National University of Computer & Emerging Sciences, Karachi

FAST School of Computing

Final Examination, Spring 2023

24th May 2023, 12:00 noon – 03:00 pm

Course Code: CS3001	Course Name: Computer Networks
Instructor Names: Dr. Sufian Hameed, Dr. Farrukh Salim, Mr. Shoaib Raza, and Ms. Yusra Kaleem	
Student Roll No:	Section No:

Instructions:

- Return the question paper.
- **All questions must be answered in answer script and according to the sequence given in the question paper.**
- In case of any ambiguity, you may make an assumption. But your assumption should not contradict any statement in the question paper.

Time: 180 minutes. **Max Points: 100**

Question # 1: **[CL0-1]** **[4 x 5 = 20 Points]**

Suppose a user Ali enters into the Class room E6 in CS block for CN Project demo. Assume that the IT department of the University is running various services to support network operations e.g. DHCP, DNS, Filestorage, and Web application (e.g. Flex, and SLATE). Describe in steps how Ali's laptop:

Part a) Proceeds to connect to the Internet.

Part b) After Project demo, Ali initiates a query to flex.nu.edu.pk to view his Project marks. Assume there is no Web cache server avialable on our institutional network. Which two techniques will be used by local DNS server to resolve the address of the webpage? Explain this with the help of a labelled diagram.

Part c) When obtaining the IP address for the host name flex.nu.edu.pk, assume the round trip time between local DNS server and DNS root server is 5RTT, between local DNS server and DNS TLD server is 4RTT, and between the clients and the local DNS server is 2RTT.

i) How long does it take for the Ali to obtain the IP address for flex.nu.edu.pk?

ii) After Ali, Bilal (on the same network) also wants to obtain the address for flex.nu.edu.pk. How long for the Bilal to obtain the IP address?

Part d) Suppose Ali is trying to access the hosted CN video lectures on Filestorage (Local server facility for accessing lecture material) and it has become 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.

Question # 2: **[CL0-2]** **[10 + 5 + 5 = 20 Points]**

Part a) Given the template FSM (Finite State Machine) of a TCP Congestion Control with three different states (slow start, congestion avoidance and fast recovery) as shown in the Figure 01. Provide the details on different transition and holding events and the corresponding actions in the FSM.

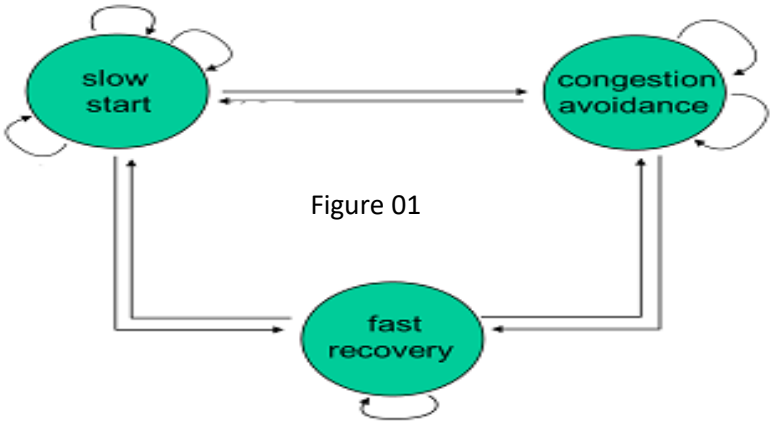


Figure 01

Part b) Network Congestion is one of the top most research topics in Computer Networks. Is there a better way than Additive Increase Multiplicative Decrease (AIMD) to "probe" for usable bandwidth?

Part c) In rdt 3.0 we introduced the concept of timer, how TCP handles the loss of data (unACKed segments). Explain the phenomenon with the help of Window Timing Diagram.

Question # 3: **[CL0-3]** **[7.5 + 7.5 + 5 = 20 Points]**

Part a) Consider there is only one router, with finite buffer capacity. The input and output link capacity of router is R. Two flows are attached to the router, each flow sharing half of the router capacity and each flow have:

i) The perfect knowledge of the router buffer capacity.
ii) Have partial knowledge, and knows only if the packet is dropped at the router (retransmission needed for lost packet).
iii) Have no knowledge about router buffer, nor about any dropped packet (guess only by acknowledgement packets).

Plot the graphs for each of the above case for only one flow, showing transport-layer input on x-axis and maximum achievable receiver throughput at y-axis.

