Data Communication Networks
HW 1: Physical Layer

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Problem 1 (15 pts)

Assume a network with these conditions. The call setup time is t_{setup} sec, the propagation delay is t_{prop} sec per hop, the packet size is P bits, and the transmission rate of each link is R bps.

(a) Compute the delay, from the first bit transmitted to the last bit received, in sending an M-bit message over a K-hop path in a circuit-switched network and in a packet-switched network. (Queuing delays are zero and the packet header size is H bits.)

(b) Consider what the circuit-switched network must do during call setup: a call setup message must be sent along the K-hop path so that the nodes along the path can allocate resources for the circuit. In addition, a call-connected message must be returned so the sender knows that the circuit has been established. Considering this requirement, how can a circuit-switched network satisfy the conditions derived in a)?

Problem 2 (10 pts)

A 1000 km long telecommunication system consists of M pieces of optical fiber cable with the same attenuation factor $\alpha = 0.25\frac{dB}{km}$ and M of the same amplifier. If we want $P_{in} = P_{out} = 2dBm$ and the input power of each amplifier to be at least $25\mu W$, find the number of pieces and the gain of each amplifier.

Problem 3 (10 pts)

The below equation gives a formula for the end-to-end delay of sending one packet of length L over N links of transmission rate R. Generalize this formula for sending P such packets back-to-back over the N links. Consider an application that transmits data at a steady rate (for example, the sender generates an N-bit unit of data every k time units). Also, when such an application starts, it will continue running for a relatively long period of time.

$$d_{end-end} = N(d_{proc} + d_{trans} + d_{prop})$$

Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?

Problem 4 (15 pts)

Consider a T1 carrier and answer the following questions:

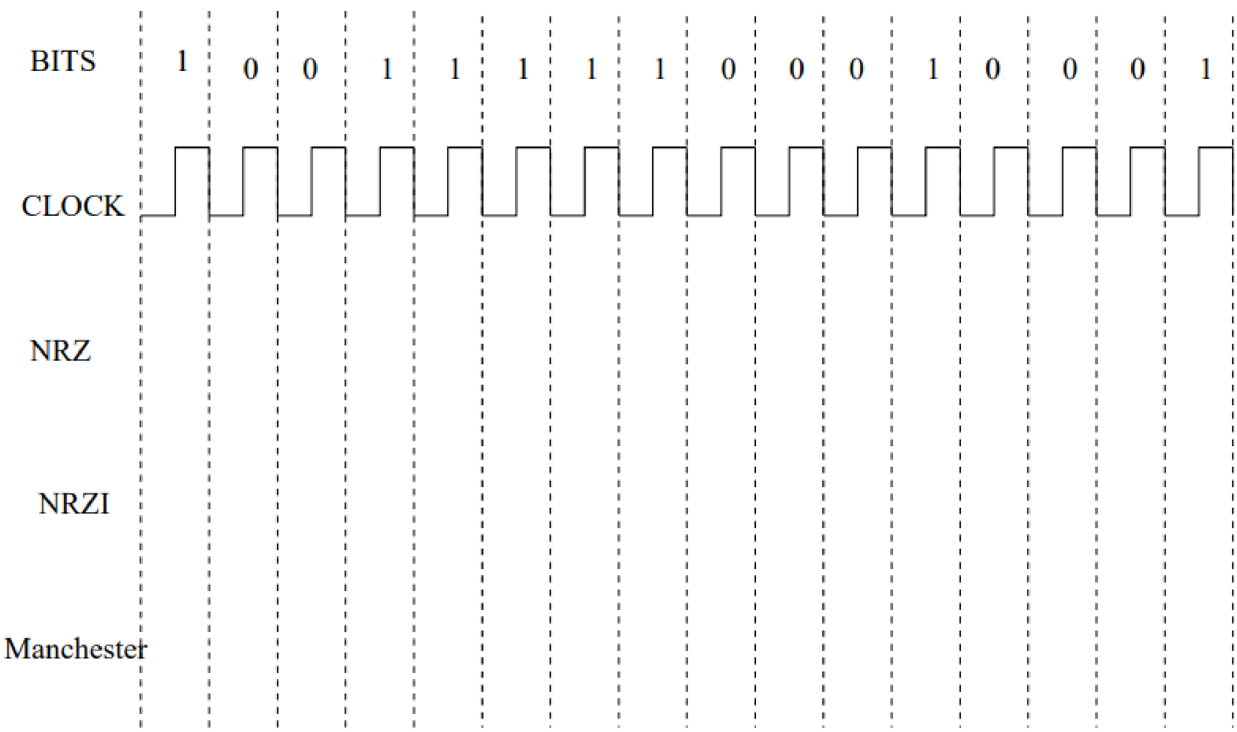
(a) We want to create cellular networks to provide call service to subscribers. To do this, we divide the area into hexagonal cells with the same area. We have 1050 separate frequency bands and each frequency band can transmit one T1 carrier. The use of similar frequency bands is prohibited in adjacent cells. What is the maximum number of frequency bands that can be assigned to each cell? In this case, how many subscribers are served by one cell?

(b) Suppose the signal sent by each BTS is lost due to attenuation at a distance of 100 meters. What is the minimum side of each cell?

(c) Solve a and b assuming that 7 frequency bands are used.

Problem 5 (10 pts)

(a) For the bit patterns shown in the figure below, show the encodings. Assume that the NRZI starts out low.



