

## Network Routing Algorithms:

### Types

#### Routing Protocols (Routing Algorithms)

- Specify a way for the router to identify other routers on the network and make dynamic decisions.
- There are several protocols:

##### (\*) OSPF : (Open Shortest Path First):

→ Used to calculate best routes for the packets to reach destination.

##### (\*\*) BGP : (Border Gateway Protocol):

→ It helps to manage how packets are routed on the internet via exchange of information b/w edge routers.

→ Provides N/w stability. If one connection goes down while forwarding, then it can adapt another network quickly.

##### (\*\*\*) IGRP (Interior Gateway Routing Protocol):

→ Specifies how routing information will be exchanged b/w gateways.

##### (\*\*\*\*) EIGRP : (Enhanced Interior Gateway Routing Protocol):

→ If the router is unable to find a path through tables, then it asks its neighbours and further the neighbours ask their neighbours until a path is found.

##### (\*) EGP (Exterior Gateway protocol):

→ Decides how info. can be exchanged b/w two neighbour gateway hosts.

→ Commonly used to exchange routing tables b/w hosts on internet.

##### (\*\*) RIP (Routing Information Protocol):

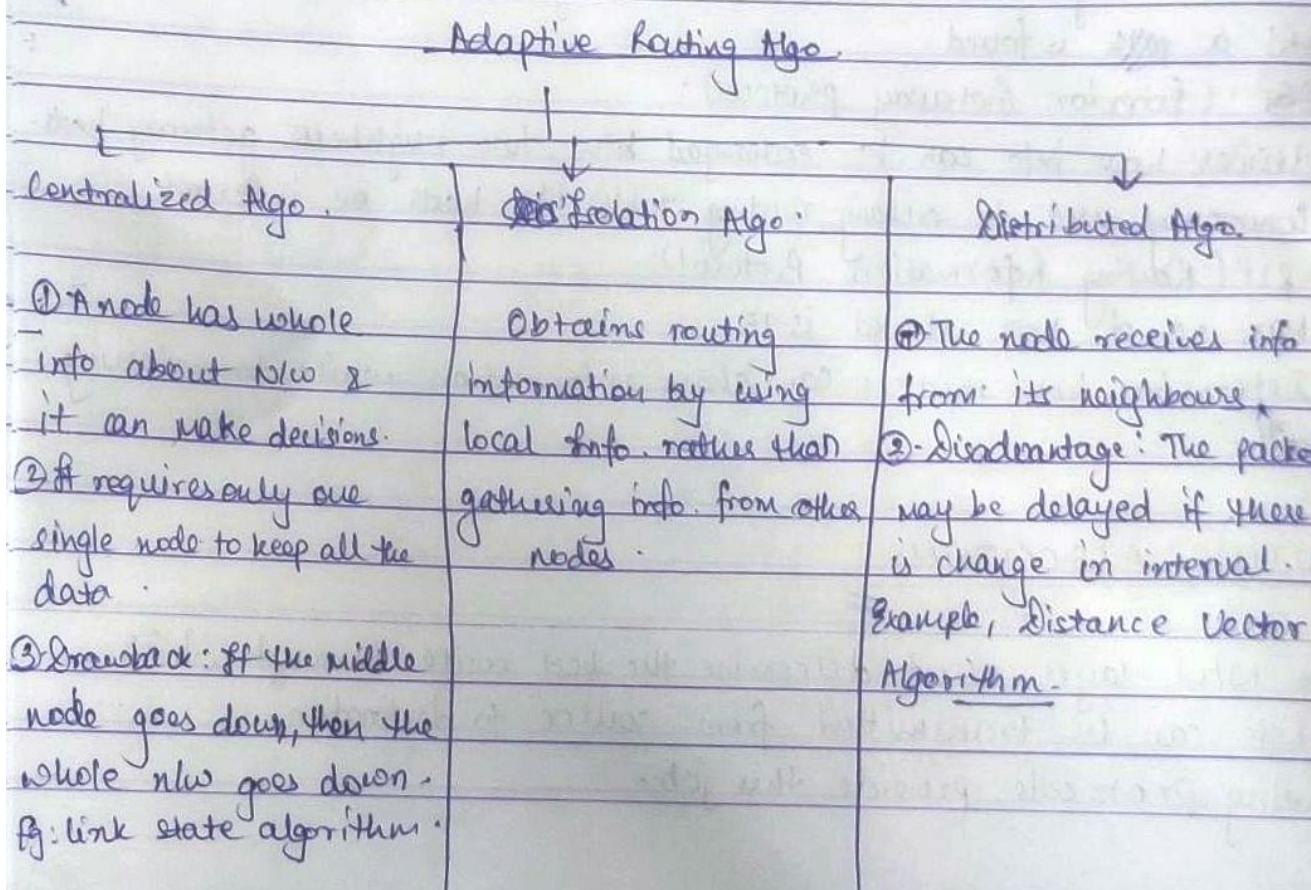
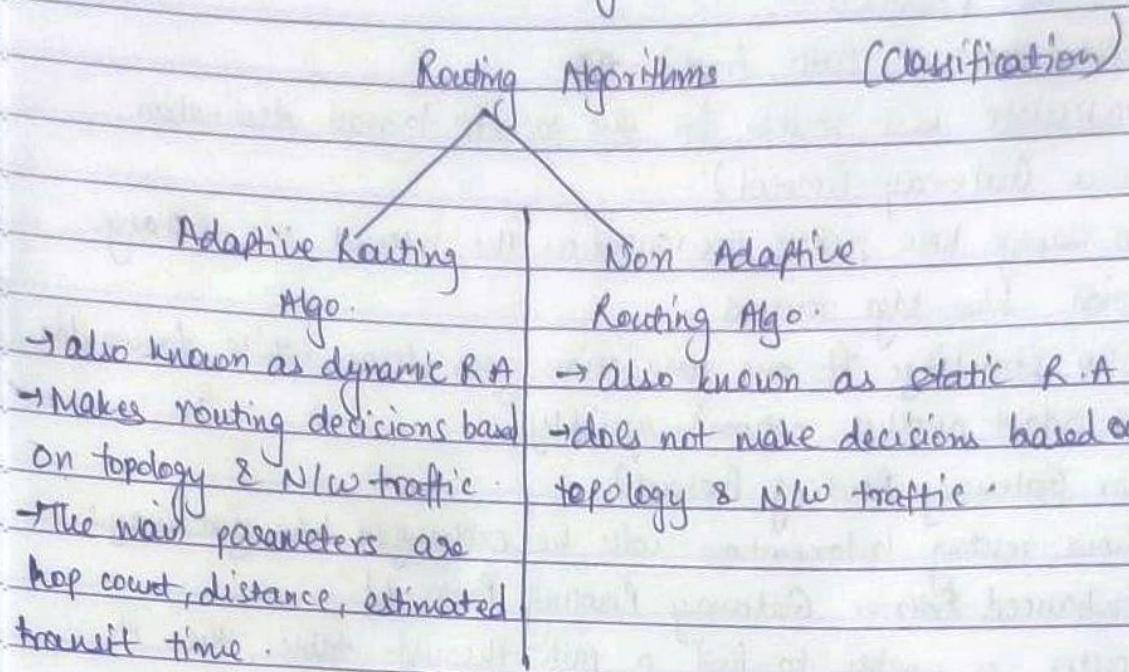
→ Max. no. of hops allowed is 15.

