Computer Networks II

Lecture No. 4

Wired LANs: Ethernet

4^{th} Year/ 1^{st} semester

DR. Lecturer . Taqwa.F.Hassan

Computer Department - College of Engineering
University of Diyala

2021-2022

ETHERNET PROTOCOL

The data-link layer and the physical layer are the territory of the local and wide area networks. This means that when we discuss these two layers, we are talking about networks that are using them

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.

Topics discussed in this section:

Data Link Layer
Physical Layer

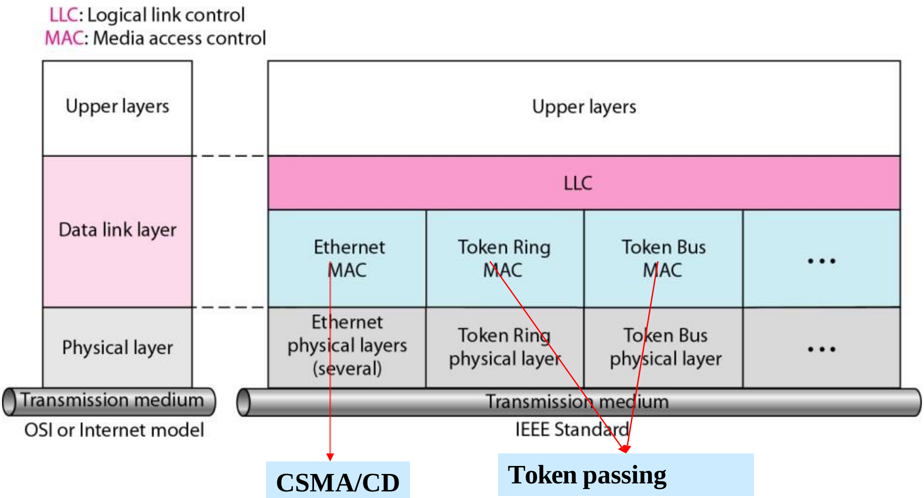
IEEE standard for LANs

IEEE divided the Data link layer into two sublayer:

- upper layer :logical link control (**LLC**); flow and error control.
- Lower sublayer : Multiple access (**MAC**); media access control.

  - Multiple access (**MAC**) → for resolving access to the shared media.
  - If channel is dedicated (point to point) we do not need the (**MAC**); sublayer.

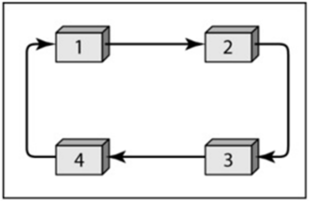
IEEE standard for LANs



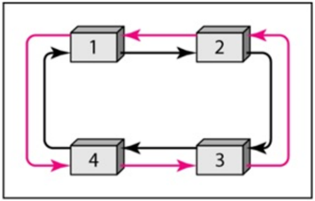
LLC (Logical link control) and MAC (Media Access Control)

- **In IEEE project 802, flow control , error control, and part of the framing duties are collected into one sublayer called the logical link control (LLC)**
- **LLC provides one single data link control for all IEEE LANs.**
- **IEEE project 802 has created a sublayer MAC that defines the specific access method for each LAN.** In contrast to the LLC, MAC contains a number of distinct modules: each defines the access method and the framing format specific to the corresponding LAN protocol
- **For example:**
  - **CSMA/CD as media access method for Ethernet LANs.**
  - **Token passing method for Token Ring and Token Bus LANs.**
- **Framing is handled in both the LLC and MAC sublayer.**

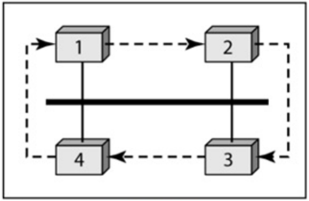
Logical ring and physical topology in token-passing access method



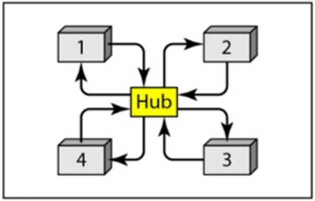
a. Physical ring



b. Dual ring



c. Bus ring ***Token bus***



d. Star ring

Physical layer

- Physical layer is dependent on the implementation and type of the physical media used.
- IEEE define detailed specifications for each LAN implementation.
- For example, although there is only one MAC sublayer for Standard Ethernet(CSMA/CD), there is a different physical layer specifications for each Ethernet implementations.

IEEE 802 Series of LAN Standards

Name	Description
IEEE 802.3	Ethernet
IEEE 802.4	Token bus
IEEE 802.5	Token Ring
IEEE 802.11a/b/g/n	Wireless LAN
IEEE 802.15.1	Bluetooth

What is Ethernet?

