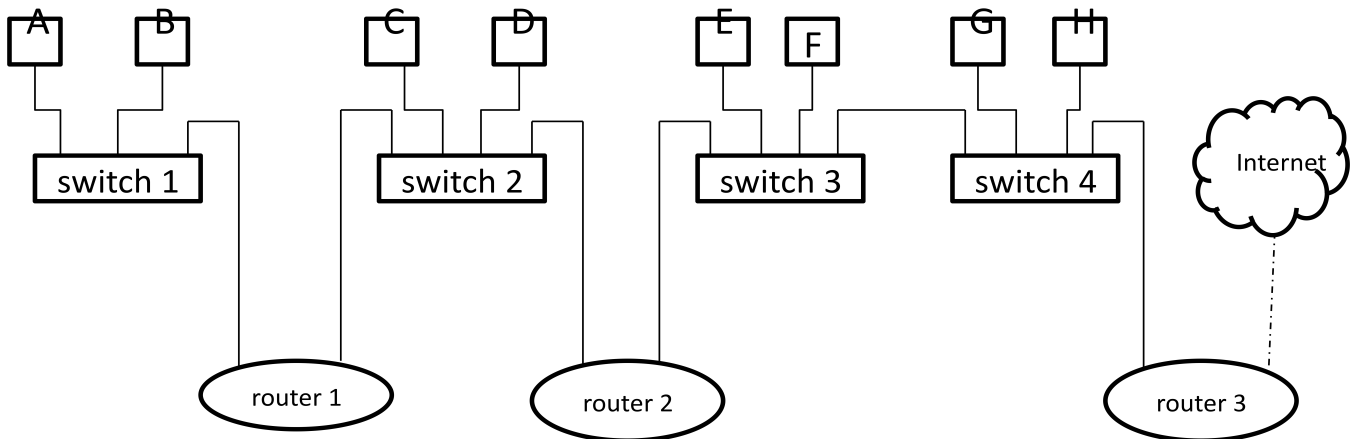


B2: Networks (25 points) IPv4 Forwarding

IMPORTANT – ANSWERS TO THIS QUESTION GO ON THE TEST PAPER ITSELF (2 PAGES). IF YOU ANSWER THIS QUESTION, TEAR OFF THESE TWO PAGES AND SUBMIT THEM WITH YOUR OTHER ANSWERS



a. (2pts) How many LANs are explicitly shown in the above diagram? _____

For questions (b) thru (d), ignore router 3's connection to the Internet

- b. (2pts) On the diagram above, assign MAC addresses wherever appropriate (abbreviations are ok).
- c. (2pts) On the diagram, assign IPv4 addresses wherever appropriate. For each LAN X, use addresses of the subnet: $X.X.X.0/24$ (e.g., for the 1st LAN, use addresses from 1.1.1.0/24)
- d. (2pt) On the diagram, assign line numbers to all appropriate switch interfaces.

For questions (e) thru (g), assume all IP forwarding tables, ARP tables, and Ethernet switching (also known as forwarding/filtering) tables are complete and up-to-date.

e. (3pts) Show the contents of switch 3's switching table.

- f. (3pts) Show the contents of host C's ARP table.
- g. (3pts) Show the contents of router 2's IPv4 forwarding table.
- h. (4pts) Consider host H sending an IPv4-PDU to host A. Show all of the Ethernet-PDUs that will be transmitted. For every Ethernet-PDU, indicate 4 addresses: Ethernet source/destination, and IPv4 source/destination.
- i. (4pts) Same as (h) except now assume the ARP table in host H is empty, and all other tables (i.e., IPv4 forwarding, the other ARP, and switch tables) are up-to-date. Show the contents of the additional Ethernet-PDUs that will be transmitted, i.e., only show Ethernet-PDUs that were not generated in your answer for (h).

