Bachelor of Information Technology 2nd Year 2nd Semester Examination 2024

Sub: Computer Networks

Full Marks: 100 Time: 3 hours

Answer either (a) or (b) from each question

Answers must be brief and to the points

1.

a. (3+3+(4+4+2))

i. Suppose all laptops in a large city are to communicate using radio transmissions from a high antenna tower. Is the data link layer or network layer more appropriate for this situation? Now suppose the city is covered by a large number of small antennas covering smaller areas. Which layer is more appropriate?

ii. In a network with distributed multiplexing using random access, assume that the distance between all node pairs is *d*. Give example of physical networks in which this could be possible.

iii. Three post offices cooperate to provide postal service. They are interconnected by mail vans which carry the mail. At each post office three processes are carried out in order to provide the postal service.

1. Collection of mail from service users
2. Sorting of mail
3. Packing of mail for the other post offices

Draw a layered model of the postal department. Define the functions and services provided by each layer. Assume that the mail packing department hands over the mail to the mail van. How a letter posted within the same postal area is processed?

b. (8+3+3+2)

i. Assume a company ABC having a manager, a secretary, a route operator, a warehouse keeper cum security officer, and a transponder with a few trucks located at Jadavpur. The company is selling computers. Suppose the manager comes to know about an order from a company XYZ located at Andaman. The manager decides to supply computer for that order. Describe the operations to deliver computers from ABC to XYZ as a series of layers.

ii. Assume that a voice channel occupies a bandwidth of 4 KHz. We need to multiplex 12 voice channels with guard bands of 500 Hz using FDM. Calculate the required bandwidth.

iii. In most networks, the data link layer handles transmission error by requesting damaged frames to be retransmitted. If the probability of a frame's being damaged is p, what is the mean number of transmissions required to send a frame if acknowledgements are never lost?

iv. A system has an n-layer protocol hierarchy. Application generates message of length M bytes. At each of the layers, an h byte header is added. What fraction of bandwidth is filled with headers?

2.

a. (6+5+5)

i. To understand the effect of window size on the performance of sliding window protocol, consider an error free channel of 1 Mbps with 20 msec propagation delay. The frame size is 256 bytes with negligible header. Acknowledgement frames can be ignored. Calculate the performance of sliding window protocol for window sizes varying from 1 to 32 in steps of 7 and plot them.

ii. Consider a 128×10^3 bits/second satellite communication link with one way propagation delay of 150 milliseconds. Selective repeat protocol is used on this link to send data with a frame size of 1 kilobyte. Neglect the transmission time of acknowledgement. What is the minimum number of bits required for the sequence number field to achieve 100% utilization?

iii. A bit stream 10011101 is transmitted using the standard CRC method. The generator polynomial is x3 + 1. Show the actual bit string transmitted. Suppose the third bit from the left is inverted during transmission. Show that this error is detected at the receiver's end.

b. (7+5+4)

i. A colony is set up in moon. The 10 Mbps link from the earth to the lunar colony measures about 242000 miles. Assume that the signal propagation speed is 186000 miles per second. Calculate the minimum round-trip time (RTT) for the link. Calculate the delay*bandwidth product for the link. If a camera on the lunar base sends 25 Mbyte image file to the earth as a sequence of 1 Kbyte packets, how many bits are needed for the sequence number if we assume the use of a sliding window protocol? What is the window size and buffer size at both sender and receiver?

ii. Suppose that instead of Go-Back-N ARQ, N simultaneous Stop-and-Wait ARQ processes are run in parallel over the same transmission line. Each frame is assigned to one of the N processes that is currently idle. The processes that have frames to send take turns transmitting in round-robin fashion. The frames carry the sequence number as well as an ID identifying which ARQ process the frame belongs to. How does the service offered by this protocol differ from the service offered by Go-Back-N ARQ?

iii. A network layer packet is split into 10 frames, each of which has an 80 percent chance of arriving undamaged. If no error control is done by the data link protocol, how many times must the message be sent on average to get the entire thing through?

