Computer Networks (CS30006)

Practice Questions

Solution

Q 1. A telephone line normally has a bandwidth of 3000 Hz (300 to 3300 Hz) assigned for data communication. The SNR is usually 3162. What will be the capacity for this channel?
Solution:
C = 3000 * $\log_2$(1 + SNR) = 3000 * 11.62 = 34860 bps

Q. 2 The SNR is often given in decibels. Assume that SNR(dB) is 36 and the channel bandwidth is 2 MHz. Calculate the theoretical channel capacity.
Solution:
SNR(dB) = 10 * $\log_{10}$(SNR)
SNR = $10^{(SNR(dB)/10)}$
SNR = $10^{3.6}$ = 3981
Hence, C = 2 * 10^6 * $\log_2$(3982) = 24 MHz

Q 3. A bit stream 10011101 is transmitted using the standard CRC method. The generator polynomial is x^3+1.

1. **What is the actual bit string transmitted?**
2. **Suppose the third bit from the left is inverted during transmission. How will receiver detect this error?**

Solution-
Part-01:

- The generator polynomial G(x) = x^3 + 1 is encoded as 1001.
- Clearly, the generator polynomial consists of 4 bits.
- So, a string of 3 zeroes is appended to the bit stream to be transmitted.
- The resulting bit stream is 10011101**000**.

Now, the binary division is performed as-

```
            10001100
1001   | 10011101000
         1001
         00001
           0000
           00011
             0000
             00110
               0000
               01101
                 1001
                 01000
                   1001
                   00010
                     0000
                     00100
                       0000
                       0100  <---- CRC
```

From here, CRC = 100.

Now,

- The code word to be transmitted is obtained by replacing the last 3 zeroes of 10011101**000** with the CRC.
- Thus, the code word transmitted to the receiver = 10011101**100**.

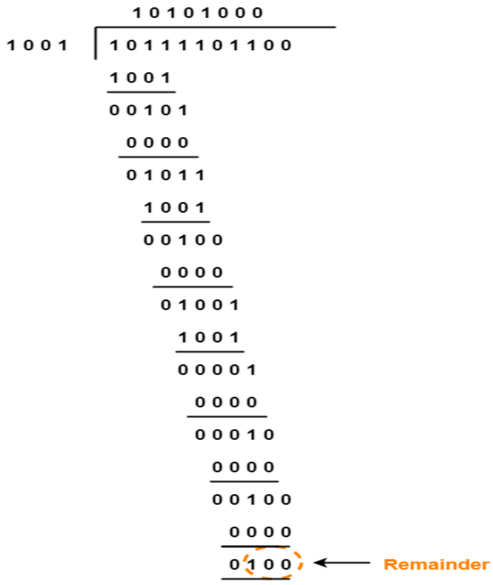
Part-02:

According to the question,

- Third bit from the left gets inverted during transmission.
- So, the bit stream received by the receiver = 10111101100.

Now,

- Receiver receives the bit stream = 10111101100.
- Receiver performs the binary division with the same generator polynomial as-



From here,

- The remainder obtained on division is a non-zero value.
- This indicates to the receiver that an error occurred in the data during the transmission.
- Therefore, receiver rejects the data and asks the sender for retransmission.

Q 4. A and B are the only two stations on Ethernet. Each has a steady queue of frames to send. Both A and B attempts to transmit a frame, collide and A wins first back off race. At the end of this successful transmission by A, both A and B attempt to transmit and collide. What is the probability that A wins the second back off race?

Solution-

According to question, we have-

1st Transmission Attempt-

- Both the stations A and B attempts to transmit a frame.
- A collision occurs.
- Back Off Algorithm runs.
- Station A wins and successfully transmits its 1^{st} data packet.

2nd Transmission Attempt-

- Station A attempts to transmit its 2^{nd} data packet.
- Station B attempts to retransmit its 1^{st} data packet.
- A collision occurs.

Now,

- We have been asked the probability of station A to transmit its 2^{nd} data packet successfully after 2^{nd} collision.
- After the 2^{nd} collision occurs, we have-

At Station A-

- 2^{nd} data packet of station A undergoes collision for the 1^{st} time.
- So, collision number for the 2^{nd} data packet of station A = 1.
- Now, station A randomly chooses a number from the range $[0,2^1-1] = [0,1]$.
- Then, station A waits for back off time and then attempts to retransmit its data packet.

