Unit-5

Introduction to Virtual Circuit

Virtual Circuits are also known as connection-oriented switching.

Virtual circuit **switching establishes a predetermined path before messages are sent**.

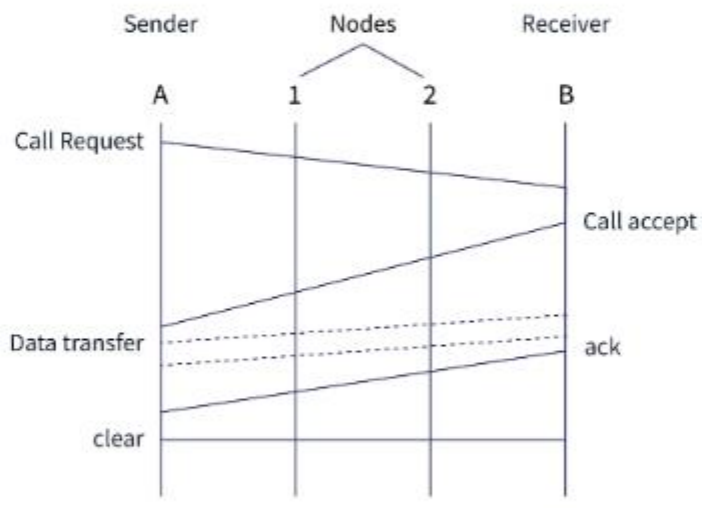
This path is known **as a virtual circuit** because it appears to the user to be an infatuated physical circuit.

The connection between the sender and the receiver is established using the call request and call accept packets.

A virtual circuit **is a logical connection between two network nodes**, usually in a telecommunications network.

The path is made up of distinct network segments that are linked together via switches.

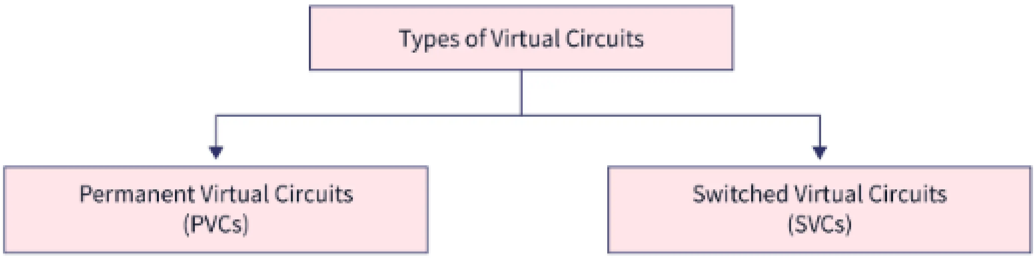
Now let's have a look at the diagram given below to understand the virtual circuits more precisely:



- A and B are the sender and the receiver in the diagram above. The nodes are 1 and 2.
- The call request and call accept packets are used to connect the sender and receiver.
- Data will be transferred after a path is created.
- Following data transfer, the receiver sends an acknowledgment signal indicating that the receiver received the message.
- A clear signal is sent if the user wishes to terminate the connection.

Types of Virtual Circuit

The two types of Virtual circuits are as follows:



Permanent Virtual Circuits (PVCs):- The switches provide **performance similar to dedicated lines and are manually configured by the communication management station** (the telco's central office).

These always-on circuits are typically employed **for high-speed communication**.

PVCs are an expensive solution for wide-area networks (WANs) since they need telco resources (switches) to be devoted to a specific communication circuit regardless of whether or not that circuit is in use.

Switched Virtual Circuits (SVCs):- When a communication **session is created**, the **switches are immediately configured**.

When the **session ends**, **SVCs are released** and **can be utilized to establish other communication paths**.

This is how regular telephone communication works.

SVCs are typically used in WANs where backups to dedicated leased lines are necessary and are charged on a per-minute or per-traffic basis.

Introduction to Datagram Networks

It is a packet-switching technique in which each packet, known as a datagram, is treated as a separate entity.

Each packet carries destination information, which the switch uses to route the packet to the correct destination.

There is no need to reserve resources because there is no specified channel for a connection session.

As a result, packets contain a header including all of the destination's information.

The intermediate nodes examine the header of a packet and choose an appropriate link to a different node closer to the destination.

