Carrier Sense Multiple Access (CSMA)

This method was developed to decrease the chances of collisions when two or more stations start sending their signals over the data link layer. Carrier Sense multiple access requires that each station **first check the state of the medium** before sending.

1-Persistent CSMA

- ★ Before sending the data, the station first listens to the channel to see if anyone else is transmitting the data at that moment.
- ★ If the channel is idle, the station transmits a frame.
- ★ If busy, then it senses the transmission medium continuously until it becomes idle.
- ★ Since the station transmits the frame with the probability of 1 when the carrier or channel is idle, this scheme of CSMA is called as 1-Persistent CSMA.

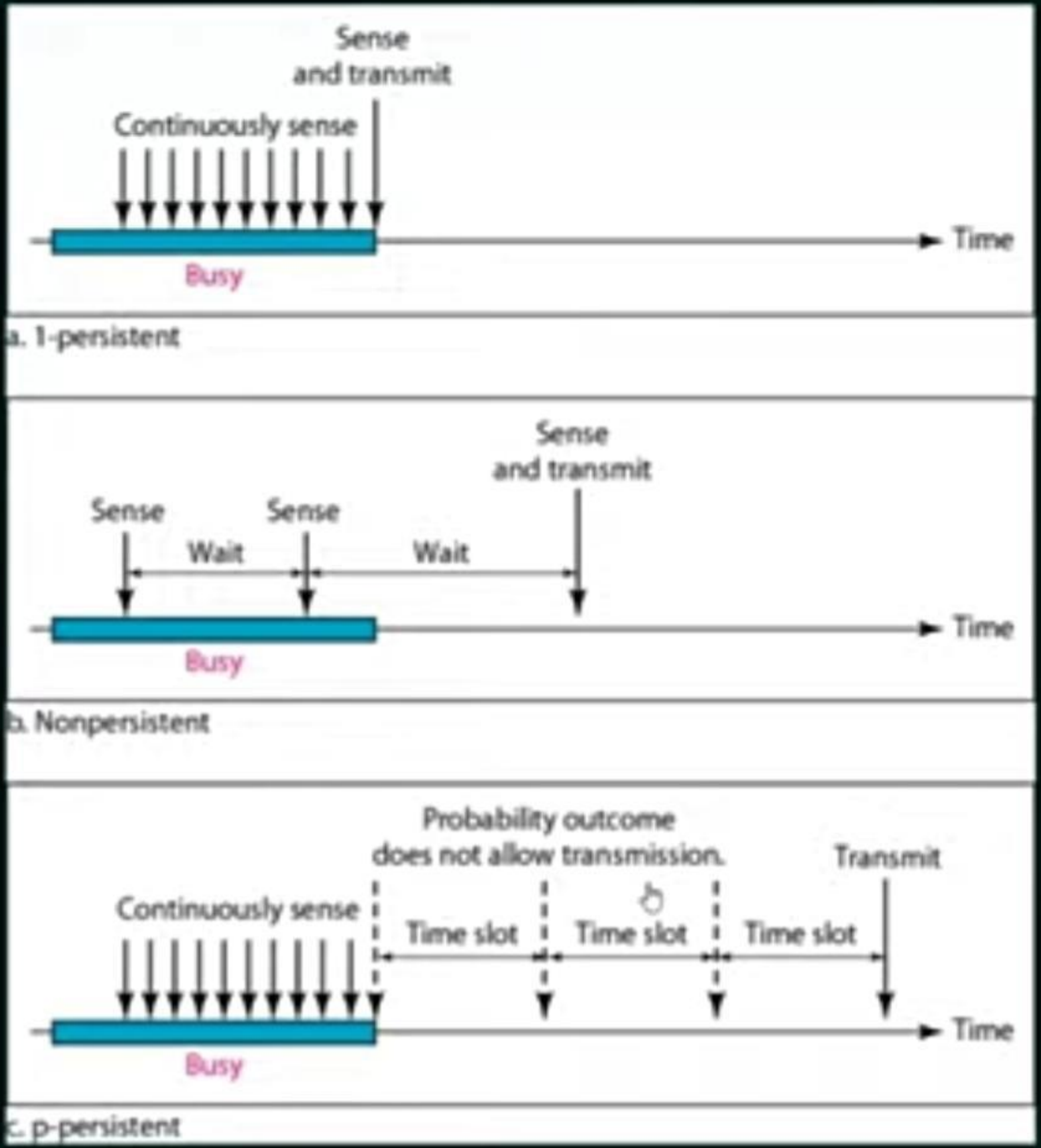
NON-PERSISTENT CSMA

- ★ Before sending, a station senses the channel. If no one else is sending, the station begins doing so itself.
- ★ However, if the channel is already in use, the station does not continually sense it for the purpose of seizing it immediately upon detecting the end of the previous transmission.
- ★ Instead, it waits a random period of time and then repeats the algorithm. Consequently, this algorithm leads to better channel utilization but longer delays than 1-persistent CSMA.

P-Persistent CSMA

- ★ It applies to slotted channels.
- ★ When a station becomes ready to send, it senses the channel.
- ★ If it is idle, it transmits with a probability P.
- ★ With a probability Q=1-P, it defers until the next slot.
- ★ If that slot is also idle, it either transmits or defers again, with probabilities P and Q.
- ★ This process is repeated until either the frame has been transmitted or another station has begun transmitting.
- ★ In the latter case, the unlucky station acts as if there had been a collision (i.e., it waits a random time and starts again).
- ★ If the station initially senses the channel busy, it waits until the next slot and applies the above algorithm.

Behaviour of three persistent methods



CSMA/CD

★ If two stations sense the channel to be idle and begin transmitting simultaneously, they will both detect the collision almost immediately.

★ Rather than finish transmitting their frames, which are irretrievably garbled anyway, they should abruptly stop transmitting as soon as the collision is detected.

★ Quickly terminating damaged frames saves time and bandwidth.

★ This protocol, known as CSMA/CD (CSMA with Collision Detection) is widely used on LANs in the MAC sublayer.

★ Access method used by Ethernet: CSMA/CD.

2. Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) –

The basic idea behind CSMA/CA is that the station should be able to receive while transmitting to detect a collision from different stations. In wired networks, if a collision has occurred then the energy of the received signal almost doubles, and the station can sense the possibility of collision. In the case of wireless networks, most of the energy is used for transmission, and the energy of the received signal increases by only 5-10% if a collision occurs. It can't be used by the station to sense collision. Therefore **CSMA/CA has been specially designed for wireless networks**.

These are three types of strategies:

1. **InterFrame Space (IFS):** When a station finds the channel busy it senses the channel again, when the station finds a channel to be idle it waits for a period of time called **IFS time**. IFS can also be used to define the priority of a station or a frame. Higher the IFS lower is the priority.
2. **Contention Window:** It is the amount of time divided into slots. A station that is ready to send frames chooses a random number of slots as **wait time**.
3. **Acknowledgments:** The positive acknowledgments and time-out timer can help guarantee a successful transmission of the frame.

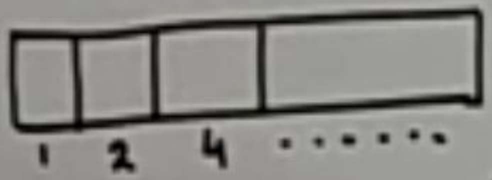
Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) → wireless N/W.

Flow Diagram:-

IFS: Interframe space
↳ period of time

↓IFS: ↑ Priority.

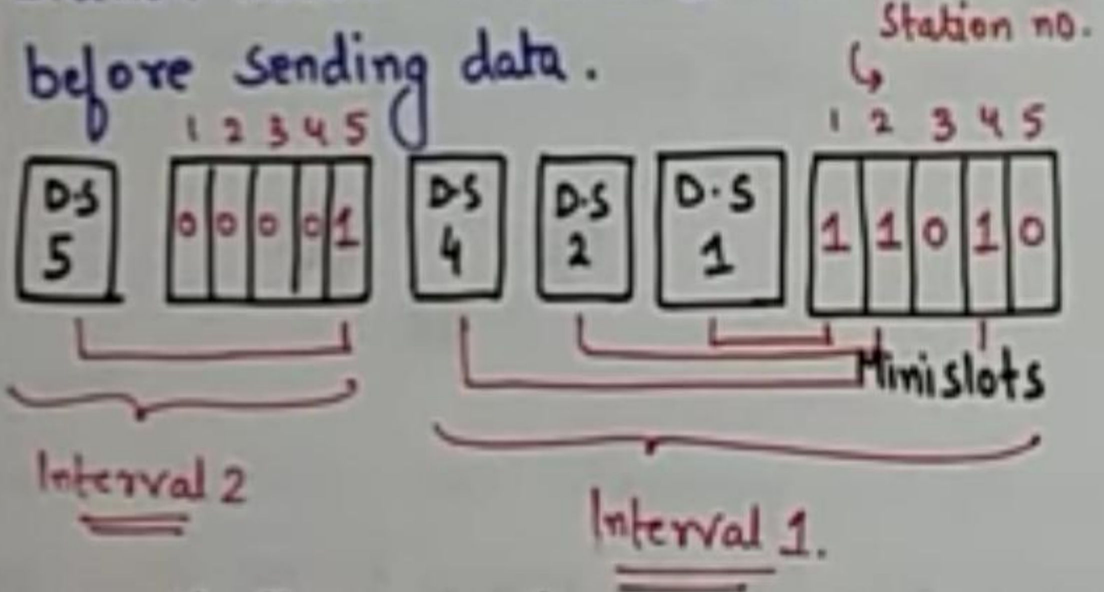
Contention Window: Amount of time divided into Slots.



Acknowledgment → +ve / → -ve] Time-out

Controlled Access:- In this technique, all the Stations consult one another to find which Station has the right to send.

(1.) Reservation Method:- In this method, a Station needs to make a reservation, before sending data.

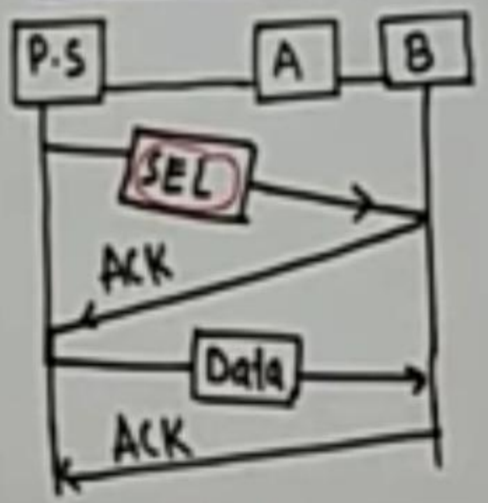


NOTE:- If there are 'N' Stations in the system, there are exactly 'N' reservation minislots in the reservation frame.

