Unit -3

Medium Access Control Layer

Presentation Prepaired by: ***Prof. Atul G. Pawar, PCCOE, Pune.***

What is MAC?

- Medium Access Control (MAC) is a sublayer of the Data-link layer.
- The protocols used to determine who goes next on a multiaccess channel belongs to a MAC sublayer.
- MAC is important in LAN which use a multiaccess channel as the basis for communication.

The Channel Allocation Problem

- There are **two schemes** to allocate a single channel among competing users:

  - 1) Static Channel Allocation.
  - 2) Dynamic Channel Allocation

Static Channel Allocation:

- - In this scheme a **Frequency Division Multiplexing** (FDM) is used for allocating a single channel among competing users.
- **Example :** If we have *N* users, the bandwidth will be divided into *N* equal-size portions.
- **- Adv.**: FDM is a **simple and efficient** allocation mechanism.
- **- Disadv.: Waste of resources** when the traffic is bursty, or the channel is lightly loaded.

• Frequency-Division Multiplexing (FDM)

In SCA schemes, a set of channels is permanently allocated to each cell in the network.

Dynamic Channel Allocation:

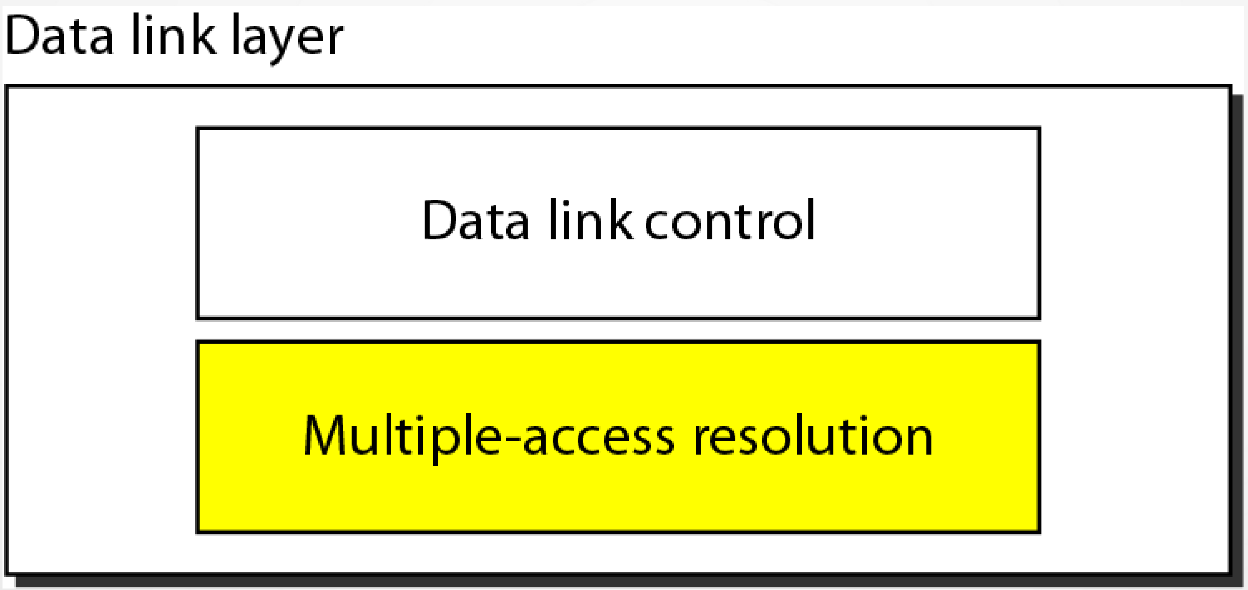
- - Before the discussion of algorithms used for dynamic allocation, we need to consider the following assumptions.
- **- Station Model**: N independent stations generate frames for transmission.
- **- Single channel Assumption**: Single channel is available for all communication.
- **Collision Assumption**
- **Continuous Time**, or **Slotted Time**
- **Carrier Sense**, or **No Carrier sense**

• Dynamic Channel Allocation (DCA) for Wireless

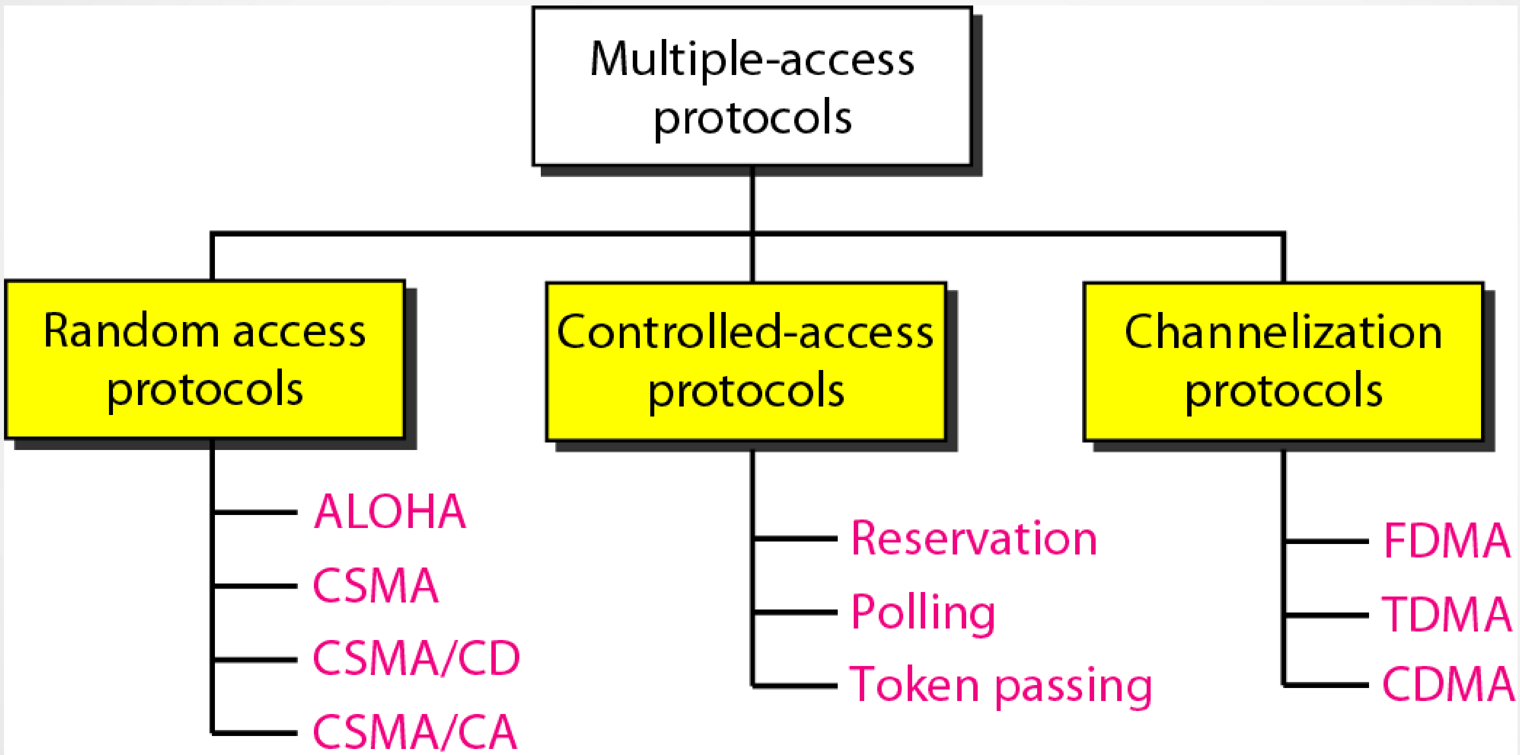
- - In DCA schemes, all channels are kept in a central pool and are assigned dynamically to new calls as they arrive in the system.
- - After each call is completed, the channel is returned to the central pool. It is fairly straightforward to select the most appropriate channel for any call based simply on current allocation and current traffic, with the aim of minimizing the interference.
- - DCA scheme can overcome the problem of SCA scheme.

•Multiple Access

- ***Data link layer divided into two functionality-oriented sublayers***



- ***Multiple-access protocols***



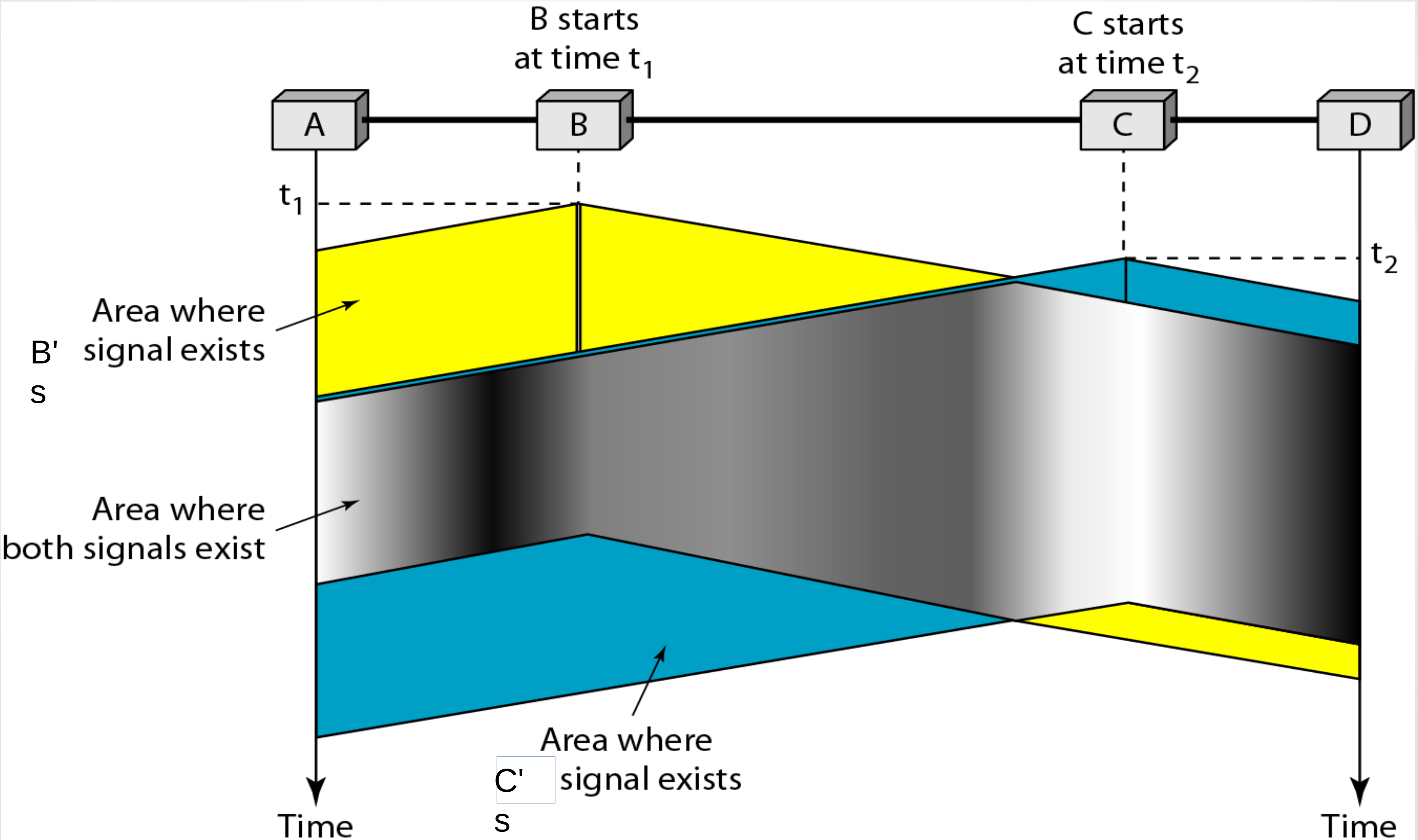
• RANDOM ACCESS

- ***- In random access or contention methods, no station is superior to another station and none is assigned the control over another.***
- ***- No station permits, or does not permit, another station to send.***
- ***-At each instance, a station that has data to send uses a procedure defined by the protocol to make a decision on whether or not to send.***

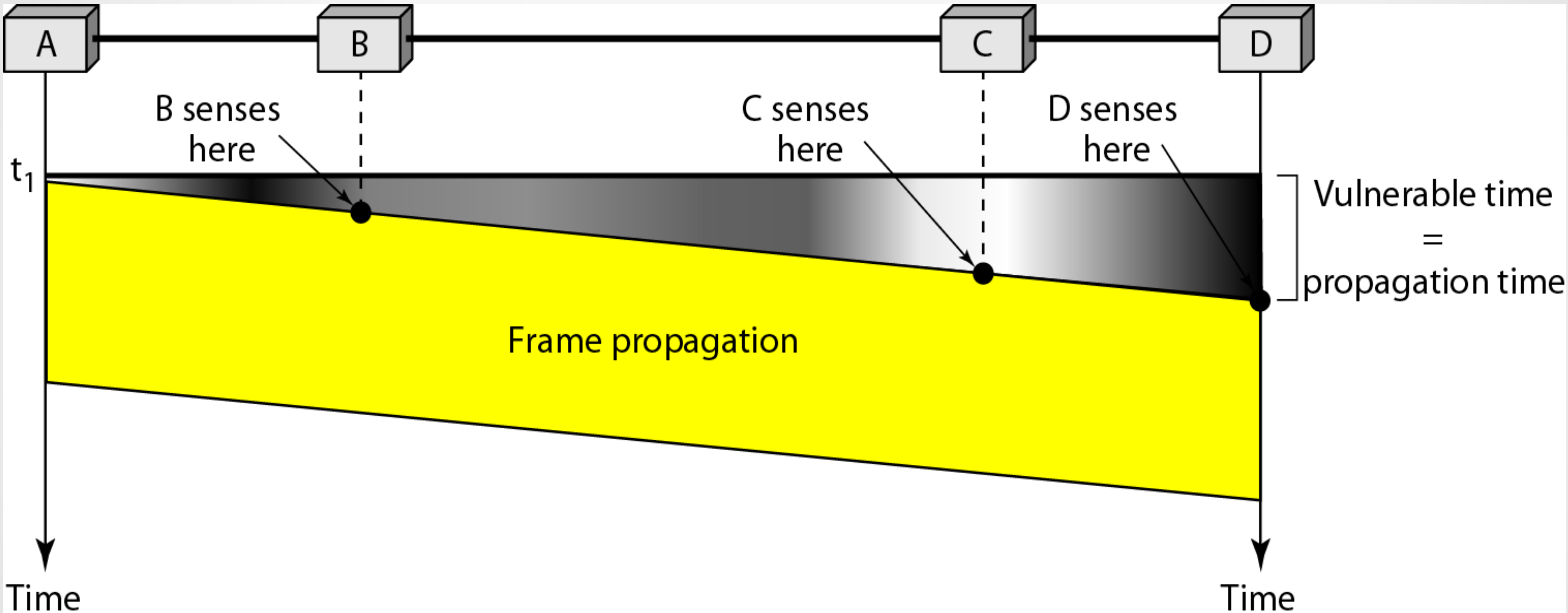
Carrier Sense Multiple Access
Carrier Sense Multiple Access with Collision Detection
- **Carrier Sense Multiple Access with Collision Avoidance**

