Problem Set 1

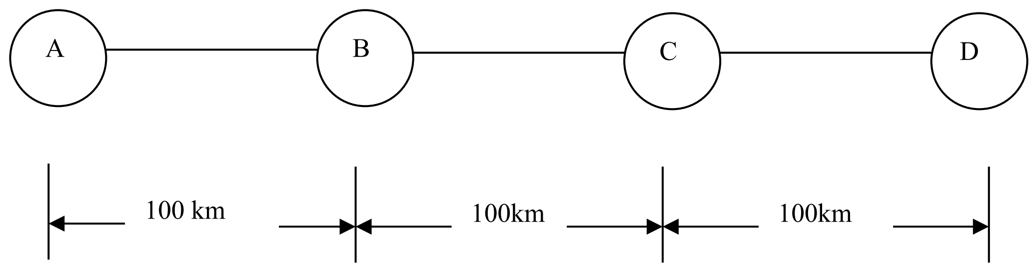
1. Why do we use layering in computer networks?

2. Name the 7 OSI layers and give the corresponding functionalities for each layer.

3. Compare the network performance of the 3 Multiple Access Protocols in terms of transmission delay.

4. Circle the correct answer
   - (i) Existing telephone networks use
     1. Packet switching
     2. Circuit switching
   - (ii) Which retransmission scheme requires less buffer space at the receiver?
     1. Selective Repeat
     2. Go Back N

5. Consider a 4-node network, A, B, C and D as shown below.



A is the sender and D is the receiver. Packets (if packet switching) traverse from A through B to C. Assume that headers for packet switching are 1000 bits. Assume the propagation rate is d = 10^3 km/sec for both path AB and path BC. Channel speed for each path is:

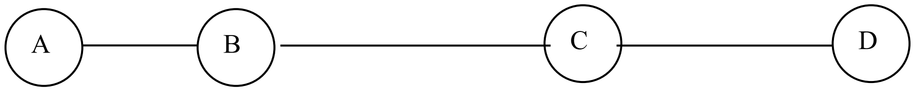
AB: b_1 = 200 kbps
BC: b_2 = 100 kbps
CD: b_1 = 200 kbps.

Distance between A and B is 100 km, BC is 100 km and CD is 100 km. Now, assume A has 1 Meg (= 10^6) bits of data to send to c, and also assume no processing delay at Nodes B and C. Answer the following questions. Show the calculation steps and write the final answer in the boxes provided.

(1) Now assume packet switching technique is used to send the data. Totally 100 packets with the same number of bits are created out of the 1 Meg bits message. Before transmission each packet has to add extra 1 k bits as a header. Calculate the time interval between the first bit of data is sent by A and the last bit is received by C.

[ ] ms

6. Consider a network of four nodes, A, B, C and D, as shown below:



A is the sender, and D is the receiver. Packets (if packet switching is used) traverse from A to B, to C, then to D. The following parameters are available.
Propagation delay between each pair of nodes:

A and B: d_1 = 10ms
B and C: d_2 = 20ms
C and D: d_3 = 15ms (where **ms** stands for milliseconds)

Channel speed between each pair of nodes:

A and B: b_1 = 500kbps
B and C: b_2 = 200kbps
C and D: b_3 = 1000kbps

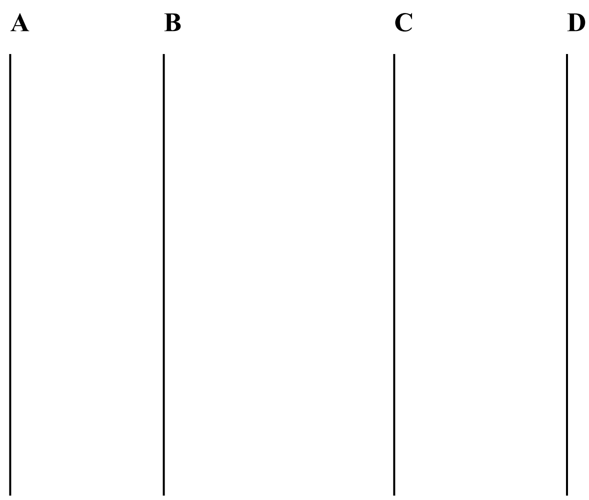
Assume that upon receiving an entire packet, an intermediate node (i.e. B and C) reassembles it immediately (without any delay). The reconstructed packet is forwarded to the next hop node as soon as the packet is reconstructed if the node is not currently transmitting a message/packet and if there is no message/packet waiting to be transmitted. If the node is currently transmitting a packet, the reconstructed packet is forwarded to the next hop node as soon as all the packets waiting to be forwarded, including the one currently being transmitted, are transmitted to the next hop node.

