# Computer Networks
## Tutorial 1

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# Data Communication

Q.1 Imagine the length of a 10Base-5 cable is 2500 metres. If the speed of propagation in a thick co-axial cable is 60% of the speed of light, how long does it take for a bit to travel from the beginning to the end of the cable? Ignore any propagation delay in the equipment. (Speed of light = $3 \times 10^8$ metres / sec)

- Solution:
- Speed of propagation = 60% x c

$= 60 \times 3 \times 10^8 / 100$

$= 18 \times 10^7$ metres / sec.

- So it would take a bit $2500 / 18 \times 10^7 = 13.9$ µsecs

# Data Communication

Q.2 A digital signaling system is required to operate at 9600 bps. If a signal element encodes a 4-bit word, what is the minimum required bandwidth of the channel? (Hint: Nyquist's Formula)

- By Nyquist's formula, the channel capacity is related to bandwidth and signaling levels by the equation $C = 2B \log_2 V$,

where V is the number of discrete signal or voltage levels.

- Here C = 9600 bps, $\log_2 V = 4$ (because a signal element encodes a 4-bit word)

$2B = C / \log_2 V$

$B = C / (2 \times \log_2 V)$

$B = 9600 / (2 \times 4)$

$B = 9600 / 8$

Hence, B = 1200 Hz.

# Data Communication

Q.3 Find out the transmission bandwidth for a video signal, the width and height are 200 and 150 pixels respectively with 128 color patterns and 16 level intensities. Further assume that 25 frames per second is acceptable to the user.

Solution:

- Bandwidth: 200x150x(7 + 4)(7 bit for color and 4 bit for 16 level) x 25 = $8.25 \times 10^6$ bits
- =8.25M bits per second.

# Data Communication

Q.4 What is the bit rate required for transmission of high-definition TV (HDTV)?

- A. HDTV uses digital signals to broadcast high quality video signals. The HDTV screen is normally maintains aspect ratio of 16:9. There are 1920 x 1080 pixels per screen and the screen is renewed 30 times per second. 24 bits represents one color pixel.
- Bitrate = 1920 x 1080 x 30 x 24 = 1,49,29,92,000 bps= 1.5 Gbps
- This is uncompressed transmission. However video is always compressed and transmitted. Final bitrate required will depend on type and level of compression employed.

# Data Communication

Q.5 What is the maximum data rate for a voice-grade line with a bandwidth of 4K Hz and a S/N ratio of 10000 to 1?

- Solution:
- Shannon's theorem
- Data rate = $B \log_2 (1 + S/N)$

$$= 4 \times 10^3 (\log_{10} 10^4 )/(\log_{10} 2 )$$

$$= 5.3 \times 10^4 \text{ bit/s}$$

# Data Communication

Q.6 The power we use at home has a frequency of 60 Hz. Determine the period of sine wave:

Solution:

- $T=1/f$

  $=1/60$

  $=0.0166s$

  $=16.6ms$

# Data Communication

Q.7 Assume we need to download text documents at the rate of 100 pages per minute. What is the required bit rate of the channel? A page is an average of 24 lines with 80 characters in each line. Assume that one character require 8 bits.

Solution:

A page is an average of 24 lines with 80 characters in each line. If we assume that one character require 8 bits. The bit rate is:

100*24*80*8=1,536,000 bpm = 25.6 Kbps

# Data Communication

Q.8 Consider a noiseless channel with a bandwidth of 3000 Hz transmitting the signal with the two levels. Calculate the maximum bit rate.

Solution: By Nyquist’s formula, the channel capacity is related to bandwidth and signaling levels by the equation $C = 2B \log_2 V$,

