Data Communication and Optical Fiber

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Introduction- Components, Networks, Protocols and standards

Basic Concepts: Line Configuration, Topology Transmission mode,

analog and digital signals, Encoding and modulating- analog-to-digital conversion, digital to analog conversion, digital data transmission,

DTE-DCE interface, modems, cable modems.

Transmission media: guided media, unguided media, and transmission impairment.

https://www.youtube.com/watch?v=mYWsllbszYQ

Introduction

- Data communication is the transfer of data or information from source to destination via some form of a transmission medium which can be wired or wireless
- Combination of Hardware and Software

Components of Data Communication

1. Message
2. Sender
3. Receiver
4. Transmission medium
5. Protocol

1. Message : It is the information to be communicated. Popular forms of information include text,numbers,audio, and video
2. Sender :It is the device to sends the data message. It can be a computer,workstation,telephone handset,video camera and so on
3. Receiver :Device That receive message.computer,workstation,telephone handset,television and so on
4. Transmission medium : Physical path by which message travels from sender to receiver. Twisted pair,coaxial cable,fiber optic cable,and radio waves
5. Protocol : A protocol is set of rules that govern data communication. It is agreed upon set of rules used by the sender and receiver to communicate data

Networks

Network -Two or more devices connected such a way that they can share information

Components of networks

Components of Network

1. Servers :Computers that hold the shared files program and network operating system Ex: mail server, database server,fax servers and web servers
2. Clients : Workstation or computers that access and use the network and shared network resources
3. Transmission media : facilities used to interconnect computers in a network.it is also called channels. Guided or unguided
4. Shared data : Data that servers provide
5. Shared printers and other peripherals : hardware devices provide by the srvers

Components of network

9. NIC : Network Interface Card is a Computer hardware component that connects a computer to a computer network

10. Local Operating System : OS in Personal computers

11. Network OS : Os in servers that allows the computers to comunicate over the network

Components of network

12. Repeater : A communication device. It regenerates ,strengthens the signal

13.Bridge : Two networks using same technology.Connects two subnets

14.Hub : Splits a network connection into multiple computers.Hub transmits data into entire network

15. Switch: It connects devices together on a computer network process and forward data to the destination device.It transmit data into needed devices or device

16. Router : Data transmits between multiple networks

Components of network

17. Network cables and connectors : Several cables like twisted pair,coaxial cable,optical fiber

18. Modem : Modulator and demodulator.

19. Wireless Access Point : WAP are a transmitter and receiver device used for wireless LAN radio signals. Separate network device with built in antenna ,transmitter, and adapter. It provides both wired and wireless connection

20. Transceivers : integrated in NIC. It detects incoming signals and place signals onto the network media

Components of network

21. Protocols : Set of rules. Set of standards and policies comprised of rules, procedures,and formats that define communication between two or more devices over a network.

22. Firewalls : Networking device either software or hardware.Protect data from outside threat.

Network Goals

1. Resource sharing . files ,programs data available to anyone on the network irrespective of physical location.
2. Reliability: Increase reliability by replicating data onto one or more machines.
3. Cost factor :Small computers have less cost compared to larger systems. So Data can be kept on large systems so that smaller machines can access it.
4. Increased performance . More processors -
5. Increased storage capacity Data can store on more computers
6. Communication medium :Any type of medium can be used very easily
7. Promote collaboration : Multiple persons can logged into the system at same time

Network criteria

1. Performance : Transit time and Response time

   Transmit time : Time to travel from one device to another device.

   Response time :elapsed time between an inquiry and a response

   Throughput and delay High throughput and less delay.

1. Reliability . Accuracy ,frequency of failure,time take to recover from failure
2. Security : Protecting data from unauthorized access, protecting data from damage ,and implementing policies and procedures from security breaches and data losses

Network Protocols and standards

The key elements of protocols are

Syntax: Structure or format of data-order in which they are presented

Semantics : The meaning of each section of bits.KOw particular pattern to be interpreted

Timing : When the data should sent?. How fast they can send

Data communication standards

Defacto(meaning “by fact” or “by convention”: Standards adopted by widespread use

De jure(by law or by regulation”): Standards organized by bodies

Examples :

ISO

International Telecommunications Union Telecommunications standard(ITU-T)

American NAtional Standards Institute(ANSI)

Institute of Electrical and Electronics Engineers(IEEE)

Transmission modes

The nature of data flow between linked devices connected over a network is determined by the communication mode.

