CS307 Computer Networks
(Endterm Exam – SOLUTION)

Section 1 – Short Questions with Explanations **Marks:** 10 points

Q1. Give your answer as true or false to show your agreement or disapproval to the following along with 1-2 sentence justification. *Note: No points will be awarded without justification*. [1x10]

i. It is necessary to have the Internet Protocol for a device to be connected to the Internet.
Answer: ***True*** *because each device on the network has at least one IP address that uniquely identifies it from all other devices in the network. OR It part of the Internet Protocol Stack used at the network layer.*

ii. In IPv6, fragmentation is done at each router in the network.
Answer: ***False*** *because IPv6 does not support fragmentation. Instead, it considers it as a burden and does not support it.*

iii. A subnet of 63 hosts can be made using 6 host bits.
Answer: ***False*** *because we need at least 7 bits for this purpose. The two addresses will be used for Subnetwork and broadcast addresses. Hence,* 2^n *-2 bits are needed.*

iv. In any network, throughput will always be smaller than the goodput.
Answer: ***False*** *because Throughput will always be greater than the goodput because goodput is messages received per unit time excluding retransmitted messages*.

v. It is possible to send HTTP traffic on port number 21.
Answer: ***False*** *because HTTP traffic has port number 80. Port 21 is used for FTP traffic.*

vi. P2P architectures are self-scalable and cost effective.
Answer: ***True*** *because new peers bring new service capacity, as well as new service demands. The host which has the chunk participates in providing service and there is no always-on dedicated server required.*

vii. A TCP socket is a half-duplex connection.
Answer: ***False*** *because it is a full-duplex connection. Both end hosts can send and receive at the same time.*

viii. Whenever an HTTP request is sent to a Server “A”, it is “A” which ALWAYS replies back to the request.
Answer: ***False*** *because there might be a Web Cache implemented with the recently updated content. In that case, Server "A" will not be the one which replies to the request.*

ix. A routing path in both OSPF and BGP protocols is same.
Answer: ***False*** *because in OSPF it is the router which contributes in the path and in BGP it is the Autonomous System.*

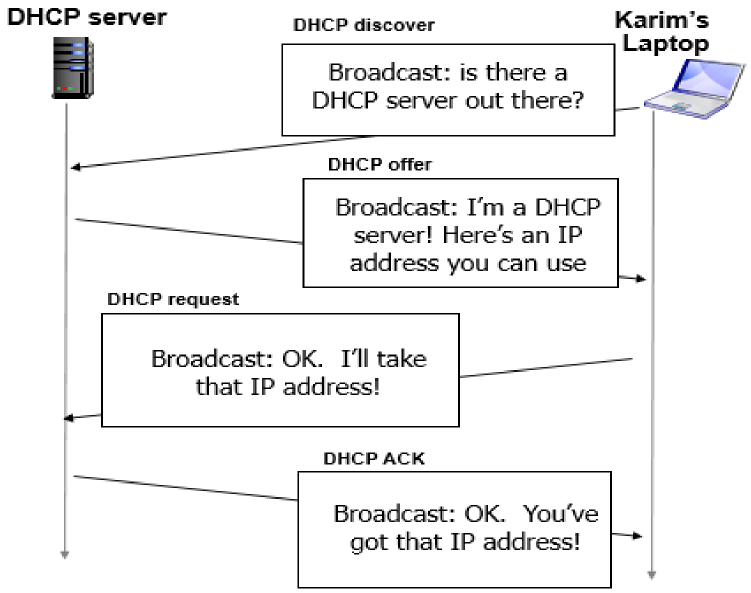
x. Destination-based forwarding and per router control is implemented in SDN.
Answer: ***False*** *because these are implemented in traditional routing. SDN supports generalized forwarding and centralized control (via controller).*

Section 2 – General Understanding **Marks:** 12 points

Q2. Suppose a user Karim enters into the university with his laptop. He is at room 12 in CS block. Assume that the IT department of the University is running various services to support network operations e.g. DHCP, DNS, Netstorage, and web application (e.g. Flex). [8]

Describe in steps how Karim’s laptop:

a) Proceeds to connect to the Internet.
Answer:
i. Connect to WiFi and sets IP address manually by asking around (10% marks only).
ii. Connects to especially setup-up WiFi connection. Set OS to get IP address using DHCP (50% marks if there are missing exchanges).



b) Initiates a query to flex.nu.edu.pk.