(2.) Polling Method:- Works with topologies. In this one device is designated as Primary Station, and the other devices are secondary Station.

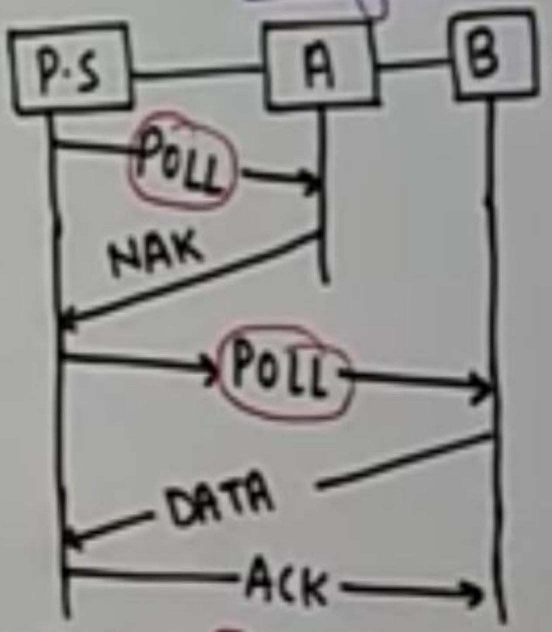
IMP:- All data exchanges must be made through the primary device.
↳ It Controls the link.

Select Function



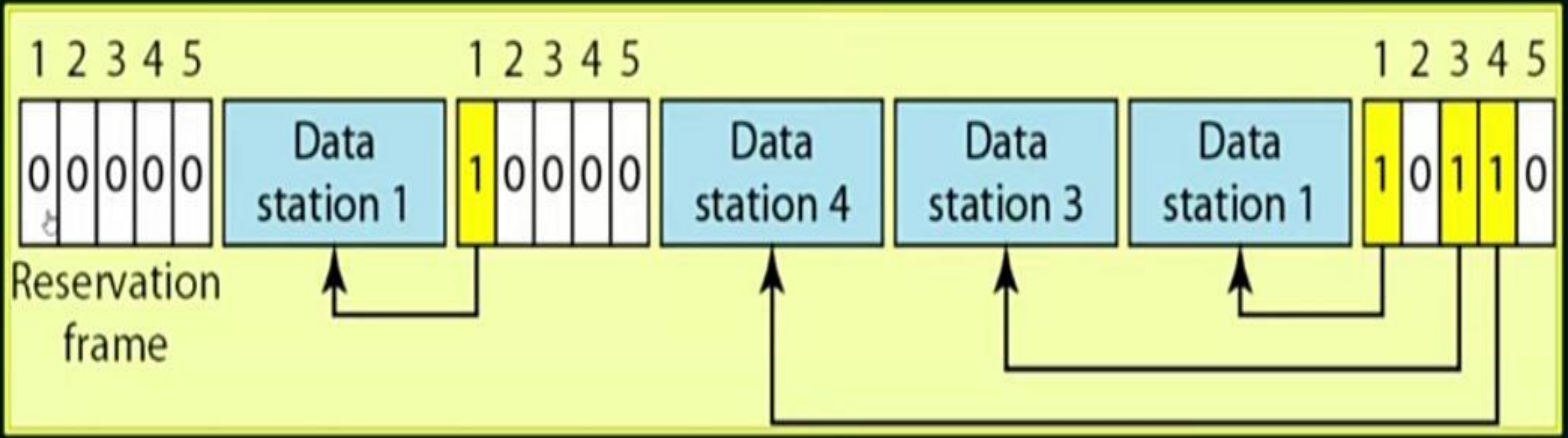
Used when Primary wants to Send Data

Polling function

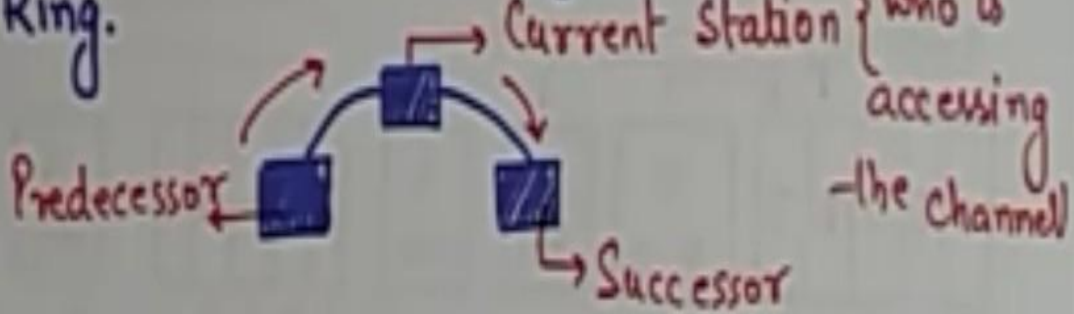


Used when Primary wants to Receive data.

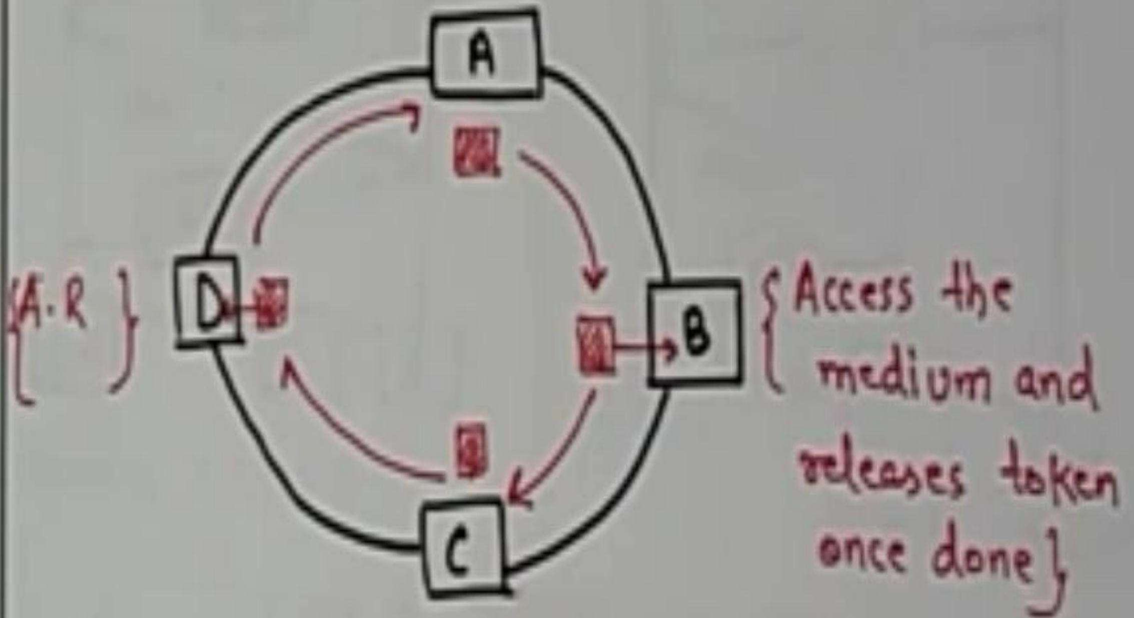
RESERVATION



(8) Token Passing Method:- In this, the stations in a network are organized in a Logical Ring.

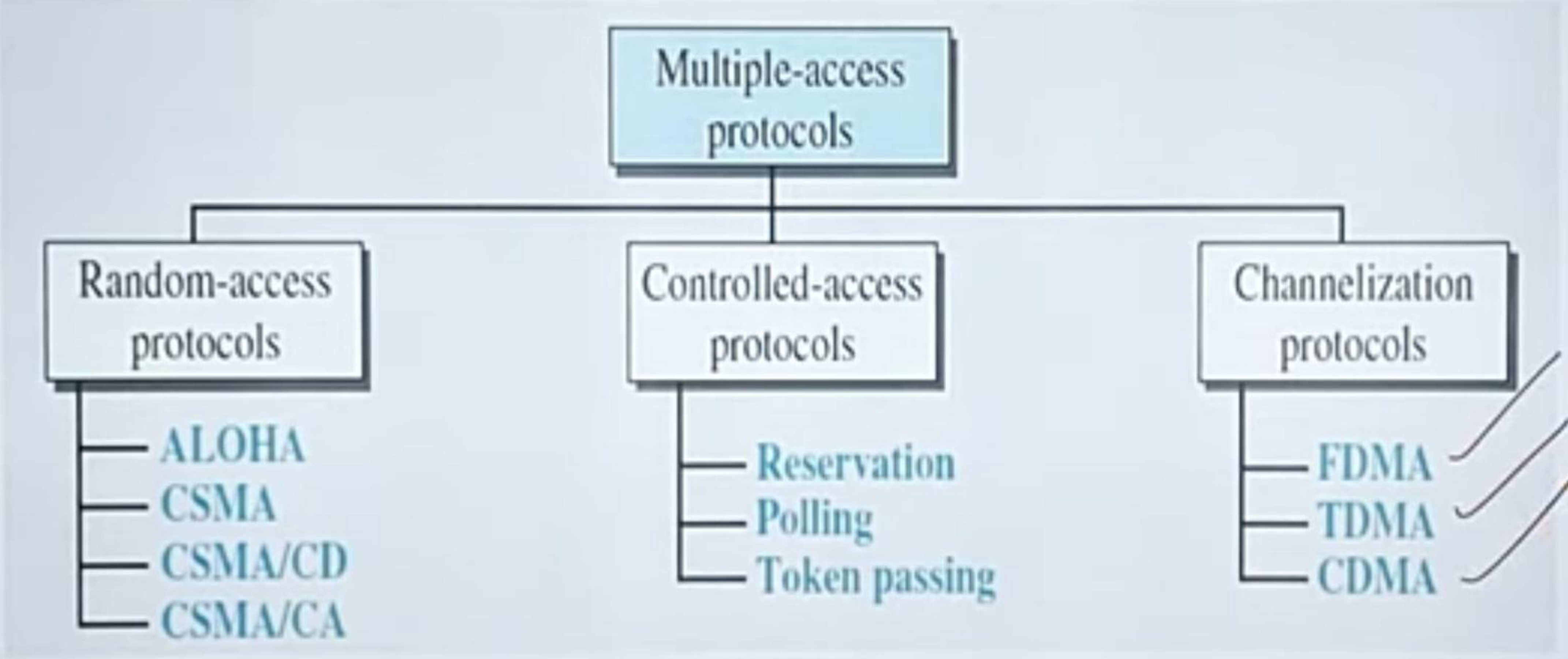


In this method, a special packet called a Token circulates through the ring. The possesion of the token gives the station right to access the channel and sends its data.



CHANNELIZATION

- Channelization is a multiple-access method in which the available bandwidth of a link is share in time, frequency, or through code, between different stations. In this section, we discuss three channelization protocols: FDMA, TDMA, and CDMA.