→ Determines how routers can share information while transferring traffic.

## ROUTING ALGORITHMS:

- The N/w layer must determine the best route through which packets can be transmitted from source to destination.
- Routing protocols provide this job.

- Routing protocols are Routing Algorithms that provide best path (or the path with least cost) from source to destination.
- Routing → Process of forwarding packets from source to destination.



## Non Adaptive Routing Algo.

flooding	Random walks
→ Every incoming packet is sent to all the nodes except the one from which it has come.	→ A packet is sent by the node to one of its neighbours randomly.
→ Disadvantage is that node may contain several copies of a particular packet.	→ Advantage is that it uses alternative routes very efficiently.

## Difference b/w Adaptive & Non Adaptive

Adaptive	Non-Adaptive
① Used by dynamic routing	① Used by static routing.
② Routing table is constructed on the basis of n/w condition.	② Constructs a static table.
③ Routing decisions are made based on topology & n/w traffic	③ Not.
④ Complex	④ Simple.

## ROUTER:

- A device used to receive, analyze & forward data packets b/w N/w
- Examines the destination IP address and uses headers of packet and routing table to select the best path.
- It is used in LAN and WAN environments.
- It shares info. with other routers.
- It is more expensive than other N/w devices such as hubs & switches.
- Works on third layer (N/w layer) of OSI model.
- An intelligent device.
- More capable than other devices.

→ It uses modem to allow communication b/w other devices on internet.

functions of Router: 2 functions: forwarding & routing.

forwarding: Router receives packets, checks its header, performs basic functions like checking checksum, looks into routing table, finds appropriate path and then forwards the packet.

Routing: Process by which router decides which path is best. It maintains a routing table.

Features of Router:

- Works on 3rd layer (N/W layer) of OSI model.
- Provides high speed internet connectivity.
- Allows user to configure the port as per requirements.
- Capable of Routing traffic.
- filter out unwanted interference. carries out encapsulation & de-encapsulation.
- Provide Redundancy.

Applications of Router:

- Used to connect h/w equipments with remote location n/w.
  - Used for fast data transmission.
  - Used by various Internet service providers.
  - Also used by software testers.
- They provide Internal Storage Capacity. (Modern Routers).

## Types of Routers:

- ①. **Wireless:**
  - used to offer wifi connectivity.
  - capable of generating wireless signal.
  - offers security by putting password and login id.
- ②. **brouter:** → combination of bridge and router.
  - Transfers data b/w n/w like a bridge.
- ③. **Core router:** → Routes data within a n/w.
  - helps to link all n/w devices.
  - provides fast and powerful data communication.
- ④. **Edge Router:** → lower capacity device.
  - placed at the boundary of a n/w.
  - Allows internal n/w to connect with external n/w.
  - uses BGP (Border Gateway Protocol) to provide connectivity.
  - 2 types: ①. Subscriber edge Router, ②. Label Edge Router
- ⑤. **Broadband Routers:** → Mainly used to provide high speed internet access.
  - Have the option of 3/4 ethernet ports for connecting laptops and desktop systems.

## Benefits of Router:

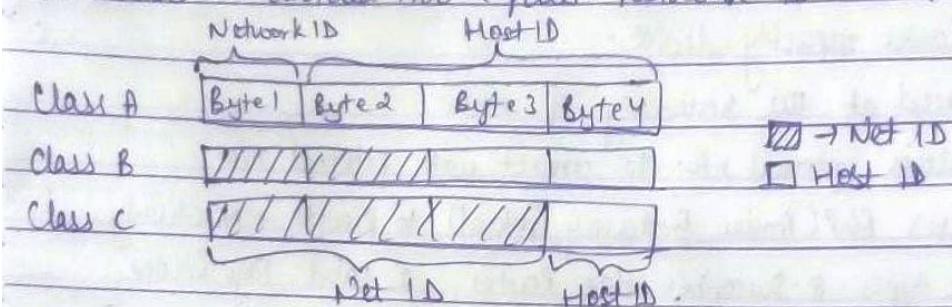
- ①. Provides security.
- ②. Enhances performance within internal n/w.
- ③. Provides reliability.
- ④. Performs functions of Repeater (regenerates the signals).

## Classful IP addressing

- IP address is 32 bit unique address having address space of  $2^{32}$ .
- 2 notations: Dotted Decimal and Hexadecimal notation.

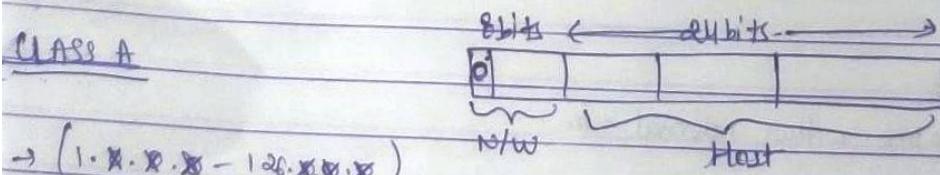
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0 to 255 bytes.

- 5 sub-classes: Class A, Class B, Class C, Class D, Class E.
- Classes D and E are reserved for multicasting & experimental purposes respectively.
- IP address is divided into 2 parts: Network ID and Host ID.



- IP addresses are globally managed by IANA (Internet Assigned Numbers Authority).

- While finding total no. of host IP addresses, & IP addresses are not counted b/c first IP address is reserved number and last is reserved for broadcast IP.