Answer: *when karim initiates a query to flex.nu.edu.pk, the host makes DNS query, query is sent to its local DNS server which has local cache of recent name-to-address translation pairs. If not query will be forwarded to TLD Server and Root level servers.*
OR

i. Do a DNS lookup to get IP address of flex domain.
ii. Show all HTTP exchanges to get the default home page.

c) Connects to another student Talha sitting in the same room (R12).
Answer:
He can connect to Talha by using ARP OR RARP protocol.

i. <u>Both you and Talha connected to LAN</u>: Need a client-server application (Local web-server) or P2P application (Bit-Torrent client) running on Talha machine.

ii. <u>Both you and Talha not connect to LAN</u>: Make a Bluetooth, WiFi direct peer to peer (P2P) connection and use custom applications (such as smart wristwatch sync etc. and file transfer)

d) Connects to another instructor Farhan in the EE department.
Answer:
i. Cannot connect to Farhan using Bluetooth or WiFi direct as he is too far away.
ii. If Farhan is connect to LAN same as part (c) above option (i).

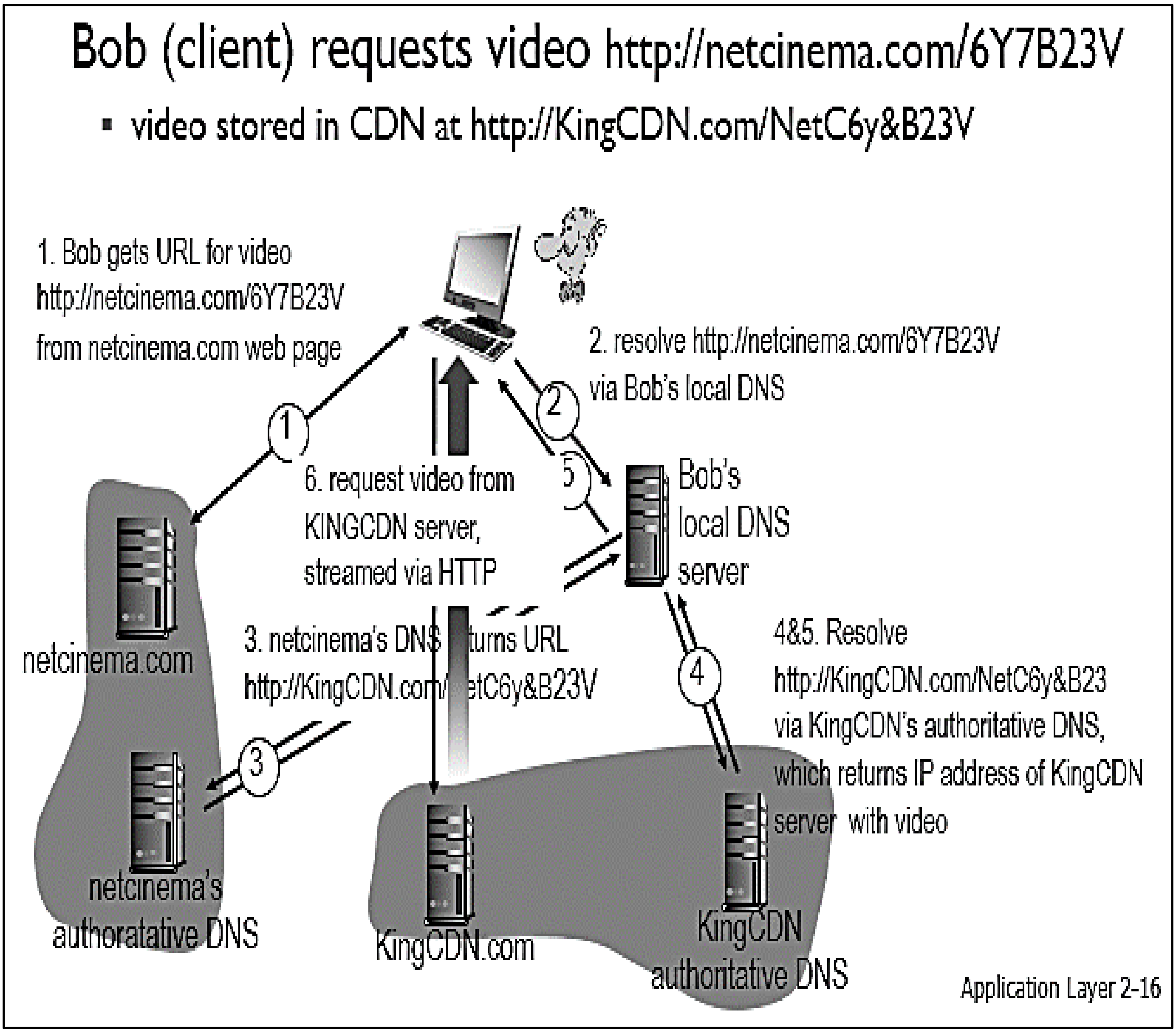
Q3. Suppose accessing the Netstorage has become a bottleneck due to multiple users trying to access the hosted CN video lectures. What application level solution will you propose to overcome this problem? Explain. [4]

