

## Answers to Sample Questions on Network Layer

1) IP Packets on a certain network can carry a maximum of only 500 bytes in the data portion. An application using TCP/IP on a node on this network generates a TCP segment with 1,000 bytes in the data portion. How many IP packets are transmitted to carry this TCP segment, and what are their sizes (including the header)?

*Answer:* The TCP segment is of size 1,020 bytes. Therefore, we will need 3 IP packets of sizes 520, 520 and 40 bytes.

2) What is the difference between routing and forwarding?

*Answer:* Forwarding is about moving a packet from a router's input link to the appropriate output link. Routing is about determining the end-to-routes between sources and destinations.

3) Consider a VC network with a 2-bit field for the VC number. Suppose that the network wants to set up a virtual circuit over four links: link A, link B, link C and link D. Suppose that each of those links is currently carrying two other virtual circuits, and the VC numbers of these other VCs are as follows:

Link A	Link B	Link C	Link D
00	01	10	11
01	10	11	00

Assume that each of the existing VCs may only traverse one of the four links.

a) If each VC is required to use the same VC number on all the four links along its path, what VC number could be assigned to the new VC?

*Answer:* Notice that there is no one common VC number that is not being used on all the four links. As a result, there is no VC number, which could be assigned to the new VC. This example illustrates a problem associated with having to pick a common VC number along the end-to-end of a virtual circuit.

b) If each VC is permitted to have a different VC number in the different links along its path, how many different combinations of four VC numbers (one for each of the four links) could be used?

*Answer:* In this case, a VC number can be assigned independently on each of the four links. Since there are two vacant VC numbers on each of these four links, the possible combinations are  $2^4 = 16$ . One example combination is (10,00,00,10).

4) Consider a datagram network using 8-bit host addresses. Suppose a router uses longest-prefix matching and has the following forwarding table:

Prefix Match	Interface
00	0
01	1
10	2
11	3

For each of the four interfaces give the associated range of destination host addresses and the number of addresses in the range.

*Answer:*

Destination Address Range	Link Interface
00000000 through 00111111	0
01000000 through 01111111	1
10000000 through 10111111	2
11000000 through 11111111	3

number of addresses in each range =  $2^6 = 64$

5) The only entries in a certain route table are (128.59.28.0/22, port 0), (128.59.28.0/23, port 1) and (128.59.28.0/24, port 2). These entries indicate CIDR network number, the prefix indication and the corresponding port to which a packet should be forwarded. If a packet arrives with a destination IP address equal to 128.59.29.18, which port will this router forward the packet to? (QUESTION FROM PREVIOUS EXAM)

*Answer:* The address of the IP packet matches 128.59.28.0 in the first 23 bits. The 24th bit is different. Since we use the longest prefix match, the router will use the port corresponding to 128.59.28.0/23 in its route table, and forward the packet to port 1.

6) Suppose datagrams are limited to 1,500 bytes (including header) between source Host A and destination Host B. Assuming a 20-byte IP header and a 20-byte TCP header, how many datagrams would be required to send an MP3 consisting of 4 million bytes.

*Answer:* MP3 file size = 4 million bytes. Assume the data is carried in TCP segments, with each TCP segment also having 20 bytes of header. Then each datagram can carry  $1500 - 40 = 1460$  bytes of the MP3 file.

Number of datagrams required =  $\left\lceil \frac{4 \times 10^6}{1460} \right\rceil = 2740$ . All but the last datagram will be

1,500 bytes; the last datagram will be  $1060+40 = 1100$  bytes. Note that here there is not fragmentation – the source host does not create datagrams larger than 1500 bytes, and these datagrams are smaller than the MTUs of the links.

7) Consider a subnet with prefix 101.101.101.64/26. Given an example of one IP address (of form xxx.xxx.xxx.xxx) that can be assigned to this network.

*Answer:* Example of IP address - 101.101.101.65

8) Suppose an ISP owns the block of addresses of the form 101.101.128/17. Suppose it wants to create four subnets from this block, with each block having the same number of IP addresses. What are the prefixes (of form a.b.c.d/x) for the four subnets?

*Answer:* Four equal size subnets – 101.101.128/19, 101.101.160/19, 101.101.192/19, 101.101.224/19.

9) Consider sending a 3,000 byte datagram into a link which has an MTU of 500 bytes. Suppose the original datagram is stamped with the identification number 422. How many fragments are generated? What are their characteristics?

