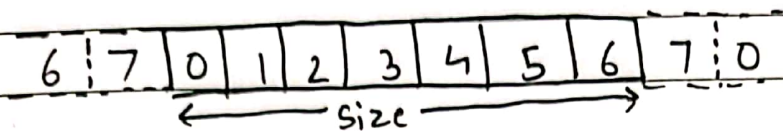
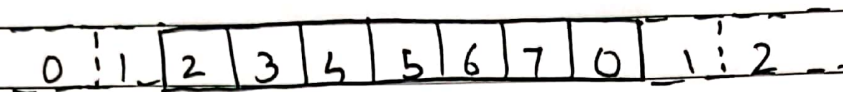


Q1) i) Initial window :-  
 $\text{Size} = 2^3 - 1$   
 $= 7$

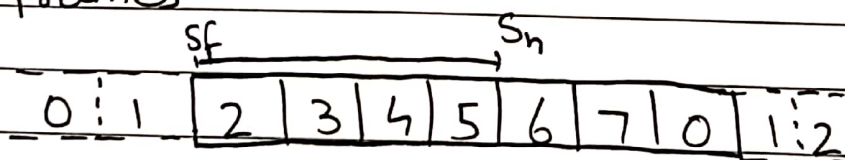


ii) Frames 0, 1 are sent and acknowledgement is received:

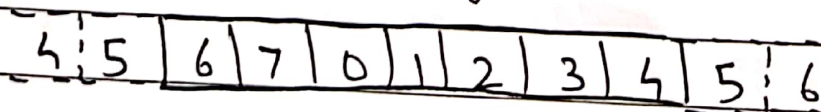


Sliding window will slide along 2 frames and now frame 2 will be ready to be sent.

iii) A timer starts when frame 2 is sent. Then frames 3, 4, 5 are also sent but as frame 2 is lost, the sender does not receive any acknowledgement and timer expires. Hence, the sender resends all the frames



iv) Now the acknowledgement of frames 2, 3, 4, 5 will be received by the sender and the sender will be ready to send frame 6



Q2) a) The sender has to send four data items which are 0x3456, 0xABCC, 0x02BC and 0xEEEE

$$\begin{array}{r}
 0x3456 = 0011010001010110 \\
 0xABCC = 1010101111001100 \\
 0x02BC = 0000001010111100 \\
 0xEEEE = + \underline{1110111011101110} \\
 \phantom{0x0000} 11101000111001100 \\
 \phantom{0x0000} \swarrow \quad \searrow \\
 \phantom{0x0000} 1101000111001101 \quad (1)
 \end{array}$$

Now taking 1's complement of (1)

$$\begin{array}{cccc}
 \underline{0010} & \underline{1110} & \underline{0011} & \underline{0010} \\
 2 & (14)E & 3 & 2
 \end{array}$$

The checksum from the sender's side is as shown above. = 2E32

So from sender's end the bits that will be send which is checksum i.e. along with the four data items.

b) Now since there are no errors at the receiver's end. So at the receiver's end, all the data items will be added along with checksum and it will be

$$\begin{array}{r}
 0010111000110010 \\
 0011010001010110 \\
 1010101111001100 \\
 1110111011101110 \\
 + \underline{0000001010111100} \\
 \underline{111111111111110} \\
 \swarrow
 \end{array}$$





Q3) Nyquist bit rate formula defines the theoretical maximum bit rate

$$\text{BitRate} = 2 \times \text{Bandwidth} \times \log_2 L$$

Bandwidth: bandwidth of the channel

L: number of signal levels used to represent data

BitRate: in bits per second.

→ Shannon Capacity states that with noise, some bits might be corrupted

Signal to noise ratio (SNR)

$$\text{SNR} = \frac{\text{Signal Power}}{\text{noise power}}$$

$$\text{Shannon capacity (C)} = B \cdot \log_2 (1 + \text{SNR})$$

→ Given,  
bandwidth = 20 kHz  
SNR<sub>db</sub> = 40

$$\text{But } \text{SNR}_{\text{db}} = 10 \log_{10} \text{SNR}$$

$$\begin{aligned} \text{SNR} &= 10^{\text{SNR}_{\text{db}}/10} \\ &= 10^4 \end{aligned}$$

$$\begin{aligned} \text{Capacity} &= B \cdot \log_2 (1 + \text{SNR}) \\ &= 20 \times \log_2 (10001) \\ &= 265.75 \text{ Kbps} \end{aligned}$$