Now, assume that A has 1 **Meg** (i.e. one million) bits of data to transmit to D. Answer the following questions. Show the calculation steps, and write the final answer in the boxes provided.

a) Assume that the packet switching technique is used to transmit data. How many packets are created from the 1 Meg bits of data? Assume that the packet size is 10kbits**.**

[ ] **packets**

b) Assume that the packet switching technique is used. Find the time (in ms) from when the first bit of data (i.e., the first bit of the first packet) is sent by A to when the last bit of data (i.e., the last bit of the last packet) is received by D. Assume that the size of the header attached to each packet is zero. The packet size is 10kbits. Use the following diagram to show your steps.
ms



c) Find out the throughput in case (c).
kbps

7. Repeat Question 10 using circuit switching. Assume that the connection request and connection accept are 1000 bits.

8. When odd parity is used, the total number of ones in a bit string after the parity bit is added is odd. Using odd parity, add the correct parity bit to the end of the following bit sequences.
    1. 111010000
    2. 01010101

   Using even parity, add the correct parity bit to the end of the following bit sequences.
    1. 11011010011
    2. 11

9. Find the bit sequence transmitted after addition of check bits to the following messages. The check bits are added using CRC scheme. Assume the CRC code polynomial as $x^4 + x^2 + 1$.
   a) 1101000
   b) 1010011
   c) 1100111

10. If the bit sequence 101001100 is received at the host, and if the code polynomial is the same as that used in Question 13, is there an error with this transmission?

11. (a) Compute the Hamming code for the following bit sequences using EVEN parity;

    (1) 1100, (2) 10110, (3) 11110, (4) 10100011.

    For (a), write out how each bit maps onto the appropriate non-power-of-two bit position using this table. You may not need to use all bit positions, so leave those bit positions blank.

Value of the bit								
Bit position	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

    For (a), calculate the binary representation for each bit position 1-8.

Bit Position	**MSB**			**LSB**
1				
2				
3				
4				
5				
6				
7				
8				

    Compute each check bit using even parity and fill in the rest of the table with the check bits. It is still possible you may not fill in the entire table.

    Do something similar for (2), (3), and (4).

    (b) Assuming EVEN parity, which bit is in error if the following erroneous Hamming code is received?

    0010011

12. Which bit is in error if the following erroneous Hamming code is received? Use Odd Parity.

0010011

The positions of each bit in the message can be defined as follows:

the received bits:	0	0	1	0	0	1	1
	↓	↓	↓	↓	↓	↓	↓
the positions of bits:	1	2	3	4	5	6	7

13. Explain how the Go-Back-N and Selective Repeat protocols work. Come up with some example transmission sequences, and illustrate how they work for them. Which one has the better throughput? Which one requires less buffer space at the receiver? (Use diagrams for your explanation if necessary)

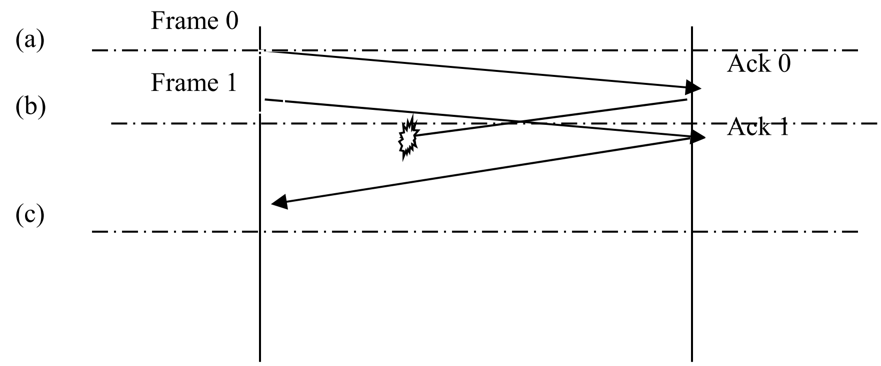
14. Repeat the above question now assuming that some data frames are lost.

15. Repeat the above question now assuming that some acknowledgement frames are lost.

16. Assume a sliding window protocol is used between two nodes to control traffic flow. Assume also that the sender's window size is four and that the receiver's window size is one. The sequence number can vary from 0 to 7. Write the contents of the sender's and receiver's sliding windows at each time instant for the following situation .

