EE 706: Communication Networks

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Midsemester Exam: **30 points** (120 min) February 24, 2012

1. Give brief answers to the following questions.

   (i) List the layers in the OSI reference model. [1 point]

   (ii) List the layers in the TCP reference model. [1 point]

   (iii) Draw the Manchester and differential Manchester waveforms corresponding to the bit string 00001111. State any assumptions you made. [1 point]

   (iv) What is the advantage of differential Manchester coding over Manchester coding? [1 point]

   (v) Byte stuff the following payload byte sequence where ESC is the escape byte and FLAG is the flag byte: 0xDE ESC ESC ESC FLAG ESC 0xFF FLAG ESC 0xEF. [1 point]

   (vi) A zero bit is stuffed after five consecutive ones to prevent the appearance of the flag sequence 01111110 (01^60) in the payload. If 0111110 (01^50) appears in the payload, the bit stuffing rule will insert a 0 after five ones even though this is not a flag. Why is this necessary? [1 point]

   (vii) Calculate the CRC parity bits corresponding to the message bit sequence 01000 when the generator polynomial is $1 + X^2 + X^3 + X^4$. [1 point]

   (viii) Suppose the received bit sequence 0011101 corresponds to 4 message bits and 3 CRC bits which were generated using the generator polynomial $X^3 + X + 1$. If someone tells us that an undetectable burst error of length 4 resulted in this received bit sequence, what are the possibilities for the transmitted sequence? [1 point]

   (ix) Suppose 2 bits are available to store frame and ACK sequence numbers in go-back-N ARQ. Illustrate a situation when a window size of 4 causes the protocol to malfunction. [1 point]

   (x) Suppose 2 bits are available to store frame and ACK sequence numbers in selective repeat ARQ. Illustrate a situation when a window size of 3 causes the protocol to malfunction. [1 point]

2. Suppose a receiver observes the following portion of a waveform corresponding to an unknown line coding scheme. The receiver does not know the symbol duration or where the symbol begins. List the possible line coding schemes which this waveform could correspond to. For each possibility, indicate the symbol boundaries and give the bit sequence the waveform corresponds to. The gray horizontal line corresponds to the zero level. [5 points]

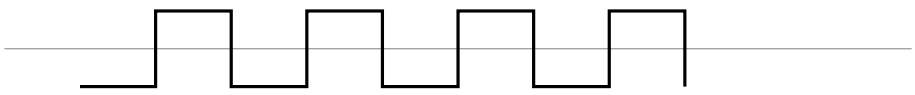

Figure 1: The waveform of the unknown line coding scheme

3. In a system using stop-and-wait ARQ, assume the following.

   (i) The channel between the source and destination is full duplex.

   (ii) No frame errors or ACK errors occur.

   (iii) The round trip time (RTT) is uniformly distributed between A and B where $B > A > 0$. This RTT includes the two way propagation delay, the frame transmission time, the ACK transmission time, all queueing delays, the frame processing time at the destination and the ACK processing time at the source.

   (iv) The frame transmission time is fixed and equal to T_f.

(v) The timeout duration is fixed and equal to T_t. The source and destination are not aware of the values of B and A but the value of T_t is chosen such that $T_t > A$ and $T_t < B - A$.

(vi) If timeout occurs before an ACK is completely processed, retransmission begins immediately irrespective of the ACK contents.

(vii) If an ACK processing completes during a frame transmission, the transmission corresponding to the ACK (if any) begins after the current frame transmission completes.

Let X be the time spent in successfully transmitting a frame. Calculate the expected value of X. Simplify your answer as much as possible. [5 points]

4. Explain how type II hybrid ARQ works. Your description should include the properties of the codes involved, the types of frames transmitted under different error conditions and the receiver operation in response to different error conditions. You can assume that ACK errors do not occur in your description. [5 points]

5. Derive the throughput efficiency of stop-and-wait ARQ using the notation in Table 1. Assume that the CRC detects all errors. [5 points]

Number of information bits in frame	n
Number of CRC bits in frame	k
Frame size in bits	$n + k$
Number of information bits in ACK	m
Number of CRC bits in ACK	k
ACK size in bits	$m + k$
Data Rate	$\frac{1}{T}$
Frame transmission time	$T_f = (n + k)T$
ACK transmission time	$T_a = (m + k)T$
One way propagation delay	τ
Sum of all processing delays	T_p
Timeout duration	T_t
Probability of frame error	P_{FE}
Probability of ACK error	P_{AE}

Table 1: Parameters used in the analysis of SW ARQ