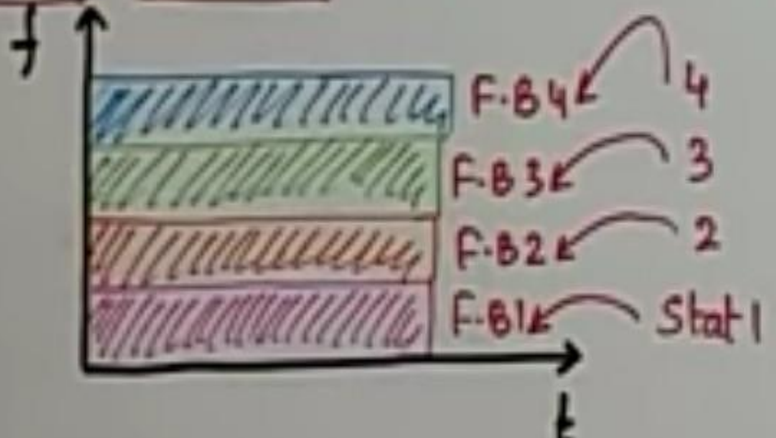


Channelization:- It is a multiple-access method in which the available bandwidth of a link is shared in time, frequency or through code.

- time → TDMA
- frequency → FDMA
- code → CDMA

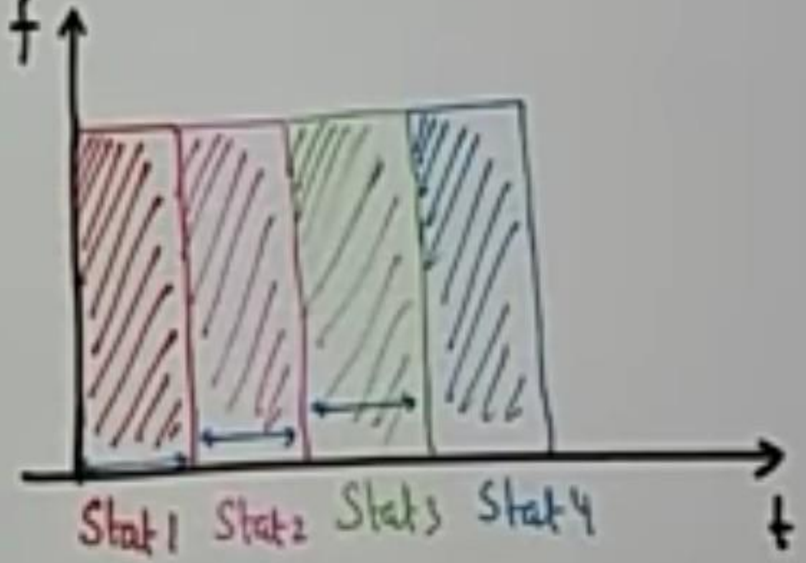
(1) Frequency-Division Multiple Access (FDMA):-

→ Available Bandwidth is divided into frequency bands. Each Station is allocated a band to send its data and it belongs to the Station all the time.



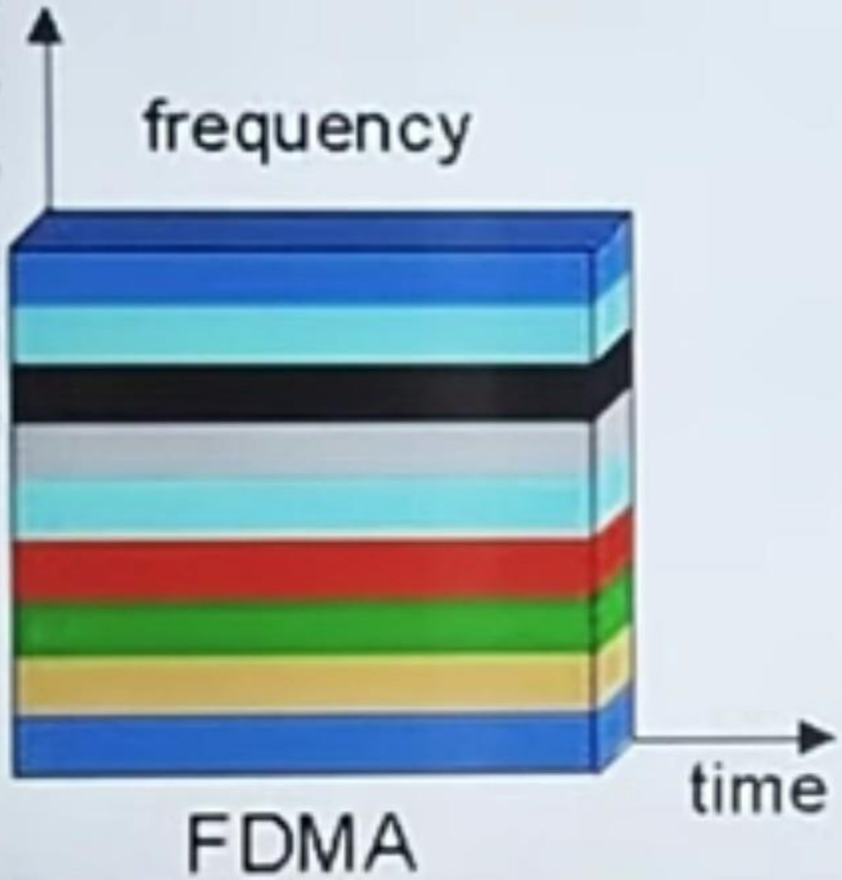
(2) Time-Division Multiple Access (TDMA):- In this method the Stations share the bandwidth of channel in TIME. Each Station is allocated a time slot during which it can send data.

[**IMP:-** In TDMA, the bandwidth is just one channel that is timeshared b/w different stations.]



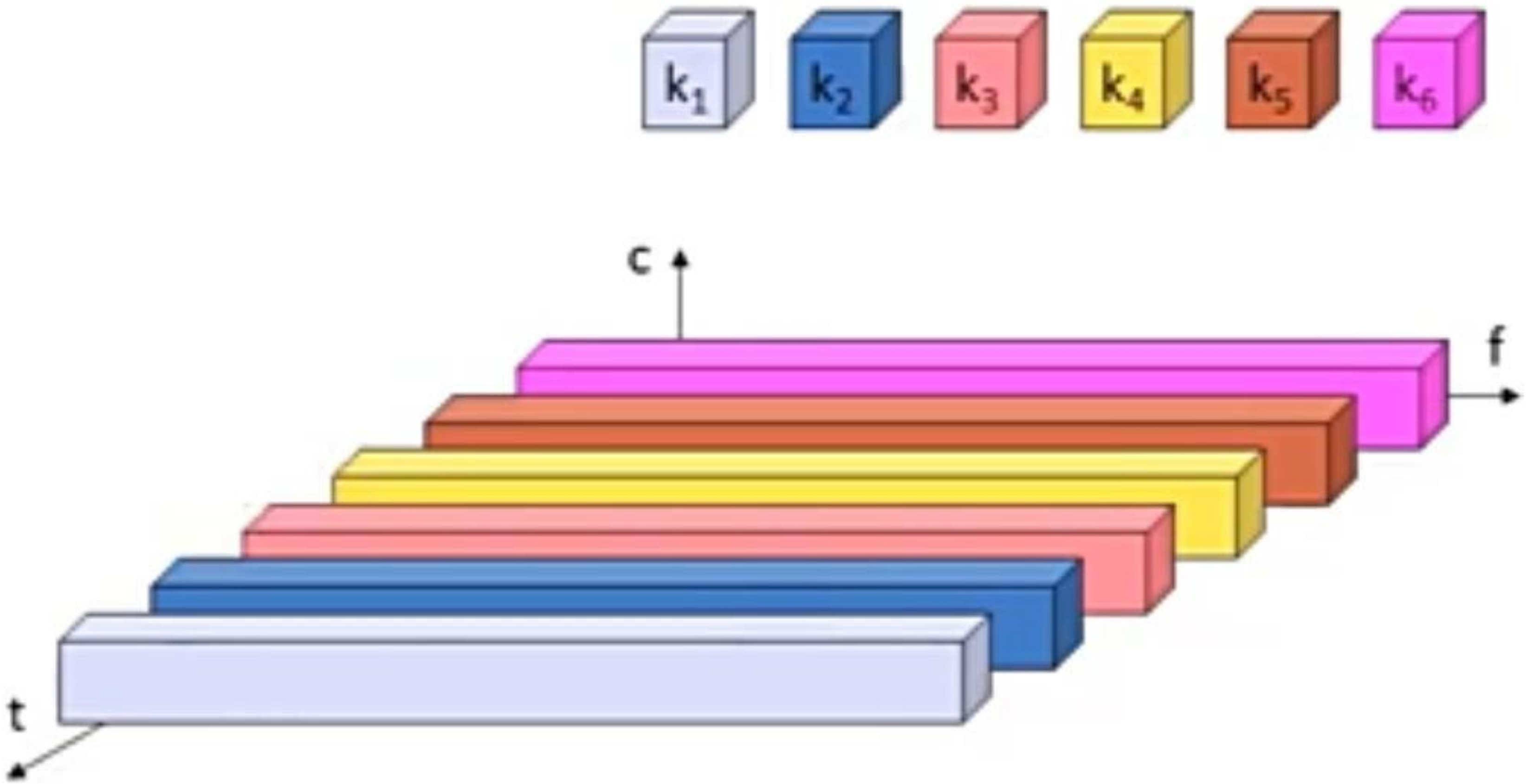
Frequency-Division Multiple Access (FDMA)

- In frequency-division multiple access (FDMA), the available bandwidth is divided into frequency bands. Each station is allocated a band to send its data.
- In other words, each band is reserved for a specific station, and it belongs to the station all the time.



Frequency	Station Name
90.4	Bol Radio
91.1	Radio City
92.7	BIG FM 92.7
93.5	RED FM
94.3	Fever
95	Mirchi95
98.3	Radio Mirchi
101.9	AIR Rainbow
102.8	AIR Vividh Bharati
104	KOOL FM
105.6	IGNOU Gyan Vani
106.4	Magic FM
107.8	Deccan Radio
107.8	Radio Charminar

TDMA



Code-Division Multiple Access (CDMA):-

In this method, one channel carries all transmission simultaneously.

CDMA means communication with different codes.

How Communication with codes takes place:-

↳ (i) If codes are multiply with each other, then the ans. is '0'.

(ii) If codes are multiply by itself, then we get 4 [no. of stn].

St1. ↳ c_1

St2. ↳ c_2

St3. St4.