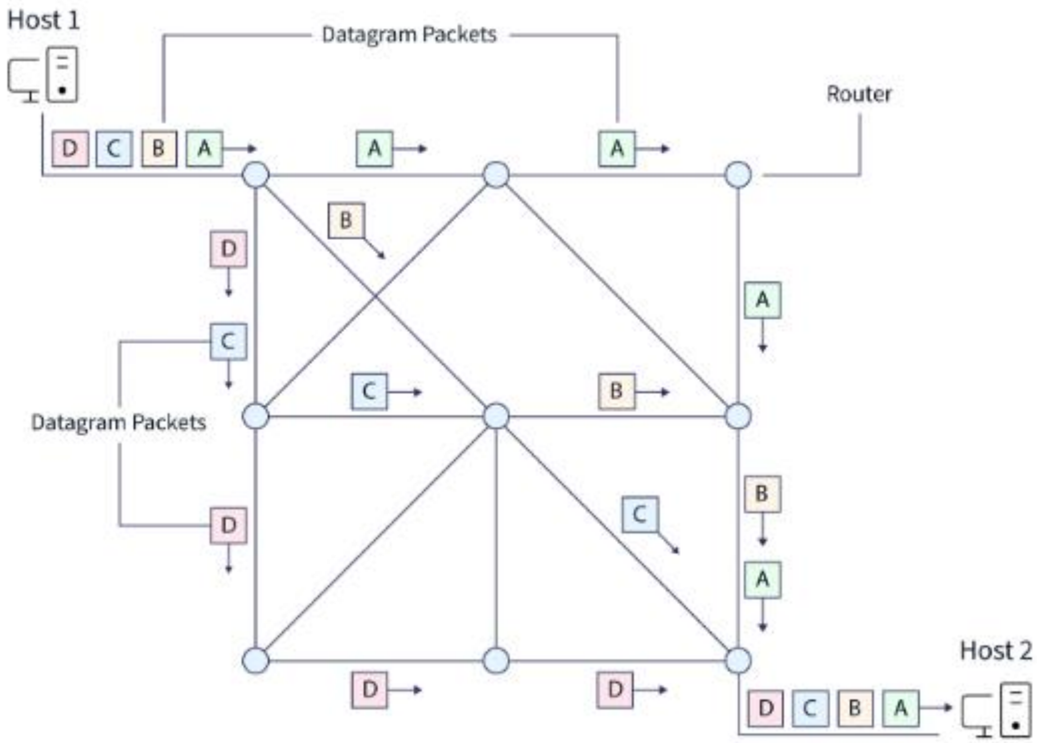
Resources in datagram networks are allocated on a First Come First Serve (FCFS) basis. When a packet arrives at a router, it must wait if other packets are being processed, regardless of its source or destination.

The diagram below displays datagram packets sent from host H1 to host H2.

The four datagram packets with the labels A, B, C, and D are all parts of the same message each being routed individually through a different route.

The message's packets arrive out of sequence at their destination.

In order to recover the original message, it is H2's obligation to reorder the packets.



Network Addressing

- Network Addressing is **one of the major responsibilities of the network layer**.
- Network **addresses are always logical, i.e., software-based addresses**.
- **A host is also known as end system that has one link to the network**. The **boundary between the host and link is known as an interface**. Therefore, the host can have only one interface.
- A **router is different from the host, in that it has two or more links that connect to it**. **When a router forwards the datagram, it forwards the packet to one of the links. The boundary between the router and link is known as an interface, and the router can have multiple interfaces, one for each of its links**. **Each interface is capable of sending and receiving the IP packets**, **so IP requires each interface to have an address**.
- **Each IP address is 32 bits long**, and they are **represented in the form of "dot-decimal notation" where each byte is written in the decimal form, and they are separated by the period. An IP address would look like 193.32.216.9 where 193 represents the decimal notation of first 8 bits of an address**, **32 represents the decimal notation of second 8 bits of an address.**

IP Address in Networking-

In networking,

- IP Address is short for Internet Protocol Address.
- It is a unique address assigned to each computing device in an IP network.
- ISP assigns IP Address to all the devices present on its network.
- Computing devices use IP Address to identify and communicate with other devices in the IP network.