Carrier Sense Multiple Access (*CSMA)*

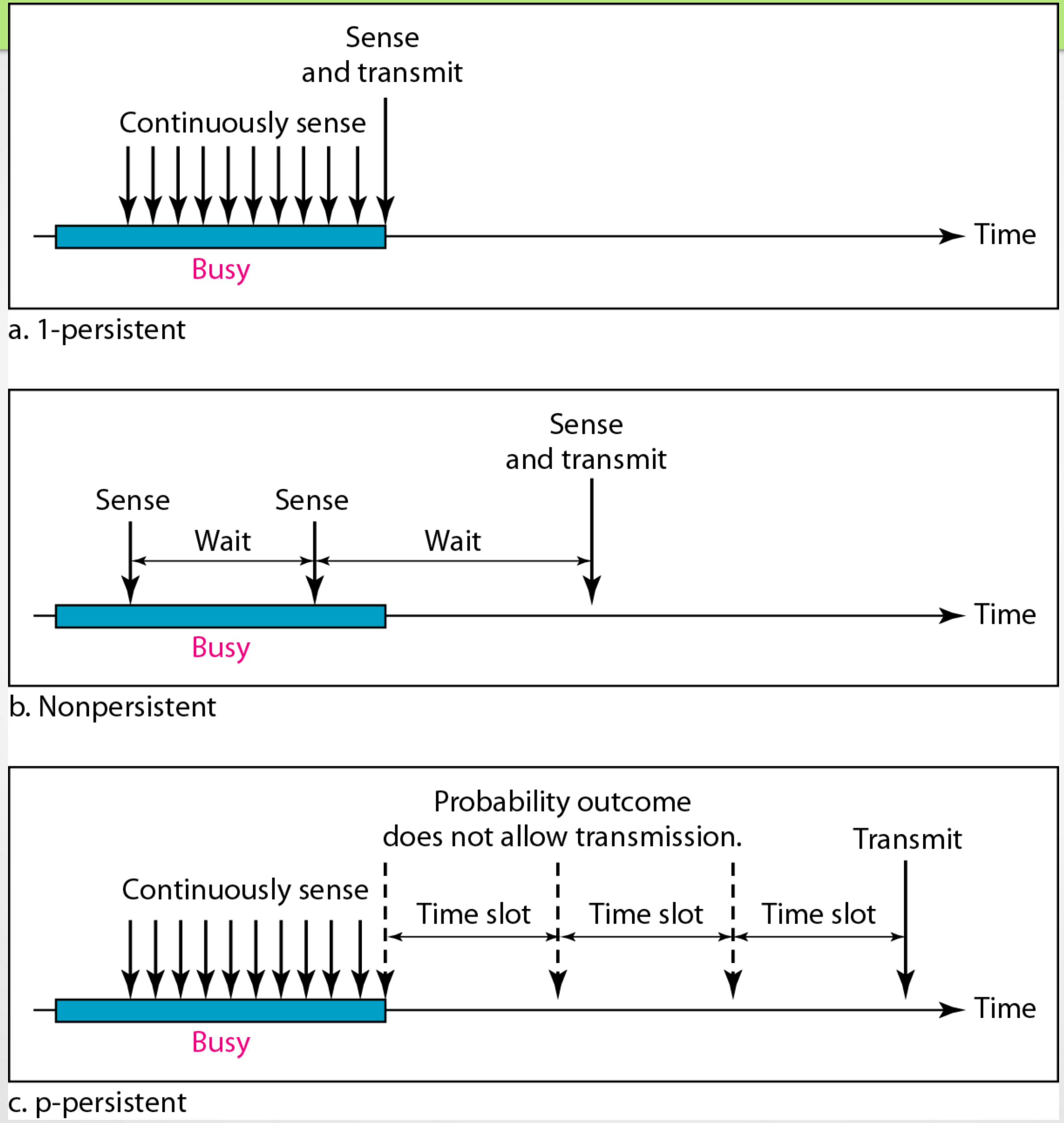
- ***Space/time model of the collision in CSMA***



- ***Vulnerable time in CSMA***



- ***Behavior of three persistence methods***



p-Persistence

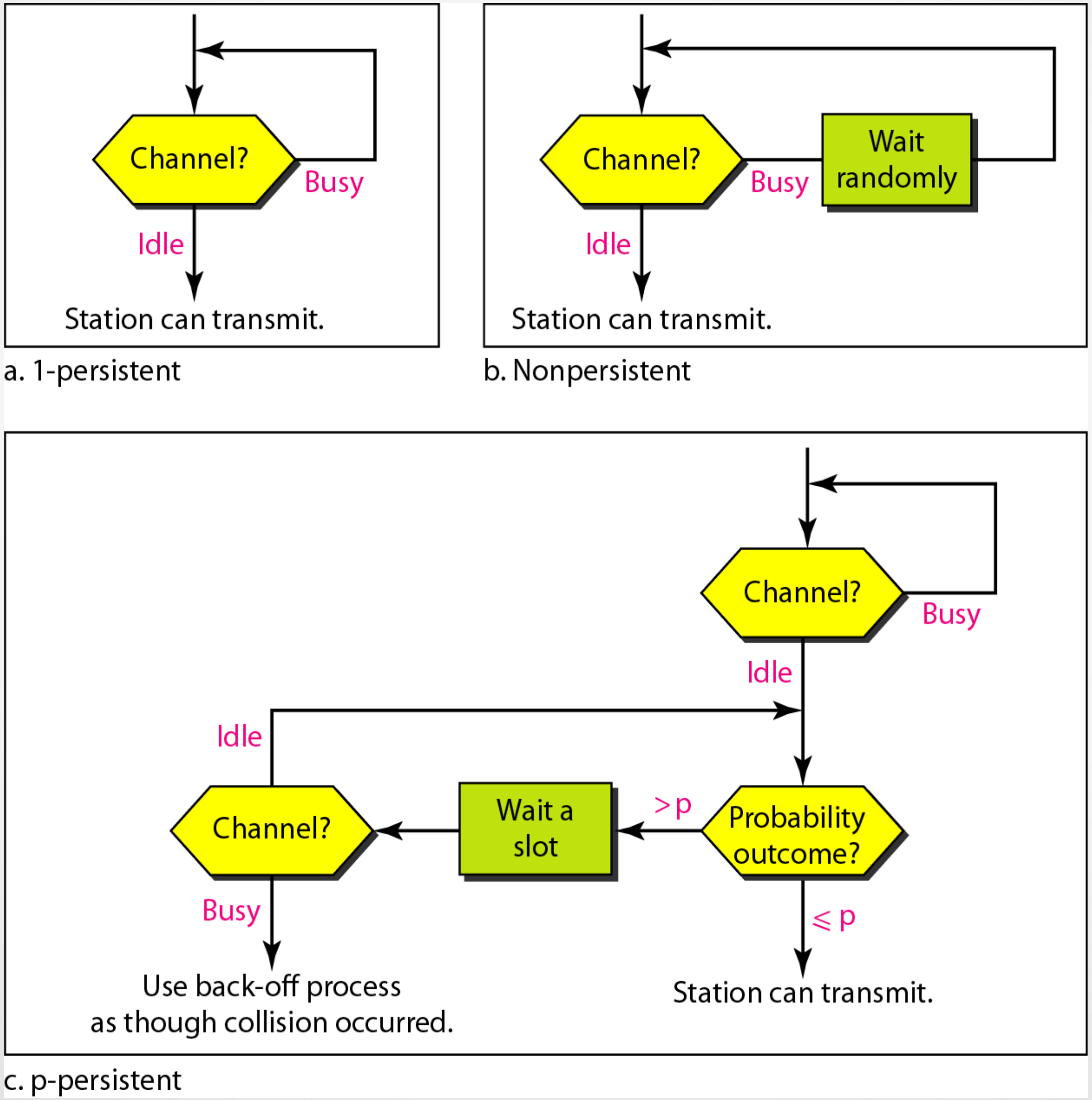
- This Method is used if the channel has time slots with a slot duration equal to or greater than the maximum propagation time.
- When station is ready to send frames, it will sense channel.
- If channel found to be busy, station will wait for next time-slot.
- But if channel is found to be idle, station transmits frame immediately with a probability p.
- The station thus waits for left probability i.e. q which is equal to 1-p, for beginning of next time-slot.
- If the next time-slot is also found idle, station transmits or waits again with probabilities p and q.
- This process repeats until either frame gets transmitted or another station starts transmitting.

p-Persistence

- In this method, after the station finds the line idle it follows these steps:

1. With probability p, the station sends its frame.
2. With probability q = 1 - p, the station waits for the beginning of the next time slot and checks the line again.
   a. If the line is idle, it goes to step 1.
   b. If the line is busy, it acts as though a collision has occurred and uses the back-off procedure.

- ***Flow diagram for three persistence methods***



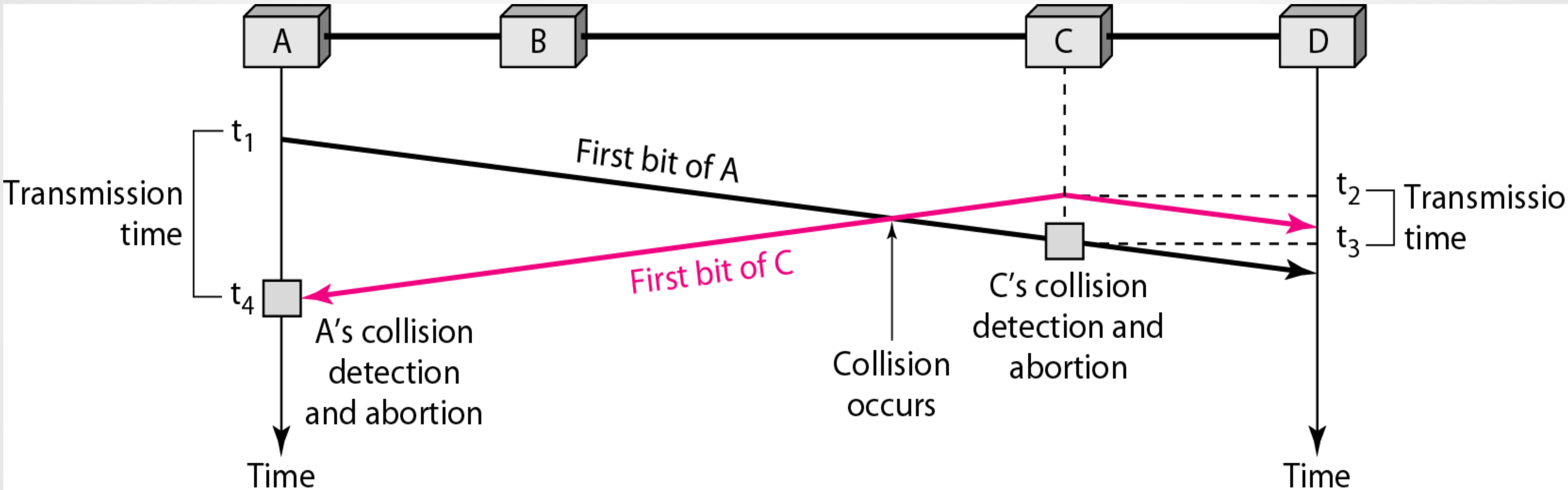
Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

Carrier sense multiple access with collision detection (CSMA/CD) augments the algorithm to handle the collision.

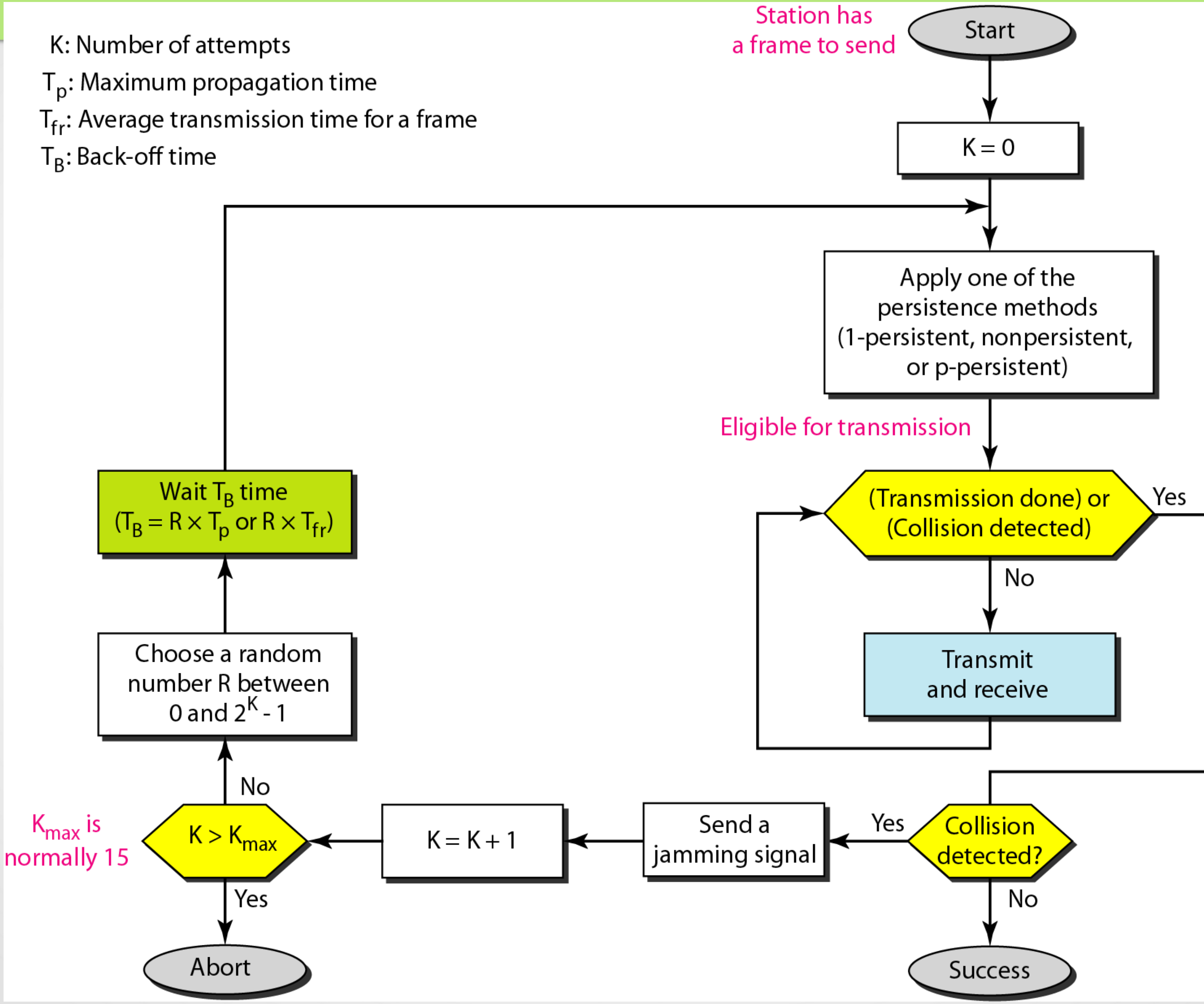
In this method, a station monitors the medium after it sends a frame to see if the transmission was successful. If so, the station is finished. If, however, there is a collision, the frame is sent again.

CSMA/CD

Collision of the first bit in CSMA/CD



- ***Flow diagram for the CSMA/CD***



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

CSMAlCA was invented for wireless network. Collisions are avoided through the use of CSMA/CA's three strategies:
the interframe space (IFS),
the contention window, and
acknowledgments.

Interframe space

- When an idle channel is found, the station does not send immediately. It waits for a period of time called the interframe space or IFS.

- The IFS time allows the front of the transmitted signal by the distant station to reach this station.

- The IFS variable can also be used to prioritize stations or frame types.

- For example, a station that is assigned a shorter IFS has a higher priority.