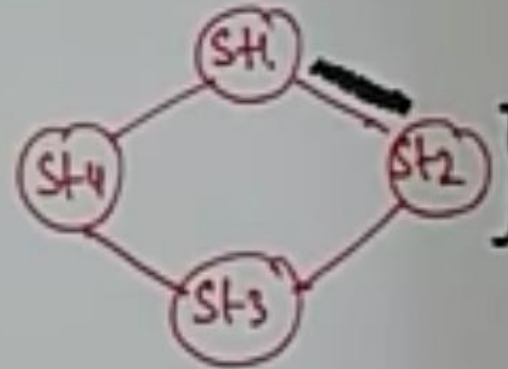
$\underline{c_2 \times c_2 = 4}$

$\underline{c_1 \times c_2 = 0}$

$$
\left.
\begin{array}{l}
St1. \rightarrow d_1 \rightarrow c_1 \Rightarrow c_1 \times d_1 \\
St2. \rightarrow d_2 \rightarrow c_2 \Rightarrow c_2 \times d_2 \\
St3. \rightarrow d_3 \rightarrow c_3 \Rightarrow c_3 \times d_3 \\
St4. \rightarrow d_4 \rightarrow c_4 \Rightarrow c_4 \times d_4
\end{array}
\right]
$$

$(c_1 \times d_1) + (c_2 \times d_2) + (c_3 \times d_3) + (c_4 \times d_4)$

on a single channel



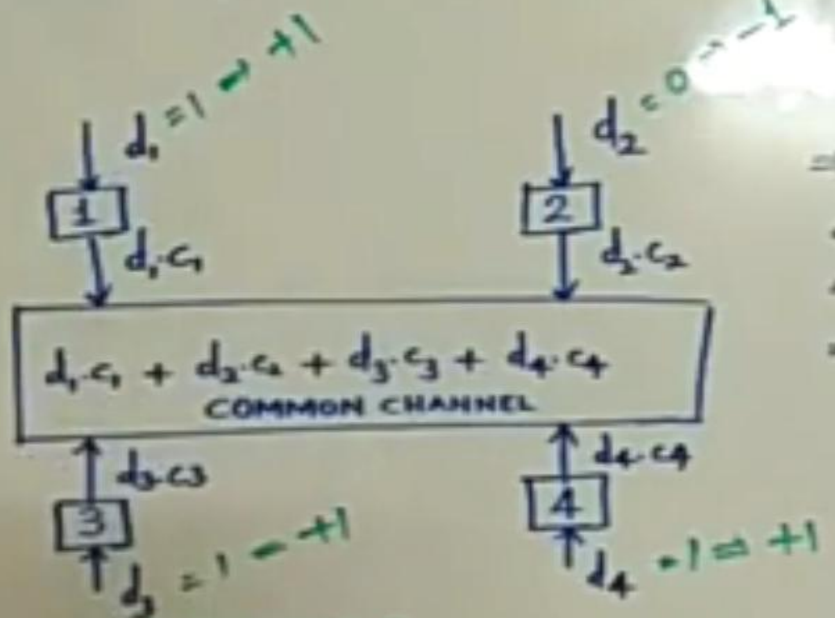
} Station 2 wants to hear what St.1 says

$$\left[(c_1 \times d_1) + (c_2 \times d_2) + (c_3 \times d_3) + (c_4 \times d_4)\right] c_1$$

$$(\underbrace{c_1 \times c_1}_{4} \times d_1) + (\underbrace{c_1 \times c_2 \times d_2}_{0}) + (\underbrace{c_1 \times c_3 \times d_3}_{0}) + (\underbrace{c_1 \times c_4 \times d_4}_{0})$$

$$= (4 \times d_1) \longrightarrow \frac{(4 \times d_1)}{4} = d_1$$

CODE DIVISION MULTIPLE ACCESS (CDMA)



Assume: $d_1 = 1,\quad d_2 = 0,\quad d_3 = 1,\quad d_4 = 1$

$= +1 \qquad = -1 \qquad = +1 \qquad = +1$

$\Rightarrow d_1 \cdot c_1 = (+1)(+1\ +1\ +1\ +1) = +1\ +1\ +1\ +1$

$\Rightarrow d_2 \cdot c_2 = (-1)(+1\ -1\ +1\ -1) = -1\ +1\ -1\ +1$

$\Rightarrow d_3 \cdot c_3 = (+1)(+1\ +1\ -1\ -1) = +1\ +1\ -1\ -1$

$\Rightarrow d_4 \cdot c_4 = (+1)(+1\ -1\ -1\ +1) = +1\ -1\ -1\ +1$

$$\boxed{(+1\ +1\ +1\ +1) + (-1\ +1\ -1\ +1) + (+1\ +1\ -1\ -1) + (+1\ -1\ -1\ +1)}$$

Common Channel

Receiving side:

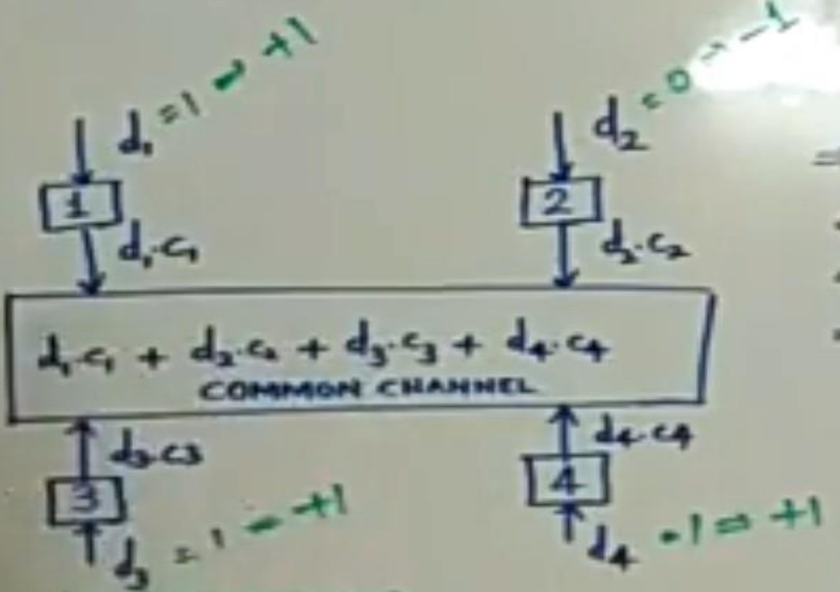
Orthogonal sequence

CHIP SEQUENCES	DATA REPRESENTATION
$c_1 = +1\ +1\ +1\ +1$	Data bit 0 ⟶ -1
$c_2 = +1\ -1\ +1\ -1$	Data bit 1 ⟶ +1
$c_3 = +1\ +1\ -1\ -1$	Silence ⟶ 0
$c_4 = +1\ -1\ -1\ +1$	

$c_1 \cdot c_2 = \cancel{(+1)} + \cancel{(-1)} + \cancel{(+1)} + \cancel{(-1)} = 0$

$c_3 \cdot c_3 = (+1) + (+1) + (+1) + (+1) = +4$

CODE DIVISION MULTIPLE ACCESS (CDMA)



Assume: $d_1 = 1$, $d_2 = 0$, $d_3 = 1$, $d_4 = 1$
$= +1$ $\quad = -1$ $\quad = +1$ $\quad = +1$

$\Rightarrow d_1 \cdot c_1 = (+1)(+1\ +1\ +1\ +1) = +1\ +1\ +1\ +1$

$\Rightarrow d_2 \cdot c_2 = (-1)(+1\ -1\ +1\ -1) = -1\ +1\ -1\ +1$

$\Rightarrow d_3 \cdot c_3 = (+1)(+1\ +1\ -1\ -1) = +1\ +1\ -1\ -1$

$\Rightarrow d_4 \cdot c_4 = (+1)(+1\ -1\ -1\ +1) = +1\ -1\ -1\ +1$

$$\boxed{(+1\ +1\ +1\ +1) + (-1\ +1\ -1\ +1) + (+1\ +1\ -1\ -1) + (+1\ -1\ -1\ +1)}$$

Common Channel $\quad (+1\ -1\ +1\ -1)$

Receiving side:

$\Rightarrow \cancel{+1}\ \cancel{-1}\ \cancel{+1}\ \cancel{-1}\ -1\ -1\ -1\ -1\ \cancel{+1}\ \cancel{-1}\ \cancel{-1}\ \cancel{+1}\ \cancel{+1}\ \cancel{+1}\ \cancel{-1}\ \cancel{-1}$

$= \underline{-4}/4 = \underline{-1} \Rightarrow \underline{0}$

Orthogonal sequence

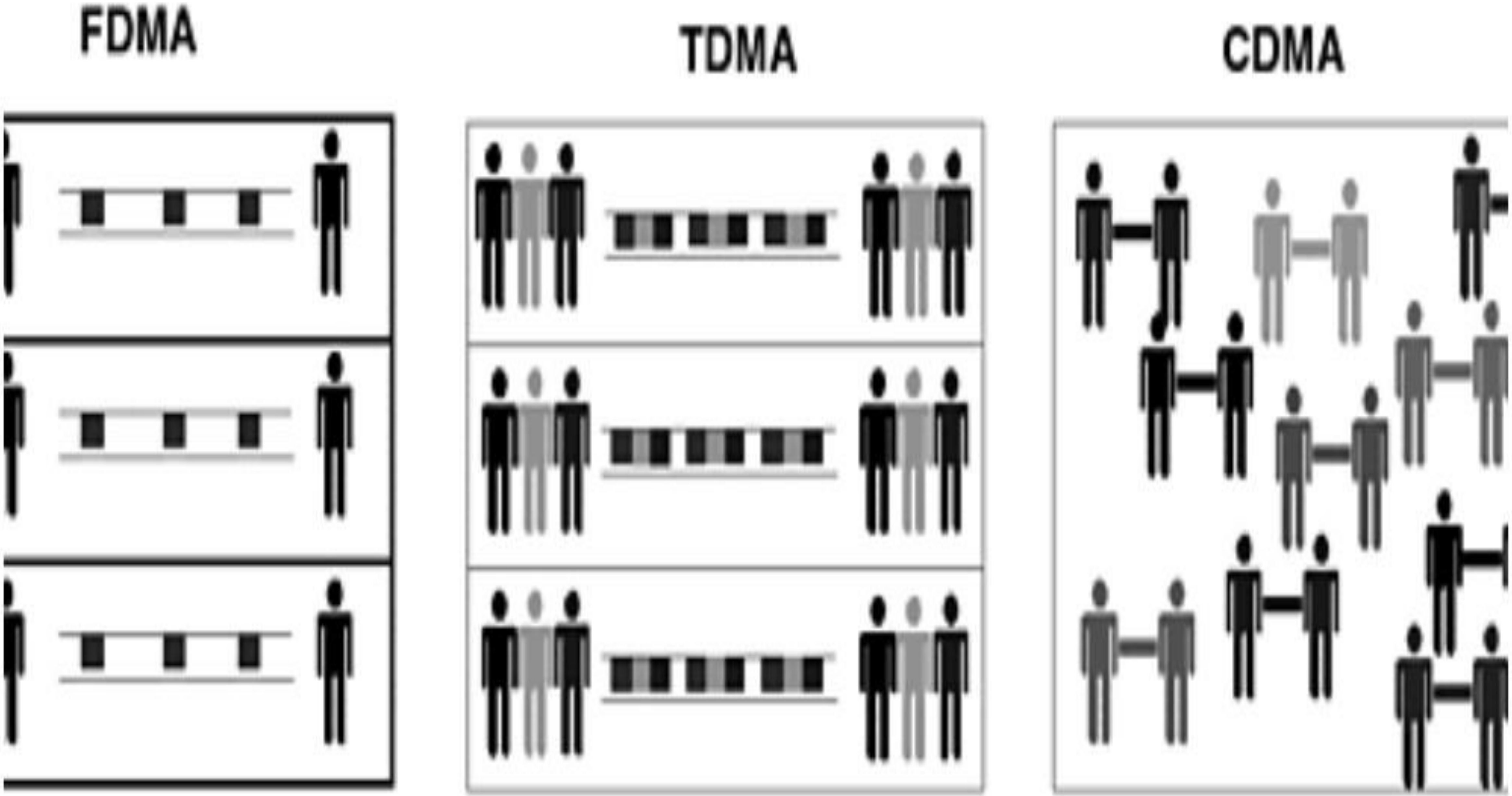
CHIP SEQUENCES	**DATA REPRESENTATION**
$c_1 = +1\ +1\ +1\ +1$	Data bit $0 \longrightarrow -1$
$c_2 = +1\ -1\ +1\ -1$	Data bit $1 \longrightarrow +1$
$c_3 = +1\ +1\ -1\ -1$	Silence $\longrightarrow 0$
$c_4 = +1\ -1\ -1\ +1$	

