BY MALVINDER SINGH BALZ

MULTIPLE-ACCESS PROTOCOLS

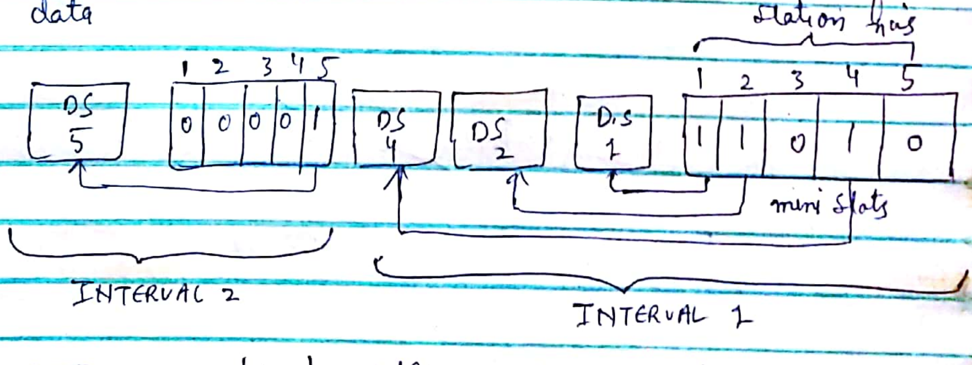
1. Random Access Protocols
   - ALOHA
     - PURE ALOHA
     - SLOTTED ALOHA
   - CSMA
   - CSMA/CD
   - CSMA/CA
2. Controlled-Access Protocols
   - RESERVATION
   - POLLING
   - TOKEN PASSING
3. Channelization Protocols
   - FDMA
   - TDMA
   - CDMA

2 CONTROLLED ACCESS

- In this technique, all the stations consult one another to find which station has the right to send.
- A station cannot send unless it has been authorized by other station.

a) **RESERVATION** — Here station needs to make a reservation before sending data. Time is divided into intervals.
In each interval, a reservation frame precedes the data frame sent in that interval.

- In this method a station needs to make a reservation before sending data



NOTE — If there are 'N' stations in the system, there are exactly 'N' reservation minislots in the reservation frame.

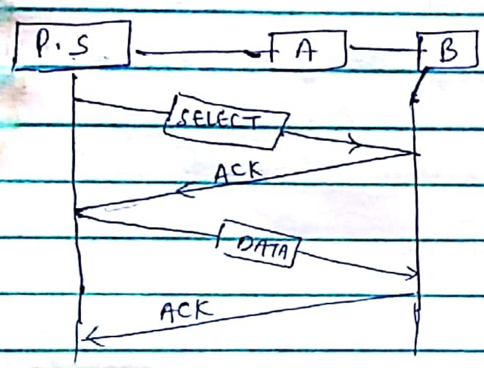
b) **POLLING** — works with topologies. In this one device is designated as Primary station & the other device as Secondary station.

- All data exchange must be made through Primary device.
- The Primary device controls the link, the secondary devices follow its instructions.

Two different function in POLLING

① SELECT FUNCTION

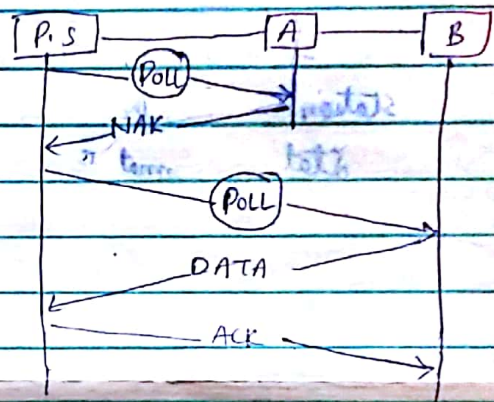
- If the Primary wants to send data, it tells the secondary to get ready to receive. This is called Select function



NOTE: used when Primary wants to send data

② POLLING FUNCTION

- If the Primary wants to receive data, it asks secondary, if they have anything to send. This is called Poll Function



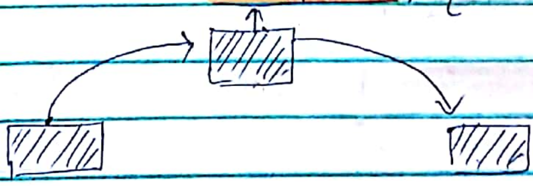
NOTE: used when Primary wants to receive data

ⓒ TOKEN PASSING METHOD

– In this, the stations in a n/w are organized in a logical ring.

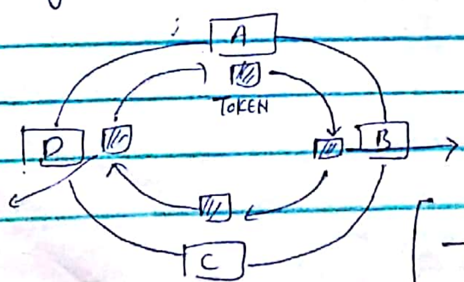
· Current Station {who is accessing the channel}

Predecessor



Successor

- In this method, a special packet called a Token circulates through the ring. The Passession of the Token gives the station right to access the channel & sends its data



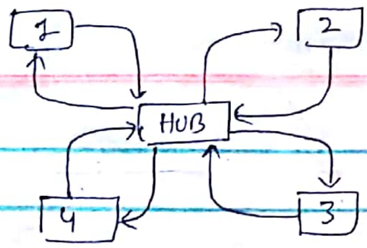
{Access the medium & release token once done}

(AR) Access release

[TOKEN MANAGEMENT is needed for this access method]

3

Logical ring - Here stations do not have to be physically connected in a ring, ring can be a logical one.