- ***Note***

- **In CSMA/CA, the IFS can also be used to define the priority of a station or a frame.**

Contention Window

- *The contention window is an amount of time divided into slots.*
- *A station that is ready to send chooses a random number of slots as its wait time.*
- *The number of slots in the window changes according to the binary exponential back-off strategy.*
- *The station needs to sense the channel after each time slot.*

- ***Note***

- **In CSMA/CA, if the station finds the channel busy, it does not restart the timer of the contention window;**
- **it stops the timer and restarts it when the channel becomes idle.**

Acknowledgment

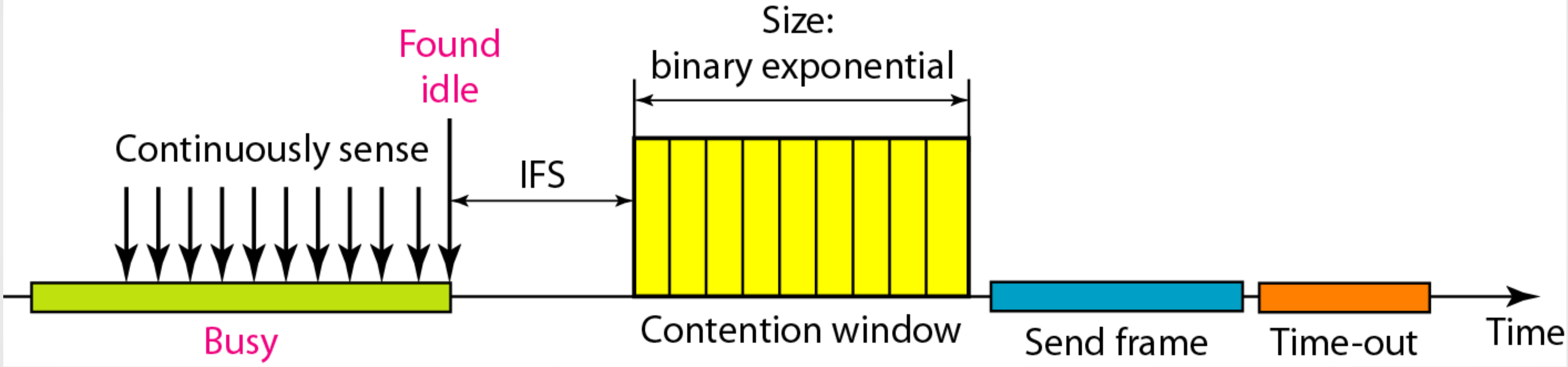
- There still may be a collision resulting in destroyed data.

- The data may be corrupted during the transmission.

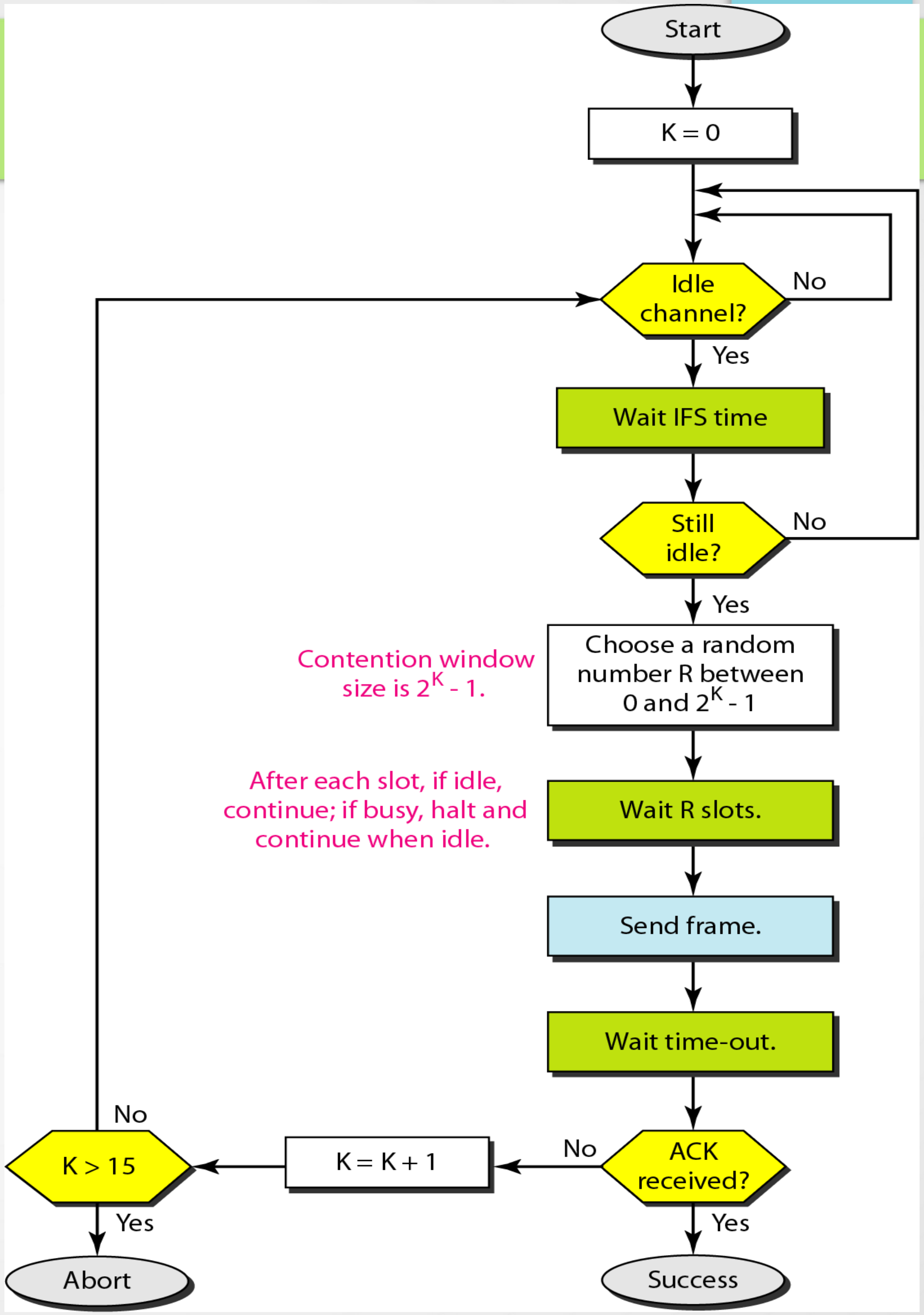
- The positive acknowledgment and the time-out timer can help

guarantee that the receiver has received the frame.

- ***Timing in CSMA/CA***



- ***Flow diagram for CSMA/CA***



Wavelength Division Multiple Access (WDMA)

- -Divide the channel into multiple smaller channels (wavelength bands) using FDM, TDM, or both, and dynamically allocate them as needed.
- - Allocate channels to users as needed which allow different
- transmissions to take place at the same time.
- - Usually used in fiber optics LANs: different conversations to use different wavelengths (frequencies) at the same time.
- - Each user uses two channels, one small channels to send control packets and another wider channel to send data.

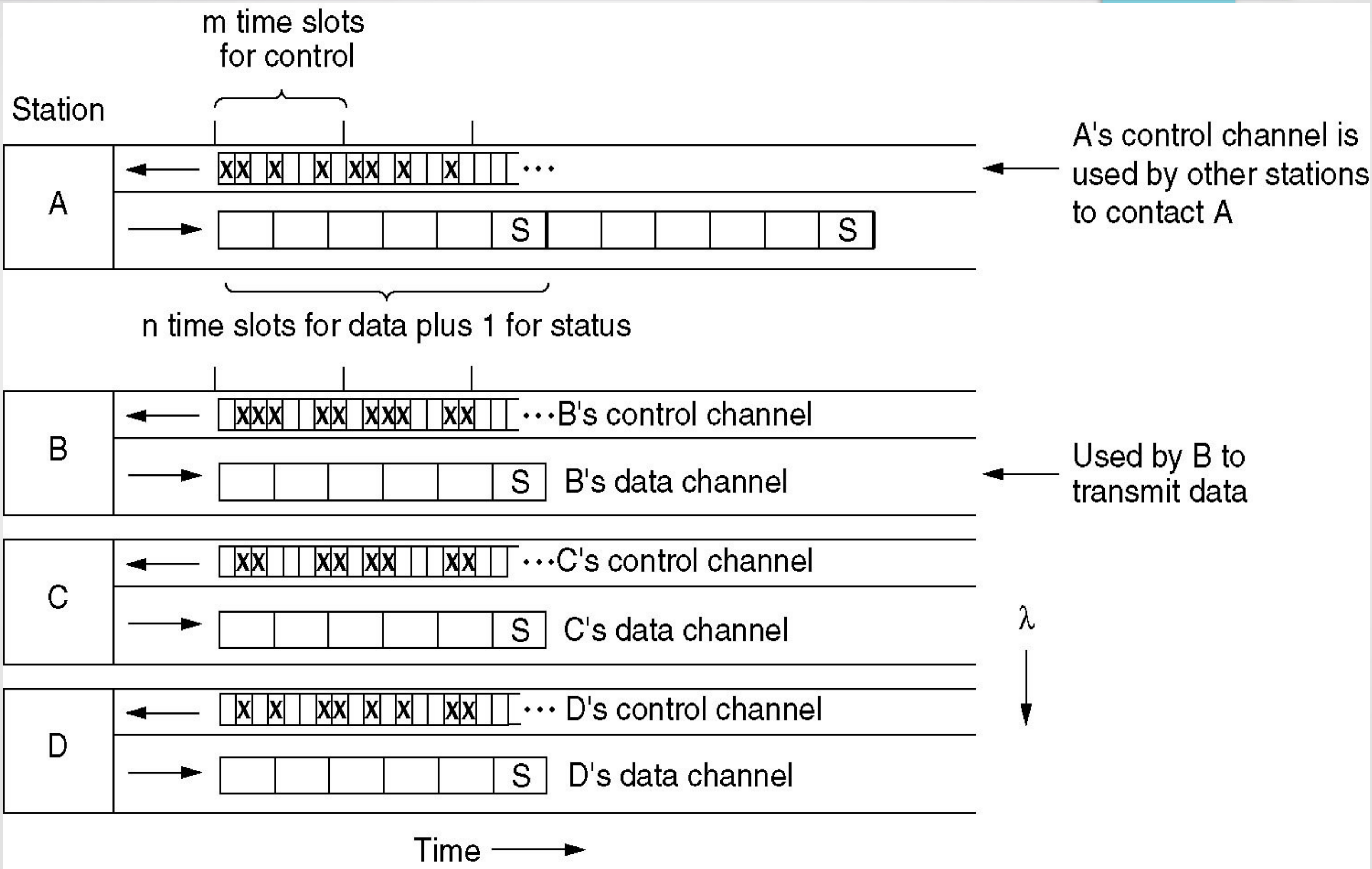
WDMA

- Each station is assigned two channels : control channel (narrow) and data channel (broad)
- m slots in control channel and n+1 slots in data channel.
- Support three classes of traffic
  - constant data rate connection-oriented traffic
  - variable data rate connection-oriented traffic
  - datagram traffic: UDP packets

WDMA Protocols

- Each station has
  - **fixed-wavelength receiver** for its own control channel
  - **tuneable transmitter** to other station’s control channel
  - **fixed-wavelength transmitter** to output data frames
  - **tuneable receiver**: selecting a data transmitter to listen to
- Communication from A to B
  - A inserts a Connection Request in a free slot on B’s control channel.
  - If B accepts, A sends its data on its data channel.

Wavelength Division Multiple Access Protocols



- **IEEE STANDARDS**

- ***In 1985, the Computer Society of the IEEE started a project, called Project 802, to set standards to enable intercommunication among equipment from a variety of manufacturers. Project 802 is a way of specifying functions of the physical layer and the data link layer of major LAN protocols.***

IEEE 802 Introduction

- IEEE 802 (Institute of Electrical and Electronics Engineers) refers to a family of IEEE standards.

- Dealing with local area network and metropolitan area network.
- Restricted to networks carrying variable-size packets.
- Specified in IEEE 802 map to the lower two layers
    - Data link layer
        - LLC sublayer
        - MAC sublayer
    - Physical layer

- The most widely used standards :
    - The Ethernet family, Token Ring, Wireless LAN.
    - Bridging and Virtual Bridged LANs.
- An individual Working Group provides the focus for each area.

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IEEE Standards

IEEE 802.1	Bridging (networking) and Network Management
IEEE 802.2	LLC (Inactive)
IEEE 802.3	**Ethernet (Wired Network)**
IEEE 802.4	Token bus (Disbanded)
IEEE 802.5	Defines the MAC layer for a Token Ring (inactive)
IEEE 802.6	MANs (DQDB) (Disbanded)
IEEE 802.7	Broadband LAN using Coaxial Cable (Disbanded)
IEEE 802.8	Fiber Optic TAG (Disbanded)
IEEE 802.9	Integrated Services LAN (ISLAN or isoEthernet)
IEEE 802.10	Interoperable LAN Security (Disbanded)
IEEE 802.11	**Wireless LAN (WLAN) & Mesh (Wi-Fi certification)**
IEEE 802.12	100BaseVG (Disbanded)
IEEE 802.13	Unused- Reserved for Fast Ethernet development
IEEE 802.14	Cable modems (Disbanded)

IEEE Standards Continue....

IEEE 802.15 Wireless PAN

IEEE 802.15.1 Bluetooth certification

IEEE 802.15.2 IEEE 802.15 and IEEE 802.11 coexistence

IEEE 802.15.3 High-Rate wireless PAN (e.g., UWB, etc.)

IEEE 802.15.4 Low-Rate wireless PAN (e.g.ZigBee,WirelessHART,MiWi, etc)

IEEE 802.15.5 Mesh networking for WPAN

IEEE 802.15.6 Body area network

IEEE 802.16 Broadband Wireless Access (WiMAX certification)