$c_1 \cdot c_3 = \cancel{(+1)} + \cancel{(-1)} + \cancel{(+1)} + \cancel{(-1)} = 0$

$c_3 \cdot c_3 = (+1) + (+1) + (+1) + (+1) = +4$

Comparison of FDMA, TDMA, CDMA

Feature	FDMA	TDMA	CDMA
High carrier frequency stability	Required	Not necessary	Not necessary
Timing/synchronization	Not required	Required	Required
Near-far problem	No	No	Yes, power control tech.
Variable transmission rate	Difficult	Easy	Easy
Fading mitigation	Equalizer not needed	Equalizer may be needed	RAKE receiver possible
Power monitoring	Difficult	Easy	Easy
Zone size	Any size	Any size	Large size difficult


FDMA
TDMA
CDMA

Ethernet:

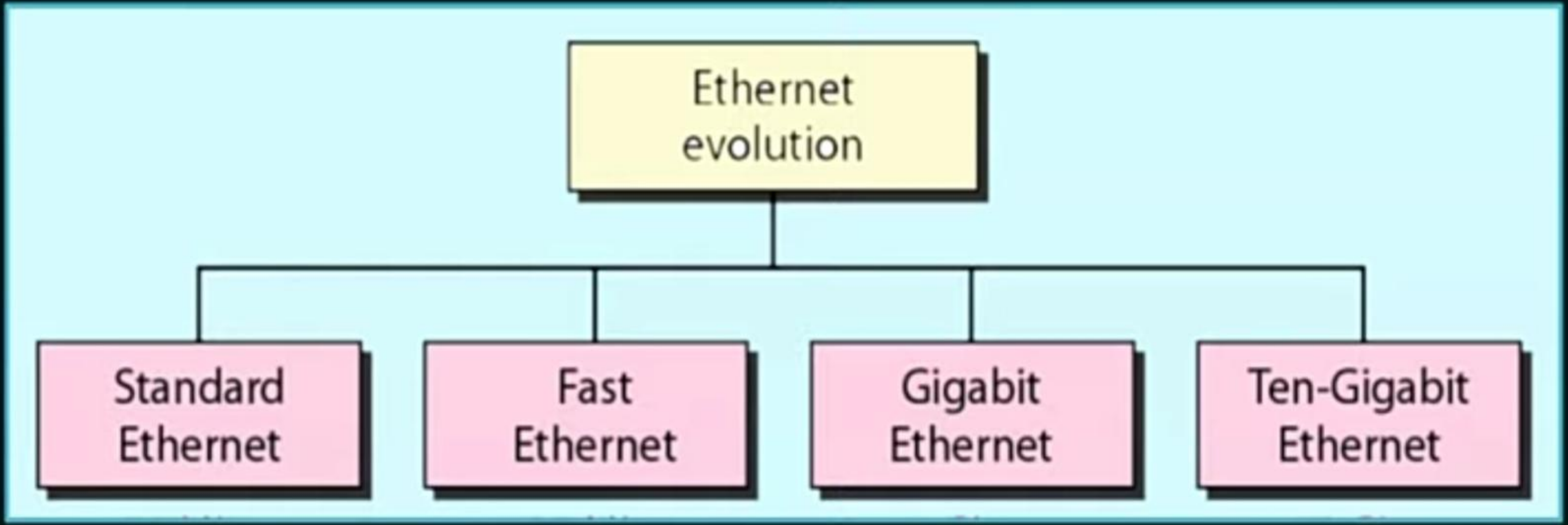
1. Ethernet is the most commonly used LAN Protocol.

2. It uses a high speed network cable. It is inexpensive and easy to install.

3. All computers in ethernet use same cable to send and receive data.

4. They must follow the same rules for communication.

EVOLUTION OF ETHERNET



10 Mbps 100 Mbps 1 Gbps 10 Gbps

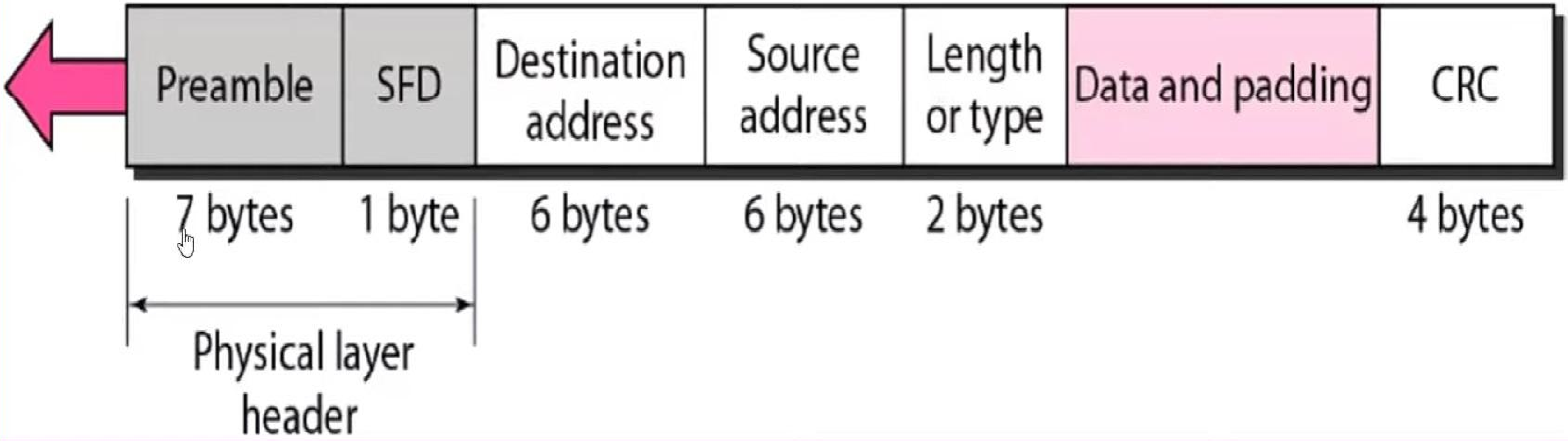
important differences between Ethernet and LAN.

Key	Ethernet	LAN
Definition	Ethernet represents Prevalent Packet Switched LAN.	LAN stands for Local Area Network.
Topology	Ethernet uses bus and star topology.	LAN uses bus, star and ring topology.
Control	Ethernet control is decentralized.	LAN control is centralized.
Transmission Media	Guided Transmission media is used in Ethernet.	Both guided and non-guided transmission media are used in LAN.
Reliability	Ethernet reliability is low.	LAN reliability is high.
Transmission	Limitations appear in Ethernet during transmission.	No limitation problem in LAN during transmission.

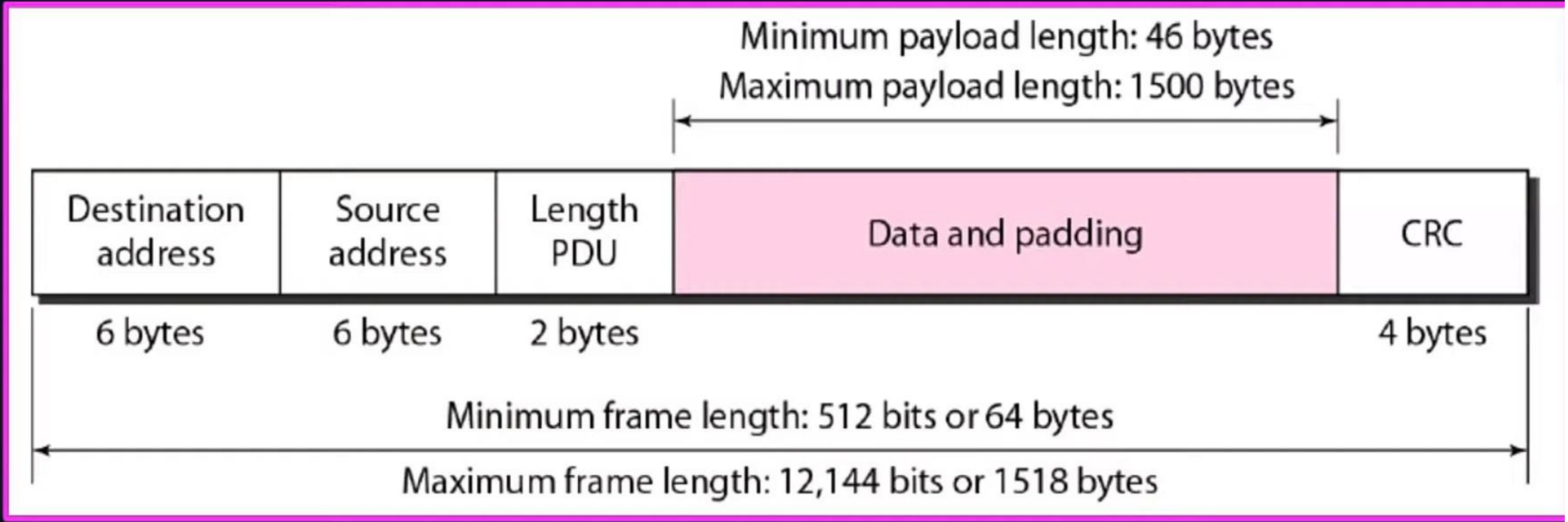
Ethernet frame format

Preamble: 56 bits of alternating 1s and 0s.