(b) Bob has built a network link technology. But some of his customers complain that when they use this technology, their packets get corrupted. He tracks the problem down to time synchronization problems between the sender and receiver on the link. To help Bob with solving this problem, write different encoding methods. Identify the problem and give a 1-2 sentence explanation about why this occurs.

(c) For each of the sub-parts, identify whether the encoding can have problems with the following four cases.
(i) Long strings of 1s. (ii) Long strings of 0s. (iii) Both long strings of 1s and 0s (iv) None of the above

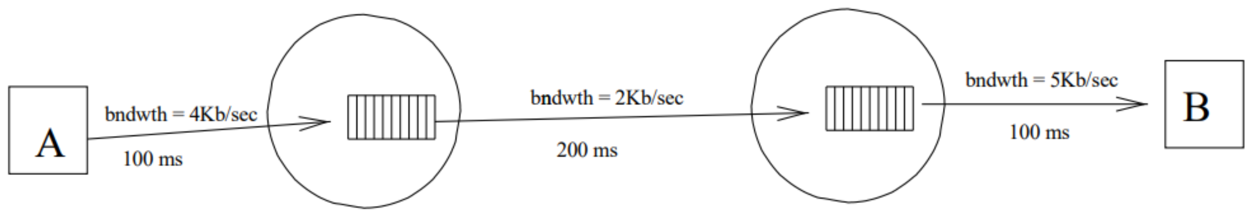
(A) Manchester

(B) NRZ

(C) NRZI

Problem 6 (10 pts)

In the network below, the routers are first-come-first-serve routers. Each router has one buffer of size 10 packets. The bandwidth of links are 4 Kb/sec, 2 Kb/sec and 5 Kb/sec respectively. The bottom number in each link is the time it takes for light to travel from one end of the link to the other. Assume that all packets are of size 1Kbit and all rates are in Kbits/second.



Provide an upper bound and a lower bound on the end-to-end delay for a packet passing from A to B. (Assume that packets lost are not counted in the upper/lower bound. Assume that all times not specified in the figure are so close to zero as to not be important).

Problem 7 (15 pts)

Suppose a R bps point-to-point is set up between ISROs Earth control station located in Bengaluru and the Mars orbiter in the Mars Orbiter Mission (MOM). Assume spherical shapes for Earth and Mars and circular motion of the orbiter around Mars. The orbiter is orbiting in the same plane that connects the centers of these two planets and Bengaluru. Assume communication is possible only if the orbiter is in the line-of-sight (LOS) from the control station. The distance between the centers of the planets is D meters. The radii of Earth and Mars are R1 and R2 meters respectively. The orbiter is orbiting at a height h meters above Mars ground. The speed of electromagnetic wave in air and space is c.

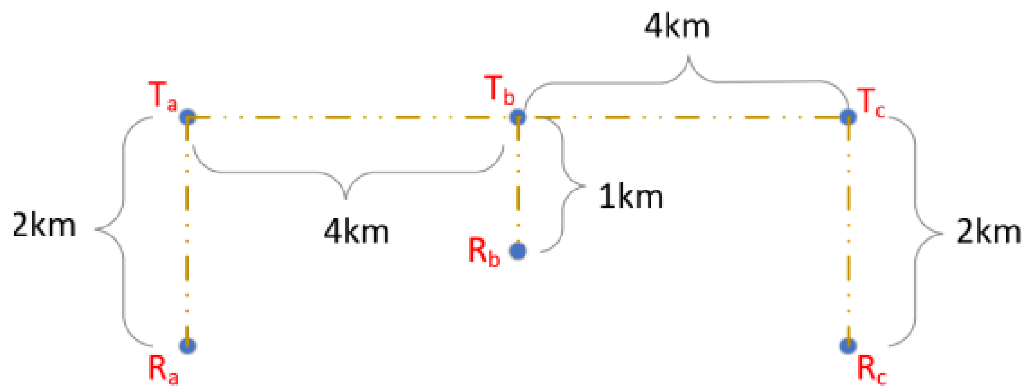
(a) Calculate the minimum and maximum round-trip-times (RTT) between the control station and the orbiter

(b) A camera on the orbiter takes pictures of Mars and sends to the Earth control station. What is the minimum and maximum time taken to send this picture to Earth if the size of the picture taken is L

Show details of your calculations in each step.

problem 8 (15 pts)

Consider a simple wireless network with three pair of transmitter and receivers, shown in figure below. T_a, T_b, T_c are transmitters and their receivers are R_a, R_b, R_c respectively. Suppose we have only one channel in this network, and none of the Multiple Access methods are used for channel reuse. Also, suppose our antennas are Omnidirectional, i.e., our antennas send or receive power in any direction equally. Also, consider that when a transmitter sends a signal with a power of P_t, the receiver gets a signal with a power of $P_r = \alpha \frac{P_t}{d^n}$ that d is the distance between the transmitter and the receiver, α is a constant value and $n = 3$. For a connection to be acceptable, the signal to interference ratio must be greater than or equal to 14, i.e., $\frac{S}{I} \geq 14$ (in a linear scale, i.e., not in dB scale). Also, the noise is ignored.



(a) T_a and T_b send signals with a power of $P_t = P_0$ simultaneously and T_c is off. Calculate $\frac{S}{I}$ for R_a, R_b. Is it acceptable T_a, T_b send equal power simultaneously?

(b) Calculate the transmitted power for transmitters such that all of them can send power simultaneously.

What Should I Do?

You must upload a pdf file containing your homework answers ($HW1\_StudentNumber.pdf$) for this assignment.