Bilkent University
Computer Engineering Department

CS 515
Mobile and Wireless Networking

Final Exam
Fall 2002-2003

Date: January 10, 2003, Friday
Duration: 120 minutes

Name of the Student	
ID of the Student	

GRADE	

1 –(30)	
2 – (10)	
3 – (18)	
4 – (5)	
5 – (4)	
6 – (4)	
7 – (8)	
8 – (8)	
9 – (8)	
10- (5)	

Please try to write as clean as possible!
No partial credits will be given for any of the questions!

Good Luck!

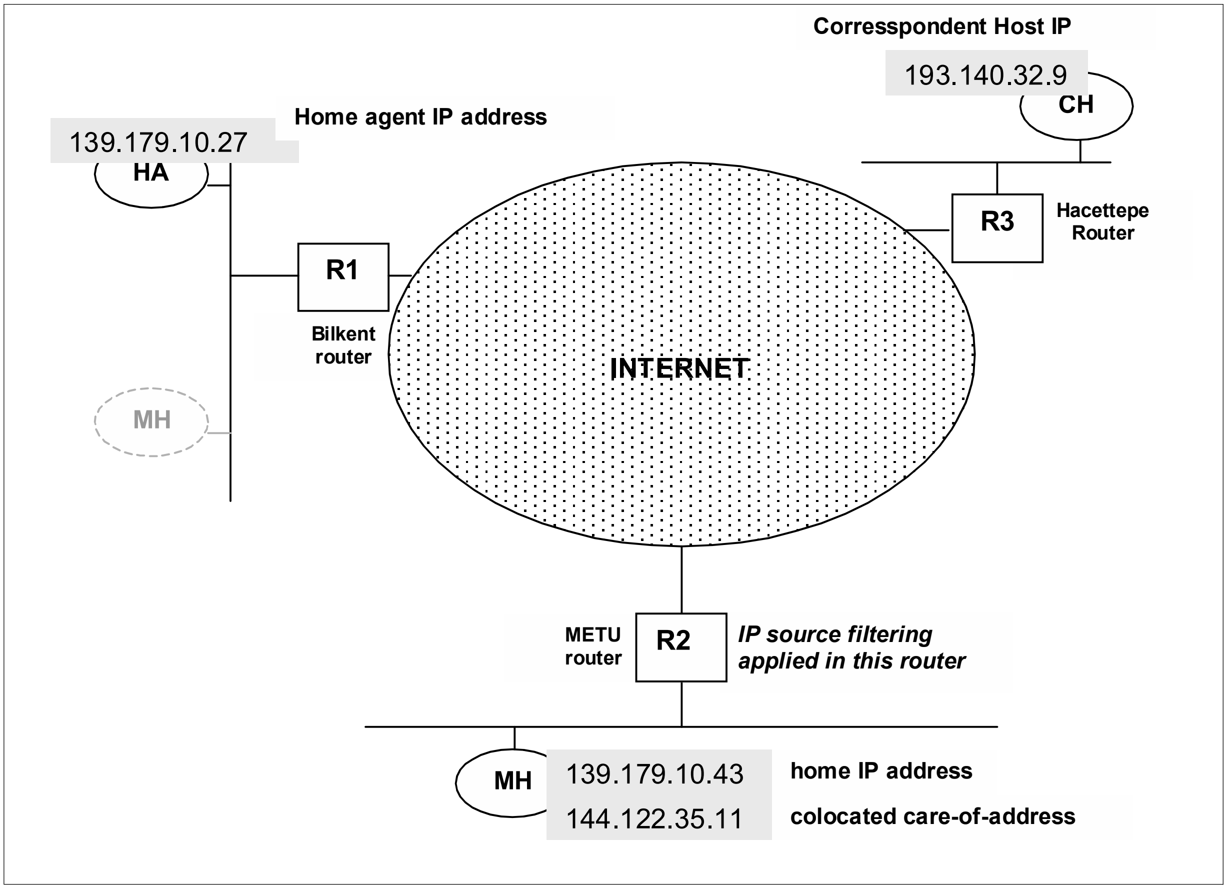
Question 1 (30 points):

Put a tick under T (True) or F (False) for each of the statements below. A correct answer will get **+1** points, a wrong answer will get **-1** points (.i.e a wrong answer will cancel a correct answer). Hence, there is a chance of getting a negative total grade for this question if you mark without knowing the answers.

