Computer Networks and Distributed Systems

Questionnaire about basic laws of communication (Nyquist, Shannon) etc.

Context

- Brief intro to Communication and Information Theory: Nyquist, Shannon-Hartley
- Links, wavelength
- Datalink protocols
- Basic Ethernet

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.

   The focus of this chapter is on the Subnetwork layer.

   The functions of this layer include the following:
   - Building frames that will encapsulate a specific type of upper-layer payload
   - Properly delimiting the standard fields that comprise a frame
   - Turning the frame's bits into signals appropriate for transmission (Line encoding)
   - Adding redundancy to the frame that allows the receiver to establish whether or not some error took place
   - Accessing the physical medium in an orderly manner that create no problems to the rest of network elements connected to it, etc.

   Ethernet is concrete subnetwork-layer technology, its PDU is known as Ethernet frame and its structure follows (Recall Lab 2 in which we received Ethernet frames and printed out their fields):

   |Destination MAC(48) | Source MAC(48) | Ethertype(16) | Payload(-)|CRC(32)|

2. Observe the network diagram of slide no. 6 of presentation http://paloalto.unileon.es/cn/lect/CN-Ch1-2018-Section4.pdf, then, respond to the following questions related to it:

   a. Is the physical layer implemented in all the network elements? Explain why it is
   All network elements must implement a physical layer protocol which will allow it to line-encode the bits so they get transmitted over the physical medium(Copper wire, Optical Fiber, etc.)

   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
   Switches operate on Ethernet frames, consequently they are oblivious about a frame's payload, whatever its type (IP packet, ARP packet, for example), all in all, switches don't run the IP protocol

   c. Why do routers have IP? By contrast to the preceding question, routers (IP routers) do run IP, actually, running IP is one of their main concerns.

d. Try to justify the great variety of link layer protocols that appear on the net diagram
Today, there exist a large number of Ethernet technologies which Physical layer protocol is capable of dealing with speeds that range from 10Mbps to 10Gbps. Each of these technologies may use a certain frame format that abstracts the details of the specific physical layer selected.

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 Nyquist 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)

      The Nyquist rate applies to time-discretization

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

   c. The Nyquist rate is a necessary condition and it never results sufficient, for example, the vertical quantization's accuracy is an essential consideration when converting the digital samples back into their continuous form

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

      According to the Nyquist's rate, the resulting analog signal's bandwidth will be half the sampling frequency or 4KHz

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.

   We can transmit at any speed of our choosing, however, if the speed chosen is higher than C, the Shannon's limit (Shannon's Channel Capacity Theorem), then the probability of error in the receiver will fast grow towards 1

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.

   $C = 2 \cdot 10^6 \log_2(1+500)$ bps $= 17{,}93 \cdot 10^6$ bps

6. In the presentations 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?

   Transmission media with high bandwidth allow transmission at high speeds

No, a higher bandwidth allows transmission at a higher speed, but, propagation speed, in principle, is not related to a higher bandwidth. Copper wires propagate electromagnetic waves at a higher –propagation- speed than that of Optical Fibers, however, Copper wires have a much smaller bandwidth than that offered by Optical Fibers.

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).

      The highest frequency results in the least wavelength; since the smallest efficient antenna is the one whose size is about the same as the wavelength, then, selecting the highest frequency will result in the smallest, efficient antenna

   b. Calculate the wavelength resulting when transmitting at 2600MHz

      Transmission speed (frequency, f) and the resulting electromagnetic wave's wavelength (λ) are related according to the following formula: $\lambda = v/f$ where v represents the light propagation speed in the considered medium. In the present case: $\lambda = 3 \cdot 10^8$ m/s / $2600 \cdot 10^6$ 1/s, the final result is:

      λ = 11,54 cm