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# Computer Networks

* Syllabus:

- Overview of the Architecture
- IP classful Addressing
  - Mask
  - Subnetting
  - Supernetting
- IP Classless Addressing
  - Variable length blocks
  - Subnetting
  - Address allocation
  - Base 256 Numbering System.
- Delivery, Forwarding and routing of IP Packets.
  - Direct vs Indirect delivery
  - Forwarding with classful addressing
  - Forwarding with classless addressing
  - Routing Table
  - Static vs Dynamic Routing Tables.
- Address Resolution Protocol (ARP)
  - Packet Format
  - Encapsulation
  - Cache
  - Queues
  - Input Module
  - output Module
  - Cache-Control Module

- Internet protocol (IP):
  - Datagram
  - Fragmentation
  - Header Adding Module
  - Processing Module
  - Queues
  - Routing Tables
  - Forwarding Module
  - Reassembly Module
  - Reassembly Table.

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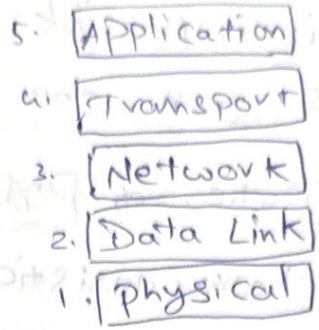
- User Datagram Protocol (UDP)
  - Port Numbers
  - Socket Addresses
  - Connectionless Services
  - Encapsulation & Decapsulation
  - UDP Package.
- Transmission Control protocol (TCP)
  - Process-to-Process communication
  - Connection-oriented Services.
  - Numbering System
  - Flow Control
  - Congestion Control.
  - Segment Format
  - Encapsulation
  - Connection Establishment & Termination
  - Data Transfer
  - sliding window P
  - TCP Timers

CHAPTER - 1

* Internet Layers: (overview)




→ Each Layers uses the services of the layers below it.

→ In developing the model, the designers distilled the process of transmitting data to its most fundamentals elements, Identified the Networking functions & collected those functions into discrete groups that became the layers. Each layer defines a family of functions distinct from those of the other layers.

09/06 → within a single Machine each layer call's upon the services of the layer below it.

→ Layer X on one machine communicates with Layer x on another machine. The communication is governed by the Protocols.

→ At each layer header can be added to the data unit. At Layer 2 a trailer is added. as well.

→ Physical Layer:

It is responsible for transmitting individual bits from one node to the next.

→ The Major Duties of Physical Layer:

- physical characteristics of Interfaces & Media
- Representation of Bits.
- Data Rate
- Synchronization of Bits.

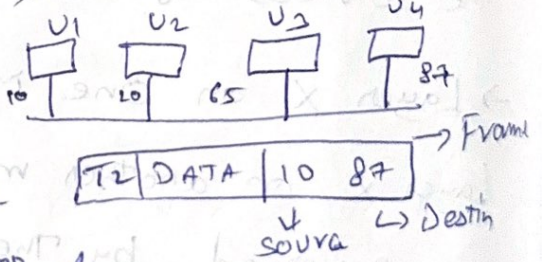
→ Data Link Layer: (local communication only).

It is responsible for transmitting frames from one node to the next.

→ The Major Duties of Data Link Layer:

- Framing: The Data link layer divides the stream of bits into manageable data units called Frames.
- Physical addressing: →

DL - LAN (Local area Netw




The data link layer adds a Header to the Frame to define the sender & receiver of the frame.

- Flow Control
- Error Control.
- Access control.

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→ Network Layer: (Global Comm.)

It is responsible for the delivery of packets from the original source to the final destination. possibly across Multiple Network.

→ The Major Duties of Network Layer:

- Logical addressing:
  The Network layer adds a header to the data unit comming from the upper layer that includes the logical addresses of the sender & the receiver.
- Routing:
  when independent network are connected to create an internetwork the connecting devices route the packets to their final destination.
- Internetworking
- Packetizing
- Fragmentation
- Address Resolution protocol (ARP).

→ Transport Layer:

It is responsible for delivery of a message from one process to another.

→ Major Duties of the Transport Layer:

- Port Addressing:

The Transport layer header must include a port number. The network layer gets each packet to the correct device, The ~~network layer~~ Transport layer gets the data to the correct process on this device.

