Indian Institute of Technology Bombay
Department of Electrical Engineering

Handout 14 EE 706 Communication Networks
Midsemester Exam **60 points** February 16, 2010

Please READ THE QUESTIONS CAREFULLY before answering.

1. Figure 1 shows an empty block diagram of the communication process involving FEC and CRC codes. Fill in the labels for the blocks from the following list: Noise Source, FEC Decoder, CRC Encoder, Information Destination, CRC Decoder, Modulator, Demodulator, Channel, FEC Encoder, Information Source. [5 points]

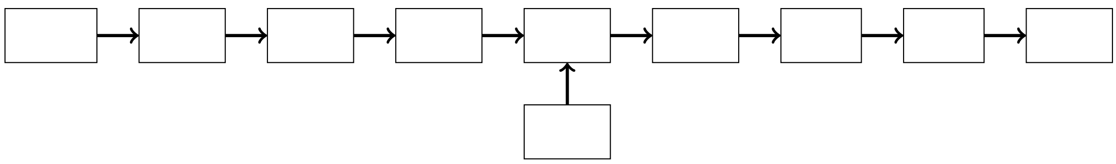
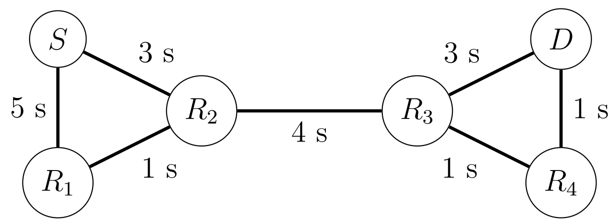


Figure 1: Basic block diagram of the communication process

2. Consider the six-node communication network shown in the below figure.

   (a) List all loop-free routes from node S to node D. [2 points]

   (b) The number alongside a link indicates the packet delay incurred on that link in seconds. Taking the routing cost of a route to be the sum of the delays of the links which constitute the route, write down the minimum-delay routing tables for the nodes S, R_1, R_2 and R_3 in the format shown in the table below. [8 points]



Routing table for S		
Reachable Node	Next Hop	Routing Cost

3. A single parity check is an error detection code which appends a single parity bit to an information bit string. The parity bit is set to 1 if the number of ones in the information bit string is odd and is set to 0 otherwise. Let the information bit string be 10101. If a single parity check bit is added to it and the resulting bit string is sent over a noisy channel, list all possible received bit strings which are declared error free at the destination. [5 points]

4. Draw the unipolar NRZ, polar NRZ, NRZI, Manchester and differential Manchester waveforms corresponding to the bit string 1100101. State any assumptions you made. [10 points]

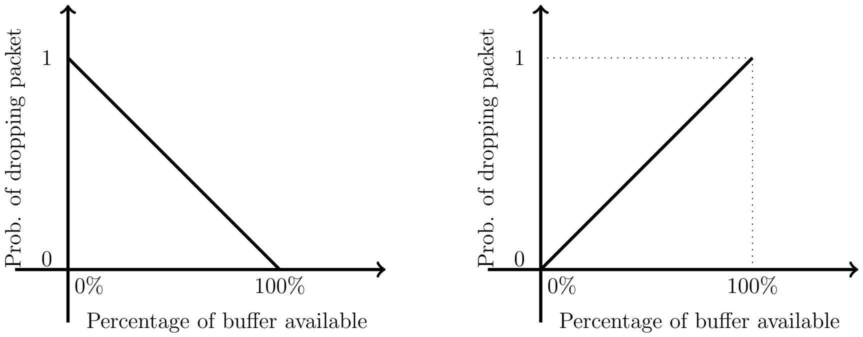
5. Figures 2a and 2b show two candidate random early detection (RED) schemes for congestion avoidance. The y-axis is the probability of dropping a received packet and the x-axis is the percentage of buffer space available or free at the receiving node.

   (a) For both schemes, calculate the probability of dropping a packet

      i. when 75% of the buffer space at the receiving node is occupied. [1 point]

      ii. when 25% of the buffer space at the receiving node is occupied. [1 point]

   (b) Which scheme is better? Explain your choice. [3 points]



(a) Scheme A (b) Scheme B

Figure 2: Two RED schemes for congestion avoidance

6. A data link layer framing protocol uses bit stuffing to prevent the flag byte 01111110 (01^60) from appearing in the payload.