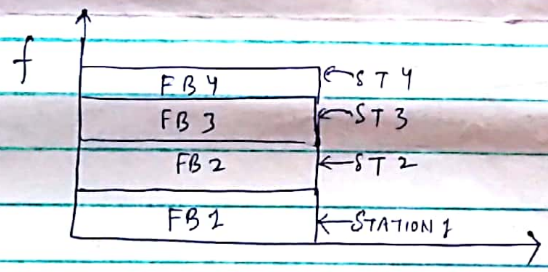


STAR RING

3 CHANNELIZATION

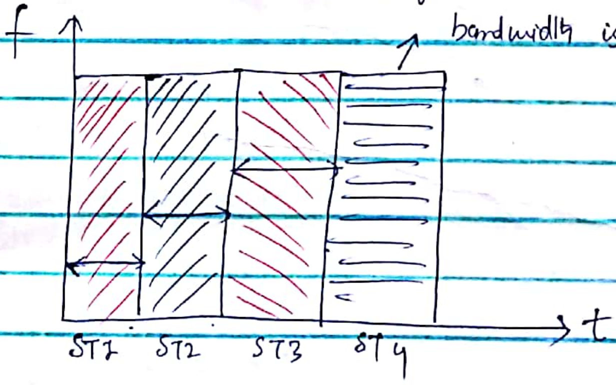
- is a multiple access method in which the available bandwidth of a link is shared in Time (TDMA), frequency (FDMA) or through code (CDMA)

a) Frequency division Multiple Access (FDMA) - available bandwidth is divided into frequency bands. Each station is allocated a band to send its data & it belongs to the station all the time.



NOTE - FDMA is an access method in the data link layer.

b) Time-division Multiple access (TDMA) - In this method, the stations share the bandwidth of channel in TIME. Each station is allocated a time slot during which it can send data.



NOTE - In TDMA, the bandwidth is just one channel that is time shared b/w different stations.

Scanned by CamScanner

(c) Code-division Multiple access (CDMA)

- In this method, one channel carries all transmissions simultaneously.
- CDMA means communication with different codes

How communication with codes Take place

a. Let us assume, we have four stations 1, 2, 3 & 4 connected to the same channel.

b. Data from Station 1 are d_1 $\xrightarrow{\text{Code assigned to } ST_1}$ C_1
Station 2 are d_2 $\xrightarrow{\text{Code to } ST_2}$ C_2
Station 3 are d_3 $\xrightarrow{ST_3}$ C_3
Station 4 are d_4 $\xrightarrow{ST_4}$ C_4

c. Two Important Properties.

a) If codes are multiplied with each other, we get 0
b) If codes are multiplied by itself, we get (4) (no. of stations)

Example

St 1 → C_1
St 2 → C_2
St3 St4

$\boxed{C_2 \times C_2 = 4}$

$\boxed{C_1 \times C_2 = 0}$

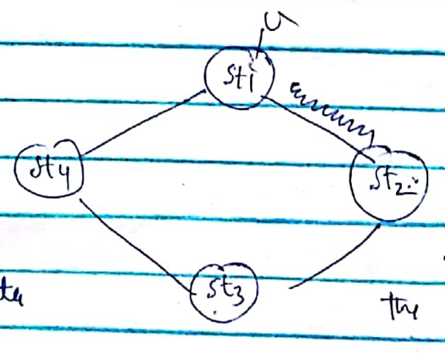
As per properties

d. Now

- St 1 ⟶ d_1 ⟶ C_1 ⟹ $C_1 \times d_1$
- St 2 ⟶ d_2 ⟶ C_2 ⟹ $C_2 \times d_2$
- St 3 ⟶ d_3 ⟶ C_3 ⟹ $C_3 \times d_3$
- St 4 ⟶ d_4 ⟶ C_4 ⟹ $C_4 \times d_4$

all stations transmit data ~~using single channel~~
$(C_1 \times d_1) + (C_2 \times d_2) + (C_3 \times d_3) + (C_4 \times d_4)$

e)



- Suppose station 1 & 2 are talking to each other. Station 2 wants to hear what station 1 is saying. It multiplies data on the channel by C_1, the code of station 1.

