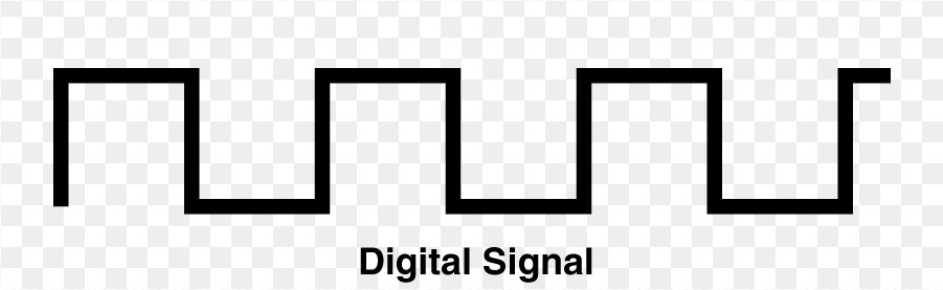
Data Communications and Computer Network

PART IV: SIGNALS

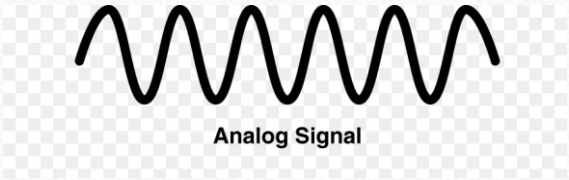
Digital Signal

- Digital signals are discrete in nature and represent sequence of voltage pulses. Digital signals are used within the circuitry of a computer system.
- A **digital signal** refers to an electrical **signal** that is converted into a pattern of bits.



Analog Signal

- Analog signals are in continuous wave form in nature and represented by continuous electromagnetic waves.
- An **analog signal** is a continuous signal that contains time-varying quantities.



Transmission impairment

- In the data communication system, analog and digital signals go through the transmission medium. Transmission media are not ideal. There are some imperfections in transmission mediums. So, the signals sent through the transmission medium are also not perfect. This imperfection cause **signal impairment**. It means that signals that are transmitted at the beginning of the medium are not the same as the signals that are received at the end of the medium that is what is sent is not what is received. These impairments tend to deteriorate the quality of analog and digital signals.

Kinds of Transmission impairment

- Attenuation
- Dispersion
- Delay Distortion
- Noise
    a. Thermal noise
    b. Intermodulation
    c. Crosstalk
    d. Impulse

Attenuation

For the receiver to interpret the data accurately, the signal must be sufficiently strong. When the signal passes through the medium, it tends to get weaker. As it covers distance, it loses strength.

Dispersion

As signal travels through the media, it tends to spread and overlaps. The amount of dispersion depends upon the frequency used.

Delay Distortion

Signals are sent over media with pre-defined speed and frequency. If the signal speed and frequency do not match, there are possibilities that signal reaches destination in arbitrary fashion. In digital media, this is very critical that some bits reach earlier than the previously sent ones.

Noise

Random disturbance or fluctuation in analog or digital signal is said to be Noise in signal, which may distort the actual information being carried. Noise can be characterized in one of the following class:

a. Thermal Noise - Heat agitates the electronic conductors of a medium which may introduce noise in the media. Up to a certain level, thermal noise is unavoidable.