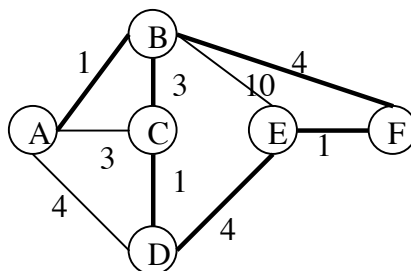
*Answer:* The maximum size of data field in each fragment = 480 (20 bytes IP header).

Thus the number of required fragments =  $\left\lceil \frac{3000 - 20}{480} \right\rceil = 7$

Each fragment will have Identification number 422. Each fragment except the last one will be of size 500 bytes (including IP header). The last datagram will be of size 120 bytes (including IP header). The offsets of the 7 fragments will be 0, 60, 120, 180, 240, 300, 360. Each of the first 6 fragments will have flag=1; the last fragment will have flag=0.

10) Consider the network shown below.

- Show the operation of Dijkstra's (Link State) algorithm for computing the least cost path from F (the rightmost node in the figure below) to all destinations. Also explicitly list all the shortest path routes from F to all destinations that are the result of the algorithm's computation.
- Show the distance table that would be computed by the distance vector algorithm in B. (Note: you do not have to run the distance vector algorithm; you should be able to compute the table by inspection.)



Answer:

Step	N	D(A), p(A)	D(B), p(B)	D(C), p(C)	D(D), p(D)	D(E), p(E)
0	F	$\infty$	4,F	$\infty$	$\infty$	1.F
1	FE	$\infty$	4.F	$\infty$	5,E	
2	FEB	5,B		7,B	5,E	
3	FEBD	5,B		6,D		
4	FEBDA			6,D		
5	FEBDAC					

The shortest path routes from F to all the destinations have been shown as thick lines in the figure above.

The destination table in B is shown below

Cost to					
A	C	D	E	F	
1	3	4	5	4	

11) Suppose a peer with user name Arnold discovers through querying that a peer with user name Bernard has a file it wants to download. Also suppose that Bernard is behind a NAT whereas Arnold isn't. Let 138.76.29.7 be the WAN-side address of the NAT and let 10.0.0.1 be the internal IP address for Bernard. Assume that the NAT is not specifically configured for the P2P application.

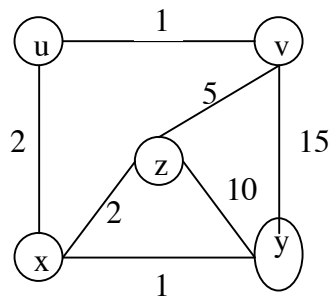
- (a) Discuss why Arnold's peer cannot initiate a TCP connection to Bernard's peer, even if Arnold knows the WAN-side address of the NAT, 138.76.29.7.

Answer: NAT will not have an entry for a connection initiated from the WAN side, hence will drop incoming packets from Arnold.

- (b) Now, suppose that Bernard has established an ongoing TCP connection to another peer, Cindy who is not behind a NAT. Also suppose that Arnold learned from Cindy that Bernard has the desired file and that Arnold can establish (or already has established) a TCP connection with Cindy. Describe how Arnold can use these two TCP connections (one from Bernard to Cindy and the other from Arnold to Cindy) to instruct Bernard to initiate a direct TCP connection (that is, not passing through Cindy) back to Arnold. This technique is sometimes called *connection reversal*. Note that even though Bernard is behind a NAT, Arnold can use this direct TCP connection to request the file, and Bernard can use the connection to deliver the file.

Answer: Bernard can know the IP address of Arnold through Cindy. Then, the p2p application can initiate a connection through NAT to Arnold and upload the file.

12) Consider the network shown below, and assume that each node initially knows the costs to each of its neighbours, Consider the distance vector algorithm and show the distance table entries at node z.



Answer: The distance table in z is:

		Cost to				
From		u	v	x	y	z
	v	1	0	3	4	5
	x	2	3	0	1	2
	y	3	4	1	0	3
	z	4	5	2	3	0

13) What is head of line blocking? Does it occur in input ports or output ports?

Answer: HOL blocking – a queued packet in an input queue must wait for transfer through the fabric because it is blocked by another packet at the head of the line. It occurs at the input port.

14) Suppose you purchase a wireless router/ADSL modem and connect it to your telephone socket. Also suppose that your ISP dynamically assigns one IP address to your connecting device (i.e. your router/modem). Also suppose that you have five PCs at home that use 802.11 to wirelessly connect to your wireless router. How are IP addresses assigned to five PCs? Does the wireless router use NAT? Why or why not?

