Lahore University Of Management Sciences
BSc (Honours) Programme
MS Computer Science Programme

Roll #: _______________________

Course Title: __________ Computer Networks________
Course Code: _______ CS 471 _______
Instructor: ___________ Irfan Uddin Ahmad ___________
Exam: __________ Final __________
(mid-term/final/others)

DO NOT OPEN THIS EXAM UNTIL TOLD TO DO SO.

The instructions below must be followed strictly. Failure to do so can result in serious grade loss.

⇒ You may not
  • talk to anyone once the exam begins.
  • leave the examination room and then return.

⇒ Keep your eyes on your own paper.
⇒ Read all questions very carefully before answering them.

Specific instructions:

2. Calculator usage: _______ Allowed _______
3. Write in pen/pencil: _______ Any. Please write clearly, avoid overwriting and crossing. _______
4. Any other instruction(s): Count the total number of sheets in this exam paper (There should be a total of 17 sheets). Solve all questions on the space provided on this question paper. Best of Luck!

__________________________________________
__________________________________________
**Question 1:** (5 points) Dr. Sajha and Dr. Majha have decided to make a “phone call” over the Internet (Internet telephony). Assume that the system they use is the one shown in the figure below. Dr. Sajha’s and Dr. Majha’s computers are connected to the Internet via their respective Internet Service Provider (ISP). To reach their respective ISP they have to go via the public telephone network. The public telephone network consists of analog “access” networks and a digital “core” network. The ISPs are digitally connected to the Internet.

How many A/D conversions (A/D, Analog to Digital) and how many D/A conversions (D/A, Digital to Analog) are performed on the signal as it propagates from Dr. Sajha’s mouth to Dr. Majha’s ear? Motivate your answer briefly.

![Diagram of Internet telephony system]

Note, each computer must be equipped with a microphone and a speaker.
**Question 2:** (8 points) A sender transmits data to a receiver at 56 kbit/s. Transmission is over an analogous media using QPSK (quadruple phase shift keying) with four different phase angles to code the digital information in a form suitable for transmission over the analogous media.

**a)** How many bits can be transferred per signal element?

**b)** Which signaling rate (baud rate) is achieved?
Question 3: (12 points) Two hosts are communicating over a link, using stop-and-wait flow control. The (one way) propagation delay is 2 ms, packet size is 1000 bits and the data rate is 2 Mbit/s.

a) Calculate the link utilization and show how the formula to calculate the utilization is derived. Declare any approximations or assumptions made.

b) How is the link utilization affected if “sliding window” flow control is used with window size of 6? Motivate your answer.
Extra Space for Question 3
Question 4: (12 points) A transmitter (A) makes use of Go-Back-N ARQ (Automatic Repeat reQuest) with a 3 bit sequence number and a window size of 7 frames to transmit information to a receiver (B). The sequence of messages is shown in the figure below. The receiver returns ACK (acknowledgement) and/or REJ (reject) messages a-d. These ACK/REJ messages contain the next sequence number expected by the receiver.

a) What kind of messages are a-d? State if a-d are ACK or REJ and give the appropriate sequence numbers.

b) Give the appropriate sequence numbers x-w.
**Question 5:** (6 points) Consider two local area networks, one Ethernet and one Token Ring.

a) Describe the principle behind the medium access protocols in use in Ethernet and in Token Ring.

b) Which is the biggest conceptual difference between these two protocols when it comes to handling of collisions?

c) Suppose all stations connected to the local area networks have information to transmit. Which of the two protocols is the most “fair” one? Motivate your answer.
**Question 6:** (16 points) CSMA/CD (Carrier Sense Multiple Access with Collision Detection) limits the maximum distance between two computers attached to the same Ethernet (10 Mbit/s).

a) Given that the minimum packet size (control information and data) for Ethernet is 500 bits and that the propagation velocity of the media is $2 \times 10^8$ meters/second, what is the maximum distance between two computers?

b) What is the maximum distance if we increase the transmission speed to 100 Mbit/s (Fast Ethernet) given that the same minimum packet size as for Ethernet is used?