   (a) What is the bit stuffing rule used at the sender? [1 point]

   (b) What is the bit destuffing rule used at the receiver? [1 point]

   (c) Apply the bit stuffing rule to the bit strings 1111111111111111111111111 (1^{25}) and 1111110111111111110111110 ($1^601^{11}01^50$) . [2 points]

   (d) Apply the bit destuffing rule to the following bit string and show where the actual flags are located. 011111101110110011111001111101100111111010111110

   [1 point]

7. 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 double-bit error which is detected by this CRC scheme.

   [2 points]

   (c) Give an example of a double-bit error which is **not** detected by this CRC scheme.

   [2 points]

   (d) Given an example of a burst error of burst length 5 which is detected by this CRC scheme. [2 points]

(e) Given an example of a burst error of burst length 5 which is **not** detected by this CRC scheme. [2 points]

8. In the following ARQ timing diagrams, fill in the missing information. You can write E to denote error frame and D to denote dropped frame.

   (a) For the stop-and-wait ARQ timing diagram in Figure 3, assume that one-bit sequence numbers are used.

      i. Write the frame number (FN) and frame sequence number (FSN) for each frame transmitted. [2 points]

      ii. Write the next expected frame number (NEFN) and next expected frame sequence number (NEFSN) for each ACK transmitted. [2 points]

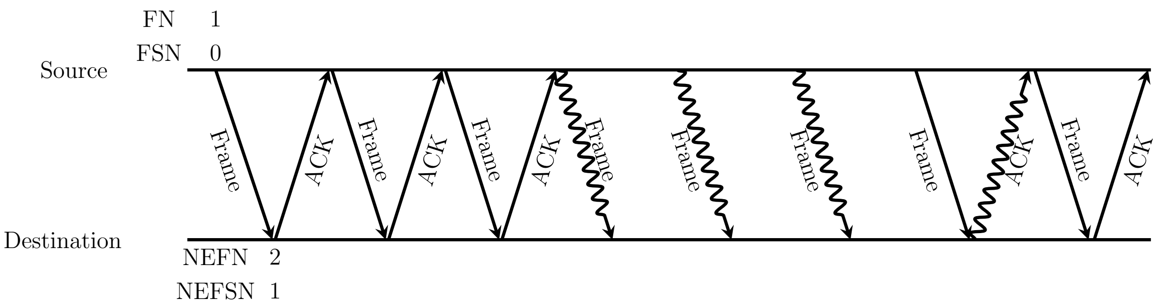


Figure 3: Stop-and-wait ARQ timing diagram

   (b) For the go-back-N ARQ timing diagram in Figure 4, assume that 2 bits have been allocated to store the sequence number in the frame and ACK headers. The ACKs are deliberately not shown in the timing diagram. Assume that all the ACKs for error-free frames are received without errors at the source.

      i. What is the maximum window size (the value of N) which allows correct operation? Use this value of N in the next two questions. [2 points]

      ii. Write the frame number (FN) and frame sequence number (FSN) for each frame transmitted. [2 points]

      iii. Write the next expected frame number (NEFN) and next expected frame sequence number (NEFSN) for each ACK transmitted. [2 points]

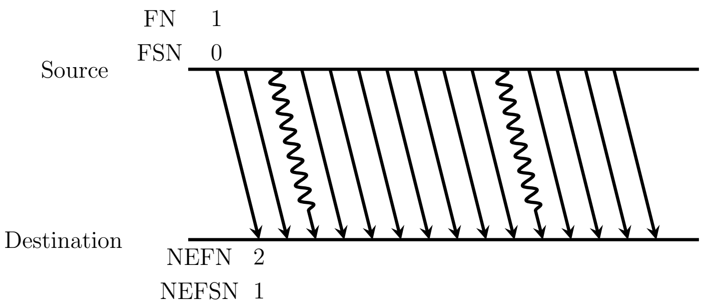


Figure 4: Go-back-N ARQ timing diagram