Answer:
This is a similar to the file upload to multiple peer we studied in the class.
Client-server model need more computer, storage and network bandwidth as the number of users accessing the shared file folders grows to a large number (video lecture where size is ~1000s of MB).
A P2P based application on each peer (like Bit torrent running on LAN) will allow a new users to use multiple copies of lectures those stored on different peers (as well as server copy) to take part of the download. Each peer PC will provide the bandwidth hence removing the bottleneck.

<u>**Section 3 – Application Layer**</u> **Marks:** 12 points

Q4. Suppose Akamai is a company that operates Content Distribution Networks and sells its services to other companies. Assume that CNN.com has a contract with Akamai, in which Akamai will distribute all of the JPEG files on the CNN.com's web pages. All non-JPEG files will continue to be distributed directly by the CNN.com. Explain how CNN.com and Akamai use DNS to redirect your requests for JPEG files on CNN's site so that the files are retrieved from an Akamai server `near' to you. [4]

Answer:
See the diagram below.



A) You, through your browser, puts in a request for a web page on CNN.com. Your browser connects to CNN.com and requests the web page. If your browser (or proxy server) doesn't have the address of CNN.com cached it will need to get the address using DNS After getting the web page your browser checks the web page to see what extra files are referenced by the web page that it needs to request. Suppose the web page references file foo.jpg.

B) When CNN.com provides the web page to your browser it replaces the reference http://www.cnn.com/webpagefiles/foo.jpg with something like htpp://www.Akamai.com/www.cnn.com/webpagefiles/foo.jpg (Note: the above is only an illustration of the fact that cnn.com is telling your browser that it should look for the picture foo.jpg at Akamai.com. The reality probably uses much more complicated URLS).

C) Your browser now uses DNS to look up the address of Akamai.com, which is the hostname for the referenced file. Because of the way DNS works, all requests for Akamai.com addresses are sent to an authoritative name server for Akamai's domain (after going through the root name server).Akamai's authoritative server checks where the request is coming from and responds, based on this information, returning the IP address of an Akamai server which is `near' you. It can do this because Akamai controls its own authoritative servers and therefore can control how they respond to DNS requests. Akamai maintains its own internal map that lets it answer which of its servers are `near' a particular given IP address.

D) Your browser then requests the jpeg file from the host at the returned IP address. The most important parts of this answer are the facts that
(a) Your browser requests the original web page from CNN
(b) CNN relabels the file so that you will have to ask Akamai for it
(c) Your browser does the DNS search for Akamai's address and Akamai's authoritative name server responds to the request based on your browser's IP address and then
(d) Your browser requests the data from the proper `nearby location.

