

ITS323/CSS331 – Capacity Examples

1 Bit Rates

What is the bit rate for high-definition TV (HDTV)? HDTV uses digital signals to broadcast high quality video signals. The HDTV screen is normally a ratio of 16:9. There are 1920 by 1080 pixels per screen, and the screen is renewed 30 times per second. 24 bits represents one colour pixel.

$$\text{Bits per second} = 1920 \times 1080 \times 30 \times 24 = 1,492,992,000 \approx 1.5\text{Gb/s}$$

The TV stations reduce this rate to 10 to 40 Mbps through compression.

2 Nyquist Capacity

Consider a voice channel being used, via modem, to transmit digital data. Assume a bandwidth of $B = 3100\text{Hz}$. Then the Nyquist capacity, C , of the channel is:

$$C = 2B = 2 \times 3100 = 6200\text{b/s}$$

If we now assume $M = 8$, a value used for some modems, then $C = 2B \log_2(M) = 2B \times 3 = 18600\text{b/s}$.

3 Shannon Capacity

Suppose the spectrum of a channel is between 3MHz and 4MHz (hence bandwidth of 1MHz) and the $\text{SNR} = 24\text{dB}$. Then absolute $\text{SNR} = 10(24/10) = 251$.

Using Shannons formula:

$$C = 1\text{MHz} \log_2(1 + \text{SNR}) = 10^6 \times \log_2(1 + 251) \approx 8 \times 10^6 = 8\text{Mb/s}$$

This is a theoretical limit, but if we assume we can reach it, then how? Nyquist's theorem also tells us:

$$C = 2B \log_2(M)$$

So $8\text{Mb/s} = 2 \times 1\text{MHz} \times \log_2(M)$. So we need $M = 16$. That is, our signal needs to be able to carry 16 different levels.