	Statement	**T**	**F**
1	In Cellular IP, routers in a campus are not aware of mobility.		
2	We need a null-modem RS232C serial cable between a DTE device and DCE device.		
3	RS232C serial communication provides full-duplex communication since we have both a transmit line and a receive line in an RS232C serial cable.		
4	PPP MTU is always fixed and it is 1520 bytes.		
5	In Mobile IP, routers are not aware of mobility unless they implement home or foreign agent functionality.		
6	RS232C can provide asynchronous transmission so that the time interval between any two consecutive bytes that are transmitted over the cable is not constant.		
7	DHCP can provide portability but not seamless mobility.		
8	In cellular IP, the exact location of the mobile is always known at the gateway.		
9	Cellular IP is a mobility solution for cellular networks that support data traffic, such as GPRS and EDGE.		
10	In Mobile IP, the period of agent advertisements affect the handoff latency.		
11	In base Mobile IP protocol, a mobile host that is changing point of attachment to a new foreign agent network does not have to register with home agent if it is not currently actively communicating.		
12	In Mobile IP, an agent advertisement is a UDP packet that is broadcasted on the connected link.		
13	A colocated care-of-address can be obtained by a dynamic IP address assignment mechanism such as PPP or DHCP.		
14	Minimal encapsulation causes smaller encapsulated IP packets compared to IP-in-IP encapsulation.		
15	Triangular routing caused by base Mobile IP protocol can be eliminated by use of binding caches at the correspondent hosts. But this requires software modifications in correspondent hosts.		

	Statement	T	F
16	In Mobile IP, a registration request packet is an ICMP packet with mobility extension.		
17	When a mobile host is using collocated care-of-address, it has to decapsulate the IP packets coming from the home agent.		
18	A foreign agent usually uses ARP protocol to learn the MAC address of a mobile host before forwarding an IP packet that is received from a home agent and intended for the mobile host.		
19	A home agent uses a technique called proxy-ARPing to attract IP packets that are destined for a mobile node that has moved away from the home network.		
20	Both an ARP request and the corresponding ARP reply are sent to hardware broadcast address 0xffffff.		
21	In wireless, sensing carrier does not always reveal the right information about the status of the wireless channel.		
22	Bluetooth uses GFSK modulation with frequency hopping, whereas BlueSky is using FSK modulation.		
23	BlueSky wireless link provides half-duplex communication.		
24	Hidden and exposed terminal problems can be eliminated or reduced by use of RTS/CTS messages.		
25	The uplink channel in BlueSky wireless link is contention-free.		
26	In IEEE 802.11b MAC protocol, sender waits for an ACK after sending a data-frame to a receiver, since it is not possible to detect if the data-frame has collided with some other transmission.		
27	Random access MAC schemes may be more suited for data traffic than coordinated MAC schemes.		
28	IEEE 802.11b systems that employ FHSS technique can support higher data-rates than systems that employ DSSS technique.		
29	BPSK is twice bandwith efficient than QPSK.		
30	Both Ethernet (IEEE 802.3) and Wireless LAN (IEEE 802.11b) MAC layers do not support *segmentation and reassembly* (SAR) (in other words *fragmentation*).		

Question 2 (10 points):



Assume that a mobile host MH is registered in Bilkent University campus network and obtained a permanent home address of 139.179.10.43. The mobile host moves to a new location in METU and obtains a new IP address (144.122.35.11) there automatically using DHCP. This new IP address will be used as the collocated care-of-address for the MH during its stay in METU. MH supports Mobile IP protocol and hence runs the mobile agent and foreign agent functionality together (this means it will be the start/end of tunnels). Both Bilkent and METU campuses are supporting Mobile IP as well.

Now, lets assume MH wants to send some data to a correspondent host CH (193.140.32.9) in Hacettepe University. The egress METU router **R3** does *source address filtering* and drops any IP packet that is going to outside of METU and that has a source IP address field set to an IP address that is not from METU IP address pool. In this case, all IP packets sent directly from MH to CH will be dropped at the METU router since MH will have its home address, which is an IP address from Bilkent University address pool, as the source IP address in the packets.