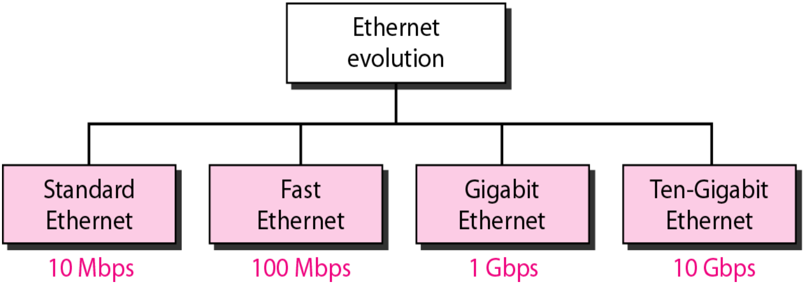
- Most widely-installed local area network (LAN) technology
- IEEE 802.3
- Uses coaxial cable or special grades of twisted pair wires
- Uses CSMA/CD protocol & Manchester Encoding
- Advance Ethernet is advance version of Ethernet which is called as Ethernet 2.0

ETHERNET IEEE 802.3

- **It is the dominant LAN technology.**
- **Cheap**
- **First widely used LAN technology**
- **Simpler and cheaper than token LANs**
- **Kept up with speed race: 10, 100, 1000 Mbps**

ETHERNET Evolution

The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC). Since then, it has gone through four generations.



STANDARD ETHERNET

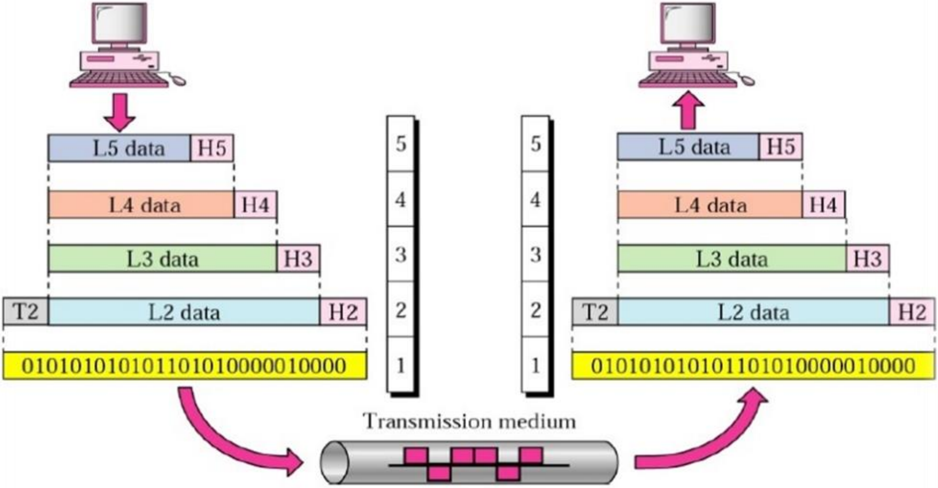
We refer to the original Ethernet technology with the data rate of 10 Mbps as the Standard Ethernet. Although most implementations have moved to other technologies in the Ethernet evolution, there are some features of the Standard Ethernet that have not changed during the evolution. We discuss this standard version first.

STANDARD ETHERNET

MAC Sublayer

- The MAC sublayer governs the operation of the random access method
- Standard Ethernet uses CSMA/CD with 1-persistent
- Ethernet dose not provide any mechanism for acknowledging received frames(unreliable medium).
- Acknowledgments must be implemented at the higher layer.
- It also frames data received from the upper layer and passes them to the physical layer.

An exchange using the Internet model



At sender:

- at each layer, a header can added to the data unit.
- At layer 2 a trailer is added as well .
- When formatted data unit passes through physical layer it is changed into an electromagnetic signal and transported along physical link.

Encapsulation:

A packet (header and data) at level 5 is encapsulated in a packet in level 4, and so on.

The data portion of packet at level N-1 carries the whole packet (data and header/trailer) from level N.

At destination:

- A data then move back up through the layer
- a headers and trailers attached to data at the corresponding layer are removed (decapsulated) and action appropriate to that layer are taken. (unwrapped/decapsulated)
- At layer 5 the message is again in form appropriate to the application and is made available to user.