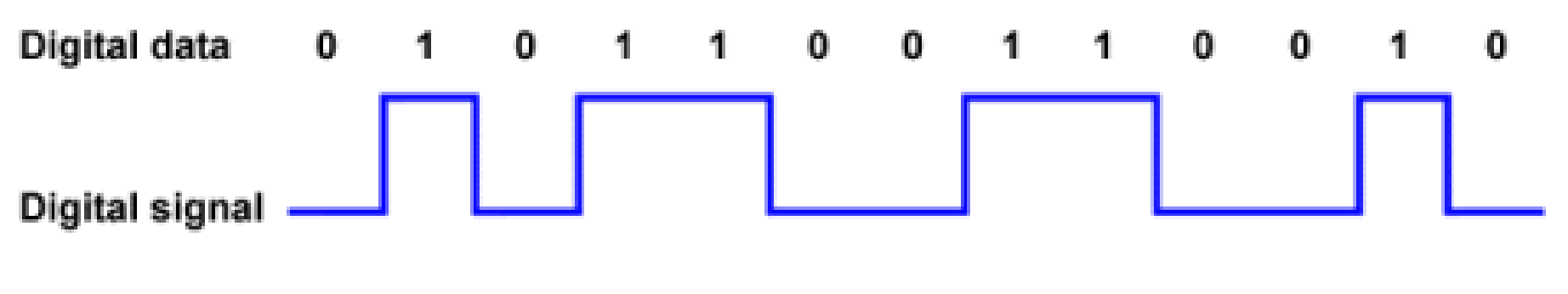
b. Intermodulation - When multiple frequencies share a medium, their interference can cause noise in the medium. Intermodulation noise occurs if two different frequencies are sharing a medium and one of them has excessive strength or the component itself is not functioning properly, then the resultant frequency may not be delivered as expected.

c. Crosstalk - This sort of noise happens when a foreign signal enters into the media. This is because signal in one medium affects the signal of second medium.

d. Impulse - This noise is introduced because of irregular disturbances such as lightening, electricity, short-circuit, or faulty components. Digital data is mostly affected by this sort of noise.

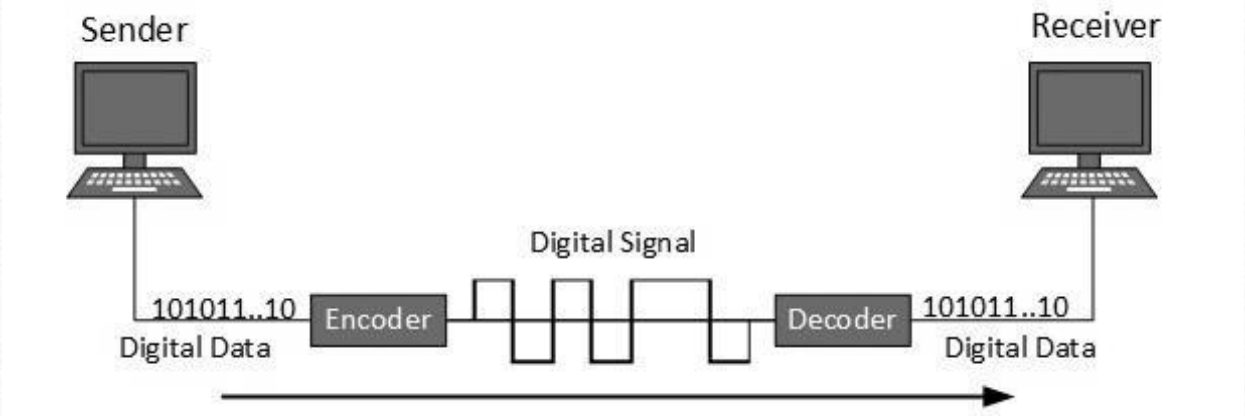
Digital Transmission

- This section explains how to convert **digital data** into **digital signals**. It can be done in two ways, line coding and block coding. For all communications, line coding is necessary whereas block coding is optional.