IEEE 802.16.1 Local Multipoint Distribution Service

IEEE 802.17 Resilient packet ring

IEEE 802.18 Radio Regulatory TAG

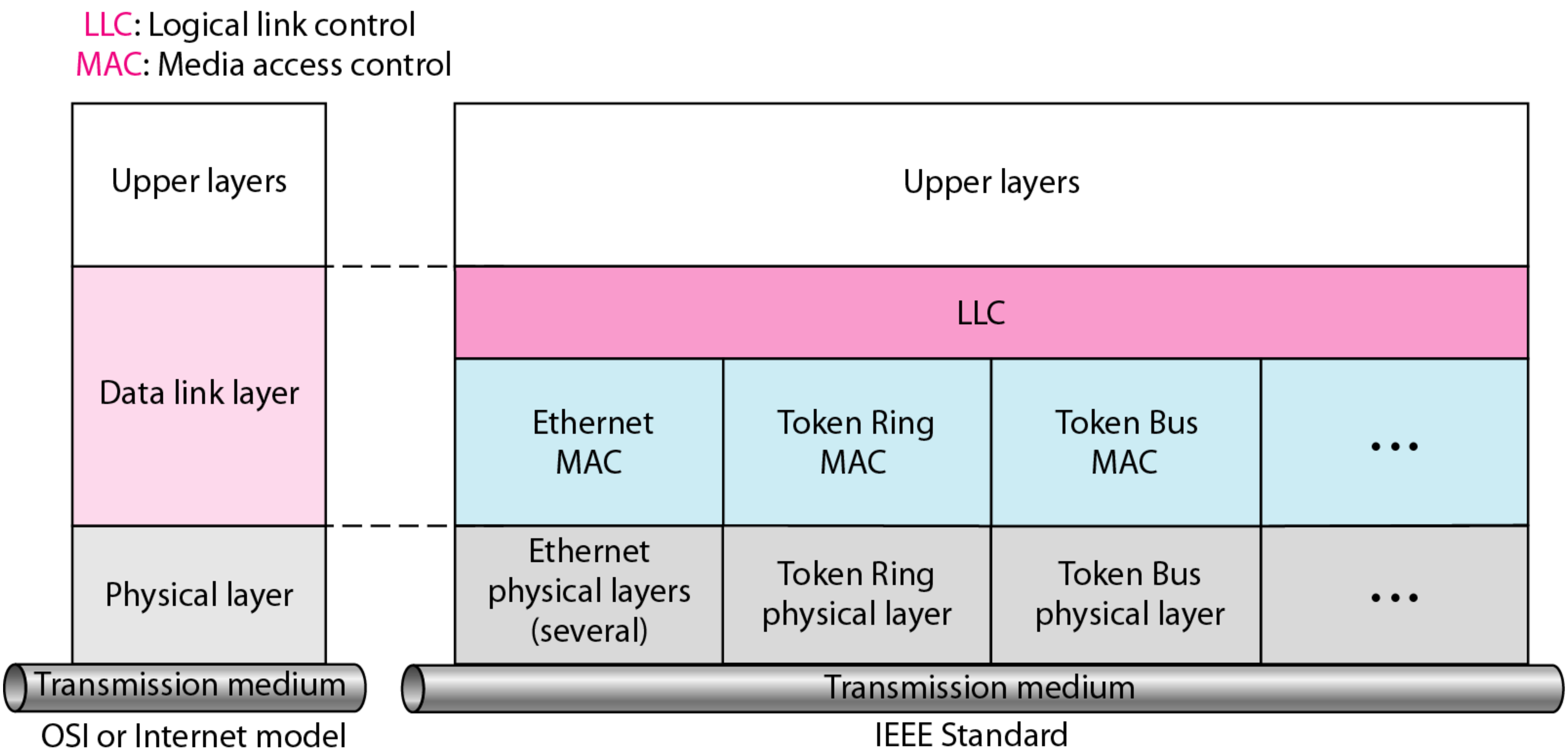
IEEE 802.19 Coexistence TAG

IEEE 802.20 Mobile Broadband Wireless Access

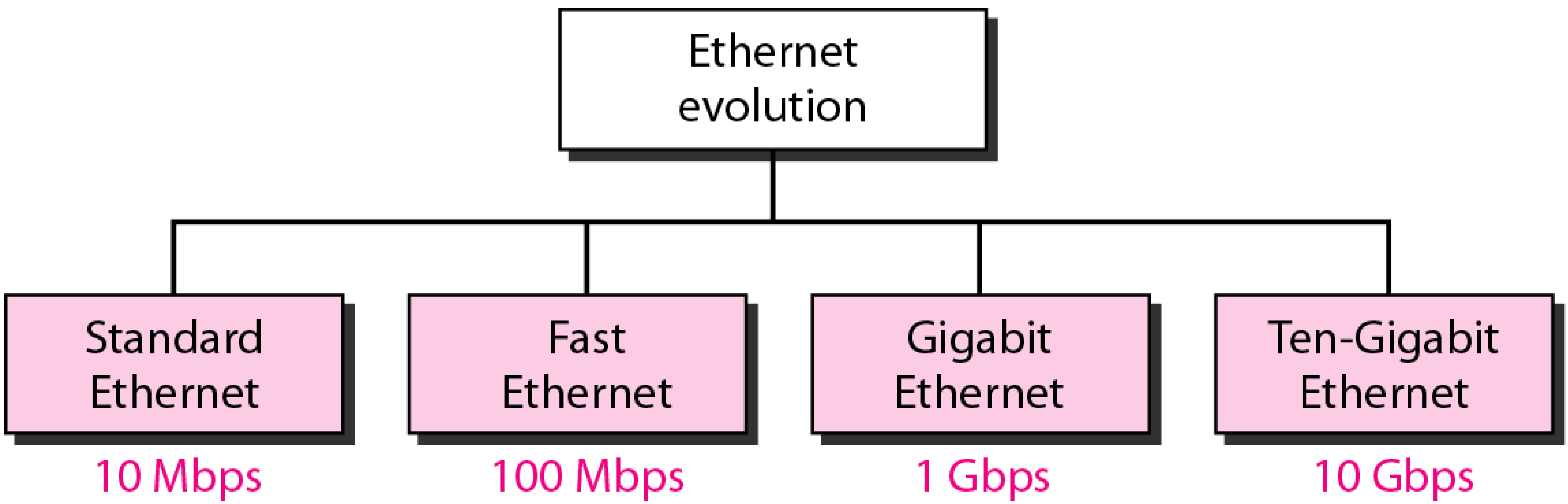
IEEE 802.21 Media Independent Handoff

IEEE 802.22 Wireless Regional Area Network

- ***IEEE standard for LANs***



- ***Ethernet evolution through four generations***



- **STANDARD ETHERNET**

- ***The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC). Since then, it has gone through four generations. We briefly discuss the Standard (or traditional) Ethernet in this section.***

• Standard Ethernet Characteristics

- **Connectionless and Unreliable Service**
  - ***Each frame sent independent***
  - ***No connection establisment or connection termination phase.***
  - ***Frame drops, sender not know about it***
  - ***Its higher level protocols duty to find out corruption, frame drop etc.***
- **Frame Format**
- **Frame Length**

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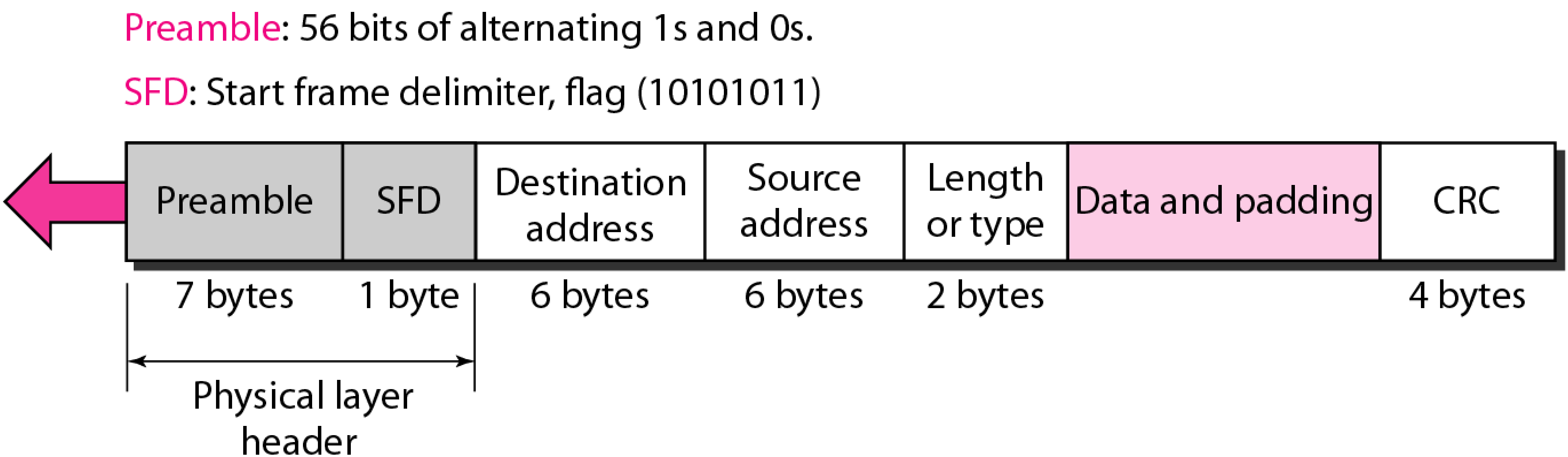
- ***802.3 MAC frame***



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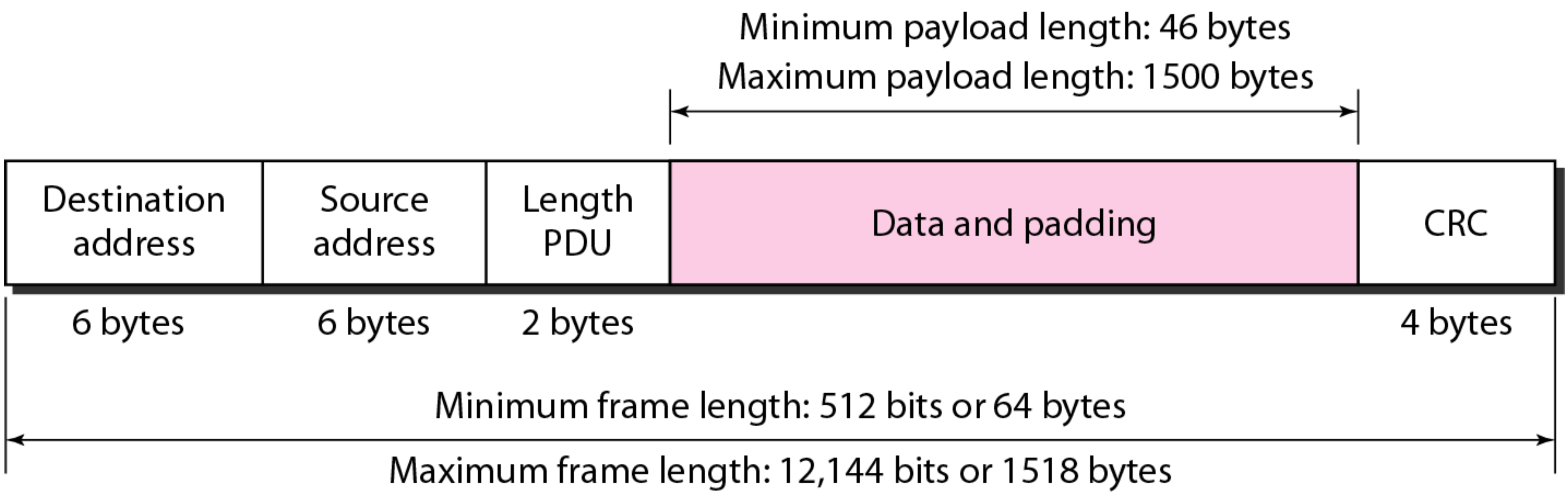
- ***Minimum and maximum Frame lengths***



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- *Note*

- **Frame length:**
- **Minimum: 64 bytes (512 bits)**
- **Maximum: 1518 bytes (12,144 bits)**

- ***Example of an Ethernet address in hexadecimal notation***

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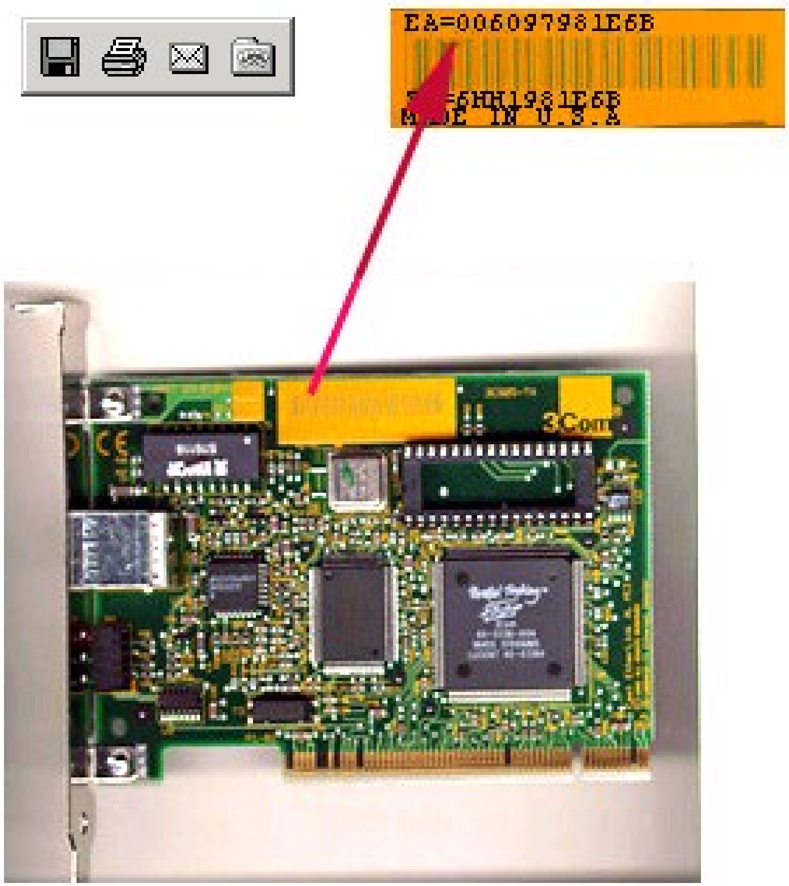
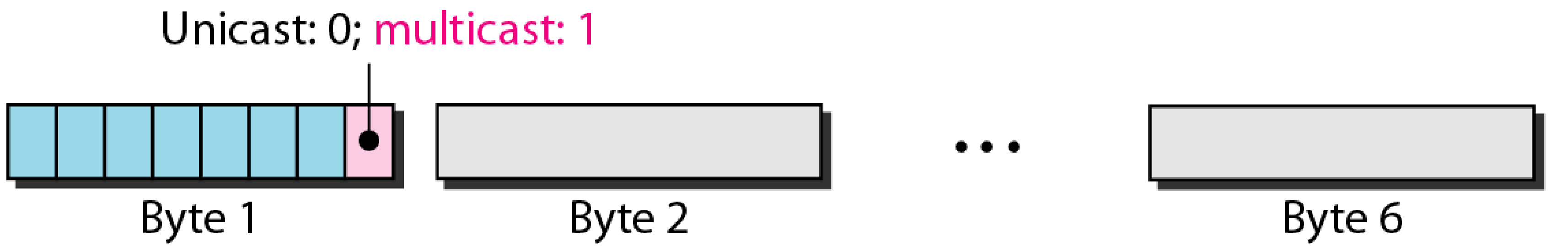
Ethernet Address for Desktop PC ethernet card



The ethernet address for the above network card is : 006097981E6B

- ***Unicast and multicast addresses***



The least significant bit of the first byte in a destination address defines the type of address. If the bit is 0, the address is unicast;otherwise, it is multicast.

Note

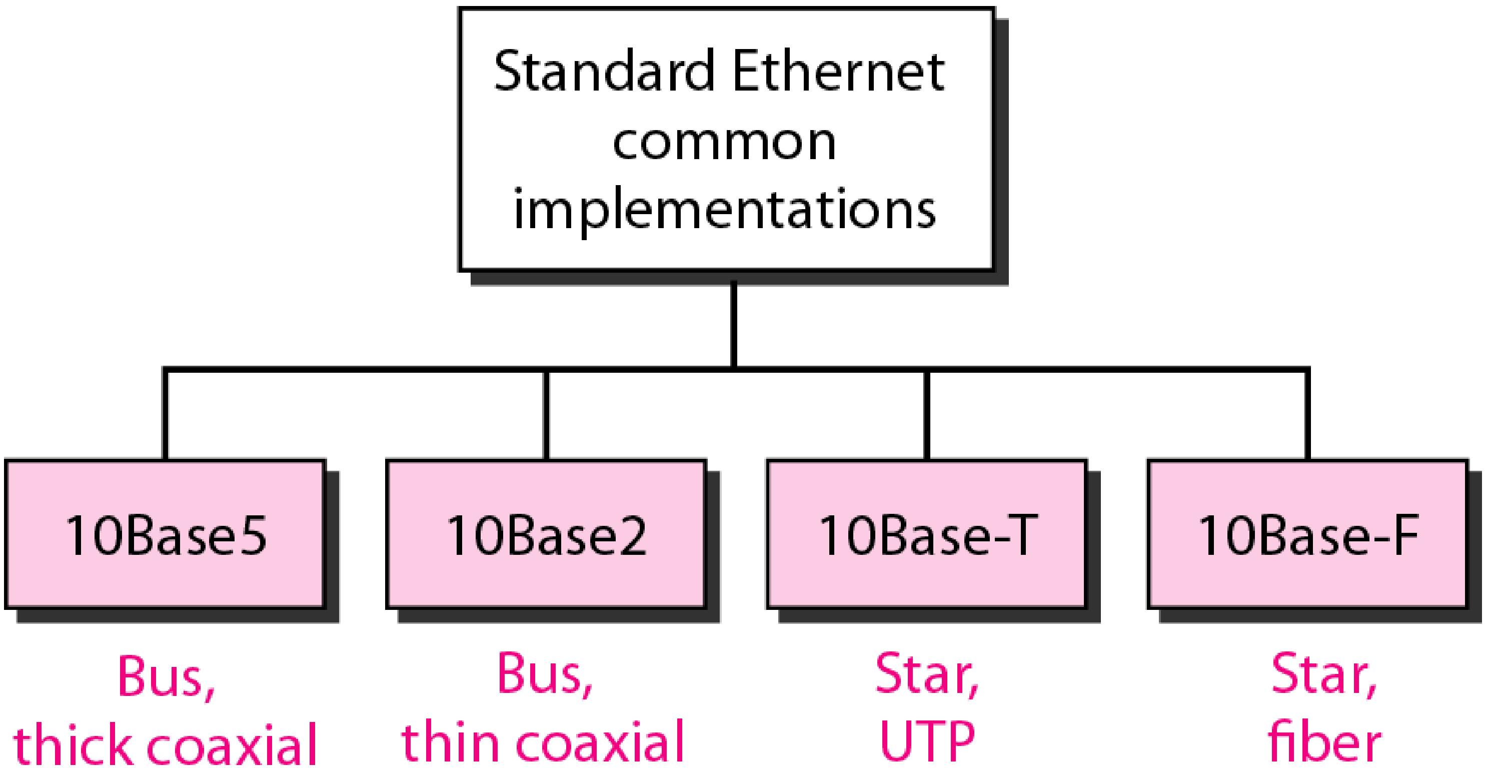
- **The broadcast destination address is a special case of the multicast address in which all bits are 1s.**