Q5. The text below shows the reply sent from the server in response to the HTTP GET message. Answer the following questions, indicating where in the message below you find the answer. [8]

HTTP/1.1 200 OK<cr><lf>Date: Tue, 07 Mar 2008 12:39:45GMT<cr><lf>Server: Apache/2.0.52 (Fedora)<cr><lf>Last-Modified: Sat, 10 Dec2005 18:27:46 GMT<cr><lf>ETag: “526c3-f228a4c80”<cr><lf> Accept-Ranges:bytes<cr><lf>Content-Length: 3874<cr><lf>Keep-Alive: timeout=max=100<cr><lf>Connection: Keep-Alive<cr><lf>Content-Type: text/html; charset=ISO-8859-1<cr><lf><cr><lf><!doctype html public “-//w3c//dtd html 4.0 transitional//en”><lf><html><lf><head><lf> <meta http-equiv=”Content-Type” content=”text/html; charset=iso-8859-1”><lf> <metaname=”GENERATOR” content=”Mozilla/4.79 [en] (Windows NT5.0; U) Netscape]”><lf> <title>CMPSCI 453 / 591 / NTU-ST550A Spring 2005 homepage</title><lf></head><lf><much more document text following here (not shown)>

a) Was the server able to successfully find the document or not? What was the time of reply?
b) When the document was last modified?
c) How many bytes are there in the document being returned?
d) What are the first 5 bytes of the document being returned? Did the server agree to a persistent connection?

Answer:

a) The status code of 200 and the phrase OK indicate that the server was able to locate the document successfully. The reply was provided on Tuesday, 07 Mar 2006 12:39:45 Greenwich Mean Time.
b) The document index.html was last modified on Saturday 10 Dec 2005 18:27:46 GMT.
c) There are 3874 bytes in the document being returned.
d) The first five bytes of the returned document are : <!doc. The server agreed to a persistent connection, as indicated by the Connection: Keep-Alive field

<u>**Section 4 – Transport Layer**</u> **Marks:** 12 points

Q6. Imagine that a sender uses RDT 3.0 with stop-and-wait. This sender sends packets of length 10 KB over a link of 1 Mbps. The average round trip time RTT is equal to 250ms. [4]

a) Calculate the channel utilization and then explain the result. (3)

Answer:

*The packet size is L=10KB=10*8*Kbits=80 Kbits*
The bandwidth is R=1Mbps=1000 kbps
The transmission time is calculated as:
L/R=80 Kb/1000 kbps =0.08 sec=80 ms
Thus, the Utilization is determined as follows:
U = (L/R)/(RTT+L/R) = 80/80+250=0.24

The channel is underutilized as it is effective only 24% of its maximum capacity.

b) How the channel utilization may be increased? (1)

Answer:

The problem is the low utilization of the system which could be solved by pipelining protocol. (Full marks is pipeline protocol diagram and explanation (see book pipelining). Otherwise up to 75% marks).

Q7. Assume that TCP at a host is behaving as shown in Figure 4.1. Answer the following questions: [8]

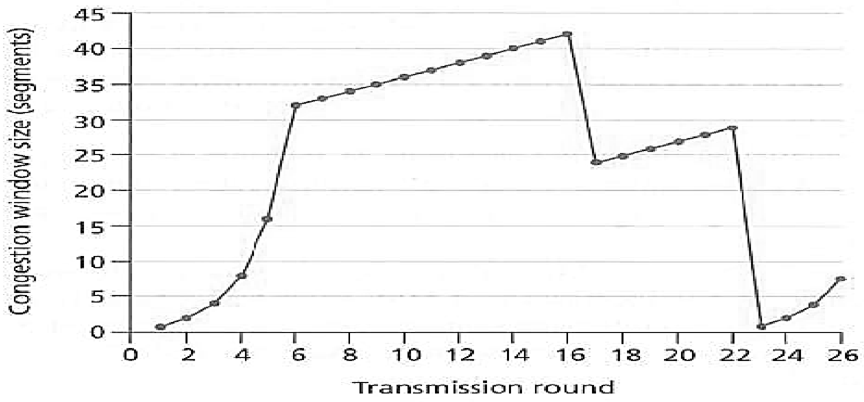


Figure 4.1

a) List various TCP phases with transmission round ranges.
Answer:
Slow Start: TCP slow start is operating in the intervals [1,6] and [23,26].
Congestion Avoidance: TCP congestion avoidance is operating in the intervals [6,16] and [17,22].

b) Explain the transitions in round 6, 17 and 23.
Answer:
i. At 6. Slow start switched to congestion avoidance after reaching ssthreshold.
ii. At 17. TCP reduces congestion window size to ssthreshold/2 after a 3 DUP ACK event.
iii. At 23. TCP goes into reduces congestion window size=1 after packet loss event.

c) In which round, the 66th TCP segment will be transmitted.
Answer:
7th Round. 63 segments are send in slow start phase which ends in 6th round. Another 31 segments are sent in 7th round including 66th segment.

d) Find the congestion window size at the end of the 10th transmission.
Answer:
The size of congestion windows is 36th segments (MSS) in 10th round.