Physical address

- *known also as the MAC or link address*
- *Is the address of a node as defined by its LAN or WAN*
- *It is included in the frame used by data link layer (Header)*
- *Ethernet uses 6-bytes (48-bits) physical address that imprinted on the NIC*

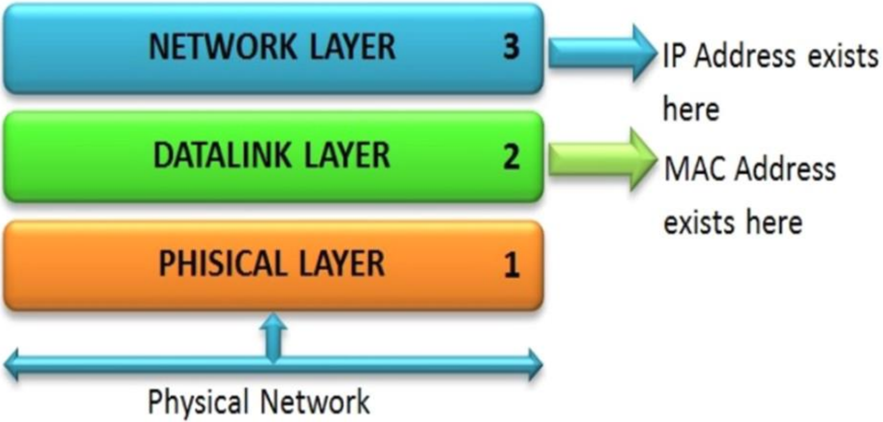
Ethernet address in hexadecimal notation

06 : 01 : 02 : 01 : 2C : 4B

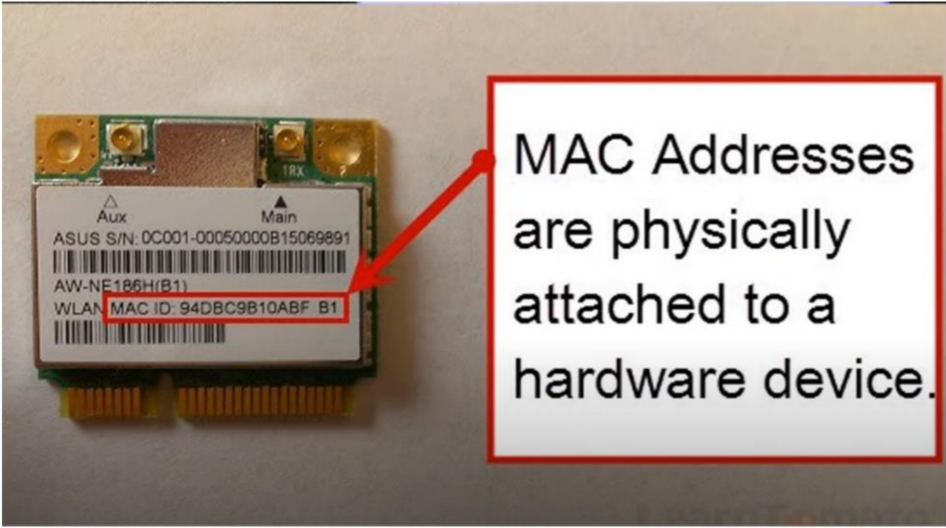
6 bytes = 12 hex digits = 48 bits

- Each station (PC or printer) has a network interface card (NIC) which provides the station with a 6-byte [48 bits] physical address (MAC adress)
- It is written in hexadecimal notation, with a colon between the bytes.

Why we need MAC Address



Note: The **Datalink Layer** which is where the MAC Address exists is where the first check is done to see who the data is for.


Aux
Main
ASUS S/N: 0C001-00050000B15069891
AW-NE186H(B1)
WLAN MAC ID: 94DBC9B10ABF B1
MAC Addresses are physically attached to a hardware device.

Example MAC Address

الجزء الخاص بلشركة المصنعة ويكون ثابت لكل الاجهزة المصنعة من هذه شركة

الجزء الخاص بلاجهزة ويكون متغير يعني لكل جهاز عنوانه

3A-34-52-C4-69-B8

Organizationally Unique Identifier (OUI)	Network Interface Controller (NIC)
3A-34-52	C4-69-B8

Converting MAC Addresses from HEX to Binary

عند تحويل عنوان الماك يجب اولا
تحويله الى النظام العشري وبعدها الى
الثنائي وقيمه محصورة من 0-9 بلنسبة
للارقام ومن A--F وقيمها بلنظام
العشري كما يلي
A=10,B=11
C=12, D=13
E=14 ,F=15

Workstation MAC Address

00-02-B3-3C-32-68 (HEX)

↓

Convertion from HEX to Binary

↓

0	0	0	2	B	3	3	C	3	2	6	8
0000	0000	0000	0010	1011	0011	0011	1100	0011	0010	0110	1000

One BIT

One BYTE

The relation:

