A Comparison of Digital Signaling Methods

How to compare various modulation schemes?

Compare on basis of SNR needed to achieve a certain prob. of error (of bit error)

For comparison to be meaningful: 2 mod. schemes should be using the same BW or data rate.

There are 2 basic criteria in comparing:

- Power efficiency $\gamma_b = \frac{E_b}{N_0}$
  SNR per bit required to achieve certain error prob. (usually $P_e = 10^{-5}$)
  Lower $r_b \Rightarrow$ more power efficient

- BW efficiency
  Spectral bit rate $r \equiv \frac{\text{bit rate}}{BW}$
  BW efficiency $= \frac{R}{W}$ b/s / Hz
  larger $r \Rightarrow$ more BW efficient

Best sys:
One at a given r_b provides highest r
One at a given r provides lowest r_b

BW & dimensionality:

Consider a signal $g(t)$ band limited to $(-B, B)$.
By sampling them, we can rep. $g(t)$ by sampling it at a rate of $\frac{1}{2B}$ i.e

$$g(t) = \sum_{i=-\infty}^{\infty} g\left(\frac{i}{2B}\right) \frac{\sin 2\pi B\left(t - i/2B\right)}{2\pi B\left(t - i/2B\right)}$$

Now if $g(t)$ is vanishing outside $(0, T)$, then we have the following nonzero samples only

$$0 \leq i/2B \leq T$$

$$\Rightarrow 0 \leq i \leq 2BT$$

$$\Rightarrow i = 0, 1, \cdots, 2BT$$

$\Rightarrow x(t)$ band limited to $2B$
time limited to T sec
is specified by $2BT$ samples.

The space of signals of duration T & BW = B has dimension 2BT.

Statement is fallacious "no signal can be both time & bandlimited at the same time" but it is approximately true

This allows us to derive BW & dimensionality

Imagine that we have the following signaling scheme:

M signals each with duration T_s (signaling interval)

Appx BW of signals is W

$\Rightarrow$ dimen. of signal space has a max of

$$N = 2WT_s$$

$$\Rightarrow W = \frac{1}{2} N \cdot \frac{1}{T_s}$$

$$= \frac{1}{2} N R_s \qquad (R_s = \text{symbol rate})$$

$$R \text{ (bit rate)} = R_s \log_2 M$$

$$\Rightarrow W = \frac{1}{2} \frac{NR}{\log_2 M}$$

$$\Rightarrow r = \frac{R}{W} = \frac{2 \log_2 M}{N}$$

Provides BW efficiency of sig. schemes in terms of

constellation size

dimensionality of constellation

Calculate BW efficiency for various mod. schemes