At Station B-

- 1^{st} data packet of station B undergoes collision for the 2^{nd} time.
- So, collision number for the 1^{st} data packet of station B = 2.
- Now, station B randomly chooses a number from the range $[0,2^2-1] = [0,3]$.
- Then, station B waits for back off time and then attempts to retransmit its data packet.

Following 8 cases are possible-

Station A	Station B	Remark
0	0	Collision
0	1	A wins
0	2	A wins
0	3	A wins
1	0	B wins

1	1	Collision
1	2	A wins
1	3	A wins

From here,

- Probability of A winning the 2^{nd} back off race = 5 / 8 = 0.625.

Q 5. Suppose nodes A and B are on same 10 Mbps Ethernet segment and the propagation delay between two nodes is 225 bit times. Suppose A and B send frames at t=0, the frames collide then at what time, they finish transmitting a jam signal. Assume a 48 bit jam signal.

<u>Solution-</u>

Propagation delay (T_p)

= 225 bit times

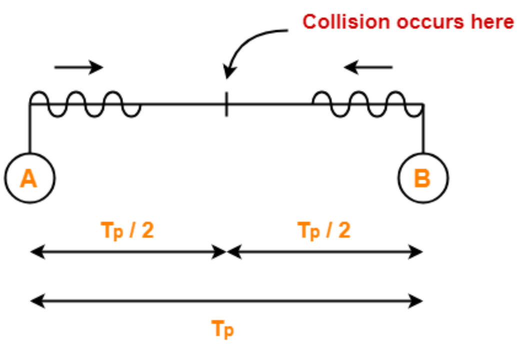
= 225 bit / 10 Mbps

= 22.5×10^{-6} sec

= 22.5 μsec

<u>At t = 0,</u>

- Nodes A and B start transmitting their frame.
- Since both the stations start simultaneously, so collision occurs at the mid way.
- Time after which collision occurs = Half of propagation delay.
- So, time after which collision occurs = 22.5 μsec / 2 = 11.25 μsec.



<u>At t = 11.25 μsec,</u>

- After collision occurs at t = 11.25 μsec, collided signals start travelling back.

- Collided signals reach the respective nodes after time = Half of propagation delay
- Collided signals reach the respective nodes after time = 22.5 μsec / 2 = 11.25 μsec.
- Thus, at t = 22.5 μsec, collided signals reach the respective nodes.

At t = 22.5 μsec,

- As soon as nodes discover the collision, they immediately release the jam signal.
- Time taken to finish transmitting the jam signal = 48 bit time = 48 bits/ 10 Mbps = 4.8 μsec.

Thus,

Time at which the jam signal is completely transmitted

= 22.5 μsec + 4.8 μsec

= 27.3 μsec or 273 bit time

Q 6. Suppose nodes A and B are attached to opposite ends of the cable with propagation delay of 12.5 ms. Both nodes attempt to transmit at t=0. Frames collide and after first collision, A draws k=0 and B draws k=1 in the exponential back off protocol. Ignore the jam signal. At what time (in seconds), is A's packet completely delivered at B if bandwidth of the link is 10 Mbps and packet size is 1000 bits.

Solution-

Given-

- Propagation delay = 12.5 ms
- Bandwidth = 10 Mbps
- Packet size = 1000 bits

Time At Which Collision Occurs-

Collision occurs at the mid way after time

= Half of Propagation delay

= 12.5 ms / 2

= 6.25 ms

Thus, collision occurs at time t = 6.25 ms.

Time At Which Collision is Discovered-

Collision is discovered in the time it takes the collided signals to reach the nodes

= Half of Propagation delay

= 12.5 ms / 2

= 6.25 ms

Thus, collision is discovered at time t = 6.25 ms + 6.25 ms = 12.5 ms.

Scene After Collision

After the collision is discovered,

- Both the nodes wait for some random back off time.
- A chooses k=0 and then waits for back off time = 0 x 25 ms = 0 ms.
- B chooses k=1 and then waits for back off time = 1 x 25 ms = 25 ms.
- From here, A begins retransmission immediately while B waits for 25 ms.

