

Indian Statistical Institute
Semester Examination: 2025
Course Name: M. Tech. in Cryptology and Security
Subject Name: Computing Systems II

Date: 29-04-2025

Maximum Marks: 100

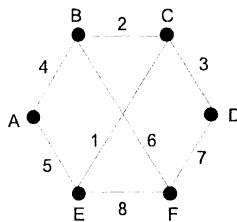
Duration: 3 hours

Instructions: You **may** attempt **all** the questions which carry a total of **110** marks. However, the maximum marks you can score is only **100**.

1. (a) Recall that a code with a minimum Hamming distance of D can correct any error pattern of $\lfloor \frac{D-1}{2} \rfloor$ or fewer errors. Show an error pattern with $\lfloor \frac{D-1}{2} \rfloor + 1$ errors that cannot be corrected by the code. [4]
(b) Consider the use of CRC with generator polynomial $G(x) = x^4 + x^3 + 1$ for error detection. Show the transmitted string for the message string 1 1 0 0 1 1. Construct a burst error of length 5 on the transmitted string in such a way that the error cannot be detected by the CRC with the given $G(x)$. [3+3=6]
(c) Describe the basic principle of direct-sequence spread spectrum. [7]
(d) State the difference between slow and fast frequency hopping. [6]
2. (a) A bitstuffing based framing uses 01111110 as the flag. (i) If the output bitstring after stuffing is 100111110010, determine the input bitstring. (ii) Determine two input bitstrings of length 12 each, so that the corresponding output bitstrings produce maximum and minimum stuffed bits. [2+(2+2)=6]
(b) Consider a 45 kbps network link connecting the earth and the moon. The two way propagation delay between the earth and the moon is 2.8 seconds.
 - i. Suppose that 9000 bits packets are sent over this link using a stop-and-wait protocol. What data transfer rate can be achieved out of it? What is the utilization of the link?
 - ii. If a sliding-window protocol is used instead, what is the smallest window size that achieves the maximum data rate? If a window size of 20 packets is used, what data rate will be achieved? Assume that no errors have occurred. [(3+2)+(3+2)=10]
(c) Suppose that a 40 Mbps line is used for 40 simultaneous sessions. Each session generates Poisson traffic with 25 packets/second. Packet lengths are exponentially distributed with a mean of 8000 bits. Which of the two options below has a lower average network delay and why?
 - i. Each of the 40 sessions is given a dedicated 1 Mbps channel.
 - ii. All the 40 sessions compete for a single 40 Mbps shared channel. [6]
(d) A 10-node network runs the CSMA MAC protocol. The maximum data rate of the network is 10 Megabits/s. Each node sends traffic at an average rate of 1 Megabit/s per node, including retries. Assume that the network's utilization is 0.75. What percentage of packets, sent by the nodes (including retries), do experience a collision? Assume that no packets get dropped in the network except due to collisions. [5]
3. (a) Consider a slotted ALOHA system with 4 nodes, in which each node transmits a frame with probability p . What is the probability P that in a given time slot, one of the 4 nodes successfully transmits a frame? Determine p that maximizes P . [2+3=5]
(b) Consider a CDMA/CD network that transmits data at a rate of 10^8 bps over a 1 km cable with no repeaters. If the minimum frame size required for this network is 1250 bytes, what is the signal speed (meter/second) in the cable? [5]

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- (c) Under what condition does bit-map perform better than contention based protocols, and why? [5]
- (d) What problems will occur if the CSMA/CD protocol is used in wireless LANs? How does CSMA/CA address the problems? [4+4=8]
4. (a) Suppose a packet of 10,000 bits is sent from A to B over a network. There is a router R between A and B , which has sufficient buffer space. The network is lightly loaded so that there are no queuing delays. Propagation delay is assumed to be negligible.
- Assume that the network is a *store and forward* packet-switched network. Both the links $A \rightarrow R$ and $R \rightarrow B$ have a transmission rate of 10 kbps. How long does it take to send the packet from A to B ?
 - Assume that the network is a circuit-switched network, whose circuit setup time is 1 second. Let the transmission rate of the circuit between A and B be X kbps. Find the values of X for which the circuit-switched network require less, equal, or more time than the packet-switched network for transmitting the packet from A to B . [4+3=7]
- (b) Consider the subnet shown below where communication delays are shown as labels on the bidirectional links. Distance vector routing is used. The following vectors have just come into router C : (5, 0, 8, 12, 6, 2) from B ; (16, 12, 6, 0, 9, 10) from D ; and (7, 6, 3, 9, 0, 4) from E . The measured delays to B , D , and E , are 2, 3, and 1, respectively. What is C 's new routing table? Mention both the outgoing link to be used and expected delay. [7]



- (c) A token bucket is characterized by a token generation rate $R = 10$ Kbytes/s, an infinite maximum output rate M and a bucket size $B = 50$ KBytes. Initially the bucket is full. Assume that a sender emits 15 KBytes every 0.5 seconds in a periodic manner, starting at $t = 0.5$ seconds.
- How many tokens are left in the bucket after 1.5 seconds?
 - How long will it take until packets start to be queued?
 - What would be the maximum burst size (KBytes) if the token bucket were modified to impose a maximum output rate M of 20 KBytes/s? [3+2+3=8]
- (d) A server has an IP address 160.36.30.110 and network mask 255.255.254.0. Find the broadcast address, network ID, and the number of hosts that can be supported. [2+2+2=6]
- (e) A large number of consecutive IP addresses are available starting at 54.128.128.0. Suppose that three organizations- A, B, and C request 1000, 3000, and 500 addresses, respectively, and in that order. For each of these addresses, give the first IP address assigned, the last IP address assigned, and the mask in the w.x.y.z/s notation. [3+3+3=9]