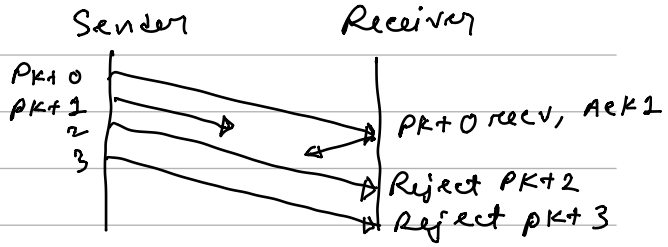
Pipelining :

Sending data in bulk sequentially.

① Go Back - N (sliding window)

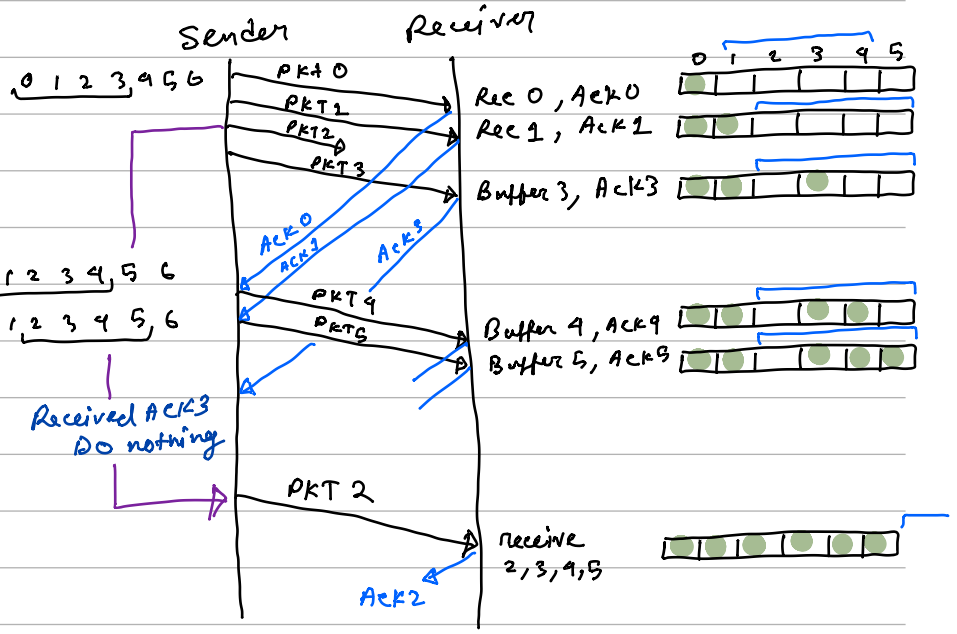
② Selective Repeat

① Go Back N:



② Selective Repeat:

* Individual Ack for each PKT.
* out of order packets are Buffered.



TCP → Tcp gets continuous data stream → breaks into segments.

Source Port 16 bit								Dest Port 16 bit
Seq No.								
Ack								
Header Len 4 bit	6 bit	URG	ACK	PSH	RST	SYN	FIN	window size 16 bit
Check Sum 16 bit								Urgent Data Pointer 16
Options + Data 40 Bytes.								
⋮								

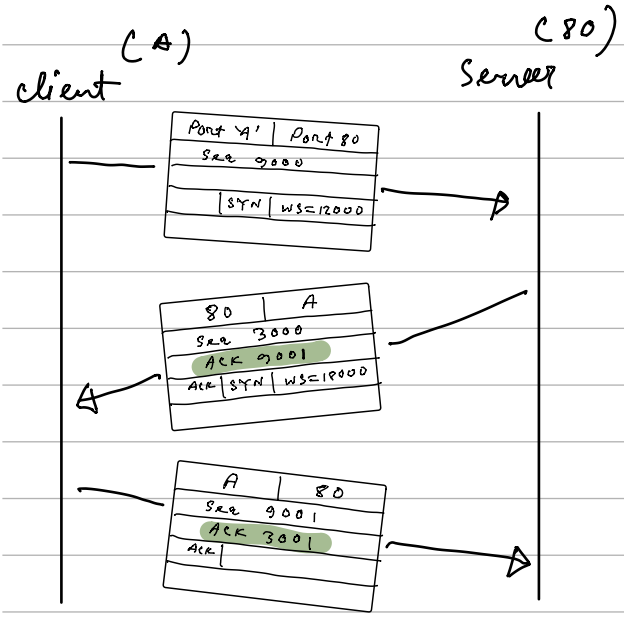
Byte Streaming
Connection Oriented
Full Duplex
Piggy backing (Go back N, SR)
Error Control
Flow Control
Congestion Control

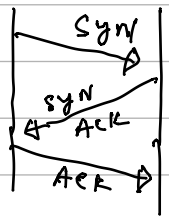
* Ack no. is always next expected Seq. no.

urg : urgent bit ; The Urgent data can be accessed by the urgent data pointer.