A solution to this problem is to *encapsulate* all the IP packets that are originating from mobile host MH at MH using *IP-in-IP encapsulation* and then tunnel them to the home agent which in turn will forward them towards the correspondent host CH.

Assume this solution is applied. Answer the following questions:

a) (1) For a packet that is traveling from MH towards HA, how many IP headers will present in the packet if you analyze the packet completely?

b) (4) Depending on your answer in a), provide the source IP address and destination IP address in each of the IP headers that will present in the packet (start from outer-most header if there are more than one headers).

i. src IP address:________________________________

dst IP address:________________________________

ii. src IP address:________________________________

dst IP address:________________________________

iii. src IP address:________________________________

dst IP address:________________________________

(fill as many as necessary depending on your answer in a))

c) (1) For a packet that is traveling from HA to CH, how many IP headers will present in the packet if you analyze the packet completely?

d) (4) Depending on your answer in c), provide the source IP address and destination IP address in each of the IP headers that will present in the packet (start from outer-most header if there are more than one headers).

i. src IP address:________________________________

dst IP address:________________________________

ii. src IP address:________________________________

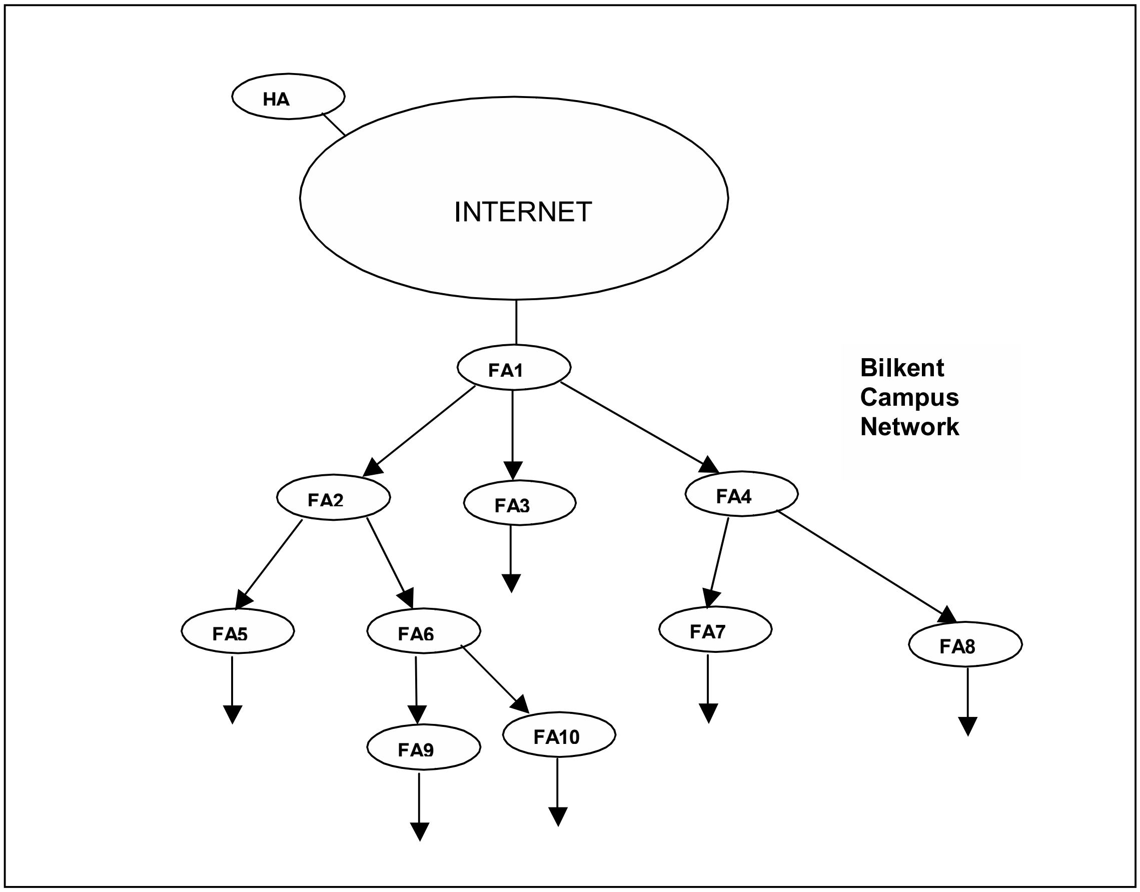
dst IP address:________________________________

iii. src IP address:________________________________

dst IP address:________________________________

(fill as many as necessary depending on your answer in c))