3.

a. (4+3+4+3+2)

i. Suppose n stations compete for the access to a shared medium using ALOHA protocol. The probability that a Station transmits a frame is p. Find out the probability that a transmission becomes successful. What is the mean number of transmissions required to successfully transmit a frame? What is the line efficiency?

ii. Ethernet is sometimes said to be inappropriate for real time computing because the worst case retransmission interval is not bounded. Under what circumstances can the same argument be leveled at the token ring? Under what circumstances does the token ring have a known worst case? Assume the number of stations on the token ring is fixed and known.

iii. Suppose two 10 Mbps Ethernet LANs each containing N/2 stations are connected by a bridge. Assume that the efficiency of each Ethernet is 80 percent. Also assume that each station transmits frames at the average rate of 100 Kbps and each frame is equally likely to be destined to any station. What is the maximum number of stations N that can be supported in this extended Ethernet?

iv. Consider a 1 Mbps 2km token ring network with 10 stations including a monitoring station. The propagation speed of the signal is 2×10^8 m/s and the token transmission time is ignored. If each station is allowed to hold the token for 2 μsec, what is the minimum time for which the monitoring station should wait before assuming that the token is lost?

v. Connecting heterogeneous networks at the data link layer is very difficult. Why?

b. (2+3+3+4+4)

i. Modern Ethernet do not use CSMA/CD. Why?

ii. Determine the maximum length of cable (in km) for transmitting data at a rate of 500Mbps in an Ethernet LAN with frame size of 10000 bits. Assume the signal speed in the cable to be 200000 km/sec.

iii. Imagine two LAN bridges, both connecting a pair of 802.4 networks. The first bridge is faced with 1000 512 byte frame per second that must be forwarded. The second is faced with 200 4096 byte frames per second. Which bridge do you think will need the faster CPU? Discuss.

iv. In an 802.5 token ring, the sender removes its frame from the ring after the transmission is complete. What modifications would be necessary in the standard to have the receiver remove the frame instead? What would the consequence of this change be?

v. The IT department of J.U. has 3 Ethernet segments, connected by two transparent bridges into a linear network. One day the network administrator quits and is replaced by a person from computer center who is an expert in token ring. The new administrator, noticing that the ends of the network are not connected, quickly orders a new transparent bridge and connects both loose ends to it, making a closed ring. What happens next?

4.

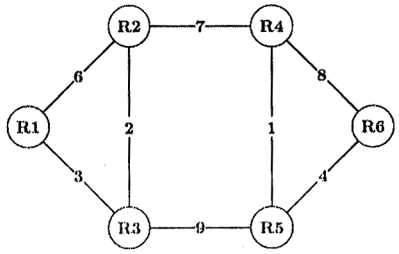
a. (5+3+5+7)

i. A computer on a 6-Mbps network is regulated by a token bucket. The token bucket is filled at a rate of 1 Mbps. It is initially filled to capacity with 8 megabits. How long can the computer transmit at the full 6 Mbps?

ii. Suppose that a datagram network has a routing algorithm that generates routing tables so that there are two disjoint paths between every source and destination that is attached to the network. Identify the benefits of this approach. What problems are introduced with this approach?

iii. As a possible congestion control mechanism in a network using virtual circuits internally, a router could refrain from acknowledging a received packet until (1) it knows its last transmission along the virtual circuit was received successfully and (2) it has a free buffer. For simplicity, assume that the routers use a stop-and-wait protocol and that each virtual circuit has one buffer dedicated to it for each direction of traffic. If it takes T sec to transmit a packet (data or acknowledgement) and there are n routers on the path, what is the rate at which packets are delivered to the destination host? Assume that transmission errors are rare and that the host-router connection is infinitely fast.

iv. Consider the following network. All the routers use the distance vector based routing algorithm to update their routing tables. Each router starts with its routing table initialized to contain an entry for each neighbor with the weight of the respective connecting link. After all the routing tables stabilize, which links in the network will never be used for carrying any data?



b. (5+5+4+6)

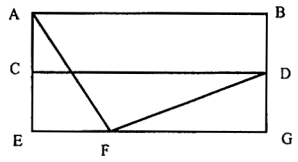
i. Below are the link state packets generated by routers in a subnet. What is the shortest distance between A and D?

A		B		C		D		E		F	
Seq		Seq		Seq		Seq		Seq		Seq	
Age		Age		Age		Age		Age		Age	
B	4	A	4	B	2	C	3	A	5	B	6
E	5	C	2	D	3	F	7	C	1	D	7
		F	6	E	1			F	8	E	8

ii. For a host machine that uses the token bucket algorithm for congestion control, the bucket has a capacity of 1 megabytes and the maximum output rate is 20 megabytes per second. Tokens arrive at a rate to sustain output at a rate of 10 megabytes per second. The machine needs to send 12 megabytes of data. What is the minimum time required to transmit entire data?

iii. What is the difference between flow control and congestion control? What are the reasons for which congestion may occur in a network?

iv. For the network given below, the routing table of the four nodes A, E, D, and G are shown. Suppose that F has estimated its delay to its neighbors A, E, D, and G as 8, 10, 12, 6 msec respectively and updates its routing table using Distance Vector Routing algorithm. Find the routing table for router F.



