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MOD 1

1.1 Data communication
Networks
Internet
Protocols & standards
Uses of computer networks

1.2 Network Models: ~~layred tasks~~,
OSI Models,
~~layers~~ layers in OSI Models
TCP/IP protocol suite.

# Network:

- Network is interconnection of set of devices capable of communication.
- A device can be a computer or a router, switch, modem. Devices are connected using wire or wirlessly.

* Local Area Network (LAN):

- Usually privately owned & connects some hosts in single office, building, etc.
- LAN can be as 2 PC's or a connection of some audio-video devices.
- Each host in a LAN has a identifier, an address, that uniquely identifies the host in LAN.
- A packet sent by host to another host carries both addresses of source host & destination host address.

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- When all hosts are connected using a cable, packet sent by one host is delivered to all other hosts.

- But now, most LAN's use a smart connecting switch which is able to recognize destination address.

- Switch reduces the traffic & allows more than one pair to communicate with each other at same time.

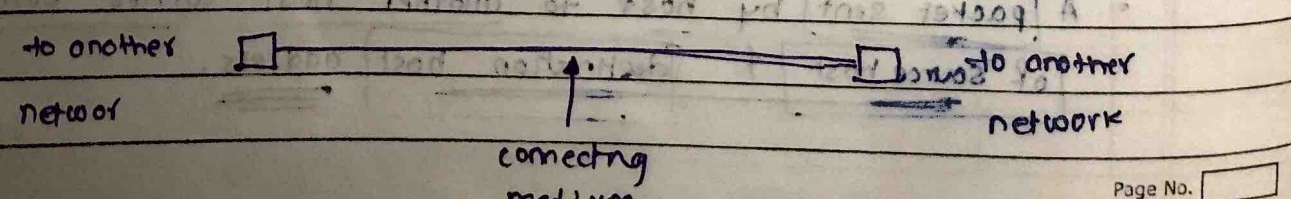
* LANS today are connected to each other & to WANS to create communication at a wider level.

* WANS (Wide Area Network)

- Interconnection of devices that are capable of communication = Network.
- Some differences in LAN & WAN, WAN has a wider geographical area, spanning a city or town.
- A LAN interconnects hosts, whereas A WAN interconnects connecting devices eg: router, modem.
- A WAN is created & ran by communication companies
- Two types of WAN's, Point to point and switched.

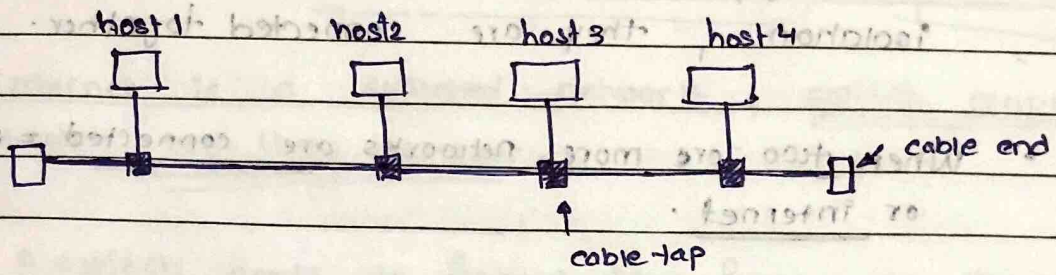
* Point to point WAN:

- Connects two connecting devices using cable or air.