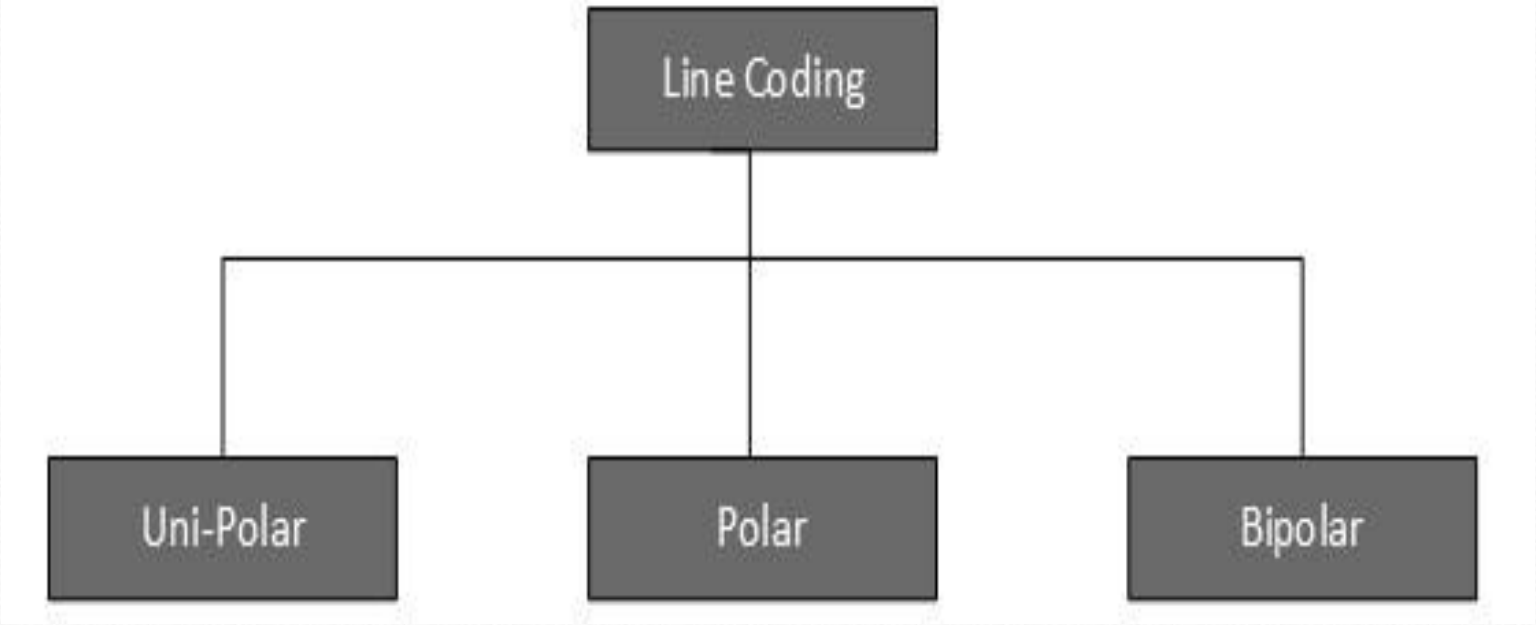


Line Coding

- The process for converting digital data into digital signal is said to be Line Coding. Digital data is found in binary format. It is represented (stored) internally as series of 1s and 0s

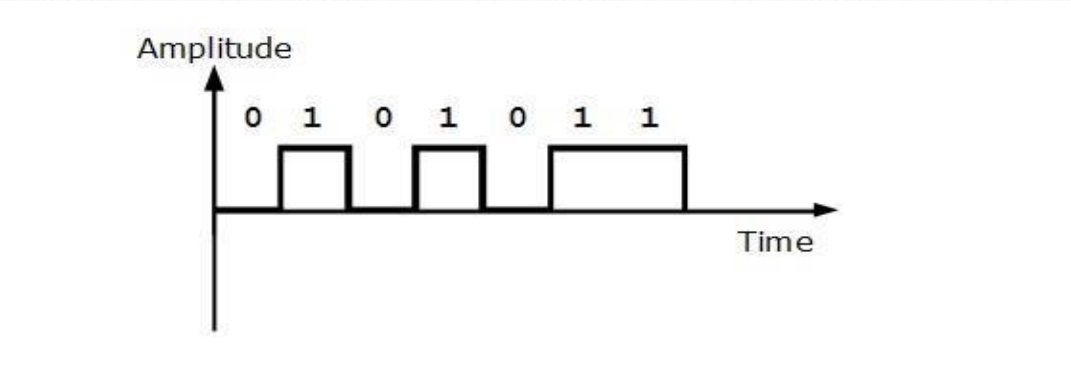


Three types of Line Coding



Unipolar

- Unipolar encoding schemes use single voltage level to represent data. In this case, to represent binary 1, high voltage is transmitted and to represent 0, no voltage is transmitted. It is also called Unipolar-Non-return-to-zero, because there is no rest condition i.e. it either represents 1 or 0.