- ***Example***

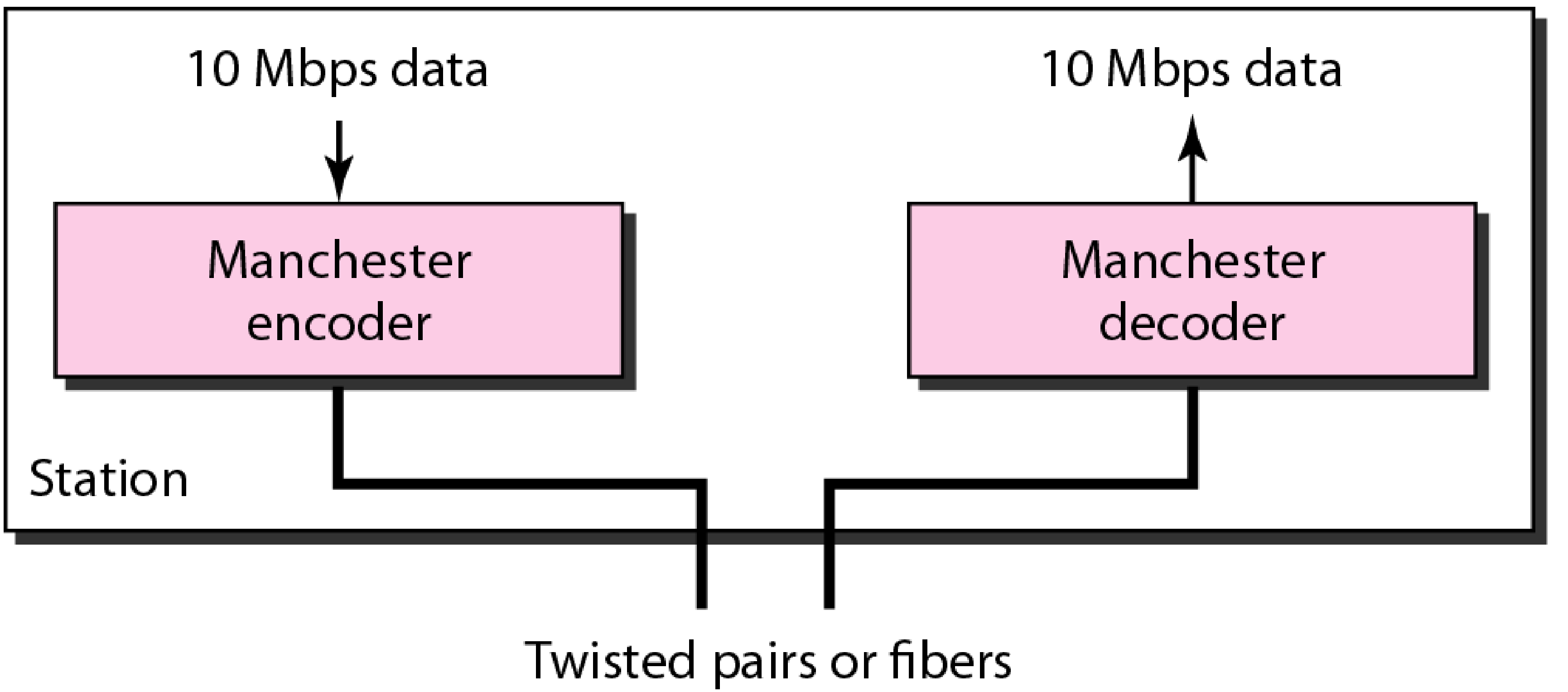
- ***Define the type of the following destination addresses:***
- ***a. 4A:30:10:21:10:1A***
- ***b. 47:20:1B:2E:08:EE***
- ***c. FF:FF:FF:FF:FF:FF***

- ***Solution***
- ***To find the type of the address, we need to look at the second hexadecimal digit from the left. If it is even, the address is unicast. If it is odd, the address is multicast. If all digits are F's, the address is broadcast. Therefore, we have the following:***
- ***a. This is a unicast address because A in binary is 1010.***
- ***b. This is a multicast address because 7 in binary is 0111.***
- ***c. This is a broadcast address because all digits are F's.***

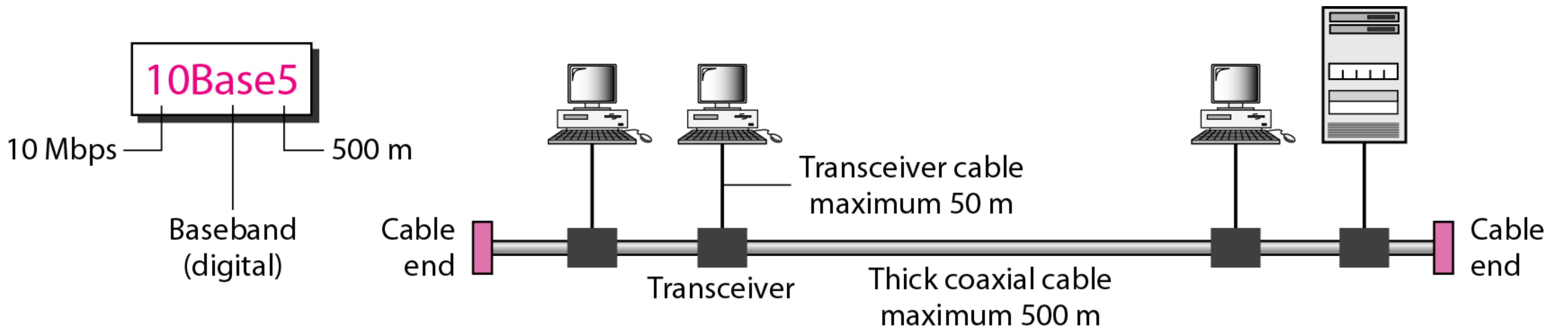
- ***Categories of Standard Ethernet***



- *Encoding in a Standard Ethernet implementation*



- **Figure *10Base5 implementation***



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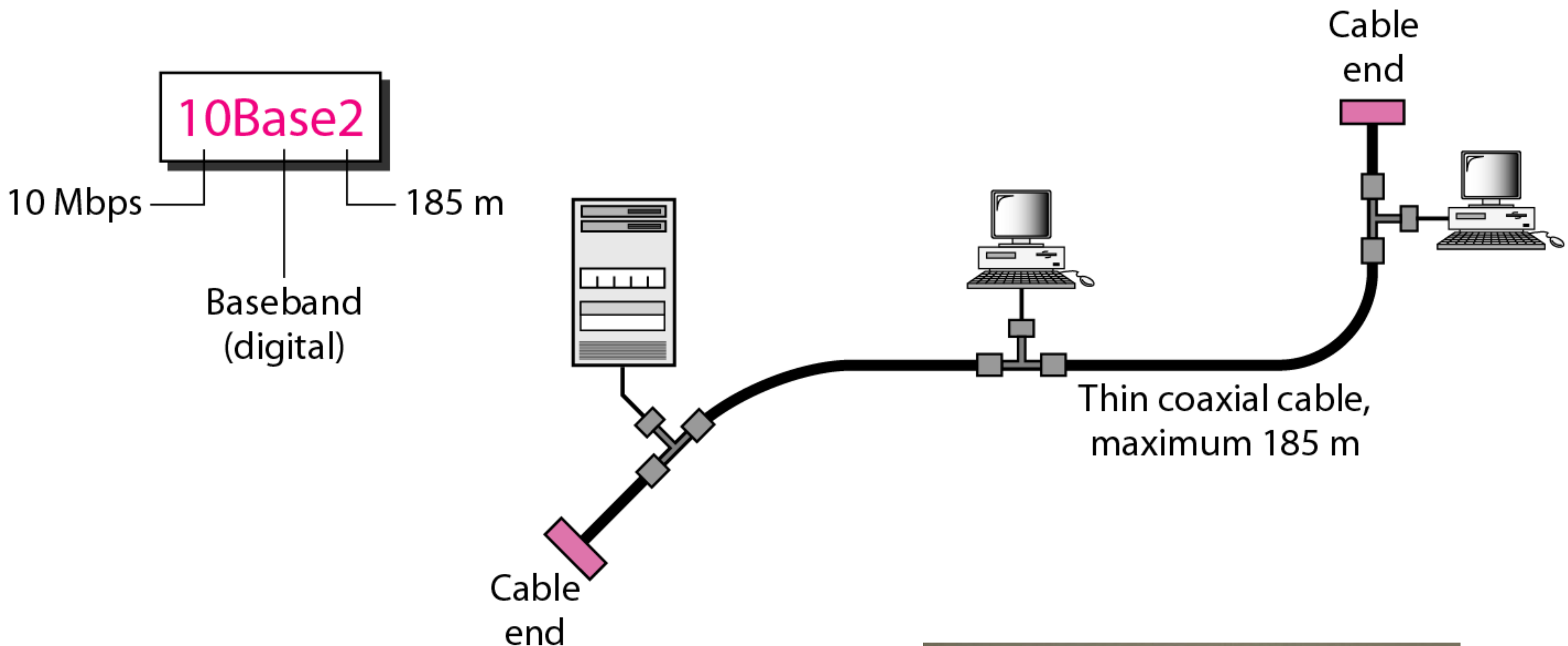
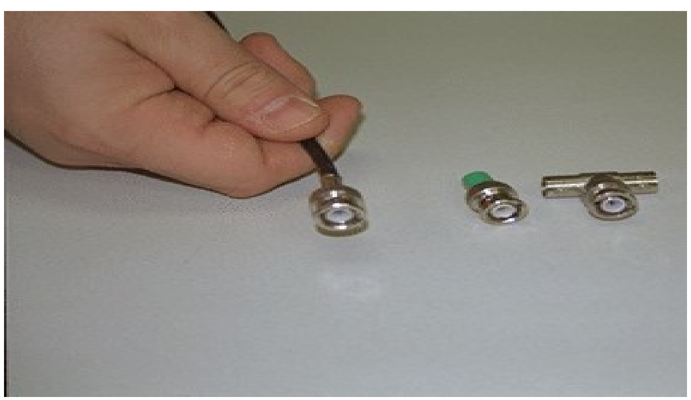
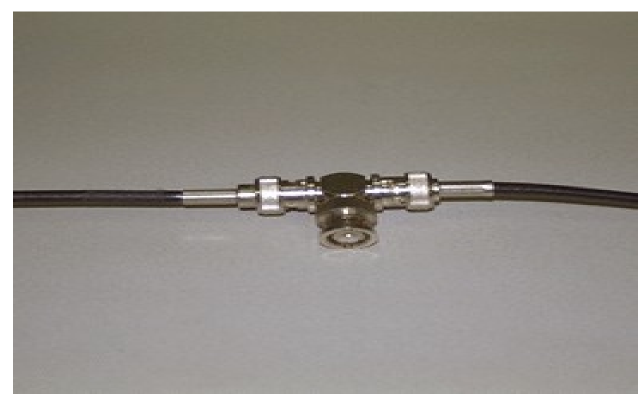
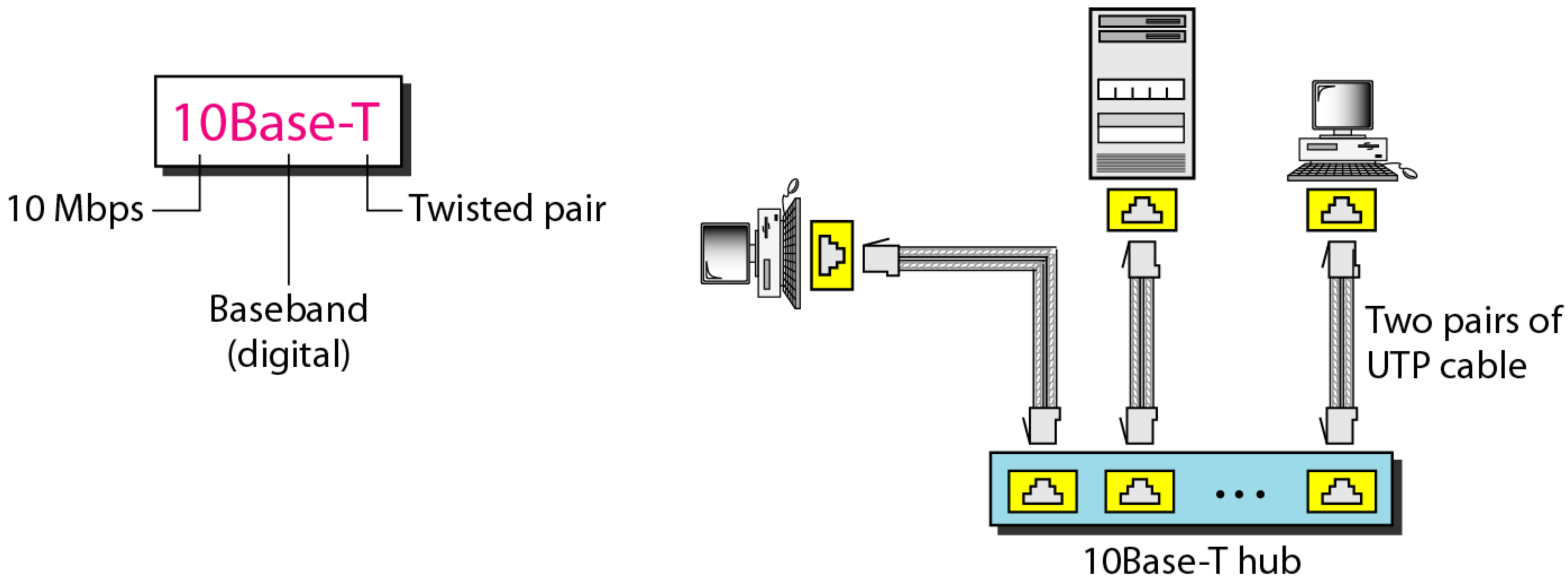
• **Figure** ***10Base2 implementation***



