C2-R4: ADVANCED COMPUTER NETWORKS

NOTE:

1.	**Answer question 1 and any FOUR from questions 2 to 7.**
2.	**Parts of the same question should be answered together and in the same sequence.**

Time: 3 Hours **Total Marks: 100**

1.

a) Compare the channel requirements for voice traffic with the requirements for the real-time transmission of music, in terms of bandwidth, delay, and jitter. What would have to improve? By approximately how much? Could any channel requirements be relaxed?

b) Show that the maximum efficiency of pure Aloha is $1/(2e)$.

c) What advantage does a circuit-switched network have over a packet-switched network? What advantages does TDM have over FDM in a circuit-switched network?

d) Why do HTTP, FTP, SMTP, and POP3 run on top of TCP rather than on UDP?

e) Describe why an application developer might choose to run an application over UDP rather than TCP.

f) Suppose a host wants to establish the reliability of a link by sending packets and measuring the percentage that are received; routers, for example, do this. Explain the difficulty of doing this over a TCP connection.

g) Give an argument why the congestion-control problem is better managed at the internet level than the ATM level, at least when only part of the internet is ATM.

(7x4)

2.

a) Suppose Ethernet physical addresses are chosen at random (using true random bits).

i) What is the probability that on a 1024-host network, two addresses will be the same?

ii) What is the probability that the above event will occur on some one or more of 2^{20} networks?

iii) What is the probability that of the 2^{30} hosts in all the networks of (ii), some pair has the same address?

b) A CSMA/CD system has three copper twisted-pair segments connected together by two repeaters. Each segment is 200 meters long. The one-way processing delay at a repeater is one microsecond. We wish to operate this system at 10 megabits per second. If the speed of the signal in copper is 2×10^8 metres per second, what is the minimum size of the frame in such a system which will ensure that a collision never goes undetected?

(9+9)

3.

a) Consider an ARQ protocol that uses only negative acknowledgments (NAKs) but no positive acknowledgments. Discuss what timeouts would need to be scheduled. Which scheme (NAK or ACK) is preferable and why?

b) Consider an ARQ algorithm running over a 20-km point-to-point fiber link.

i) Compute the propagation delay for this link, assuming that the speed of light is 2×10^8 m/s in the fiber.

ii) Suggest a suitable timeout value for the ARQ algorithm to use.

iii) Why might it still be possible for the ARQ algorithm to time out and retransmit a frame, given this timeout value?

(9+9)

4.

a) An M/M/1 queueing system has arrival rate equal to 10 customers per second and service rate equal to 11 customers per second.
   - i) What is the average number of customers in the system?
   - ii) What is the average time spent by a customer in the system?
   - iii) What is the average time spent by a customer waiting in the queue?
   - iv) What is the average number of customers in the queue?

b) State and Prove Little's Theorem.

(9+9)

5.

a) Explain RED congestion avoidance mechanism and the approaches to QoS support.

b) TCP uses a host-centric, feedback based, windows based resource allocation model. How might TCP have designed to use instead the following models?
   - i) Host-centric, feedback based, and rate based
   - ii) Router-centric and feedback based

(9+9)

6.

a) What is the size of the multicast address space? Suppose now that two multi-cast groups randomly choose a multicast address. What is the probability that they choose the same address? Suppose now that 1,000 multicast groups are ongoing at the same time and choose their multicast group addresses at random. What is the probability that they interfere with each other?

b) Suppose datagrams are limited to 1,500 bytes (including header) between source Host A and destination Host B. Assuming a 20-byte IP header, how many datagrams would be required to send an MP3 consisting of 4 million bytes? Explain how you computed your answer.

(9+9)

7.

a) Suppose BLAST runs over a 10-Mbps Ethernet, sending 32K messages.
   - i) If the Ethernet packets can hold 1500 bytes of data, and option less IP headers are used as well as BLAST headers, how many Ethernet packets are required per message?
   - ii) Calculate the delay due to sending a 32K message over Ethernet directly and broken into pieces as in (i), with one bridge.

   Ignore propagation delays, headers, collisions, and inter packet gaps.

b) 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 100 ms to transfer a 10-MB file, and the TCP receive window is 1 MB. If TCP sends 1-KB packets (assuming no congestion and no lost packets):
   - i) How many RTTs does it take until slow start opens the send window to 1 MB?
   - ii) How many RTTs does it take to send the file?
   - iii) If the time to send the file is given by the number of required RTTs multiplied by the link latency, what is the effective throughput for the transfer? What percentage of the link bandwidth is utilized?

(9+9)