Waiting Time For A-

- After winning the back off race, node A gets the authority to retransmit immediately.
- But node A does not retransmit immediately.
- It waits for the channel to clear from the last bit aborted by it on discovering the collision.
- Time taken by the last bit to get off the channel = Propagation delay = 12.5 ms.
- So, node A waits for time = 12.5 ms and then starts the retransmission.
- Thus, node A starts the retransmission at time t = 12.5 ms + 12.5 ms = 25 ms.

Time Taken in Delivering Packet To Node B-

Time taken to deliver the packet to node B

= Transmission delay + Propagation delay

= (1000 bits / 10 Mbps) + 12.5 ms

= 100 μs + 12.5 ms

= 0.1 ms + 12.5 ms

= 12.6 ms

Thus, At time t = 25 ms + 12.6 ms = 37.6 ms, the packet is delivered to node B.

Q 7. If the packet size is 1 KB and propagation time is 15 msec, the channel capacity is 10^9 b/sec, then find the transmission time and utilization of sender in stop and wait protocol.

Solution:

a = T_p / T_t=15 msec / 1.024 μsec= 15000 μsec / 1.024 μsec = 14648.46

Sender Utilization or Efficiency (η) = 1 / 1+2a = 1 / (1 + 2 x 1468.46)=

1 / 29297.92 = 0.0000341 = 0.00341 %

Q 8. Host A is sending data to host B over a full duplex link. A and B are using the sliding window protocol for flow control. The send and receive window sizes are 5 packets each. Data packets (sent only from A to B) are all 1000 bytes long and the transmission time for such a packet is 50 μs. Acknowledgement packets (sent only from B to A) are very small and require

negligible transmission time. The propagation delay over the link is 200 μs. What is the maximum achievable throughput in this communication?

Solution:

Given-

- Sender window size = Receiver window size = 5
- Packet size = 1000 bytes
- Transmission delay (T_t) = 50 μs
- Propagation delay (T_p) = 200 μs

<u>Calculating Bandwidth-</u>

Transmission delay = Packet size / Bandwidth

So, Bandwidth = Packet Size / Transmission delay (T_t) = 1000 bytes / 50 μs = (1000 x 8 bits) / (50 x 10^{-6} sec) = 160 Mbps

<u>Calculating Value of 'a'-</u>

a = T_p / T_t = 200 μsec / 50 μsec = 4

Optimal window size = 1 + 2a = 1 + 2 x 4 = 9

<u>Calculating Efficiency-</u>

Efficiency (η) = Sender window size / Optimal window size = 5 / 9 = 0.5555 = 55.55%

<u>Calculating Maximum Achievable Throughput-</u>

Maximum achievable throughput = Efficiency (η) x Bandwidth = 0.5555 x 160 Mbps = 88.88 Mbps = 88.88 x 10^6 bps or 11.11 x 10^6 Bps

Q 9. Consider a token ring topology with N stations (numbered 1 to N) running token ring protocol where the stations are equally spaced. When a station gets the token it is allowed to send one frame of fixed size. Ring latency is t_p, while the transmission time of a frame is t_t. All other latencies can be neglected. What is the maximum utilization of the token ring when t_t = 36 ms, t_p = 30 ms, N = 15.

Solution:

Maximum efficiency of token ring = (t_t)/(t_t +(t_p/n))
t_t= 36 ms
t_t =30 ms and n=15,
efficiency = (36)/(36+30/15) = 36/38 = .947

Q 10. A 2 km long broadcast LAN has 10^7 bps bandwidth and uses CSMA / CD. The signal travels along the wire at 2 x 10^8 m/sec. What is the minimum packet size that can be used on this network?

Solution:

Given-

- Distance = 2 km
- Bandwidth = 10^7 bps

- Speed = 2×10^8 m/sec

Propagation delay (T_p) = Distance / Propagation speed = 2 km / (2×10^8 m/sec) = 2×10^3 m / (2×10^8 m/sec) = 10^{-5} sec

Minimum frame size = 2 x Propagation delay x Bandwidth = 2×10^{-5} sec x 10^7 bits per sec = 200 bits or 25 bytes

Q 11. On a wireless link, the probability of packet error is 0.2. A stop and wait protocol is used to transfer data across the link. The channel condition is assumed to be independent from transmission to transmission. What is the average number of transmission attempts required to transfer 100 packets?

