

**ECE 461– Internetworking
Fall 2009**

Quiz 1

Instructions (read carefully):

- The time for this quiz is 50 minutes.
- This is a closed book and closed notes in-class exam.
- Non-programmable calculators are permitted
- The only other aid permitted are the aid sheet included in this quiz.
- Write your answers on the pages provided, using front and back if needed. Use extra sheets if needed.
- Do not give aid or receive aid from other students.
- Show all steps of your solutions.
- Make sure your answers are legible. If we cannot read an answer, we will not grade it.

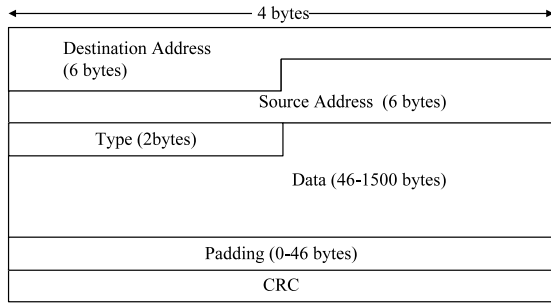
	Max Points	
1	5	
2	10	
3	10	
4	5	
5	10	
6	10	
Total	50	

**STAPLE EXTRA SHEETS WITH YOUR SOLUTIONS TO THIS SHEET
BEFORE TURNING IN !**

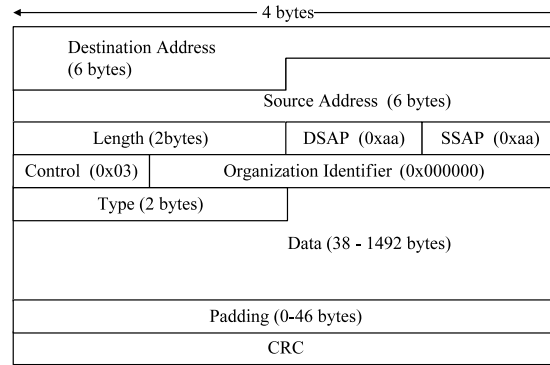
Name: _____

Email: _____

Problem 1. (5 points) There are two types of Ethernet frames, Ethernet II and IEEE 802.3. Both types of frames can be found on an Ethernet network. The frame format of the two frame types is shown in the figure below:



(a) Ethernet II



(b) IEEE 802.3

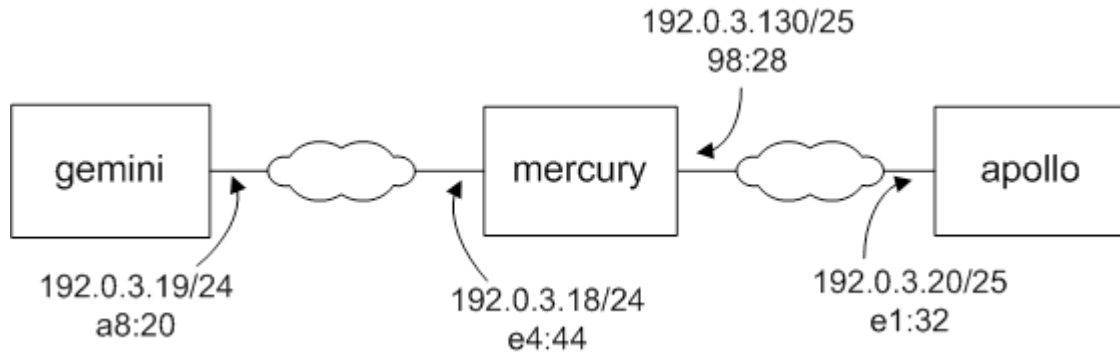
Since the frame formats are different, an Ethernet adapter card that receives a frame must determine if the incoming frame is of type Ethernet II or of type IEEE 802.3. Describe how an Ethernet adapter card makes this determination.

Solution:

Ethernet cards use bytes 13-14 to make the determination. All valid values of the Type field are larger than the max. value of the Length field.