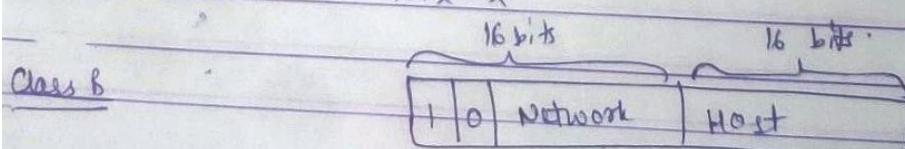


$$\rightarrow (1.0.0.0 - 126.255.255)$$

- Higher order bit is always set to 0. Remaining 7 bits are used to determine N/W id.

$$\rightarrow 2^7 - 2 \rightarrow \text{N/W id} \quad 2^{24} - 2 \rightarrow \text{Host ID.}$$

$$\rightarrow \text{Subnet mask} \rightarrow 255.x.x.x$$



→ (128.0.X.X - 191.255.X.X)

→ Higher order bits are always set to 10.

→  $2^{14} - 2 \rightarrow$  N/w Id &  $2^{16} - 2 \rightarrow$  Host address.

→ Subnet mask: 255.255.X.X.

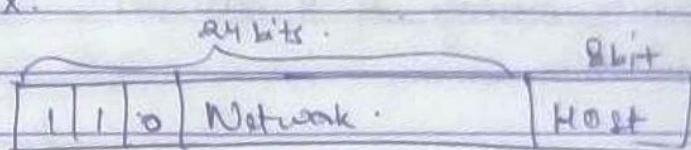
### Class C

→ (192.0.0.X - 223.255.255.X)

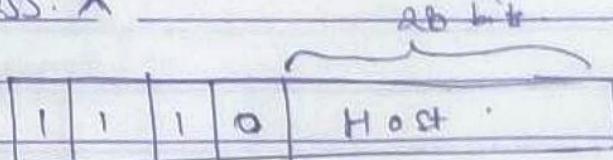
→ Higher order bits → 110

→  $2^{21} - 2 \rightarrow$  N/w id &  $2^8 \rightarrow$  Host

→ Subnet mask: 255.255.255.X



### Class D



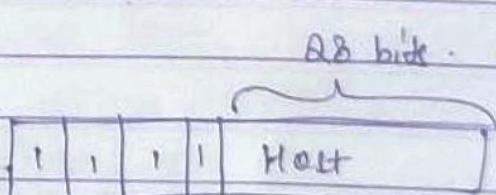
→ 224.0.0.0 - 239.255.255.255

→ Higher order bits → 1110

### Class E:

→ 240.0.0.0 - 255.255.255.254

→ Higher order bits → 1111



Special Addresses: → 169.254.0.0 - 169.254.0.16 : Link local Address.

→ 127.0.0.0 - 127.0.0.8 → Loop back Address.

→ 0.0.0.0 - 0.0.0.8 → Used to communicate within current n/w.

→ Note: N/w id cannot start with 127 b/c. it is reserved for loop back function.

Problems in classfull Addressing: Millions of IP addresses are wasted.

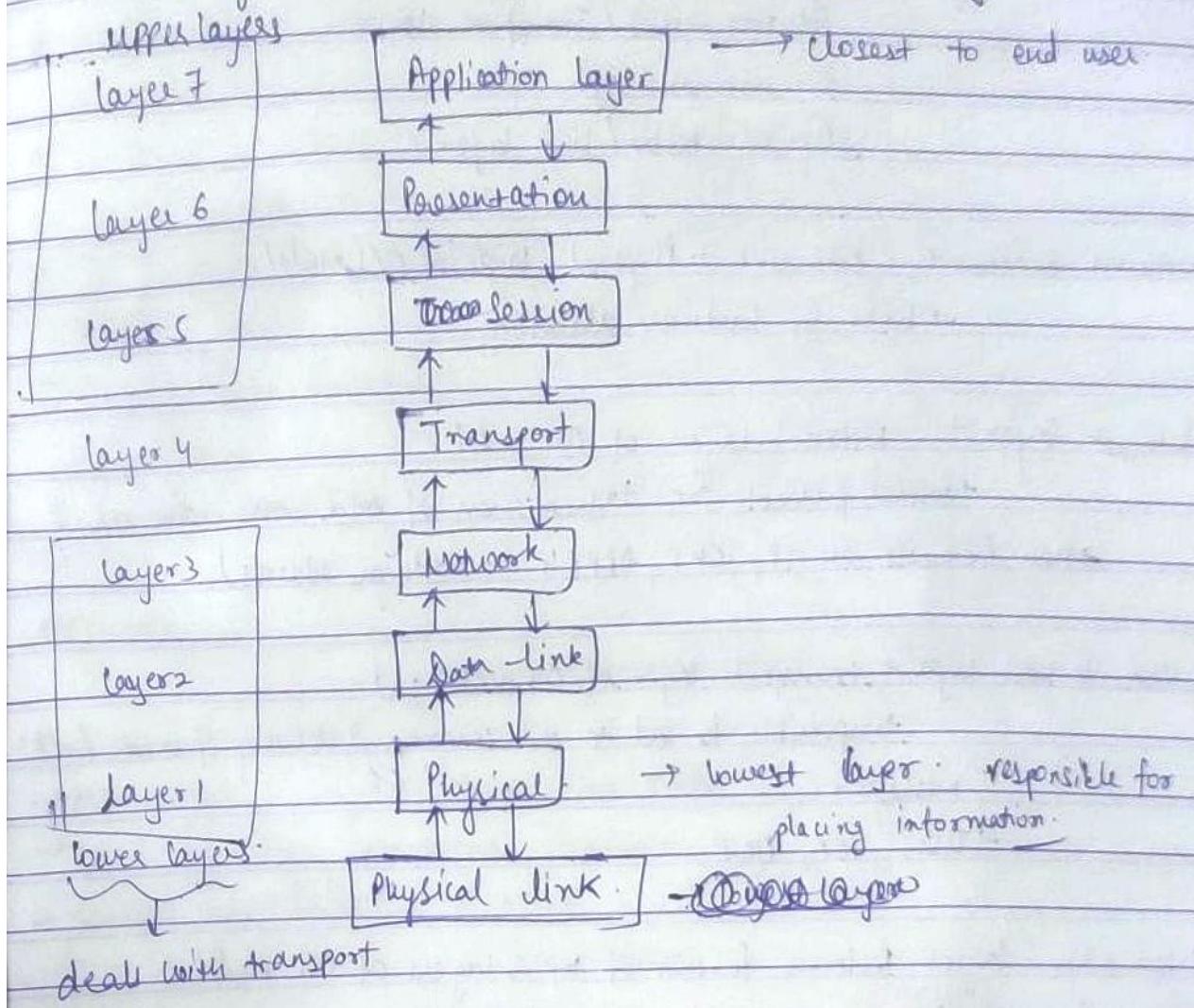
### Classless Addressing:

- To reduce wastage of IP addresses.
- Uses subnetting.

### SUBNETTING

## OSI Reference Model (Open System Interconnection)

- consists of seven layers. Each layer performs a particular function.
- task assigned to each layer is performed independently.