Polar Encoding

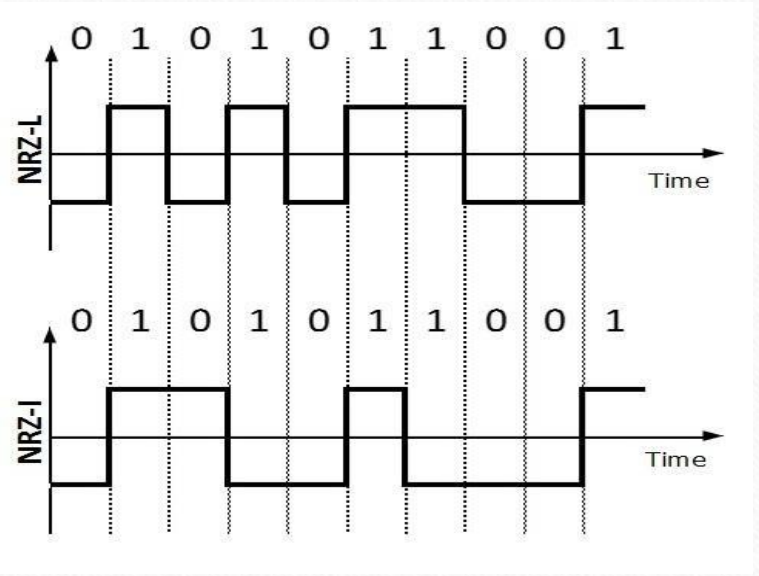
- Polar encoding scheme uses multiple voltage levels to represent binary values. Polar encodings is available in four types:
  a. **Polar Non Return to Zero (Polar NRZ)**
  b. **Return to Zero (RZ)**

Polar Non Return to Zero (Polar NRZ)

- It uses two different voltage levels to represent binary values. Generally, positive voltage represents 1 and negative value represents 0. It is also NRZ because there is no rest condition.

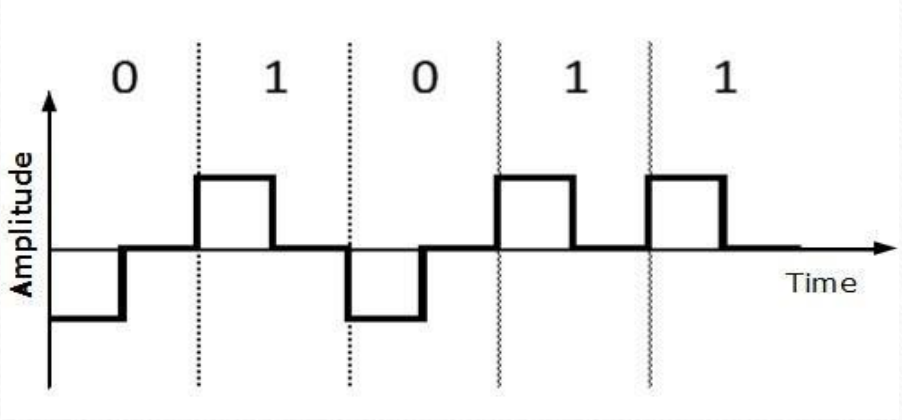
NRZ scheme has two variants: NRZ-L and NRZ-I.

- NRZ-L changes voltage level at when a different bit is encountered whereas
- NRZ-I changes voltage when a 1 is encountered.



Return to Zero (RZ)

- Problem with NRZ is that the receiver cannot conclude when a bit ended and when the next bit is started, in case when sender and receiver's clock are not synchronized.
- RZ uses three voltage levels, positive voltage to represent 1, negative voltage to represent 0 and zero voltage for none. Signals change during bits not between bits.