when St_2 wants St_1 data

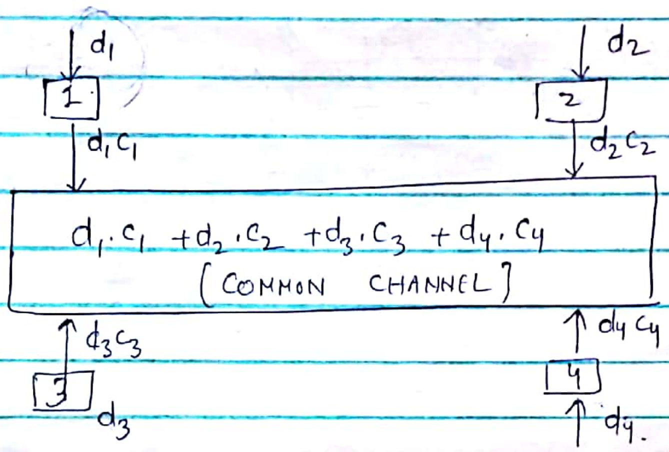
$$\text{data} = \left[(C_1 \times d_1) + (C_2 \times d_2) + (C_3 \times d_3) + (C_4 \times dy)\right] \cdot C_1$$
$$= \underbrace{(C_1 \times C_1 \cdot \times d_1)}_{\downarrow} + \underbrace{(C_2 \times C_1 \times d_2)}_{0} + \underbrace{(C_3 \times C_1 \times d_3)}_{0} + \underbrace{(C_4 \times C_1 \times d_4)}_{0}$$

2)

$= 4 \times d_1$ (Here station 2 divides the result by 4 to get the data from Station 1)

$= \dfrac{\cancel{4} \times d_1}{\cancel{4}} = d_1$

So d_1 is the data transmitted by station 1



<u>Chip Sequence</u> – CDMA is based on <u>Coding Theory</u>. Each station is assigned a code which is a sequence of numbers called chips

$c_1 = +1 \quad +1 \quad +1 \quad +1$

$c_2 = +1 \quad -1 \quad +1 \quad -1$

$c_3 = +1 \quad +1 \quad -1 \quad -1$

$c_4 = +1 \quad -1 \quad -1 \quad +1$

<u>DATA REPRESENTATION</u>

DATA BIT 0 $\longrightarrow -1$

DATA BIT 1 $\longrightarrow +1$

SILENCE $\longrightarrow 0$

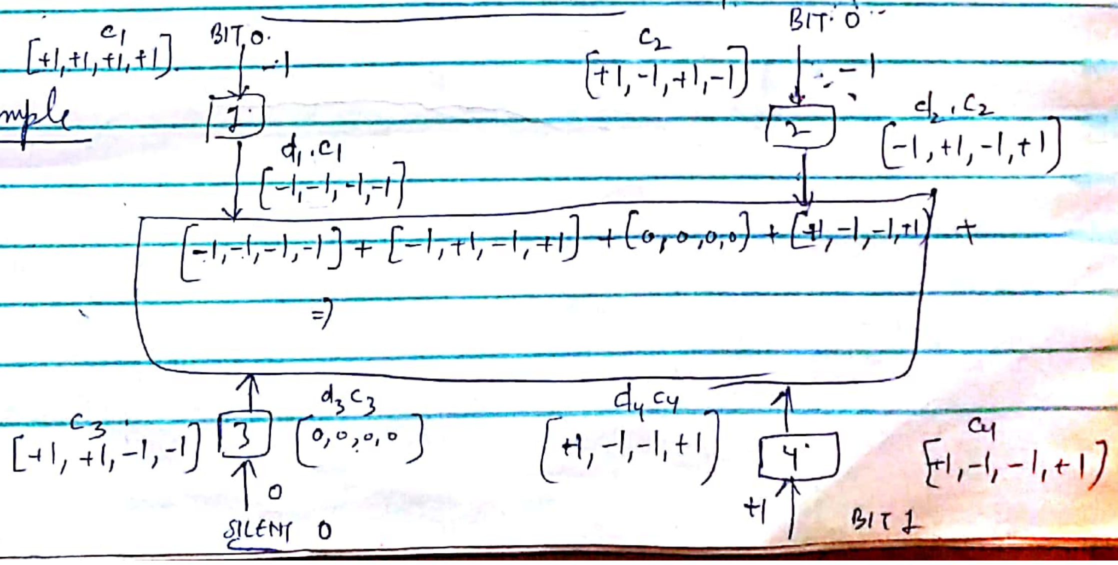
$c_1 \cdot c_2 = +1 \ -1 \ +1 \ -1 = 0$

$c_1 \cdot c_3 = +1 \ +1 \ -1 \ -1 = 0$

BUT $c_3 \cdot c_3 =$

$$\begin{array}{rrrr} +1 & +1 & -1 & -1 \\ +1 & +1 & -1 & -1 \\ \times & & & \\ \hline +1 & +1 & +1 & +1 \end{array} = 4$$

<u>Example</u>



Now Assume that station 3 wants data of station 2

$$[-1,+1,-1,-1]+[-1,+1,-1,+1]+[0,0,0,0]+[+1,-1,-1,+1]\times[c_2]$$

$$\times[+1,-1,+1,-1]$$

$$\Rightarrow \underbrace{[\cancel{-1},\cancel{+1},\cancel{-1},\cancel{+1}]}_{0}+\underbrace{[-1-1,-1,-1]}_{-4}+\underset{0}{0}+\underbrace{\cancel{1}+\cancel{1}-\cancel{1}-\cancel{1}}_{0}$$

$$-4+0$$

$$\Rightarrow \boxed{-4}/4=\boxed{-1}$$

$(a-b)(a+$

Data bit $=\boxed{0}$

WIRED LANS : ETHERNET

- Predominant technologies associated with LAN
  - a) Ethernet
  - b) Token ring
  - c) Token Bus
  - d) FDDI
  - e) ATM LAN.

QUR QUORA

- ETHERNET is by far, the dominant Technology.