Types Of IP Address-

IP Addresses may be of the following two types-

1. Static IP Address
2. Dynamic IP Address

1. Static IP Address-

- Static IP Address is an IP Address that once assigned to a network element always remains the same.
- They are configured manually.

2. Dynamic IP Address-

- Dynamic IP Address is a temporarily assigned IP Address to a network element.
- It can be assigned to a different device if it is not in use.
- DHCP or PPPoE assigns dynamic IP addresses.

IP Address Format-

- IP Address is a 32 bit binary address written as 4 numbers separated by dots.
- The 4 numbers are called as octets where each octet has 8 bits.
- The octets are divided into 2 components- Net ID and Host ID.

Format of an IP Address

- **Network ID represents the IP Address of the network and is used to identify the network.**
- **Host ID represents the IP Address of the host and is used to identify the host within the network.**

<u>IP Address Example-</u>

Example of an IP Address is- 00000001.10100000.00001010.11110000

(Binary Representation)

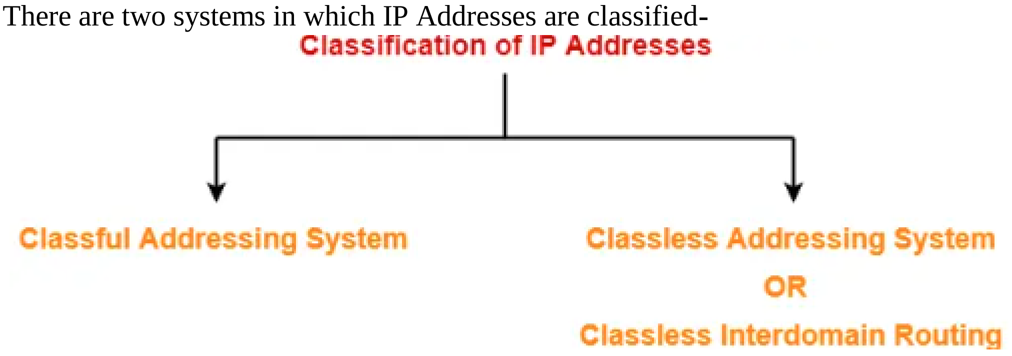
OR

1.160.10.240

(Decimal Representation)

IP Addressing-

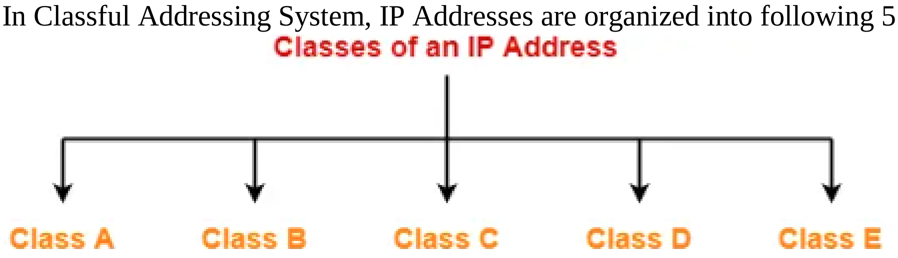
There are two systems in which IP Addresses are classified-



1. Classful Addressing System
2. Classless Addressing System

Classful Addressing-

In Classful Addressing System, IP Addresses are organized into following 5 classes-



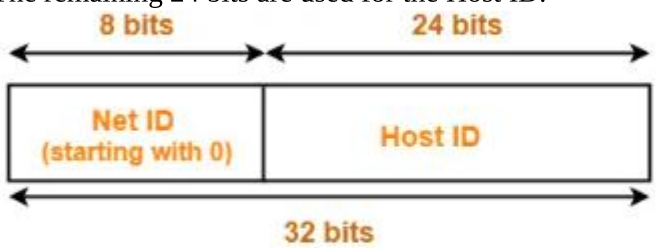
1. Class A
2. Class B
3. Class C
4. Class D
5. Class E

1. Class A-

If the 32 bit binary address **starts with a bit 0**, then IP Address belongs to class A.

In class A IP Address,

- The first 8 bits are used for the Network ID.
- The remaining 24 bits are used for the Host ID.



