Université Paris Dauphine
Computer Networks

Homework 1: Physical Layer

Part I:

1. Is an oil pipeline a simplex system, a half-duplex system, a full-duplex system, or none of the above? What about a river or a walkie-talkie-style communication?
2. What are the advantages of fiber optics over copper as a transmission medium? Is there any downside of using fiber optics over copper?
3. It is desired to send a sequence of computer screen images over an optical fiber. The screen is 3840 × 2160 pixels, each pixel being 24 bits. There are 50 screen images per second. What data rate is needed is needed?
4. Radio antennas often work best when the diameter of the antenna is equal to the wavelength of the radio wave. Reasonable antennas range from 1 cm to 1 meter in diameter. What frequency range (band) does this cover?
5. Identify three physical properties that limit the maximum data rate of digital communication channels used in practice. Explain your answer.
6. A noiseless 10-kHz channel is sampled every 1 msec. What is the maximum data rate?
7. Is the Nyquist theorem true for high-quality single-mode optical fiber or only for copper wire?
8. Television channels are 6 MHz wide. How many bits/sec can be sent if four-level digital signals are used? Assume a noiseless channel.
9. If a binary signal is sent over a 3-kHz channel whose signal-to-noise ratio is 20 dB, what is the maximum achievable data rate?

Part II:

1. You need to select a line code that will only be used to send the bit sequences 10101010 and 00111100. Which of the lines codes shown in Fig. 2-14 is not a good candidate? Consider both bandwidth efficiency and clock recovery.
2. What is the minimum bandwidth needed to achieve a data rate of B bits/sec if the signal is transmitted using NRZ, MLT-3, and Manchester encoding? Explain.
3. In the discussion about orthogonality of CDMA chip sequences, it was stated that if S•T = 0 then S•T is also 0. Prove this.
4. Consider a CDMA system with 4 transmitting base stations (A, B, C, and D). Each base station received a unique sequence of chips as shown in Fig.1 (a) and their signal representation is shown in Fig.1 (b). In Fig.1 (c), we show 6 examples of transmissions: S1 only base station C is transmitting and it transmits bit 1; in S2 base stations B and C are both transmitting bit 1 simultaneously; in S3, base stations A and B are simultaneously transmitting a bit 1 and a bit 0, respectively; etc. The operations to

recover base station's C signal is shown in Fig.1 (d) with respect to the signals in Fig.1 (d). Regarding this system, answer the questions below:

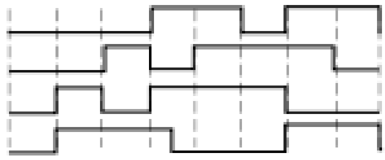
A = (−1 −1 −1 +1 +1 −1 +1 +1)

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)



(b)

$S_1 = C \quad = (-1\ +1\ -1\ +1\ +1\ +1\ -1\ -1)$

$S_2 = B+C \quad = (-2\ \ 0\ \ 0\ \ 0\ +2\ +2\ \ 0\ -2)$

$S_3 = A+\bar{B} \quad = (\ 0\ \ 0\ -2\ +2\ \ 0\ -2\ \ 0\ +2)$

$S_4 = A+\bar{B}+C \quad = (-1\ +1\ -3\ +3\ +1\ -1\ -1\ +1)$

$S_5 = A+B+C+D = (-4\ \ 0\ -2\ \ 0\ +2\ \ 0\ +2\ -2)$

$S_6 = A+B+\bar{C}+D = (-2\ -2\ \ 0\ -2\ \ 0\ -2\ +4\ \ 0)$

(c)

$S_1 \bullet C = [1+1+1+1+1+1+1+1]/8 = 1$

$S_2 \bullet C = [2+0+0+0+2+2+0+2]/8 = 1$

$S_3 \bullet C = [0+0+2+2+0-2+0-2]/8 = 0$

$S_4 \bullet C = [1+1+3+3+1-1+1-1]/8 = 1$

$S_5 \bullet C = [4+0+2+0+2+0-2+2]/8 = 1$

$S_6 \bullet C = [2-2+0-2+0-2-4+0]/8 = -1$

(d)

a. Suppose that A, B, and C are simultaneously transmitting 0 bits. What is the resulting chip sequence?
b. A receiver gets the following chips: (-1+1-3+1-1-3+1+1). Which stations transmitted, and which bits each one sent?
c. A base station schedules a single slot for devices A and B to send data. During this time, other stations remain silent. Due to noise, some of the chips are lost. The base station receives the following sequence : (0,0, ?,2, ?, ?,0,-2). What are the bit values transmitted by stations A and B?
d. Suppose four more stations are added. Provide the chip sequences of these stations.