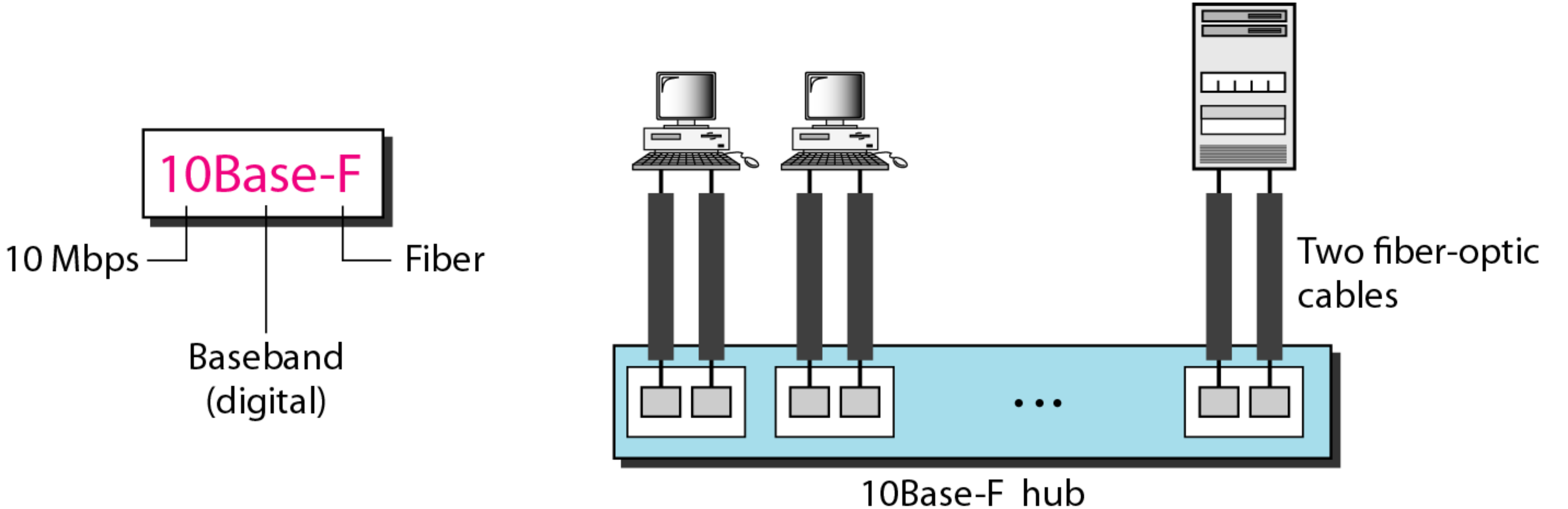




- **Figure *10Base-T implementation***



- **Figure *10Base-F implementation***



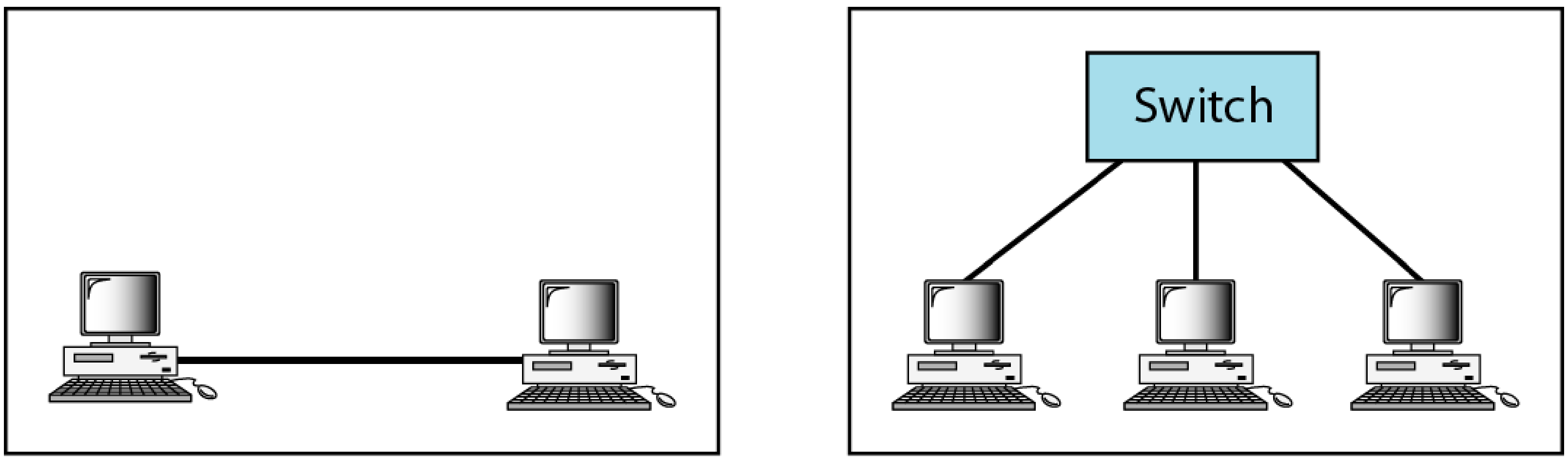
- **Table** ***Summary of Standard Ethernet implementations***

Characteristics	*10Base5*	*10Base2*	*10Base-T*	*10Base-F*
Media	Thick coaxial cable	Thin coaxial cable	2 UTP	2 Fiber
Maximum length	500 m	185 m	100 m	2000 m
Line encoding	Manchester	Manchester	Manchester	Manchester

FAST ETHERNET

Fast Ethernet was designed to compete with LAN protocols such as FDDI (Fiber Distributed Data Interface) or Fiber Channel. IEEE created Fast Ethernet under the name 802.3u. Fast Ethernet is backward-compatible with Standard Ethernet, but it can transmit data 10 times faster at a rate of 100 Mbps.

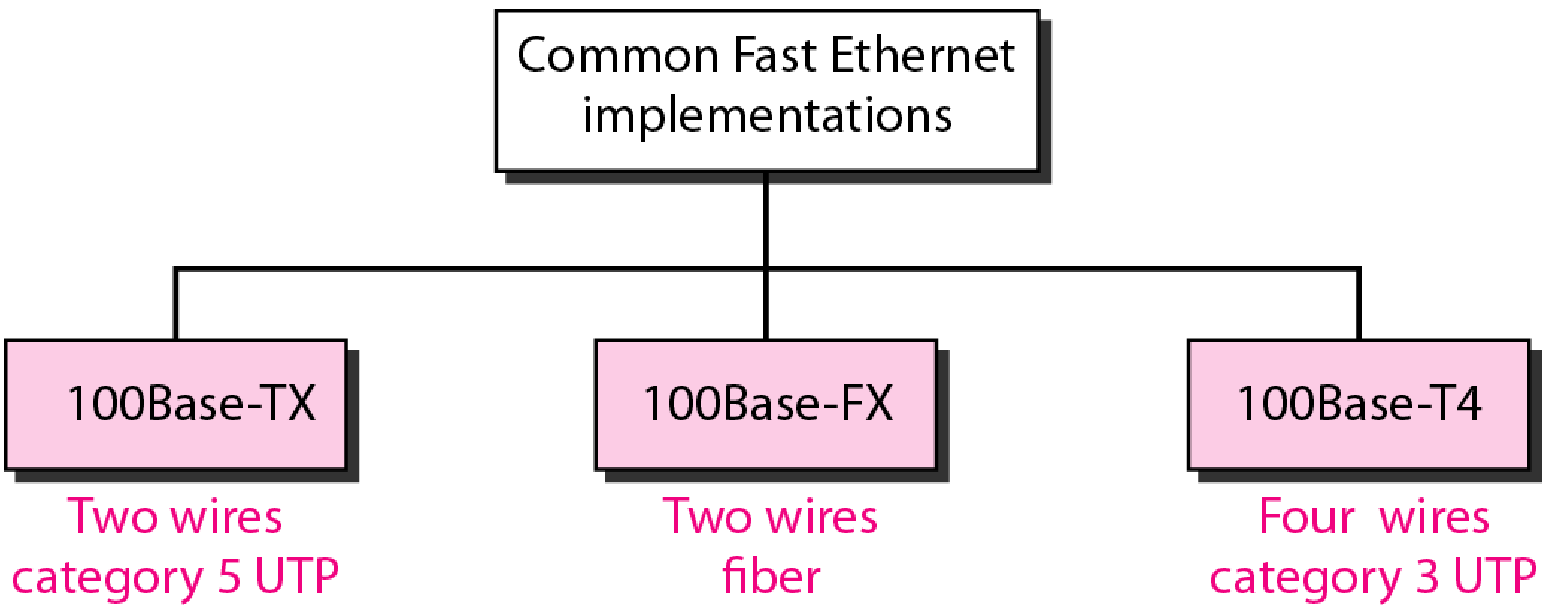
Fast Ethernet topology



a. Point-to-point

b. Star

Fast Ethernet implementations



Fast Ethernet

- 100 Mbps transmission rate
- same frame format, media access, and collision detection rules as 10 Mbps Ethernet
- can **combine 10 Mbps** Ethernet and Fast Ethernet on same network using a ***switch***
- media: twisted pair (CAT 5) or fiber optic cable (no coax)
- Star-wire topology
  - Similar to 10BASE-T

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

Table- *Summary of Fast Ethernet implementations*

Characteristics	*100Base-TX*	*100Base-FX*	*100Base-T4*
Media	Cat 5 UTP or STP	Fiber	Cat 4 UTP
Number of wires	2	2	4
Maximum length	100 m	100 m	100 m
Block encoding	4B/5B	4B/5B	
Line encoding	MLT-3	NRZ-I	8B/6T

GIGABIT ETHERNET

- ***The need for an even higher data rate resulted in the design of the Gigabit Ethernet protocol (1000 Mbps). The IEEE committee calls the standard 802.3z.***

MAC Sublayer

- **Physical Layer**
- **Ten-Gigabit Ethernet**

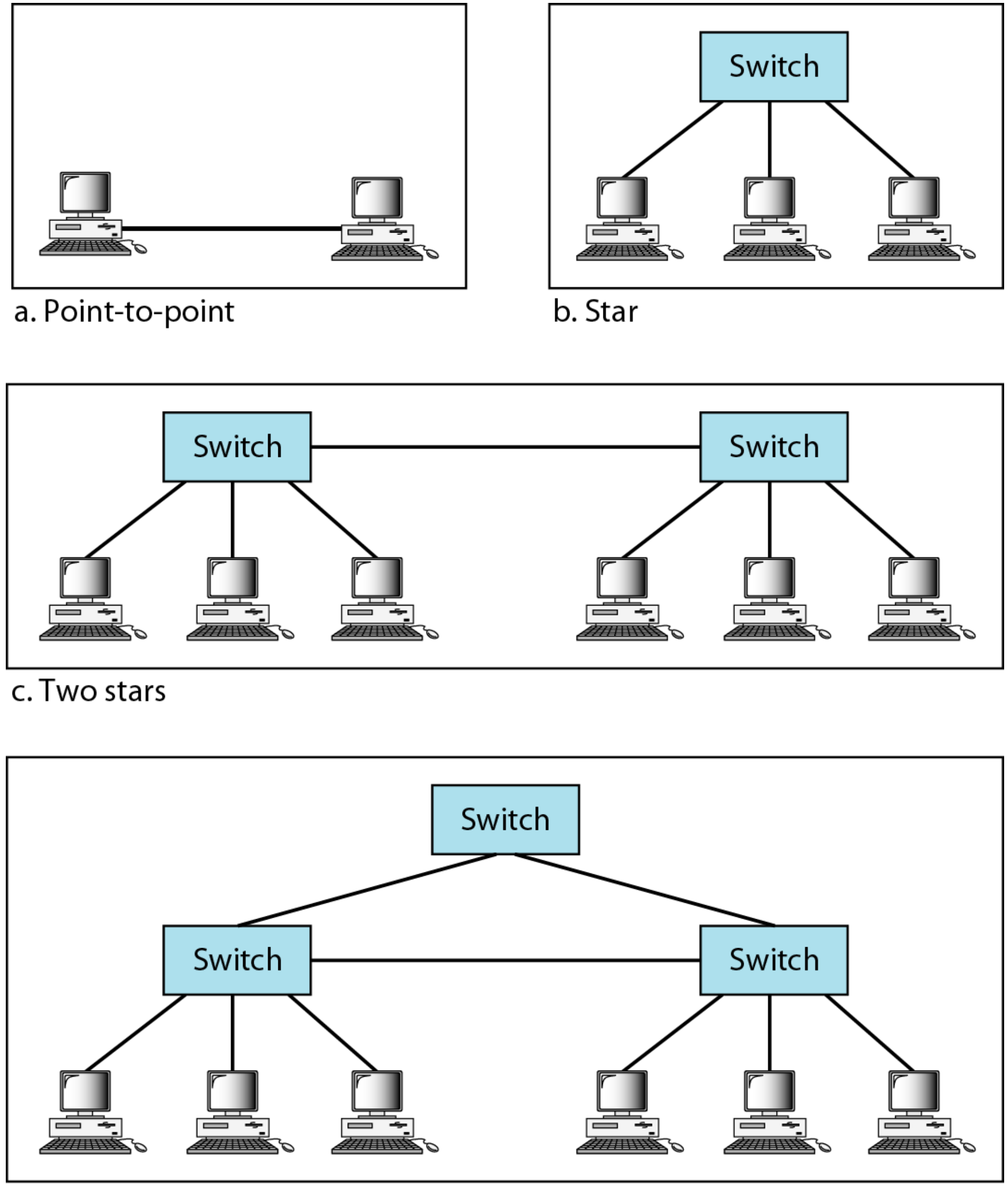
Goals of Gigabit Ethernet

Upgrade the data rate to 1 Gbps.
Make it compatible with Standard or Fast Ethernet.
Use the same 48 bits address.
Use the same frame format.
Keep the same minimum and maximum frame lengths.

Note

In the full-duplex mode of Gigabit Ethernet, there is no collision; the maximum length of the cable is determined by the signal attenuation in the cable.

Topologies of Gigabit Ethernet



a. Point-to-point

b. Star

c. Two stars

d. Hierarchy of stars

Gigabit Ethernet implementations

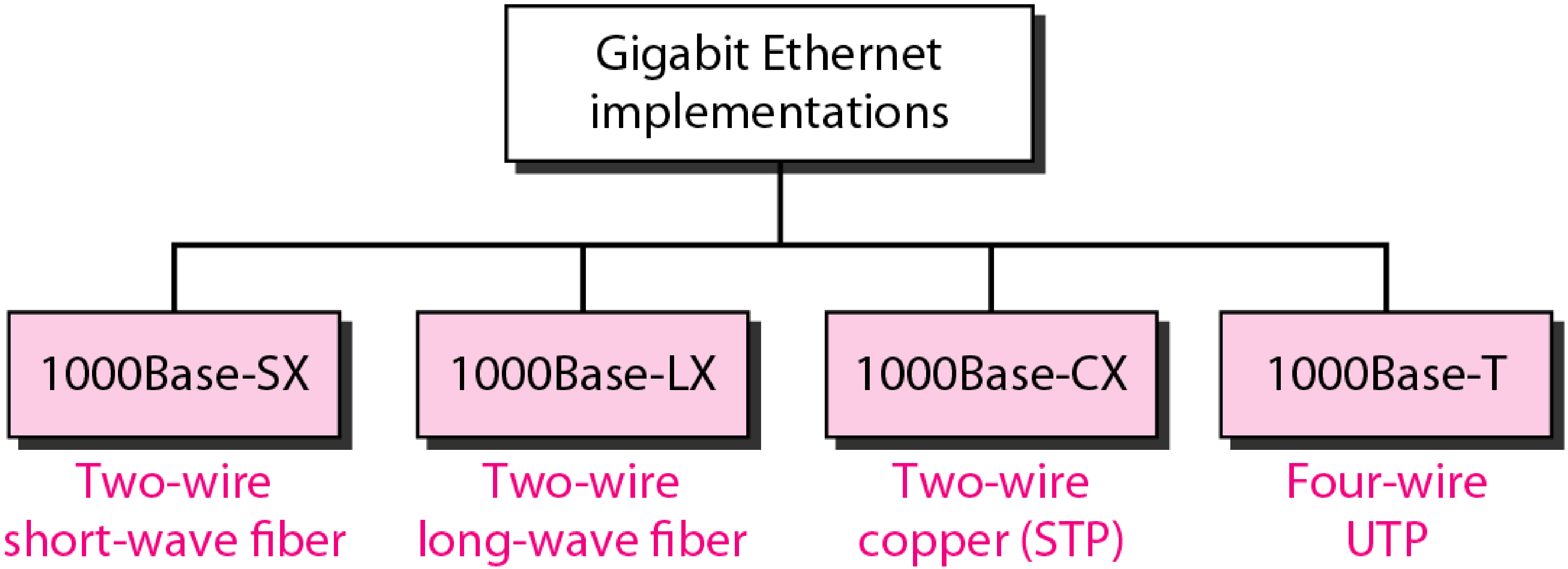


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Table-*Summary of Gigabit Ethernet implementations*

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

Ten Gigabit Ethernet

The IEEE committee created Ten – Gigabit Ethernet and called it Standard 802.3ae.