09/13 - Segmentation and Reassembly:

A message is divided into Transmittable segments, and each segment containing a sequence number. These numbers enable the Transport layer to reassemble the message upon arrival at the destination.

- Connection Control:

The Transport layer can be either connectionless or connection oriented. In a Connectionless Transport Layer each data unit is independently delivered to the Transport layer at the destination ~~machine~~ device.

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makes a
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The segmen
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- Flow Co
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is perfor
across a
- Error Co

→ Application

Th
Providin

→ Basic a

Summary:

To move packets
from source to dest
To provide inter

A connection oriented Transport layer makes a connection with the Transport layer at the destination device before delivering the segments. After the data are transferred the connection is Terminated.

- Flow Control :

Flow Control at the Transport layer is performed End-to-End rather than a across a single link.

- Error Control

→ Application Layer :

The application layer is responsible for Providing services to the user.

→ Basic application - Email
- web browsing
- File Transfer.

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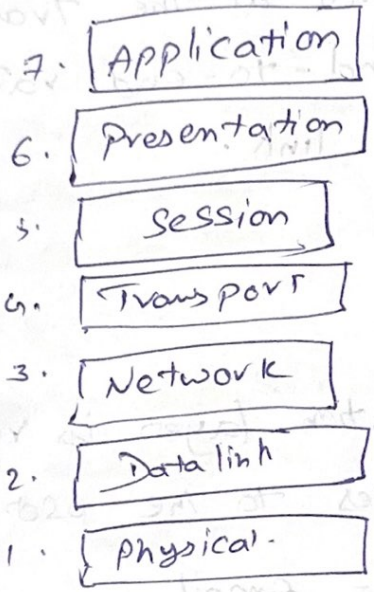
Summary :

| | |
|---|---|
| Application | — To allow access to Network resources. |
| Transport | — To provide reliable process-to-process message delivery & error recovery |
| Network | — To move packets from source to destination. To provide internetworking |
| Data Link | — To organize bits into frames To provide hop-to-hop delivery. |
| Physical | — To transfer bits over medium; to provide mechanical & electrical specifications. |

## * Open System Interconnection Model (OSI):

It was designed by the international organization for Standardization. This is a theoritical model designed to show how a protocol stack should be implemented.

OSI




→ Session Layer - Establishes sessions between communicating applications on the communicating devices.

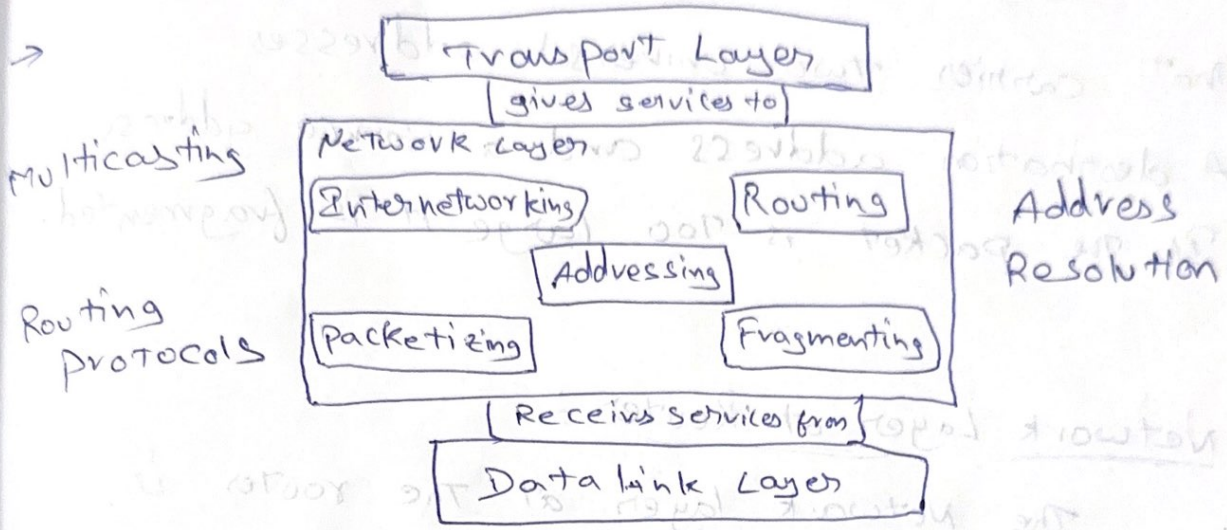
→ Presentation Layer: It Translates data to a standard format, manages encryption and data compression.

