



University of Global Village (UGV) Barishal, Bangladesh

Lectures By

Lectures On: **MAC Address**

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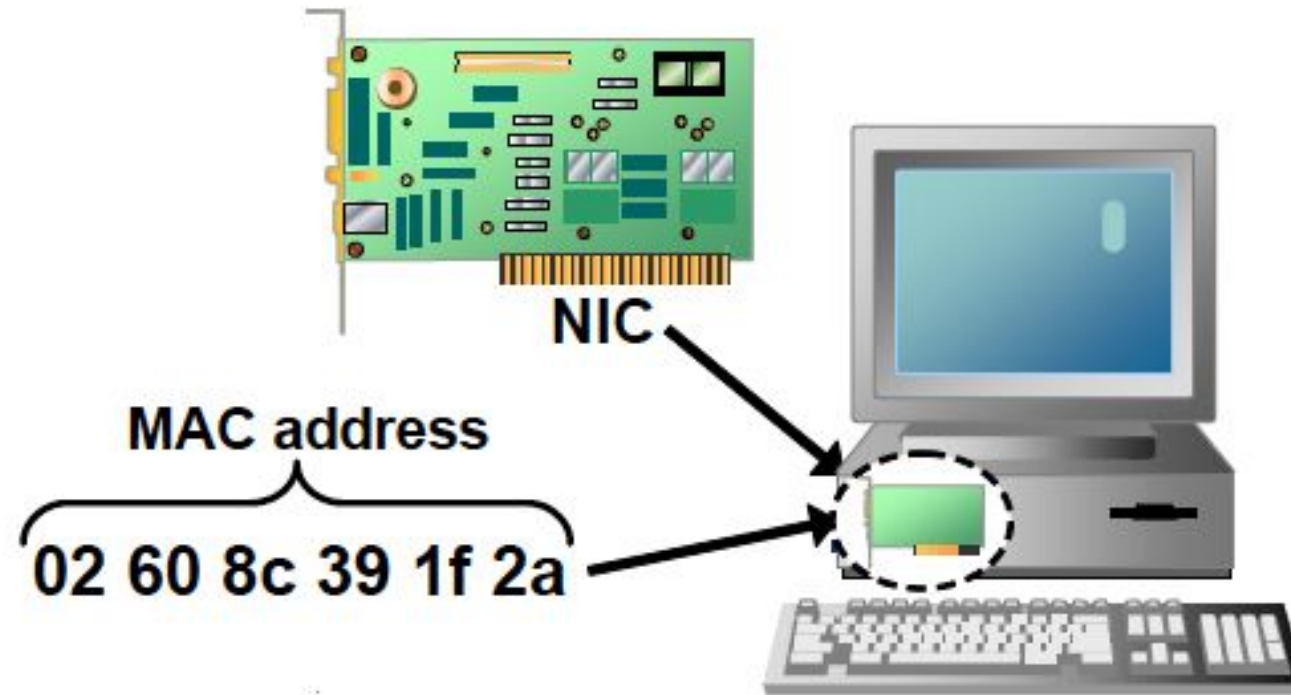
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What is an MAC Address?

- MAC address is the **physical address**, which uniquely identifies each device on a given network.



What is an MAC Address?

- To make communication between two networked devices, we need two addresses: IP address and **MAC address**.
- It is assigned to the **NIC** (Network Interface card) of each device that can be connected to the internet.
- It stands for **Media Access Control**, and also known as **Physical address**, **hardware address**, or **BIA** (Burned In Address).

What is an MAC Address?

- It is globally unique; it means two devices **cannot** have the same MAC address.
- It is represented in a hexadecimal format on each device, such as **00:0a:95:9d:67:16**.
- It is **12-digit**, and **48 bits** long, out of which the first 24 bits are used for **OUI**(Organization Unique Identifier), and 24 bits are for **NIC/vendor-specific or UAA**.

What is an MAC Address?

- It is provided by the device's vendor at the time of **manufacturing** and embedded in its **NIC**, which is ideally cannot be changed.
- The ARP protocol is used to associate a logical address with a physical or MAC address

Note: Address Resolution Protocol (ARP)

MAC Address Definition?

- To communicate or transfer data from one computer to another, we need an address. In Computer networks, various types of addresses are introduced; each works at a different layer. A MAC address, which stands for Media Access Control Address, is a physical address that works at the **Data Link Layer**.

Why do we need MAC if we have IP?

- This is a common student question. Use this analogy:
- **IP Address** is like your **Mailing Address** (It changes if you move houses/networks).
- **MAC Address** is like your **National ID/NID** (It stays with you forever, regardless of where you are).
- **Function:** IP is used to find the network; MAC is used to find the specific device *within* that network.

