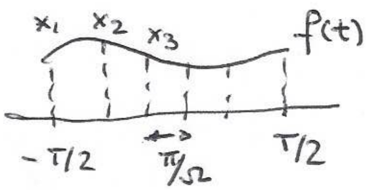
ADDENDUM TO LEC3

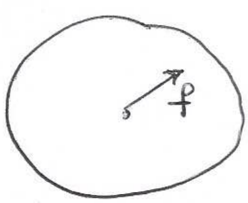
Layer	
APPLICATION TRANSPORT	HOSTS
NETWORK DATA LINK PHYSICAL	ROUTERS

Last lecture we considered signals at physical layer and derived the capacity formula

$$\boxed{C = W \log(1 + SNR)} \qquad SNR = \frac{P}{N} = \frac{\text{signal power}}{\text{noise power}}$$



we considered a signal transmitted in an interval $[-T/2, T/2]$ and asked how many distinct signals can I transmit over this interval?



signal is a point in a space of $N_0 = \frac{\Omega T}{\pi}$ dimensions

because by sampling theorem is identified by $\frac{T}{\pi/\Omega}$ samples $-(x_1 x_2 \dots x_{N_0})$

$$\# \text{signals} \quad M = \left(\frac{S+N}{N}\right)^{N_0/2}$$

$$\# \text{bits to identify a signal} = \log M = \frac{N_0}{2} \log(1+SNR)$$

By transmitting 1 signal I transmit

$$\frac{1}{T} \frac{\Omega T}{2\pi} \log(1+SNR) = W \log(1+SNR) \text{ bits/sec}$$

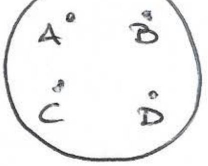
Example Email: My dear Massimo, ...

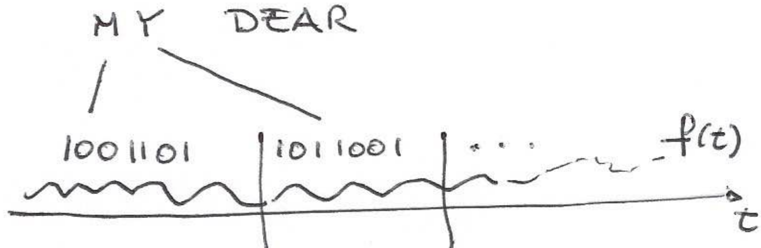
Assume for simplicity each packet corresponds to one letter

M	Y		D	E	A	R

Assume ASCII code of 7 bits per character e.g. $D = 1000100$

There are $2^7 = 128$ characters, each of them can be considered a different signal to transmit





Assume we send 7 bits/sec = 1 character per second
To do so we need a bandwidth & signal power such that

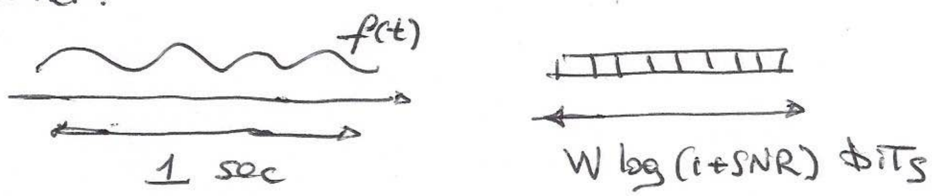
$$W \log(1+SNR) > 7 \text{ bits/sec}$$

Assume we send $7 \cdot 10^6$ = 7 Mbs = 1 Mil char/sec

$$W \log(1+SNR) > 7 \cdot 10^6 \text{ bits/sec}$$

The positioning of the letters A, B, C, D in the signal space depends on the choice of the sampled values $(x_1 x_2 \dots x_{N_0})$ which are the coordinates identifying one signal and are selected by the <u>Physical layer</u> engineer that designs an appropriate code for transmission called a "constellation" of possible signals.

Note that same reasoning works for different size of packets. Our signal just represents a certain number of bits every second:



Next, we look at the operation at the <u>network level</u> for how to route packets by the routers.