8 bits = 1 Byte

3 Bytes or 24 Bits

6 Bytes or 48 Bits

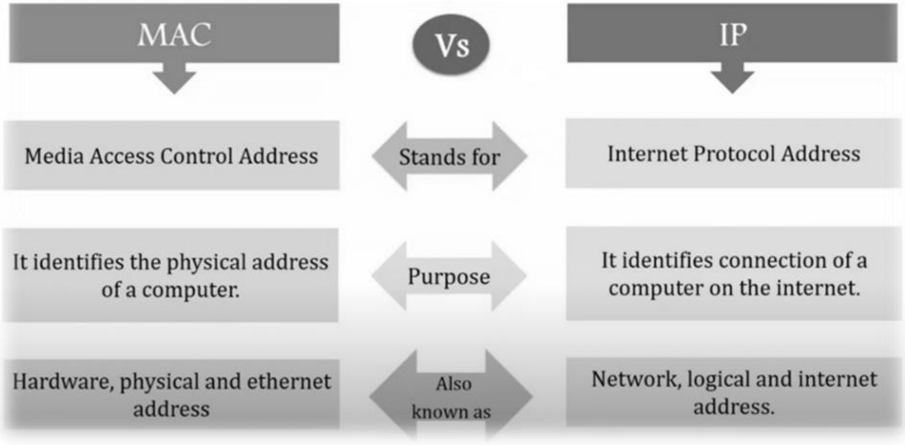
The MAC Address is always expressed in a HEX format and is always 6 bytes or 48 bits long.

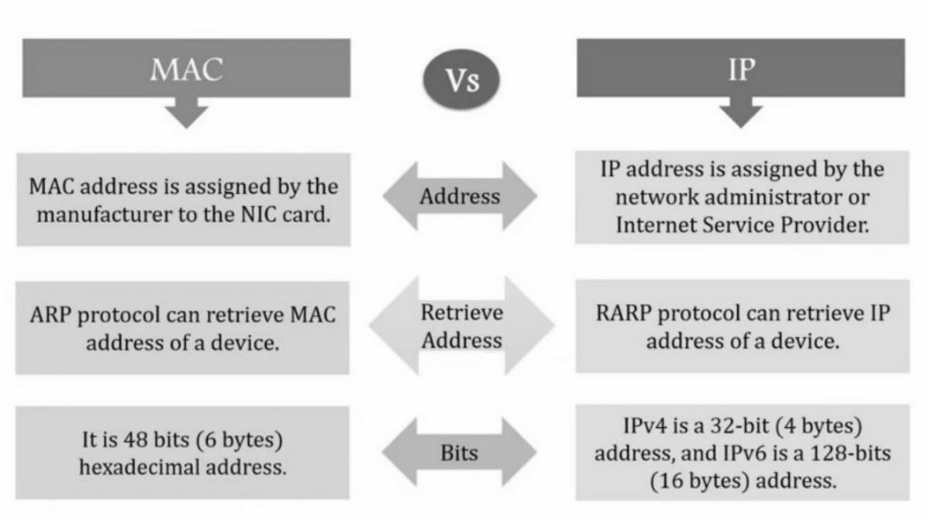
اصغر قيمة لل MAC هي ان
تكون كل الحقول اصفار
00-00-00-00-00-00
واكبر قيمة هي كل الحقول F
FF-FF-FF-FF-FF-FF

Logical address (IP)

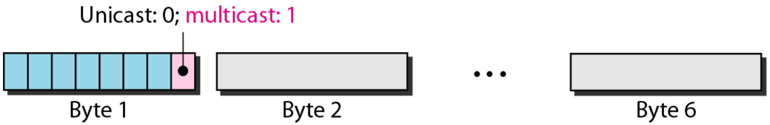
- *IP addresses are necessary for universal communications that are independent of physical network.*
- *No two host address on the internet can have the same IP address*
- ***IP addresses 32-bit address that uniquley define a host connected to the Internet***

The physical addresses will change from hop to hop, but the logical addresses remain the same.


MAC
Vs
IP
Media Access Control Address
Stands for
Internet Protocol Address
It identifies the physical address of a computer.
Purpose
It identifies connection of a computer on the internet.
Hardware, physical and ethernet address
Also known as
Network, logical and internet address.


MAC
Vs
IP
MAC address is assigned by the manufacturer to the NIC card.
Address
IP address is assigned by the network administrator or Internet Service Provider.
ARP protocol can retrieve MAC address of a device.
Retrieve Address
RARP protocol can retrieve IP address of a device.
It is 48 bits (6 bytes) hexadecimal address.
Bits
IPv4 is a 32-bit (4 bytes) address, and IPv6 is a 128-bits (16 bytes) address.