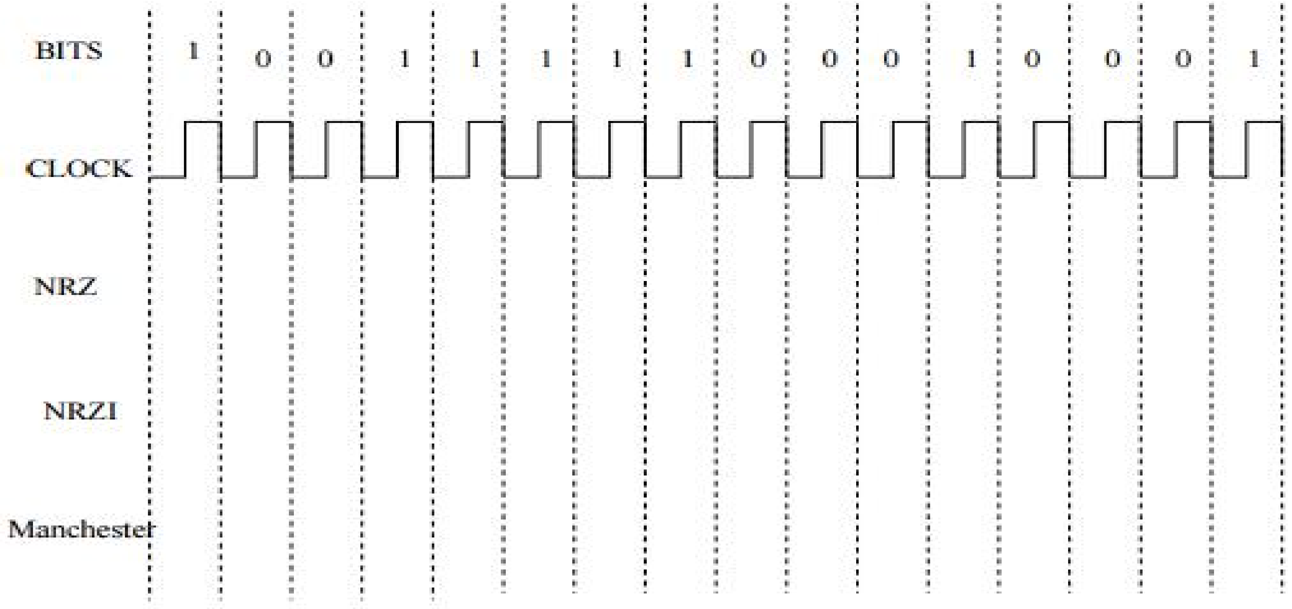
where V is the number of discrete signal or voltage levels.

Bitrate = $2 * 3000 * \log_2 2$

= 6000 bps

# Data Communication

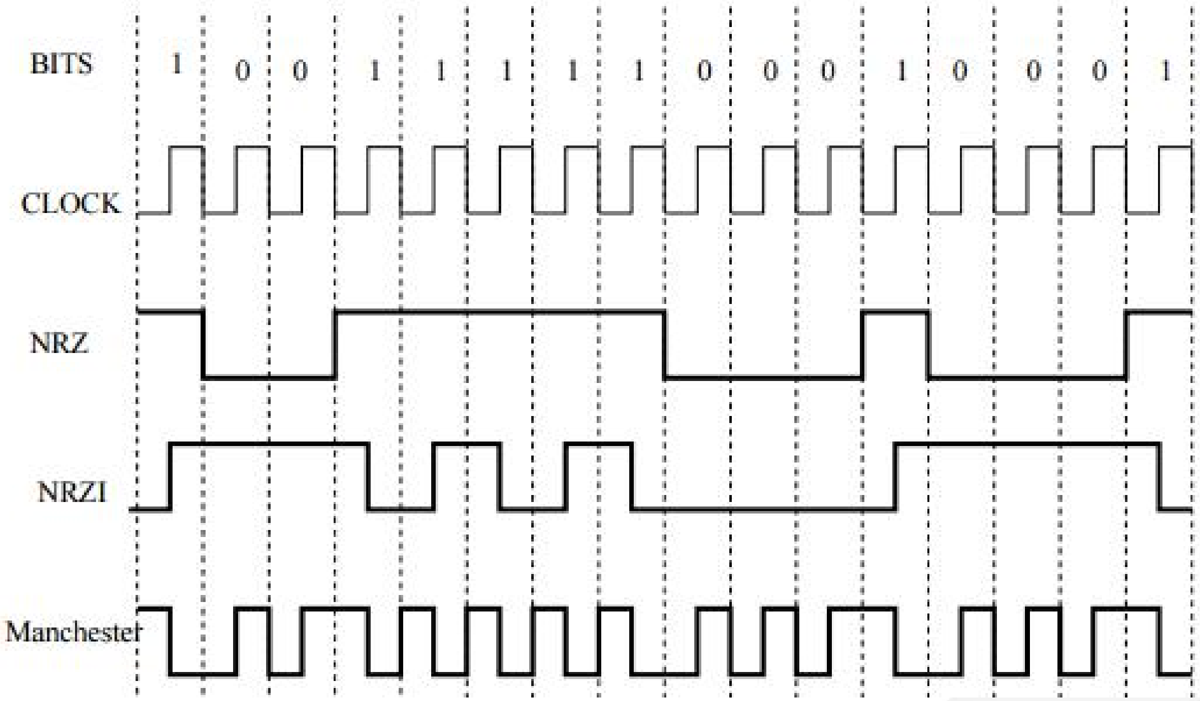
Q.9 Show the NRZ, Manchester, and NRZI encodings for the bit pattern shown in the figure below. Assume that the NRZI signal starts out low.