1. Simplex
2. Half duplex Mode
3. Full duplex

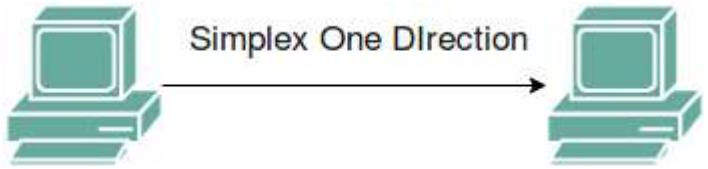
SIMPLEX

In Simplex mode, the communication is unidirectional, as on a one-way street.

Only one of the two devices on a link can transmit, the other can only receive.

The simplex mode can use the entire capacity of the channel to send data in one direction.

Example: Keyboard and traditional monitors

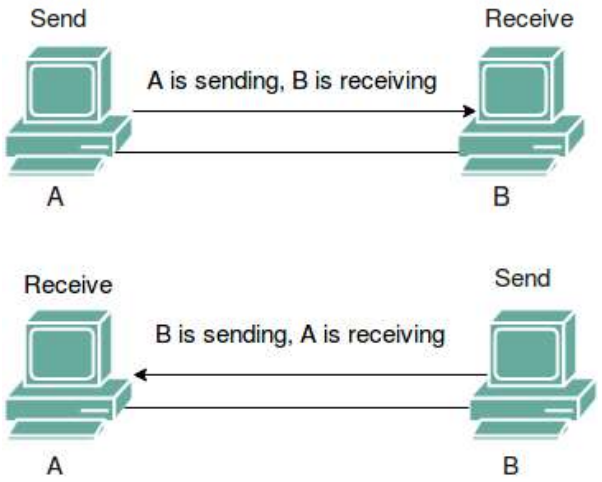


2.Half duplex Mode

In half-duplex mode, each station can both transmit and receive, but not at the same time.

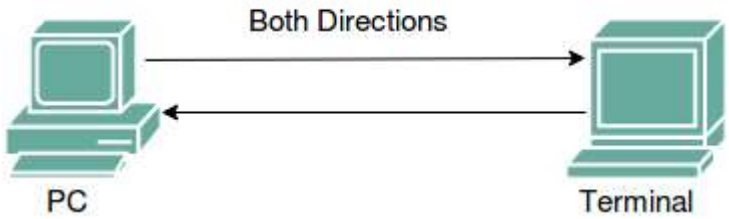
When one device is sending, the other can only receive, and vice versa.

The half-duplex mode is used in cases where there is no need for communication in both direction at the same time.



1. Full duplex

In full-duplex mode, both stations can transmit and receive simultaneously. In full_duplex mode, signals going in one direction share the capacity of the link with signals going in other direction,



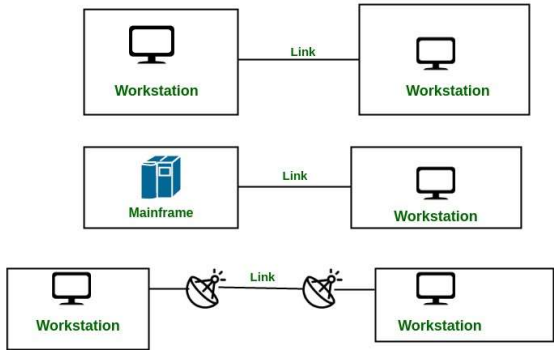
Line Configuration

A Network is nothing but a connection made through connection links between two or more devices. Devices can be a computer, printer or any other device that is capable to send and receive data. There are two ways to connect the devices :

1. Point-to-Point connection
2. Multipoint connection

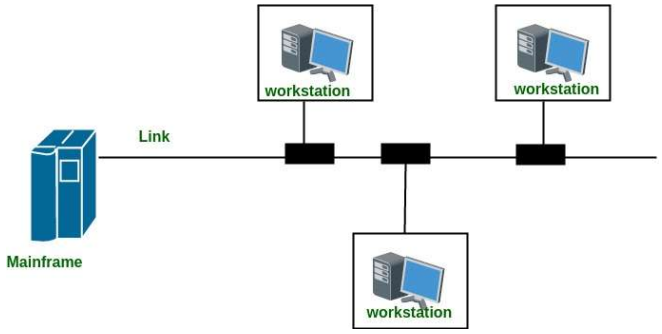
Point-to-Point

1. A point-to-point connection provides a dedicated link between two devices.
2. The entire capacity of the link is reserved for transmission between those two devices.
3. Most point-to-point connections use a actual length of wire or cable to connect the two end, but other options such as microwave or satellite links are also possible.
4. Point to point network topology is considered to be one of the easiest and most conventional network topologies.
5. It is also the simplest to establish and understand.