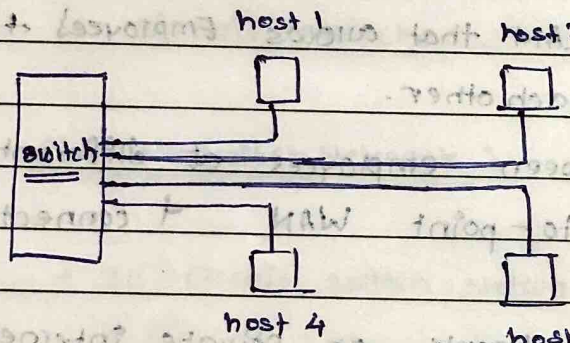


## * LAN - Diagram

(a) In past → common cable

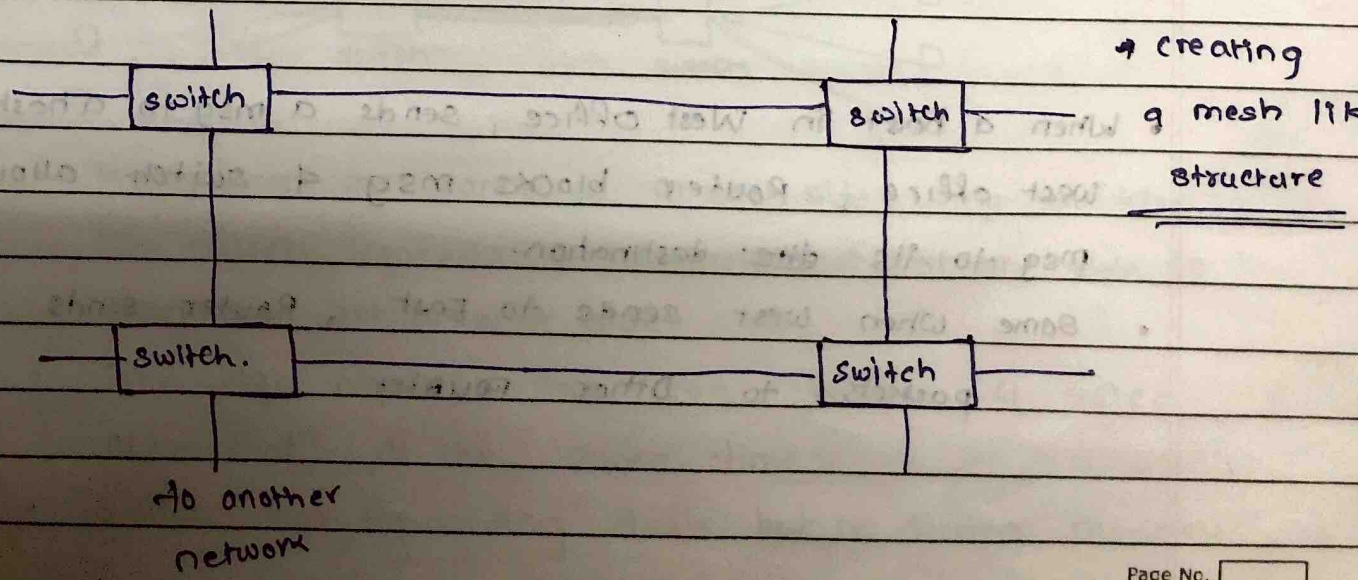



(b) In present → using switch.




## * Switched WAN

- A network with more than two ends.
- It is a combination of several point-to-point WANs that are connected by switches



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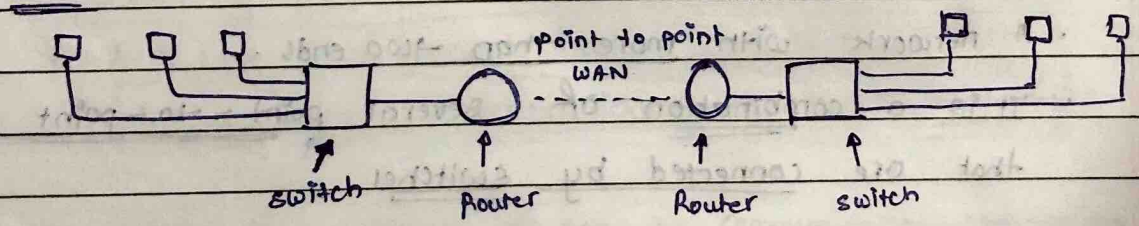
## * Internetwork :

- In today, LAN & WAN can't be seen in isolation, they are connected together.
- When two or more networks are connected = inter networks or internet.
- Eg: organization has 2 offices, one at East coast & other at west coast.
  - Each office has a LAN that allows Employees to communicate with each other.
  - To communicate between employees at different offices, we use a point-to-point WAN & connect two LANS.
  - Now we have a internetwork or private internet.




- When a host in West office, sends a msg to a host in west office, Router blocks msg & switch allows the msg to its ~~dire~~ destination.
- Same when west sends to East, Router sends packets to Other Router.

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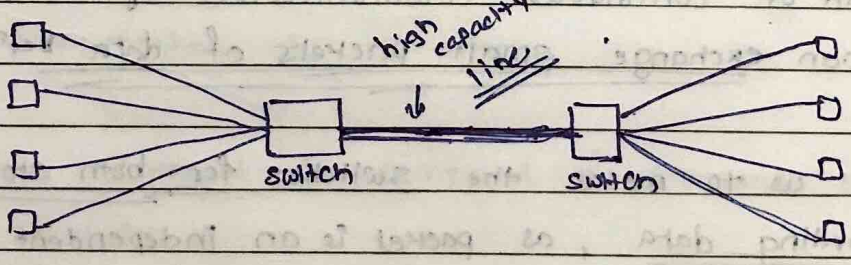
## * Switching :

- Internet is a combination of links & switches.
- Internet is a switched network, switch connects at least two links together.
- A switch needs to forward data from one link to another.
- Two most common types of switches are :
  circuit-switched & packet-switched

## * Circuit switch Network :

- In circuit switch Network, a dedicated connection, called a circuit, is always available betn two end systems.
- The switch will make circuit active or inactive.
- Circuit switched network is common in telephones.




- 4 telephones are connected at each side using switch.
- The switch connects a telephone set at one side to telephone set at other side.
- The high capacity line can handle 4 voice communicat$^{n}$ at the same time.
- Switch has forwarding task but no storing capacity.