Unicast and multicast addresses



- Source address is always a unicast address – the frames comes from only one station.
- Destination address can be:
  - unicast: defines only one recipient; one to one
  - multicast: a group of addresses; one to many
  - Broadcast: the recipients are all the stations on the LAN

Note

- **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.**
- **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**

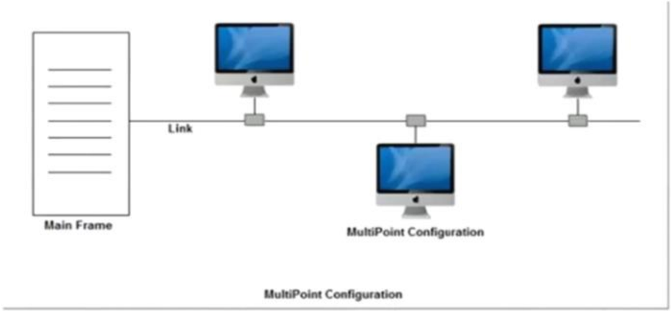
c. FF:FF:FF:FF:FF:FF

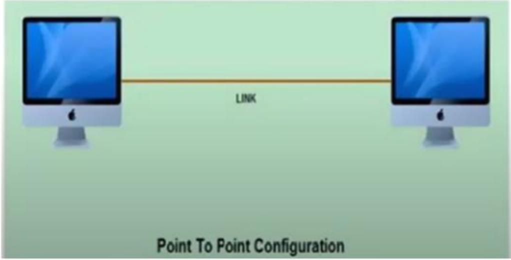
Solution

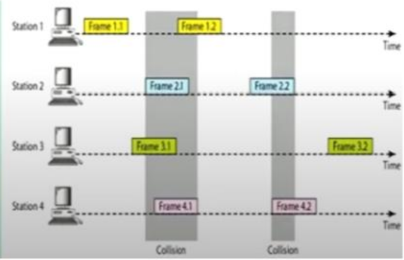
To find the type of the address, we need to look at the second hexadecimal digit from the left. If it is even, the address is unicast. If it is odd, the address is multicast. If all digits are F's, the address is broadcast. Therefore, we have the following:

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.

Multiple Access CSMA/CD



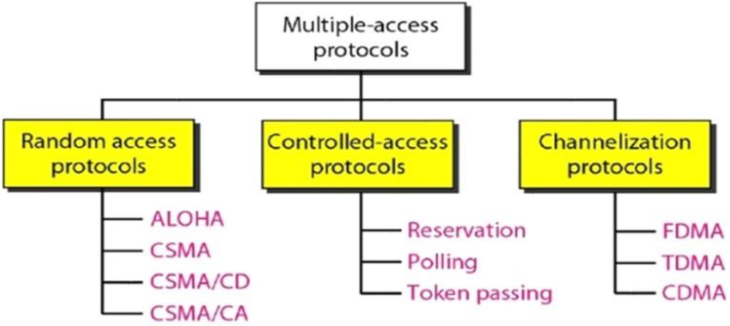




Multiple-access protocols

- *When more than two nodes send at the same time , the transmitted frames collide.*
- *All collide frames are lost and the bandwidth of the broadcast channel will be wasted.*
- We need multiple –access protocol to coordinate access to multipoint or broadcast link (Nodes or stations are connected to or use a common link)
- *Multiple access protocols are needed in wire and wireless LANs and satellite networks*

Multiple-access protocols



1- 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. This decision depends on the state of the medium(idle or busy)

Random Access Methods:

- **ALOHA**
- **Carrier Sense Multiple Access ; CSMA**
- **Carrier Sense Multiple Access with Collision Detection (CSMA/CD)**
- **Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)**

1-RANDOM ACCESS

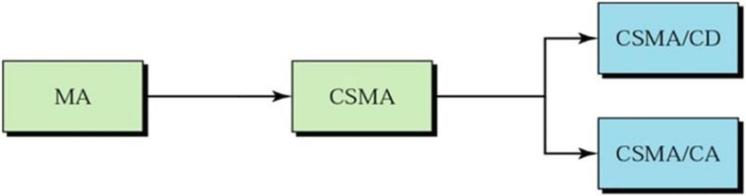
- Each station has the right to the medium without being controlled by any other station.
- Two features gives the method its name:
  - There is no schedule time for a station totransmit:

    → transmission is random among stations
  - Stations compete with one another to access the medium

    → Contention method.
- Collision: an access conflict occurs when more than one station tries to send, as a result the frame will be either destroyed or modified.