Multipoint

1. It is also called Multidrop configuration. In this connection two or more devices share a single link.
2. More than two devices share the link that is the capacity of the channel is shared now. With shared capacity, there can be two possibilities in a Multipoint Line configuration:



Network Topologies

The way in which the computers are connected

1. Star network
2. Ring Network
3. Bus Network
4. Mesh network
5. Tree network

Consideration for choosing Topology

The availability and cost of physical communication lines between nodes and lines bandwidth

The capability of a node to route information to other nodes

Delay due to information

Reliability of communication between nodes when there is breakdown of line or code

Strategy of controlling communication between nodes in the network

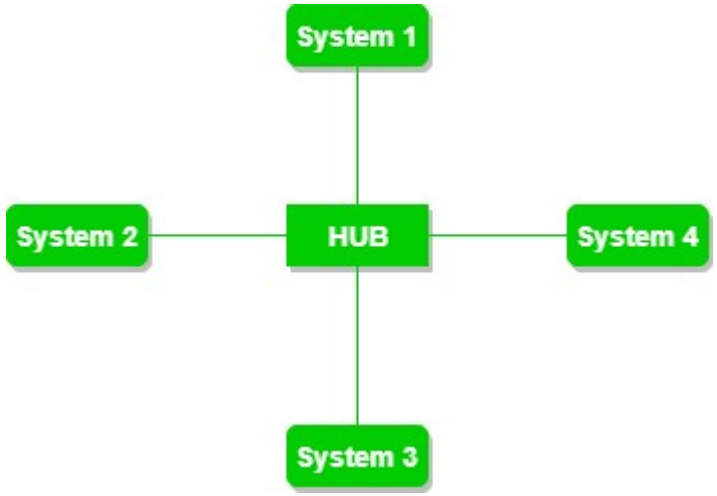
Size of the network

Expandability of the system

Star Topology :

In star topology, all the devices are connected to a single hub through a cable.

This hub is the central node and all others nodes are connected to the central node.



Star Topology-Advantages

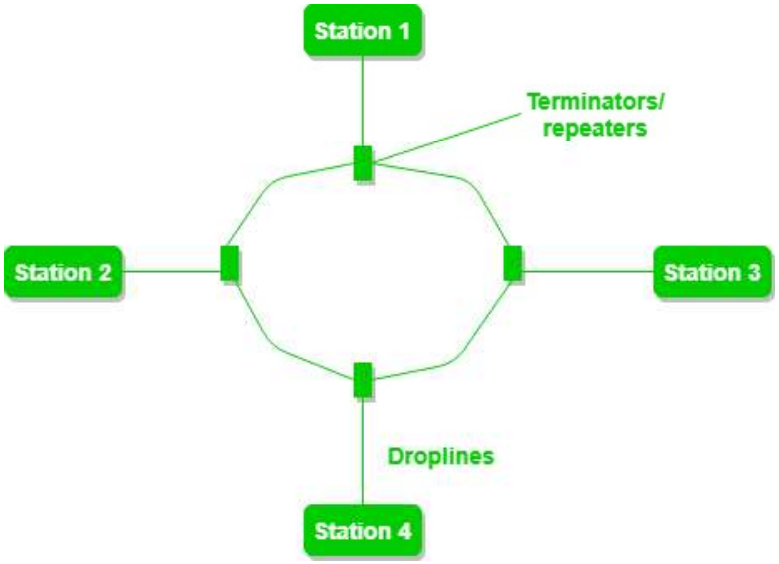
- Minimal line cost
- Transmission delay does not increase by adding new nodes
- If any local computer fails the remaining portion of the network is unaffected
- Flexible
- Provides a centralised control and problem diagnosis
- Access protocols are simple

Star Topology-Disadvantages

- Depends on the central computer
- Each device require its own cable segment
- Installation and configuration is difficult

Ring Network

it forms a ring connecting devices with its exactly two neighboring devices.