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- In 1st case, all telephone sets are busy, 4 pep. at one side are talking to 4 pep. at other side. The capacity of thick line is fully used.

- In 2nd case, only one telephone set at one side is connected to telephone set at other side, only one fourth of thick line capacity is used.

- Thus, through this we get to know, *circuit - switch network is efficient only when it is working at full capacity.

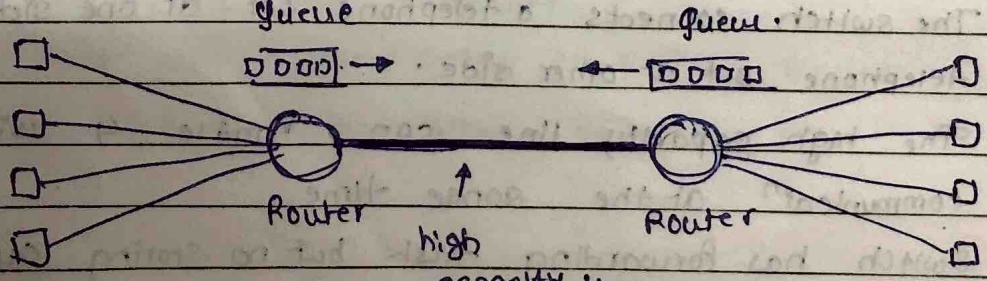
- The reason to make capacity of thick line = capacity of 4 voice lines, is to make sure, all get connected to each other at once.

* **Packet - switched Network:**

- In computer based network, communication is done in by sending & recieving blocks of data → packets.

- Instead of continuous communication eg: as telephone, we can exchange small packets of data betn 2 computers.

- Allows us to make the switches for both storing & forwarding data, as packet is an independent entity & can be stored.

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- A router in a packet-switch network, has a queue, that can store & forward packets.

- Now assume that, capacity of thick line is twice capacity of data line connecting computers & routers.

so, if only two computers i.e. one at each side communicates with each other, packets do not have to wait for transmission.

But if packet arrives to router, when thick line is full, the packets should be stored & forwarded in the order they arrived.

* Packet-switch network is more efficient than circuit switch networks.

* The Internet:

- The internet is the connection of two or more networks & communicating with eachother.

- The Internet is composed of thousands of interconnected networks.

- There is a difference in internet → Connectn of 2 or more networks
  . Internet → thousands of interconnected networks.

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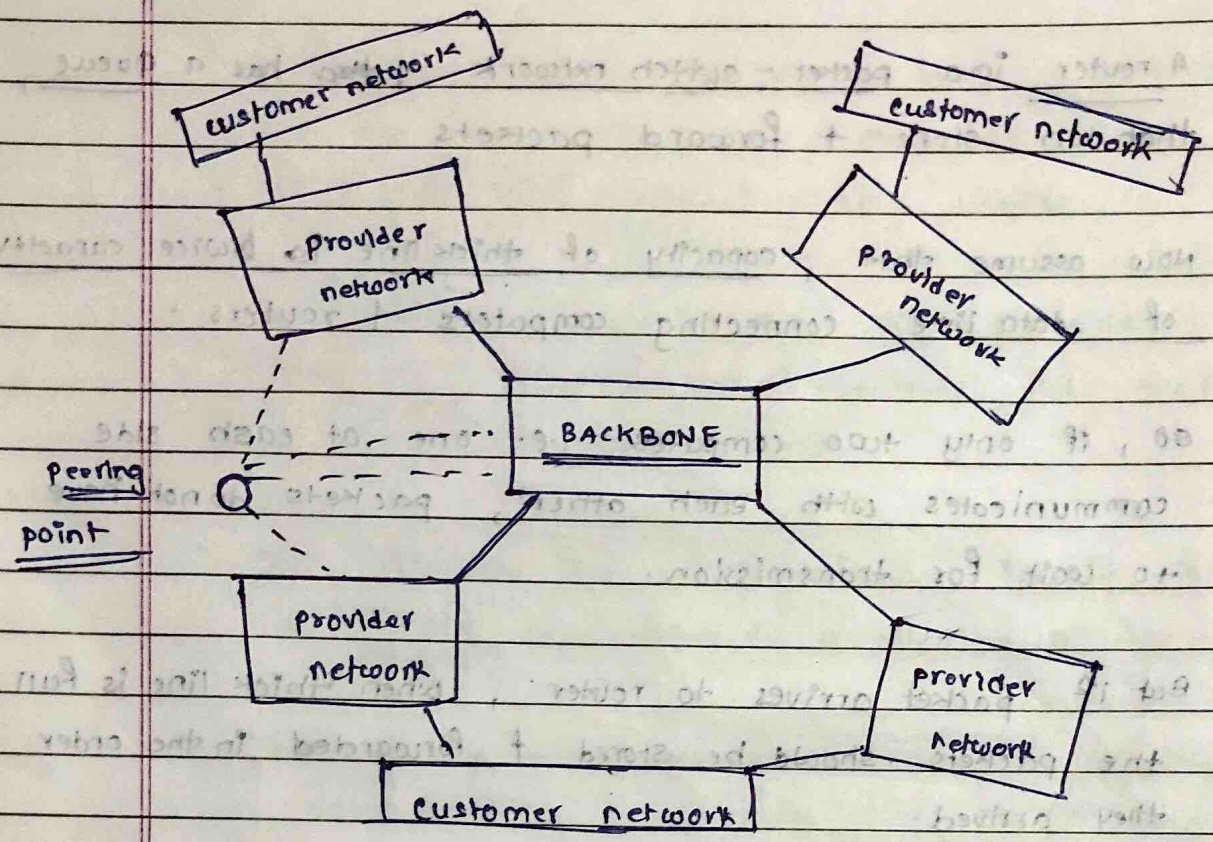