Manchester

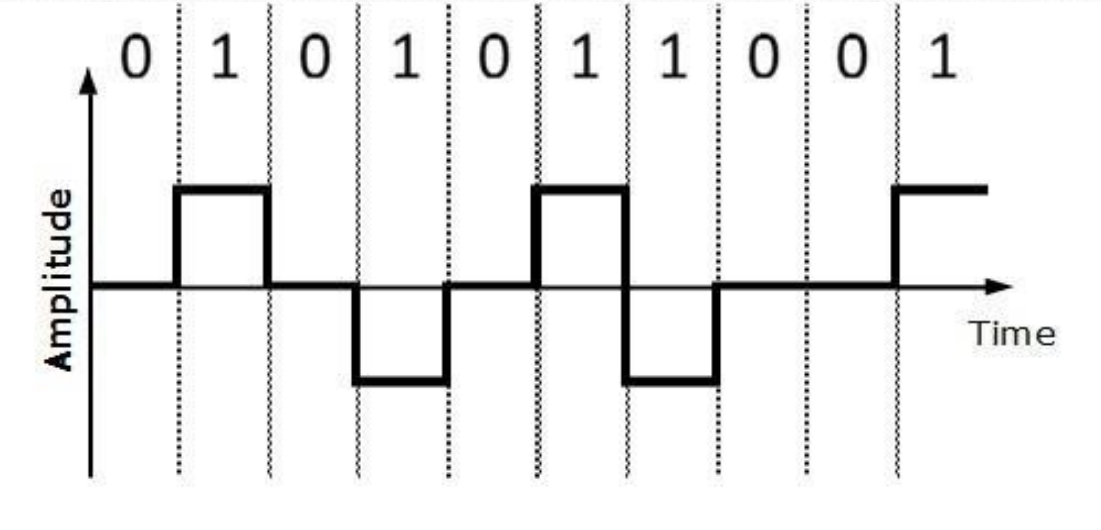
- This encoding scheme is a combination of RZ and NRZ-L. Bit time is divided into two halves. It transits in the middle of the bit and changes phase when a different bit is encountered.

Differential Manchester

- This encoding scheme is a combination of RZ and NRZ-I. It also transits at the middle of the bit but changes phase only when 1 is encountered.

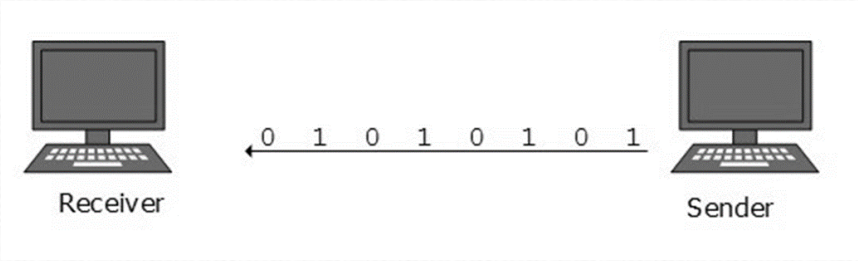
Bipolar

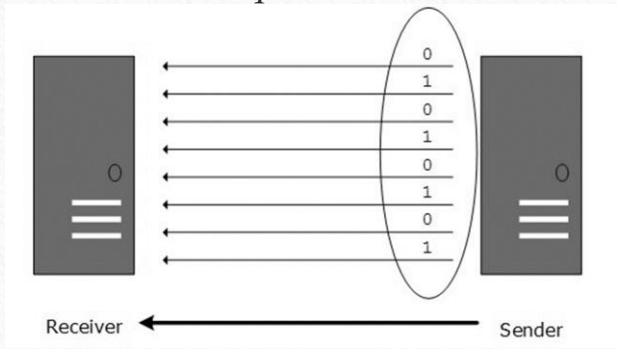
- Bipolar encoding uses three voltage levels, positive, negative, and zero. Zero voltage represents binary 0 and bit 1 is represented by altering positive and negative voltages.



