Data Communication Networks
Homework 1: Physical Layer

Dr. MohammadReza Pakravan

Circuit Switching VS Packet Switching

Question 1 (10 pts)

An L-bit message is sent over a k-hop path. The call setup time, the propagation delay per hop, the packet size and the transmission rate of all links are t seconds, s seconds, n bits and r bps respectively,

(a) What is the total delay, if the message is sent over the circuit-switched network?

(b) What is the total delay, if the message is sent over the (lightly loaded) packet-switched network? (For the packet-switched network, assume that the processing and queuing delays at each hop are zero and ignore any packet header overhead)

(c) Under what conditions does the circuit-switched network have a lower delay?

Question 2 (10 pts)

Suppose users share a 1 Mbps link which each user transmits only 10 percent of the time and requires 100 kbps when transmitting.

(a) How many users can be supported, if circuit switching is used?

(b) Suppose there are 40 users. When packet switching is used, Find the probability that at any given time, exactly n users are transmitting simultaneously.

(c) When packet switching is used, find the probability that there are more than 10 users transmitting simultaneously.

(d) What is your conclusion about the number of users that could be supported with packet switching compared to circuit switching?

(e) What happens if all the users synchronize in their use of the shared link? What is your conclusion about the use of circuit versus packet switching, is there a clear favorite?

Question 3 (13 pts)

According to figure 1, answer the following questions

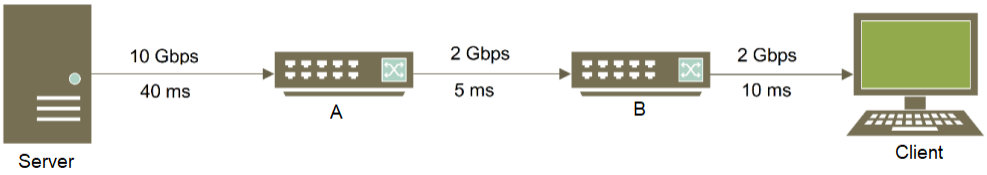

Figure 1: Packet VS Circuit Switched Networks

(a) The server sends 2 packets to the client (the size of each packet is 15KB). The transmission rates and the propagation delays are written in figure 1. Considering the queuing delay, how long does it take to send the packets in a store-and-forward packet-switched network?

(b) The server sends a 30 KB file to the client in a circuit-switched network. The link delays are written in figure 1. The transmission rate between the server and the client in this circuit-switched network is the minimum of all the transmission rates written in figure 1. How long does it take to send the file? (the setup time is 3 seconds)

Attenuation

Question 1 (15 pts)

In figure 2, the transmitted power is $125mW$, and the minimum acceptable SNR at the receiver is $30dB$.

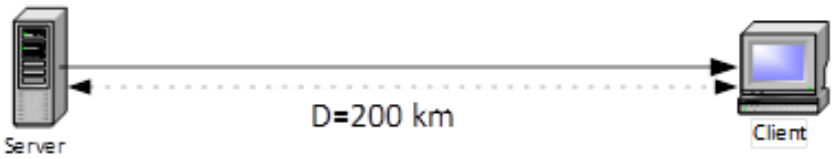

Figure 2: Server and client

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

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

(b) 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.

(c) Repeat the previous parts assuming the server and the client are connected with an optical fiber, and the transmission loss of the line is $0.3\frac{dB}{km}$.

Coding

Question 1 (15 pts)

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

(a) 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.).

(b) For each one of the aforementioned encodings, identify whether it can have problems regarding clock synchronization with:

- Long strings of consecutive 0s
- Long strings of consecutive 1s

Question 2 (7 pts)

Consider the following chip sequences. If station A transmits 1 bit and station B transmits 0 bit, the output will be $(0, +2, 0, -2)$.

$$A : (+1, \alpha, \beta, \gamma)$$
$$B : (+1, -1, -1, +1)$$
$$C : (+1, -1, +1, -1)$$

(a) What is the output if station A transmits 0 bit and station C transmits 0 bit?

(b) What did the stations transmit if the output is $(-1, -1, -1, +3)$?

Question 3 (5 pts)

We received a bipolar modulated signal. The received signal contains 15 bits, but we lose 6 bits of this signal because of the noise. The other 9 bits are shown in figure 3. Find all possible sequences.

