Computer Facilities and Network Management

BUS3150

Tutorial - Week 4

***** FOR TUTORS ONLY *****

The answers provided here are only brief guides. If you have any comments or suggestions for improvement to this, please let me know so that your improvements may be included in this document.

Objective of this tutorial:
The objective of this tutorial is to strengthen the conceptual understanding of the material covered in the lecture by reflecting on the material in small groups. The tutor will provide feedback to enhance your understanding and diminish misunderstandings, if any.

How to participate in the tutorial:
Form groups of four to five students in each and discuss the answers for the following reflective questions with the group members. After spending about ten minutes for each question, discussing with group members, discuss your solutions with the tutor and other groups. The tutor will provide feedback on your solutions.

ADVANCED: These types of questions will not be on the exam.

Question 1 - Consider the multipoint line configuration.

(a) For the multipoint configuration, only one device can transmit at a time. Why?

If multiple devices transmit at the same time, their signals will be on the medium at the same time and interfere with each other. These signals will overlap and become garbled.

(b) There are two methods of enforcing the rule that only one device can transmit. In the centralised method, one station is in control and can either transmit or allow a specified other station to transmit. In the decentralised method, the stations jointly cooperate in taking turns. You will learn more about this in the future, however what do you currently see as the advantages and disadvantages of the two methods?

- *See Stallings Section 15.3 (7th Ed. pg 481).*

Question 2 - Consider the sample signals shown in Figure 1.

(a) Describe each of these signals using terms such as periodic, aperiodic, discrete and continuous.

- *Signal (a) is a periodic square wave which is discrete.*
- *Signal (b) is an aperiodic signal which is continuous.*
- *Signal (c) is a periodic sine wave which is continuous.*

(b) What are the three characteristics of a periodic signal? Use Figure 1 to describe these characteristics.

Peak amplitude, frequency, and phase. Period is inversely proportional to the frequency (T=1/f). See lecture notes for week 3.

(c) What does the term "wavelength" mean? How is it related to the period of a signal?

See lecture notes for week 3.

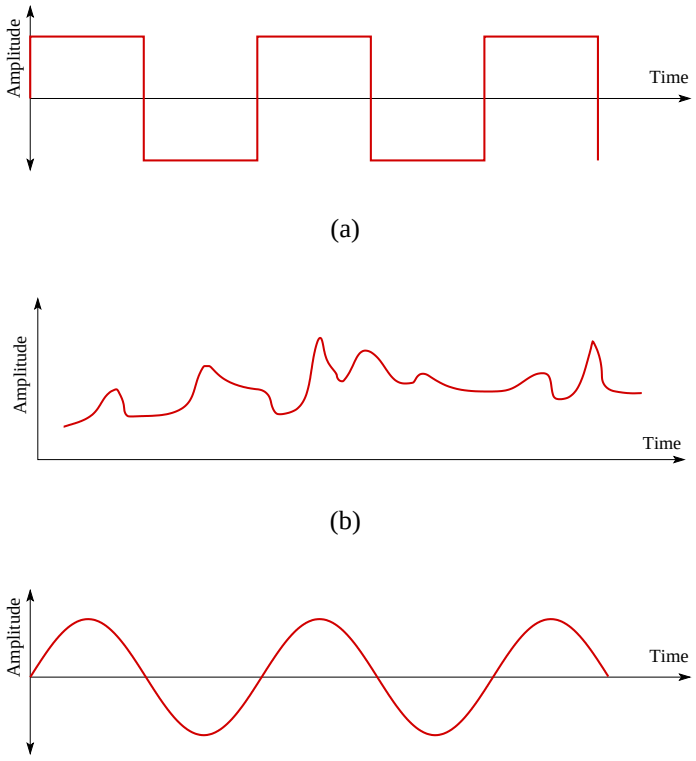

Figure 1: Sample signals.

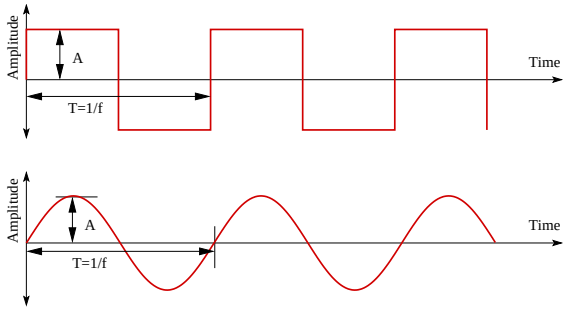

Figure 2: ANSWER

Question 3 - What is the difference between an amplifier and a repeater?

