TUTORIAL – 1
ECE-337

1. Suppose the size of an uncompressed text file is 1 megabyte.
a. How long does it take to download the file over a 32 kilobit/second modem?
c. Suppose data compression (1:16) is applied to the text file. How much does the transmission change?

Solution:

T_{32k} = 8 (1024) (1024) / 32000 = 262.144 seconds
If we assume a maximum compression ratio of 1:6, then we have the following times for the 32 kilobit:
T_{32k} = 8 (1024) (1024) / (32000 x 6) = 43.69 sec

2. A scanner has a resolution of 600 x 600 pixels/square inch. How many bits are produced by an 8-inch x 10-inch image if scanning uses 8 bits/pixel? 24 bits/pixel?

Solution:

The number of pixels is 600x600x8x10 = 28.8×10^6 pixels per picture.
With 8 bits/pixel representation, we have: 28.8×10^6 x 8 = 230.4 Mbits per picture.
With 24 bits/pixel representation, we have: 28.8×10^6 x 24 = 691.2 Mbits per picture.

3. A digital transmission system has a bit rate of 45 megabits/second. How many PCM voice calls can be carried by the system?

Solution:

PCM channels = (45×10^6 bits/sec) / (64×10^3 bits/sec channel) = 703 channels.

4. Consider an analog repeater system in which the signal has power σ_x^2 and each stage adds noise with power σ_n^2. For simplicity assume that each repeater recovers the original signal without distortion but that the noise accumulates. Find the SNR after n repeater links. Write the expression in decibels: SNR dB = $10 \log_{10}$SNR.

Solution:
After n stages, the signal power is σ_x^2 and the noise power is $n\sigma_n^2$, so the SNR is:
SNR dB = $10 \log_{10}\sigma_x^2/n\sigma_n^2 = 10 \log_{10}\sigma_x^2/\sigma_n^2 + 10 \log_{10} 1/n = 10 \log_{10}\sigma_x^2/\sigma_n^2 - 10 \log_{10} n$

5. Suppose that a link between two telephone offices has 50 repeaters. Suppose that the probability that a repeater fails during a year is 0.01, and that repeaters fail independently of each other.
a. What is the probability that the link does not fail at all during one year?
b. Repeat (a) with 10 repeaters; with 1 repeater.

Solution:
Let p be the probability that a repeater fails during a year, then 1 – p is the probability that it does not fail, and the probability that all 50 repeaters do not fail is $(1 - .01)^{50} \approx e^{-50(.01)} = 0.605$ where we have used the approximation $(1 - p)^n \approx e^{-np}$ which is valid for large n and small p.

The probability that all 10 repeaters do not fail is $(1 - .01)^{10} \approx e^{-10(.01)} = 0.905$, and the probability that a single repeater does not fail is 0.99.

The moral of the calculations is that a system that requires the functioning of a large number of relatively reliable components may be fairly unreliable. In terms of repeaters, this implies that minimizing the number of repeaters needed in a link is important from the point of view of reliability. Of course this also reduces the cost expended to install and maintain the repeaters.

6. Suppose that a signal has twice the power as a noise signal that is added to it. Find the SNR in decibels. Repeat if the signal has 10 times the noise power? 2^n times the noise power? 10^k times the noise power?

Solution:

SNR dB = $10 \log_{10} \sigma_x^2 / \sigma_n^2 = 10 \log_{10} 2 = 3.01$ dB

SNR dB = $10 \log_{10} 10 = 10$ dB

SNR dB = $10 \log_{10} 2^n = = 10n \log_{10} 2 = 3.01n$ dB

SNR dB = $10 \log_{10} 10^k = 10k$ dB

7. An audio digitizing utility in a PC samples an input signal at a rate of 44 kHz and 16 bits/sample. How big a file is required to record 20 seconds?

Solution:

R = 44 x 10^3 x **16 = 704** x 10^3 bps

Number of bits generated in 20 seconds = 20 x 704 x 10^3 bits = 14080 x 10^3

The file size = (14080 x 10^3 **)** / (8 x 1024) ≈ 1719 K bytes ≈ 1.7 M bytes