Question 3 (18 points):



Assume Bilkent University campus network supports Mobile IP with Hierarchical Foreign Agents. Foreign agents are deployed throughout the campus with the hierarchical structure shown above. Each agent broadcasts an *agent advertisement message* every 200ms. Each link above is a 10Base-T Ethernet link with 10 Mbps link capacity.

An agent advertisement message contains one or more care-of-address(es) that are advertised by a foreign agent. The format of an agent advertisement message is as follows:

Ethernet Header 14 bytes	**IP Header 20 bytes**	**ICMP Header 8 bytes**	**Mobility extension-fixed part: 8 bytes**	**Mobility extension – one or more IP addresses (*n* IP addresses): 4*n* bytes**

Answer the following questions:

a) (2) How many messages per second are generated as agent advertisements messages?

b) (2) What is size of the smallest agent advertisement message (including ethernet header)?

c) (2) What is size of the largest agent advertisement message (including ethernet header) ?

d) (4) What is the total advertisement message traffic in the campus network? Express your answer in units of bytes/second. (Note: you should include also the ethernet header bytes in your count).

e) (2) What is the percentage of advertisement traffic to network capacity?

f) (6) Assume a mobile host MH is initially connected to foreign agent FA5. Then it starts traveling and gets connected to the following foreign agents in order: FA9, FA10, FA7, FA8. That means a total of four handoffs occur. Assume a registration packet (no matter how big it is) travels a link between two agents or a link between the mobile and an agent in 1 ms (one way). Assume node and processing delays are zero. Assume agent advertisements are received immediately upon each handoff without any delay.

   Compute the approximate handoff latencies for the following handoffs:

   i. Handoff from FA5 to FA9:

   ii. Handoff from FA9 to FA10:

   iii. Handoff from FA10 to FA7:

   iv. Handoff from FA7 to FA8:

Question 4 (5 points):

Given the following input byte sequence (in hex): **4f 7d 34 1a 7e 7d 00 01 0a 7e 2b 4c**

a) (3) Provide the output after byte stuffing algorithm for PPP is applied to the sequence.

b) (2) Compute the percentage increase in the original sequence length.

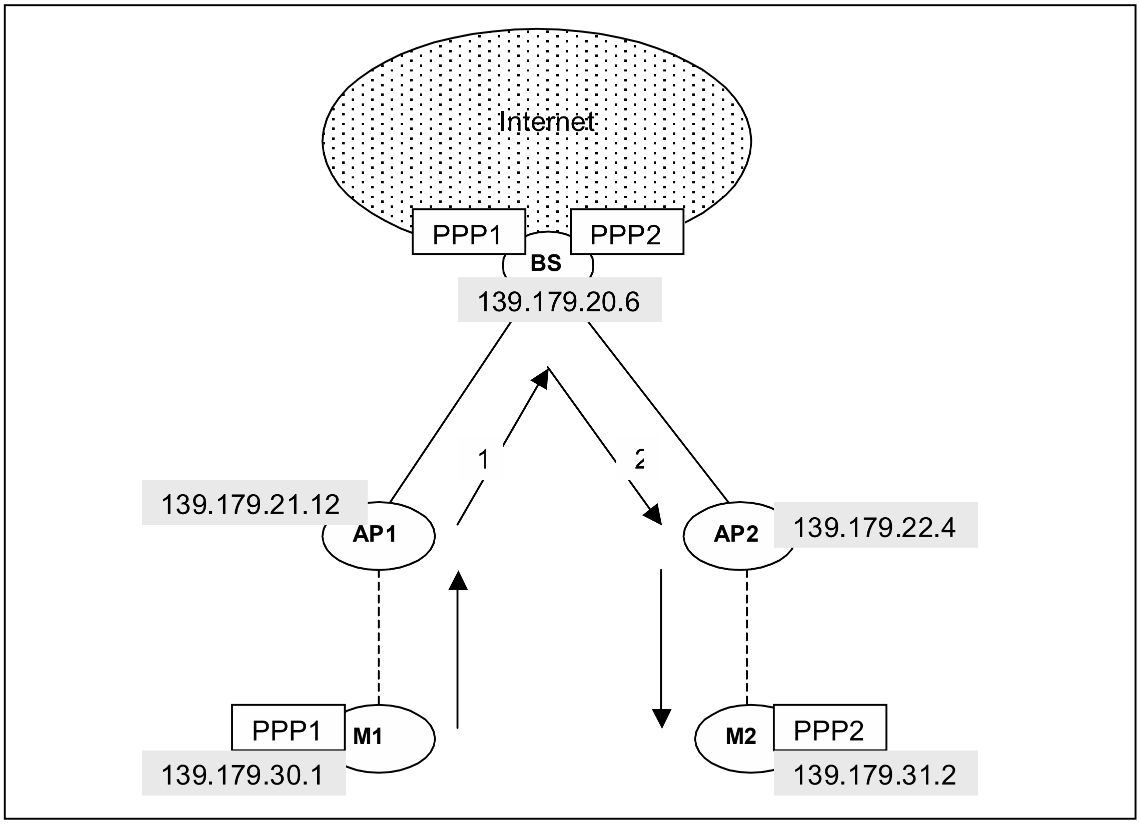
Question 5 (4 points):