## functions:

- Physical layer → provides physical medium through which bits are transferred.
- Data link → used for error-free transfer of data frames/framing/flow control.
- Network: Responsible for moving packets from source to destination.
- Transport: Provides reliable message delivery. Protocols used → TCP & UDP.
- Session: Used to establish, manage and terminate sessions. synchronization.
- Presentation → responsible for translation, encryption.
- Application: Provides services to user.

## → IP Protocol Stack Architecture: TCP/IP

→ Contains 4 layers: ①. Process/Application layer

②. Host to Host / Transport layer

③. Internet layer

④. N/w Access / Link layer.

① Network Access → Data link + Physical layer of OSI model.

→ looks for hardware addressing.

②. Internet layer → Network layer of OSI model.

→ defines protocols for transmission of data over entire Netw.

→ Main protocols are IP, ICMP, ARP (IP → hardware address).

③. Host-to-host layer: → transport layer of OSI model.

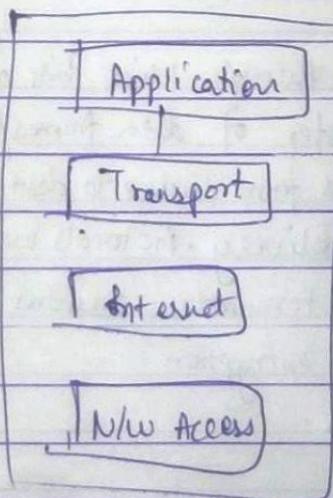
→ responsible for end-to-end connection & delivery of error-free messages.

→ Uses TCP, UDP.

④. Application layer: performs function of top 3 layers of OSI model.

→ responsible for node-to-node communication.

→ Protocols used: HTTP, SSH, NTP.



## TCP / IP

- ① Implementation of OSI model.
- ② Model around which Internet is developed.
- ③ 4 layers
- ④ More reliable
- ⑤ 16 protocols were developed than model.
- ⑥ Supports only connectionless communication.
- ⑦ Protocol dependent

## OSI

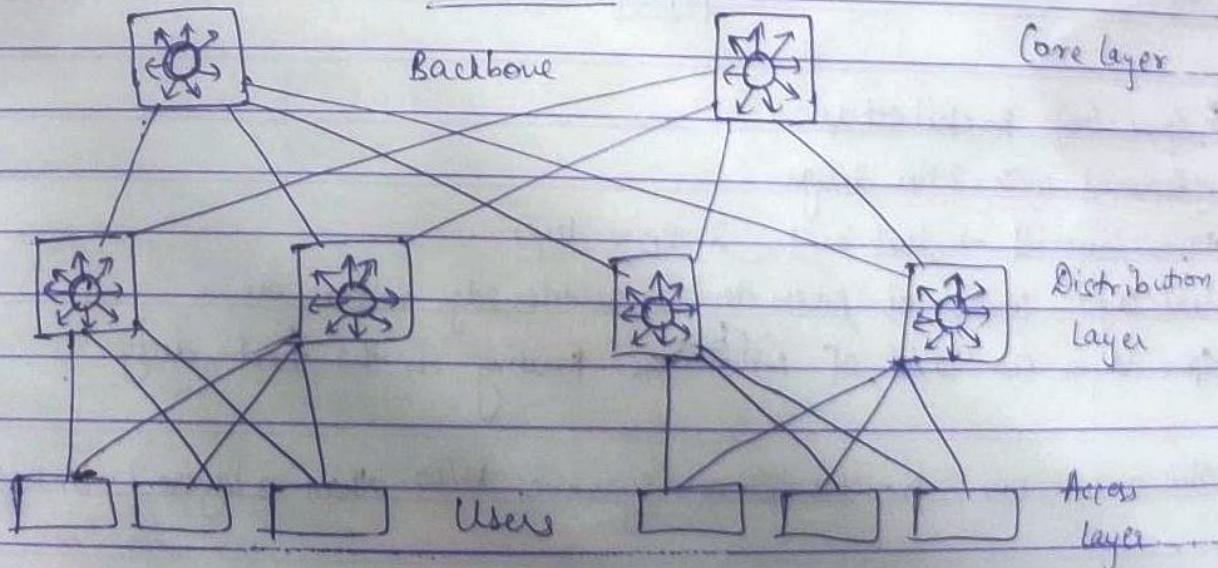
- ① Reference Model
- ② Theoretical.
- ③ 7 layers.
- ④ ↓
- ⑤ Model was developed before.
- ⑥ Connectionless & connection-oriented both.
- ⑦ Protocol independent.

## NETWORK TOPOLOGY ARCHITECTURE

### 3 tier architecture

- Also called 3 layered Hierarchical Model.
- Used by large enterprises. Expensive.
- Consists of 3 layers : (a) Access  
(b) Distribution  
(c) Core

### 3 tier Architecture

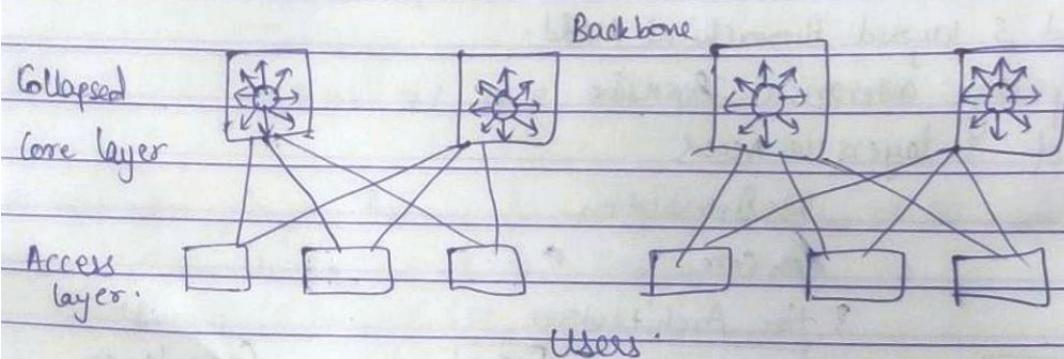


(a) Access layer → lowest layer  
→ closest to end users.

(b) Distribution layer → Middle layer  
→ Works as bridge of Access layer and Core layer.  
→ Redundancy is used to overcome single point of failure.

(c) Core layer: → known as backbone network.  
→ connects distribution layer devices.  
→ Routing Protocols are used in this layer.

② 2 Tier Architecture: → Also called 2 layered Hierarchical Model.  
→ Used by small enterprises.  
→ Combining core & distribution layer into one layer.  
→ Two layers: (a) Collapsed core layer  
(b) Access layer.