- Internet is a backbone, providernetwork & several customer networks.

* ① • At the toplevel is the backbone. are large networks owned by companies eg: (AT & T).

② • The backbone are connected through some strong complex switching system called peering.

③ At second level are provider networks, that use service of the backbone. For a fee.

④ • Provider networks are connected to backbone & sometimes, other provider networks.

⑤ • The customer networks are at the edge of Internet that use the service. Provided by Internet

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* Backbone & provider network are Internet service providers
  - ↓ international (ISP)
  - ↓ Regional (ISP).

# Accessing the Internet: [Telephone (Dial, DLS), Wire/cable (TV), Wireless (WAN)]

- ~~Internet today~~ The physical connection bet^n user & provider (IPs) is done using (Point to point WAN)

* Using telephone networks: (Telephone line ki line → me internet).
  - Today most of business have telephone services, i.e. they already have a network of telephone system.
  - Now since most of telephones are already connected to internet, we can change the voice line bet^n house & telephone center to a point to point WAN.
  - This changing voice line to point to point WAN can be done by 2 ways:
    1. Dial up-services: to add a modem to telephone that converts data to voice.
       - The software on computers dials ISP & imitates making a telephone connection.
       - ~~or most used now~~ Very slow service & can either be used for telephone voice or internet.

basically → add a modem to telephone to convert ~~voice~~ data to voice.
→ computer will call / dial to ISP to get internet.
* → can either use internet or voice.

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② DSL service: telephone companies have started providing highspeed internet.

- The DSL does the same, allows the line to be used simultaneously for voice & data comm.

* Using cable Networks: (TV cable ⇒ internet)

- As we use cable TV services for broadcasting, providers have included high speed Internet to their cables.
- (These providers are) changing cables to connect to Internet. upgrading cables
- Speed of Internet depends upon how many are using same cable.

* Using wireless Networks:

- recently become much popular, as we can get internet through a combination of wired & wireless connections.
- Can get internet through a wireless WAN.

* Direct connection to Internet:

- A large organization can itself be an ISP & connected to Internet.
- Lease a WAN & connect it to ISP.
- Eg: Large university with several campuses, create an internetwork & then connect Internetwork to Internet.

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## Hardware & software:

- For communication to happen, we need both hardware & software
- combination of hardware & software can be done through protocol layering.

## Protocol layering

- A protocol defines the rules that a sender & receiver needs to follow for communication.
- When communication is simple we may need only one simple protocol. But when communicatn is complex, we may need to divide tasks betn layers.
- When we divide, we need to give protocol to each layer, → Protocol layering.

* complex task → several simple tasks. ∴ Protocal layering.

- Modularity → independent layers, can be changed easily (only one layer).
- Advantange is → it allows us to seperate services from implementation [services = layers].
- A layer needs to get data from the lower layer to give services to upper layer.

* Advantage: communication does not always use only two ends systems., there are intermediate systems, that need only some layer. not all.

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## Principles of protocol layering: (opposite task, object at corresponding layer identical).

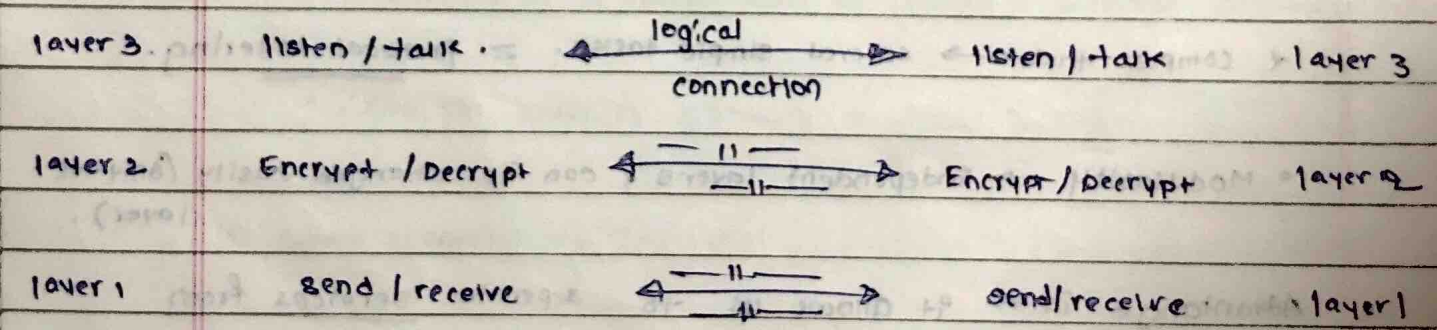
- First → if we want bidirectional communication, we need to make each layer, so that it can do two opposite tasks.

