Computer Networks and Distributed Systems

Quesrtionnaire Ch2: Shannon Th. through PCM encodings

Context

- Based on this lecture presentation: http://paloalto.unileon.es/cn/ch2-2017.pdf
  - Brief intro to Communication and Information Theory: Nyquist, Shannon-Hartley
  - Links, wavelength
  - PCM Line Encoding (NRZ, NRZ-i and Manchester)

1. Which Internet Architecture layer is this chapter focused on? Briefly list the functions of this layer and the name and the structure of its PDU (Protocol Data Unit) in the case of the Ethernet technology.

2. Observe the network diagram of slide no. 6, then, respond to the following questions related to it:

    a. Is the physical layer implemented in all the network elements? Explain why it is

    b. Switches have no IP, try to justify this on the basis of the board discussions we held in the labs as we were evolving the lab practicals

    c. Why do routers have IP?

    d. Try to justify the great variety of link layer protocols that appear on the net diagram

3. We can digitize the variables that represent a real-world process like the surrounding sound by turning time, which is considered continuous, into a discrete variable, then, at each discrete-time value we must quantize the sound which consists of assigning the correct discrete value to its sound power (Air pressure). Nyquist established an important result known as the Nyquist rate or criterion:

    a. We want to find out whether Nyquist rate applies to the discretization process (continuous time to discrete time) or the quantization process (Continuous air-pressure to discrete air-pressure)

    b. Is the Nyquist rate a sufficient condition or a necessary condition for obtaining the original signal from the digitized samples?

    c. We are digitizing music at a 8Ksamples/sec, then, when converting the samples back into real sound, what will that sound bandwidth be?

4. Over a communication channel, can we transmit at a speed as high as we wish? Carefully discuss this question according to Shannon-Hartley theorem.

5. Compute the Shannon capacity of a channel with a 2MHz bandwidth whose SNR=500. In order to increase the channel capacity in this case, you can choose to double either the bandwidth or the SNR: which one

would you choose? Explain why.

6. In slide 8 on the presentation mentioned above, you can observe that the different transmission media offer different bandwidths. Why is it good to have transmission media with high bandwidth? Does a higher bandwidth mean a higher propagation speed?

7. The following URL gives us a listing of the frequency bands used by European LTE mobile operators, among them, Movistar uses these frequencies: 800 MHz, 1800MHz and 2600MHz:

   https://en.wikipedia.org/wiki/List_of_LTE_networks_in_Europe

   a. Calculate the electromagnetic signals' resulting wavelengths and briefly discuss the advantage to using the highest frequency (Recall the lectures when I explained the efficiency of an antenna).

   b. Calculate the wavelength resulting when transmitting at 2600MHz

8. There exist a number of PCM line encoding techniques, among them, we note the importance of NRZ, which you used in the Digital Electronics lab, however, in this course on Computer Networks, we are only interested in PCM signals such as NRZ-i and Manchester. Provide a brief explanation about why we don't use NRZ in Computer Networks.

9. Briefly explain the voltage levels used at the output of a CMOS NOT gate for representing a 0 and a 1. Observe that all CMOS NOT gates must follow these specifications, in particular, we want to note that each binary value is represented by a continuous range of voltages and that in between them, there exists a region in which no signal should remain for a long time.

10. By contrast to logic gates, line encoders (NRZi, Manchester, etc.) don't have such a stringent specification but the receiver keeps the average value of the input signals it has seen so far and decodes a 1 when the input signal's value is greater than the average voltage and 0 otherwise. What adverse effect is derived when a signal stays on the same level for a long number of bit times? What's the name of this effect?

11. Assume a 4B/5B + NRZ-I encoder for this exercise. We want to transmit the following sequence of 20 binary symbols: 0100 0000 0000 0000 0001

    a. What's the length of the longest string of bits 0 present in the sequence?

    b. What's the length of the longest string of bits 0 present in the output of the 4B/5B encoder? Is this result consistent with the 4B/5B encoder's mission?

    c. What's the length of the longest string of bits 1 present in the output of the 4B/5B encoder? Now, carry out the NRZ-I line encoding, then, count the longest string of bit times in which the signal stays on the high level and also count the longest string of bit times in which the signal stays on the low level. Contrast each of the results obtained with the results obtained in a) and in b).

    d. Assume the encoder is using a bit time $\tau=0.1\mu s$. Calculate the transmitting clock frequency corresponding to this value of τ.

   e. Estimate the sampling clock derived by the receiver by calculating the average distance between signal level changes.

12. Assume, now a Manchester encoder:
    a. Encode the same bit sequence used in the preceding exercise

    b. Assume the encoder is using a bit time $\tau=0.1\mu s$. Calculate the transmitting clock frequency corresponding to this value of τ.

    c. Estimate the sampling clock derived by the receiver by calculating the average distance between signal level changes.

13. Practice line and channel encoding by solving exercises 1 and 3 of chapter 2.