Ring-Advantages

- Relatively easy to install and reconfigure
- Link failure can be easily found
- No one can monopolize the network
- More reliable than star network

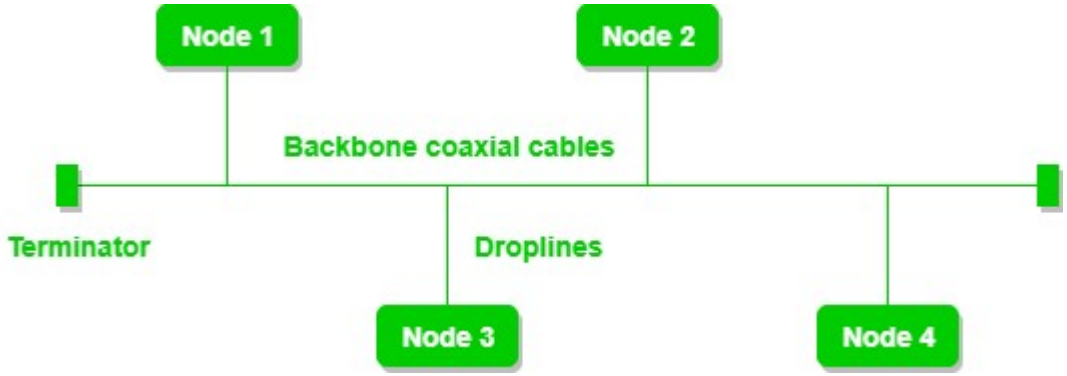
Ring Disadvantages

- Communication delay is directly proportional to the number of nodes in the network
- Maximum ring length and number of devices is limited
- Adding or removing nodes disrupts the network

BUS topology

Nodes are connected on a single communication channel

All can receive but only one will respond



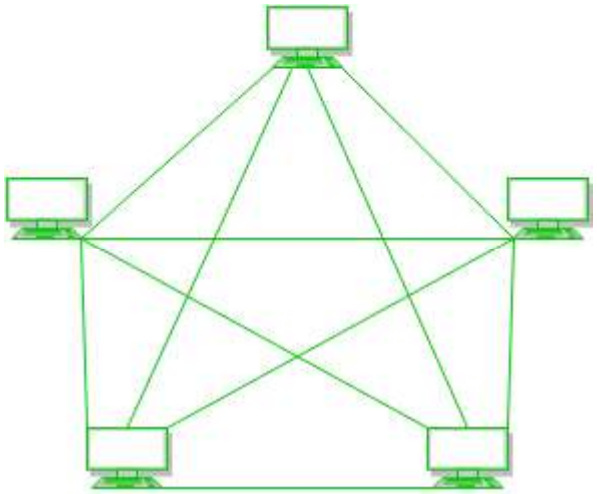
BUS topology Advantages

- Reduction of the physical line
- Reliability of the network is high
- Addition of the new computer t the network is easy
- Easy to install
- Cost of network is low
- The bus can be extended by using repeaters

BUS topology Disadvantages

- Each node must have good communication and decision making capability
- If the communication line fails entire system breaks down
- Heavy network traffic can slow a bus considerably
- Difficult reconnection and fault isolation
- Signal reflection at the taps can cause degradation in quality

Mesh network



Mesh network advantages

- Dedicated link between nodes ensures optimum data rate and less traffic problem
- Better privacy and security
- Mesh topology is robust
- Failure of any link will not cause failure of entire network
- Fault identification and fault isolation is easy

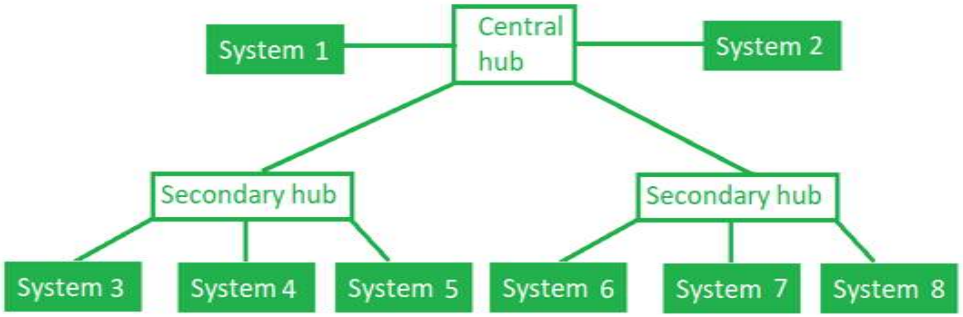
Mesh network disadvantages

- Large amount of cabling and I/O ports required
- Hardware required for each links and reudant link increased cost
- Difficulty in installation
- Difficult to reconfigure