GSM is using 890-915 MHz spectrum band for reverse channels and 935-960MHz spectrum band for forward channels. GSM also uses 100 KHz guard band at the beginning and at the end of each spectrum band (i.e., 200 KHz guard band per simplex spectrum band). GSM radio channels are using 200 KHz channel bandwith. How many total duplex channels can be supported in GSM to carry data/control traffic?

Question 6 (4 points):

Bluetooth radio channel for a piconet is a frequency hopping channel with hop rate of 1600 hops/second (it hops through 79 different carrier frequencies). Bluetooth can support 1Mbps maximum data-rate over this piconet radio channel. What is the maximum number of bits that can be transmitted without changing carrier frequency in a Bluetooth piconet radio channel.

Question 7 (8 points):

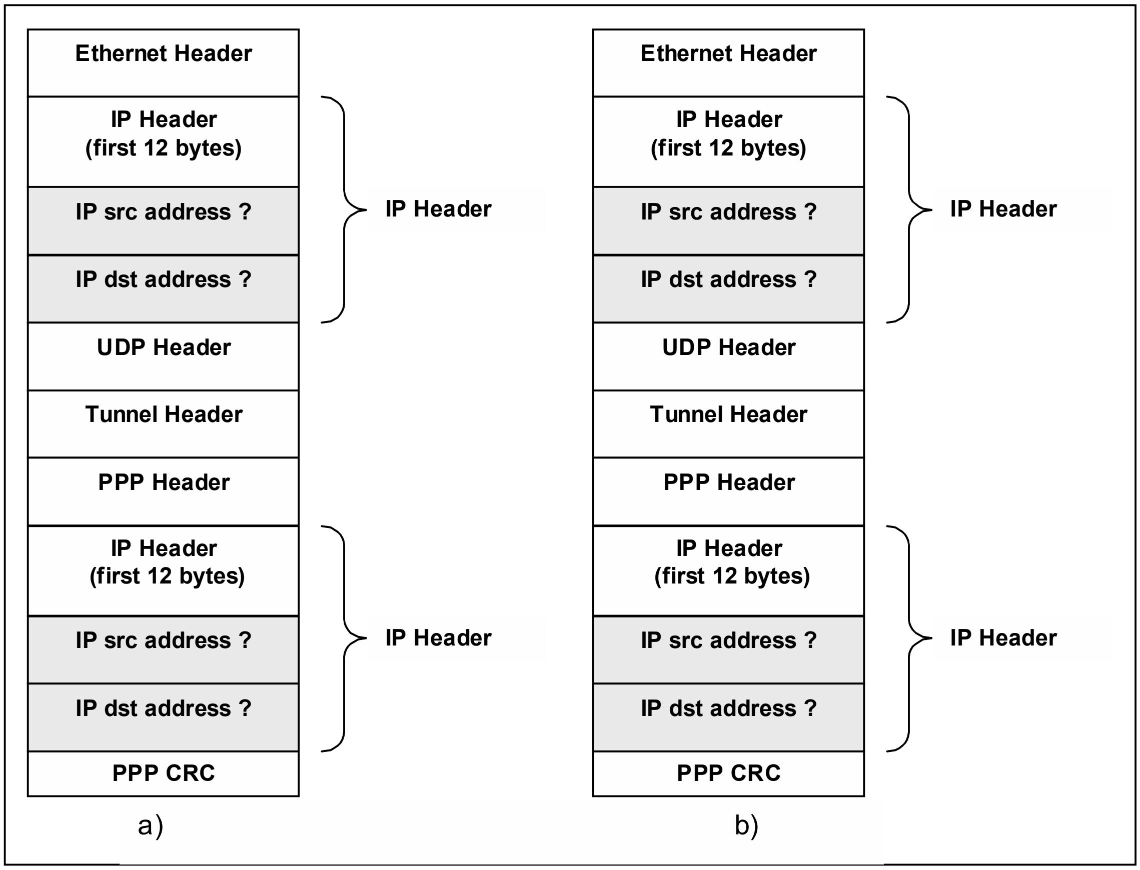


In the figure above, BlueSky mobility is used to support seamless roaming between access points. In BlueSky mobility, all traffic from mobile hosts are