PSH: Push ; To send data immediately ; not wait for buffer to fill.

TCP Connection :

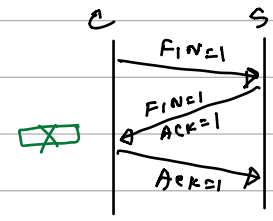




ACK = Seq no. + 1

Connection Termination:

(i)



got FIN=1, Now client deallocates resources

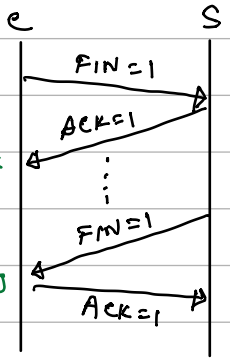
C ⟷ S

Server no longer can send data

Server deallocates Resources (Half Closed)

C → S client cant send data only ACK.

(ii)



Server can still send data to client, client did not revoke resources. *

got FIN=1, Now client deallocates resources

C ⟷ S

Server no longer can send data

Server deallocates Resources (Half Closed)

C → S client cant send data only ACK.

Physical Layer

- Cables & Connectors
- Physical Topology
- Hardwares (Repeaters, Hubs)
- Transmission Mode.
- Multiplexing → Instead of using multiple channel, use 1 channel & multiplex n signals.
- Encoding
  - ↳ encode in Analog / Digital (FM)

Devices in Computer Network:

Hardware:
1. Cables
2. Repeaters
3. Hubs

4. Bridges
5. Switches
6. Routers

Hardware + Softwares

7. Gateway
8. IDS
9. Firewall

Security Purposes

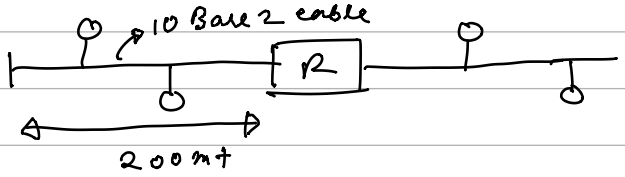
10. Modem (modulator - demodulator)

① Cables:

- unshielded Twisted Pair
  - electrical
  - 10 Base 2 → attenuation distance = 200 mt.
  - 10 Base 5
  - 10 mbits/s
- Coaxial Cable
- Optical Fiber
  - ↳ Light signal.
  - 10 Base Fx → generally 2 Km

Attenuation: after 200 meter strength of signal decreases.

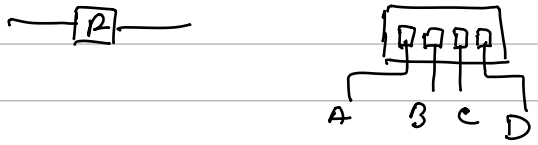
② Repeaters : regenerates signal strength before Attenuation.

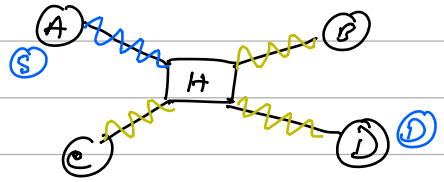


- ✓ Repeter is 2 Port device
- ✓ Forwarding Device
- ✓ No filtering.

③ Hub : Hub is multiport Repeater.

used in star topology

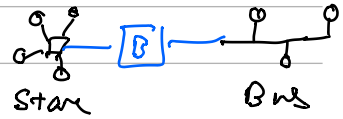




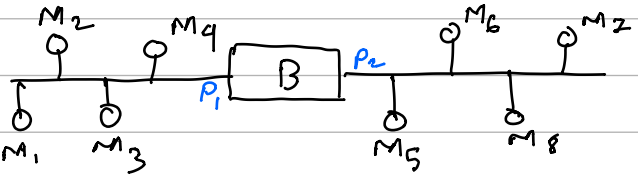
- ✓ Forwarding Device
- ✓ No filtering.