<u>Section 5 – Data plane of Network Layer</u> **Marks:** 16 points

Q8. Assign a class C IP address 220.23.16.0/24 to all interfaces of subnets in the network shown in Figure 5.1. Assume a maximum host count of 30 or less, which are connected to switches S1, S2, S3 and router interfaces R1, R2, and R3 respectively. *Note: Points will only be awarded on showing detail working related to subnet calculations including network and broadcast address.* [8]

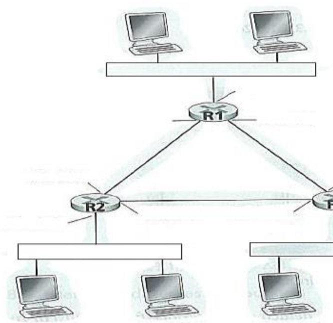
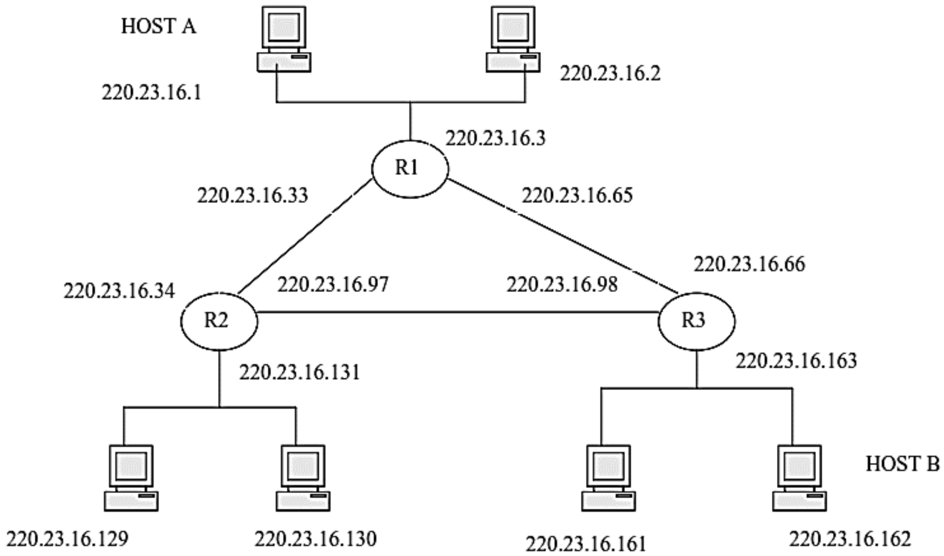


Figure 5.1

Answer:
Here "30 or less" was just to confuse students. This simply means maximum 30 hosts per subnet.