Two Types of Transmission Mode

- Parallel Transmission - The binary bits are organized into groups of fixed length. Both sender and receiver are connected in parallel with the equal number of data lines. Both computers distinguish between high order and low order data lines. The sender sends all the bits at once on all lines. Because the data lines are equal to the number of bits in a group or data frame, a complete group of bits (data frame) is sent in one go. Advantage of Parallel transmission is high speed and disadvantage is the cost of wires, as it is equal to the number of bits sent in parallel.
- Serial Transmission - In serial transmission, bits are sent one after another in a queue manner. Serial transmission requires only one communication channel.





Serial transmission can be either asynchronous or synchronous.

- **Asynchronous Serial Transmission** - It is named so because there is no importance of timing. Data-bits have specific pattern and they help receiver recognize the start and end data bits. For example, a 0 is prefixed on every data byte and one or more 1s are added at the end. Two continuous data-frames (bytes) may have a gap between them.
- **Synchronous Serial Transmission** - Timing in synchronous transmission has importance as there is no mechanism followed to recognize start and end data bits. There is no pattern or prefix/suffix method. Data bits are sent in burst mode without maintaining gap between bytes (8bits). Single burst of data bits may contain a number of bytes. Therefore, timing becomes very important. It is up to the receiver to recognize and separate bits into bytes. The advantage of synchronous transmission is high speed, and it has no overhead of extra header and footer bits as in asynchronous transmission.

Network Routing

- When a device has multiple paths to reach a destination, it always selects one path by preferring it over others. This selection process is termed as Routing. Routing is done by special network devices called routers or it can be done by means of software processes. The software based routers have limited functionality and limited scope. A router is always configured with some default route. A default route tells the router where to forward a packet if there is no route found for specific destination. In case there are multiple path existing to reach the same destination, router can make decision based on the following information:

a. Hop Count Bandwidth

b. Metric

c. Prefix-length

d. Delay

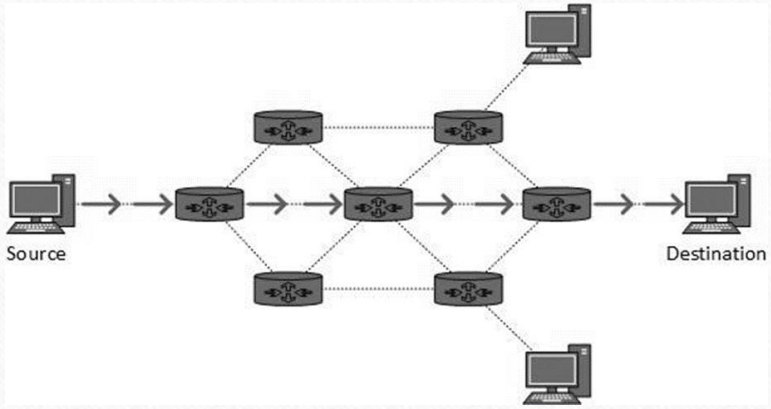
- Routes can be statically configured or dynamically learnt. One route can be configured to be preferred over others.

Types of Routing

- Unicast
- Broadcast
- Multicast
- Anycast

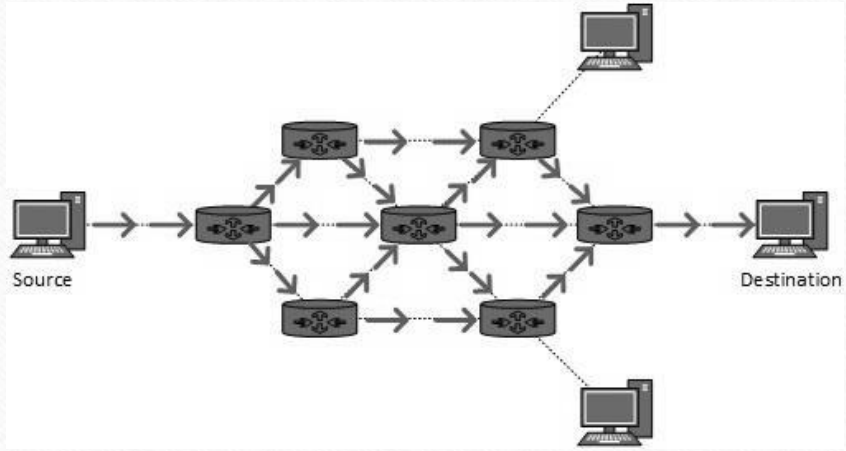
Unicast

- Most of the traffic on the internet and intranets known as unicast data or unicast traffic is sent with specified destination. Routing unicast data over the internet is called unicast routing. It is the simplest form of routing because the destination is already known. Hence the router just has to look up the routing table and forward the packet to next hop.