④ Bridg : can connect 2 Different LANs

↳ works in Physical & Link layer *



* | Source MAC | Dest MAC |



Types → Static <mac addr, Port no.> Table

(Problem : when new device comes constantly update table)

→ Dynamic

↳ Initially Table empty, when connection happen, that time fill mac, port table.

mac	Port
m1	P1
m2	P1
m3	P1
m4	P1
m5	P2
m6	P2
⋮	

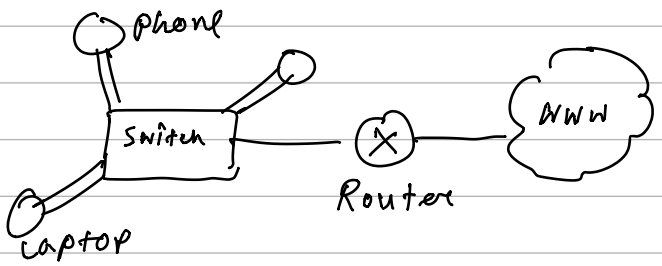
- ✓ Forwarding device
- ✓ Filters signal
- ✓ No collision — Has buffer to store incoming data.
- ✓ Bridges are Unit Data Protocol

(make spanning Tree to select where to send data) No loop Round Trip count.

⑤ **Switch** : Multiport Bridge.

↳ Link Layer device

- ✓ Full Duplex links
- ✓ Traffic is minimal
- ✓ Collision domain 0.

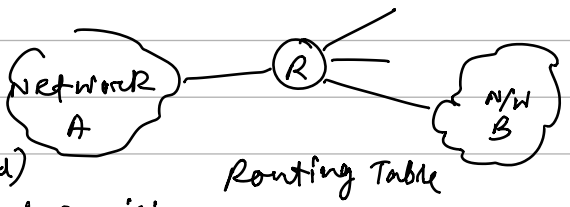


(generally devices are connected to switch not routers)

⑥ **Routers** : Hub, bridge, switch are common for LAN
Routers are the Big Boss holds WAN / Internet

↳ Works on Physical, Link, Network layers.
i.e. Routers work on both MAC & IP addresses.

- ✓ Forwarding
- ✓ Filtering *
- ✓ Routing (can specifically forward)
- ✓ Flooding (when can't find specific addr in Routing table then send signal to everyone)



- ✓ No collision (Buffer)

* e.g. ARP (Address Resolution Protocol) tell me the Mac Addr corresponding any IP addr.

Router Blocks ARP Requests.

○ Circuit Switching : Purely physical, Used for Tele communication.

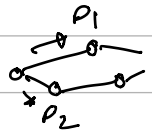
↳ Dedicated Path & Contignous Flow (always in Sequence)

○ Packet Switching : → Virtual Circuit Switching
→ Datagram Switching.

Link & Network Layer

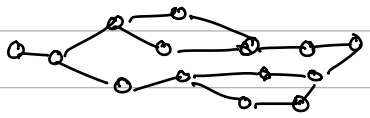
- ✓ Store and Forward (Buffer)
- ✓ Pipelining used

Datagram Switching	Virtual Circuit Sw
○ Connection less	presences virtual Connection.
○ Out of Order	Order maintained
○ High overhead	low
○ Packet loss ↑	Packet loss ↓



○ Message Switching:

Brought the concept of deviding the Data into messages store & forward Hop by Hop



↳ Packet Switching is just upgrade of Message Switching.

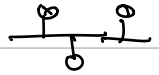
Data Link Layer :

Flow Control : stop & Wait, Go Back N, Selective Repeat
Error Control : CheckSum, CRC (Cyclic Redundancy Check)
Access Control : CSMA / Collision Detection, Aloha, Token Ring / Bus

* CRC 4B integer x (Data + 4Bit(Data %0x)) %0x = = 0 ✓
≠ 0 ✗

Medium Access Control (Multiple Access Control) MAC :

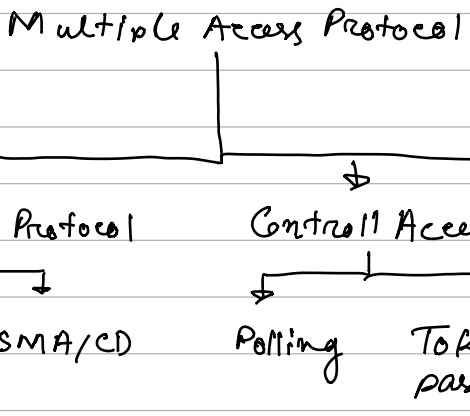
(Link Layer)



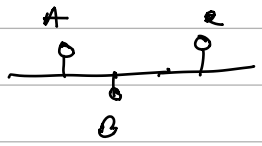
mac is needed when there's collision of link access

in mesh topology all are connected to other

there no need for MAC

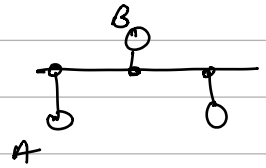


Alloha :



A can send whenever there's need.
There Ack To check whether message was received by C. If not then collision happened, resend.

