Data Networks
HW 1: Physical Layer

Dr. Mohammad reza Pakravan

Problems

Question 1 (15 pts)

In this problem the transmission time of a message over a K-hop path in the case of circuit-switching is compared with the case of packet-switching. Suppose the whole message consists L bits. The line rate on each hop is R bps. If we use packet switching, the queuing delay of each hop is δ. The packet size and header size are P and H bits, respectively (L >> P+H).

1. Assume the circuit setup time is S sec and the propagation delay is D sec per hop. Find the total transmission time of the message in both a circuit-switched network and a packet-switched network. Under what conditions does the packet network have a lower transmission time?

2. For L = 100 bits, H = 8 bits, R = 56 Kbps, D = 1.5 ms, δ = 0.4 ms and K = 3 hops in packet-switching mode, calculate the minimum possible transmission time.

Question 2 (15 pts)

In figure 1, the transmitted power is 125mW, and the minimum acceptable SNR at the receiver is 30dB

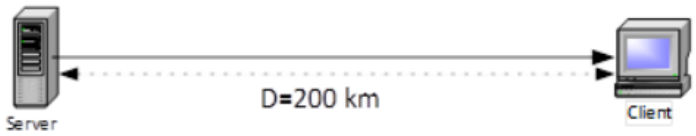


Figure 1: Server and client

$$N_0 = 4 \times 10^{-21} \frac{W}{Hz}, BW = 400kHz$$

1. Suppose the server is connected to the client with a Copper cable, and the transmission loss of the line is 2 dB km . Is it possible to have a successful connection without using any amplifier?

2. Assume that we have m identical amplifiers, each with a gain of 10dB. If your answer to the last part is no, find the minimum of m to have a successful connection.

3. Repeat the previous parts assuming the server and the client are connected with an optical fiber, and the transmission loss of the line is 0.3 dB km .

Question 3 (15 pts)

1. Consider a CDMA system with the following chip sequences:
   A = (-1 -1 -1 +1 +1 -1 +1 +1) B = (-1 -1 +1 -1 +1 +1 +1 -1)
   C = (-1 +1 -1 +1 +1 +1 -1 -1) D = (-1 +1 -1 -1 -1 -1 +1 -1)
   A is receiving an 8-bit integer from B. A receives the following sequences in order. (S_0 is LSB and S_7 is MSB and the number is 2's complement)
   S_0 = (-1 -1 +1 +1 +3 +3 -1 -1) S_1 = (+1 -3 +3 -1 +1 +1 +1 +1)
   S_2 = (0 0 +2 -2 0 +2 0 -2) S_3 = (0 0 -2 +2 0 -2 0 +2)
   S_4 = (0 +2 -2 +2 0 0 -2 0) S_5 = (-2 0 0 0 +2 +2 0 -2)
   S_6 = (0 +2 -2 0 -2 -2 0 0) S_7 = (-2 0 0 -2 0 0 +2 -2)
   What is the number?

2. Explain how broadcasting and multi-casting can be implemented using CDMA?

Question4 (15 pts)

In a bitstream consider that the probability of having a 0 is four times having a 1.

1. Compare the power of bitstreams encoded with (i) Manchester encoding, (ii) NRZ (with 0 amplitude for 0), (iii) NRZI (with 0 amplitude for 0) and, (iv) AMI (Alternate Mark Inversion, also called Bipolar encoding.)

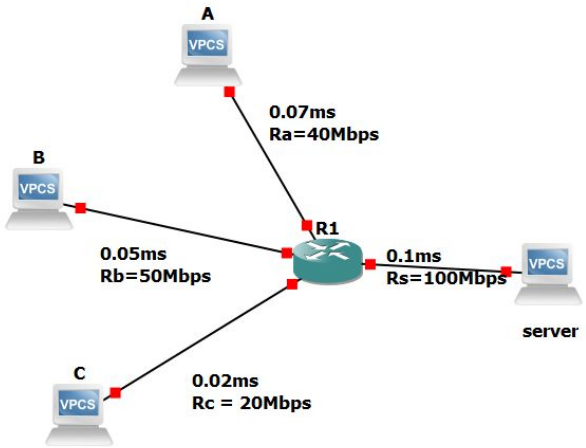
2. For each one of the aforementioned encodings, identify whether it can have problems regarding clock synchronization with:

   (a) Long strings of consecutive 0s

   (b) Long strings of consecutive 1s

Question 5 (10 pts)

In the following network, the server sends a packet to A and then sends a packet to B and then to C and repeats this. The size of each packet is 1KB and the router spends 0.01 ms for routing of each packet. How long must the third packet toward B wait in the queue?



Question 6 (15 pts)

Consider a T1 carrier and answer the following questions:

1. 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?

2. 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?

3. Solve a and b assuming that 7 frequency bands are used.

Question 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.

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

2. 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

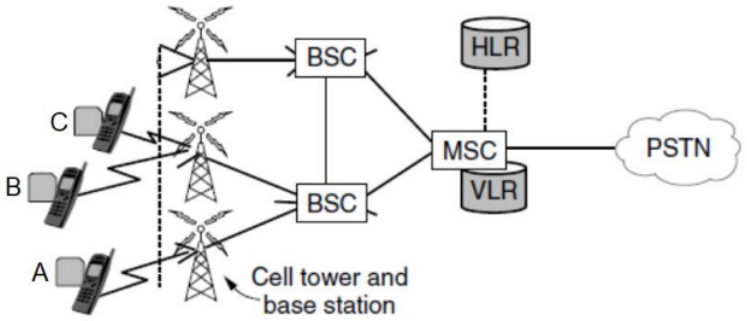
Show the details of your calculations in each step.

Question 8 (10 pts)

Choose True or False for each of the following statements or questions. Provide sufficient conclusions and calculations.

1. By using a voice-band modem, we are connected to an ISP which has a digital connection to PSTN. Is it true that we can download a file with a limited rate of 33.6 kbps because of quantization noise?

2. When B calls A, BSC will serve as an intermediary for the connection. However, when B calls C, neither BSC nor MSC will act as intermediaries since C's number is readily accessible in the BTS database.



3. When we are transmitting a 6MB file across a 1Gbps network with a round trip time of 200msec, the throughput is 193.55Mbps. In the case of ignoring ACKs, the throughput increases to 324.32Mbps.

4. By making some changes to (k)th-layer services, the (k+1)th-layer protocols should be reconfigured. But there is no need to change the (k-1)th-layer protocols.

5. By using a voice-band modem, we are connected to an ISP which has a digital connection to PSTN. Is it true that we can download a file with a limited rate of 33.6 kbps because of quantization noise?