c) For Gigabit Ethernet (1000Mbit/s) the minimum packet size allowed is increased by a factor of 8. What is then the maximum distance between two computers?

d) Calculate the time it takes to transfer (from starting to send the first bit until the last bit is received) a TCP acknowledgement between two computers 50 meters away, using Ethernet, Fast Ethernet or Gigabit Ethernet respectively. Assume that an Ethernet frame contains 18 bytes of control information (header and trailer), and that the TCP acknowledgement requires 20 bytes of TCP header, no TCP data and 20 bytes of IP header.
Extra Space for Question 6
**Question 7:** (12 points) The figure below shows a network where C is a bridge, E is a router, and A, B, D, F are ordinary computers. All networks are of type Ethernet. Assume A sends an IP datagram to F and consider this message at the places marked a, b, and c in the figure.

**a)** Give the source and destination MAC (medium access control) addresses, and the source and destination IP (Internet protocol) addresses contained in the message when it is at the locations a, b, and c.

**b)** How would your answer change if addresses k, m, n and p are changed to k’, m’, n’ and p’ respectively?
**Question 8:** (9 points) You have to connect the local Ethernet networks of your department (see figure below). The department has two working groups. The members of a group communicate with each other frequently, and use the same resources (servers, printers, etc.). The members of different groups communicate infrequently. The members of the first group use computers connected to LAN1 and LAN2, while the members of the other group use computers on LAN3 and LAN4. LAN1, LAN2 and LAN3 are located in the same building on the same floor, while LAN4 is at a remote site on the other end of the city.

a) You are using devices A-E to connect the LANs to each other and to the Internet. For which devices A-E would you use repeater, bridge and router to keep the network simple but efficient? Motivate your answer!

b) Why do you use two connections (B and D) to the Internet from LAN1, LAN2 and LAN3 that are directly connected to each other?
Extra Space for Question 8
Question 9: (8 points) Higher layer Internet protocols may run over the transport protocols TCP (Transmission Control Protocol) or UDP (User Datagram Protocol), or directly over IP (Internet Protocol). For each of the following higher layer protocols, explain briefly what service they provide and give the preferable underlying protocol (IP, TCP or UDP). Motivate your answer briefly.

a) File Transfer Protocol (FTP)
b) Internet Control Message Protocol (ICMP)
c) IP Telephony
d) Telnet
**Question 10:** (12 points) Dr. Sajha is about to transfer a file to Dr. Majha using FTP (File Transfer Protocol). Dr. Sajha’s and Dr. Majha’s computers are connected via a hub, two routers and a bridge as shown in the figure below. All links consist of 10BaseT Ethernet segments. For each of the protocols below, state in which nodes (1-6) the protocol is (normally) implemented. Motivate your answer briefly.

a) FTP (File Transfer Protocol)
b) CSMA/CD (Carrier Sense Multiple Access with Collision Detection)
c) IP (Internet Protocol)
d) TCP (Transmission Control Protocol)
e) Manchester Encoding
f) ARP (Address Resolution Protocol)

![Network Diagram]

Note: All links are 10BaseT Ethernet segments.
Extra Space for Question 10
Useful Formulae:

Fourier analysis:
\[ a_n = \frac{2}{T} \int_0^T g(t) \sin(2\pi nt) \, dt \]
\[ b_n = \frac{2}{T} \int_0^T g(t) \cos(2\pi nt) \, dt \]
\[ c = \frac{2}{T} \int_0^T g(t) \, dt \]

Nyquist Theorem: \[ C = 2H \log_2 (V) \]
Shannon Theorem: \[ C = H \log_2 (1 + S/N) \]

Poisson distribution: \[ Pr[k] = \frac{G^k e^{-G}}{k!} \]

Pure ALOHA: \[ S = GP_0 \]
\[ P_0 = e^{-2G} \]

Slotted ALOHA: \[ S = GP_0 \]
\[ P_0 = e^{-G} \]