Carrier - Sensor Multiple Access (CSMA)



Before sending; check whether there's already signal on cable.

* Due to propagation delay

False Positive occur

✓ CSMA/CD ; Collision detection

↳ After sending Data the node can estimate whether there were any collision by calculating how much time it could have taken vs when another incoming signal received.

✓ CSMA/CA ; Collision Avoidance

↳ Used in WLAN.

☐ Ethernet Frame Format :

↳ used in LAN

↳ uses CSMA/CD (Mac Protocol)

e.g. 10 Base 2 (Thin) , 10 Base 5 (Thick) , 100 Base Fx , 10 Gb Base T.

- Topology = Bus
- 1 mbits/s to 400 Giga bits/s.

↳ Destination source Address (MAC Addresses)

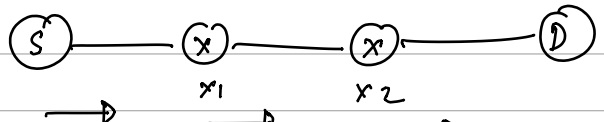
Preamble	SFD	DA	SA	Length	Data	CRC
7 B	1B	6 B	6 B	2B	46 - 1500 B	4B

Physical Layer — Link Layer

* Preamble : 10 10 10 ··· 10 7B
SFD : 10 10 10 11

} these 2 are just to make the device alert that data is coming.

e.g.



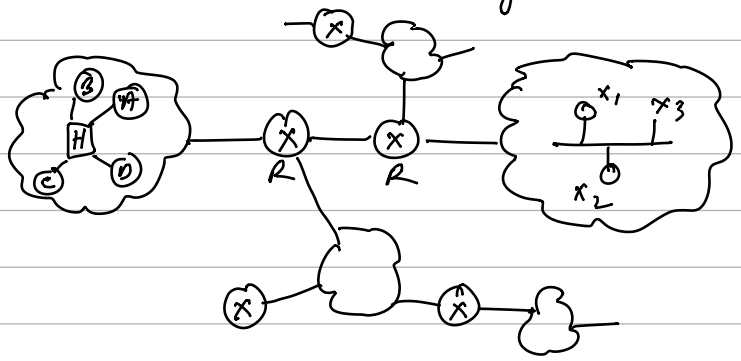
S doesn't know mac addr of D

SA = S, DA = X1
SA = X1, DA = X2
SA = X2, DA = D

* Finding Next node i.e. DA by ARP protocol.

Network Layer :

↳ responsibility Host to Host delivery (source to destination)
does so using logical Address (IP)



IP has info of
① Network that host Belong
② Host

- Routing methods : ① RIP (Routing Information Protocol)
  ② OSPF
  major responsibility is shortest path finding
- Fragmentation :
- Congestion Control :

in 1960 ARPANet gave the classes.

class A : 0 _ _ _ _ _ _ _ : _____ : _____ : _____
Network 2^7 Host 2^{29}

class B : 1 0 _ _ _ _ _ _ : _____ : _____ : _____
Network 2^{19} Host 2^{16}

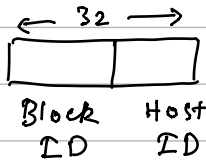
class C : 1 1 0 _ _ _ _ _ : _____ : _____ : _____
Network 2^{21} Host 2^8

class D : 1 1 1 0 _ _ _ _ : _____ : _____ : _____
↳ Given to Groups, Not given to any Network.

class E : 1 1 1 1 _ _ _ _ : _____ : _____ : _____
↳ Military purposes.

* After 1993 classless Addressing became popular.

Classless Addressing :

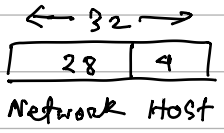


notation

$x.y.z.w / n$

↳ mask (The part that represent Network)

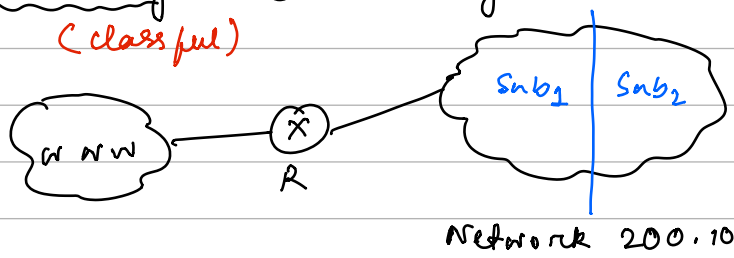
E.g. $200.10.20.9/28$ ⇒



Unlike Classful Addressing, where mask is predefined for a class, Here mask is with the IP.