Evolution of random-access methods

- ***ALOHA** : uses **MA*** (**Multiple Access) No carrier sense**
- ***CSMA*** **: Carrier Sense MultipleAccess**
- ***CSMA/CD*** **: Collision Detection**
- ***CSMA/CA*** **Collision Avoidance**



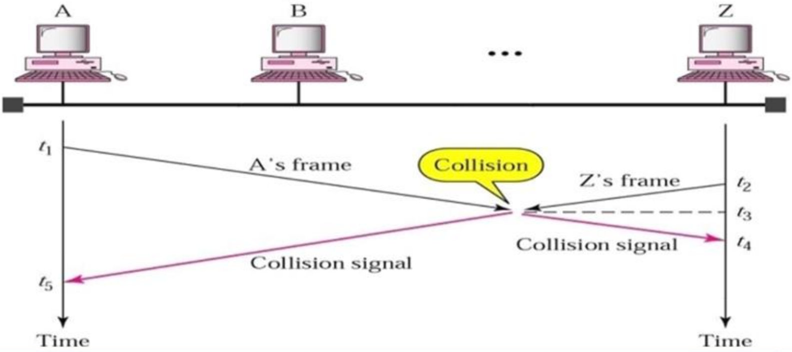
RANDOM ACCESS

Each station follows a procedure that answer the following questions to avoid collision:

- **When can the station access the medium?**
- **What can the station do if the medium is busy?**
- **How can the station determine the success or failure of the transmission?**
- **What can the station do if there is an access conflict (collision)?**

Carrier Sense Multiple Access (CSMA)

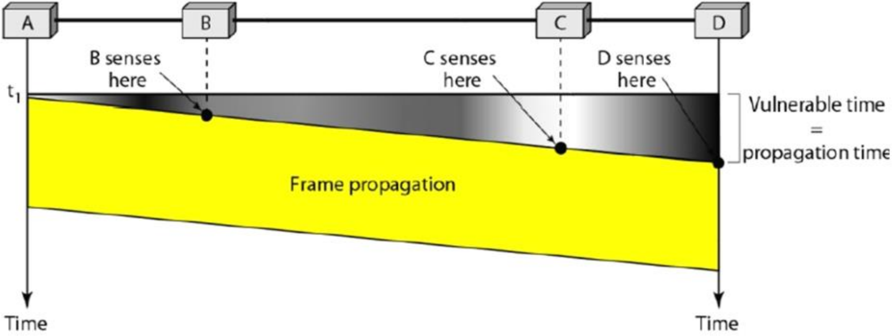
- **Sense the carrier before transmit : *"listen before you talk"***
- **CSMA can reduce the possibility of collision, but it can not eliminate it because of the propagation delay (a station may sense the medium and find it idle, only because the first bit of a frame sent by another station has not been received)**



Vulnerable time in CSMA

Vulnerable time : time in which there is a possibility of collision

- Vulnerable time for CSMA is the **max propagation time Tp** needed for a signal to propagate from one end of the medium to the other

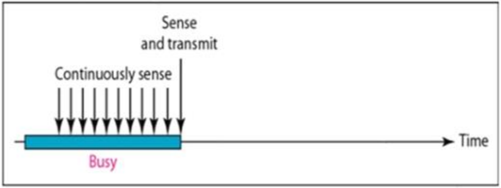


persistence methods

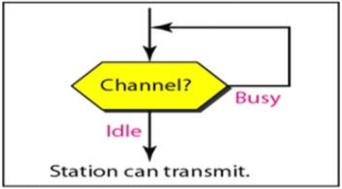
- ***What should a station do if the channel is busy?***

- ***What should a station do if the channel is idle?***

1-persistence methods



a. 1-persistent



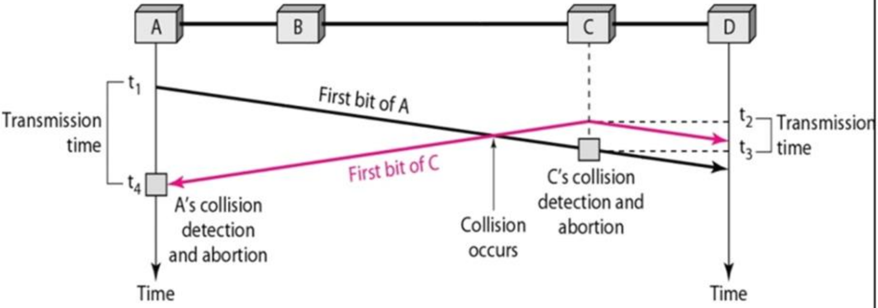
a. 1-persistent

- When the sender (station) is ready to transmit data, it checks if the medium is busy. If so, it senses the medium continually until it becomes idle
- If line is idle, sends the frame immediately (with probability of 1).