SFD: Start frame delimiter, flag (10101011)



Ethernet frame – Min and Max Length



Frame length:

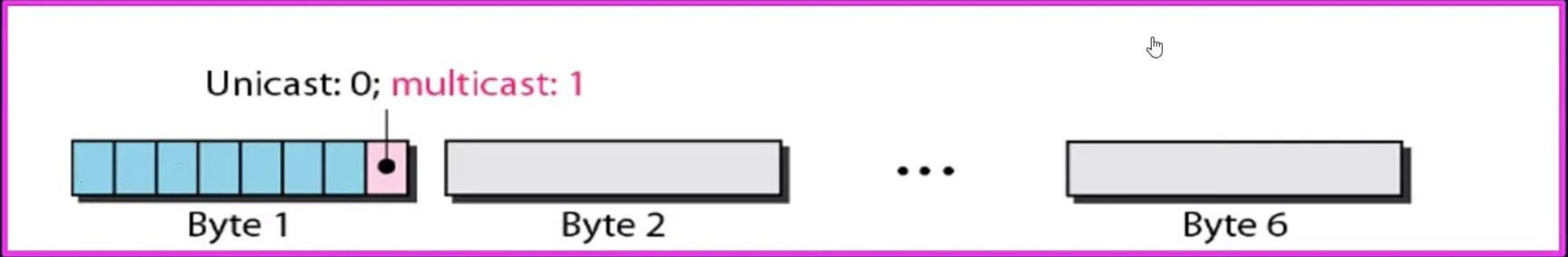
Minimum: 64 bytes (512 bits)

Maximum: 1518 bytes (12,144 bits)

Ethernet address

Example – 06:01:02:01:2C:4B

06:01:02:01:2C:4B <=> 6 bytes <=> 12 hex digits <=>48 bits



The least significant bit of the first byte defines the type of address.

If the bit is 0, the address is unicast; otherwise, it is multicast.

If all bits are 1, then it is broadcast address

MAC

A1 : 2B : C4 : D2 : 89 : A5

A1 - 2B - C4 - D2 - 89 - A5

1B 1B 1B 1B 1B 1B

6 Byte

48 bit

MAC

A2 : 2B : C4 : D2 : 89 : A5

→ Types

① Unicast

② Multicast

③ Broadcast

LSB 1 byte → '0'

A 2

1010 0010

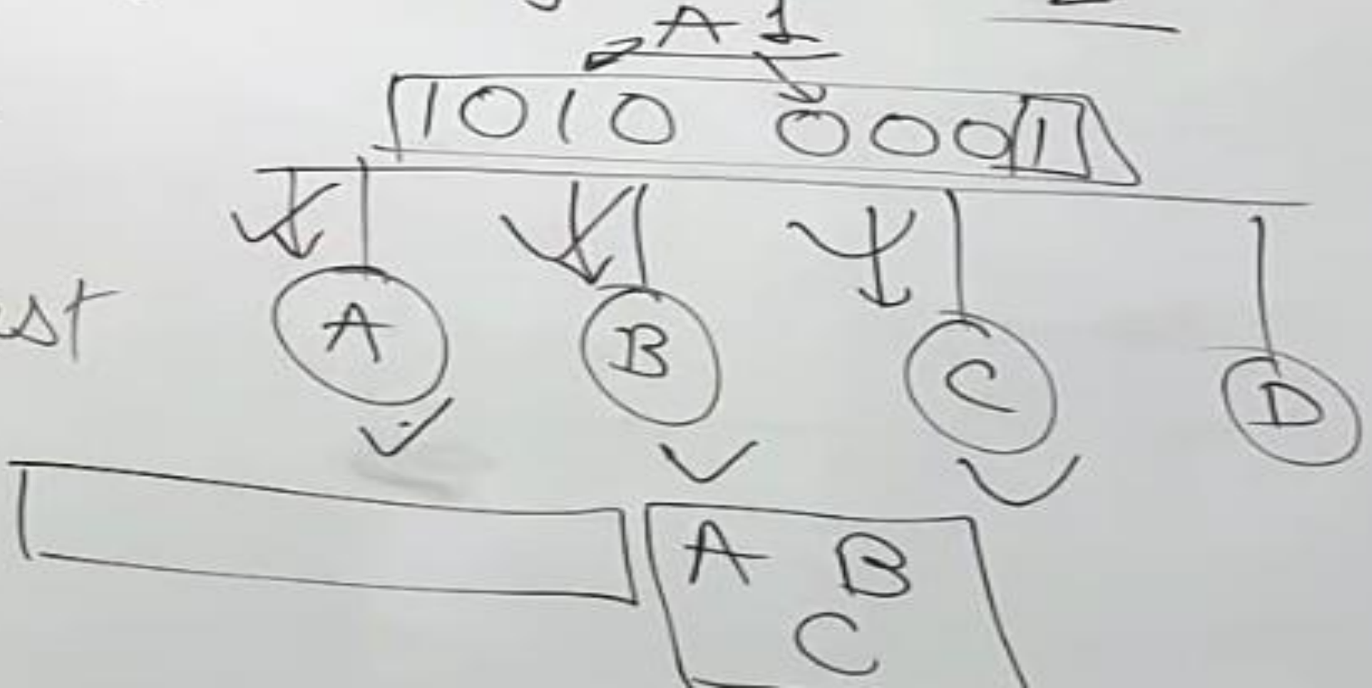
MAC

A1 : 2B : C4 : D2 : 89 : A5

→ Types

1. Unicast
2. Multicast
3. Broadcast

LSB 1 byte → '1'