Subnetting : Divide Big network into small network.

(classful)



Sub1 : 200.10.3.0 ------

Sub2 : 200.10.3.1 ------

For Sub 1

Subnet ID : 200.10.3.0 ✓

Broadcast : 200.10.3.127 ✓

usable address 126

For Sub 2

Subnet ID : 200.10.3.128 ✓

Broadcast : 200.10.3.255 ✓

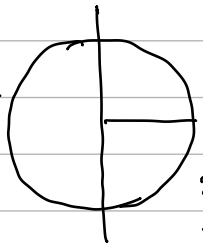
usable address 126

Variable length Subnetting :

200.10.3.0 ---

ID → 200.10.3.0

Bro → 200.10.3.127



200.10.3.10 ---

200.10.3.128 ✓

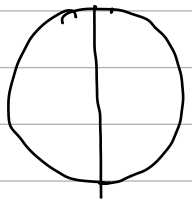
200.10.3.191 ✓

200.10.3.11 ---

200.10.3.192 ✓

200.10.3.255 ✓

Subnetting in CIDR (classless InterDomain Routing):



Sub1 : 195.10.20.128/27 ↔ 195.10.20.159/27

Sub2 : 195.10.20.160/27 ↔ 195.10.20.191/27

195.10.20.128/26

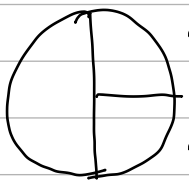
26	6

Network ID = 195.10.20.10 000000

195.10.20.10 0 ------ 195.10.20.10 1 ------

variable Subnetting in CIDR:

245.298.1000 0 ---.0 → 245.298.128.0/21 → 245.298.135.255/21



245.298.1000 10 ---.0 → 245.298.136.0/22 → 245.298.139.255/22

245.298.1000 11 ---.0 → 245.298.140.0/22 → 245.298.143.255/22

original network 245.298.128.0/20

Routing Protocols:

Idea: Sending packet to right path (optimal)

* Routing Table (Contains the state of the whole Network.
  ↳ can be static or Dynamic.

To generate Dynamic Routing table used →

- Routing Protocols
  - Intra domain
    - Distance Vector (RIP) — Routing Information Protocol
    - Link state (OSPF) — Open Shortest Path First
  - Interdomain
    - Path vector. (BGP)

○ Distance vector: All node have a data structure

List	cost	Next
N_1	0	N_1
N_2	1	N_2
N_3	∞	–
N_4	∞	–

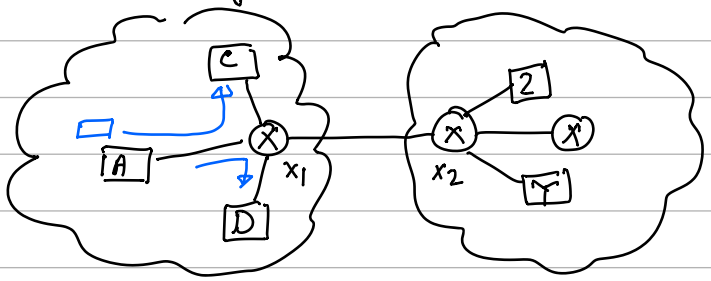
if any value updated The Node share the cost vector with it's neighbors only.

○ Linked State Routing: single source shortest path for all nodes.

☐ Address Resolution Protocol (ARP): IP → MAC

↳ Layer 3 Network Layer Protocol Logical → Physical address.

* ARP Request is always Broadcast Type.
Reply is unicast Type.



ARP request from A to find mac of C.
A will Broadcast

IP_A	MAC_A	IPc	11111...

48 Bit

○ ARP can be done Host → Host Router → Host
Host → Router Router → Router.

* if A request $\{IP_A, MAC_A, IP_Y, 111...\}$ → goes to Router x_1 $\{IP_A, MAC_A, IP_Y, 111...\}$ ↓ goes to Router x_2 $\{IP_A, MAC_A, IP_Y, 111...\}$

☐ Network Address Translation (NAT):

Many colleges have 10.8.0.1 IP.
Idea: All hostels have same room no. 001, 002, 101, 102 etc.
Privatize the Network

NAT Translation Table	
PrivateIP	PublicIP
10.8.0.2	101.10.22.33

↓ This is Destination IP (Google.com)