Class A IP Address

Total Number Of IP Addresses-

Total no. of IP Addresses available in class A = Numbers possible due to remaining available 31 bits

$= 2^{31}$

Total Number Of Networks-

Total no. of networks available in class A

= Numbers possible due to remaining available 7 bits in the Net ID – 2

$= 2^7 - 2$

= 126

Total Number Of Hosts-

Total no. of hosts that can be configured in class A

= Numbers possible due to available 24 bits in the Host ID – 2

= $2^{24} - 2$

Range Of 1st Octet-

We have-

- Minimum value of 1st octet = 00000000 = 0
- Maximum value of 1st octet = 01111111 = 127

From here,

- Range of 1st octet = [0, 127]
- But 2 networks are reserved and unused.
- So, Range of 1st octet = [1, 126]

Use-

Class A is used by organizations requiring very large size networks like NASA, Pentagon etc.

In class A, total number of IP Addresses available for networks are 2 less.

This is to account for the two reserved network IP Addresses 0.xxx.xxx.xxx and 127.xxx.xxx.xxx.

IP Address 0.0.0.0 is reserved for broadcasting requirements.

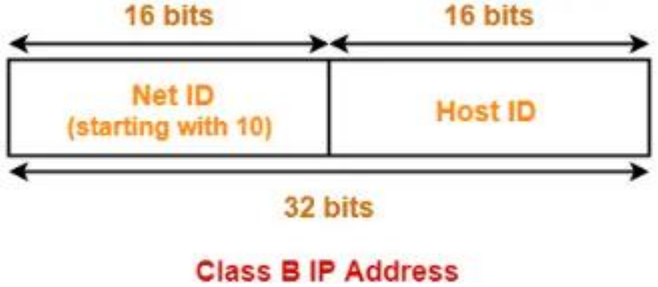
IP Address 127.0.0.1 is reserved for loopback address used for software testing.

2. Class B-

If the 32 bit binary address **starts with bits 10**, then IP Address belongs to class B.

In class B IP Address,

- The first 16 bits are used for the Network ID.
- The remaining 16 bits are used for the Host ID.



<u>Total Number Of IP Addresses-</u>

Total no. of IP Addresses available in class B = Numbers possible due to remaining available 30 bits

= 2^{30}

<u>Total Number Of Networks-</u>

Total no. of networks available in class B = Nos. possible due to remaining available 14 bits in the Net ID

= 2^{14}

<u>Total Number Of Hosts-</u>

Total no. of hosts that can be configured in class B = Nos. possible due to available 16 bits in the Host ID – 2

$= 2^{16} – 2$

Range Of 1st Octet-

We have-

- Minimum value of 1st octet = 10000000 = 128
- Maximum value of 1st octet = 10111111 = 191

So, Range of 1st octet = [128, 191]

Use-

- Class B is used by organizations requiring medium size networks like IRCTC, banks etc.

In all the classes, total number of hosts that can be configured are 2 less.

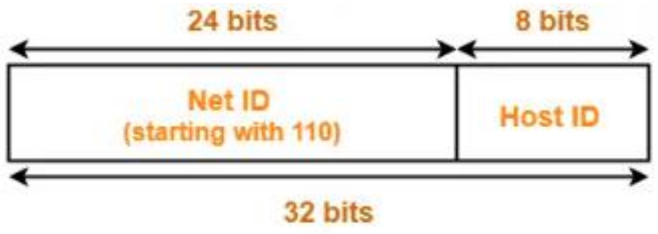
- This is to account for the two reserved IP addresses in which all the bits for host ID are either zero or one.
- When all Host ID bits are 0, it represents the Network ID for the network.
- When all Host ID bits are 1, it represents the Broadcast Address.

3. Class C-

If the 32 bit binary address **starts with bits 110**, then IP Address belongs to class C.

In class C IP Address,

- The first 24 bits are used for the Network ID.
- The remaining 8 bits are used for the Host ID.



Class C IP Address

Total Number Of IP Addresses-

Total no. of IP Addresses available in class C = Numbers possible due to remaining available 29 bits

$= 2^{29}$

Total Number Of Networks-

Total no. of networks available in class C = Numbers possible due to remaining available 21 bits in the Net ID

$= 2^{21}$

Total Number Of Hosts-

Total number of hosts that can be configured in class C = Numbers possible due to available 8 bits in the Host ID – 2

$= 2^8 – 2$

Range Of 1st Octet-

We have-

- Minimum value of 1st octet = 11000000 = 192
- Maximum value of 1st octet = 110111111 = 223

So, Range of 1st octet = [192, 223]

Use-

- Class C is used by organizations requiring small to medium size networks.
- For example- engineering colleges, small universities, small offices etc.

