Q1. Station A uses 45 byte packets to transmit messages to Station B using a sliding window protocol. The round trip time delay between A and B is 60ms and the bottleneck bandwidth on the path A and B is 120kbps. What is the optimal window size that A should use? **(4 Marks)**

Ans: Frame size = 45 byte
Round trip time (RTT) delay between A and B is = 60ms= 2*30 ms
T_p= 30 ms

$$T_t = \frac{45 * 8}{120} = 3\,ms$$

$$N = (1 + 2a) = \left(1 + 2 * \frac{T_p}{T_t}\right) = \left(1 + 2 * \frac{30}{3}\right) = 21$$

Q2.(a) If each frame carries 1000 bits of data, how long does it take to send 2 million (2,000,000) bits of data using (a) Stop-and-Wait ARQ, (b) Go-Back-N ARQ and (iii) Selective Repeat ARQ. Assume that all three ARQs are using 4 bits for representing sequence numbers. The distance between sender and receiver is 5000 Km and the propagation speed is 2 x10^8 s/ m. Ignore transmission, waiting and processing delays. Assume no data or control frame is lost or damaged. **(4 Marks)**

Ans: a. RTT = 25+25 ms=50ms
window size = 2^4 = 16
Number of frames = 2,000,000/1000= 2000
Stop-and-Wait ARQ= 50ms ×Number of frames= 50×2000 =10^5 ms = 100 s
Go-Back-N ARQ = (Number of frames/window size) × 50 ms = 6250 ms = 6.25 s
Selective Repeat request = 6.25 s

Q2.(b) For the above problem, to achieve minimum delay for transmission of 2 million bits using (a) Go-back-N protocol and (b) Selective repeat ARQ, what will be the optimal size of windows at the sender and receiver side? Also find out the optimal number of required bits to incorporate sequence numbers for both the protocols. Ignore transmission, waiting and processing delays. **(4 Marks)**

Ans: b. As there are no transmission delays. So, the window size N = (1+2a) where $a = T_p/T_t$, as there is no transmission delay so a = ∞, so N = ∞, i.e. the window is of size infinity. So at ones 2000 frame scan be transmitted from the sender to have optimal delay. So in case of Go-back-N protocol sender window size N = 2000 and receiver window size =1. And in case of Selective repeat ARQ sender window size and receiver window size both are equal i.e. N =2000.

Q3. Suppose a sender A needs to send a message consisting of 11 frames to receiver B using a sliding window (window size 4) and Go-Back-N ARQ flow control strategy. All packets are ready and immediately available for transmission. If the 5th frame in the queue that A transmits gets lost at the first attempt (but no ACKs from B ever get lost), then what is the total number of frames that A will transmit for sending the entire message to B? **(4 Marks)**

Ans: Total no. of frames to be sent = 11

Window size = 4

If the 5th frame in the queue is lost

11	10	9	8	7	6	5	4	3	2	1

Only 5th frame is lost. Not every 5th Frame

#step 1- Since the sender window size is 4. So the sender will sends 4 packets 1,2,3,4
So, total no. of frames sent till now from the sender side is = 4

#step 2- After getting the ACK for the frame with sequence no. 1, the content of the window will be 2,3,4,5 and the 5th frame will be sent
So, total no. of frames sent till now from the sender side is = (4+1) = 5

#step 3- After getting the ACK for the frame with sequence no. 2, the content of the window will be 3,4,5, 6 and the 6th frame will be sent
So, total no. of frames sent till now from the sender side is = (5+1) = 6

#step 4- After getting the ACK for the frame with sequence no. 3, the content of the window will be 4,5,6, 7 and the 7th frame will be sent
So, total no. of frames sent till now from the sender side is = (6+1) = 7

#step 5- After getting the ACK for the frame with sequence no. 4, the content of the window will be 5,6,7,8 and the 8th frame will be sent
So, total no. of frames sent till now from the sender side is = (7+1) = 8

#step 5- As the 5th frame is lost so no ACK for this frame will receive from the receiver B, the content of the window will be 5,6,7,8
As the 5th frame is in error so again all the frame in the window have to be retransmitted

So, total no. of frames sent till now from the sender side is = (8+4) = 12

#step 6- After getting the ACK for the frame with sequence no. 8, the content of the window will be 9,10,11 and the 11th frame will be sent
So, total no. of frames sent till now from the sender side is = (12+1) = 13

#step 7- After getting the ACK for the frame with sequence no. 9, the content of the window will be 10,11 and as all frames are already sent and only waiting for acknowledgment

So, total no. of frames sent till now from the sender side is = (12+1) = 13

Q4. (a) A group of k stations share 200 kbps slotted Aloha channel. Each station outputs a 400 bits frame on an average of 1000 ms even if the previous one has not been sent. What is the required value of k? **(4 Marks)**

Ans: Throughput of each stations = Number of bits sent per sec = $\frac{400\ bits}{1000\ ms}$ = 400 bits/sec

Throughput for slotted Aloha = Efficiency * Bandwidth = 0.368*200 Kbps

Total no. of stations = = $\frac{0.368*200\text{ Kbps}}{400\ bits} = 184\ stations$

Q4. (b) Discuss how the efficiency of slotted Aloha is more than pure Aloha? **(2 Marks)**

Q5. A 50 Kbps satellite link has a propagation delay of 500 ms. The transmitter employs the "Go Back 16 ARQ" scheme. Assuming that each frame is 200 bytes long, what is the maximum data rate possible? **(4 Marks)**

Ans: $T_p = 500$ ms

$T_t = 32$ ms

a = 15.625

Efficiency = 0.496

Efficiency × BW

0.496 × 50 Kbps.

maximum data rate possible = 24.8 Kbps=25 Kbps

Q6. Station A uses 45 byte packets to transmit messages to Station B using a sliding window protocol. The round trip time delay between A and B is 60ms and the bottleneck bandwidth on the path A and B is 120kbps. What is the optimal window size that A should use?

Ans: 21

Q7. Explain the difference between: **(6 Marks)**
a. 1-persistent, p-persistent and non-persistent CSMA
b. Hub, Switch, and Bridges

Q8. Suppose we want to transmit the message 11001001 and protect it from errors using CRC polynomial $x^3 + 1$. Use polynomial long division to determine the message that should be transmitted. Corrupt the left-most third bit of the transmitted message and show that the error is detected by the receiver using CRC technique. **(5 Marks)**

Data : 11001001

Divisor : x^3+1

$x^3+0\cdot x^2+0\cdot x+x^0$

1001

$L-1=(4-1)=3$

```
          11010011
      ______________
1001 ) 11001001000
       1001
       ----
        1011
        1001
        ----
         0100
         0000
         ----
          1000
          1001
          ----
           0011
           0000
           ----
            0110
            0000
            ----
             1100
             1001
             ----
              1010
              1001
              ----
               011
```

remainder

⇓

CRC

Data transmitted to be

11001001011

Transmitted msg = 11001001011

↑ error

11010011 = 11001001111

```
       ____________
1001 ) 11001001111
       1001
       ----
        1011
        1001
        ----
         0100
         0000
         ----
          1000
          1001
          ----
           0011
           0000
           ----
            0111
            0000
            ----
```

```
       ______
1001 ) 1111
       1001
       ----
        1101
        1001
        ----
         100
```

remainder non-zero

so error is there