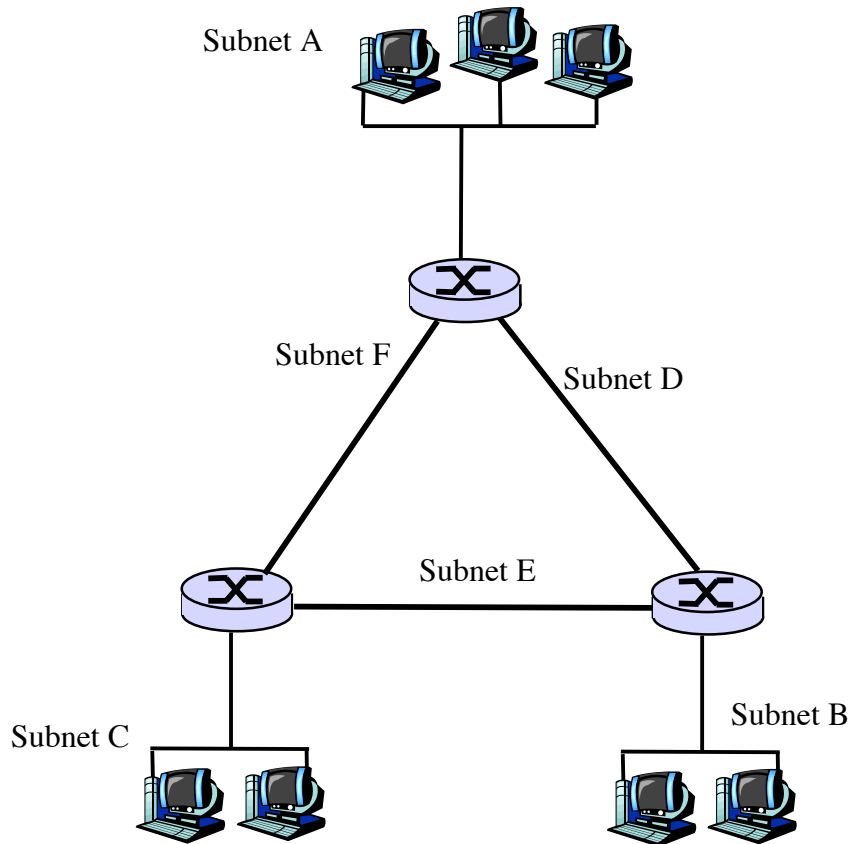
Answer: Typically the wireless router includes a DHCP server. DHCP is used to assign IP addresses to the 5 PCs and to the router interface. Yes, the wireless router also uses NAT as it obtains only one IP address from the ISP.

15) Consider the following topology. Assign network addresses to each of these 6 subnets, with the following constraints:

- All addresses must be allocated from 214.97.254/23
- Subnet A should have enough addresses to support 250 interfaces
- Subnet B should have enough addresses to support 120 interfaces
- Subnet C should have enough addresses to support 120 interfaces
- Of course, subnets D, E and F should each be able to support 2 interfaces

For each subnet, the assignment should either take the form  $a.b.c.d/x$  or  $a.b.c.d/x - e.f.g.h/y$

Now using the address assignments from above, provide the forwarding tables (using longest prefix matching) for each of the three routers.



*Answer:*

From 214.97.254/23, one possible assignment is as follows:

Subnet A: 214.97.255/24 (256 addresses)

Subnet B: 214.97.254.0/25 - 214.97.254.0/29 (128-8 = 120 addresses)

Subnet C: 214.97.254.128/25 (128 addresses)

Subnet D: 214.97.254.0/31 (2 addresses)

Subnet E: 214.97.254.2/31 (2 addresses)

Subnet F: 214.97.254.4/30 (4 addresses)

To simplify the solution, assume that no datagrams have router interfaces as ultimate destinations.

**Router 1**

**Longest Prefix Match**

11010110 01100001 11111111  
 11010110 01100001 11111110 0000000  
 11010110 01100001 11111110 000001

**Outgoing Interface**

Subnet A  
 Subnet D  
 Subnet F

**Router 2**

**Longest Prefix Match**

11010110 01100001 11111111 0000000  
11010110 01100001 11111110 0  
11010110 01100001 11111110 0000001

**Outgoing Interface**

Subnet D  
Subnet B  
Subnet E

**Router 3**

**Longest Prefix Match**

11010110 01100001 11111111 000001  
11010110 01100001 11111110 0000001  
11010110 01100001 11111110 1

**Outgoing Interface**

Subnet F  
Subnet E  
Subnet C