- Second → two objects under each layer at both sides should be identical.

## logical Connections:

- logical connection btn two layers, so we can have layer to layer communication.

* logical connection between peer layers.



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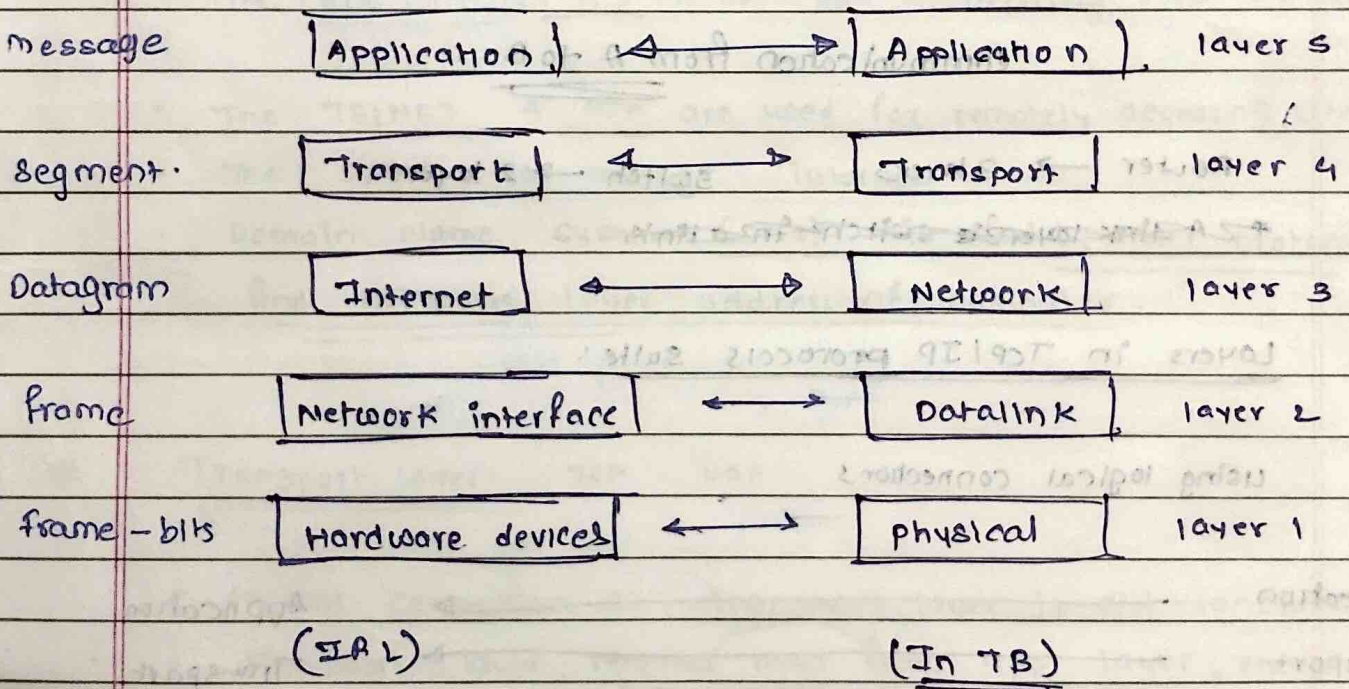
# TCP/IP protocol: (Transmisson Control protocol/Internet protocol)

- TCP/IP is a set of protocals at different layers.
- Hierarchical protocol made up of interactive modules. i.e. upperlevel protocol is supported by one ovo more lowerlevel protocols.
- The OG TCP/IP suite was defined as 4 ~~protocol~~ softwares built on a hardware.
- Now it is a 5 layer model.