END - Chapter-1.

# CHAPTER - 2

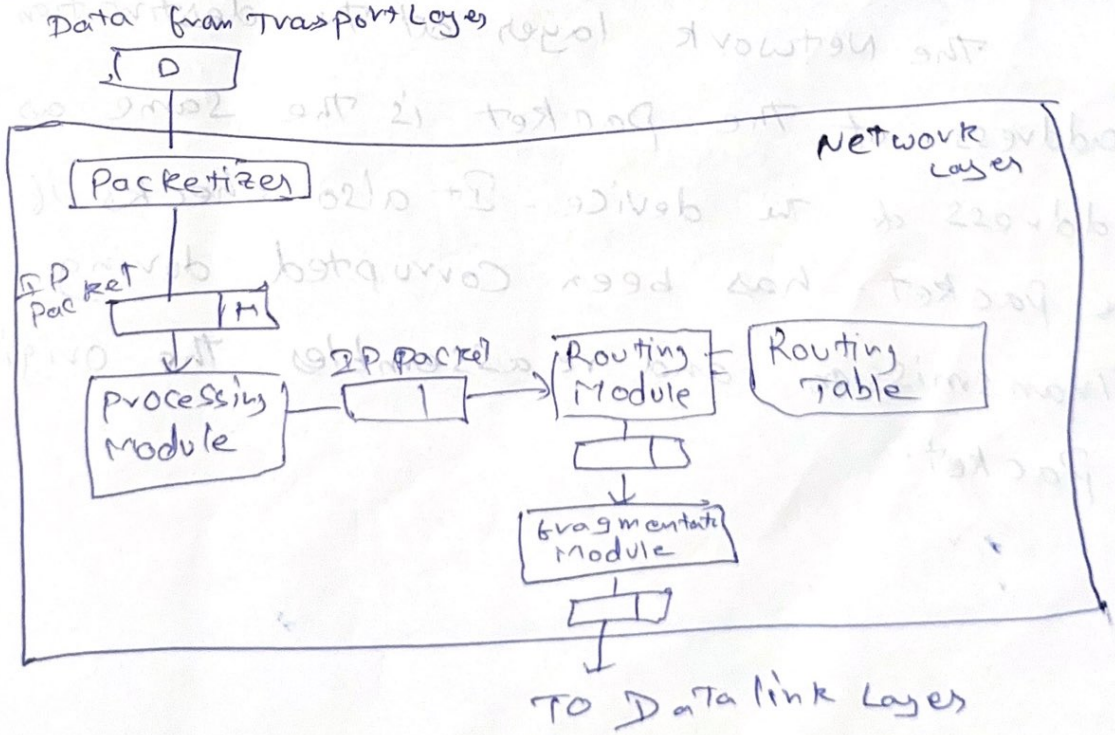
# NETWORK Layer.

→




→ Duties –
1. Internetworking
2. Addressing (IP)
3. Routing
4. Packetizing
5. Fragmenting

→ Network at Source



→ Network Layer at Source:

It is responsible for creating a Packet that carries two universal addresses. A destination address and a Source address. If the packet is too large it is fragmented