Tree Topology

Hierarchical topology

Combination of bus and star topology



Tree topology advantages

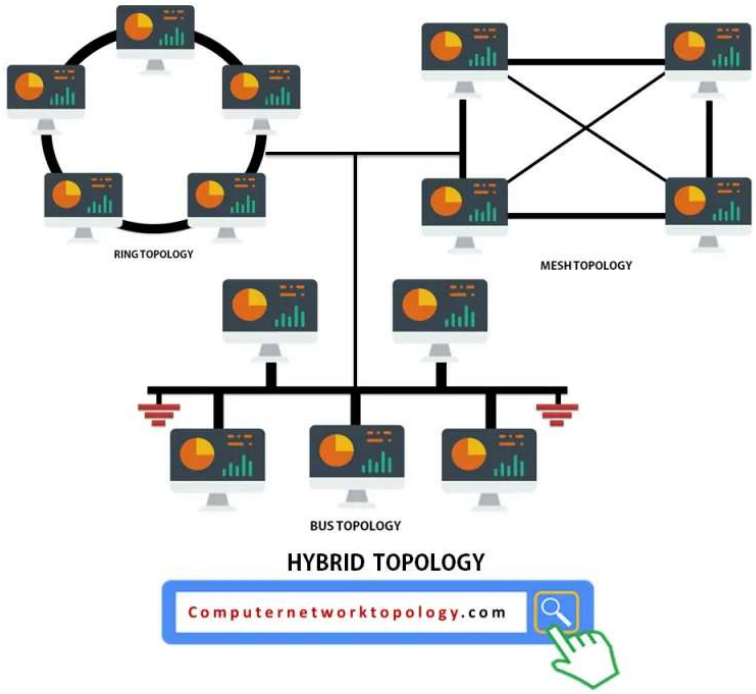
Point to point wiring for individual segment

Support by several hardware and software vendors

Ring topology Disadvantages

- Length of segment is limited by the type of cabling used
- If the backbone line breaks the entire segment goes down
- More difficult to configure and wire than other topologies

Hybrid Topology



Data and Signals

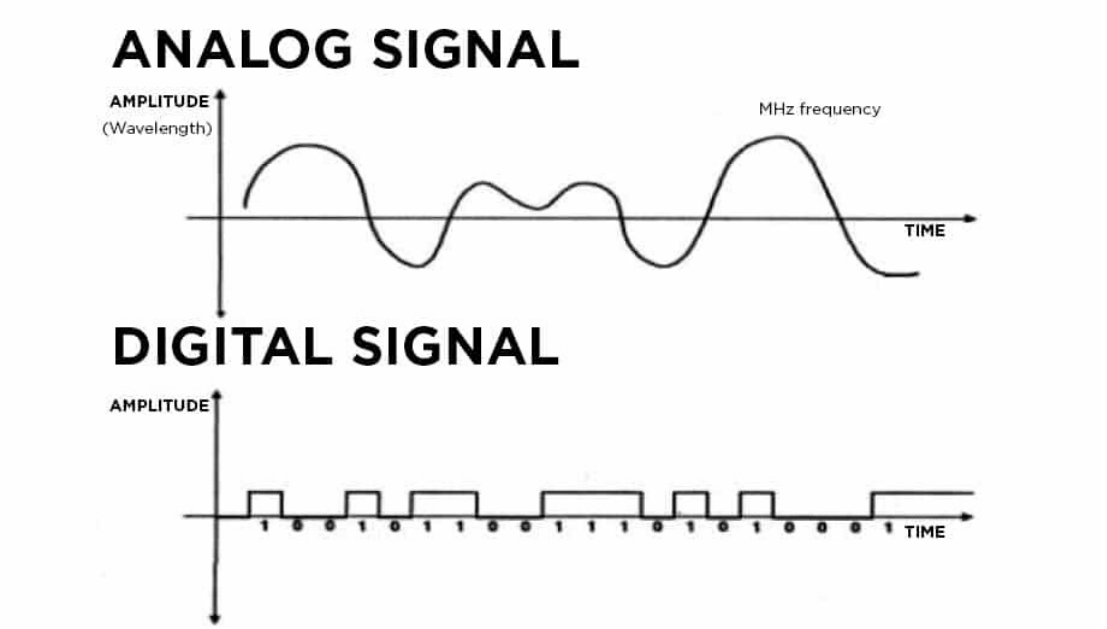
Data must be converted into appropriate signal

Signals can be either Analog Or Digital

Analog refers to information that is continuous

Digital data refers to information that has discrete states

Analog and Digital Signals



Encoding and Modulation

- In digital transmission -The digital or analog signals is encoded into digital signal (encoding)
- In analog transmission- The digital or analog signal is modulated into analog transmission(Modulation)
- Digital to Digital-Line coding,Block coding,Scrambling
- Analog to Digital- Pulse Code Modulation(PCM) and Delta Modulation(DM)
- Digital to Analog-Amplitude Shift Key(ASK),Frequency Shift Key(FSK),and Phase Shift Key(PSK),Quadrature Amplitude Modulation(QAM)
- Analog to Analog-Amplitude Modulation(AM),Frequency Modulation(FM),Phase Modulation(PM)

Digital to Digital transmission

Digital encoding

1. Line coding
2. Block coding
3. Scrambling

Line Coding

It assumes that data are stored as sequence of bits .

