National University of Computer and Emerging Sciences, Lahore Campus

Course:	Computer Networks	Course Code:	CS-3001
Program:	BS (Computer Science)	Semester:	Fall 2023
Duration:	N/A	Total Marks:	50
Submit Date:	06-Sep-2023	Weight	2.0%
Section:	BCS (5B)	Page(s):	3
Exam:	Assignment 01	Roll No.	

Name & Section:

Due Date: 6th September, 2023 during lecture time
Submission Mode & Time: Handwritten solutions to be submitted during the lecture.
Provide answers to the below questions, mostly taken from the course textbook.
You must have to write all the steps involved in the solutions. Writing just the answer will greatly reduce the marks.

Question # 1: **[1 + 2 + 2 marks, CLO # 1]**

Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R1 = 500 kbps, R2 = 2 Mbps, and R3 = 1 Mbps.

a. Assuming no other traffic in the network, what is the throughput for the file transfer?

b. Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

c. Repeat (a) and (b), but now with R2 reduced to 100 kbps.

Question # 2: **[2 + 2 + 1 marks, CLO # 1]**

Suppose end system A wants to send a large file to end system B. At a very high level, describe how end system A creates packets from the file.

When one of these packets arrives to a router, what information in the packet does the router use to determine the link onto which the packet is forwarded?

Why is packet switching in the Internet analogous to driving from one city to another and asking directions along the way?

Question # 3: **[2 + 1 + 1 + 1 marks, CLO # 1]**

What is an application-layer message? A transport-layer segment? A network-layer datagram? A link-layer frame?

Question # 4: **[2 + 2 + 1 marks, CLO # 1]**

Which layers in the Internet protocol stack does a router process? Which layers does a link-layer switch process? Which layers does a host process?

Question # 5: **[0.5 + 0.5 + 0.5 + 0.5 + 0.5 + 0.5 + 2 marks, CLO # 1]**

This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is "s meters/sec". Host A is to send a packet of size L bits to Host B.

a. Express the propagation delay, d_{prop}, in terms of m and s.

b. Determine the transmission time of the packet, d_{trans}, in terms of L and R.

c. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.

d. Suppose Host A begins to transmit the packet at time t = 0. At time t = d_{trans}, where is the last bit of the packet?

e. Suppose d_{prop} is greater than d_{trans}. At time t = d_{trans}, where is the first bit of the packet?

f. Suppose d_{prop} is less than d_{trans}. At time t = d_{trans}, where is the first bit of the packet?

g. Suppose s = 2.5 x 10^8, L = 1500 bytes, and R = 10 Mbps. Find the distance m so that d_{prop} equals d_{trans}.

Question # 6: **[5 marks, CLO # 1]**

In this problem, we consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A converts analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 56-byte packets. There is one link between Hosts A and B; its transmission rate is 10 Mbps and its propagation delay is 10 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

Question # 7: **[2 + 3 marks, CLO # 1]**

Consider a packet of length L that begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let d_i, s_i, and R_i denote the length, propagation speed, and the transmission rate of link i, for i = 1, 2, 3. The packet switch delays

each packet by d_{proc}. Assuming no queuing delays, in terms of di, si, Ri, (i = 1, 2, 3), and L, what is the total end-to-end delay for the packet?

Suppose now the packet is 1,500 bytes, the propagation speed on all three links is 2.5 x 10^8 m/s, the transmission rates of all three links are 2.5 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second link is 4,000 km, and the length of the last link is 1,000 km. For these values, what is the end-to-end delay?

Question # 8: **[2 + 3 marks, CLO # 1]**

A packet switch receives a packet and determines the outbound link to which the packet should be forwarded. When the packet arrives, one other packet is halfway done being transmitted on this outbound link and four other packets are waiting to be transmitted. Packets are transmitted in order of arrival. Suppose all packets are 1,500 bytes and the link rate is 2.5 Mbps. What is the queuing delay for the packet? More generally, what is the queuing delay when all packets have length L, the transmission rate is R, x bits of the currently-being-transmitted packet have been transmitted, and n packets are already in the queue?

Question # 9: **[5 marks, CLO # 1]**

Suppose you would like to urgently deliver 50 terabytes data from Boston to Los Angeles. You have available a 100 Mbps dedicated link for data transfer. Would you prefer to transmit the data via this link or instead use FedEx overnight delivery? Explain.

Question # 10: **[1 mark each, CLO # 1]**

Suppose two hosts, A and B, are separated by 20,000 kilometers and are connected by a direct link of R = 5 Mbps. Suppose the propagation speed over the link is 2.5 x 10^8 meters/sec.

a. Calculate the bandwidth-delay product, R x d_{prop}.

b. Consider sending a file of 800,000 bits from Host A to Host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any given time?

c. Provide an interpretation of the bandwidth-delay product.

d. What is the width (in meters) of a bit in the link? Is it longer than a football field?

e. Derive a general expression for the width of a bit in terms of the propagation speed s, the transmission rate R, and the length of the link m.