Review of Lecture 1.2

Comparison of Physical Media

The criteria for comparison are the following:

a. Velocity of Propagation
b. Bit Rate
c. Error rate
d. Electromagnetic Interference (EMI)
f. Cost (both initial and maintenance)
g. Speed of deployment
i. Broadcast property

Comparison of 3 types of Mainstream Media

Copper

— least expensive, offers moderate bandwidth over medium distances, susceptible to noise and interference

Fiber

— Highest bandwidth, needs repeater stations every few miles, offers immunity from noise, interference etc

Satellite

— offers large geographic spread and broadcast capability at medium bit rates

Bandwidth Concepts

Noise-free channel binary signalling

$C = 2W$ (Nyquist's theorem)

Noise-free channel m-ary signalling

$C = 2W \log_2 m$

Noisy channel with signal-to-noise S/N

$C = W \log_2 (1 + S/N)$

(Shannon's theorem)

W = Analog Bandwidth

C = Digital Bandwidth (Channel capacity)

Ch 1 - Worked-out Example 1

Problem:

What would be the channel capacity of a channel with 3 KHZ analog bandwidth

(i) if it was noise free using binary signalling
(ii) if it was noise free using 16 level signalling
(iii)if it was noisy with S/N = 30 db

W = Analog Bandwidth
C = Digital Bandwidth (Channel capacity)

Solution:

(i) Use Nyquist's theorem for binary signalling $C = 2W$

$C = 2 \times 3$ Kbps $= 6$ Kbps

(ii) Use Nyquist's theorem with M-ary signalling $C = 2W \log_2 m$

$C = 2 \times 3 \times \log_2 16 = 24$ Kbps

(iii) Use Shannon's theorem for noisy channels $C = W \log_2 (1+ (S/N))$

First convert S/N in db to its absolute value

S/N in db $= 10 \log_{10} (S/N)$

$30 = 10 \log_{10} (S/N)$ gives $S/N = 1000$

$C = 3 \times \log_2 (1000+1) = 29.9$ Kbps

Ch 1 - Worked-out Example 2

Problem:

Calculate the channel capacity of a fiber optic link operating at a wavelength of 1300 nm with a spread of 10 nm on either side. Assume S/N = 30 db

Solution:

- The two extreme wavelengths are 1290 nm and 1310 nm
- Find the frequencies corresponding to these wavelengths and take the difference to get the bandwidth
- Noisy channel with signal-to-noise S/N

$$C = W \log 2\ (1 + S/N)\ \text{(Shannon's theorem)}$$

velocity = frequency x wavelength ($v = f\ \lambda$)

$2 \times 10^{8} = f_1 \times 1290 \times 10^{-9}$ gives $f_1 = 155$ THz

$= f_2 \times 1310 \times 10^{-9}$ gives $f_2 = 152.6$ THz

Bandwidth = $f_1 - f_2 = 2.4$ THz

$10 \log_{10} (S/N) = 30$ gives $S/N = 1000$

Channel Capacity = $2.4 \times \log_2 (1+ 1000)$ = **23.91 Tbps**

Q&A