ECE 461– Internetworking
Fall 2010

Quiz 1 - Solutions

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 aid permitted are the two aid sheets 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	10	
2	10	
3	10	
4	10	
5	10	
6	10	
Total	70	

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

Name: _____

Email: _____

Problem 1. *(10 points)*

Below is the traffic capture of a packet in hexadecimal notation. The capture consists of an Ethernet II header, followed by an IP header, followed by a TCP header. (Hint: Each digit corresponds to 4 bits.)

```
00e0 f923 a820 00a0 2471 e444 0800^4500 002c 9d08 4000 8006
8bff 808f 8990 808f 4715^065b 0050 0009 465b 0000 0000 6002
2000 598e 0000 0204 05b4
```

a. *(2 points)* Indicate the beginning and end of the IP header.

b. *(2 points)* Provide the value of the Source IP Address and the Destination IP address (Use dotted decimal notation !)

c. *(2 points)* How can you tell that the Ethernet header is followed by an IP header? How can you tell that the IP header is followed by a TCP header? Indicate the relevant information in the captured data.

d. *(2 points)* How can you tell from the captured data that the IP datagram has not been fragmented? Indicate the relevant information in the captured data.

e. *(2 points)* How can you tell that there is no payload following the TCP header? Since there is no payload in the above packet, what is the purpose of this packet?

(a) see ^ above.
(b) Source IP address: 128.143.137.144
Destination IP address: 128.143.71.21

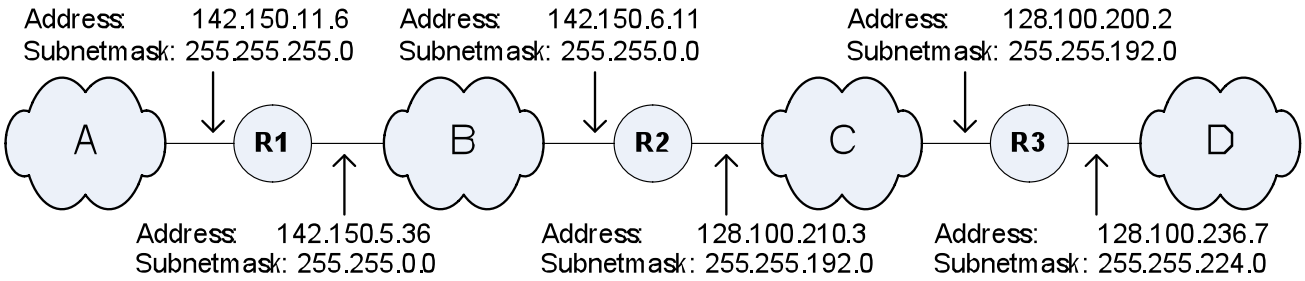
(c) See bold entries above.
Type filed in Ethernet header (type = 0x800) indicates IP in payload.
Protocol field in IP header (protocol=6) indicates TCP in payload

(d) See underline data.
Flags are set to: 010 = 1st bit = 0
2nd bit = DF=1
3rd bit = MF=0
Payment offset is set to all 0's

(e) (see green solution)
IP header total length = 44 bytes
IP header size = 5 x 4 = 20 bytes
TCP header size = 6 x 4 = 24 bytes.
→ IP and TCP header length are equal to IP header size.
Purpose of packet is in the flag (The second bit from the right is set to 1) →
SYN packet
1. URG: Urgent Pointer field significant
2. ACK: Acknowledgment field significant

3. PSH: Push Function
4. RST: Reset the connection
5. **SYN: Synchronize sequence numbers**
6. FIN: No more data from sender

Problem 2. *(10 points)*
Consider the following figure with four IP subnetworks (A, B, C, D) and three routers (R1, R2, R3). The IP configuration of the router interfaces is indicated.



a. *(5 points)* Consider the following hosts and their IP addresses:

Host	IP address	Solution
H1	142.150.7.23	B
H2	128.100.197.4	C
H3	128.100.240.22	C+D

For each host, determine the subnetworks, if any, that the host can be placed on. For each feasible placement, provide the name of the subnetwork (A,B,C, D) and the required subnetmask.

b. *(3 points)* Fill up the remaining routing table entries at router R2 (One entry is given.)