# layered Architecture:

- To show, how layers of TCP/IP are involved in communication betn 2 hosts, we will use suite in 3 LAN (links)

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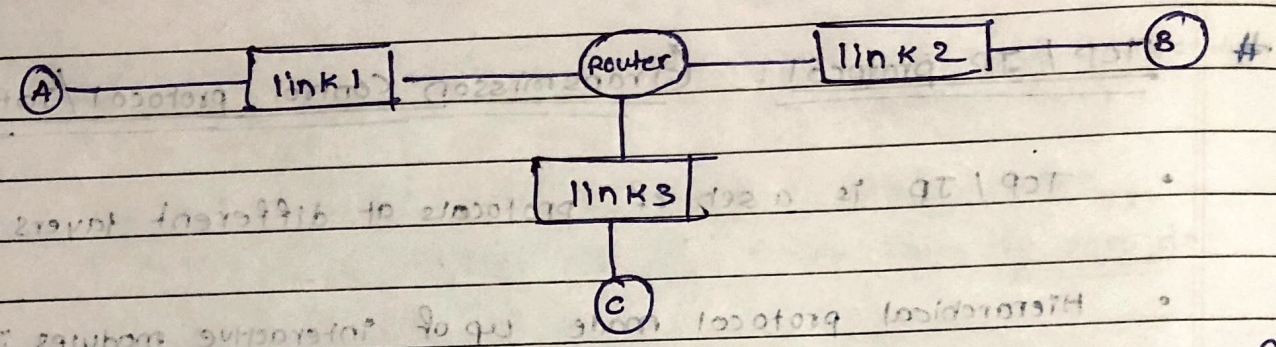
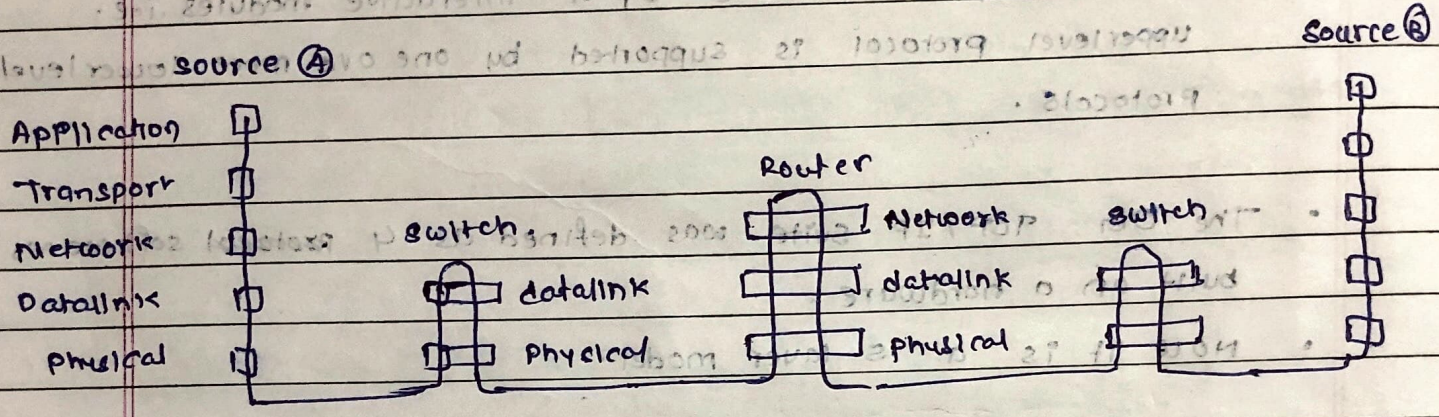


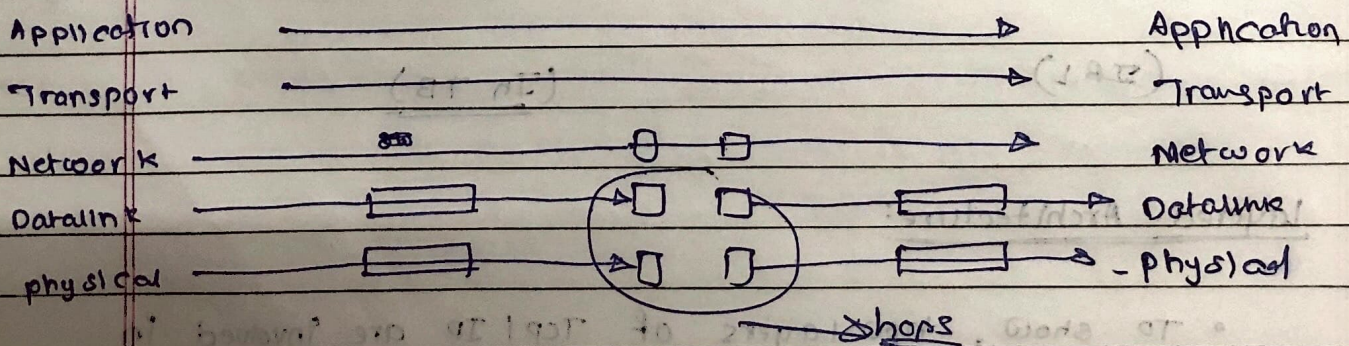

communication from A to B

Router → 3 layers ← switch → 2 layers.

~~# 2A link layer is switch in a link.~~

# Layers in TCP/IP protocols suite:

Using logical connections




* Domain of top 3 layers = Internet
* last 2 layers = link.

# though identical obj are in bet^n 2 host, they also exist in bet^n hops.

each layer is independent.