Goals:

Upgrade the data rate to 10 Gbps.

Make it compatible with Standard, Fast and Gigabit Ethernet.

Use the same 48 bits address.

Use the same frame format.

Keep the same minimum and maximum frame lengths.

Allow the interconnection of existing LANs into a MAN or a WAN.

Make Ethernet compatible with technologies such as Frame Relay and ATM.

Table-*Summary of Ten-Gigabit Ethernet implementations*

Characteristics	*10GBase-S*	*10GBase-L*	*10GBase-E*
Media	Short-wave 850-nm multimode	Long-wave 1310-nm single mode	Extended 1550-mm single mode
Maximum length	300 m	10 km	40 km

Binary Exponential Backoff Algo.

- - If a collision is detected, delay and try again.
- - Delay time is selected using binary exponential backoff.
- - For each retransmission, a multiplier in the range 0 to $2^k - 1$ is randomly chosen and multiplied by Tp (maximum propagation time) or T_{fr} (the average time required to send out a frame) to find T_B.

- Note that in this procedure, the range of the random numbers increases after each collision.

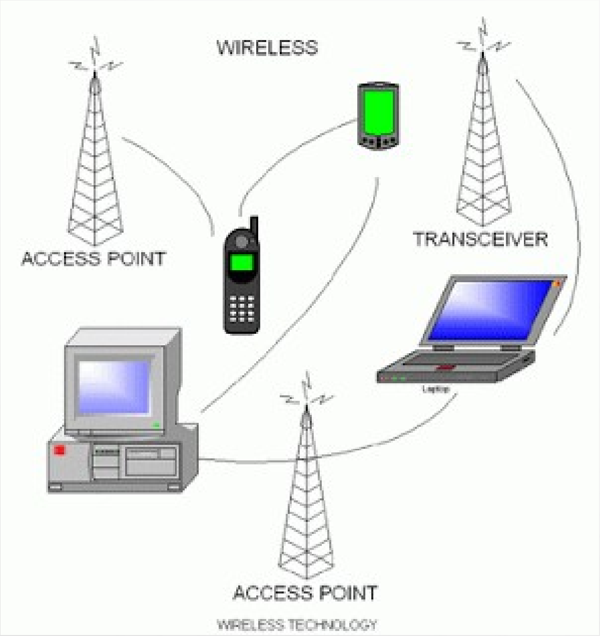
- The value of K max is usually chosen as 15.

Binary Exponential Backoff Algo.

- - Eg.:
  - 1st time: choose K from {0,1} then delay = K * Tp
  - 2nd time: choose K from {0,1,2,3} then delay = K * Tp
  - *nth* time: delay = K * Tp, for K=0.....2^n – 1
  - give up after several tries (usually 15)
    - Report transmit error to host
- - Why not just choose from small set for K
  - This works fine for a small number of hosts
  - Large number of nodes would result in more collisions

Wireless Transmission

- *Wireless transmission is a form of unguided media. Wireless communication involves no physical link established between two or more devices, communicating wirelessly. Wireless signals are spread over in the air and are received and interpret by appropriate antennas.*



IEEE 802.11

- ***IEEE has defined the specifications for a wireless LAN, called IEEE 802.11, which covers the physical and data link layers.***

Requirements of Wireless LAN

- **Requirements / Properties of wireless LAN :**

1. No. Of Nodes
2. Throughput
3. Connection to backbone LAN
4. Service Area / Cell
5. Hand off/roaming
6. Dynamic configuration
7. Battery power consumption

Applications of Wireless LAN

1. LAN extension

Reduce the cost of the installation of LAN cabling.

2. Cross building interconnect

To connect the LAN in nearby buildings, they can be wired or wireless LANs.

3. Nomadic acces

It provides a wireless link between a LAN hub and a mobile data terminal equipped with an antenna.

4. Ad hoc networking

An ad hoc network is peer – to -peer network set up temporarily to meet some immediate need.

WLAN Architecture

- ***The standard defines two kinds of services :***
- ***1. Basic Service Set (BSS)***
- ***2. Extended Service Set (ESS)***

- **1. Basic Service Set (BSS)**

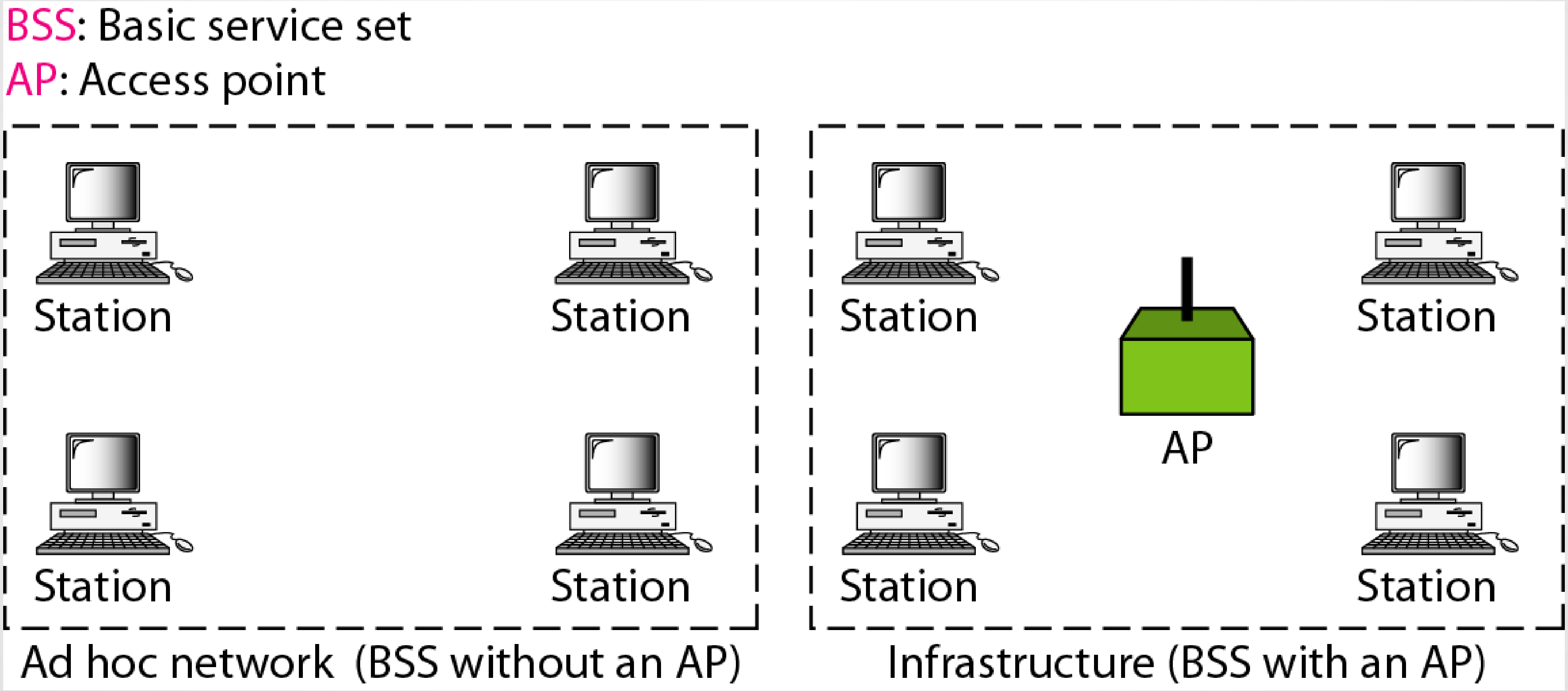
A BSS is made of stationary or mobile wireless stations and an optional central base station, known as the Access Point (AP).

- The BSS without an AP is a stand alone network and cannot send data to other BSSs, it is called an *ad hoc architecture.*
- A BSS with an AP is sometimes referred to as an *infrastructure network.*

Note

- **A BSS without an AP is called an ad hoc network;**
- **a BSS with an AP is called an infrastructure network.**

Basic service sets (BSSs)



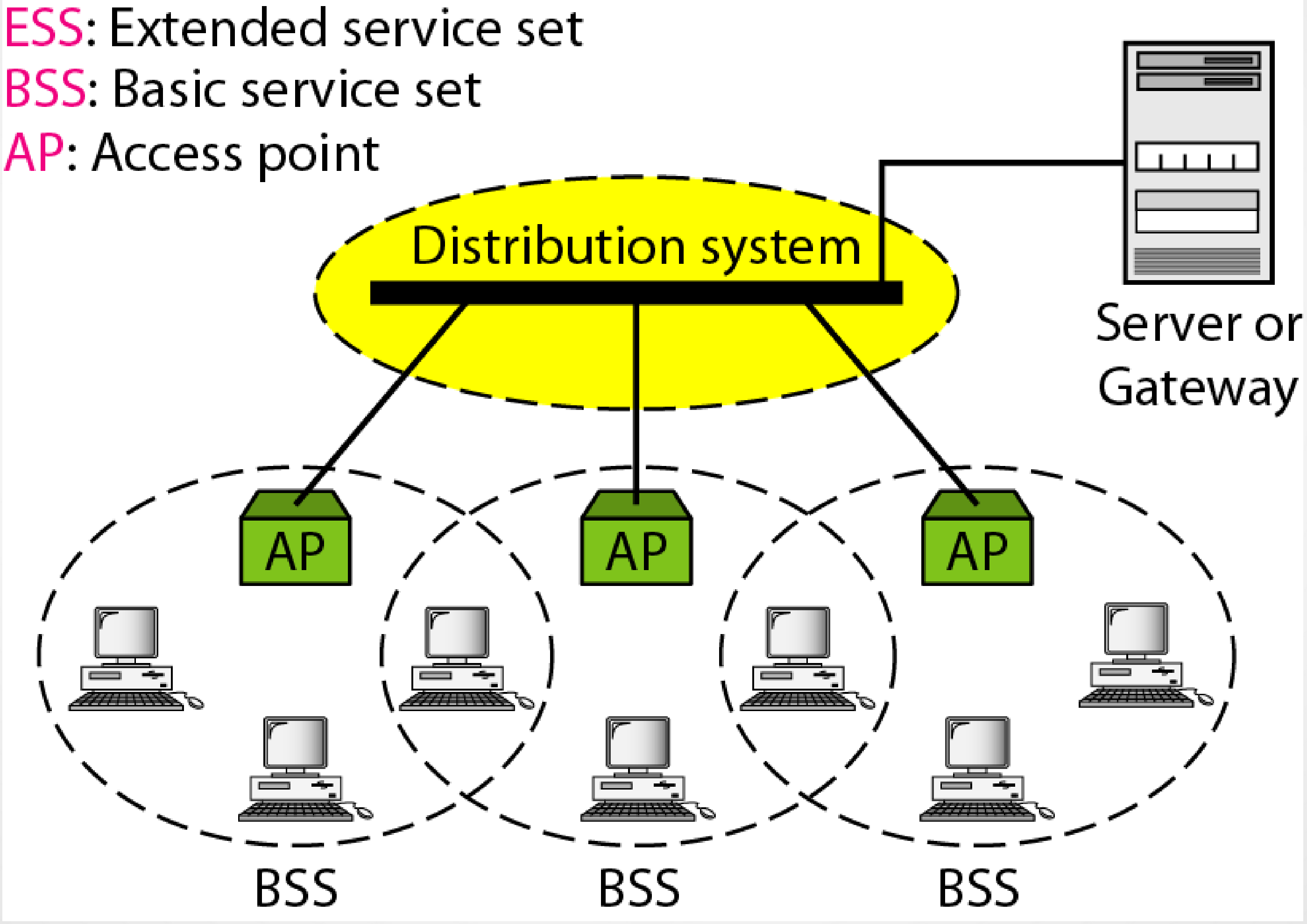
Architecture Continue.....

- **2. Extended Service Set (ESS)**

-An ESS is made up of two or more BSSs with APs.

- -In this, BSSs are connected through a distribution system, which is usually a wired LAN.
- -The distribution system connects the APs in the BSSs.
- -Distribution System can be any IEEE LAN such as an Ethernet.
- -ESS uses two types of stations: Mobile & Stationary.
- -Mobile stations are normal stations inside a BSS.
- -The stationary stations are AP stations that are part of a wired LAN.

Extended service sets (ESSs)



Fragmentation

- The wireless environment is very noisy; a corrupt frame has to be Retransmitted.

- The protocol, therefore, recommends fragmentation-the division of a large frame into smaller ones.

- It is more efficient to resend a small frame than a large one.

802.11 (Wi-Fi i.e. Wireless LAN)

- Each of the transmission techniques makes it possible to send a MAC frame over the air from one station to another.
- They differ, however, in the technology used and speeds achievable.
- All of the 802.11 techniques use short-range radios to transmit signals in either the 2.4-GHz or the 5-GHz ISM frequency bands.
- All of the transmission methods also define multiple rates.
- The idea is that different rates can be used depending on the current conditions.

IEEE 802.11a OFDM

Introduction to OFDM System

- Orthogonal frequency division multiplexing (OFDM) is a multi-carrier transmission technique, which divides the available spectrum into many sub-carriers, each one being modulated by a low data rate stream.