- *Amplifiers boost a signal without regard to the content of the signal. They are typically used for analog signals, however they can also be used for digital signals,*

though a repeater for digital is better. Amplifiers not only amplify the signal, they also amplify the noise.

- *Unlike amplifiers, repeaters are concerned with the data content of the signal. A repeater receives signal, extracts the bit pattern and retransmits the bit pattern with a new noise free signal. They are typically used for digital signals, however they can also be used for analog signals which contain digital data.*

Question 4 - What key factors affect channel capacity?

Bandwidth, noise and error rate. Noise includes thermal, intermodulation, crosstalk and impulse. Most noise is expected on the link, therefore, the power of the signal at the receiver must be larger than the power of the noise added to the signal in the transmission path. The power of the signal at the receiver will be reduced due to attenuation in the transmission path.

Question 5 - What are attenuation and crosstalk?

- *Attenuation: signal strength reduces with distance along a transmission path. It depends on the transmission medium, and is an increasing function of frequency.*
- *Crosstalk: a signal from one line is picked up by another.*

Question 6 - What do the terms "spectrum" and "absolute bandwidth" of a signal mean? Identify them with respect to the following waveform.

$$S(t) = \frac{4}{\pi}(\sin(2\pi f t) + \frac{1}{3}\sin(2\pi(3f)t) + \frac{1}{5}\sin(2\pi(5f)t))$$

- *Spectrum: the range of frequencies contained in a signal. In the above signal, there are frequencies ranging from* f *to* $5f$.
- *Absolute bandwidth: the width of the spectrum. In the above signal, the absolute bandwidth is* $5f - f = 4f$ *Hz.*

Question 7 - ADVANCED: Study the works of Shannon and Nyquist on channel capacity. Each places an upper limit on the bit rate of a channel based on two different approaches. How are the two related?

Nyquist analysed the theoretical capacity of a noiseless channel and found that in this case the signalling rate is limited solely by the channel bandwidth ($C = 2B\log_2 M$ *where* C *is capacity,* B *is the bandwidth of the channel and* M *is the number of signal levels). Shannon addressed the question of what signalling rate can be achieved over a channel with a given bandwidth, a given signal power, and in the presence of noise (*$C = B\log_2(1+SNR)$*, where SNR is the signal to noise ratio of the channel). Both consider only channels which are free from errors. A combination of the two formula may be used to determine the capacity of a channel in the presence of noise (Shannon) and the number of signal levels required to achieve the capacity (Nyquist).*

Question 8 - ADVANCED: Consider a communications channel being used by a cable modem network. The channel has use of the spectrum between 103MHz and 109MHz. The design signal-to-noise ratio is 22dB. You will need to use the Shannon and Nyquist equations to calculate the following.

(a) What is the theoretical maximum capacity of the channel in bps?

$$\begin{aligned} SNR &= 10^{\frac{SNR_{dB}}{10}} && (1)\\ &= 10^{\frac{22}{10}} && (2)\\ &= 158.5 && (3)\\ C &= B\log_2(1+SNR) && (4)\\ &= 6,000,000\log_2(1+158.5) && (5)\\ &= 43,903,896bps && (6)\\ & && (7) \end{aligned}$$

(b) For near DVD quality video, a digital video transmission requires on average 6 Mbps. How many video broadcasts can be carried by the channel.

$$\begin{aligned} N &= \frac{43,903,896}{6,000,000} && (8)\\ &= 7.317 \ \textit{which gives 7 complete channels.} && (9) \end{aligned}$$

(c) Assuming the capacity of the channel could be realised, how many signal levels would be needed?

$$\begin{aligned} C &= 2B\log_2 M && (10)\\ M &= 2^{\frac{C}{2B}} && (11)\\ &= 2^{\frac{43,903,896}{12,000,000}} && (12)\\ &= 12.6. && (13) \end{aligned}$$

Should be a power of two, so either $2^3 = 8$ or $2^4 = 16$ levels. However, if we select 16 signal levels, the receiver will have a difficult job of correctly sampling these levels in the presence of the 22 dB of noise as proven by Shannon.

(d) What advantage, if any, would there be in using twice this number of signal levels?

Twice the signal levels could increase the capacity of the channel by 2B bps if there was a corresponding increase in the signal-to-noise ratio of the channel. Without the increase in SNR, the receiver will have a difficult task in discerning the extra signal levels (as aforementioned). This usually results in an increase bit error rate (BER).