App → http, FTP, SMTP, DNS.

Trans → TCP, UDP

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(Process to communicate with other process)

# Application layer: (HTTP, FTP, SMTP, SNMP, SSH TELNET, DNS)

* logical connectn betn 2 application layer is end-to-end.

* To communicate in application layer:
  → processor sends a request to other processor & receives a response.
  → Process to process communication is the duty of app. layer

- The (HTTP) is the vehicle for accessing WWW
- The simple mail transfer p' (SMTP) is main protocol used in e-mail service.
- The File T. Por (FTP) is used for tranferring files to other hosts.
- The TELNET & SSH are used for remotely accessing site.
- The SNMP to manage internet.
- Domain Name system (DNS) is used by other protocols to find network layer address of computer.

# Transport layer: TCP UDP

- logical connection at transport layer is end-to-end.
- Transport layer receives msg from app. layer, encapsulates it in transport layer packet & sends through the logical connection to transport layer of destination.
- Transport layer gives services to app. layer.
- We need end to end transport layer, to seperate task & duties.
- More than one protocol in transport layer.

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• We have more than one protocol in transport layer, each is designed for some specific task.

→ main → TCP Transmission control.

• TCP is a connection oriented protocol, first establishes a connection betn transport layers of 2 hosts.

• TCP creates a logical pipe for transferring stream of data.

• TCP provides flow control, error control & congestion control to reduce the loss.

→ other common protocol is : user datagram P (UDP)

• A connectionless protocol, each UD is an entity independent of travelling without being related to previous or next.

• UDP is simple protocol that does not provide flow, error & congestion control.

• SCTP is present to respond to new application.

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# For error, flow & congestion, app. should rely on transport layer.

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(Datagram)

# Network layer: (IP, routing, auxiliary DHPC, ARP, ICMP, IGMP)

- Responsible for creating connection betn source host & destination host.
- Communication at network layer is host to host.
- Since there can be several routers in the path, the routers decide which path is the best suitable.
- We need network layer because routers do not need application & transport layer.
- Network layer responsible for sending packets to destination.
- The network layer in Internet includes main protocols, IP, that defines the format of packet, ie datagram at network layer.
- IP also defines format & structure of address in this layer.

IP.
- IP is also ~~ben~~ responsible for routing a packet from source to destination.

* IP is a connectionless protocol, that provides no flow, error & congestion control.
- Network layer has unicast (1-1) & (1-m) & multicast routing protocols.

* Routing is responsibility of IP. Routing Protocol creates tables for routers to help them in routing.

DNS & DHCP → network layer address of host.

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- The Network layer has some auxiliary protocals, that help IP to do its routing task.
  1. The internet control message P (ICMP) to report problems with routing of packets.
  2. The Internet Group Management (IGMP) to help IP in multitasking
  3. The Dynamic Host Config (DHCP) helps IP to get network layer address for Host
  4. The Address resolution protocol (ARP) help find IP, link layer of host or a router when network layer address is given.

(frame)

# Data link layer (encapsulate data into frame)

- In internet, it is connected by various links that are connected by routers.
- The routers are responsible for best route / path
- The next link is found by the routers; but the data link layer is responsible for moveing data across the link.
- Link can be wired LAN. with link layer switch, wireless LAN, wired WAN or wireless WAN.

* Data link layer is responsible for moving packets through links.

Network → datagram
Datalink → frame (bits)

App → msg
Transp → segment
Network → datagram
Datalink → frame
Physical → bits

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- The data link layer takes the datagram & encapsulates it in a packet called frame.

# Physical layer: (Transmission media).

- Physical layer is responsible for carrying individual bits in frame across link
- The communication betn 2 devices at physical layer is logical. because there is another hidden layer → transmission media under physical layer.
- The ~~transmission~~ two devices are connected by a trans. medium (air / wire)
- Transmission medium does not carry bit/bit/ carries electrical signals / optical signals
- So bits received in frames from datalink layer are transformed then sent through transmission media.

* convert bit to signal → send through transmission media.

application → message
Transport → segment
Network → Datagram
Datalink → Frame
Date __/__/____ physical → Transmission Media



# Encapsulation & Decapsulation :

- We show encapsulation in source host
  decapsulation in destination host
  & encapsulation & decapsulation in router.

## Encapsulation at source host :

① At app. layer data to be exchanged is reffered as message. A message does not have a header & footer generally, if it has, the entire is considered as message.
Message is passed to transport layer.

② Transport layer takes msg as payload, that has to transport it to the destination.
Transport layer adds header to the message, that contains identifiers of source & destination. & some info that is required for end to end delivery. Info for flow, error & congestion control.
The result is transport layer packet = segment (in TCP) & (UDP)

③ The network layer takes transport layer packets as payload & add its own header. Header has info about address of source & destination.
The result of network layer packet = Datagram

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④ Datalink layer takes over the packet of network layer and adds its own header, that contains link layer address of host or next hop (router).
The result of linked layer packet = frame.