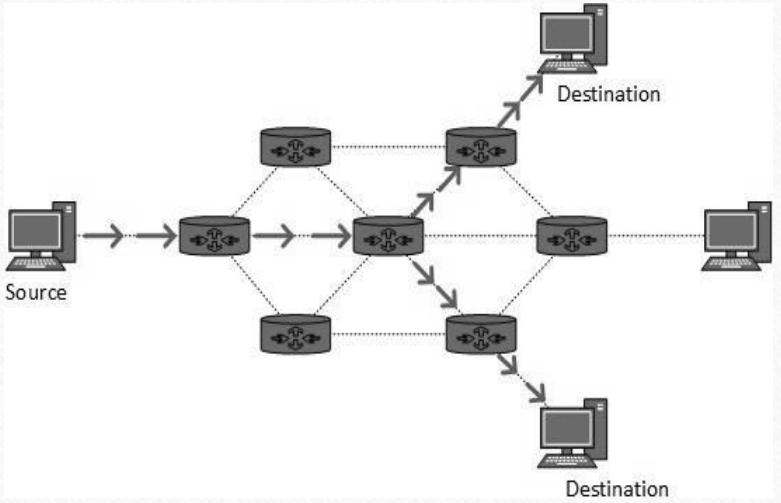
Broadcast

- By default, the broadcast packets are not routed and forwarded by the routers on any network. Routers create broadcast domains. But it can be configured to forward broadcasts in some special cases. A broadcast message is destined to all network devices.



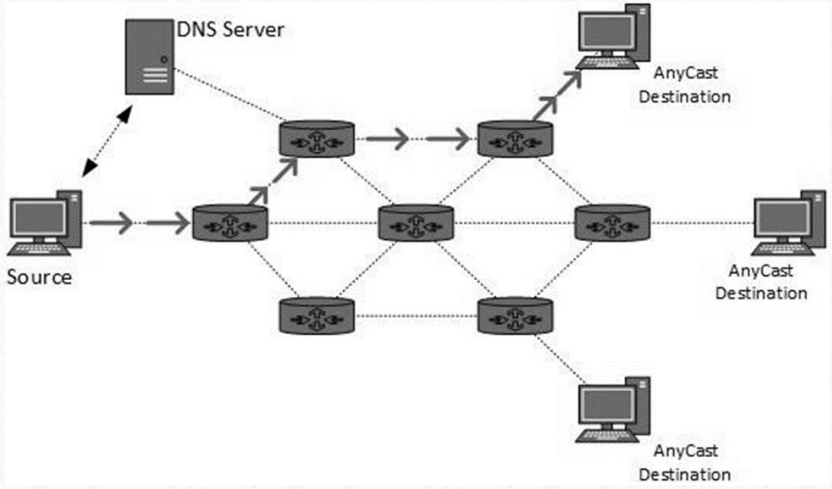
Multicast

- Multicast routing is special case of broadcast routing with significance difference and challenges. In broadcast routing, packets are sent to all nodes even if they do not want it. But in Multicast routing, the data is sent to only nodes which wants to receive the packets.



Anycast

- Anycast packet forwarding is a mechanism where multiple hosts can have same logical address. When a packet destined to this logical address is received, it is sent to the host which is nearest in routing topology.



Assignment

- What is Dynamic and Static IP address
- What are the different classes of IPv4 address
- What is ARP?
- What is a port number in data communications, give 10 examples of port number and its use.