③ Spine Leaf Architecture:

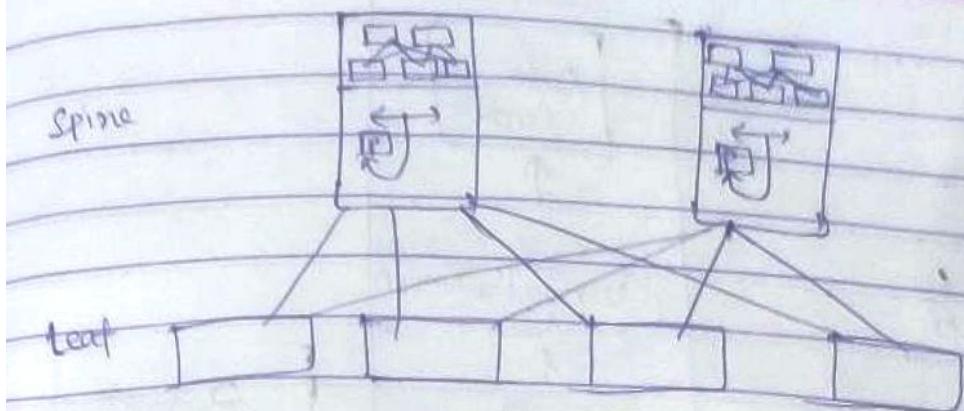
→ Replaced with 3 tier design.

→ Two layered → leaf layer & spine layer.

leaf layer consists of Access devices, switches, edge routers, etc.

spine layer: core layer of Architecture. Routing is the first duty.

→ This architecture provides more dynamic N/W. than 3 layered Architecture.

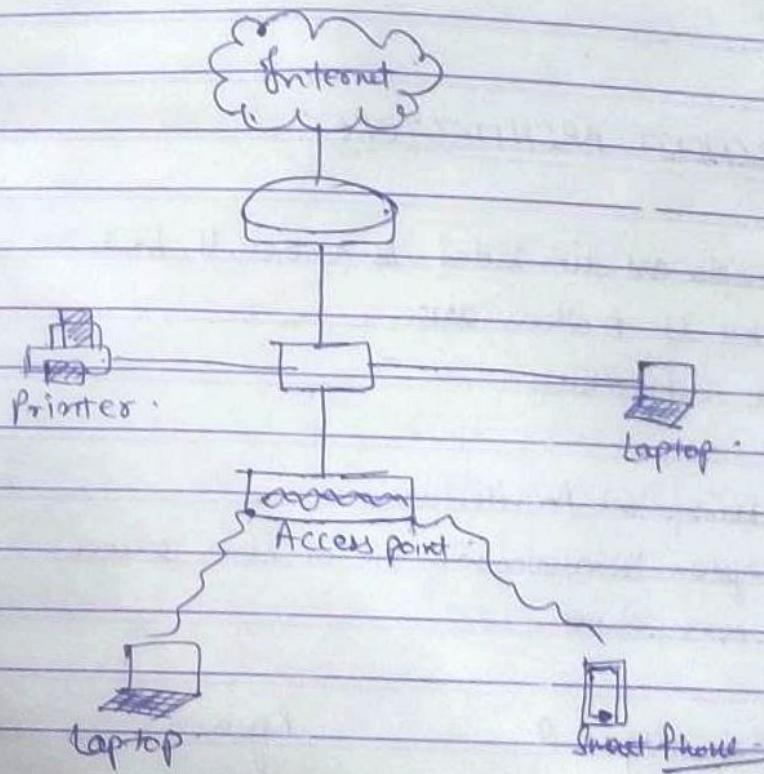


#### ④ Small Office / Home Office (SOHO) Architecture.

→ Simplest N/w architecture.

→ There is a small switch, router & connected devices like PC, printer, etc.

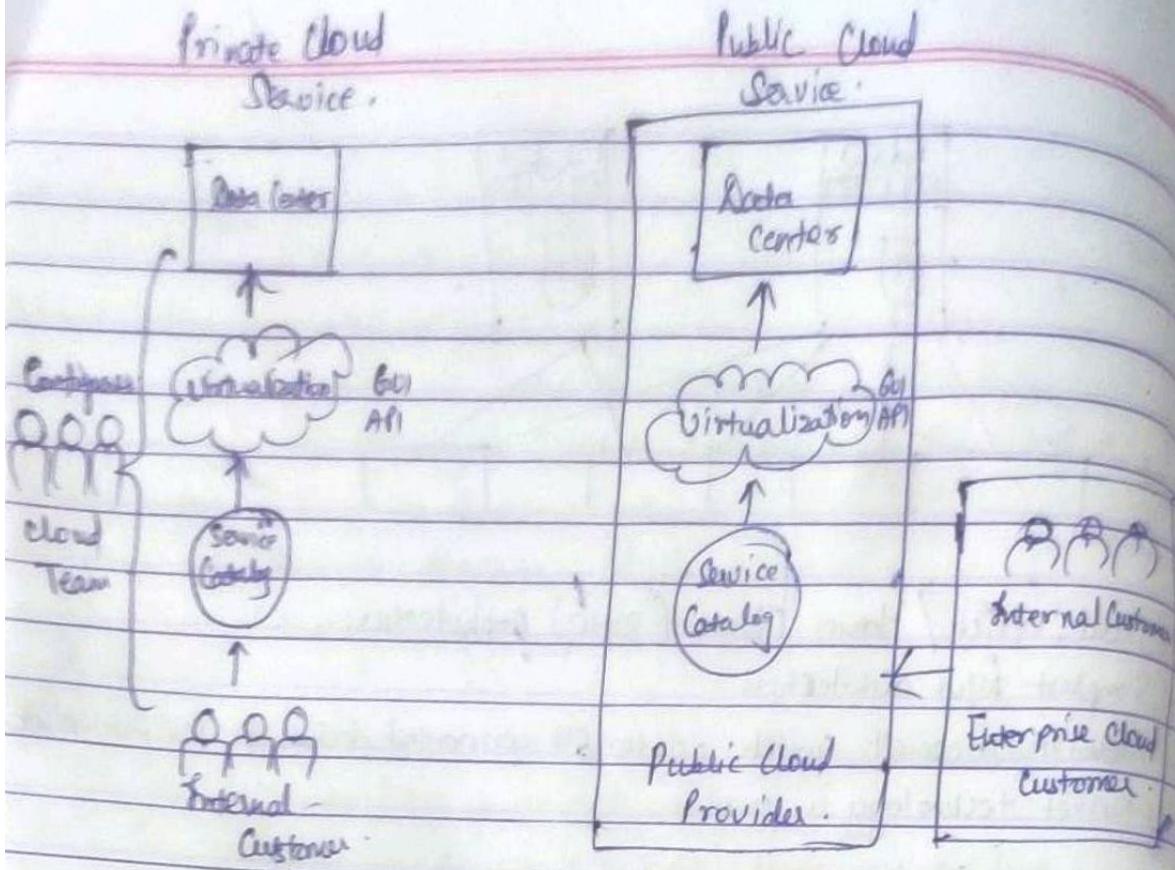
→ Ethernet technology is used.