The process of converting these sequence of bits into digital signal is known as line coding

1. Unipolar
2. Polar
3. Bipolar
4. Multilevel
5. Multi Transmission

Videos

1. https://www.youtube.com/watch?v=nkSebRJ0cG0
2. https://www.youtube.com/watch?v=t1zpzRB0wOs
3. https://www.youtube.com/watch?v=5V8p6EOjuF0
4. https://www.youtube.com/watch?v=fVvv9NUlMxA&t=3s
5. https://www.youtube.com/watch?v=CU0JQ7nLSjs&t=4s

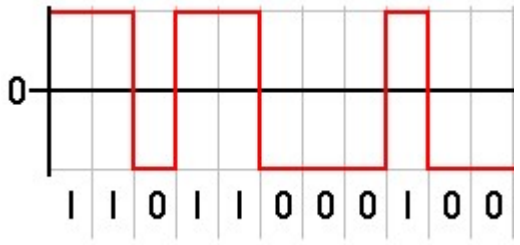
1. Unipolar -NRZ-Non Return to Zero

Positive voltage defines bit 1

Zero voltage defines bit 0

It does not return to zero at the middle of the bit ie it is called as NRZ

It is very costly



2.polar Scheme

The voltage are on both sides of the time axis.

0 positive

1 negative

a)Non return to zero

b) return to zero

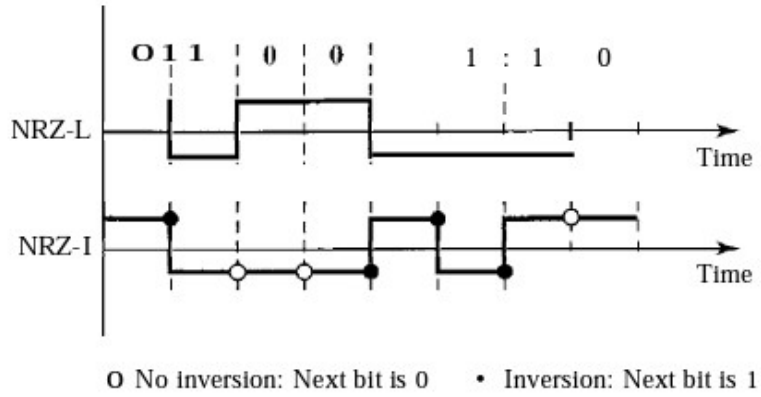
c)Biphase Manchester and Differential Manchester

a. Non return to Zero

Two variations NRZ-L(NRZ-Level)

NRZ-I(NRZ-Invert) Change bit is 1-no change bit is 0

The running average of the received signal power is called baseline



Return to Zero(RZ)

The problem with NRZ encoding occurs when the sender and receiver clocks are not synchronized

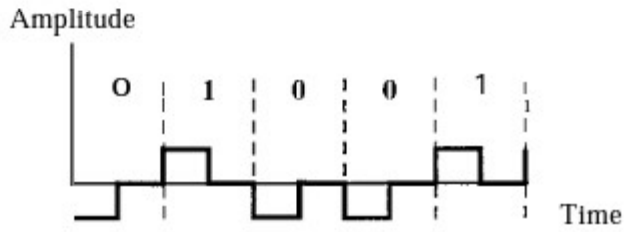
The solution is RZ

It uses three values positive

Negative

Zero

Signal changes between the bit.



Return to Zero(RZ)