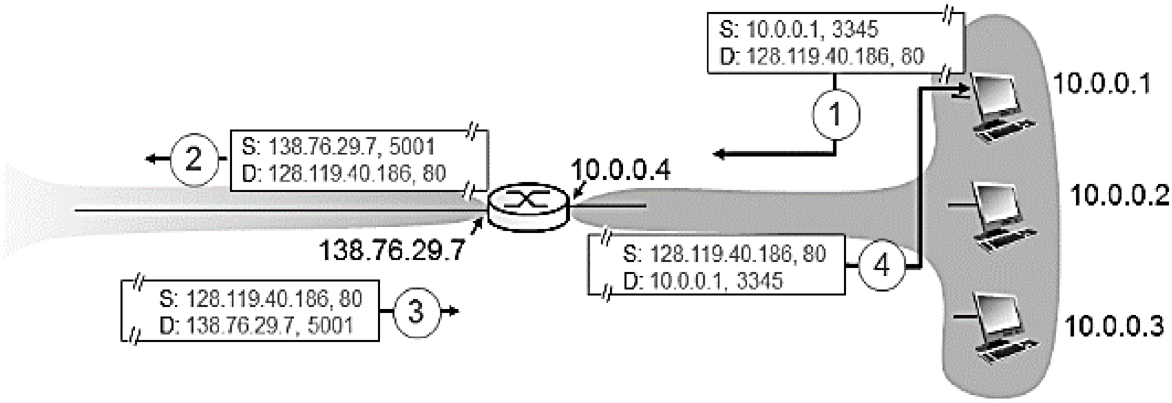


Subnet # 1 = 220.23.16.0/27, IP Subnet range: 220.23.16.0 – 220.23.16.31
Subnet # 2 = 220.23.16.32/27, IP Subnet range: 220.23.16.32 – 220.23.16.63
Subnet # 3 = 220.23.16.64/27, IP Subnet range: 220.23.16.64 – 220.23.16.95
Subnet # 4 = 220.23.16.96/27, IP Subnet range: 220.23.16.96 – 220.23.16.127
Subnet # 5 = 220.23.16.128/27, IP Subnet range: 220.23.16.128 – 220.23.16.159
Subnet # 6 = 220.23.16.160/27 IP Subnet range: 220.23.16.160 – 220.23.16.191

Default Subnet Mask: 255.255.255.0
Custom Subnet Mask: 255.255.255.224 (i.e all /27 subnets)

Q9. Explain how a higher education institution, such as FAST-NU Karachi campus, can use private IP addresses for its 3000 devices as PCs and mobile devices and still manage internet connectivity using NAT and one public IP address. First, give a label diagram explaining how you setup NAT within a campus network of three labs, and office spaces for faculty, admin and accounts. Later explain, how an IP datagrams from a private IP address are send and received from the campus network to access bbc.co.uk website. [4]

Answer:



50% marks for diagram with explanation (refer to book for explanation). Another 50% marks for explaining how a datagram will traverse in and out of the NAT from a PC (say 10.0.0.1) to bbc.co.uk website.

Q10. Why IP fragmentation was implemented in IPv4? Explain how IPv6 solves the issue for which IP fragmentation was designed in IPv4. [4]

Answer:

i. *Each IP datagram need to fit in a frame at the source PC using its MTU size (e.g. ~1500 for Ethernet). If it encounters a MTU size of < 1500 while passing through Internet (a mesh connection of routers) the router with lower MTU interface fragment IP datagram into two or more datagram. These datagrams travels the Internet without change (if they haven't encounter another lower MTU) and are assembled back by the destination network layer. (3 marks)*

ii. *IPv6 perform a MTU path discovery to the destination IP address before sending the packets and uses the lowest MTU. (1 marks) ….**See book for further details***

Section 6 – Control plane of Network Layer **Marks:** 14 points

Q11. a) How a link-state routing protocol works differently from a distance vector protocol? Explain this difference using a comparison chart. [4]

Answer:

Link State Protocol	***Distance Vector Protocol***
1. Routers exchange Link state advertisement to collect global knowledge at each router. Each advertisement has router IDs and cost of connected interfaces.	*1. Each router process local knowledge (cost of its own interfaces and directly connected neighbors) using DV algorithm (bellman-ford) and create distance vectors (DV).*
	2.
2. LS algorithm (Dijkstra) will run at each node to construct shortest path w.r.t that node.	*3. The router exchanges DVs to all the routers in the network (using broadcast).*
	4.
3. Forwarding Tables are created on the same router based on shortest path info.	*5. Each router upon receiving a DV recalculates shortest path to other routers, hence generating a new view of the network.*
	6.
4. Any changes (new routers or interface cost changes) will retriggers the process.	*7. If recalculation results in changed DVs at a router, it again send its DV to all other routers.*
	8. The exchanges of DV in the network stops when new DVs received at routers does not change their stage.

b) Consider the network graph shown in Figure 6.1 with nodes A to F. Apply Dijkstra's algorithm to find the least cost path from Node A to all other nodes. [4]