IEEE STANDARDS

- In 1985, Computer Society of IEEE ~~Standard~~ Started a Project called Project 802 to set standards to enable intercommunication among equipment from a variety of manufacturers.

- The standard was adapted by ANSI (American National standards institute in 1987.

- The IEEE subdivided the data link layer into two sublayers
  - a) logical link control (LLC) : Provides flow & error control for upper layer protocols
  - b) MEDIA ACCESS control (MAC) - multiple access methods including random access, controlled access & channelization.

UPPER LAYERS	UPPER LAYERS			
DATA LINK LAYER		LLC		
	ETHERNET MAC	TOKEN RING MAC	TOKEN BUS MAC	- - - -
PHYSICAL LAYER	ETHERNET PL	TOKEN RING PL	TOKEN BUS PL	

IEEE STANDARDS FOR LANS

ETHERNET EVOLUTION

- STANDARD ETHERNET — 10 Mbps
- FAST ETHERNET — 100 Mbps
- GIGABIT ETHERNET — 1 Gbps
- TEN GIGABIT ETHERNET — 10 Gbps

① STANDARD ETHERNET

- In ST, the MAC Sublayer governs the operation of the access method
- It also frames the data received from upper layer & passes them to the physical layer.

802.3 MAC Frame Format (802.3 – Ethernet LAN) 802.2 (LLC)

PREAMBLE	SFD	DESTINATION ADDRESS	SOURCE ADDRESS	LENGTH OR TYPE	DATA & PADDING	CRC
7 bytes	1 BYTE	6 BYTES	6 BYTES	2 BYTES		4 BYTES

← PHYSICAL LAYER HEADER →

a) Preamble – 7 bytes (56 bits) alerts the receiving system to the coming frame & enables it to synchronize its input timing

b) SFD (Start Frame delimiter) – The second field (1 byte 10101011) signals the begining of the frame

- The SFD warns the station or stations that this is the last chance of synchronization
- The last 2 bits is 11 & alerts the receiver that the next field is the destination address.

c) Destination address (DA) – is a 6 byte & contains physical address of the sender of the Packet.

d) Length or Type – defines no. of bytes in the data field

e) Data – data encapsulation from the upper layer Protocols. It is minimum of 46 bytes & maximum of 1500 bytes

f) CRC – The field contains error detection information

NOTE –

802.1 Internetworking
802.2 LLC
802.3 Ethernet LAN
802.4 Token Bus LAN
802.5 Token Ring LAN
802.6 MAN

FRAME LENGTH

Minimum Payload length : 46 bytes
Maximum ——— : 1500 bytes

DESTINATION ADDRESS	SOURCE ADDRESS	LENGTH /bu	DATA & PADDING	CRC
6 bytes	6 Bytes	2 BYTES		4 BYTES

Minimum FRAME LENGH : 512 bits or 64 BYTES
Maximum Frame length : 12,144 BITS or 1518 BYTES

- 18 BYTES OF Header & Trailer (6 bytes of SA, 6 Bytes of DA, 2 bytes of length /Type & 4 bytes of CRC)

THEN
- a) Minimum length of data from upper layer is
  64 − 18 = 46 bytes
- b) Maximum length of Payload is 1500 byte.
  ie 1518 − 18
  = 1500 bytes

If upper layer packet is less than 46 bytes, Padding is added to make up the difference.

ADDRESSING − Each station on the Ethernet n/w (such as PC, workstation or Printer) has its own NIC (network interface card)

- NIC fits inside the station & provides the station with a 6 byte (48 bits) Physical address.

NOTE
0
1
2
3
4
5
6
7
8
9
10 — A
11 — B
12 — C
13 — D
14 — E
15 — F

Example of Ethernet address 06 : 01 : 02 : 01 : 2C : 4D

- A source address is always a Unicast address as frame comes only from one station
- The destination address however can be Unicast, Multicast or broadcast
- If the least significant bit of the first byte in a destination address is 0, the address is Unicast else Multicast
  LSB
- Broadcast is a special case of Multicast in which all bits are 1's

Example – Define the type of destination address

a) 4A : 30 : 10 : 21 : 10 : 1A — A (1010) = 10 even

b) 47 : 20 : 1B : 2E : 08 : EE — 7 (0111) . odd

c) FF : FF : FF : FF : FF : FF — all digits are Fs (1s) even) — Broadcast address

Sol:- look the 2nd hexadecimal digit from the left

- 1) If it is even, the address is unicast
  If it's odd, The address is multicast
  If all the digits are 1, the address is broadcast address

CATEGORIES OF STANDARD ETHERNET

Standard Ethernet common implementations

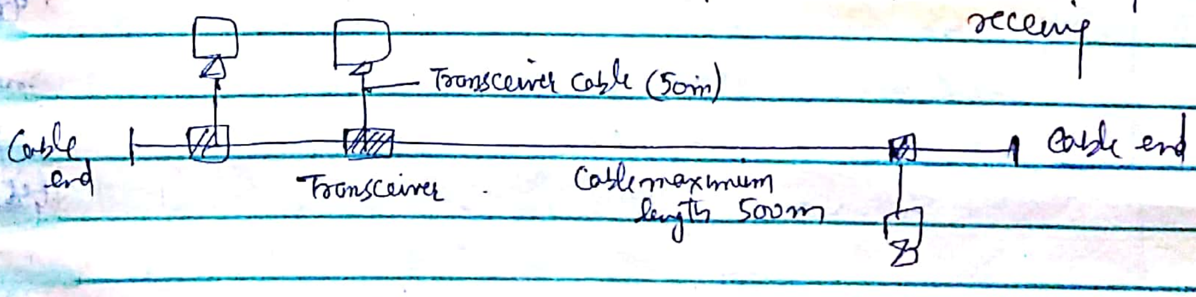
10 BASE 5	10 BASE 2	10 BASE-T	10 BASE-F
BUS	BUS	STAR	STAR
THICK COAXIAL	THIN COAXIAL	UTP	FIBER

