EE 706: Communication Networks

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Mid-semester Exam: **30 points** (120 min) February 25, 2011

1. Suppose a communication link uses the single parity check (SPC) code as the error detecting code and the 3-repetition code as the FEC code. Suppose the source wants to send the bit string 1011.

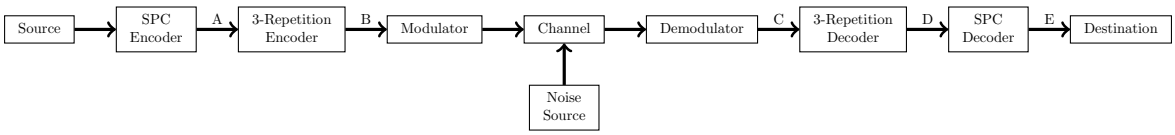


Figure 1: Block diagram of the communication process which uses a SPC and a 3-repetition code.

   (a) What is the bit string seen at the output of the SPC encoder, i.e. at point A of Figure 1? [1 point]

   (b) What is the bit string seen at the output of the 3-repetition encoder, i.e. at point B of Figure 1? [1 point]

   (c) If the bit string which appears the at the output of the demodulator (point C) is 110110100110101, what is the bit string which appears at the output of the channel decoder (point D in Figure 1)? [1 point]

   (d) If the bit string which appears the at the output of the demodulator (point C) is 110110100110101, what is the bit string which appears at the output of the SPC decoder (point E in Figure 1)? [1 point]

2. Draw the unipolar NRZ, polar NRZ, polar RZ, NRZI, Manchester and differential Manchester waveforms corresponding to the bit string 10101010. State any assumptions you made with respect to the level of the signal to the left of the first bit's waveform. [3 points]

3. Suppose a CRC scheme uses the generator polynomial $g(X) = (X+1)(X^3+X+1)$.

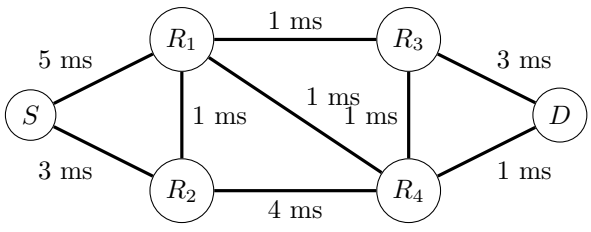
   (a) Generate CRC check bits for the information bits strings 1111 and 1010. [2 points]

   (b) Give an example of a three-bit error which is detected by this CRC scheme. [1 point]

   (c) Give an example of a three-bit error which is **not** detected by this CRC scheme. [1 point]

   (d) Give two examples of burst errors of burst length 5 which are **not** detected by this CRC scheme. [1 point]

4. Consider the six-node communication network shown in the below figure. The times next to the links correspond to link propagation delays. Suppose that the source S's routing table consists of the minimum delay routes.



(a) If the processing time of a frame or an ACK at a node is 0.5 milliseconds, the frame duration is 5 milliseconds and ACK duration is 1 millisecond, what value of stop-and-wait ARQ timeout should the source S use to communicate to destination D? [2 points]

(b) If the source S wants to use go-back-N ARQ, what is the minimum value of the window size N? [2 points]

5. (a) Derive the throughput efficiency of stop-and-wait ARQ under the assumption that there are no ACK errors. Assume the following notation: T_f is the frame transmission duration, T_a is the ACK transmission duration, T_t is the timeout duration, T is the bit duration, n is the number of information bits in a frame, k is the number of redundancy bits in a frame, m is the total number of bits in an ACK, τ is the propagation delay, T_p is the sum of the processing times at sender and receiver, P_{FE} is the frame error probability. [5 points]

(b) In calculating the throughput efficiency of SW ARQ, you calculated the mean of the random variable X which corresponds to the time the sender is involved in sending a frame successfully. What is the variance of this random variable X? (*Hint:* Use the identity $\text{var}(X) = E[X^2] - (E[X])^2$) [3 points]

(c) Using Chebyshev's inequality, calculate a threshold value such that the time spent by the sender in sending a frame is less than this threshold with probability at least 0.99. [2 points]

$$\text{Chebyshev's inequality: } \Pr\left[|X - E(X)| \geq a\right] \leq \frac{\text{var}(X)}{a^2} \quad \text{for } a > 0$$

6. An eavesdropper is listening to an ongoing transmission between a source S and a destination D. She is situated very close to the source and receives all the transmitted frames without error, even frames which the destination receives with errors. She is unable to receive the acknowledgements sent by the destination. After observing a sequence of frame transmissions, she wants to know what type of ARQ is being used. Assume that she can read the frame sequence numbers.

(a) If the frame sequence numbers seen by the eavesdropper are 1,2,3,4,5,6,7,8,4,5,6,7,8,9, what is the type of ARQ being used? What is the window size N? What can be inferred about the distance of the destination from the source? [2 points]

(b) If the frame sequence numbers seen by the eavesdropper are 1,2,3,4,5,6,7,8,4,9,10,11,12, what is the type of ARQ being used? What is the window size N? What can be inferred about the distance of the destination from the source? [2 points]