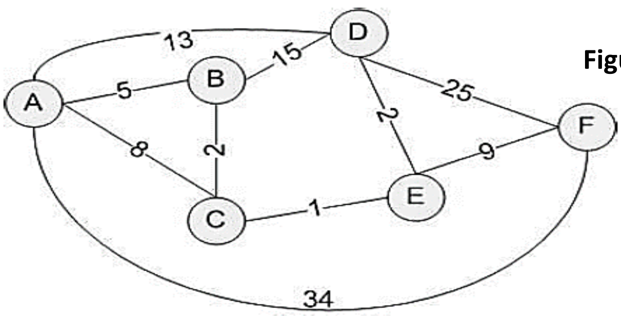
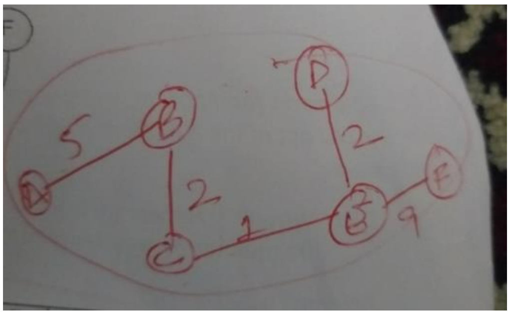


Figure 6.1

Answer:

Step	S	D(B),p(B)	D(C),p(C)	D(D),p(D)	D(E),p(E)	D(F),p(F)
0 (Initialization)	A	5,A	8,A	13,A	∞	34,A
1	AB		7,B			
2	ABC				8,C	
3	ABCE			10,E		17,E
4	ABCED					
5	ABCEDF					



Q12. A group of autonomous systems is shown in Figure 6.2. Answer the following questions: [6]

a) Identify all BGP speaking routers in this network and label them appropriately as per your knowledge of BGP protocol.
Answer:
eBGP runs of border routers then interconnect two Autonomous Systems (AS). iBGP is used to flood BGP routes inside an Autonomous Systems (AS). Therefore,

eBGP speaking routers as per Figure 6.2 are: 2a, 1b, 4c, 1a, 4a, 3a.
iBGP speaking routers could be: 2c, 2b, 4b, 1c, 1d, 3c, 3b.

b) Using your knowledge of BGP protocol, how a PC attached to router 2c will reach Server A, if the link between router 2a and 1b is not operational.