Solution:

Given-

- Probability of packet error = 0.2
- We have to transfer 100 packets

Now,

- When we transfer 100 packets, number of packets in which error will occur = 0.2 x 100 = 20.
- Then, these 20 packets will have to be retransmitted.
- When we retransmit 20 packets, number of packets in which error will occur = 0.2 x 20 = 4.
- Then, these 4 packets will have to be retransmitted.
- When we retransmit 4 packets, number of packets in which error will occur = 0.2 x 4 = 0.8 ≅ 1.
- Then, this 1 packet will have to be retransmitted.

From here, average number of transmission attempts required = 100 + 20 + 4 + 1 = 125.

Q 12. Consider 1 Mbps error free line. The maximum frame size is 1000 bits. New packets are generated about 1 sec apart. The time out interval is 10 msec. If the ack timer is eliminated. How many times the average message be transmitted?

Solution:

- Transmission delay (T_t) = L / B = 1000 bits / 10^6 bits per sec = 1 msec.
- After packet is put on the link, the time out timer is started which is 10 msec long.
- The next packet is transmitted after 1 sec = 1000 msec.
- If no acknowledgement is received within 10 msec, the packet will be retransmitted.
- We have been asked how many times the average message be transmitted i.e. how many retransmissions are possible.
- Retransmission occurs or not depends on the propagation delay (Tp).

- If T_p is more, time out will occur and retransmission will take place but if T_p is less, then there will be no time out.
- Since propagation delay (Tp) is not given in the question, therefore we can not say anything.

Q. 13. A token ring LAN network interconnects M stations using Star Topology in the following way. All the input and output lines of the token ring station interface are connected to a cabinet where the actual ring is placed. Suppose that distance from each station to a cabinet is 100 m and ring latency per station is 8 bits, packets are 1250 B and bandwidth is 25 Mbps.

1. **Find the ring latency normalized to packet transmission time.**
2. **Find the minimum number of packets transmitted by stations, if stations are allowed to transmit an unlimited number of packet / token. ($v = 2 \times 10^8$ m/sec)**

Solution:

Part-01:

Calculating Transmission delay-

Transmission delay= Packet size / Bandwidth= 1250 B / 25 Mbps = (1250 x 8 bits) / (25×10^6 bits per sec) = 400 μsec

Calculating Propagation delay-

Propagation delay = Distance / Speed= (200 x M meters) / (2×10^8 m/sec) = (200 x M) / (2×10^8) sec = 100 x M x 10^{-8} sec = M μsec

Calculating Bit delay in seconds-

Bit delay= Ring latency per station= 8 bits= 8 bits / 25 Mbps = 0.32 μsec

Calculating Ring latency-

Ring latency= Propagation delay + N x Bit delay = M μsec + M x 0.32 μsec = 1.32 x M μsec

Calculating Ring latency normalized to packet transmission delay-

Ring latency normalized to packet transmission time= Ring latency / Packet transmission time= 1.32 x M μsec / 400 μsec= 0.0033 x M

Part-02:

- The number of packets a station can transmit after holding a token depends on Token Holding Time and the strategy used.
- Since no information is given in the question about the Time Holding Time, so we assume that there is no restriction on holding the token.
- Thus, a station can send **infinite** number of packets after getting a token.

Q 14. Consider a 10 Mbps Ethernet LAN that has stations attached to a 2.5 km long coaxial cable. Given that the transmission speed is 2.3×10^8 m/sec, the packet size is 128 bytes out of which 30 bytes are overhead, find the effective transmission rate and maximum rate at which the network can send data.