B3: Networks (25 points) *Transport Layer*

- a. (8 pts) Suppose we want to design a protocol to achieve Reliable Data Transfer over a channel that has packet loss but no errors, i.e., bits/packets are never corrupted, but packets may fail to reach the destination. The channel does not re-order packets and also has no delayed duplicates. Only positive ACKs will be used. Which of the following features of conventional ARQ protocols would be required in this protocol and which would not be required? Give adequate justification for your answers. A simple Yes/No response without any justification will not receive any credit.
- (i) Checksums with error detection on packets and/or ACKs.
 - (ii) Timeouts with retransmission at sender.
 - (iii) Sequence numbers on packets.
 - (iv) Sequence numbers on ACKs.
- b. (2 pts) If a Go-Back-N receiver receives a packet whose sequence number is *not* the next expected sequence number, should it return an ACK? Explain why or why not.
- c. (6 pts) A full-duplex satellite channel has a transmission rate of 10 Mbps and a propagation delay of 0.4 seconds (total time for up to the satellite and down to earth). The Go-Back-N protocol is used to transmit packets over this channel with a window size of 50 packets. The size of an ACK is 100 bytes, and the processing time at either end is 10 milliseconds. Assuming there are no errors on the channel, what should be the packet size in bytes to keep the channel continuously busy in the forward direction?
- d. (4 pts) Suppose a TCP sender establishes a connection with a receiver, sends a large amount of data and then goes idle (since the sender application has no more data to send) at time t_1 . The TCP connection remains open but idle for a relatively long period of time. The sender application then wants to send more data at time t_2 . Since the same TCP connection is used for this second phase of data transfer, the TCP parameters *cwnd* and *ssthresh* used by TCP's congestion control algorithm retain their values from time t_1 when starting to send data at time t_2 . What are the consequences for TCP's congestion control by retaining these values? What are the advantages and disadvantages of doing so?
- e. (3 pts) Distinguish between the slow start and congestion avoidance phases of TCP congestion control. Is slow start growth logarithmic, linear, or exponential?
- f. (2 pts) What does it mean to say that a FIN segment results in a TCP connection becoming "half-closed"? What is a major benefit of only half-closing a connection instead of fully closing it in a single step?

B4: Networks (25 points) *Application Layer*

- a. (3 pts) An HTTP client wants to retrieve a Web document at a given URL. The IP address of the HTTP server is initially unknown. What transport and application-layer protocols besides HTTP are needed in this scenario?
- b. (12 pts) Alice sitting at a Web browser wants to retrieve a Web document from a server. The initial downloaded object is 1 Mbits long, and it contains 10 referenced objects, each of length 1 Mbits, from the same server. The client and server are connected by a single link of length 200 km. The signal propagation speed is 2×10^8 meters per second. Each data packet contains 1 Mbits of application data and you can ignore the size of headers in these packets. Packets containing only control (e.g. ACK or handshaking) and also HTTP requests are all 1000 bits long. The transmission rate on the link is 1 Mbps. If the link is shared by N parallel connections, then assume that each connection gets $1/N$ of the link bandwidth.

For each of the following cases, find the total time it will take for Alice to view the complete web document. Show your detailed work and provide explanations for your answers.

- (i) Non-persistent HTTP with no parallel TCP connections.
 - (ii) Non-persistent HTTP with the browser configured for 10 parallel connections.
 - (iii) Persistent HTTP with no parallel TCP connections.
 - (iv) Persistent HTTP with the browser configured for 10 parallel connections.
- c. (4 pts) Is any one of the above four cases significantly better than the others? If it is, explain why that is the case. If none of them is significantly better than the others, explain why that is so.
 - d. (4 pts) Without re-doing the computations, explain whether or not your answer to part (c) would be the same if the link transmission rate was increased to 1 Gbps. Justify your answer.
 - e. (2 pts) Now suppose that Alice shares the 1 Mbps link to the server with ten other users. Each of these other users uses non-persistent HTTP without parallel connections to retrieve the same Web document that Alice is trying to get. Which of the above four cases would be best for Alice to use now? Why?