# Data Communication

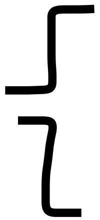
- Solution:

NRZ : no change
NRZ-L : invert bits (zeros to ones; ones to zeros)
NRZ-I : invert bits if ones encountered
Manchester : no change (simply apply convention shown in left side)
Defferential Manchester : change path if one encountered; otherwise no.




0:

1:



G.E Thomas : 0 : goes from low to high , 1: goes from high to low
IEEE 802.3 : 0 goes from high to low , 1 goes from low to high

# Data Communication

Q.10 What is baudrate of standard 10-Mbps Ethernet ?

Ans. Manchestor encoding (phase encoding) uses is a line code in which the encoding of each data bit has at least one transition and occupies the same time. It therefore has no DC component, and is self-clocking.

- Standard 10BASE-T uses Manchestor encoding. For every bit, it needs two symbols resulting into baudrate of twice the bitrate.
- So standard 10-Mbps Ethernet has baudrate of 20 Mbaud/s or 20 MHz
- For 100 Mbps Ethernet, if Manchestor encoding is used 200 MHz waveform frequency is required. CAT5 UTP is only rated at 100MHz. So 100BASE-FX uses NRZI. To decrease the frequency even further 100BASE-TX adds variation to NRZI called MLT-3 or NRZI-3.

# Data Communication

Q.11 A two-level signal having a baud rate of 50 symbols/second is now extended to 8 levels, what will be the new baud rate?

- Ans. No Change

# Data Communication

- Q.12 Match OSI seven layers in column A to the description/characteristics in column B. Each column in A may match a few columns in B.

| | Column A | Column B | Match |
|---|---|---|---|
| L | 7 Application | A Message flow control between end-to-end hosts | 4 |
| B,K | 6 Presentation | B Compress and Decompress files | 6 |
| M | 5 Session | C Frame sequencing checking | 2 |
| A,J | 4 Transport | D Cyclic redundancy error detection | 1 / 2 |
| F,I,N | 3 Network | E To be connected to a synchronous modem | 1 |
| C,D,H,O | 2 Data link | F Manage host-to-host communication services | 3 |
| D,E,G | 1 Physical | G Concerns with strings of bits | 1 |
| | | H Addresses physical device in the network | 2 |
| | | I Route the packet to targeted machine | 3 |
| | | J Message segmentation and blocking | 4 |
| | | K Convert ASC II into EBCDIC format | 6 |
| | | L file transfer or Telnet | 7 |
| | | M Manage message dialogue | 5 |
| | | N Handle network congestion | 3 |
| | | O Maintain a error free transmission link | 2 |

# Data Communication

Q. The number of point to point links required in a fully connected network for 50 entities is

- Ans. 50 x 49 = 2450 (unidirectional link) else (50 x 49)/2

# Data Communication

Q. Suppose we want to digitize human voice. What is bit rate, assuming 8 bits per sample:

Human voice normally contains frequencies from 0 to 4000Hz.

$C = 2 B \log_2 (V)$
$= 2 * 4000 * 8$

- Solution:
- Sampling rate (Nyquist) : 4000 x 2 = 8000 samples/s
- Bit rate : 8000 x 8 = 64000 bps = 64 kbps

# Data Communication

Q. What signal-to-noise ratio is needed to put a T1 carrier on a 50-kHz line?

Data rate on a T1 line is 1.544 Mbits/sec.

- Ans. To send a T1 signal we need $H \log_2(1+S/N)=1.544 \times 10^6$ with $H = 50,000$.
- This yields $S/N=2^{30}-1$, which is about 93 dB.