tunneled to a backend server (BS). A mobile host M1 is connected to network through access point AP1. PPP connection originating at M1 is terminated at BS and all PPP traffic from mobile M1 is tunneled to BS. A mobile host M2 is connected to the network through access point AP2. Again, PPP connection originating at M2 is terminated at BS and all PPP traffic from mobile M2 is tunneled to BS.

M1 wants to send an IP packet to M2. The IP packet is encapsulated using PPP and sent to AP1. AP1 further tunnels the PPP encapsulated packet to BS. BS re-tunnels the PPP encapsulated packet to AP2. AP2 de-tunnels the PPP packet and forwards it to the M2. M2 strips off PPP framing and gives the original IP packet to the IP layer of M2.

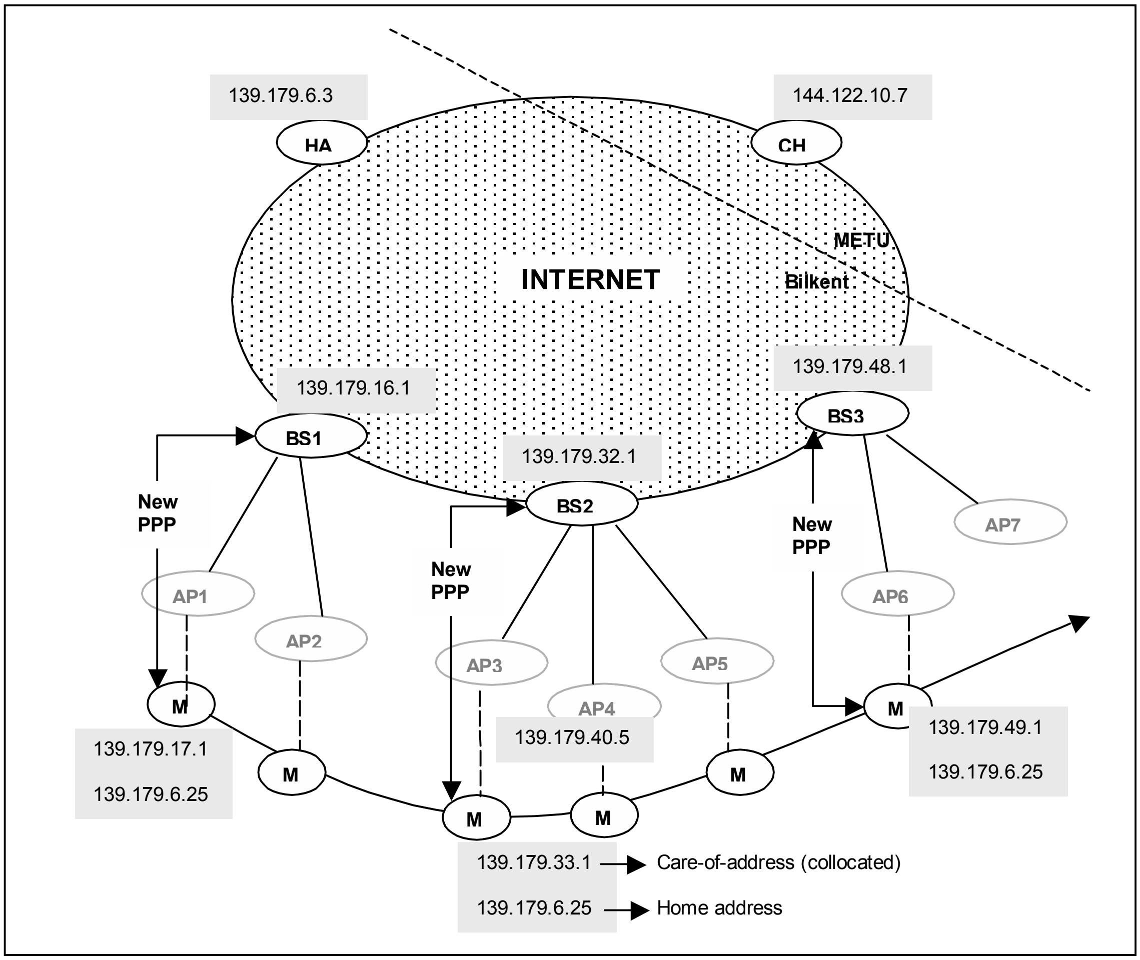
While the PPP encapsulated packet travels from AP1 to BS and then from BS to AP2, fill out the contents of the shaded fields of the frames that you will see on the link 1 and 2 in the figure above (you can mark on the figure).