Part b) For the network shown in Figure 02, suppose that the desired forwarding behavior is that packets from Host H1 or Host H2 destined to Host H5 or Host H6 are to be forwarded from s3 to s1, and then from s1 to s2 (thus completely avoiding the use of the link between s3 and s2).

i) Write down the flow table entry for s3, so that datagram sent from Host H1 or Host H2 are forwarded to s1 over interface 3.
ii) Write down the flow table entry for s1, so that datagram arriving at port 1 of s1, from s3, are forwarded to s2 over outgoing interface 4.
iii) Finally write down the flow table entry for s2, for forwarding to required destinations.

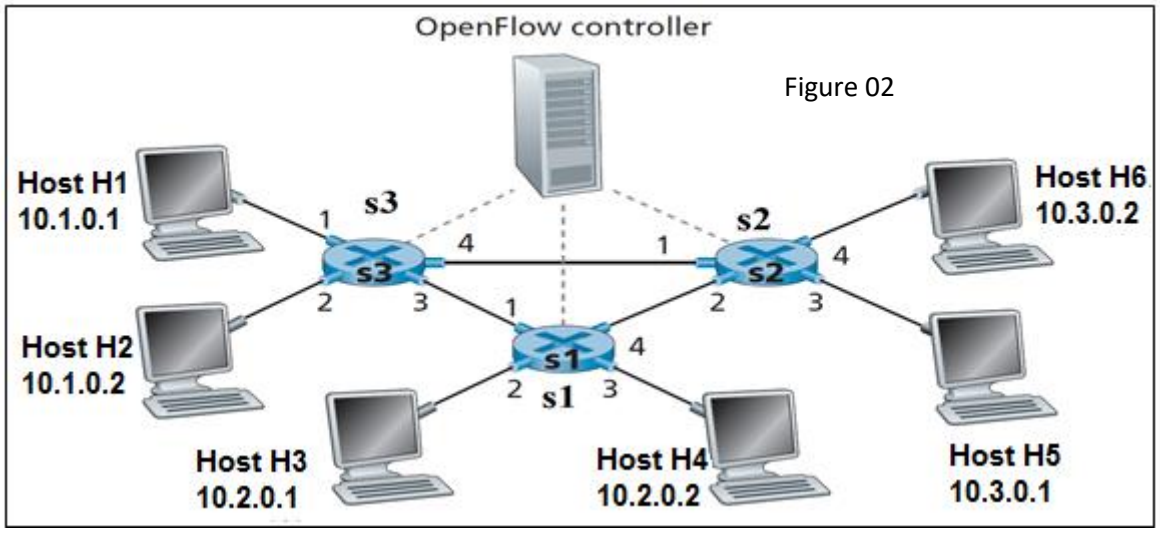


Figure 02

Part c) A point-to-point satellite transmission link of 5 Gbps and 30ms propagation delay connecting two computers uses a stop-and-wait ARQ strategy. All packets consist of 10,000 bits and average round trip time RTT is 50ms.

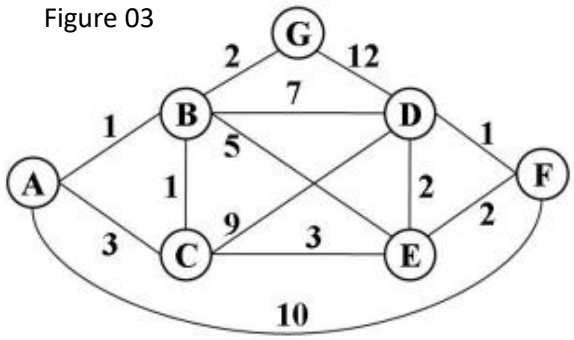
i) Calculate the link efficiency (utilization) when only one packet is sent.
ii) Calculate the new link efficiency (utilization) when pipelining is applied, now sender send three packets back-to-back.

Question # 4: **[CL0-2]** **[7.5 + 7.5 + 5 = 20 Points]**

Part a) Consider the graph given in Figure 03. With the indicated link costs, use Dijkstra shortest-path algorithm to compute the shortest path from node A to all other nodes. Use the table given below for computations. Show the forwarding table for node A.