S/N ration = 10log_10 (S/N)  dB

# Data Communication

Q. What is the maximum bit rate achievable in a V.32 standard modem if the baud rate is 1200 and no error correction is used.(Hint:V.32 modem has 32 symbols)

- Solution:

  Since there are 32 symbols, 5 bits can be encoded.

  At 1200 baud, this provides $5 \times 1200 = 6000$ bps.

# Data Communication

Q. Ten signals, each requiring 4000 Hz, are multiplexed on to

Frequency Division Multiplexing

a single channel using FDM. How much minimum bandwidth is required for the multiplexed channel? Assume that the guard bands are 400 Hz wide.

- Solution. There are ten 4000 Hz signals. We need nine guard bands to avoid any interference. The minimum bandwidth required is $4000 \times 10 + 400 \times 9 = 43{,}600$ Hz.

# Data Communication

Q. Three packet-switching networks each contain n nodes. The first network has a star topology with a central switch, the second is a (bidirectional) ring, and the third is fully interconnected, with a wire from every node to every other node. What are the best-, average-, and-worst case transmission paths in hops?

- Ans. The three networks have the following properties:

Star: best case = 2, average case = 2, worst case = 2

Ring: best case = 1, average case =n/4, worst case =n/2

Full interconnect: best case = 1, average case = 1, worst case = 1

# Data Communication

Q. A 1000 km long cable operates at 1 Mbps. The propagation speed in the cable is 2/3 the speed of the light. How many bits fit in the cable?

Ans.

The propagation speed in the cable is 200,000 km/sec, or 200 km/msec, so a 1000-km cable will be filled in 5 msec.

No of bits in the cable is no of bits transmitted at 1Mbps in 5 ms

$= 10^6 \times 5 \times 10^{-3} = 5000$

Tp = d/v =1x10^6 / 2x10^8 = 5×10–3
No of bits = Tp x bandwidth = 5×10–3 x 1x10^6 = 5000

# Data Communication

Q. Consider a channel with source and destination having distance between them of 10km. Propagation delay is 10μsec/km. What will be the data rate of the channel if it is given that the RTT is equal to the transmission delay and packet size is of 125 bytes?

- Ans.

Effective propgation delay = $10 \times 10^{-6} \times 10 = 10^{-4}$ sec

RTT = $2 \times 10^{-4}$ sec which is also equal to transmission time of 125 byte pkt

Data rate = pkt size / trans time = $125 \times 8 / 2 \times 10^{-4} = 5 \times 10^{6}$ = 5 Mbps

# Data Communication

Q. If the distance between A and B is 4000km, how long does it take computer A to receive ACK for a packet? Use the speed of light for propagation speed and assume time between receiving and sending ACK is zero.

- Ans.

Effective propagation delay is 4000 $x10^3$ / 3 $x10^8$ = 1.3333 x $10^{-2}$ sec

RTT = 2.6666 x $10^{-2}$ sec

# Data Communication

- Q. A disadvantage of a broadcast subnet is the capacity wasted when multiple hosts attempt to access the channel at the same time. As a simplistic example, suppose that time is divided into discrete slots, with each of the n hosts attempting to use the channel with probability p during each slot. What fraction of the slots are wasted due to collisions?
- Ans. Distinguish total events into n+2 events.
- Events 1 through n consist of the corresponding host successfully attempting to use the channel, i.e., without a collision. The probability of each of these events is $p(1-p)^{n-1}$.
- Event n+1 is an idle channel, with probability $(1-p)^{n}$.
- Event n+2 is a collision.
- Since these n+2 events are exhaustive, their probabilities must sum to unity. The probability of a collision, which is equal to the fraction of slots wasted, is then just $1 - np(1-p)^{n-1} - (1-p)^{n}$.

# Data Communication

- Q. In some networks, the data link layer handles transmission errors by requesting damaged frames to be retransmitted. If the probability of a frame's being damaged is p, what is the mean number of transmissions required to send a frame? Assume that acknowledgements are never lost.

- Ans. The probability, Pk, of a frame requiring exactly k transmissions is the probability of the first $k-1$ attempts failing, and $k^{th}$ attempt is successful is $p^{k-1} \times (1-p)$.

- The mean number of transmission is then just

- $\sum_{k=1}^{\infty} k\, Pk = \sum_{k=1}^{\infty} k\, p^{k-1}\,(1-p) = \frac{1}{1-p}$