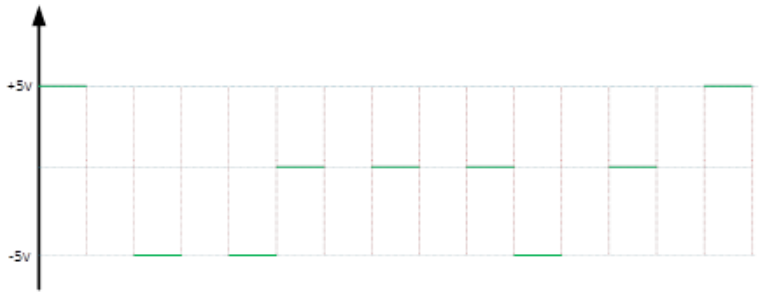

Figure 3: Received sequence

Cellular Network

Question 1 (10 pts)

For creating a cellular network to provide call service to subscribers, we divide the area into identical equilateral triangle cells. We have 27720 separate frequency bands and each frequency band can transmit one E1 carrier. Using the same frequency bands is prohibited in adjacent cells with a common edge or vertex. Is it possible for a cell to serve 180,000 users simultaneously? Why?

Question 2 (10 pts)

Consider a simple wireless network with three pair of transmitter and receivers, shown in figure 4. 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.

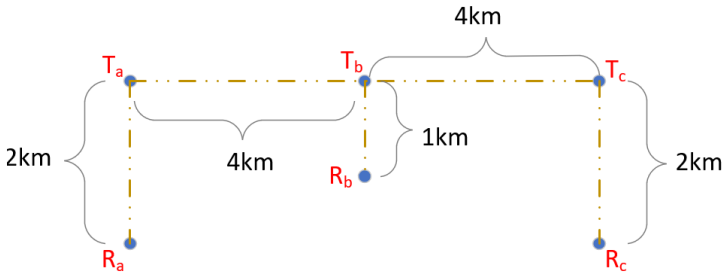

Figure 4: Cellular network

(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.

Question 3 (15 pts)

According to the following figure, mobile moves across the straight line between two base stations. The distance between the base stations is $D = 1600m$. Mobile receives a signal with a power of $P_{r,i}$ from base station i

$$P_{r,i}(d) = -40 \log_{10}(d_i) + \chi_i(dB), i = 1, 2.$$

which d is the distance between the base station and the mobile. The χ term shows the variations of channel due to random effects such as rain, wind, etc. We model this parameter as a gaussian random variable with zero mean and $\sigma = 6dB$. Also, suppose χ_1 and χ_2 are independent.

For having a good call, the received power should be more than $P_{r_{min}} = -92dBm$, and if the received power is less than $P_{r_{Handoff}} = -86dBm$, mobile switches its base station to get more power.

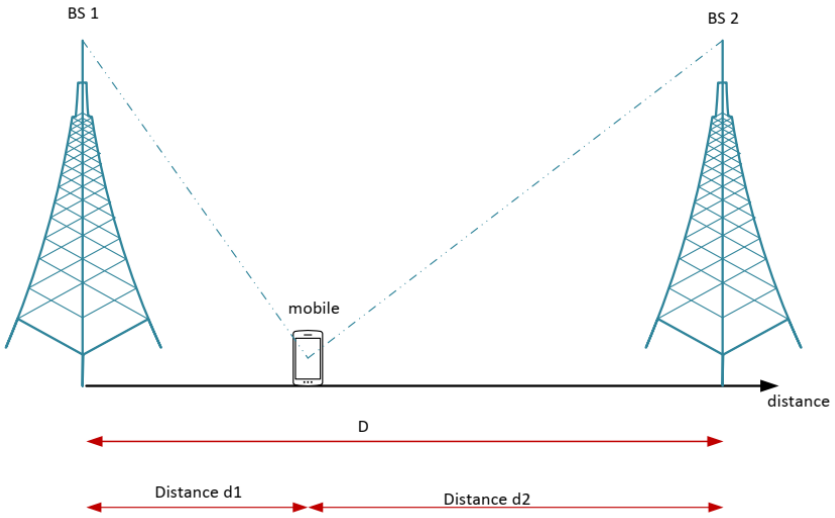

Figure 5: Mobile and base stations

At the beginning of moving, the mobile connects to base station 1.

(a) At what distance from base station 1 does Pr[mobile switches its base station] equal 0.8?

(b) If switching the base station takes five seconds, what is the maximum speed for the mobile? Do not Consider the noise (i.e., ignore χ term)

What Should I Do?

You must upload a pdf file containing your homework answers (YourName StudentNumber.pdf) for this assignment.