#### ⑤ On-Premises and Cloud Architecture.

→ Public cloud : Provides cloud services to other companies.

Private cloud : Provides cloud services to local users in the same company.

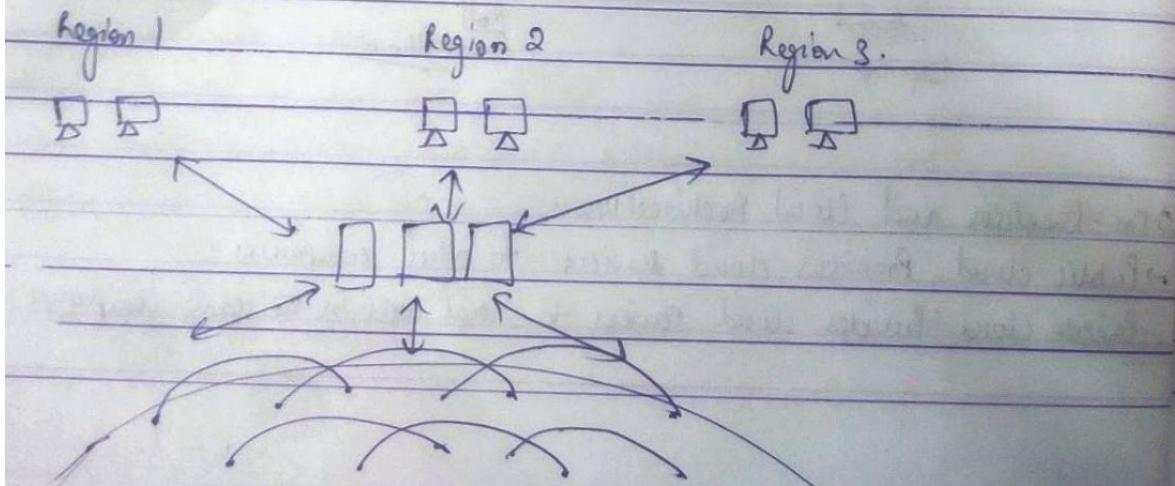


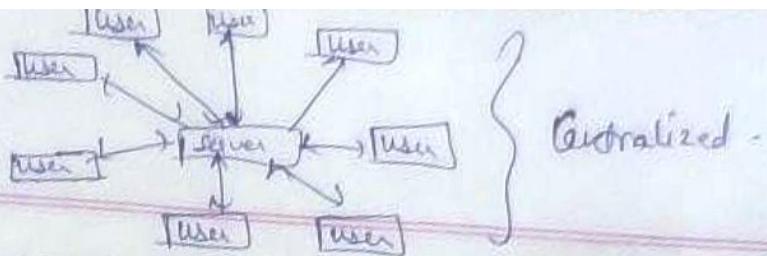
### NETWORK MANAGEMENT ARCHITECTURE:

- Networks becoming complex and distributed. As a result, hardware failures, & performance, etc. problems arise.
- 3 N/w management architectures.

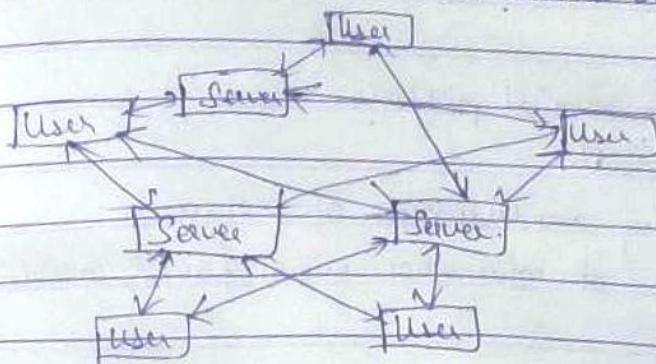
#### ① Centralized N/w Management Architecture.

- Single management system installation with one or more servers.
- Consists of one or more clients.

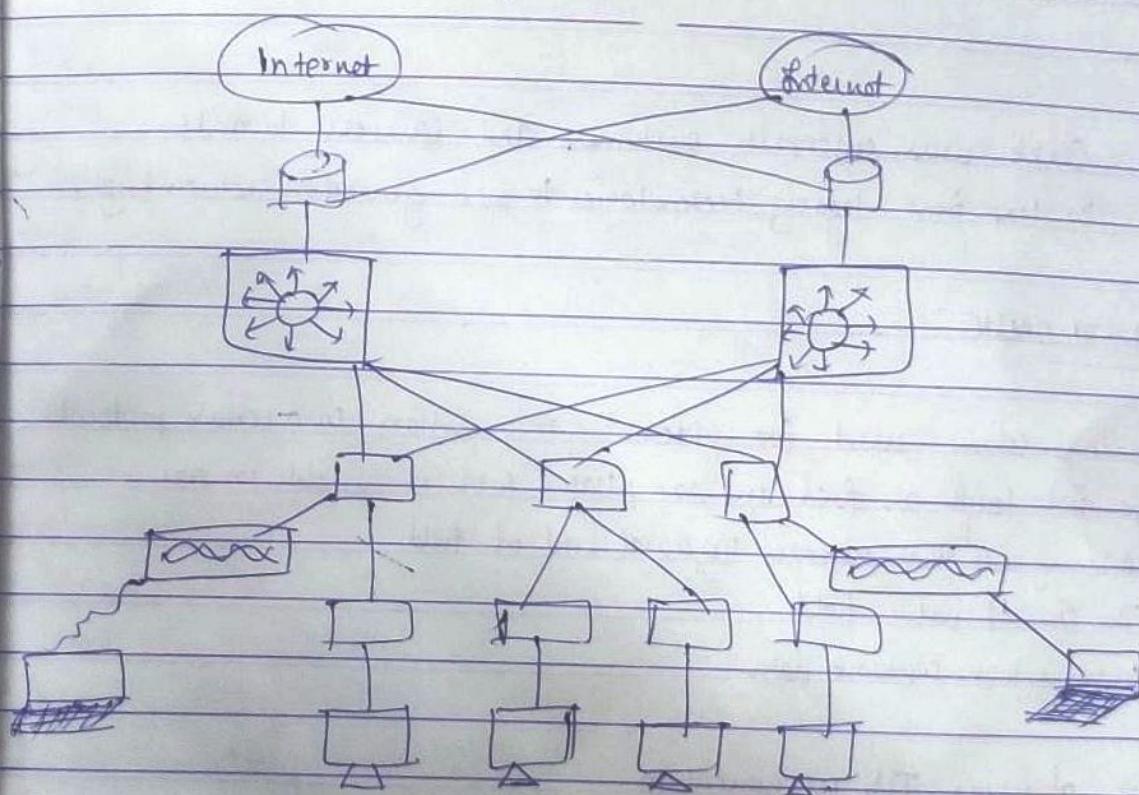




- ② Distributed N/W Management Architecture:
- Multiple installation of Management Systems.
  - Contains 3 servers. Clients located at all regions.



