Indian Statistical Institute
Mid-Semester Examination: 2018
Course Name: M. Tech in Computer Science
Subject Name: Computer Networks

Date: 28-02-2018 Maximum Marks: 60 Duration: $2\frac{1}{2}$ hours

Instructions:

You **may** attempt **all** questions which cary a total of **65** marks. However, the maximum marks you can score is only **60**.

1. Consider a bit stuffing framing method where both start and end of a frame is indicated by the flag $01^k0$ where $1^k$ denotes $k$ consecutive ones.

   (a) What should be the bit stuffing rules at the transmitter? [2]

   (b) What should be the bit destuffing rules at the receiver? [2]

   (c) Is it necessary to stuff a 0 in $01^{k-1}0$? [2]

   (d) Assuming all bit patterns are equally likely, compute the expected overhead for a data packet of length $L$. Your expression for overhead calculation should include the flag length as well as the stuffed bits. [4]

2. (a) For the bit stream 1 0 0 1 1 1 1 1 0 0 0 1 0 0 0 1, sketch the waveforms for each of the following encoding schemes.

      i. NRZI

      ii. Manchester. [3+3=6]

   (b) Consider a communication link with bandwidth $B = 4000$ Hz and $S/N = 30$ dB. Calculate its maximum data rate in bits per second according to Shannon's theorem. Nyquist's theorem cannot be applied here because a factor is unknown. Point out what factor is unknown. [3+1=4]

   (c) Consider an audio signal with frequency components below 4000 Hz. Consider generating a PCM signal out of it using 5-bit PAM samples. If samples are taken according to the sampling theorem, what data rate is achieved? [3]

   (d) Briefly describe the effect of delta on quantizing noise and slope overload noise in delta modulation. [4]

3. (a) State the balance property and run property of a maximum length pseudo noise sequence? [1+2=3]

   (b) Consider an MFSK scheme with carrier frequency $f_c$ equal to 250 kHz, difference frequency $f_d$ equal to 25 KHz, number of different signal elements $M$ equal to 8, and number of bits per signal element $L$ equal to 3.

      i. Make a frequency assignment for each of the eight possible 3-bit data combinations. [4]

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ii. Suppose we wish to apply FHSS to this MFSK scheme with $k = 2$; that is, the system will hop among four different carrier frequencies. Let $T_c$ be the period at which the MFSK carrier frequency changes and $T_s$ is the duration of a signal element. Consider a **slow FHSS** with $T_c$ being $2T_s$. Show the sequence of frequencies used, and the times the frequency changes occur, for transmitting the bit string 011110001. Assume that the PN sequence for generating the frequency hops is 0011. [5]

4. (a) Consider a CRC code with the generator polynomial $g(X) = 1+X+X^4$. Determine if the codeword described by the polynomial $c(X) = 1 + X + X^3 + X^7$ is a valid codeword for this generator polynomial. [5]

   (b) The $(4, 3)$ odd parity code is a code where 1 odd parity bit is appended to 3 message bits to produce 4-bit codewords. The error detecting capability of a code is defined as the maximum value of $t$ such that all error patterns with $t$ or less erroneous bits can be detected by the code. A code is linear if, and only if, the sum of any two codewords is another codeword.

   i. Is $(4, 3)$ odd parity code a linear block code? [3]

   ii. Find the error detecting capability of the $(4, 3)$ odd parity code. [3]

   (c) Suppose that a parity check code has a minimum Hamming distance $d$. Show that if the Hamming distance between a codeword and a given string is less than $d/2$, the Hamming distance between any other codeword and the given string must exceed $d/2$. [5]

5. (a) Suppose two nodes communicate with each other using a stop-and-wait protocol. The data packet size is 10000 bits. The total round-trip time (RTT) between the nodes is equal to 0.2 milliseconds (this includes the time to process the packet, transmit an ACK, process the ACK and transmit the ACK) **plus** the transmission time of the 10000 bit packet over the link. Let $l$ be the bi-directional packet loss probability and $R$ be the data rate of the link. Suppose you have two options to configure your connection with the following properties: 1) if you choose $R = 10$ Megabits/s, then $l$ will be 1/11, 2) if you choose $R = 20$ Megabits/s, then $l$ will be 1/4. For both bit rates, the retransmission timeout (RTO) is 2.4 milliseconds.

   i. For each bit rate, calculate the expected time, in milliseconds, to successfully deliver a packet and get an ACK for it. [6]

   ii. Suppose your goal is to select the bit rate that provides the higher throughput for a stream of packets that need to be delivered reliably between the nodes. Which bit rate would you choose to achieve your goal? [2]

   (b) A Go-back-N ARQ uses a window of size 15. How many bits are needed to define the sequence number. [2]