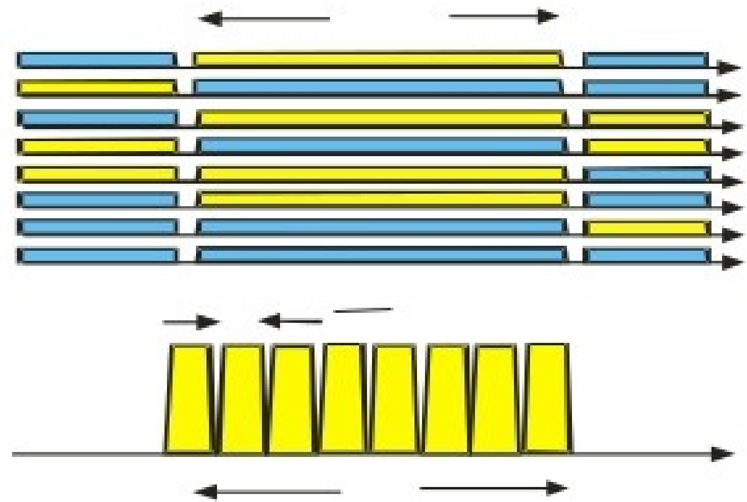
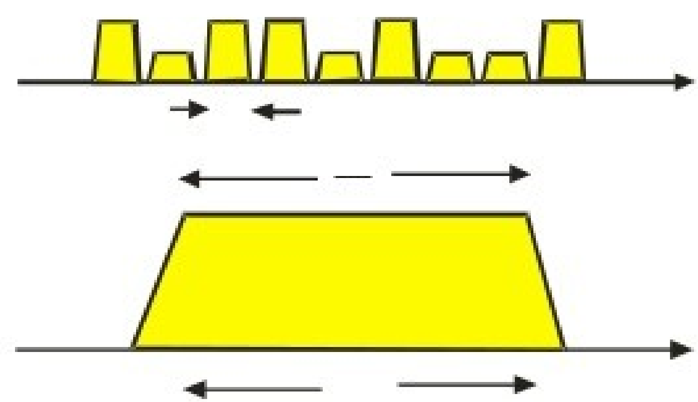


Fig:1 Multi-Carrier System



W=Bandwidth
T= Sample time

Fig:2 Single Carrier System

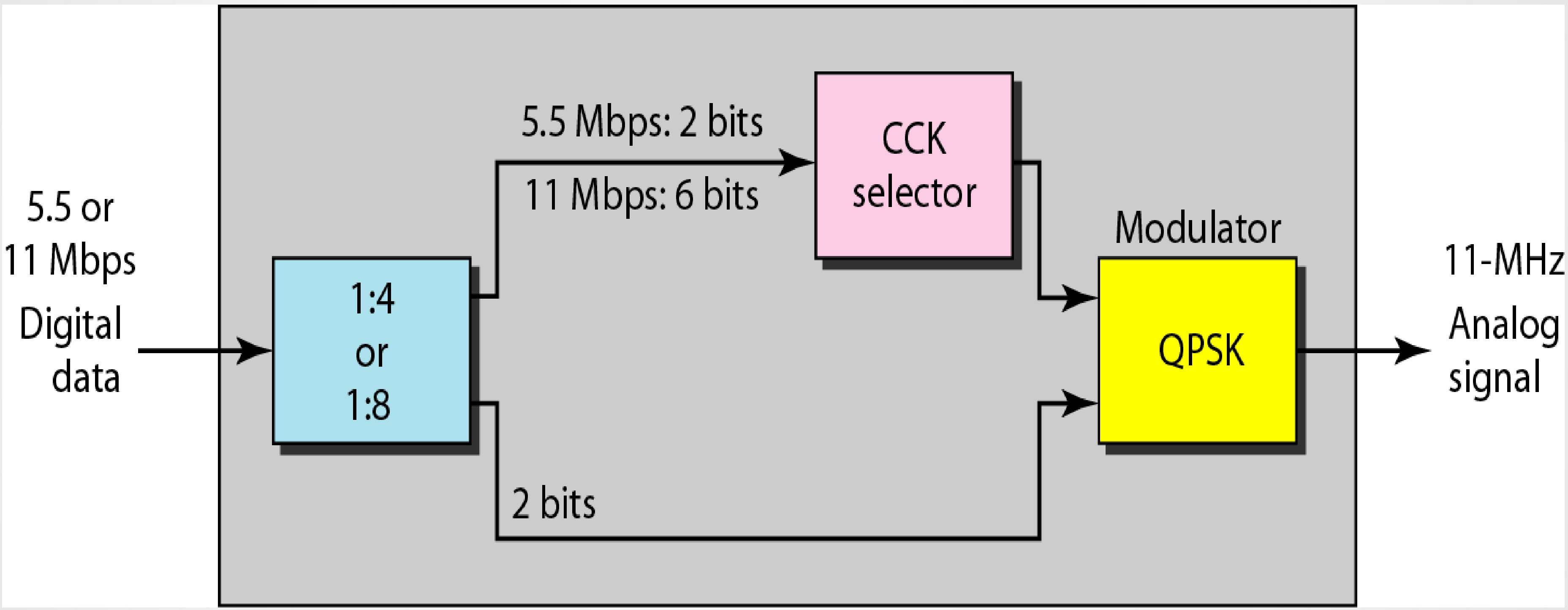
IEEE 802.11a (OFDM)

- IEEE 802.11a describes the orthogonal frequency-division multiplexing (OFDM) method for signal generation in a 5-GHz ISM band.
- OFDM is similar to FDM, with one major difference:
  All the subbands are used by one source at a given time.
- Sources contend with one another at the data link layer for access.
- The band is divided into 52 subbands, with 48 subbands for sending 48 groups of bits at a time and 4 subbands for control information.
- This scheme is similar to ADSL.
- Dividing the band into subbands reduce the effects of interference.
- OFDM uses PSK and QAM for modulation.
- The common data rates are 18 Mbps (PSK) and 54 Mbps (QAM).

IEEE 802.11b (DSSS)

- IEEE 802.11b describes the high-rate direct sequence spread spectrum (HR-DSSS) method for signal generation in the 2.4-GHz ISM band.
- HR-DSSS is similar to DSSS except for the encoding method, which is called complementary code keying (CCK).
- CCK encodes 4 or 8 bits to one CCK symbol.
- HR-DSSS defines four data rates: 1,2, 5.5, and 11 Mbps.
- The first two use the same modulation techniques as DSSS.
- The 5.5-Mbps version uses BPSK and transmits at 1.375 Mbaud/s with 4-bit CCK encoding.
- The 11-Mbps version uses QPSK and transmits at 1.375 Mbaud/s with 8-bit CCK encoding.

IEEE 802.11b DSSS



IEEE 802.11a Vs 802.11b

	802.11a	802.11b
Modulation Scheme	OFDM	DSSS
Spectrum (GHz)	5.15-5.35, 5.725-5.825	2.4 – 2.485
Data Rate (Mbps)	6 - 54	1 – 11
Subchannels	48 independent	11 overlapping
Interference / Application	HyperLAN	Microwave, Cordless Phones,Bluetooth, HomeRF, Light Bulbs!

IEEE 802.11g

- In July 1999, IEEE pushed for another protocol of 802.11 to extend the 2.4Ghz frequency to increase data rate beyond 20Mbps.
- 802.11g was approved in June 2003, It is backward-compatible with 802.11b, i.e. CCK.
- This new specification defines forward error correction and OFDM using the 2.4-GHz ISM band.
- The modulation technique achieves a 22 or 54-Mbps data rate.
- But the modulation technique used is OFDM.
- There is an inverse relationship between wavelength and range.

IEEE 802.11g Continue....

- A signal transmitted at a lower frequency range of spectrum will carry further than a signal transmitted in a higher frequency range.
- 802.11g should operate in 2.4Ghz frequency band and gives high range.
- 802.11g technology will be the standard for next generation of wireless networking.
- The benefits of 802.11g are: providing an increase in LAN speed, backward compatible with 802.11b products, and offer higher range and coverage for networks.
- 802.11g is an exciting technology that offers the performance of 802.11a, and the range of 802.11b.

IEEE 802.11n

- IEEE committee began work on a high-throughput physical layer called 802.11n. It was ratified in 2009.
- The goal for 802.11n was throughput of at least 100 Mbps after all the wireless overheads were removed.
- This goal called for a raw speed increase of at least a factor of four.
- To make it happen, the committee doubled the channels from 20 MHz to 40 MHz and reduced framing overheads by allowing a group of frames to be sent together.

IEEE 802.11n Continue...

More significantly, however, 802.11n uses up to four antennas to transmit up to 4 streams of information at the same time.

- The signals of the streams interfere at the receiver, but they can be separated using MIMO (Multiple Input Multiple Output) communications techniques.
- The use of multiple antennas gives a large speed boost, or better range and reliability instead.
- MIMO, like OFDM, is one of those clever communications ideas that is changing wireless designs and which we are all likely to hear a lot about in the future.

IEEE 802.11ac

- IEEE 802.11ac is a wireless networking standard in the 802.11 family.
- It providing high-throughput wireless local area networks (WLANs) on the 5 GHz band.
- The standard was developed from 2011 - 2013 and approved in Jan. 2014.
- 802.11ac is a faster and more scalable version of 802.11n.
- This specification has expected multi-station WLAN throughput of at least 1 Gbps and a single link throughput of at least 500 Mbps.
- Multi-user MIMO (MU-MIMO) : Multiple devices, each with potentially multiple Antennas, transmit or receive independent data streams simultaneously .

IEEE 802.11ad

- 60GHz support i.e Gigabit data rates.

- It supports session switching between the 2.4GHz, 5GHz and 60GHz bands.

- Appropriate for shorter range in-room use cases.

- Using frequencies in the millimetre range IEEE 802.11ad microwave Wi-Fi Has a range that is measured of a few metres.

- The aim is that it will be used for very short range (across a room) high volume data transfers such as HD video transfers.

- When longer ranges are needed standards such as 802.11ac can be used.

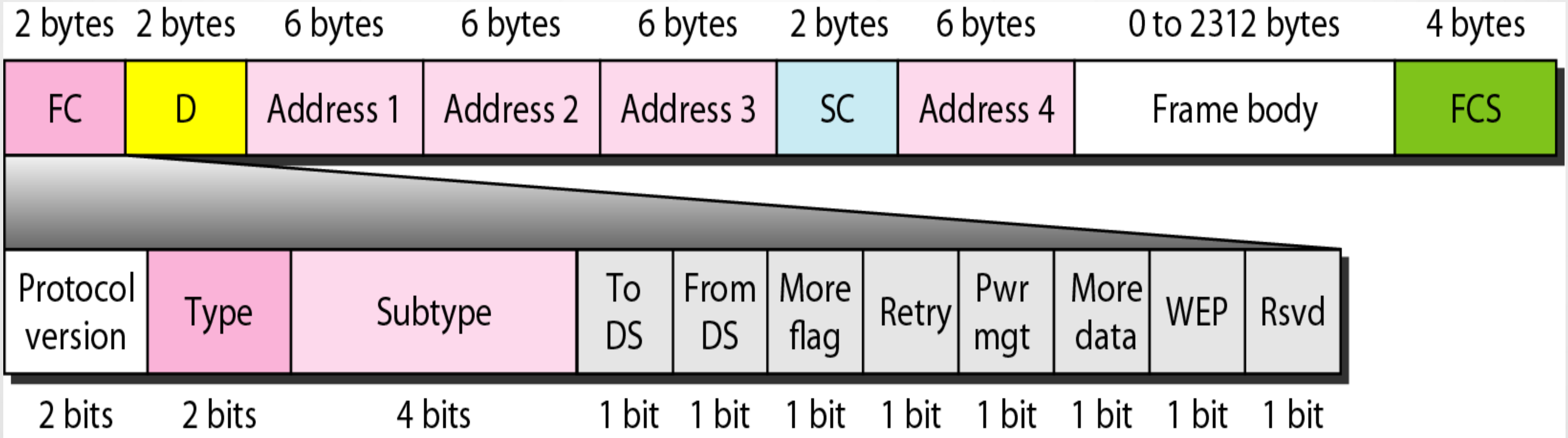
- In order to provide the industry support and an easy marketing name, the IEEE and Wireless Gigabit Alliance have worked together on developing the IEEE 802.11ad WiGig standard.

- The peak transmission rate of 802.11ad is 7 Gbit/s.

TABLE 1: IEEE 802.11 PHY STANDARDS						
Release date	Standard	Band (GHz)	Bandwidth (MHz)	Modulation	Advanced antenna technologies	Maximum data rate
1997	802.11	2.4	20	DSSS, FHSS	N/A	2 Mbits/s
1999	802.11b	2.4	20	DSSS	N/A	11 Mbits/s
1999	802.11a	5	20	OFDM	N/A	54 Mbits/s
2003	802.11g	2.4	20	DSSS, OFDM	N/A	54 Mbits/s
2009	802.11n	2.4, 5	20, 40	OFDM	MIMO, up to four spatial streams	600 Mbits/s
2012 (expected)	802.11ad	60	2160	SC, OFDM	Beamforming	6.76 Gbits/s
2013 (expected)	802.11ac	5	40, 80, 160	OFDM	MIMO, MU-MIMO, up to eight spatial streams	6.93 Gbits/s

802.11 Frame Format

The MAC layer frame consists of nine fields, as shown in Figure :



Frame Format Continue.......

1. Frame Control (FC) :

The FC field is 2 bytes long and defines the type of frame and some control information.

Field	*Explanation*
Version	Current version is 0
Type	Type of information: management (00), control (01), or data (10)
Subtype	Subtype of each type (see Table 14.2)
To DS	Defined later
From DS	Defined later
More flag	When set to 1, means more fragments
Retry	When set to 1, means retransmitted frame
Pwr mgt	When set to 1, means station is in power management mode
More data	When set to 1, means station has more data to send
WEP	Wired equivalent privacy (encryption implemented)
Rsvd	Reserved

Frame Format Continue.......

2. D : In all frame types except one, this field defines the duration of the transmission that is used to set the value of NAV.

3. Addresses: There are four address fields, each 6 bytes long. The meaning of each address field depends on the value of the ***To DS*** and ***From DS*** subfields and will be discussed later.

4. Sequence control: This field defines the sequence number of the frame to be used in flow control.

5. Frame body: This field, which can be between 0 and 2312 bytes, contains information based on the type and the subtype defined in the FC field.

6. FCS: The FCS field is 4 bytes long and contains a CRC-32 error detection sequence.

Frame Types

A wireless LAN defined by IEEE 802.11 has three categories of frames:

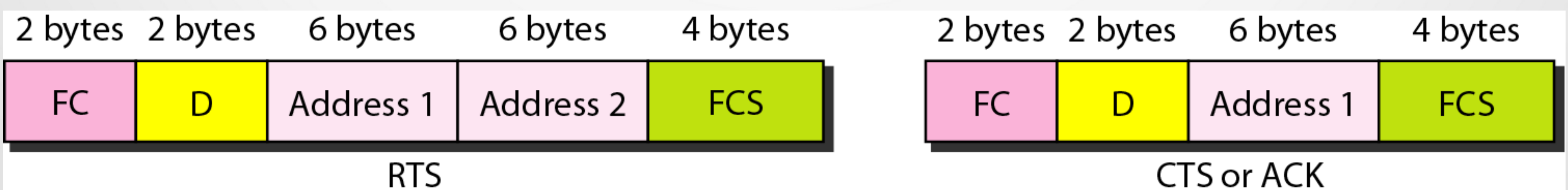
1. Management frames,
2. Control frames, and
3. Data frames.

1. Management Frames:

- Management frames are used for the initial communication between stations and access points.

2. Control Frames :

- Control frames are used for accessing the channel and acknowledging frames.



Frame Types Continue...

For control frames the value of the type field is 0 1 ; the values of the subtype fields for frames we have discussed are shown in following Table :

Subtype	*Meaning*
1011	Request to send (RTS)
1100	Clear to send (CTS)
1101	Acknowledgment (ACK)

3. Data Frames:

- Data frames are used for carrying data and control information.

Addressing Mechanism

- The IEEE 802.11 addressing mechanism specifies four cases, defined by the value of the two flags in the FC field, ***To DS*** and ***From DS***.
- Each flag can be either 0 or 1, resulting in four different situations.
- The interpretation of the four addresses (address 1 to address 4) in the MAC frame depends on the value of these flags, as shown in Table :

To DS	*From DS*	*Address 1*	*Address 2*	*Address 3*	*Address 4*
0	0	Destination	Source	BSS ID	N/A
0	1	Destination	Sending AP	Source	N/A
1	0	Receiving AP	Source	Destination	N/A
1	1	Receiving AP	Sending AP	Destination	Source

-Address 1 is always the address of the next device.
- Address 2 is always the address of the previous device.
- Address 3 is the address of the final destination station if it is not defined by address 1.
- Address 4 is the address of the original source station if it is not the same as address 2.

Addressing Mechanism Continue...

Case 1:

00 In this case, To DS = 0 and From DS = O.

This means that the frame is not going to a distribution system (To DS = 0)

and is not coming from a distribution system (From DS = 0).

The frame is going from one station in a BSS to another without passing

through the distribution system.

The ACK frame should be sent to the original sender.

Case 2:

01 In this case, To DS = 0 and From DS = 1.

This means that the frame is coming from a distribution system (From DS = 1).

The frame is coming from an AP and going to a station.

The ACK should be sent to the AP.

Note that address 3 contains the original sender of the frame (in another BSS).

Addressing Mechanism Continue...

Case 3:

10 In this case, To DS = 1 and From DS = 0.

This means that the frame is going to a distribution system (To DS = 1).

The frame is going from a station to an AP.

The ACK is sent to the original station.

The address 3 contains the final destination of the frame (in another BSS).

Case 4:

11 In this case, To DS = 1 and From DS = 1.

This is the case in which the distribution system is also wireless.

The frame is going from one AP to another AP in a wireless DS.

Here, we need four addresses to define the original sender, the final destination, and two intermediate APs.

Addressing mechanisms