Interface	Address/prefixLength
eth0 of PC_1	
eth0 of $R1$	
eth1 of $R1$	
eth0 of PC_2	
eth0 of $R2$	
eth1 of $R2$	
eth0 of PC_3	

(c) (7.5pts) The third step is to configure each PC's and router's routing table. Your configurations must be consistent with your answers to the previous questions, and allow each pair of PCs to ping each other without causing ICMP router redirect messages or the need to enable proxy ARP on routers. Show the content of the routing tables after your configurations. (Hint: Pleaes do not forget to add routes to directly connected networks.)

Network prefix	Next Hop Gateway	Interface

(a) PC_1's routing table.

Network prefix	Next Hop Gateway	Interface

(b) R_1's routing table.

Network prefix	Next Hop Gateway	Interface

(c) PC_2's routing table.

Network prefix	Next Hop Gateway	Interface

(d) R_2's routing table.

Network prefix	Next Hop Gateway	Interface

(e) PC_3's routing table.

(d) (6pts) Suppose you have configured the routing tables correctly, and your network is ready to work! When all PCs and routers' ARP caches are empty, a ping is sent from PC_1 to PC_3. Before PC_1 can send the ping packet, it must send an ARP request. Fill the content of the ARP request. You may use MAC_x or IP_x to represent the Ethernet or IP address of an interface, where $x \in \{PC_1, R_{10}, R_{11}, PC_2, R_{20}, R_{21}, PC_3\}$. For instance, use IP_{PC1} to represent the IP address you allocate to PC_1, and IP_{R10} to represent the IP address you allocate to eth0 of R_1.

Destination address in the Ethernet header	
Source address in the Ethernet header	
Source hardware address in the ARP request	
Source protocol address in the ARP request	
Target hardware address in the ARP request	
Target protocol address in the ARP request	

(e) (1.5pts) Who will respond to the ARP request?

(f) (6pts) What is the content of the ARP reply? Use the notations defined in (c).

Destination address in the Ethernet header	
Source address in the Ethernet header	
Source hardware address in the ARP reply	
Source protocol address in the ARP reply	
Target hardware address in the ARP reply	
Target protocol address in the ARP reply	

(g) (4pts) When the ping packet is on LAN1, what are the source and destination addresses in the IP header? What are the source and destination addresses in the Ethernet header? Use the notations defined in (c).

Source address in the IP header	
Destination address in the IP header	
Source address in the Ethernet header	
Destination address in the Ethernet header	

(h) (4pts) When the ping packet is on LAN2, what are the source and destination addresses in the IP header? What are the source and destination addresses in the Ethernet header? Use the notations defined in (c).

Source address in the IP header	
Destination address in the IP header	
Source address in the Ethernet header	
Destination address in the Ethernet header	

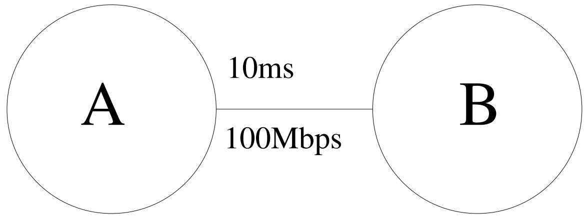

Figure 2: A two-node network topology.

3. (15pts) Figure 2 shows a simple two-node topology. Node A is sending a 1GB file to Node B using the sliding window protocol. Suppose each data frame's size is 1K bytes and the ACK size is 40 bytes. Answer the following questions.

   (a) (4pts) How long does it take for A to send one packet to B and receive an ACK from B? Suppose the CPU processing time at A or B is neglibile.

   (b) (6pts) Suppose A's sending window size is 4K bytes or four frames, and the receiver's receiving window size is 10MB, or 10,000 frames. How long will it take for A to send the 1GB file? What is A's throughput for this connection? (Hint: please take into consideration the time it takes for an ACK to travel from B to A.)

(c) (5pts) As you can see, A's throughput is much less than the link bandwidth. To improve performance, node A can increase its sending window size. What's A's minimum sending window size that allows it to achieve the maximum throughput?