Time	***Event at sender***	***Event at receiver***
1	frame 0 sent	(none)
2	frame 1 sent	frame 0 received, frame 0 ack sent
3	frame 0 ack received	frame 1 received, frame 1 ack sent
4	frame 2 sent	(none)
5	frame 3 sent	(none)
6	frame 1 ack received	frame 2 received, frame 2 ack sent
7	frame 4 sent	frame 3 received, frame 3 ack sent
8	frame 2 ack received	frame 4 received, frame 4 ack sent
9	frame 4 ack received	(none)

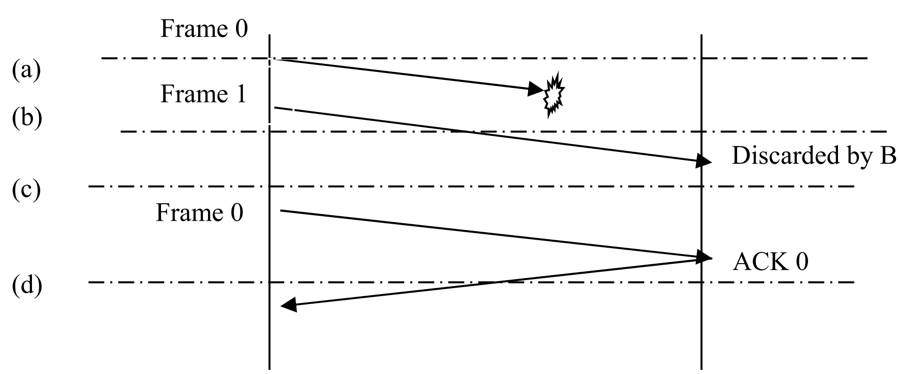
17. Consider the sliding window protocol. A is the sender, and B is the receiver. Two bits are used for a frame sequence number, and thus, the frame sequence number varies from 0 to 3. The sender's (**A's)** and the receiver's (**B's)** window sizes are the same and are both equal to 2. See the following diagram.



Assume that at time (a), the sender's window is empty and that the receiver's window contains 0, 1. A sends frames one by one. All frames (frames 0,1) are received by B without any loss/error. Acknowledgement for frame 0 is lost; A receives Acknowledgement for frame 1 successfully.

Show the contents of the sender's window and of the receiver's window at time (b) and (c).

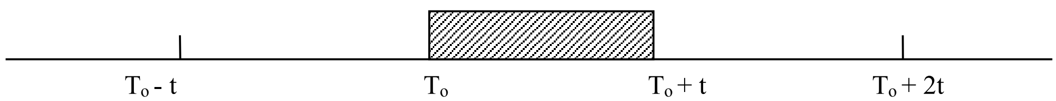
18. Consider the sliding window protocol with Go-Back-N retransmission protocol. A is the sender, and B is the receiver. Two bits are used for a frame sequence number, and thus, the frame sequence number varies from 0 to 3. The sender's (**A's)** window sizes is 2. See the following diagram.



Assume that at time (a), the sender's window is empty and that the receiver's window contains 0, 1. A sends frames one by one. Frame 0 is lost on the way; frame 1 is received by B without any error but B discards it. B doesn't send acknowledgement for discarded frames. At time (c), A timeouts frame 0 and resends frame 0. Finally acknowledgement for frame 0 is received by A without any error.

Show the contents of the sender's window and of the receiver's window at time (b), (c) and (d).

19. Given the time for packet transmission, mark the vulnerable period for ALOHA and slotted ALOHA, give your reasons.



20. Assume that several stations share a channel and use fixed-size packets to communicate. The 2 farthest stations are A and B. The transmission time for 1 packet is t_1. The propagation delay is t_2.

    a) For Pure ALOHA protocol, the vulnerable period is __________
    b) For slotted ALOHA, the vulnerable period is ___________
    c) For 1-Persistent CSMA, the vulnerable period is ____________

21. What are the differences between 1-Persistent, Non-Persistent, and P-Persistent CSMA.

22. Host A and B are connected with a Ethernet LAN. CSMA/CD is used in their communication. Suppose the end to end distance between A and B is 500 meters. The Channel speed is 10Mbps and propagation speed is 200m/μsec. Suppose at time 0, A has a 512 bits packet to send to B. and after 2 μsec, B also has a 512 bits data packet send to A. Will transmission of A and B collide? Describe your reasons. If collision happens, when will A detect it?

23. In P-Persistent CSMA, assume station A is the only one who has a packet to send.

    a) What's the probability that station A will send out the packet when it senses an idle channel?
    b) What's the probability that station A tries exactly 'n' times before sending out the packet successfully?
    c) What's the probability that station A tries less than 'n' times before sending out the packet successfully?
    d) If there are n stations, all of them have a packet to send and sense the idle channel at time *t*, what's the probability that no packet will be sent at time *t*?

e) Same assumption as in e), what’s the probability that a collision will happen at time *t*?

24. What does CSMA/CD stand for? Explain the CSMA/CD protocol used in Ethernet. What is Carrier Sense (CS)? What is Collision Detection (CD)? How do they improve network utilization?