A 10
B 11
C 12
D 13
E 14
F 15

10 BASE 5 : THICK ETHERNET

10 BASE 5
10Mbps – Baseband (digital) – 500m

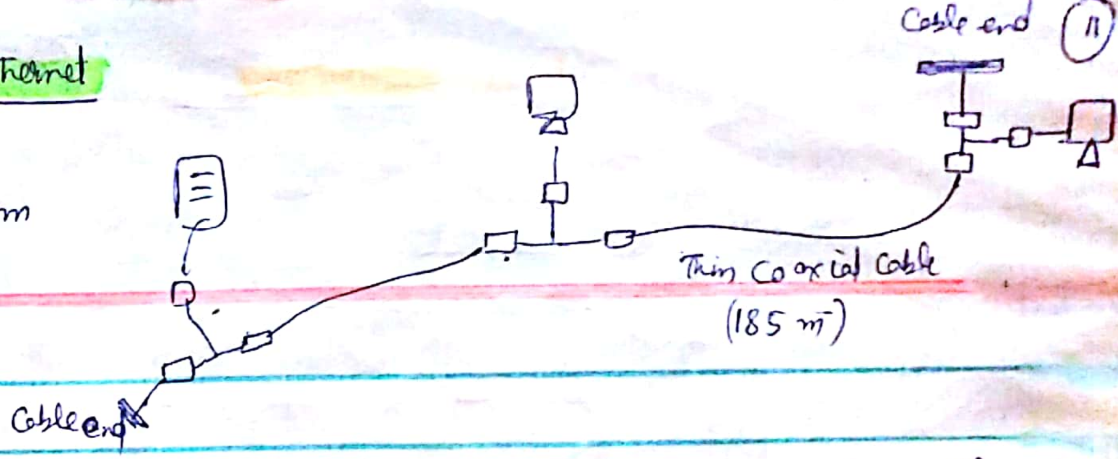
- 10 Base5 uses a bus topology with an external transceiver connected via a tap to Thick coaxial cable
- Transceiver is responsible for transmitting, receiving & detecting collision
- The transceiver is connected to the station via a transceiver cable that provides separate paths for sending & receiving



4 7 1
0100 1010,
0100 0111

10 Base 2 : Thin Ethernet

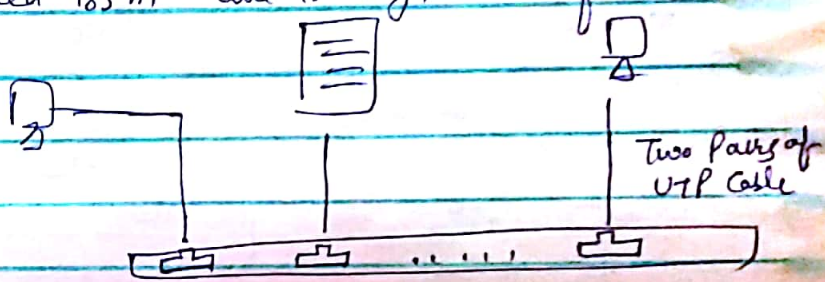
10 Base 2
10mbps — — 185m



- 10 Base2 uses bus topology but cable is much thinner & more flexible
- Implementation is more cost effective than 10 base5 because thin co-axial is less expensive than thick coaxial cable. Also T connectors are much cheaper than taps
- As coaxial cable is flexible so installation is simpler
- length of cable cannot exceed 185m due to high level of attenuation

10 BASE T : Twisted Pair Ethernet

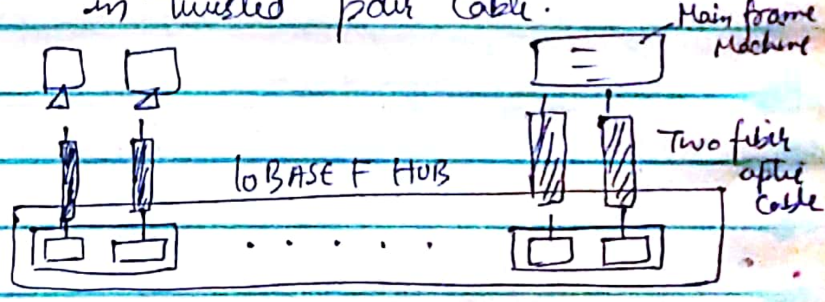
10mbps — Twisted pair — 100 m



- uses Star topology (SWITCH)
- Stations are connected to a hub via two pairs of twisted cable.
- Two pairs of twisted cable create two paths (one for sending & one for receiving) b/w the Station & the hub.
- Any collision here happens in the hub
- Maximum cable length of cable is 100 m to minimize the effect of attenuation in twisted pair cable.

