Numerical Problems from OSI Reference Model and Physical Layer

1. Suppose a file of size 100 KB (kilo bytes) has been send to a destination host through an intermediate router. Assume that the network has been configured with OSI reference model, and each layer introduces a delay of 1 ms. A coaxial cable is connected between source to router and router to destination. The length of cable between source to router is 1000 kms and router to destination is 1500 km. The signal speed inside the cable is about 2,00,000 km/sec and it supports the data rate of 1000 kbps. Determine the time required to reach the file from source to destination.

2. Design a FDM scheme for multiplexing 10 voice channels. Each voice channel has spectral components up to 4 KHz. Suggest the appropriate carrier frequencies and the overall bandwidth required to carry out the FDM.

3. Draw the encoded signal waveforms for the data bits 11010110 using (i) NRZ-L, (ii) NRZ- I, (iii) RZ, (iv) Manchester and (v) Differential Manchester coding schemes. Comment the above coding schemes w.r.t (i) DC component, (ii) synchronization, (iii) bandwidth, (iv) error detection and (v) complexity.

4. A telephone line allows the signal frequencies between 300 to 3300 Hz. Calculate the theoretical highest bit rate of the above mentioned telephone channel for the signal to noise ratio of 4096.

5. A cable operator uses one of the cable TV channels to provide data transmission for each resident. What are the possible baud rate and data rate offered to each resident, if the operator uses a 128-QAM modulation technique. (Hint: Bandwidth required for the transmission of one TV channel is approximately 6 MHz)

6. Consider a voice signal has prominent frequencies up to 3.5 KHz, and having the amplitude ranging from -5 V to +5 V. Choose an uniform quantizer with a step size of 0.5 V. An even parity check scheme is employed for error detection. Thirty such voice channels are mixed using synchronous TDM (sync-TDM). The output frame of the synchronous TDM consists of single sample from each voice signal. For frame synchronization, two bytes of control information will be placed at the beginning of each frame. (a) Determine the maximum quantization error that will occur in the digitization process, (b) What will be the data rate for encoding the voice channel, with and without error detection ?, (c) What will be the output Sync-TDM frame length in micro seconds ? (d) Determine the number of bits present in the output sync-TDM frame. (e) Determine the output data rate of the sync-TDM. (f) What will be the effective channel utilization, if all channels have enough data for transmission ? (g) If 40% of the channels have no data for transmission (on average) at any point of time, what will be the channel utilization in the case of (i) sync-TDM and (ii) statistical TDM ?

7. A constellation diagram consists of 16 points lie on two concentric circles. Each circle has eight points and the points are equally spaced. Determine the optimal modulation scheme that suit the above constellation pattern. Find the baud rate for the transmission of voice channel at a rate of 64 Kbps using the above modulation scheme.

8. Design FDM and TDM schemes for multiplexing 10 voice channels. Each voice channel has spectral components up to 4 KHz. Suggest the appropriate carrier frequencies and the overall bandwidth required to carry out the FDM. Find the data rate and bandwidth required in the case of TDM for the following constraints: 256 level uniform quantization, odd parity check for error detection, differential Manchester coding for encoding and five harmonics for the desired error performance.

9. Four data channels (digital), each transmitting at 10 Mbps, use a satellite channel of 5 MHz. Design an appropriate mulliplexing configuration scheme?

10. The file of size 1MB has to be delivered at California, which is originating from Kharagpur. The routing will be performed using virtual circuits. The established virtual circuit for transferring the given file is as follows: Kharagpur - Kolkota – Delhi – Moscow – Frankfurt – Paris – London – New York – Chicago – California. Assume that the network architecture follows the OSI reference model, and each layer contributes a delay of 2 ms to perform its functionalities. The total path length given by the virtual circuit is about 15000 Km, and each link offer a data rate of 10 Mbps. Propagation delay will be roughly about 5 $\mu s / Km$. For transmission of the file, it is split into 1000 pieces and the control information (headers) appended by all the layers together yields 10% of the actual information. Determine the following delay components, which contribute to the overall delivery time. (i) Transmission time, (ii) Total delay contributed by processing at the layers, (iii) Propagation delay and (iv) Overall delivery time

11. A high quality image requires a spatial resolution of about 0.002 inch, which means that about 500 pixels (i.e., samples) per inch are needed in a digital representation. Assuming that the color image size is 10 by 12 inches, and each pixel is coded with 24 bits. Determine the transmission time of the above mentioned color image through the following channels: (a) Twisted pair with a band width of 10 MHz, (b) Coaxial cable with a band width of 100 MHz and (c) Optical fiber with a band width of 1000 MHz The image is transmitted using Non-Return-to-Zero (NRZ) coding scheme by representing two bits per period. For the desired error performance, minimum of 10 harmonics are needed to be transmitted.

12. The synchronous TDM system combines 25 digital sources, each of 100 kbps. Each output slot carries 4 bits from each digital source, one extra bit is added to each frame for synchronization.
    (i) What is the size of the output frame in bits?
    (ii) What is the output frame rate?
    (iii) What is the duration of an output frame?
    (iv) What is the output data rate?
    (v) What is the effective utilization (in %) of the channel?