3. Class D-

If the 32 bit binary address **starts with bits 1110**, then IP Address belongs to class D.

- Class D is not divided into Network ID and Host ID.

Class D IP Address

Total Number Of IP Addresses-

Total No. of IP Addresses available in class D = Numbers possible due to remaining available 28 bits

= 2^{28}

Range Of 1st Octet-

We have-

- Minimum value of 1st octet = 11100000 = 224
- Maximum value of 1st octet = 11101111 = 239

So, Range of 1st octet = [224, 239]

Use-

- Class D is reserved for multicasting.
- In multicasting, there is no need to extract host address from the IP Address.
- This is because data is not destined for a particular host.

5. Class E-

If the 32 bit binary address starts with bits 1111, then IP Address belongs to class E.

Class E is not divided into Network ID and Host ID.

Class E IP Address

Total Number Of IP Addresses-

Total number of IP Addresses available in class E
= Numbers possible due to remaining available 28 bits
= 228

Range Of 1st Octet-

We have-
Minimum value of 1st octet = 11110000 = 240
Maximum value of 1st octet = 11111111 = 255

So, Range of 1st octet = [240, 255]

Use-

Class E is reserved for future or experimental purposes.

Classes of IP Address-

All the classes of IP Address are summarized in the following table-

Class of IP Address	Total Number of IP Addresses	1st Octet Decimal Range	Number of Networks available	Hosts per network	Default Subnet Mask
Class A	231	1 – 126	27 – 2	224 – 2	255.0.0.0
Class B	230	128 – 191	214	216 – 2	255.255.0.0
Class C	229	192 – 223	221	28 – 2	255.255.255.0
Class D	228	224 – 239	Not defined	Not defined	Not defined
Class E	228	240 – 254	Not defined	Not defined	Not defined

Important Notes-
Note-01:
All the hosts in a single network always have the same network ID but different Host ID. However, two hosts in two different networks can have the same host ID.

Note-02:
A single network interface can be associated with more than one IP Address.

Note-03:
There is no relation between MAC Address and IP Address of a host.

Note-04:
IP Address of the network called Net ID is obtained by setting all the bits for Host ID to zero.

Note-05:
Class A Networks accounts for half of the total available IP Addresses.

Note-06:

In class A, total number of IP Addresses available for networks are 2 less.

This is to account for the two reserved network IP Addresses 0.xxx.xxx.xxx and 127.xxx.xxx.xxx.
IP Address 0.0.0.0 is reserved **for broadcasting requirements**.
IP Address 127.0.0.1 is reserved **for loopback address used for software testing**.

Note-07:

In all the classes, total number of hosts that can be configured are 2 less.

This is to account for the two reserved IP addresses in which all the bits for host ID are either zero or one.
When all Host ID bits are 0, it represents the Network ID for the network.
When all Host ID bits are 1, it represents the Broadcast Address.

Note-08:
Only those devices which have the network layer will have IP Address.
So, switches, hubs and repeaters does not have any IP Address.

Rules for assigning Host ID:

The Host ID **is used to determine the host within any network**. The Host ID is assigned based on the following rules:

- The Host ID **must be unique within any network**.
- The **Host ID in which all the bits are set to 0 cannot be assigned as it is used to represent the network ID of the IP address**.
- The Host ID **in which all the bits are set to 1 cannot be assigned as it is reserved for the multicast address**.

Rules for assigning Network ID:

If **the hosts are located within the same local network, then they are assigned with the same network ID**. The following are the rules for assigning Network ID:

- The network ID **cannot start with 127 as 127 is used by Class A**.
- The Network ID **in which all the bits are set to 0 cannot be assigned as it is used to specify a particular host on the local network**.
- The Network ID **in which all the bits are set to 1 cannot be assigned as it is reserved for the multicast address**.

Classless Addressing-

- Classless Addressing is an improved IP Addressing system.
- It makes the allocation of IP Addresses more efficient.
- **It replaces the older classful addressing system based on classes**.
- It is also known as **Classless Inter Domain Routing (CIDR)**.

