TCOM 370

April 1, 1997 Exam 2 1 Hr. 15 Mins.

One Summary Sheet Allowed

Equal Points for all Four Problems

Problem 1

Binary messages of length 4 are protected by a 3-bit frame check sequence generated by a CRC code with generator polynomial X^3+X^2+1.

(a) Find the transmitted 7-bit codeword sequences corresponding to the specific messages 0000, 1101, and 1001

(b) For this CRC code, mapping 16 length-4 sequences into 16 length-7 sequences, what is the minimum Hamming distance? (Explain your answer clearly).

(c) In the codeword corresponding to message 0000 found in part (a), suppose the last four contiguous bits are all in error.

(i) Will this be detected at the receiver?
(ii) Can you generalize your response in (i)?

Problem 2

A source produces independent symbols from an alphabet of three letters. Each source symbol can be A, B, or C with respective probability 0.5, 0.25 and 0.25.

(a) What is the source entropy H ?

(b) Find a Huffman code for the individual letters of the source alphabet. What is the average number of bits per symbol for this code?

(c) You are asked to design a code for *blocks of two symbols* from the source at a time. The alphabet for this extended source is of size 9.

(i) Can such a code provide better performance than the one in part (a)?
(ii) Find a best uniquely-decodable code for encoding blocks of two symbols at a time.
(iii) What is the average number of bits per source symbol for your code?

Problem 3

A Go-Back-N ARQ scheme using ACKs and NACKs is implemented on a full-duplex link with the following parameters:

Transmit window size K=2, transmitter re-uses a *minimum set of sequence numbers*
ACK and NACK frames are of *negligible duration*
I-frames are of fixed time-duration T_{ix}
One-way *propagation delay = one I-frame duration*
Processing times for I-frames, ACK and NACK frames = *half of I-frame duration*
Transmitter *time-out interval = seven I-frame durations;* no receiver time-out interval implemented

(Note that the I-frame duration is the unit of time measurement in this description).

Draw the *frame sequence diagram* for the case where the *second transmitter frame is lost* in transit; all other frames are propagated without error. Indicate when frames are accepted by the receiver. (Extend your diagram to 13 I-frame durations from start of transmission. Use the grided sheet to draw the diagram on.)

Problem 4

Consider a full-duplex, 30,000 Km satellite link between two earth stations. Each I-frame is no longer than 1200 bits, ACK and NACK frames are 300 bits long, and all frames include 4 bits for a sequence number. Data rate in both directions is 60 Kbps. Propagation delay is 3.33 μsec/Km. Processing delays and processing times are negligible. You have a choice of using Idle RQ, Go-Back-N, or Selective Repeat (SR). For this link,

(a) What is the maximum utilization factor for Idle RQ ?

(b) What are the maximum transmit and receive window sizes for SR ?

(c) What are the maximum transmit and receive window sizes for Go-Back-N?

(d) What are the maximum utilization factors for (i) SR and (ii) Go-Back-N?

(e) Suppose I-frames are badly hit and have an error rate of $P_f = 10^{-1}$. (ACK and NACK frames always come through without error.) Which protocol will give you the best utilization factor ?

[Given: For Go-Back-N with transmit window size K, frame error probability P_f, and considering *only* propagation delay T_p and I-frame duration T_{ix}, the utilization factor is

$$U_{\text{with error}} = U_{\text{no error}} \frac{1-P_f}{1-P_f + \min\{(1+2a), K\} P_f} \qquad \text{where } a = \frac{T_p}{T_{ix}}$$]