Problem 2. (10 points) Address Resolution Protocol

In the figure below, *gemin*i and *apollo* are hosts and *mercury* is a router. Proxy ARP is enabled on *mercury*. The figure shows the IP addresses and MAC addresses of all interfaces (For simplicity, we assume that MAC addresses are 2 bytes long). Assume that the ARP caches are empty on all systems.



Suppose *gemin*i wants to send a single IP datagram to host *apollo*.

- (5 points) Describe the ARP Request and ARP Reply packets that are being sent in this scenario. For each ARP packet, indicate the source and destination MAC addresses, and describe the contents of the ARP packet. (In ARP Requests, the contents is “Who has (IP address) Tell (MAC address)?”, and in ARP Replies, the contents is “(IP Address) is at (MAC address)”).
- (5 points) When *gemin*i sends the IP datagram, what is the source and destination IP address in the IP header, and what is the source and destination MAC address in the Ethernet header?

Gemini sends ARP Request

srcMAC: a8:20
destMAC: ff:ff:ff:ff:ff:ff
“Who has 192.0.3.129 Tell a8:20”

Mercury sends ARP Reply

srcMAC: e4:44
destMAC: a8:20
“192.0.3.129 is at e4:44”

<<Now IP datagram is sent from Gemini to Mercury>>

Mercury sends ARP Request

srcMAC: 98:28
destMAC: ff:ff:ff:ff:ff:ff
“Who has 192.0.3.129 Tell 98:28”

Apollo sends ARP Reply

srcMAC: e1:32
destMAC: 98:28
“192.0.3.130 is at e1:32”

<<Now IP datagram is sent from Mercury to Apollo >>

(b)

srcMAC: a8:20
destMAC: e4:44
src IP: 192.0.3.19
dest IP: 192.0.3.129

Problem 3. (10 points) IP Addressing

Assume that you have been assigned the 64.212.130.0/23 network block.

- c. (2 points) Define an subnet mask that allows the creation of 200 hosts on each subnet.
 - d. (2 points) What is the maximum number of hosts that can be assigned to each subnet?
 - e. (3 points) What is the maximum number of subnets that can be defined? Provide the IP addresses of the subnets.
 - f. (3 points) Provide the broadcast address for each subnet from (c).
- a. $2^7 < 200 \text{ hosts} < 2^8 \rightarrow$ We need 8 bits. So, the subnet mask is 255.255.255.0 or /24.
- b. 254. (Host number all zeros and all ones are reserved for network address and broadcast address, respectively)
- c. There are only two subnets:
64.212.130.0/24
64.212.131.0/24
- d. 64.212.130.255/24 and 64.212.131.255

Problem 4. (10 points) IP Addressing

Below are some of the IP address ranges that are allocated to the University of Toronto:

- a. 128.100.0.0 – 128.100.255.255
- b. 192.139.244.0 – 192.139.244.255
- c. 192.12.174.0 – 192.12.183.255
- d. 199.212.42.0 – 199.212.43.255
- e. 207.34.12.0 - 207.34.23.255

For each line, express the entire range of addresses by CIDR address blocks (i.e., IP network address and a prefix length). The number of address blocks used for each line should be kept as small as possible.

- a. 128.100.0.0/16
- b. 192.139.244.0/24
- c. 192.12.174.0/23, 192.12.176.0/21
- d. 199.212.42.0/23
- e. 207.34.12.0/22, 207.34.16.0/21

Problem 5. (10 points) IP Fragmentation

Consider an IP datagram arrives at a router with the following fields in the IP header:

Length of IP header: 20 bytes
Total length of IP datagram: 996 bytes
DF flag: 0
MF flag: 1
Fragment offset: 122

Suppose this datagram must be transmitted on a network where the MTU is only 500 bytes.