Solution-

Given-

- Bandwidth = 10 Mbps
- Distance = 2.5 km
- Transmission speed = 2.3 x 10^8 m/sec
- Total packet size = 128 bytes
- Overhead = 30 bytes

Calculating Transmission Delay-

Transmission delay (T_t) = Packet size / Bandwidth= 128 bytes / 10 Mbps= (128 x 8 bits) / (10 x 10^6 bits per sec)= 1024 / 10^7 sec= 102.4 μsec

Calculating Propagation Delay-

Propagation delay (T_p)= Distance / Speed= 2.5 km / (2.3 x 10^8 m/sec)= (2.5 x 10^3 m) / (2.3 x 10^8 m/sec)= 1.08 x 10^{-5} sec= 10.8 μsec

Calculating Value of 'a'-

a= T_p / T_t= 10.8 μsec / 102.4 μsec= 0.105

Calculating Efficiency-

Efficiency(η)= 1 / (1 + 6.44 x a)= 1 / (1 + 6.44 x 0.105)= 1 / 1.67= 0.59= 59%

Calculating Maximum Rate-

Maximum rate or Throughput= Efficiency x Bandwidth= 0.59 x 10 Mbps= 5.9 Mbps

Calculating Effective Transmission Rate-

Effective transmission rate= Throughput x (128-30 / 128)= 5.9 Mbps x (98 / 128)= 0.77 x 5.9 Mbps= 4.52 Mbps

Q 15. Suppose 5 machines are trying to transmit using p-persistent CSMA with p = 0.02. If they all sense the medium to be free at the same time, what is the probability that one of them will be able to transmit with no collision?

Solution:

There are 6 nodes with p=0.02. So if all nodes sense channel to be idle, then probability of any 1 node, say node1 to successfully transmit is 0.02*0.98*0.98*0.98*0.98 = 0.01844 (the rest of the nodes should back off, not transmit). As there are 5 nodes and any one can be a successful transmitter, so overall probability of successful packet transmission by any one node = 5*0.0018 = 0.0.092

Q 16. We have 14 sources, each creating 500 8-bit characters per second. Since only some of these sources are active at any moment, we use statistical TDM to combine these sources using character interleaving. Each frame carries 6 slots at a time, but we need to add four-bit addresses to each slot. Answer the following questions:

a. What is the advantage of using statistical TDM over synchronous TDM

b. What is the size of an output frame in bits?

c. What is the output frame rate?

d. What is the duration of an output frame?
e. What is the output data rate?
Solution:
a. Prevents wastage of resources
b. Frame size = 6 × (8 + 4) = 72 bits.
c. We can assume that we have only 6 input lines. Each frame needs to carry one character from each of these lines. This means that the frame rate is 500 frames/s.
d. Frame duration = 1 /(frame rate) = 1 /500 = 2 ms.
e. Data rate = (500 frames/s) × (72 bits/frame) = 36 kbps.

Q. 17. Assume that a voice channel occupies a bandwidth of 7 Hz. We need to multiplex 20 voice channels with guard bands of 1000 Hz using FDM. Calculate the required bandwidth.

Solution:
To multiplex 10 voice channels, we need nineteen guard bands. The required bandwidth is then B = (7 Hz) × 20 + (1000 Hz) × 19 **= 19.**140KHz

Q. 18. 7 data sources, 2 with a bit rate of 200 kbps, and 3 with a bit rate of 400 kbps are to be combined using TDM. The sources are bit-multiplexed (1 slot in a frame = 1 bit), with 1 control/synchronizing bit per frame. What is the duration of the frame?

Solution:

Each frame carries 1 bit from each 400-kbps source. Frame rate = 400,000 frames/s. Frame duration = 1 /(frame rate) = 1 /400,000 = 2.5 ms

Q 19. A group of N stations shares a 56-kbps pure ALOHA channel. Each station outputs a 1000-bit frame on an average of once every 100 sec, even if the previous one has not yet been sent (e.g., the stations can buffer outgoing frames). What is the maximum value of N?
Solution:
With pure ALOHA the usable bandwidth is 0.184x56 kbs=10.3 kbps. Each station requires 10 bps, so N=10300/10=1030 stations.

Q 20. A switch designed for use with fast Ethernet has a backplane that can move 10 Gbps. How many frames/sec can it handle in the worst case? Hint: the worst case is an endless stream of 64-byte frames.
Solution:
The worst case is an endless stream of 64-byte 64 byte = 512 bits frames. If the backplane can handle 10 Gbps = 10^9 bps. The number of frames it can handle is 10^9 bit / 512 bit This is 1,953,125 frames / sec.