- ③ Hierarchical N/W management Architecture
- Multiple installations of Management Systems.
  - Same as distributed Architecture except that it adds additional layer, Manager of Managers (MoM).



→ is a combination of telephone networks, including worldwide, including telephone lines, satellites, fibre optic cables etc.

### \* Public-Switched Telephone Network :-

- It is used for providing public telecomm.
- The PSTN ~~networks~~ are called POTS (Plain old Telephone System).
- These networks are operated regionally, locally, nationally and internationally using telephone lines, fibre optic cables etc.

### \* Properties of PSTN :-

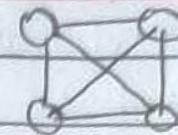
- (i) The individual network can be owned by national government, regional government or private telephone operators.
- (ii) Its main objective is to transmit human voice in recognizable form.
- (iii) Aggregation of circuit switched networks of the world.
- (iv) The interconnection bet<sup>n</sup> the different parts of telephone system is done by switching centers. This allows multiple telephone & cellular networks to communicate with each other.
- (v) The operation of PSTN follows ITU-T standards.

### \* Switching Hierarchy and Routing :-

- The interconnectivity of calls bet<sup>n</sup> different areas having different exchanges is done with the help of trunk lines bet<sup>n</sup> exchanges.
- The group of trunk lines that are used to interconnect different exchanges are called Trunk groups.
- In the process of interconnecting exchanges, there are 3 basic topologies such as :-
  - Mesh topology
  - Star topology
  - Hierarchical topology.

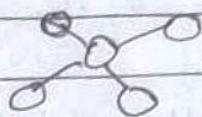
(i) Mesh Topology :-

- Fully connected n/w.
- The no. of trunk groups in a mesh topology is  $\propto$  to square of exchanges being connected.
- Used in metropolitan areas where there is heavy traffic.



(ii) Star Topology :-

- Star Topology utilizes an intermediate exchange called tandem exchange through which all other exchanges communicate.
- Used when traffic levels are low.



(iii) Hierarchical :-

- The hierarchical topology is used to handle heavy traffic with minimal no. of trunk groups.
- The traffic flows through the final route which highest level of hierarchy.
- If traffic intensity bet<sup>n</sup> any pair of exchanges is high direct trunk routes may be established bet<sup>n</sup> them called high usage network.

\* How do PSTN phone lines work?

- When you dial a phone no.

Step 1 :- Your telephone set converts sound waves into electrical signals. These signals are then transmitted to a terminal via a cable.

Step 2 :- The terminal transmits it to central office.

Step 3 :- The CO then encodes the call in form of electrical signals through fibre optic cable. The fibre optic then carries these signals in form of light pulses to ~~for~~ their final destination.

Step 4 :- Your call is routed to tandem office (responsible for transmitting calls to distant central offices) or a central office (for local calls).

Step 5 :- When your call reaches the origin office, the signal is converted back to electrical signal and then routed to a terminal.

Step 6 :- The terminal routes the call to appropriate no. Upon receiving the call, the telephone set ~~wires~~ converts the electrical signals back to sound waves.

#### \* PSTN - Understanding The Art of Switching :-

- PSTNs are all about switching, which forms the backbone of traditional phone m/w.
- 4 types of switching which takes place at different levels :-

##### 1. The Local Exchange :-

- A local exchange may consist of one or more exchanges which link subscriber to PSTN like.
- All telephones are connected to the local exchange in specific areas.
- If you dial the no. of a person located in building next to yours, your call won't leave your local exchange and will be routed to the person as soon as it reaches the local exchange.

## 2. The Tandem office :-

- also called junction n/w.
- A Tandem office ~~serves~~ serves a large geographic area comprising several local exchanges while managing switches between local exchanges.
- e.g., let's say you dial a no. of a client who lives in same city but in another suburb. In this case your ~~call~~ call will be routed to a tandem office from your local exchange and the tandem office will route the signal on its local exchange near your client's location.

## 3. The Toll office :-

- This is where any national long-distance switching takes place.

## 4. The International gateway :-

- They manage international call switching, routing domestic calls to the appropriate companies.

## \* Communication And Technology :-

- Communication technology is the transfer of messages (info.) among people or machines through the use of technology.
- This processing of information can help people make decisions, solve problems, and control machines.

## \* The System Model :-

How does communication fit the system model?

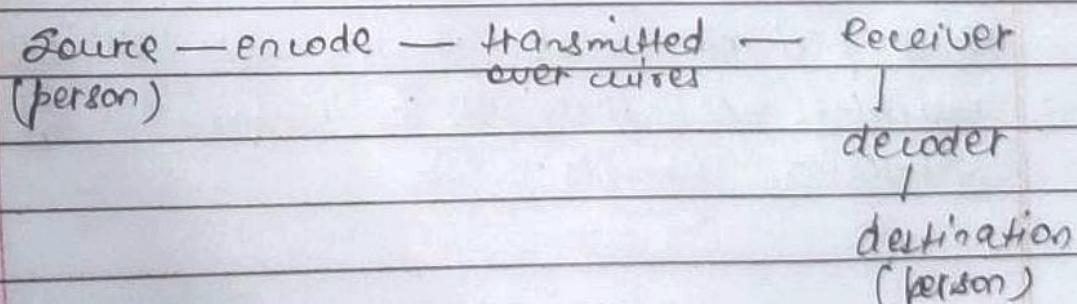
- A system can be broken down into input, process, output and feedback. This is the system model.
- Communication system includes all the inputs, processes, outputs and feedback associated with sending and receiving messages.
- The message is the input, how the message is moved is the process, the reception of message on another end is output, feedback may relate to static or clarity.
- e.g, when you write an article for school newspaper about computer lab.

Your words, pictures, the time you spend, and the computer you use are inputs.