N	D(B)	D(C)	D(D)	D(E)	D(F)	D(G)
A	∞	∞	∞	∞	∞	∞

Figure 03

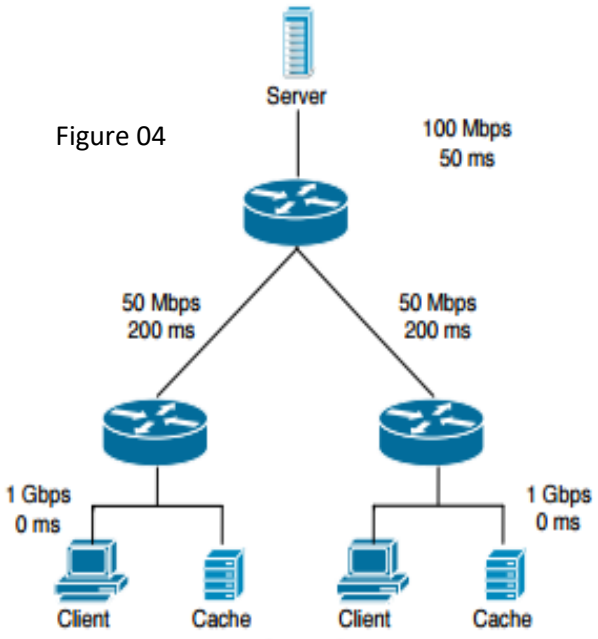


Part b) Consider the scenario as shown in Figure 04 in which a server is connected to a router by a 100Mbps link with a 50ms propagation delay. Initially this router is also connected to two routers, each over a 50Mbps link with a 200ms propagation delay. A 1 Gbps link connects a host and a cache (if present) to each of these routers and we assume that this link has 0 propagation delay. All packets in the network are 20,000 bits long.

i) What is the end-to-end delay from when a packet is transmitted by the server to when it is received by the client? In this case, we assume there are no caches, there's no queuing delay at the routers, and the packet processing delays at routers and nodes are all 0?
ii) Here we assume that client hosts send requests for files directly to the server (caches are not used or off in this case). What is the maximum rate at which the server can deliver data to a single client if we assume no other clients are making requests?

iii) Again we assume only one active client but in this case the caches are on and behave like HTTP caches. A client's HTTP GET is always first directed to its local cache. 65% of the requests can be satisfied by the local cache. What is the average rate at which the client can receive data in this case?

Figure 04



Part c) 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 your setup NAT within a campus network of three labs, and office spaces for faculty, admin and accounts. Later explain, how an IP datagram from a private IP address are send and received from the campus network to access bbc.co.uk website.

Question # 5: **[CL0-3]** **[2 x 10= 20 Points]**

Part a) You have been given the IP address 192.168.9.0/24. Now you have to assign IP addresses to the different department's LAN as shown in network Figure 05.