Chances of collision is high.

Carrier Sense Multiple Access collision detection CSMA/CD

"Listen-while-talk" **protocol. A host listens even while it is transmitting, and if a collision is detected, stops transmitting**

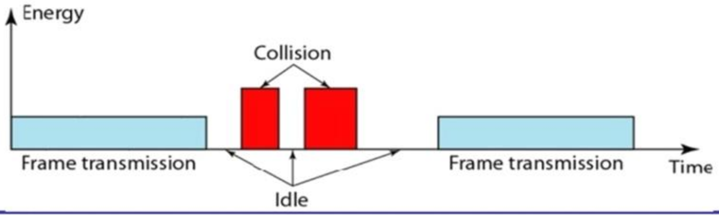


Collision Detection

How the station detects a collision?

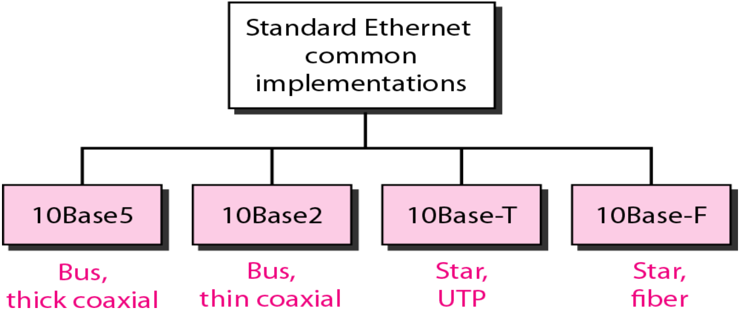
- **Detecting voltage level on the line**
- **Detecting energy level .**

- **Energy in channel can have three values: zero, normal, and abnormal.**
- **at zero level, the channel is idle**
- **At the normal level, a station has successfully captured the channel and is sending its frame.**
- **At the abnormal level, there is a collision and the level of the energy twice the normal level.**



Categories of Standard Ethernet

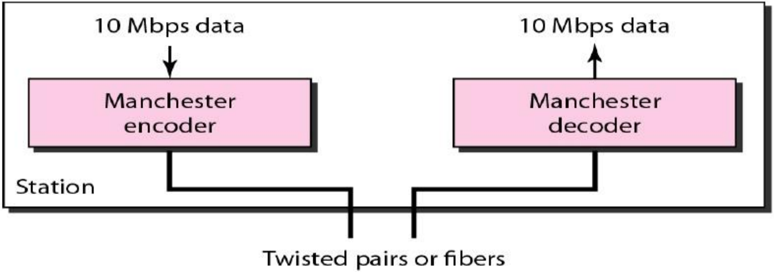
The Standard Ethernet defines several physical layer implementation, four of the most common:



Limitation of 10Base5 and 10Base2 is that communication is <u>half-duplex.</u>

Why half deplux??

Encoding in a Standard Ethernet implementation



- **All standard implementations use digital signaling(baseband) at 10 Mbps.**
- **At the sender, data are converted to a digital signal using the Manchester scheme.**
- At the receiver, the received signal is interpreted as Manchester and decoded into data.
- **Uses CSMA/CD with 1-persistent**

Summary of Standard Ethernet implementations

	10Base 5	10Base2	10Base-T	10Base-F
Media	Thick coaxial cable	Thin coaxial cable	Two UTP	2 Fiber
Maximum length	500 m	185 m	100 m	2000 m
Topology	Bus	Bus	Star	star
Data rate	10Mbps	10Mbps	10Mbps	10Mbps
Line coding	Manchester	Manchester	Manchester	Manchester

CHANGES IN THE STANDARD

The 10-Mbps Standard Ethernet has gone through several changes before moving to the higher data rates. These changes actually opened the road to the evolution of the Ethernet to become compatible with other high-data-rate LANs.

Topics discussed in this section:

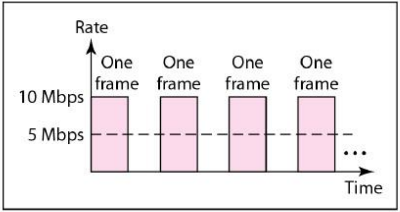
Bridged Ethernet
Switched Ethernet
Full-Duplex Ethernet

Bridged Ethernet

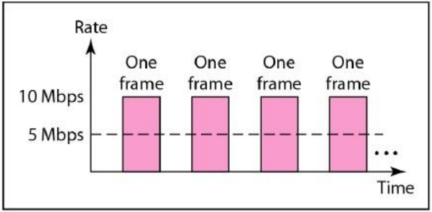
Have two effects on an Ethernet LAN:

1. **They rise the bandwidth**
2. **They separate collision domains.**

Without bridges, all the stations share the bandwidth of the network.