10 BASE F : Fiber Ethernet

Fiber



- Uses a star topology to connect stations to a hub
- Stations are connected to the hub using two fiber optic cables

FAST ETHERNET

- It can transmit 10 times faster at a rate of 100 Mbps.
- Keep the same frame format
- Keep the same 48-bit address
- Keep same minimum & maximum frame length
- Compatible with Standard Ethernet.

It was designed to allow incompatible devices to connect to one another.

FAST ETHERNET IMPLEMENTATION

100 BASE-TX
- Two wires category
- CAT 5 UTP
- Transmits 100 mbPS data

100 BASE-FX
- Two WIRES (recv & send)
- FIBER
- Star Topology
- 412 meters

100 BASE-T4
- FOUR WIRES
- CATEGORY 3 UTP
- Star topology

GIGABIT ETHERNET

The goal of Gigabit Ethernet can be summarized as follows

1. upgrade the data rate to 1 GBPS.
2. Make it compatible with Standard or Fast Ethernet
3. use the Same 48 bit address
4. use the Same frame format.
5. Keep the Same minimum & maximum frame length

Gigabit Ethernet has two distinctive approaches for Medium access

Full duplex

- In F.D Mode, there is a central Switch connected to all computers or other Switches
- Each Switch has buffers for each input port in which data are stored until they are transmitted.
- There is no collision in this mode means no CSMA/CD is used

Half duplex

- A switch can be replaced by a hub which acts as the common cable in which a collision might occur
- It uses CSMA/CD
- Three methods have been defined.

③

① Traditional

- we keep minimum length of frame as in traditional Ethernet (512 bits)
- Maximum n/w length is 25 m
- This method is used when computers are connected in one single room

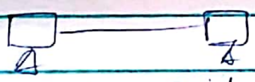
② Carrier Extension

- Minimum length of the frame is 512 bytes i.e 8 times longer than earlier
- If length of frame is less than 4096 bits, Padding is added
- Maximum length of n/w is increased 8 times to a length of 200m

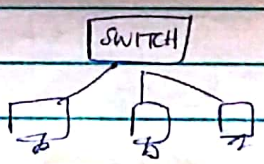
③ Frame Bursting –

- Carrier extension is inefficient when we have a series of short frames to send
- To improve efficiency, frame bursting is used
- To make these multiple frames to look like one frame padding is used

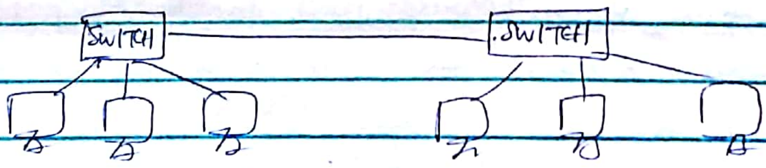
Topologies of Gigabit Ethernet



Point to Point



STAR



Two Star

GIGABIT ETHERNET IMPLEMENTATION

- 1000 BASE – SX
  - Two wire
  - Short wave fiber
- 1000 Base – LX
  - Two – wire
  - Long-wave fiber
- 1000 BASE – CX
  - Two wire
  - Copper (STP)
- 1000 BASE T
  - Four wire (Pair)
  - UTP

BRIDGED ETHERNET

- The first step in the Ethernet Evolution was the division of a LAN by Bridges.

- Bridges have two effects on an Ethernet

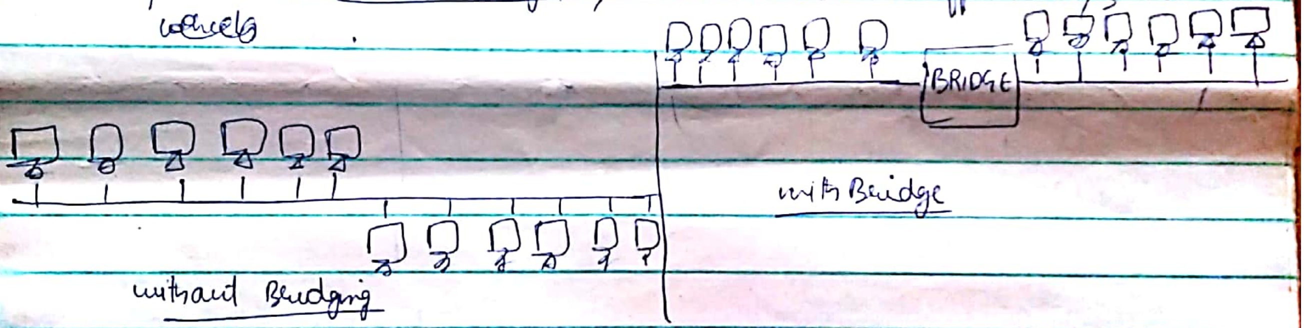
  ① They raise the bandwidth ② Separate collision domains

BRIDGE – connects two LANS to another LAN that uses the same Protocol (ex Ethernet)

① Raising the bandwidth

- A bridge divides the n/w into two or more n/ws.
- In Figure below, a n/w with 12 stations is divided into two n/ws each with 6 stations.
- Now each n/w has a capacity of 10 mbps. The 10 mbps capacity in each segment is now shared b/w 6 stations. (not 12 stations) ie $10/6$ mbps instead of $10/12$ Mbps.