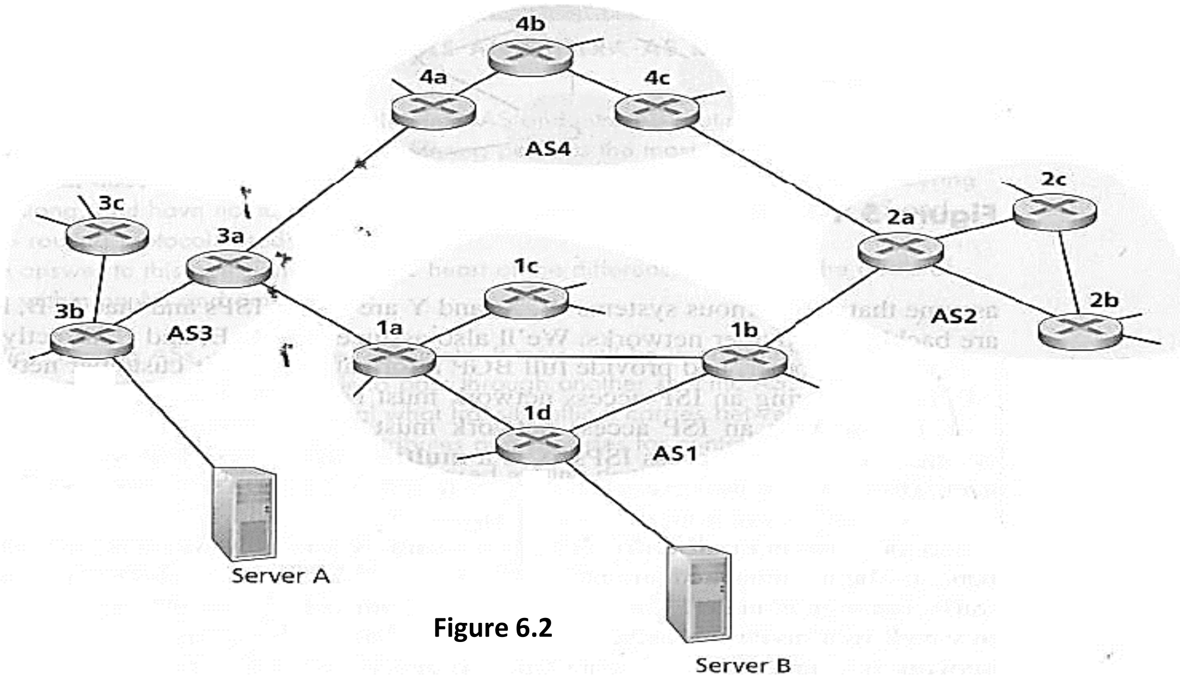


Figure 6.2

Answer: *The PC attached to router 2c in AS2 will learn the BGP path to server A, which is connected to AS3 as per Figure 6.2, as follows (following details required in the answer):*

i. *Server A. AS3 advertises the IP prefix (containing the host address of server A) to AS4 and AS1.*

ii. *AS4 router 4a sends this route to router 4c (iBGP messages). The router 4c advertise this route to router 2a (eBGP) belonging to AS2. AS4, in this scenario, behaves as a Transit AS.*

iii. *The router 1a in AS1 send the server A IP prefix learned from AS3 3a router to router 1c, 1d and 1b through iBGP messages. However, router 1b cannot advertise this route to router 2a of AS2 as the link between 1b and 2a is not operational.*

iv. *Router 2a send iBGP messages to 2c and 2b where forwarding table entries are added for IP prefix of server A. Hence, enabling a PC connect to 2c network easily exchange IP datagrams to Server A.*

Section 7 – Data Link Layer **Marks:** 4 points

Q13. Consider the network in Figure 7.1 with switched networks at both interfaces of router R. Explain in steps how an IP datagram is delivered from the Network Layer of PC A to Network Layer at PC B inside a Layer 2 frame. Your answer should provide details about the use of Layer 2 protocols, and the creation of new L2 frames at various interfaces, if required.

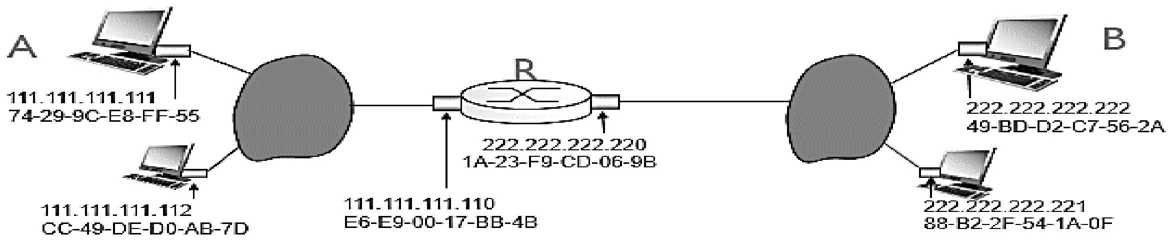


Figure 7.1

Answer: The following steps were required:

PC A

1. *IP datagram with a source IP address 111.111.111.111 is encapsulated in a Layer 2 (L2) Ethernet frame.*

2. *The Ether frame needs to be deliver to router interface router R having an IP address 111.111.111.110. This interface is on the same subnet and act as a default gateway to access the Internet. Therefore PC A need its MAC address.*

3. *Address Resolution Protocol (ARP) is used to broadcast a query to all interfacing (hosts + router) on the 111.111.111/24 subnet and only router interface response with its MAC address (E6-E9-00-17-BB-4B) to PC A.*

4. *The PC A places the source and destination MAC in the L2 frame and send it on the switched Ethernet.*

Router A

1. *Router A interface connect to PC A network receive the frame de-encapsulate it and send it to its network layer for forwarding, which determines that it goes out interface with IP address 222.222.222.220. This interface is directly connected to PC B and therefore can be delivered directly.*

2. *Router A interface connect to PC B uses the ARP again to get the MAC address of PC B and send send the frame to PC B by putting its and PC B MAC address in the L2 frame.*

PC B

1. *Upon receiving the frame from Router interface it un-packs the frame, get the IP datagram and pass it to network layer for further processing.*

---------- (X) ----------