CIDR Block-

When a user asks for specific number of IP Addresses,

- CIDR **dynamically assigns a block of IP Addresses based on certain rules**.
- This **block contains the required number of IP Addresses as demanded by the user**.
- This block of IP Addresses is called as a **CIDR block**.

Rules For Creating CIDR Block-

A CIDR block is created based on the following 3 rules-

Rule-01:

- **All the IP Addresses in the CIDR block must be contiguous**.

Rule-02:

- **The size of the block must be presentable as power of 2**.
- **Size of the block is the total number of IP Addresses contained in the block**.
- **Size of any CIDR block will always be in the form 2^1, 2^2, 2^3, 2^4, 2^5 and so on**.

Rule-03:

- **First IP Address of the block must be divisible by the size of the block**.

REMEMBER

If any binary pattern consisting of (m + n) bits is divided by 2^n, then-

- Remainder is least significant n bits
- Quotient is most significant m bits

So, any binary pattern is divisible by 2^n, if and only if its least significant n bits are 0.

Examples-

Consider a binary pattern-

01100100.00000001.00000010.01000000

(represented as 100.1.2.64)

- It is divisible by 2^5 since its least significant 5 bits are zero.
- It is divisible by 2^6 since its least significant 6 bits are zero.
- It is not divisible by 2^7 since its least significant 7 bits are not zero.

CIDR Notation-

CIDR IP Addresses look like-

a.b.c.d / n

- **They end with a slash followed by a number called as IP network prefix**.
- **IP network prefix tells the number of bits used for the identification of network**.
- **Remaining bits are used for the identification of hosts in the network**.

Example-

An example of CIDR IP Address is-

182.0.1.2 / 28

It suggests-

- 28 bits are used for the identification of network.
- Remaining 4 bits are used for the identification of hosts in the network.

Problem-05:

Perform CIDR aggregation on the following IP Addresses-

128.56.24.0/24

128.56.25.0/24

128.56.26.0/24

128.56.27.0/24

Solution-

All the 4 given entities represent CIDR block in itself.

We have to now perform the aggregation of these 4 blocks.

Rule-01:

- According to Rule-01, all the IP Addresses must be contiguous.
- Clearly, all the IP Addresses are contiguous.
- So, Rule-01 is satisfied.

Rule-02:

- According to Rule-02, size of the block must be presentable as 2^n.
- Total number of IP Addresses = $2^8 + 2^8 + 2^8 + 2^8 = 2^2 \times 2^8 = 2^{10}$.
- So, Rule-02 is satisfied.

Rule-03:

- According to Rule-03, first IP Address must be divisible by size of the block.
- So, 128.56.24.0 must be divisible by 2^{10}.

- 128.56.24.0 = 128.56.000110**00**.**00000000** is divisible by 2^{10} since its 10 least significant bits are zero.
- So, Rule-03 is satisfied.

Since all the 3 rules are satisfied, so they can be aggregated.

CIDR Representation-

We have-

- Size of the block = Total number of IP Addresses = 2^{10}.
- To have 2^{10} total number of IP Addresses, 10 bits are required in the Host ID part.
- So, Number of bits in the Network ID part = 32 – 10 = 22.

Thus,

CIDR Representation = 128.56.24.0/22

Problem-06:

Perform CIDR aggregation on the following IP Addresses-

200.96.86.0/24

200.96.87.0/24

200.96.88.0/24

200.96.89.0/24

Solution-

All the 4 given entities represent CIDR block in itself.

We have to now perform the aggregation of these 4 blocks.

Rule-01:

- According to Rule-01, all the IP Addresses must be contiguous.

- Clearly, all the IP Addresses are contiguous.
- So, Rule-01 is satisfied.

Rule-02:

- According to Rule-02, size of the block must be presentable as 2^n.
- Total number of IP Addresses = $2^8 + 2^8 + 2^8 + 2^8 = 2^2 \times 2^8 = 2^{10}$.
- So, Rule-02 is satisfied.

Rule-03:

- According to Rule-03, first IP Address must be divisible by size of the block.
- So, 200.96.86.0 must be divisible by 2^{10}.
- 200.96.86.0 = 200.96.010101**10**.**00000000** is not divisible by 2^{10} since its 10 least significant bits are not zero.
- So, Rule-03 is unsatisfied.

Since all the 3 rules are not satisfied, so they can not be aggregated.