a) (4) from AP1 to BS
b) (4) from BS to AP2


Ethernet Header
IP Header (first 12 bytes)
IP src address ?
IP dst address ?
IP Header
UDP Header
Tunnel Header
PPP Header
IP Header (first 12 bytes)
IP src address ?
IP dst address ?
IP Header
PPP CRC
a)
Ethernet Header
IP Header (first 12 bytes)
IP src address ?
IP dst address ?
IP Header
UDP Header
Tunnel Header
PPP Header
IP Header (first 12 bytes)
IP src address ?
IP dst address ?
IP Header
PPP CRC
b)

Question 8 (8 points):

BlueSky mobility and Mobile IP can be used together as shown in the figure below. BlueSky mobiliy can be used for micro-mobility around a backend server (BS), while changing from one access point to an other one. Mobile IP can be used for macro-mobility for roaming between backend servers (BSs), while changing from one backend server to an other one.



In the figure, three backend servers (BS1, BS2, BS3) are used. Each backend server serves a number of access points. A mobile host M (with home IP address 139.179.6.25) is traveling starting from the cell of left-most access point AP1 towards the cell of right-most access point AP7. While M is handing off between access points that are served by the **same** backend server, BlueSky mobility is active and PPP connection is not re-established. In this case, M retains its care-of-address together with its permanent home address. While M is handing off between access points that are served by **different** backend servers, a new PPP connection is established and a new care-of-address is obtained. The new care-of-address is then indicated to the home agent through Mobile IP registration process. In this way, Mobile IP is only invoked for handoffs between access points that belong to different backend servers.

Lets say a correspondent host CH sends an IP packet to the home address of mobile host M. Assume that M is currently connected to access point AP4. AP4 has an IP address of 139.179.40.5. While the packet is traveling from BS2 to AP4:

a) (2) How many IP headers will exist in the packet, if you analyze the packet completely?

b) (6) Depending on your answer in a), for each IP header that exists in the packet, provide the source IP address and destination IP address in the header (start from the outer-most header if there are more than one headers).