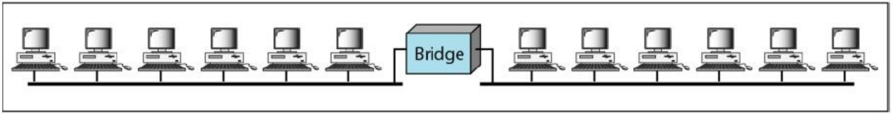
a. First station



b. Second station

Bridged Ethernet: Raising the Bandwidth

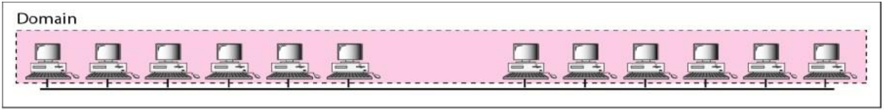
a. Without bridging



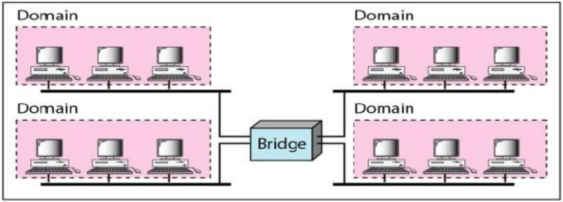
b. With bridging

- Bridges divide the network into two.
- Each network is independent.
- With bridges, 10 Mbps network is shared only by 6 [actually 7 as bridge acts as one station] stations.

Bridged Ethernet: *Separate Collision* domains



a. Without bridging

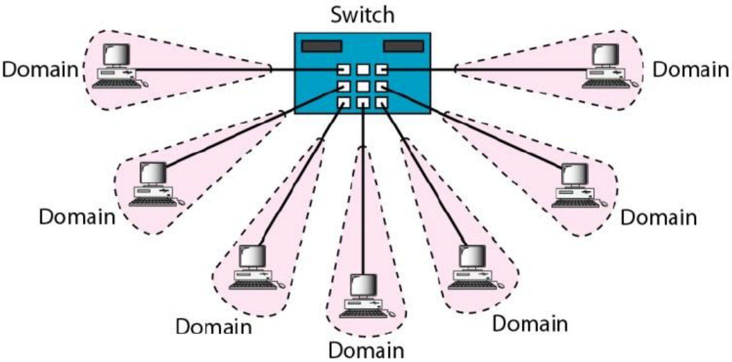


b. With bridging

Using bridges:

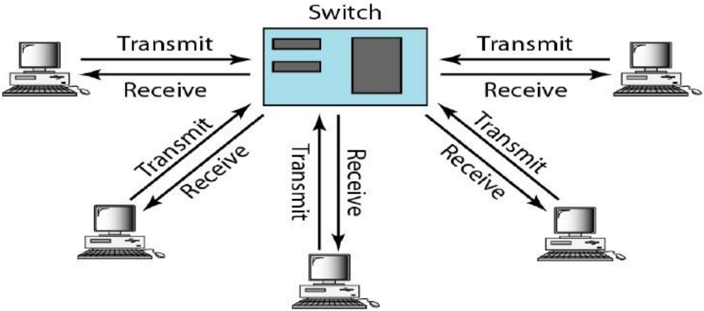
- Collision domain becomes much smaller and the probability of collision is reduced
- Raising the B-W

Switched Ethernet



A layer 2 switch is an N-port bridge with additional sophistication that allows faster handling of the packets.

Full-duplex switched Ethernet



- In full duplex switch there are two links, one for sending and one for receiving, **we don't need CSMA/CD here|(no collision).**
- Increases the capacity of each domain from 10 to 20 Mbps.

FAST ETHERNET

In the 1990s, Ethernet made a big jump by increasing the transmission rate to 100 Mbps, and the new generation was called the Fast Ethernet. The designers of the Fast Ethernet needed to make it compatible with the Standard Ethernet. The MAC sublayer was left unchanged. But the features of the Standard Ethernet that depend on the transmission rate, had to be changed.

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 it the Standard 802.3z. The goals of the Gigabit Ethernet were to upgrade the data rate to 1 Gbps, but keep the address length, the frame format, and the maximum and minimum frame length the same.

10-GIGABIT EHTERNET

In recent years, there has been another look into the Ethernet for use in metropolitan areas. The idea is to extend the technology, the data rate, and the coverage distance so that the Ethernet can be used as LAN and MAN (metropolitan area network). The IEEE committee created 10 Gigabit Ethernet and called it Standard 802.3ae.

Thank you for listening

Taqwa Altameemi