Network with Prefix	Next hop
142.150.11.0/24	128.142.150.5.36
142.150.0.0/16	direct
128.100.192.0/18	direct
128.100.224.0/19	128.100.200.2

c. *(2 points)* Could two hosts have the same IP address but different subnetmasks? Explain your answer.

Answer is No, but there is >1 reason:

- Largest prefix match will select entry for smallest subnet (i.e., longest prefix).
- ARP resolution is no longer unique.

Problem 3. *(10 Points)*

a. *(2 points)* Explain why the use of CIDR (Classless Interdomain routing) in the Internet helps to reduce the size of routing tables.

b. *(2 points)* Using CIDR leads to a hierarchical allocation of IP addresses. What is a disadvantage of allocating IP addresses in a hierarchical fashion? Explain.

c. *(2 points)* Express the entire Class B address space using the CIDR notation for IP addresses.

d. *(4 points)* In the following routing table, indicate the entries that result in a match for destination address "128.9.200.20"? On which interface will an IP datagram with this destination address be transmitted? Explain.

Network with Prefix	**Interface**	**Solutions**
128.0.0.0/8	3	Hit
128.9.0.0/16	5	Hit
128.9.192.0/20	2	Hit
128.9.192.0/22	4	
128.9.192.0/24	7	
128.9.200.0/24	8	Hit
128.9.200.0/28	10	
128.9.200.16/28	1	Hit → Selected Interface
128.9.200.16/30	9	
128.9.192.8/30	6	

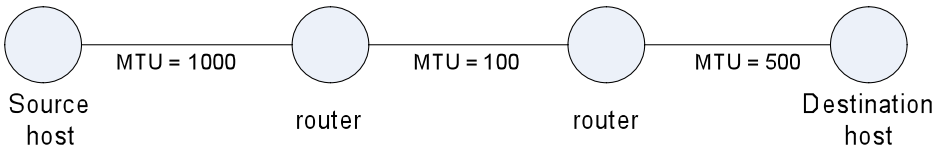
a) CIDR permits aggregation for path with same outgoing interface.

b) When IP addresses are derived hierarchically, then IP addresses are a subblock of those from the ISP. Changing ISP then requires changing IP addresses.

c) 128.0.0.0/2

d) see table

Problem 4. *(10 points)* The "Path MTU" is the smallest MTU of each hop between the source and the destination. In the example below, the path MTU is given by 100 bytes.



a. *(4 Points)* Explain how a source host that has knowledge of the Path MTU can improve the performance of IP datagram transmissions to a destination host.

b. *(6 Points)* Describe how a source host can take advantage of the ICMP protocol to determine the Path MTU to a destination host.

a) When a source knows the Path MTU, it can enforce that IP datagrams do not exceed the Path MTU. In this way, fragmentation is avoided. This will improve performance.

b) (This was discussed in one of the lectures).
If the DF bit is set in an IP datagram, a packet is not fragmented if it exceeds the MTU. Instead an ICMP message is sent to the source. The ICMP message has Type=3, Code-4, meaning "Fragmentation Needed and DF Bit Set".

The procedure is as follows: A source sends a large datagram to the destination, if it receives an ICMP message (of above type and code), then the datagram has exceeded the MTU on one link.
Next, the source sends a smaller IP datagrams, and waits for an ICMP.

This procedure is repeated until ICMP message is received. This means the Path MTU is found.

Problem 5. *(10 points)* **IP Fragmentation**

Consider an IP datagram with the following characteristics:

Length of IP header:	20 bytes
Total length of IP datagram:	1000 bytes
DF flag:	0
MF flag:	0
Fragment offset:	0

Suppose this datagram must be transmitted on a network where the MTU is only 512 bytes.

(a) *(2 points)* Explain why this IP datagram must be fragmented. How many fragments will be created?