Destinations	Table for A	Table for E	Table for D	Table for G
A	0	24	20	21
B	40	27	8	24
C	14	7	30	22
D	17	20	0	19
E	21	0	14	22
F	9	11	7	10
G	24	12	22	0

5.

a. (7+5+4)

i. Suppose P, Q, and R are network service providers with respective CIDR address allocations C1.0.0.0/8, C2.0.0.0/8, and C3.0.0.0/8. Each providers customers initially receive address allocations that are a subset of the provider's.

P has the following customers:

PA, with allocation C1.A3.0.0/16

PB, with allocation C1.B0.0.0/12

Q has the following customers:

QA, with allocation C2.0A.10.0/20

QB, with allocation C2.0B.0.0/16

Assume there are no other providers or customers:

1. Give routing table for P, Q, and R assuming each provider connects to both of the other.
2. Now assume P is connected to Q and Q is connected to R, but P and R are not directly connected. Give tables for P and R.

ii. Suppose a router receives 600 bytes IP packet and has to forward the packet to a network with MTU of 200 bytes. Assume that the IP header is 20 bytes. Show the fragments that the router creates and specify the relevant values in each fragment header.

iii. Three subnets have the following network prefixes:

57.6.96.0/21, 57.6.104.0/21, 57.6.112.0/21, and 57.6.120.0/21

If these network prefixes are aggregated into a single route, what will be the aggregated network prefix and the mask?

b. (6+6+4)

i. Consider three IP networks A, B, and C. Host H_A in network A sends messages each containing 180 bytes of application data to a host H_C in network C. The TCP layer prefixes a 20 byte header to the message. This passes through an intermediate network B. The maximum packet size, including 20

byte IP header, in each network is 1000, 100, and 1000 bytes respectively. The network A and network B are connected through a 1 Mbps link, while B and C are connected by a 512 kbps link. Assuming that the packets are correctly delivered, how many bytes, including headers are delivered to the IP layer at the destination for one application message, in the best case? What is the rate at which application data is transferred to host H_C?

ii. An organization has been assigned the prefix 212.1.1.0/24 and wants to form subnets for four departments, with hosts as follows:

A 75 hosts

B 35 hosts

C 20 hosts

D 18 hosts

1. Give a possible arrangement of subnet masks to make this possible.
2. Suggest what the organization might do if department D grows to 32 hosts.

iii. A router has the following routes in its routing table:

Route	Outgoing Interface
10.0.0.0/8	E0
10.0.0.0/16	E1
10.0.1.0/24	S0
10.1.1.0/24	S1
10.1.0.0/16	S0
10.1.0.0/24	E1
10.1.1.1/32	S2

A packet arrives at the router with a destination address of 10.1.1.1. Which interface will the router use to forward that packet?

6.

a. (6+3+2+5)

i. Suppose you are transferring a file of 10 MB over a network, which has a capacity of 20 MB and 50 msec one-way delay. The packet size used in network is 1 KB. The initial slow start threshold is set to 10 MB. What is the effective throughput achievable for TCP?

ii. Suppose a user has two browser applications active at the same time and suppose that the applications are accessing the same server to retrieve HTTP documents at the same time. How does the server tell the difference between two applications?

iii. "TCP is a Byte stream not a message stream". Why?

iv. Consider a window controlled transfer over a connection with a RTT of 200 ms. The bottleneck link speed on the path is 2 Mbps. The data packet length is 1000 bytes. Assume that there is only one connection over the bottleneck link.

a. Determine the minimum window (in number of packets) required so that the bottleneck link is fully utilized (ignore the ACK transmission times).
b. If a window of 20 packets is used, determine the maximum possible utilization of the bottleneck link.
c. What happens if a window of 80 packets is used?

b. (2+7+2+5)

i. In addition to having acknowledgement field in the TCP header, ACK bit is also provided. What would happen if the ACK bit were not provided?

ii. Assume that TCP implements an extension that allows window sizes much larger than 64 KB. Suppose that you are using this extended TCP over a 1-Gbps link with a latency of 50ms to transfer a 10 MB file, and the TCP receive window is 1 MB. If TCP sends 1-KB packets, how many RTTs does it take until slow start opens the send window to 1 MB? How many RTTs does it take to send the file? Assume no congestion and no lost packets.

iii. Why do we use delayed acknowledgement and how?

iv. You are hired to design a reliable byte-stream protocol that uses a sliding window (like TCP). This protocol will run over a 1-Gbps network. The RTT of the network is 100ms, and the maximum segment lifetime is 30 seconds. How many bits would you include in the window size and sequence number fields of your protocol?