3 DATA RATE LIMIT

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THAPAR INSTITUTE
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Course: Computer and Communication Networks

Topic: Data Rate Limits

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Data Rate Limit

- **Data rate** is a term to denote the **transmission speed**, or the number of bits per second transferred.
- How fast we can send **data**, in bits per second, over a channel.
- The transported data rate on the network is high than the useful **data rate** for the user.
- In data communication, the **data rate** is often expressed in bytes per second (B/s).

Effecting Factors

- Availability of Bandwidth
- Levels of signal we use
- Quality of Channel (level of noise)

Formula to Calculate data rate :

- Noiseless Channel: Nyquist Bit Rate
- Noisy Channel: Shannon Capacity

Nyquist Theorem

- provides a prescription for the nominal sampling interval required to avoid aliasing.
- The sampling frequency should be at least twice the highest frequency contained in the signal.

  In mathematical terms: $f_s \geq 2f_c$

- ✓ f_s is the sampling frequency (how often samples are taken per unit of time or space)
- ✓ f_c is the highest frequency contained in the signal

Noiseless Channel: Nyquist Bit Rate

- max bit rate at which digital data can be transmitted over a noiseless communication channel (c*hannel is always noisy)*

$$C = 2.B.log_2 M[bps]$$

B - Bandwidth in Hz

M – number of discrete levels in digital signal

**Increases the level of the signal may reduce the reliability of system*

Noisy Channel: Shannon Capacity

- Highest data rate for noisy channel is defined as :

$$C = B.log_2(1 + SNR)\ [bps]$$

Bandwidth of channel is B,

SNR is signal to noise ratio

**Every Channel has impriment are : atténuation, Delay distorsion or impulse noise.*

** No indication of levels we can use.*

The Shannon capacity gives us the upper limit!

The Nyquist formula tells us how many levels we need!

Example : Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with two signal levels. What is the maximum bit rate.

Solution:

The maximum bit rate can be calculated as

Bitrate =2 x 3000 x log_2 2 =6000 bps

Example: We have a channel with a 1 MHz bandwidth. The SNR for this channel is 63; what is the appropriate bit rate and number of signal level?

Solution: First use Shannon formula to find the upper limit on the channel's data-rate

C = B log2 (1 + SNR) = $10^6\ log_2$ (1 + 63) = $10^6\ log_2$ (64) = 6 Mbps

Although the Shannon formula gives us 6 Mbps, this is the upper limit. For better performance choose something lower, e.g. 4 Mbps. Then use the Nyquist formula to find the number of signal levels.

4 Mbps = 2 × 1 MHz × log_2 L

L = 4

Thank You