- If we use a 4 Port bridge, each station is now offered $10/3$ Mbps which

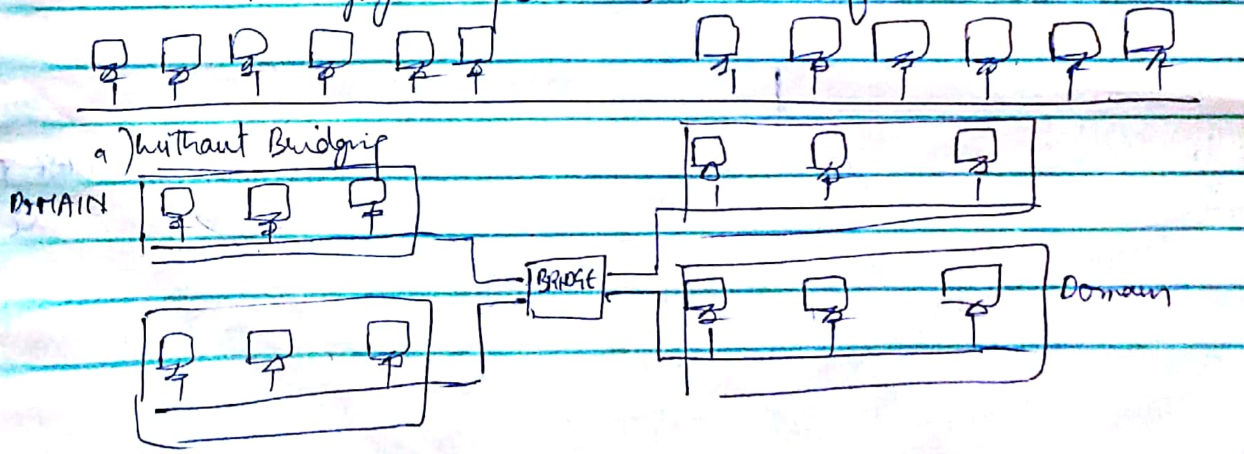


② Separating collision Domains

– Another advantage of a bridge is the separation of a collision domain.

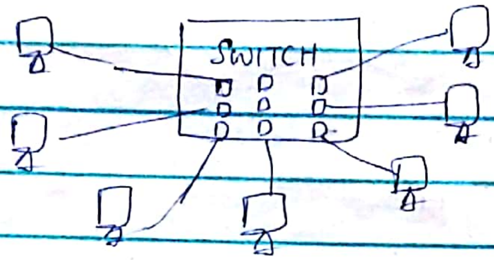
- The collision domain becomes much smaller & the Probability of collision is reduced tremendously when we use bridge.

- without bridging, 12 stations contend for access to the medium. with bridging only 3 stations contend for access to the medium



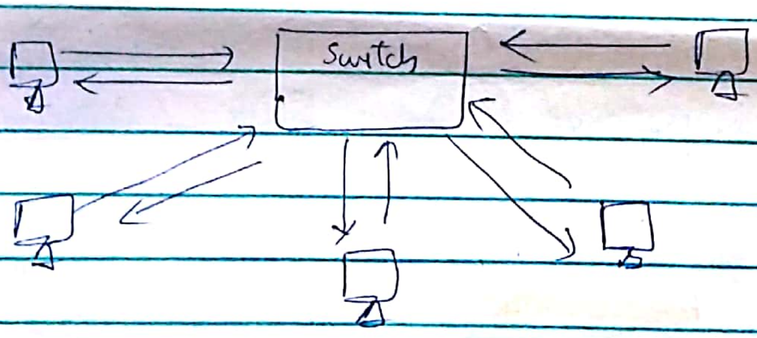
SWITCHED ETHERNET

- The idea of a bridged LAN can be extended to a switched LAN.
- Instead of having two to four n/ws, why not have N n/w's where N is the no. of stations on LAN.
- In this way, the bandwidth is shared only b/w the stations & the switch. In addition collision domain is divided into N domains.



Multi Port Ethernet bridge

- Full duplex Ethernet -
  - One of the limitations of 10Base5 & 10Base 2 is that communication is half duplex
  - The next step in the evolution was to move from switched Ethernet to full duplex switched Ethernet. It increases the capacity of each domain from 10 to 20 mbps.



use of two links b/w switch & the station

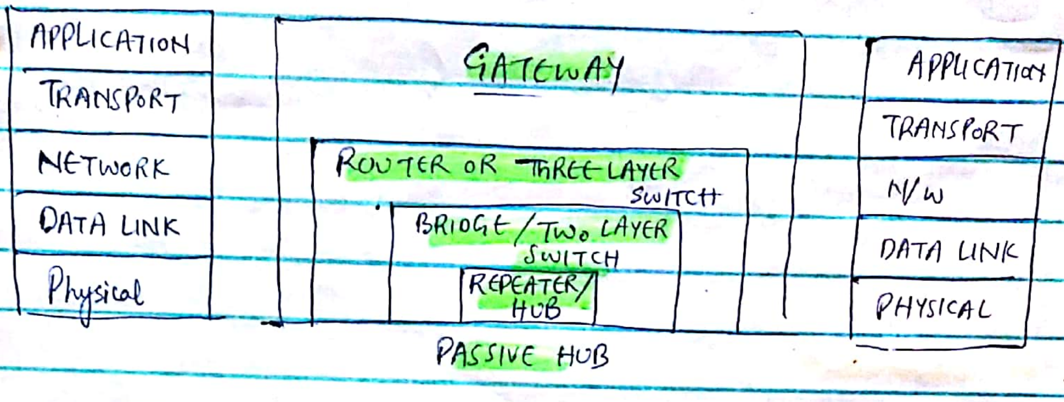
- No Need for CSMA/CD.