MAC

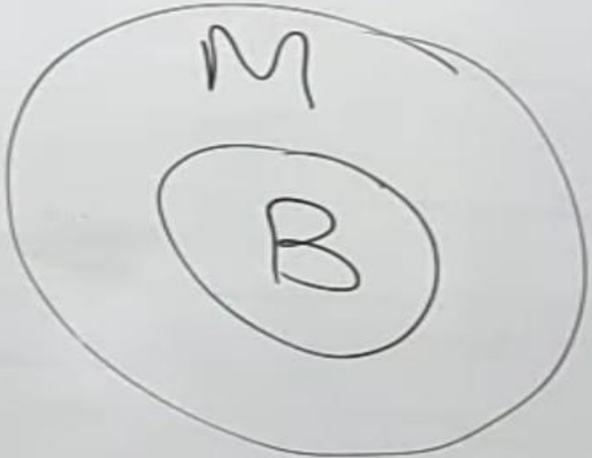
A1 : 2B : C4 : D2 : 89 : A5

→ **Types**

1. Unicast
2. Multicast
3. Broadcast

LSB → 1

FF : FF : FF : FF : FF : FF



Network Cables

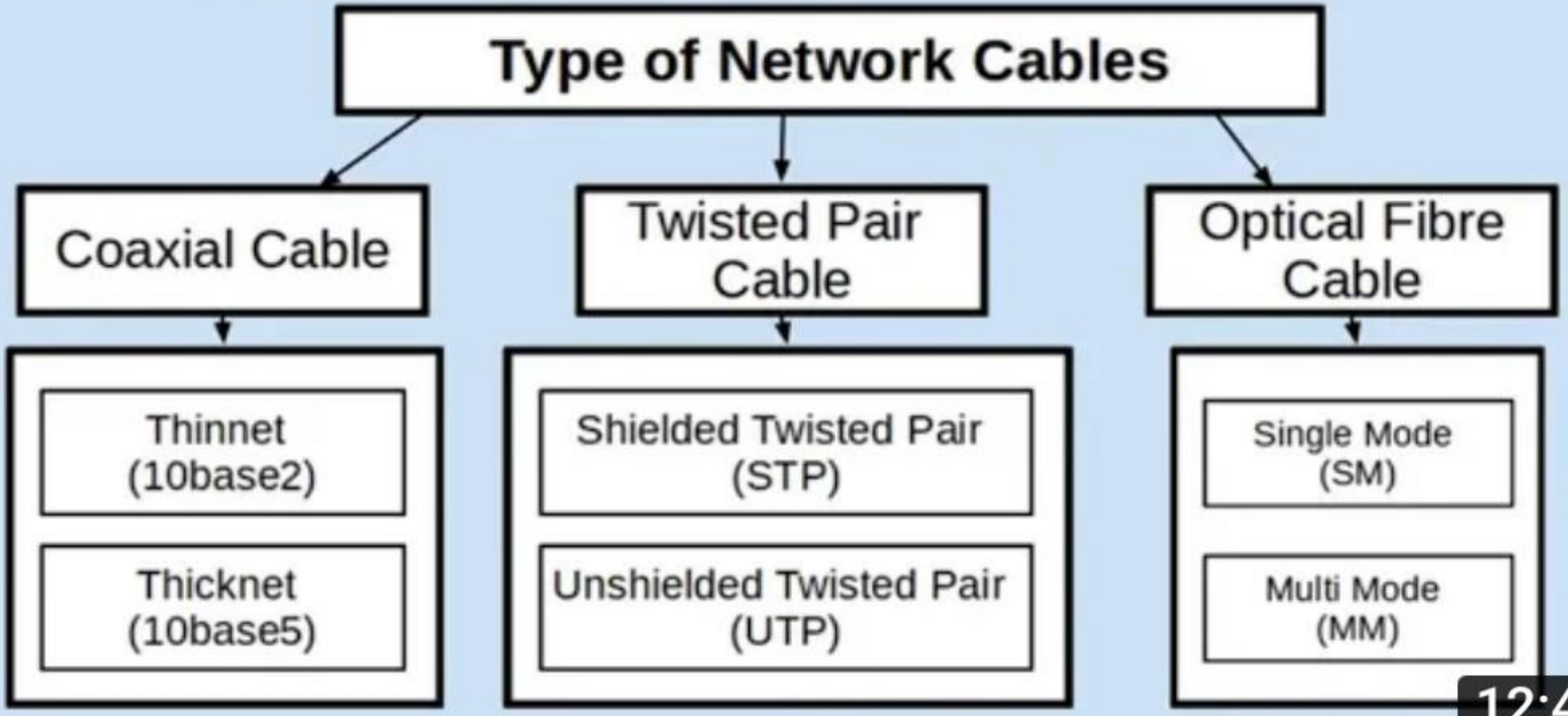
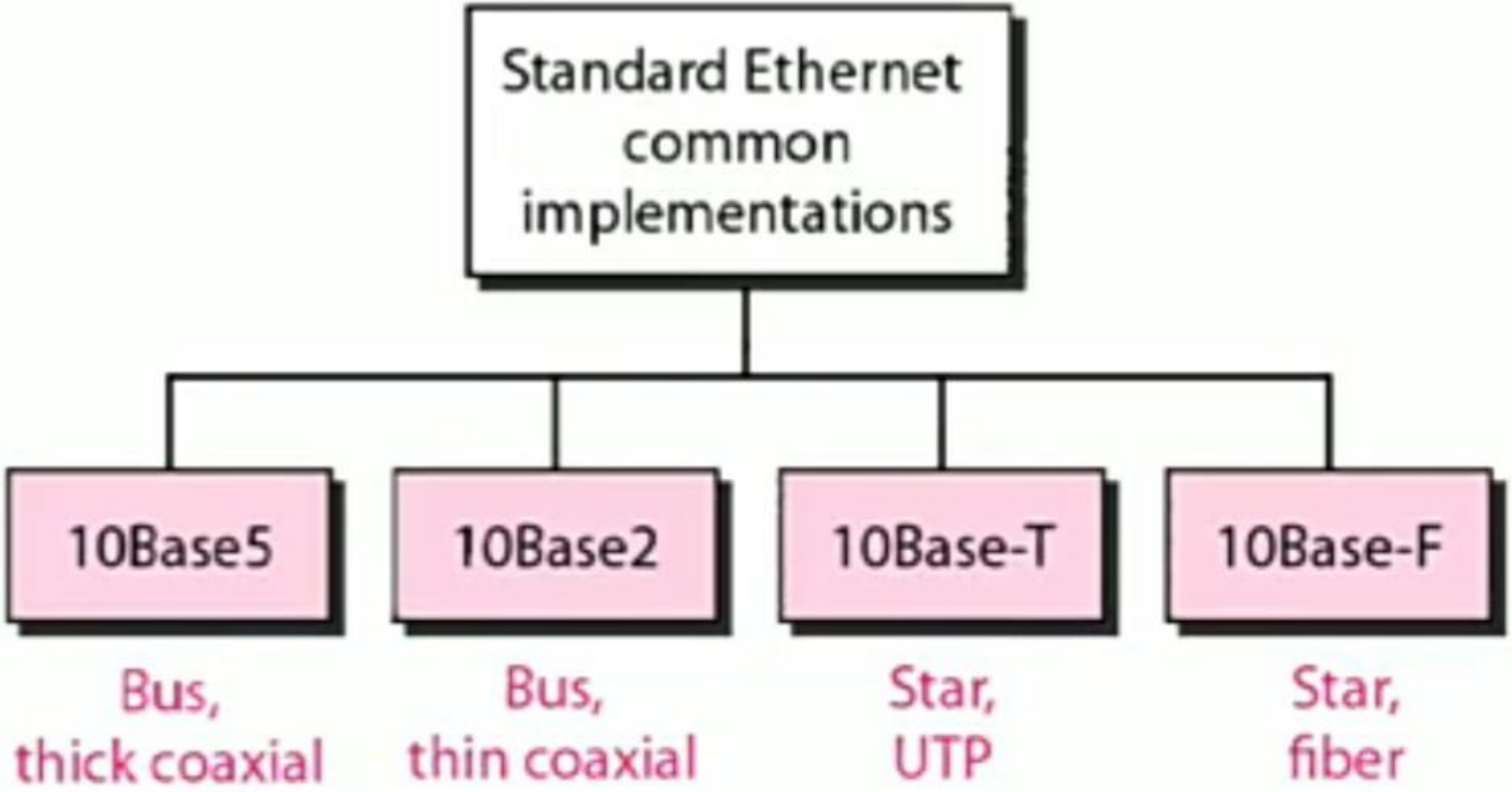


Figure 13.8 ***Categories of Standard Ethernet***



10BASE5 - “Thicknet”

10BASE2 - “Thinnet”

10BASE-T

a. 10Base5: Thick Ethernet

The first implementation is called 10Base5, thick Ethernet, or Thicknet. The nickname derives from the size of the cable, which is roughly the size of a garden hose and too stiff to bend with your hands. 10Base5 was the first Ethernet specification to use a bus topology with an external transceiver (transmitter/receiver) connected via a tap to a thick coaxial cable

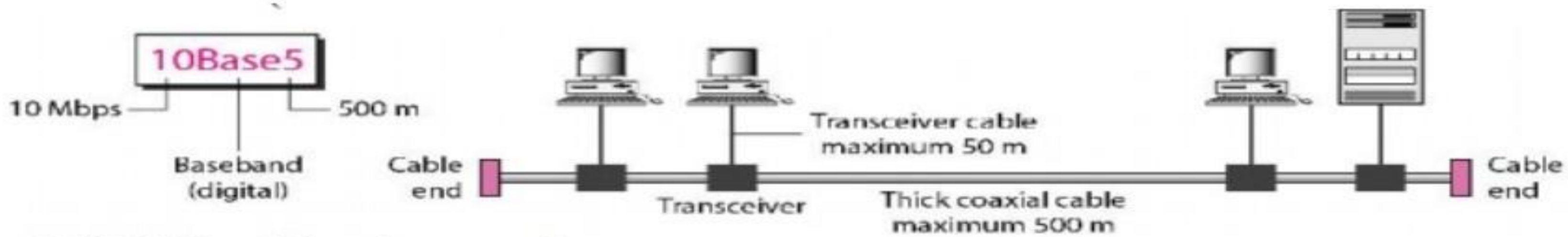


Figure 2.55 10Base5 implementation

b. 10Base2: Thin Ethernet

The second implementation is called 10Base2, thin Ethernet, or Cheapernet. 10Base2 also uses a bus topology, but the cable is much thinner and more flexible. The cable can be bent to pass very close to the stations. In this case, the transceiver is normally part of the network interface card (NIC), which is installed inside the station.

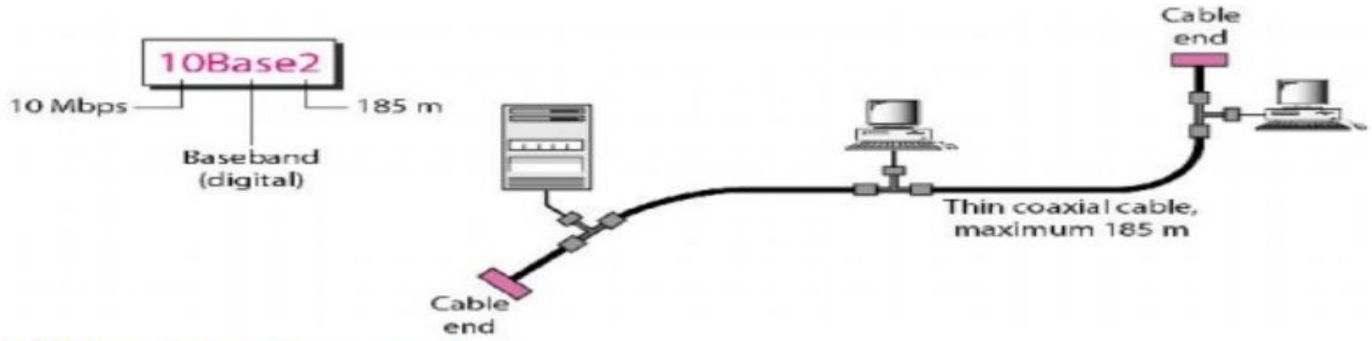


Figure 2.56 10Base2 Implementation

c. 10Base-T: Twisted-Pair Ethernet

The third implementation is called 10Base-T or twisted-pair Ethernet. 10Base-T uses a physical star topology. The stations are connected to a hub via two pairs of twisted cable.

Note that two pairs of twisted cable create two paths between the station and the hub. Any collision here happens in the hub. Compared to 10Base5 or 10Base2, we can see that the hub actually replaces the coaxial cable as far as a collision is concerned. The maximum length of the twisted cable here is defined as 100 m, to minimize the effect of attenuation in the twisted cable.

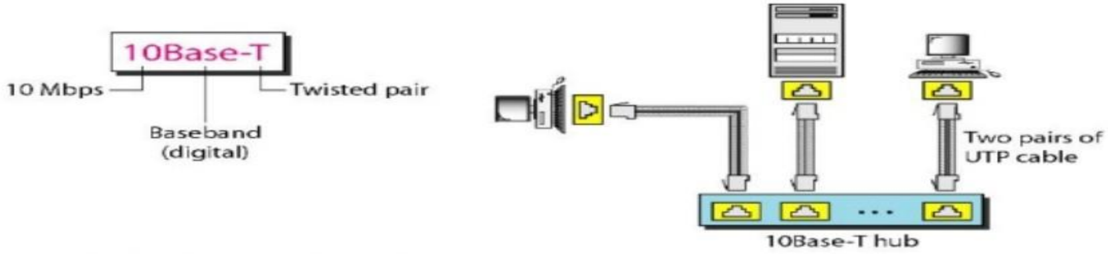


Figure 2.57. 10Base-T implementation

d. 10Base-F: Fiber Ethernet

Although there are several types of optical fiber 10-Mbps Ethernet, the most common is called 10Base-F. 10Base-F uses a star topology to connect stations to a hub. The stations are connected to the hub using two fiber-optic cables