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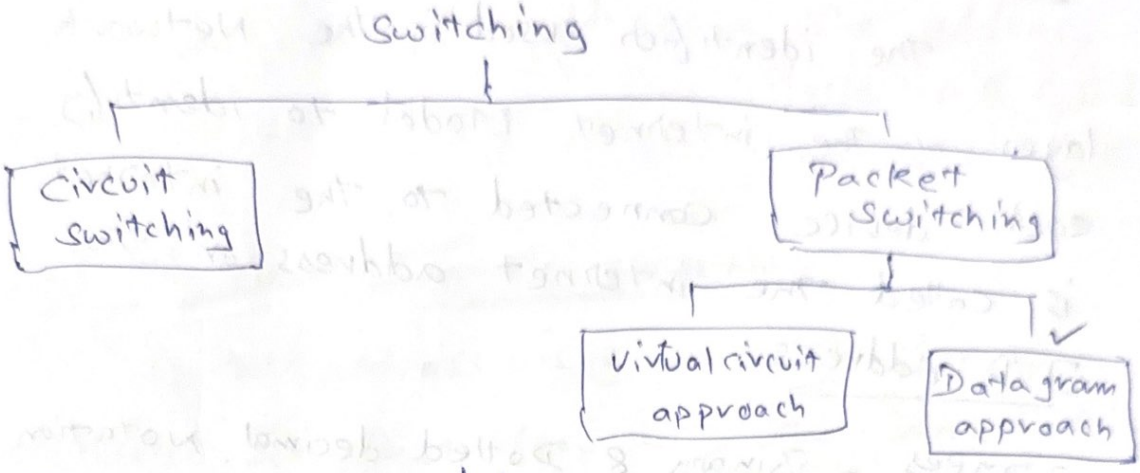
→ Network Layer at Router:

The Network layer at the routers is responsible for routing the packet. The routers finds the interface from which the packet must be sent. In addition the packet may be fragmented if necessary.

→ Network Layer at Destination:

The Network layer at the destination makes sure that address of the packet is the same as the address of the device. It also checks if the packet has been corrupted during Transmission and reassembles the original Packet.

→ Switching:




→ Datagram approach:

② In the datagram approach to Packet switching each packet is Treated independently of all others. Packets in this approach are referred to as Datagrams.

① Switching at the network layer in the Internet is done using the datagram approach to Packet switching.

③ Communication at the network layer in the internet is connectionless.

## * IP Addressing:

The identifiers used in the Network layer of the internet Model to identify each device connected to the internet is called the internet address or the IP Address.

2 Types - Binary & Dotted decimal Notation

### 1. Binary Notation:

In the Binary notation the IP address is displayed as 32-Bits.

(1-Byte-8 bits)

- Internet Addresses are usually written in the Decimal form with a DOT seperating the Bytes.

10000000 00001011 00000011 00011111

128 . 11 . 3 . 31

2) 111/55
110
1

2) 111/55
10
11
10
1

0000 0000
$2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

## * Classful Addressing:

In classful addressing, the address space is divided into five classes: A, B, C, D & E.

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→ Find the class in binary Notation:

If the address is given in the binary notation, the first few bits can immediately tell us the class of the address.

| | First Byte |
|---|---|
| class A | 0 |
| class B | 10 |
| class C | 110 |
| class D | 1110 |
| class E | 1111 |

when the address is given in dotted decimal notation then, we need to look only at the first Byte to determine the class of the address.

→ Find the class in Decimal Notation:

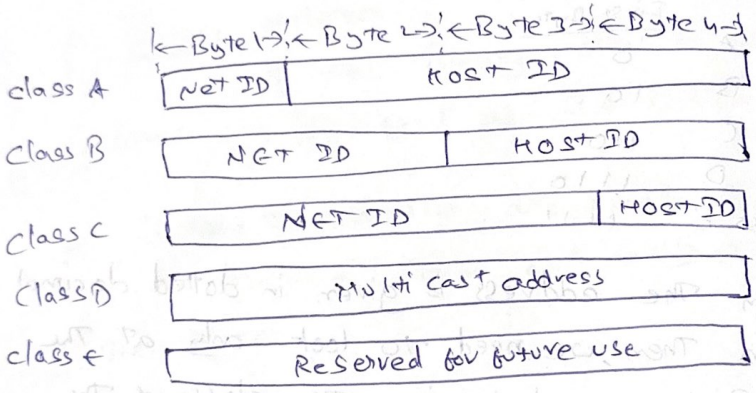
| | First Byte |
|---|---|
| Class A | 0 to 127 |
| class B | 128 to 191 |
| class C | 192 to 223 |
| class D | 224 to 239 |
| class E | 240 to 255 |

→ Why do we need these classes:

1. Addresses in classes A, B & C are for Unicast communication. from one source to one destination

2. Addresses in class D are for Multicast communication from one source to a group of destination.

3. Addresses in class E are Reserved.




→ An IP Address in classes A, B, & C is divided into NET ID & HOST ID.

