Assignment-7

IIT2022155

1) For a (6,3) parity check code, we have 6 bits, 3 data bits ($D_1 D_2 D_3$) and 3 parity bits ($P_1 P_2 P_3$)

$P_1 = D_1 \oplus D_2 \oplus D_4 \oplus D_5$

$P_2 = D_2 \oplus D_3 \oplus D_4 \oplus D_6$

$P_3 = D_1 \oplus D_3 \oplus D_5 \oplus D_6$

Min distance = Min no. of bit changes required to go from one Valid Codeword to other = 3

The Code can detect upto 2 errors. If there are more parity check will not match.

The code can correct a single error.

3) Encoding

$g(x) = x^3 + x + 1$ message vector = 1101

Perform modulo-2 addition (XOR) b/w these

$1101 \oplus (x^2 + x + 1) = 0000110$

Encoded vector ⇒ 0000110

Decoding

Received Code vector = 0001110 (with error at 4th position)

Perform XOR between this & $g(x)$

$0001110 \oplus (x^3 + x + 1) = 1000$

⇓ error at 4th position

2) $L = 1000$ bits $\quad B = 1$ Mbits/s

$T_t = \frac{1000}{10^6} = 1$ ms

$T_p = 270$ ms $\quad a = \frac{T_p}{T_t} = 270$

From sequence numbers = 3 bits

a) stop & wait protocol

Channel utilization / Efficiency $= \frac{1}{1+2a} = 0.18\%$

b) Go-Back-N Protocol

Window size of sender $= 2^n - 1$

$= 2^3 - 1 = 7$

channel utilization / efficiency $= \frac{N}{1+2a} = 1.29\%$

c) Selective Repeat protocol

window size of sender $= \frac{2^m}{2} = \frac{2^3}{2} = 4$

channel utilization / efficiency $= \frac{N}{1+2a} = 0.74\%$

5) Bit rate = 4 Kbps

$T_p = 20$ ms

$\eta = \frac{\text{Transmission time of packet}}{(\text{Trans of packet} + 2T_p)}$

$= \frac{x}{x + 2 \times 20 \times 10^{-3}} \geq \frac{1}{2}$ $\quad x = 160$ bits

4) (i) In absence of error or lost frames, sender can continue sending frames without waiting for acknowledgement

$\Rightarrow T_{max} = 2 \times T_{min} + 2T_p$

(ii) If isolated errors can occur in feedback direction (acknowledgement) sender must wait for a timeout period before transmitting a frame

$T_{max} = 2 \times T_{min} + 2 \times T_p + T_{timeout}$

6) $m(x) = x^2 + x^3 + x^4$

$g(x) = 1 + x^4 + x^6 + x^7 + x^8$

encoding $= T(x) = x^n(x) \bmod g(x)$

$= x^6 + x^7 + x^8$

7) & 11) (i) $T_{round\ trip} = 2 \times T_{frame} \times (W-1)$

$= W = \frac{T_{round\ trip}}{2 \times T_{frame}} + 1 = \frac{40ms}{2ms} + 1 = 21$ ms

(ii) No. of bits $= \log_2(W) = \log_2(21) = 5$

(iii) Sender window will get exhausted when sender has sent frames upto window size (W) and there are unacknowledged frame within the window. Once the sender window is full it will wait for acknowledgement before sending new frames.

(iv) 50% channel utilisation → Sender should always have frams n transmit

25% channel utilisation → Sender window should be partially filled.

3) (BH) Code [modulo-2]

Code vectors

1011001 $P_1 = 0$ $P_2 = 1$ $P_3 = 0$

$P_1 = P_1 \oplus P_2 \oplus P_4 = 1 \oplus 0 \oplus 1 = 0$

$P_2 = D_1 \oplus D_3 \oplus D_4 = 1 \oplus 1 \oplus 1 = 1$

$P_3 = D_2 \oplus D_3 \oplus D_4 = 0 \oplus 1 \oplus 1 = 0$

1001110

$P_1 = D_1 \oplus D_2 \oplus D_4 = 1 \oplus 0 \oplus 1 = 0$

$P_2 = D_1 \oplus D_3 \oplus D_4 = 1 \oplus 1 \oplus 1 = 1$

$P_3 = D_2 \oplus D_3 \oplus D_4 = 0 \oplus 1 \oplus 1 = 0$

1100101

$P_1 = D_1 \oplus D_2 \oplus D_4 = 1 \oplus 1 \oplus 1 = 1$

$P_2 = D_1 \oplus D_3 \oplus D_4 = 1 \oplus 0 \oplus 1 = 0$

$P_3 = D_2 \oplus D_3 \oplus D_4 = 1 \oplus 0 \oplus 1 = 0$

minimum distance : is min no. of bit flips req to go from one valid Code vector to another

min distance (d) = 2

Error detection & correction Capability

Error detection Capability = $d - 1 = 2 - 1 = 1$ error can be detected

Error detection Capalu = $\frac{d-1}{2} = \frac{1}{2}$ error can be corr (2 > 0)

9) 001100 → message
(5,7) → cyclic code

$g(x) = 1 + x^4 + x^6 + x^7 + x^8$
$m(x) = 00\,11100$

$T(x) = m(x) \bmod g(x) = 111000$
Code vector = $m(x) + T(x)$
$= 00\,11100 + 111000$

Code vector = 111100.

10) $T_p = \frac{\text{Distance}}{\text{Propogation speed}} = \frac{5 \times 10^6}{2 \times 10^8} = 0.025\,s$

(i) stop and wait ARQ:

$T_{round-trip} = 2 \times T_p = 0.05\,s$
$T_{stop\ and\ wait} = \frac{\text{Data size}}{\text{Transmission Rate}} + T_{round-trip}$
$= \frac{1 \times 10^6}{2 \times 10^6} + 0.05 = 0.55\,s$

(ii) Go Back N ARQ

$T_{Goback} = \frac{\text{No of frames} \times \text{frame size}}{\text{Transmission Rate}} + T_p$

$= \frac{1000 \times 10^6}{\frac{1000}{2 \times 10^6}} + 0.025 = 0.52\,sec$

(iii) selective repeat ARQ

$$T_{selective\ repeat} = \frac{\text{No of frame} \times \text{frame size}}{\text{Transmission rate}} + T_p$$

$$= \frac{1000 * 10^6}{\frac{1000}{2 \times 10^6}} + 0.025 = 0.525 \text{ sec}$$