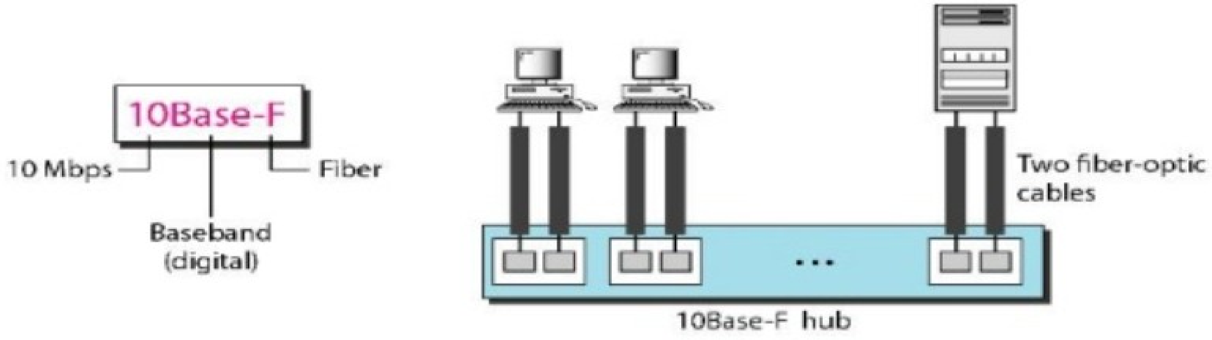


Figure 2.58. 10Base-F implementation

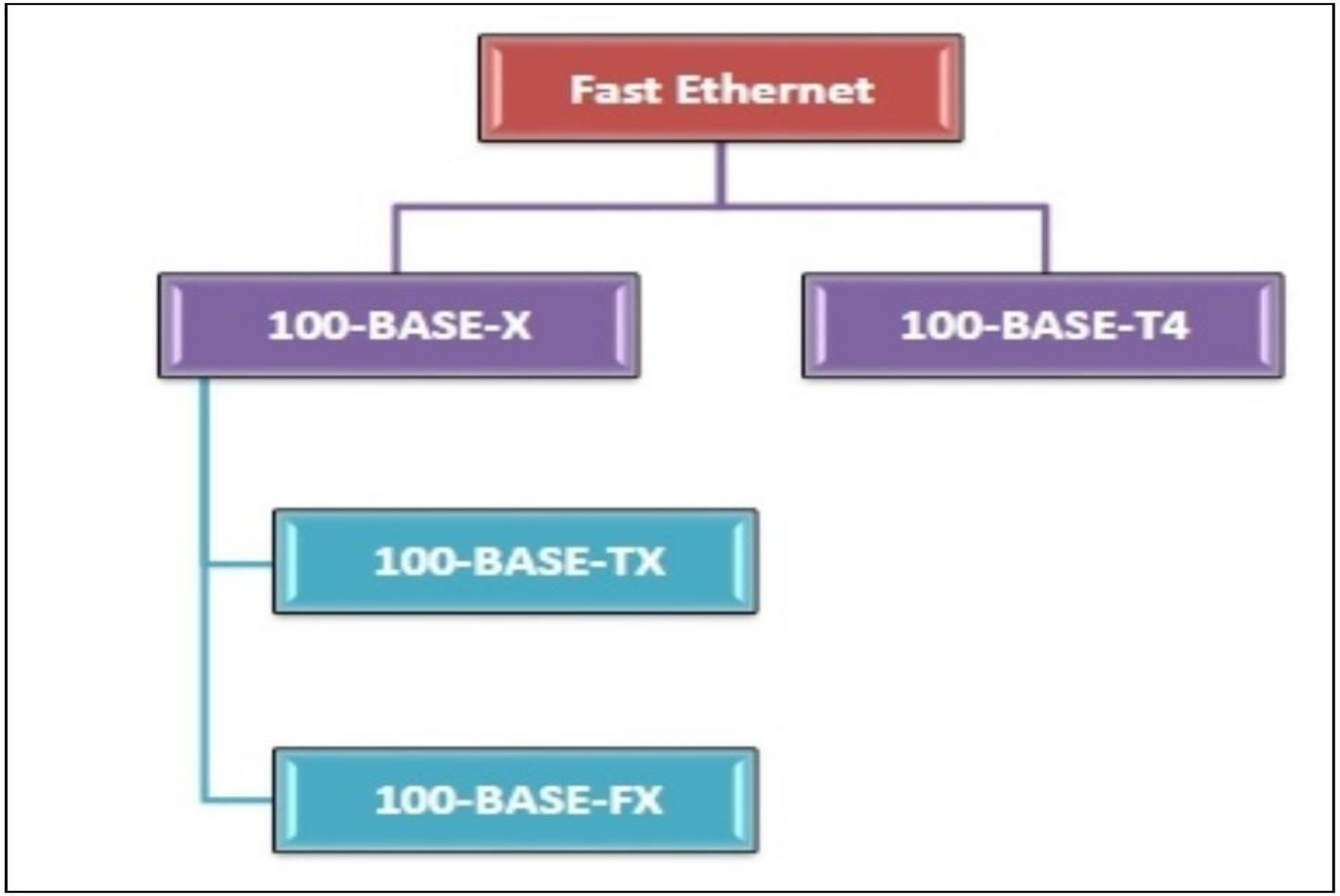
Characteristic\Cable	10Base5	10Base2	10BaseT	10BaseF
Medium	Thick Coaxial Cable	Thin Coaxial Cable	Twisted Pair	Optical Fiber
Maximum Length of segment	500 m	200 m	100 m	2 Km
Topology	Bus	Bus	Star	Star
Advantages	Used for connecting workstation with tap on the cable	Low cost	Existing environment can use Hub and connect the stations	Good noise immunity and good to use

Ethernet

Normal Ethernet:- 10 Mbps
Fast Ethernet:- 100 Mbps
GigaBit Ethernet:- 1000 Mbps or 1Gbps
10 GIgaBit Ethernet:- 10 Gbps

Varieties of Fast Ethernet

The common varieties of fast Ethernet are 100-Base-TX, 100-BASE-FX and 100-Base-T4.



Fast Ethernet (100 BASE-T)

Fast Ethernet provides 100 Mbps speed & introduced in 1995

100 BASE-T4, 100 BASE-TX, 100 BASE-FX

Fast Ethernet generate more delay comparatively.

The coverage limit of Fast Ethernet is up to 10 km.

Fast Ethernet is the Successor of 10-Base-T Ethernet.

- **100-Base-TX**
  - This has either two pairs of unshielded twisted pairs (UTP) category 5 wires or two shielded twisted pairs (STP) type 1 wires. One pair transmits frames from hub to the device and the other from device to hub.
  - Maximum distance between hub and station is 100m.
  - It has a data rate of 125 Mbps.
  - It uses MLT-3 encoding scheme along with 4B/5B block coding.

- **100-BASE-FX**
  - This has two pairs of optical fibers. One pair transmits frames from hub to the device and the other from device to hub.
  - Maximum distance between hub and station is 2000m.
  - It has a data rate of 125 Mbps.
  - It uses NRZ-I encoding scheme along with 4B/5B block coding.

- **100-Base-T4**
  - This has four pairs of UTP of Category 3, two of which are bi-directional and the other two are unidirectional.
  - In each direction, three pairs can be used simultaneously for data transmission.
  - Each twisted pair is capable of transmitting a maximum of 25Mbaud data. Thus the three pairs can handle a maximum of 75Mbaud data.
  - It uses the encoding scheme 8B/6T (eight binary/six ternary).

Fast Ethernet [IEEE 802.3u]

Three Choices

Name	Cable	Max. segment	Advantages
100Base-T4	Twisted pair	100 m	Uses category 3 UTP
100Base-TX	Twisted pair	100 m	Full duplex at 100 Mbps
100Base-FX	Fiber optics	2000 m	Full duplex at 100 Mbps; long runs

Figure 4-21.The original fast Ethernet cabling.

Gigabit Ethernet Design

The design of the Gigabit Ethernet can be summarized with the help of the following given points:

1.It is compatible with standard or fast ethernet.

2.It provides the data rate of 1 Gbps.

3.It makes use of an 8-bit address.

4.Provides the support of auto-negotiation.

5.It keeps the same minimum and maximum lengths of frames.

Ethernet is basically a physical and data link layer technology for Local Area Network(LAN). Gigabit Ethernet was developed in June 1998.

- Gigabit Ethernet provides the data rate of 1000 Mbps or we can say 1Gbps.
- The Gigabit Ethernet(IEEE 802.3z) addresses the two layers of the OSI reference Model:
    - Layer 2(Data Link Layer) mainly describes how data can be organized in the form of frames and then sent over the network.
    - Layer 1(Physical Layer) mainly describes the medium of the network and signaling specifications.

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Benefits of Gigabit Ethernet

Gigabit Ethernet provides the following benefits:

- **Reliability.** Fiber optic cables used in some gigabit internet offerings are more durable and reliable than traditional copper wiring.
- **Speed.** A transmission speed of 1 Gbps should be more than enough for most online applications today.
- **Less latency.** Reduced latency rates range from 5 milliseconds to 20 ms.
- **Transferring or streaming video data.** Gigabit Ethernet can smoothly stream 4K content at a high frame rate.
- **Multiuser support.** High-speed internet can be split into multiple tasks to support multiple devices.

Gigabit Ethernet

- Summary

Characteristics	*1000Base-SX*	*1000Base-LX*	*1000Base-CX*	*1000Base-T*
Media	Fiber short-wave	Fiber long-wave	STP	Cat 5 UTP
Number of wires	2	2	2	4
Maximum length	550 m	5000 m	25 m	100 m
Block encoding	8B/10B	8B/10B	8B/10B	
Line encoding	NRZ	NRZ	NRZ	4D-PAM5

Carrier Extension

In order to allow a longer network, the minimum frame length is increased. This approach mainly defines the minimum length of a frame equals 512 bytes (that is equal to 4096 bits); which means that the minimum length is 8 times longer.

This approach basically forces a station to add extension bits (i.e padding) to any frame whose size is less than 4096 bits.

Frame bursting may be also combined with frame aggregation. In this case, a concatenated sequence of multiple frames is transmitted instead of separate small frames. This eliminates the inter-frame gaps and overheads for headers and gaps completely. This is particularly suitable in cases where the frames contain small payload sizes. This is shown in the following diagram −

- **Advantages of Gigabit Ethernet**

- There is an increase in the bandwidth and it leads to higher performance.
- There is a low cost of acquisition and ownership.
- It provides full compatibility.
- By using the full-duplex approach the effective bandwidth gets virtually doubled.
- It can transfer a large amount of data across the network quickly.

- **Disadvantages of Gigabit Ethernet**

- 1000Base-T requires 4 pairs of wiring in order to transfer the data.

- 1000Base-T does not support the full-duplex mode.

Fast Ethernet (100 BASE-T)	Gigabit Ethernet(1000 BASE X)
Fast Ethernet provides 100 Mbps speed & introduced in 1995	Gigabit Ethernet offers 1 Gbps speed. It came into use in 1999
100 BASE-T4, 100 BASE-TX, 100 BASE-FX	1000 BASE-SX, 1000 BASE-LX, 1000 BASE-CX, 1000 BASE-T
Fast Ethernet generate more delay comparatively.	Gigabit Ethernet generate less delay than Fast Ethernet.
The coverage limit of Fast Ethernet is up to 10 km.	While the coverage limit of Gigabit Ethernet is up to 70 km.
Fast Ethernet is the Successor of 10-Base-T Ethernet.	Gigabit Ethernet is the successor of Fast Ethernet.

- 10-Gigabit Ethernet is basically the faster-speed version of Ethernet.

- It will support the data rate of 10 Gb/s.

. It was first defined by the IEEE 802.3ae-2002 standard

- it will not support the half-duplex operation mode.

Table: 10-Gigabit Ethernet Cabling

Name	Cable	Max. segment	Advantages
10GBase-SR	Fiber Optics	Up to 300 m	Multimode fiber (0.85μ)
10GBase-LR	Fiber Optics	10 km	Single-mode fiber (1.3μ)
10GBase-ER	Fiber Optics	40 km	Single-mode fiber (1.5μ)