Putting the newspaper together and printing it are parts of the process. The final output is the newspaper.

## \* Communication Subsystems :-

- Communication systems usually include several subsystems that help transmit information.
- The subsystems are made up of a source, an encoder, a transmitter, a receiver, a decoder and a destination.



### \* Forms of communication :-

- communication systems can be grouped by the way they carry messages.
  - Biological communication
  - Graphic "
  - wave "

### \* Telecommunication :-

- communication over a distance is ~~called~~ telecommunication.
- Most telecommunication systems use electronic or optoelectronic devices.

### \* Satellites and Telecomm :-

- Satellites are also telecommunication devices.
- Satellites can help produce maps, provide climate info., track weather patterns and observe what people are building in other parts of the world.

### \* Modes of communication :-

- Technology has given us new modes of communication.
- • people to people :- most basic mode "
- people-to-machine :- Over time people gained knowledge and skills needed to build complex communication devices and used this mode.
- Machine to people :- People also created graphic communication system to transmit their message using pointed word which uses this mode.
- machines-to-machines & transmission of electrical signals.

- \* Impact of comm. Technology :-
  - when people say world is getting smaller, they mean technology allows us to communicate instantly with anyone anywhere.
  - political, social, economic and environmental issues are influenced by comm. technology.

- \* Standard committees - ITU - International Telecomm. Union :-

- The ITU is a specialized agency of the United Nations that is responsible for issues that concern information and communication technologies (ICT)
- The ITU is the body through which government and the private sectors coordinate global telecommunication networks and services.
- ITU is active in areas including ~~broadband~~ broadband internet, latest-generation wireless technologies, aeronautical and maritime navigation, TV broadcasting and next-generation networks.
- ITU also organizes worldwide ~~and~~ and regional exhibitions and forums.
- ITU is committed to connecting all the world's people - wherever they live whatever their means.

- \* The IETF mission includes :-

- (i) Identifying and preparing solutions to operational and technical problems in the internet
- (ii) specifying the development of features to these technical problems over the internet.

(ii) Providing a forum for the exchange of info. within the internet community b/w users, researchers, agency and new managers.

\* Steering group :-

- The Internet Engineering Group (IENG) is a body composed of the IETF chair and area directors.
- It provides final technical review of Internet standards and is responsible for management of day-to-day management of IETF.

Task Force

→ The chair of IENG is the director of the general Area, who also serves as the overall IETF chair.

→ Members of IENG include two directors of each of following areas :-

- Applicability area
- Internet area
- Routing area
- Security area
- Transport and services area.

\* International Standards Organization (ISO) :-

→ It is an independent, non-government, voluntary standards organization.

→ It issues standards for a vast no. of subjects that may be industrial or commercial in nature.

→ Its members are national standard organizations of member countries.

- ISO has over 2000 technical committees (TC), each of which defines the standards for a particular subject.
- Each TC has sub-committees which in turn has working groups (WG).

(NIST)

- \* National Institute of Standards and Technology
- NIST is a metrology laboratory of US Department of commerce.
- It issues standards and organizes laboratory programs in fields of nanoscience and technology, engineering, IT etc.

(IEEE)

- \* Institute of Electrical and Electronic Engineers :-
- It aims for educational and technical advancements in the fields of electrical engineering, electronics engineering, computer engineering, telecommunications and other related fields.

\* Network Standards :-

- N/W standards defines rule for data communication
- During data communication, a no. of standards may be used simultaneously at different layers
  - Application layer - HTTP, HTML, POP, IMAP
  - Transport " - TCP, SPX
  - N/W " - IP, IPX
  - Data-link " - Ethernet IEEE, Frame Relay
  - Physical " - RS-232 C (cable).



### \* Types of standards :-

#### (i) de facto :-

- Followed without any formal plan or approval by any organization.
- They came into existence due to traditions or goals.  
e.g., HTTP.

#### (ii) de jure :-

- Adopted through legislation by any officially recognized standards organization.
- Most of the communication standards that are used today are de jure.

### \* ITU has 3-main sectors :-

#### (i) ITU-T :-

- It is the Telecommunication standardization sector.
- Defines global as well as local standards for Internet access, communication protocols and many other communications.

#### (ii) ITU-R :-

- It is the Radio-communication sector.
- It co-ordinates the allocation and management of radio-frequency spectrum that aid in satellite enabled devices such as phone calls, online maps and navigation.

(PPP) ITU- $\circ$  :-

- It is the telecommunication development sector.
- It strives to bridge the "digital divide" between countries.

\* Membership of ITU is of 2-types :-

1. UN members
2. Private organizations.

## Internet Engineering Task force

Missions:

- Identify and Propose solutions for technical problems.
- Specify the development of protocols
- Making recommendations regarding standardization of protocols.
- Providing a forum for exchange of information within Internet community.

MFA forums Introduction:

- Originally three forums: 9 frame Relay forum
- 9 ATM forum
- 9 MPLS forum.

The MFA → Consolidates the 3 forums in order to optimize strengths of each.

Mission → enable users, enterprise customers and carriers to make the leap from legacy technologies to next generation networking.

TYPE LENGTH VALUE :

- An encoding scheme used for optional information in a certain protocol.
- The type and length are fixed in size; value field is variable in size.

Type - A binary code that indicates ~~the~~ kind of field.

Length - The size of value field.

Value - bytes which contains data.

Advantages of using TLV representation

- TLV sequences are easily searched.
- TLV elements can be placed in any order inside message body.

→ TLV elements are typically used in binary format which makes parsing faster.

### Format

Byte	Description
1	Tag (MSB)
2	Tag (LSB)
3	Length (MSB)
4	Length (LSB)
5	Value [0] (Data)
:	:
	value [n]

## NETWORK PROTOCOL ANALYZER

- Software tool used to capture and analyze the data traffic in NIO.
- They can build graphic map, generate alarms when the no. of packets increase above a certain level.

### Functions :

- Capture packets from LAN & with Adapters.
- Advanced filtering.
- Save data to disk.
- Create network maps.
- Display error rates.
- Display statistics.
- Programmable alerts, unusual action alerts.

## Network Monitoring

(iii)

- NPA, often used to monitor the performance of n/w.
- The advantages it can display network utilization, no. of collisions, No. of defective frames, etc.
- To display alarms, errors, etc.

NPA are usually used for collecting & analyzing captured data.

NPA can detect and notify about defective frames and warn about expired frames.

- Also called packet Analyzers, protocol analyzer, packet sniffers.
- N/W analyzers convert the raw binary data into human readable format.
- legal use is to maintain n/w security.
- Illegal use is by hackers for unauthorized access.

Process is also known as sniffing.