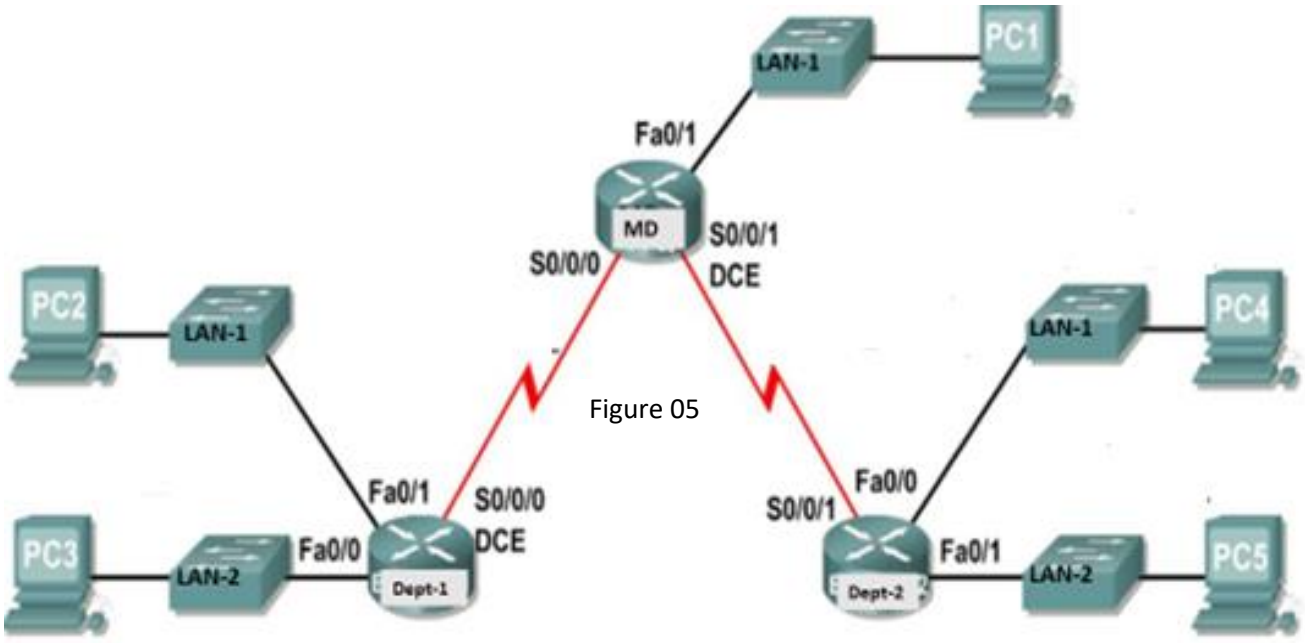


Figure 05

The network has the following addressing requirements:

i) The Department-1 LAN-1 will require 50 host IP addresses.
ii) The Department-1 LAN-2 will require 120 host IP addresses.
iii) The Department-2 LAN 1 will require 10 host IP addresses.
iv) The Department-2 LAN 2 will require 18 host IP addresses.

Fill the following table in your answer script with the details of the sub-networks that the Departments can create to fit its LAN's needs.

Subnet No.	Network Address	Custom Subnet Mask	Host Range	No. Of Hosts
Department-1 LAN-1				
Department-1 LAN-2				
Department-2 LAN-1				
Department-2 LAN-2				

Part b) Consider the network as shown below in Figure 06.

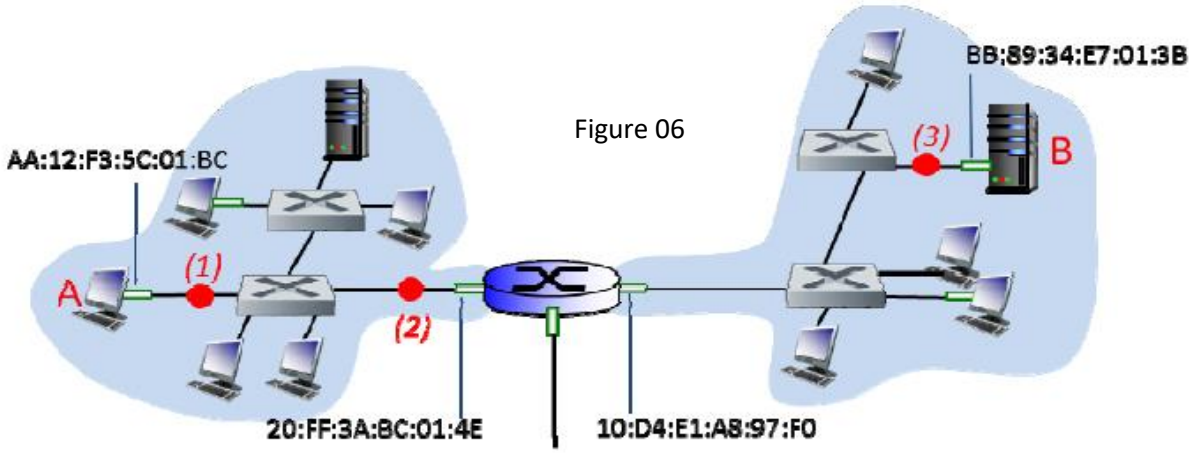


Figure 06

i) Assign IP address ranges to the subnets containing hosts A and B, and assign IP addresses in these ranges to hosts A and B. (You don't have to assign IP addresses to any hosts except A and B, but you do need to specify the address range being used by each subnet). Your subnet addressing should use the smallest amount of address space possible.

ii) What IP address range can the router advertise to the outside for all of the hosts reachable in these two subnets? Again, you should choose your answer in i) above so that the minimum-size address space is advertised here.

iii) Does the router interface with link-layer address 20:FF:3A:BC:01:4E have an IP address? If so, what is the role of the IP address of the router's IP interface in forwarding datagrams through the router?

iv) Consider an IP datagram being sent from A to B using Ethernet as the link layer protocol in all links in the figure above. What are the (a) Ethernet source and destination addresses and (b) IP source and destination addresses of the IP datagram encapsulated within the Ethernet frame at points (1), (2), and (3) in the above example for a datagram going from A to B.

v) Suppose A sends out an ARP request, and this ARP request is in the very first frame sent in the network above (i.e., even before the original A-to-B datagram). How many of the 11 hosts in the network receive the frame containing this ARP request? Explain your answer briefly.

Best of Luck!!!