  In Full duplex switched Ethernet, each station is connected to a switch via two separate links to send & receive independently without worrying about collision. (no need for Carrier Sensing)

CONNECTING DEVICES

· Connecting devices can operate in different layer's of the Internet model.

· Connecting devices are divided into five different categories based on the layer in which they operate in a n/w.



① Those which operate below Physical layer — Passive hub

② Those which operate at Physical layer — Repeater or Active hub

③ Those which operate at Physical and data link layer — Bridge or a two layer Switch.

④ Those which operate at Physical + data link + network layer — Router & a three layer Switch.

5 Those which can operate at all five layer's — (GATEWAY)

① PASSIVE HUB

· A Passive hub is just a connector

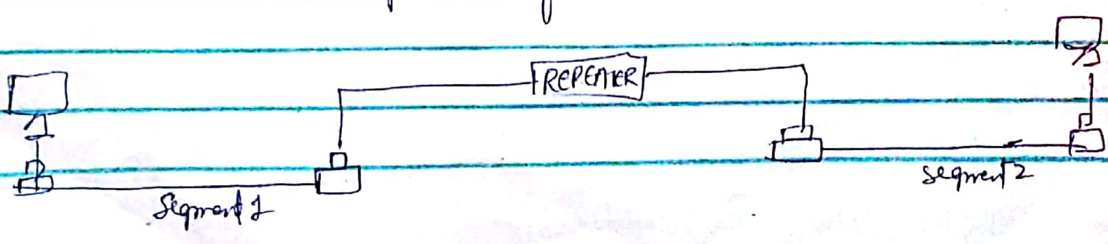
· It connects wires comming from different branches.

· In internet model, it is below the physical layer.

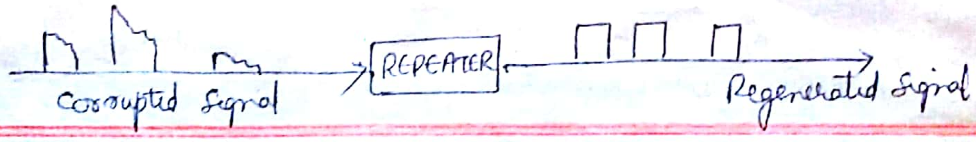
② REPEATERS — device operates in the physical layer.

· A repeater receives a signal & before it becomes too weak or corrupted, regenerates the original bit pattern.

· It connects two segments of the same LAN



A repeater does not amplify the signal, it regenerates the signal

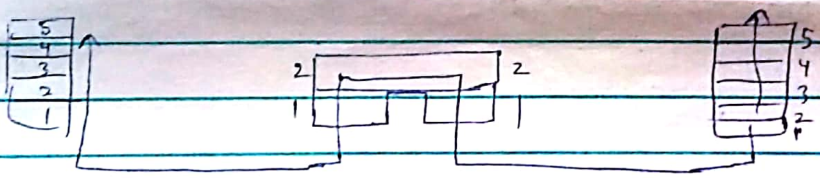


ACTIVE HUB – A multiport repeater used to create connections b/w stations in a physical star topology

BRIDGE –

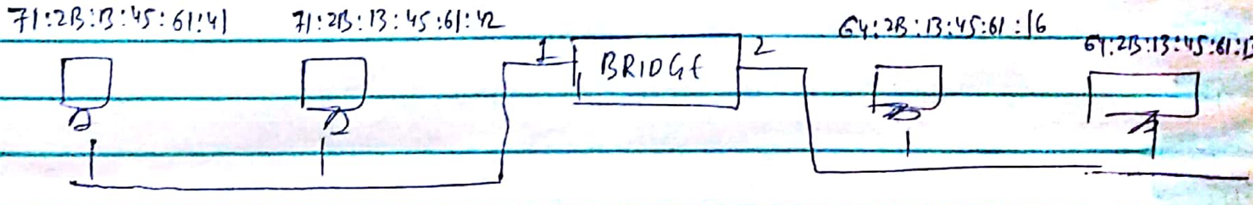
- operates in both Physical & the data link layer.
- At a Physical layer – it regenerates the signal it receives.
- At data link layer – bridge checks Physical (MAC) address contained in the frame.

Imp. A bridge has filtering capacity. – it can check the destination address of a frame & decide if the frame should be forwarded or dropped. If frame is to be forwarded, the decision must specify the port. A bridge has a table that maps addresses to ports



ADDRESS	PORT
71:2B:13:45:61:41	1
71:2B:13:45:61:42	1
64:2B:13:45:61:16	2
64:2B:13:45:61:13	2

BRIDGE TABLE



- A. To Table, Frame for 712B134561 41 leave through Port 1, therefore there is no need for forwarding & frame is dropped.
- On other hand, if frame for 712B13456141 arrives at port 2, the departing port is port 1 & frame is forwarded.