It require high bandwidth -two signal changes to encode a bit

It require 3 volatges

Biphase

RZ and NRZ-L combine in Manchester Scheme

The duration of the bit is divided into two halves

Voltage remains at one level during the first half

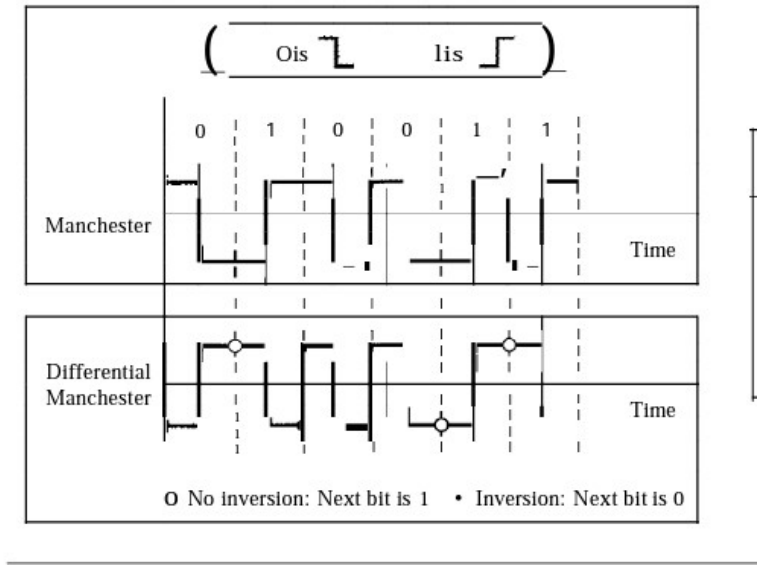
Moves to other levels in the second half

The transition a the middle of the bit provide synchronization

Biphase-Differential Manchester

Combines the idea of Rz NRZ-I

Always transition at the middle of the bit



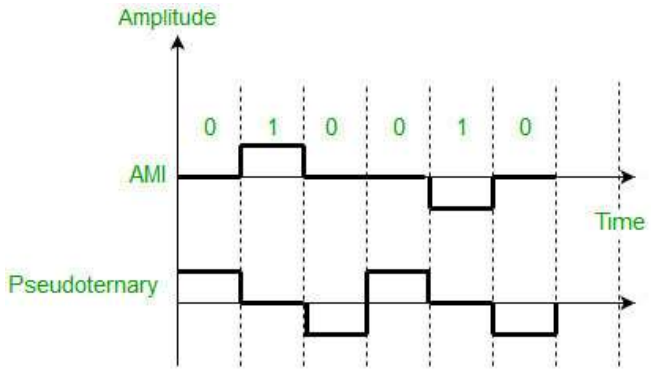
Bipolar Scheme

Also called multilevel binary

Positive,negative, and zero

AMI(Alternate Mark Inversion),Pseudoternary:

AMI: Mark comes from telegraphy and means 1. Alternate 1 inversion



Multilevel Schemes

Two types of data elements(0,1)

Group of m data elements can produce a combination of 2^m data patterns

If there is L different levels of signals L^n combination of signal patterns

If 2^m=L^n then each data pattern is encoded into one signal pattern

mBnL

M-length of binary pattern

B-Binary data

N-length of signal pattern

L-number of levels in signaling

Multilevel Schemes

L=B (Binary)=2

L=T(3)

L=Q(4)

Example:2 B1Q

Multi Transmission

The multiline transmission, three level (MLT-3) scheme uses three levels (+v, 0, and -V) and three transition rules to move between the levels.

1. If the next bit is 0, there is no transition.

2. If the next bit is 1 and the current level is not 0, the next level is 0.

3. If the next bit is 1 and the current level is 0, the next level is the opposite of the last non zero level.

2.Block Coding

redundancy to ensure synchronization and to provide some kind of inherent error detecting.

Block coding can give us this redundancy and improve the performance of line coding

lock coding changes a block of m bits into a block of n bits, where n is larger than m.

Block coding is referred to as an mB/nB encoding technique.

Block coding normally involves three steps: division, substitution, and combination

In the division step, a sequence of bits is divided into groups of m bits

4B/5B

The four binary/five binary (4B/5B) coding scheme was designed to be used in combination with NRZ-I.

A long sequence of 0 s can make the receiver clock lose synchronization

In 4B/5B, the 5-bit output that replaces the 4-bit input has no more than one leading zero (left bit) and no more than two trailing zeros (right bits)

So when different groups are combined to make a new sequence, there are never more than three consecutive 0s.

3.Scrambling

Biphase schemes that are suitable for dedicated links between stations in a LAN are not suitable for long-distance communication because of their wide bandwidth requirement.

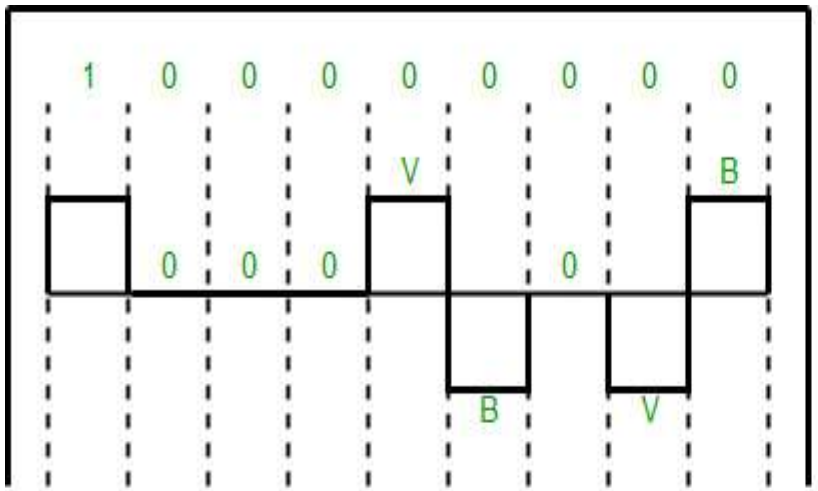
The combination of block coding and NRZ line coding is not suitable for long-distance encoding either, because of the DC component