Class A : 1 Byte define

Class B : 2 Bytes - NET I

Class C : 3 Bytes - NET I

→ Class A is divided each block having The first block co 0.0.0.0 to 0.2 2nd Block 1.0.0.0 to 1.2

- The number of Class A is $2^{24}$
- Millions of ad

→ Class B: It is with each block 16 blocks ea addresses lea Assignment 1st Block: 12 Last Block. 19

- The no. of class B is
- Millions o

Class A : 1 Byte defines NetID, 3 Bytes define HostID

Class B : 2 Bytes - NetID, 2 Bytes HostID

Class C : 3 Bytes - NetID, 1 Bytes HostID.

→ Class A is divided into 128 blocks with each block having a different NetID.
The first block covers addresses from
0.0.0.0 to 0.255.255.255.
2nd Block 1.0.0.0 to 1.255.255.255.

- The number of addresses in each block of Class A is $2^{24} = 256^3 = 16,777,216$.
- Millions of addresses are wasted.

→ Class B : It is divided into 16,384 blocks (191-127).256
with each block having a different NetID.
16 blocks are reserved for private addresses leaving 16,368 blocks for Assignment to organization.

1st Block: 128.~~256~~0.0.0 to 128.0.255.255
Last Block. 191.255.0.0 to 191.255.255.255

- The no. of addresses in each block of class B is $2^{16} = 2^6 \cdot 2^{10} \approx 64,000$.
- Millions of addresses are wasted.

→ Class C: It is divided into 2,097,152 Blocks with each block having different Net ID. 256 blocks are used for private address leaving 2,096,896 blocks for assignment to Organizations.

- no of h addresses - $2^8$ - 256

1st Block : 192.0.0.0 to 192.0.0.255

Last Block : 223.255.255.0 to 223.255.255.255

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* Network Address & (Net Id) & (Host ID)

The Network address is an address that defines the network itself. It can NOT assigned to a HOST.

→ Properties of the Network Address:

1. All HOST ID Bytes are 0's.
2. The Network address defines the Network to the Rest of the Internet.
3. The Network address is the first address in the Block.

- In classful addre
address is the on
the Organization.

→ A NETWORK ADDRE
net id. A network
net id & host id ,

* IP addresses are
levels of hierarc
- the first addre
The Network add
by routers outsi
route packets

* A Network wit
- often the n
into several Su
Subnetwork ha
address.

Network
↓
Subnetwork
↓

Sub ne

- In classful addressing, the Network address is the one that is assigned to the organization.

→ A NETWORK ADDRESS is different from a net id. A network address has both net id & host id, with 0s for the host id.

* IP addresses are designed with two levels of hierarchy.

- the first address in the Block defines the Network address. This address is used by routers outside the organization to route packets destined for this Network.

* A Network with 3 Levels of Hierarchy (Subnetted):

- often the network needs to be divided into several Subnetwork (Subnets) with each Subnetwork having its own Subnetwork address.

Network
↓
Subnetwork
↓
Host

Subnet: 1st 2 of Host ID

141.14.0.0

00000000 00000000
↳ Subnet

0 — 00
64 — 01
128 — 10
192 — 11

* when we divide a network into several subnets. we have 3 levels of Hierarchy.

① - Site (Network)

② - Subnetwork

③ - HOST

- The routers outside the organization route the packet based on the Network address. The router inside the organization routes the packet based on the Subnetwork address.

* Mask:

A 32-Bit number called the Mask is the routing key. The router outside the organization use a default mask, the routers inside the organizations use a subnet mask.

→ Default Mask: A Default mask is a 32-bit binary number that gives the network address when ANDed with an address in the block.

↳ logical

| x | y | x AND y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Mask Address

Defaults Masks:

| class | using slash |
|---|---|
| A | /8 |
| B | /16 |
| C | /24 |

→ The Network a
by applying the de
address in the bloc
It retains the n
sets the hostid

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→ Subnet Mask:

255.255.0

Default Mask 1111 1111

255.255.224

Subnet Mask 1111 1111 111

| x | y | x AND y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Mask Address

Defaults Masks:

| class | using Slash | Dotted |
|---|---|---|
| A | /8 | 255.0.0.0 |
| B | /16 | 255.255.0.0 |
| C | /24 | 255.255.255.0 |

→ The Network address can be found by applying the default mask to any address in the block (including itself). It retains the netid of the block & sets the hostid to 0's.