- (a) (3 points) From the header information above, you can tell that this IP datagram is part of an IP datagram that has been fragmented before? Make an educated guess on the minimal total length of the original datagram (before it was fragmented for the first time).
- (b) (5 points) Explain why this IP datagram must be fragmented again. How many fragments will be created?
- (c) (5 points) After the fragmentation is performed, provide the value of the following fields for each of the fragments:
 - o Total length (in bytes)
 - o Value of DF flag
 - o Value of MF flag
 - o Value of Fragment offset (as a decimal number)

(a) There are two indications that the packet has been fragmented before: (1) the payload has a positive offset and (2) the More Fragment (MF) flag is set.

The original datagram was at least 1973 bytes long:

- 1. this fragment has payload of 976 bytes
(total length- IP header = 996-20)
- 2. prev fragment also has payload of 976 bytes
(payload offset x 8 = 976)
- 3. the next fragment has a payload of min. 1 byte
- 4. original header has a length of min. 20 bytes

(b) The IP datagram must be fragmented (again) because the length (996 bytes) exceeds the MTU of 500 bytes.
A total of 3 fragments must be created
With an MTU of 500 bytes and with 20 bytes for the header), we have max. 480 bytes payload in a datagram (This would also be the offset for the second segment).

Original payload: 976 bytes
Paylod in 1st fragment 480 bytes
Paylod in 2nd fragment 480 bytes

Payload in 3rd fragment 16 bytes

- (c) Note: The value in the offset field must be multiplied by 8.
 Note: The offset must take into account the offset in original datagram (i.e, we must add $122 \times 8 = 976$)

	1st Segment	2nd Segment	3rd Segment
Total Length (in bytes)	500	500	36
DF Flag	0	0	0
MF Flag	1	1	1
Value of Fragment offset field	122	182	242

Problem 6. (10 points) IP Routing Tables

Consider the following routing table:

Network Destination	Next Hop
142.150.0.0/22	A
142.150.4.0/22	A
142.150.8.0/21	A
142.150.16.0/21	C
142.150.24.0/21	A
142.150.32.0/22	A
142.150.36.0/22	A
142.150.40.0/21	A
142.150.48.0/20	A

- (5 Points) Aggregate the routing table to the maximum degree allowed.
- (5 Points) Suppose the next hop for network destination 142.150.16.0/21 changes to "A". Show how the routing table aggregation changes.

(a)

These are the entries with next hop "A", grouped into three groups:

```

142.150.0.0/22 = 1000 1110.1001 0110.0000 0000.0000 0000
142.150.4.0/22 = 1000 1110.1001 0110.0000 0100.0000 0000
142.150.8.0/21 = 1000 1110.1001 0110.0000 1000.0000 0000

142.150.24.0/21 = 1000 1110.1001 0110.0001 1000.0000 0000

142.150.32.0/22 = 1000 1110.1001 0110.0010 0000.0000 0000
142.150.36.0/22 = 1000 1110.1001 0110.0010 0100.0000 0000
142.150.40.0/21 = 1000 1110.1001 0110.0010 1000.0000 0000
142.150.48.0/20 = 1000 1110.1001 0110.0011 0000.0000 0000

```

The first group can be summarized to:

142.150.0.0/20 = 1000 1110.1001 0110.0000 0000.0000 0000

The second group (with one entry) cannot be aggregated:

142.150.24.0/21 = 1000 1110.1001 0110.0001 1000.0000 0000

The third group can be summarized to:

142.150.32.0/19 = 1000 1110.1001 0110.0010 0000.0000 0000

This results in a routing table:

Network Destination	Next Hop
142.150.0.0/20	A
142.150.24.0/21	A
142.150.16.0/21	C
142.150.32.0/19	A

(b)

These are the entries after the change:

142.150.0.0/20 = 1000 1110.1001 0110.0000 0000.0000 0000

142.150.24.0/21 = 1000 1110.1001 0110.0001 1000.0000 0000

142.150.16.0/21 = 1000 1110.1001 0110.0001 0000.0000 0000

142.150.32.0/19 = 1000 1110.1001 0110.0010 0000.0000 0000

These entries can be summarized in a single entry:

142.150.0.0/18 = 1000 1110.1001 0110.0000 0000.0000 0000

So, the routing table is:

Network Destination	Next Hop
142.150.0.0/18	A