1. src IP address:________________________________

   dst IP address:________________________________

2. src IP address:________________________________

   dst IP address:________________________________

3. src IP address:________________________________

   dst IP address:________________________________

4. src IP address:________________________________

   dst IP address:________________________________

5. src IP address:________________________________

   dst IP address:________________________________

(fill as many as necessary depending on your answer in a))

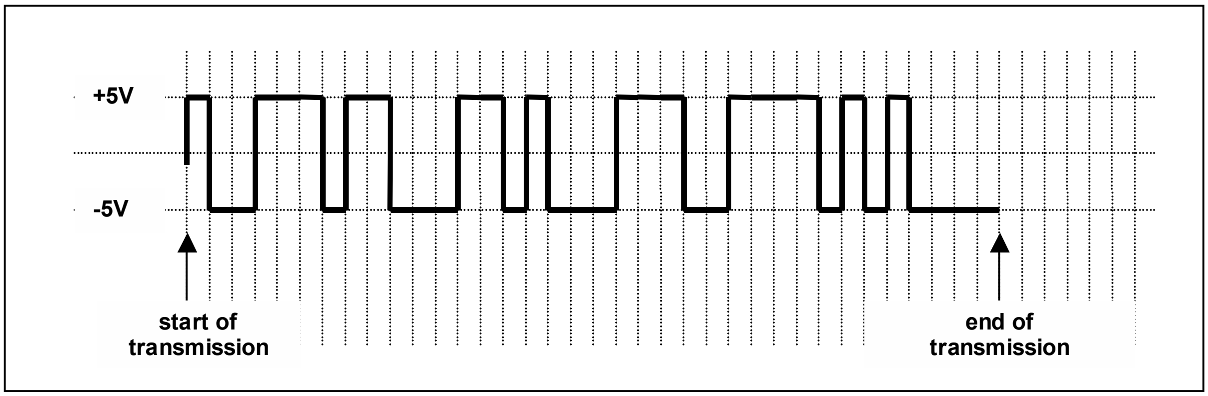
Question 9 (8 points):

Assume an RS-232C serial connection between two computers is using the following connection parameters:

Baudrate: 9600 bits/second
Start bit state: logic 0 (number of start bits is 1)
Number of data bits: 8
Number of parity bits: 1 [**Even parity is used** (*)]
Number of Stop bits: 2

(*) Even parity means: data bits and parity bit together should contain *even* number of 1's.

The signal shown in the figure is observed on an oscilloscope connected to the transmit line of the RS-232C cable.



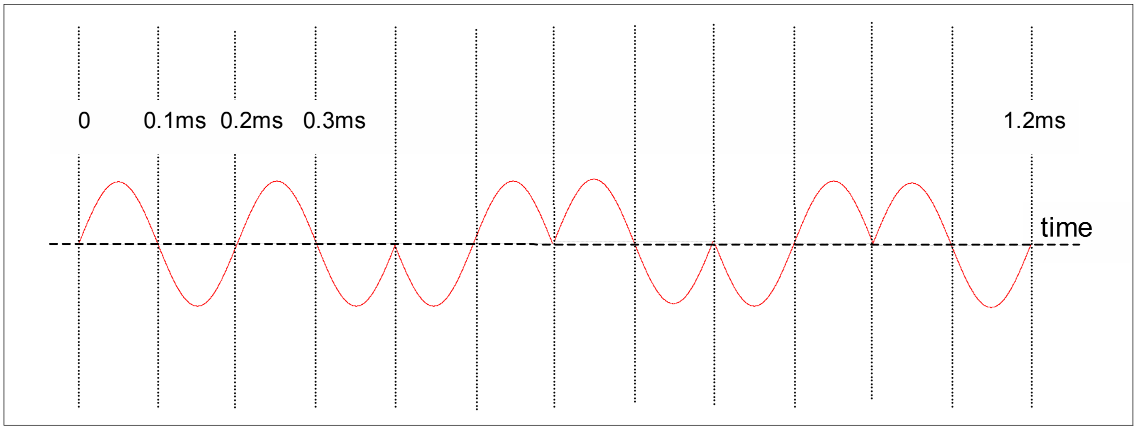
Answer the following questions:

a) (4) What is the information (data bit sequence) that is encoded into the signal that is shown in the figure.

b) (2) How long does it take from the start of transmission until the end of transmission according to the figure.

c) (2) What is the maximum user data-rate (in bits/second) that can be transmitted over this serial line with the parameters shown in the beginning of the question?

Question 10 (5 points):



A digital bit stream that is coming to a **BPSK** modulator is modulated over the air and the above pattern is observed for the modulated signal in the air. The data bit-rate coming to the modulator is 5000 bps. Which data bit pattern is respresented with the signal above? (Namely, what is the data bit sequence encoded into the signal above?).