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→ Subnet Mask:

255.255.0.0

Default Mask | 1111 1111 | 1111 1111 | 0000 0000 | 0000 0000 |

255.255.224.0

Subnet Mask | 1111 1111 | 1111 1111 | 111 | 0 0000 | 0000 0000 |

↳ depends upon subnets.

like 4 SN - 2 dotted decimal
8 SN - 3

→ Subnet Mask:

The Number of 1's in a Subnet Mask is more than the number of 1's in the corresponding default mask.

If the number of subnets is N, the number of extra 1's is $\underline{Log_2 N}$.

ex: Destination Address - 190.240.33.91.
Find the Subnetwork address.

Ans: Assume Subnet Mask as — /19

class - B / 19 - 8+8+3

33 to Binary

001 0 0001

→ Dotted - 00100000 - 32

So Ans is 190.240.32.0

2) 141.14.72.24 - DA

/18 - 8+8+2

SM - 255.255.192.0

128+64 = 11 000000

72 01001000

01000000 - 64

141.14.64.0

→ The Default mask creates the network address.

→ The Subnet mask creates the Subnetwork address.

→ Given an IP address we can find the Subnet address the same way we found the network address. we apply the mask to the address.

eg: DA - 200.45.34.56, Mas 255.255.240.0.

class - BC ✗ wrong Question

Mask 255.255.240.0 → 11110000

34 - 00100010 → 20

00100000

32

→ 200.45.32.0

→ The number of subnetworks can be found by counting the extra 1's that are added to the default mask to make the Subnet mask.

For example, if the number of extra 1's is 3, Then number of Subnets is $2^3 = 8$.

→ The number of ad... can be found by counting the Number of 0's in the Subnet Mask.

For eg: if the number of 0's is 13, The number of possible addresses is $2^{13} = 8192$.

→ The first address in each Subnet (with Host ID all 0's is the Subnet address.

The last address in each subnet with host Id all 1's is reserved for broadcast inside the Subnet.

## * Super Network:

In Supernetting an organization can combine several C blocks to create a larger range of addresses. Several Networks are combined to create a Supernetwork.

when an organization is granted a block of addresses. The first addresses in the block and the mask define the block. (The Range ...

eg: 195.14.192. ... address but the ... That this addresss ... with the mask ...

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## * Multi Homed Devi...

A Device ... different networ... Device and will ...

- An Inter... of a device to ... a device from ... That its IP ad...

### Special Address:

Special address:

Network address

Direct broadcast ad...

limited broadcast ...

This host on this Net...

specific host ...

Loopback addr...

block. (The Range of Addresses).

Eg: 195.14.192.3/24 shows a class C address but the address 195.14.192.3/21 shows that this address belongs to the Supernet with the mask 255.255.248.0

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* Multi Homed Device:

A Device that is connected to different networks is called a MULTI-Homed Device and will have more than one address.

- An Internet address defines the connection of a device to a Specific Network. Moving a device from one network to another means that its IP address will change.

Special Address:

| Special address | Net id | Host id | Source/Destination |
|---|---|---|---|
| Network address | Specific | All 0's | None |
| Direct broadcast address | Specific | All 1s | Dest |
| limited broadcast | All 1's | All 1s | Dest |
| This host on this Network | All 0's | All 0s | Source |
| Specific host | All 0's | Specific | Dest |
| Loopback address | 127 | Any | Dest |

→ The first address in a block defines Network Address.

→ Direct Broad cast address:

If the HOST ID is all 1's, the address is called direct broad cast address.

It is used by router to send the Packe To all host's in a specific network. All Host will accept a packet having this type of destination address.

→ Limited Broad cast address:

An address with all 1's for Net ID & HOST ID (32 bits) defines broad cast address in the current network.

A HOST wants to send a message to every other host can use this address as a destination address in an IP packet. A router will block the packet having this type of address to confine the broad-casting to the local Network.