B1. NETWORKS (25 points)

(a) (7 points) Describe the relative advantages and disadvantages among hub, switch, and router.

(b) (5 points) You are to build a CSMA/CD LAN running at 1 Gbps over a 1 km (kilometer) cable with no repeaters. The signal propagates in the cable at the speed of 200,000 km/sec. What is the minimum frame size?

(c) (6 points) Internet is made up of networks with different link layer technologies. To support such heterogeneity, Internet adopts a best-effort IP datagram delivery service with a global IP addressing scheme. Name the protocol running at the link layer which is also critical to facilitate such heterogeneity, and explain how this protocol works and why this protocol is necessary in the overall Internet architecture.

(d) (7 points) Data frames of 1000 bits are transmitted over a 1 Mbps satellite wireless link. Acknowledgements are always piggybacked onto data frames. Assume that the one-way propagation delay is 270 milliseconds, the frame headers are very short, and 3-bit sequence number are used. What is the maximum achievable link utilization for
(a) stop-and-wait protocol,
(b) go-back-N protocol, and
(c) selective repeat protocol?

22. NETWORKS (25 points)

(a) (4 points) The Network Layer in the Internet consists of the IP Protocol and a variety of routing protocols. The scalability of the Internet architecture directly depends on the scalability of the protocols and associated mechanisms in the Network Layer. Indicate which of the following features are vital towards the scalability of the Internet's Network Layer:

Reliable data transfer, multiplexing and demultiplexing, 16-byte long addresses, hierarchical addresses, fragmentation and reassembly, longest prefix matching, poisoned reverse, centralized routing algorithms, route aggregation, use of checksums on the IP header, hierarchical routing, tunneling, three-way handshake, virtual circuits.

(b) (6 points) From the features in part (a) that you picked as being vital to scalability, take any three and for each of these features, explain what it means and why it is so important in making the Internet's Network Layer scalable.

(c) (9 points) What is meant by an intra-AS routing protocol and an inter-AS routing protocol? What are the similarities and differences between (i) RIP and OSPF, and between (ii) RIP and BGP?

(d) (6 points) An organization has been allocated the space of IP addresses 214.97.128.0/21. What is the maximum number of host addresses that can be assigned from this space? Suppose the organization wants to have five subnets as follows: Subnet A to support 250 hosts, Subnets B and C to support 120 hosts each, and Subnets D and E to support two hosts each. Assign network addresses to each of these five subnets.

B3. NETWORKS (25 points)

For the TCP protocol:

(a) (4 pts) Explain how the retransmission timer value is calculated (you must specify the correct formulas for the calculation), when the timer is reset, and what happens when the timer expires.

(b) (4 pts) Explain what is "fast retransmit" and how it is triggered.

(c) (7 pts) Describe the 3-way handshake specifying all the messages and actions upon the sending/receipt of each message. For an action you must specify which state does sender or receiver go to, whether it allocates some memory and what is stored in this memory. For messages, you must specify the message type and what information is carried inside the message.

(d) (10 pts) Assume the TCP protocol with fast retransmit. The sender starts sending packet 1 at time 0 and the RTT is 10ms. All packets sent are 1 MSS long. Ignore packet transmission delay and assume that all packets in the window are sent simultaneously. Also assume that the retransmission timeout interval is 10 ms. Packets 5, 52 and 80 are lost. The sender learns of the packet 5 loss via the retransmission timer timeout. It learns about loss of packets 52 and 80 via triple duplicate acknowledgment. Fill the cwnd values in the table on the next page, and indicate the numbers of packets sent at each time interval. In the fourth column indicate if the TCP protocol performs slow-start or congestion avoidance in the given time interval. Include the page with the table containing your answer in your answer pages for this question.

Table for Networks Question B3(d):

Time (ms)	Cwnd (packets)	Packets sent (numbers)	TCP state
0			
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			
200			

. NETWORKS (25 points)

ur task is to design a "pseudo reliable" transport protocol to the llowing specification. All packets sent must eventually be received at ceiver and delivered to the application, but it is not necessary that delivered in the same order that they are sent. The network layer is reliable in which the underlying channel may introduce errors into ckets, lose packets entirely, or deliver packets in a different sequen om which they were transmitted. You are asked to use the Go-Back-N otocol as a starting point for the design of this new protocol. Answer llowing questions. You don't need to provide any code or pseudo-code f ur answers, but try to be as precise as possible.

(7 points) The protocol you are asked to design is "pseudo reliable. es this simplify your task, or make it harder? Explain your answer! As rt of this answer, explain whether or not the unmodified Go-Back-N otocol will serve your needs. If not, then explain why not. If yes, th plain why it may be necessary to design a new protocol. Under what rcumstances (e.g. low/high bandwidth, low/high delay, low/high loss ra uld the new protocol work better than Go-Back-N?

(2 points) Similar to the Go-Back-N protocol, you may assume that th der has a finite buffer space of N packets (the Window size). What is sonable assumption to make in your new protocol for the amount of buf ce in the Receiver? Justify your answer.

(2 points) What should be the semantics of an acknowledgement in you protocol?

(7 points) Actions of the Sender:
(i) What information does the Sender need to keep track of? Hint: example, base of the window, next sequence number to be transmitte etc.
(ii) What should be the actions of the Sender when it receives an acknowledgement?
(iii) What should the Sender do when a timeout occurs?

(7 points) Actions of the Receiver:
(i) What information does the Receiver need to keep track of?
(ii) How does the Receiver detect a duplicate packet, and what doe do when it receives a duplicate packet?
(iii) What does the Receiver do when it receives a packet for the first time?