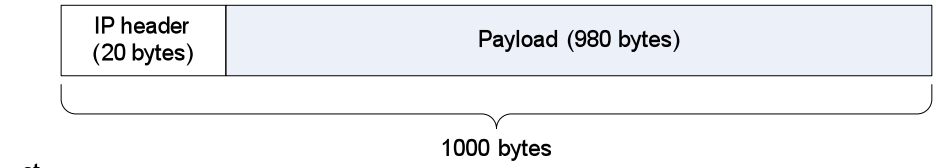
(b) *(6 points)* After the fragmentation is performed, provide the value of the following fields for each of the fragments:
- Total length (in bytes)
- Value of DF flag
- Value of MF flag
- Value of Fragment offset (as a decimal number)

(c) *(2 points)* What does a router do, if the value of the DF flag of an IP datagram is set to one?

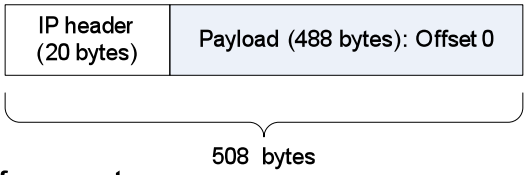
(a) There are 3 segments (not 2).
Explanation: The IP datagram has (1000 bytes) = (20 bytes header) + (980 bytes payload).
The key insight is that the offset value must be a multiple of 8. With 512 bytes (-20 bytes for the header), we have 492 bytes of the max. payload to be put into the first fragment (This would also be the offset for the second segment). Since 492 is not divisible by 8, we have to go to the largest number smaller than 492, that is divisible by 8. This gives us 488.

So, we can put 488 bytes in the 1st segment. This leaves (980-488=492 bytes) of payload. We can put another 488 bytes into the second segment. This leaves (492 - 488 = 4 bytes) for a third segment.

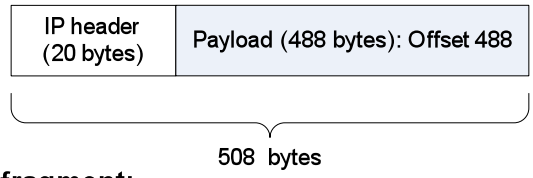
The following picture explains the fragmentation:



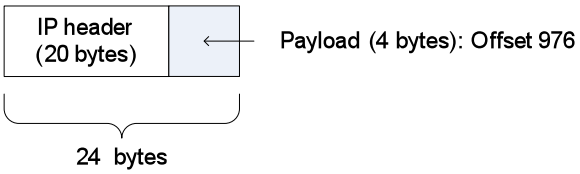
1st fragment:



2nd fragment:



3rd fragment:

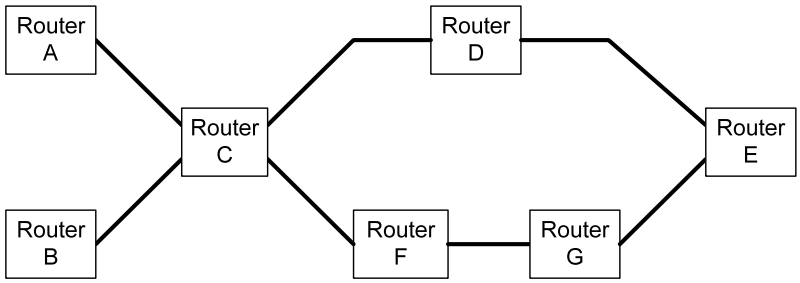


(b)

	1st Segment	2nd Segment	3rd Segment
Total Length (in bytes)	508	508	24
DF Flag	0	0	0
MF Flag	1	1	0
Fragment offset (in bytes)	0	488	976

(c)
If the DF flag is set to zero and the datagram size exceeds the MTU, the datagram is dropped and an ICMP message (Code 4 = Fragmentation Needed and DF Bit Set) is sent to the source of the datagram.

Problem 6. *(10 points)*
In the network topology below with seven routers, the objective is that traffic from A to E, traverses the path A-C-D-E and traffic from B to E should traverse the path B-C-F-G-E.



a. *(5 points)* Describe a key problem in achieving this objective in an IP network.

b. *(5 points)* Propose a method to overcome the problem.

Solution:
The arrangement of routers in Figure 3 is referred to as "the fish tail topology" (the fish's tail is to the left). It is the classical example to describe the limitations of the destination-based routing approach in IP networks.
The problem can only be solved by fundamentally changing the behavior or IP routing:

- source routing (but then the route has to be known at A and B)
- consider source and destination address when performing routing
- rely on a connection-oriented approach.