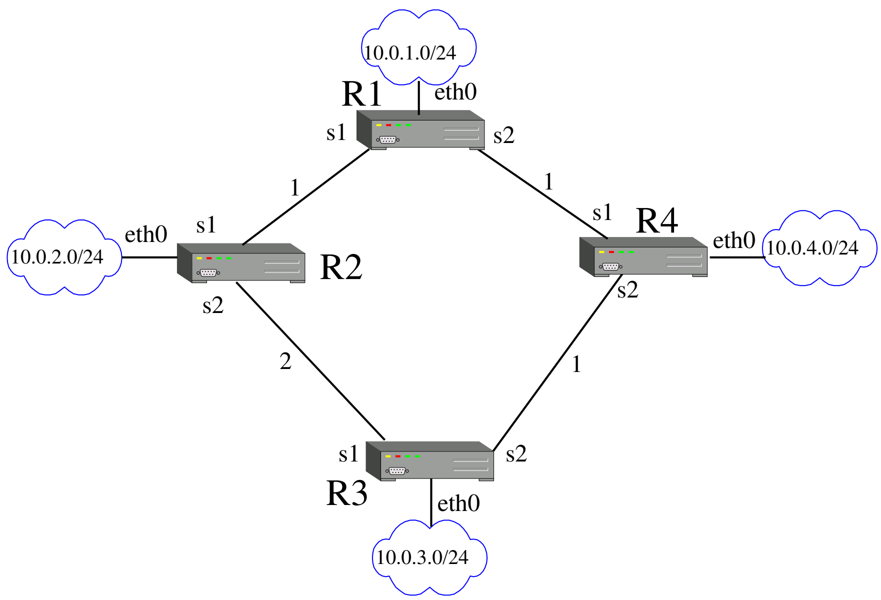

Figure 3: Distance vector routing.

4. (16pts) Figure 3 shows a simple network with four routers. Each router R_i attaches to a /24 subnet, and routers are connected via point-to-point serial links. The network uses a distance vector routing protocol. All link costs are specified in the figure. All links have cost 1 except the link between R_2 and R_3. Answer the following questions.

   (a) (1pt) After the distance vector routing protocol converges, which next hop does R_3 uses to reach the network 10.0.1.0/24?

   (b) (4pts) Suppose split horizon is enabled. What is the distance vector R_3 advertises to R_2 and R_4? (Hint: Note that in a routing protocol, each "destination" in the distance vector is a network prefix.)

(c) (2pts) A distance vector routing protocol sends both periodic and triggered routing updates. Suppose the link from R_1 to the network 10.0.1.0/24 fails. What routing update regarding the network 10.0.1.0/24 will R_1 send to its neighbors R_2 and R_4?

(d) (2pts) What will R_2 and R_4 do when they receive R_1's latest update regarding 10.0.1.0/24? (Hint: specify both how R_2 and R_4 update their routing tables and what messages they send to their neighbors.)

(e) (1pt) Suppose R_2 sends a periodic update regarding 10.0.1.0/24 to R_3 before it receives R_1's latest update regarding 10.0.1.0/24 after R_1's link to 10.0.1.0/24 fails. What is the content of this periodic update?

(f) (4pts) Can the count-to-infinity problem occur in this topology with split horizon enabled? If so, explain the update sequence that leads to count-to-infinity. If not, explain why.

(g) (2pts) Suppose we modify the distance vector protocol such that each router inserts its own IP address to a routing update it sends to its neighbors. Can this modification help fix the count-to-infinity problem? Explain why.

Survey

(5pts) We, the course staff of CS356, would like to hear what you think of the course. Please provide your feedback for the following questions. You will tear off this page from your exam papers so that your opinions will remain anonymous. We will write down your name when you turn in the survey and credit you for your feedback. Thank you!

1. Has the course met your expectations of an undergraduate networking class so far? If not, please explain the areas where the course has not met your expectations.

2. Are the lectures given a) at an approxpriate speed; b) too fast; c) too slow? Please circle one answer.

3. Do you have any suggestion on how the course materials might be improved?

4. Do you have any suggestion on how the instructor might improve her teaching quality?

5. Do you have any suggestion on how the TA might improve his teaching quality?

Scratch page