Frame is passed through physical layer for transmission.

* Decapsulation & Encapsulation at Router:

① After the set of bits are delivered to datalink layer, it decapsulates the datagram from frame and passes it to network layer.

② The network layer only inspects the address in datagram header & sends it to next table to find the next hop & destination.
The contents are not changed.
The datagram is then passed to ~~next~~ datalink layer of next link.

③ Datalink layer encapsulates datagram in a frame & passes it to physical layer.

* Decapsulation at Destination Host: Involves error checking.

* each layer only decapsulates the packets received, removes the payload & delivers the payload to next high layer protocol, until it reaches app layer.

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# Addressing

* Any communication that involves two parties needs to be addressed:

source address & destination address.

* Except for physical, every layer does addressing.

because, in physical layer, operation is done on bit.

| Packets | layers | address |
|---|---|---|
| message | Application | Names |
| segment | Transport | Port no. |
| Datagram | Network | logical address (Global) |
| frame | Datalink | link layer address (MAC address) |
| bits | Physical (electrical) | |

* network layer address uniquly defines connection of source to Internet.

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## Multiplexing & Demultiplexing:

- Multiplexing in this case means → protocol at a layer can encapsulate a packet from several next higher layers protocol.

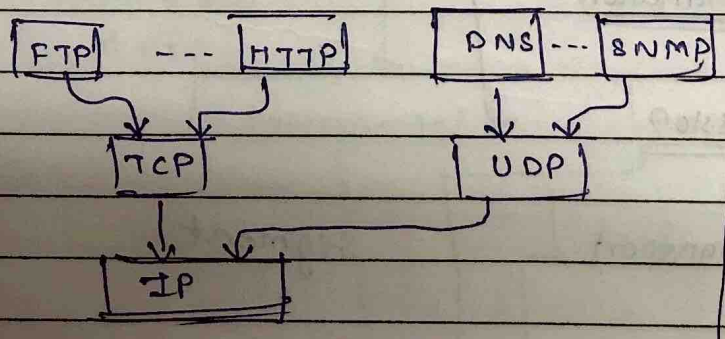
- Demultiplexing: protocol at a layer can decapsulate ~~a packet~~ and deliver a packet to several next higher level protocol.

* To be able to multiplex & demultiplex, protocols needs to understand, to which protocol the encapsulated packet belong.

* At transport level either UDP or TCP can accept msg from several app. layer protocols.

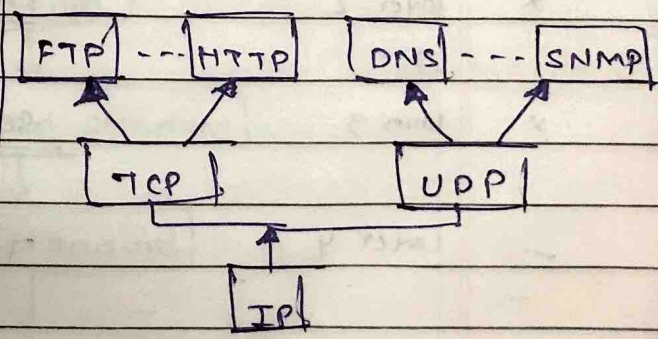
* At network layer, IP can ~~accept~~ accept a segment from TCP or from UDP.

* In Datalink layer, frame may carry payload from IP & other protocols ARP.




Encapsulation.

Multiplexing




Decapsulation.

Demultiplexing.

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# The OSI MODEL (Open System Interconnections)

* An open system is set of protocols that allow 2 systems to communicate regardlessly their architecture.

* • Purpose of OSI is to show, how communication can be done, without changing the underlying hardware or software.

• OSI model is the basis of creation of protocol.

• used for understanding & designing a network architecture.

• OSI is a layered framework that allows communication betn all types of computer systems.
consists of (7) steps seperate but related layers.

OSI Model ≠ layers (interconnected)

| | | | |
|---|---|---|---|
| ✓ | layer 1 | Application | Message |
| × | layer 2 | Presentation | Application in TCP/IP. |
| × | layer 3 | Session | |
| ✓ | layer 4 | Transport | segment |
| ✓ | layer 5 | Network | Datagram |
| ✓ | layer 6 | Datalink | underlying lan & WAN Tech. frame |
| ✓ | layer 7 | Physical | transmission media |

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Presentation
&
Session

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## * OSI vs TCP/IP

- In TCP/IP, application layer is the combination of application, session & presentation layer of OSI.
- Reason for not adding presentation & session were:
  1. TCP/IP has more than one transport layer protocol.
  2. Application layers is not only one piece of software. many app. may be developed at this layer.

## # Lack of success of OIS Model:

reasons

1. TCP/IP was fully used so no chance of again changing.
2. Presentation & session were not fully defined layers, actual protocols were not defined nor described.
3. Not good enough performance.

## # Maturity level of RFC.