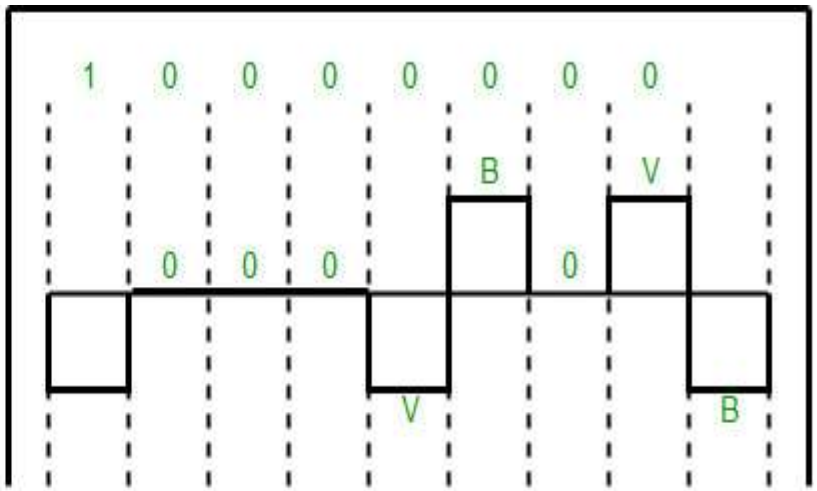
B8ZS

Bipolar with 8 zero substitution

000VB0VB

The V in the sequence denotes violation; The B in the sequence denotes bipolar


1 0 0 0 0 0 0 0 0
V
B
0 0 0 0
B
V


1 0 0 0 0 0 0 0
B
V
0 0 0 0
V
B

Analog to Digital Transmission

1. PCM(Pulse Code Modulation)
2. Delta Modulation

1. PCM

3 step process

i) Analog signal is scrambled(Sampling)

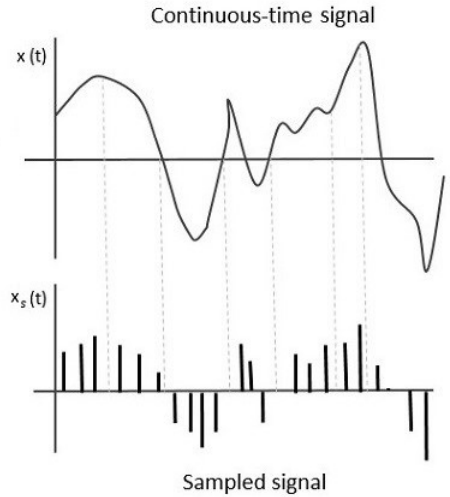
ii) Sampled signal is quantized(Quantization)

iii)The quantized values are encoded as stream of bits(Encoding)

https://www.youtube.com/watch?v=HlGJ6xxbz8s

i) Sampling

The process of converting continuous time signals into equivalent discrete time signals, can be termed as Sampling. A certain instant of data is continually sampled in the sampling process.



SAMPLING

1)Ideal

2)Natural

3)Flat-Top

1)Ideal: pulses from analog signals are sampled

2)natural sampling:High speed switch is turned on for only the small period of time when the sampling occurs

3)Flat Top : Sample and Hold creates a flat top sampling

Sampling

https://www.youtube.com/watch?v=yWqrx08UeUs

Quantization

The result of sampling is a series of pulses with amplitude values between the maximum and minimum amplitudes of the signal.

These of amplitudes can be infinite with non integral values between the two limits.

These values cannot be used in the encoding process

Steps in Quantization

1.We assume that the original analog signal has instantaneous amplitudes between Vmin and Vmax'

2.We divide the range into Lzones,eachofheight~(delta). Vmax-Vrnin~=-==-:::--=L3.Weassignquantizedvaluesof0toL-Itothemidpointofeachzone.4.Weapproximatethevalueofthesampleamplitudetothequantizedvalues.