What is network interface card (NIC)?

- Network Interface Card (NIC) is a hardware component that is present on the computer. It is used to connect different networking devices such as computers and servers to share data over the connected network. It provides functionality such as support for I/O interrupt, Direct Memory Access (DMA) interfaces, partitioning, and data transmission.
- NIC is important for us to establish a wired or wireless connection over the network.
- **Network Interface Card is also known as Network Interface Controller, Network Adapter, Ethernet card, Connection card, and LAN (Local Area Network) Adapter.**



What is network interface card (NIC)?

Purpose:

- NIC allows both wired and wireless communications.
- NIC allows communications between computers connected via local area network (LAN) as well as communications over large-scale network through Internet Protocol (IP).
- NIC is both a physical layer and a data link layer device, i.e. it provides the necessary hardware circuitry so that the physical layer processes and some data link layer processes can run on it.

Format of MAC Address

- MAC Address is a 12-digit hexadecimal number (6-Byte binary number), which is mostly represented by Colon-Hexadecimal notation.
- The First 6-digits (say 00:40:96) of MAC Address **identifies** the manufacturer, called **OUI** (Organizational Unique Identifier). IEEE Registration Authority Committee assigns these MAC prefixes to its registered vendors.



Anatomy of a MAC Address

- A MAC address is divided into two equal parts:
- **OUI (Organizationally Unique Identifier):** The first 24 bits (3 bytes). This code is assigned to the manufacturer (like Intel, Cisco, or Realtek) by the IEEE.
- **UAA (Universally Administered Address):** The last 24 bits (3 bytes). This is a unique serial number assigned by the manufacturer to that specific NIC.

Format of MAC Address

Here are some OUI of well-known manufacturers :

- CC:46:D6 - Cisco
- 3C:5A:B4 - Google, Inc.
- 3C:D9:2B - Hewlett Packard
- 00:9A:CD - HUAWEI TECHNOLOGIES CO.,LTD

The rightmost six digits represent Network Interface Controller, which is assigned by the manufacturer.

Format of MAC Address

- MAC address is represented by **Colon-Hexadecimal notation**.
- But this is just a conversion, not mandatory.
- MAC address can be represented using any of the following formats:

Hyphen-Hexadecimal notation

00-0a-83-b1-c0-8e

Colon-Hexadecimal notation

00:0a:83:b1:c0:8e

Period-separated hexadecimal notation

000.a83.b1c.08e

Note: Colon-Hexadecimal notation is used by *Linux OS* and Period-separated Hexadecimal notation is used by *Cisco Systems*.

How to find MAC Address

Command for UNIX/Linux - `ifconfig -a`
`ip link list`
`ip address show`

Command for Windows OS - `ipconfig /all`

MacOS - `TCP/IP Control Panel`

Note – LAN technologies like Token Ring, and Ethernet use MAC Addresses as their Physical address but there are some networks (**AppleTalk**) that do not use MAC addresses.

How to find MAC Address

- Check Local MAC: * Command: **ipconfig /all** (Windows) or **ifconfig** (Linux). Look for: "Physical Address".
- View Neighbor MACs: * Command: **arp -a**.
- Observation: Notice how some are Dynamic (Unicast) and some are Static (Multicast/Broadcast).
- Manufacturer Lookup: * Ask students to take the first 3 bytes of their MAC and search it on a "**MAC OUI Lookup**" website to see who manufactured their Wi-Fi card.

Introduction to MAC Address Types

Media Access Control (MAC) addresses are 48-bit identifiers.

- Based on the destination, Ethernet frames are categorized into three types:
 - **Unicast:** One-to-One communication.
 - **Multicast:** One-to-Many communication.
 - **Broadcast:** One-to-All communication.
- The nature of the address is determined by the **I/G (Individual/Group)** bit, which is the **Least Significant Bit (LSB)** of the first octet.

Types of MAC Address:

- Types of MAC Address:

1. Unicast
2. Multicast
3. Broadcast

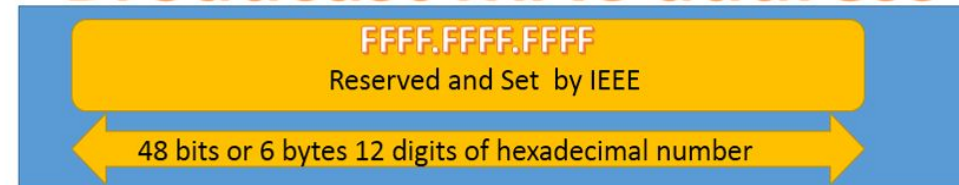
Unicast MAC address



Multicast MAC address



Broadcast MAC address



Types of MAC Address:

1. Unicast:

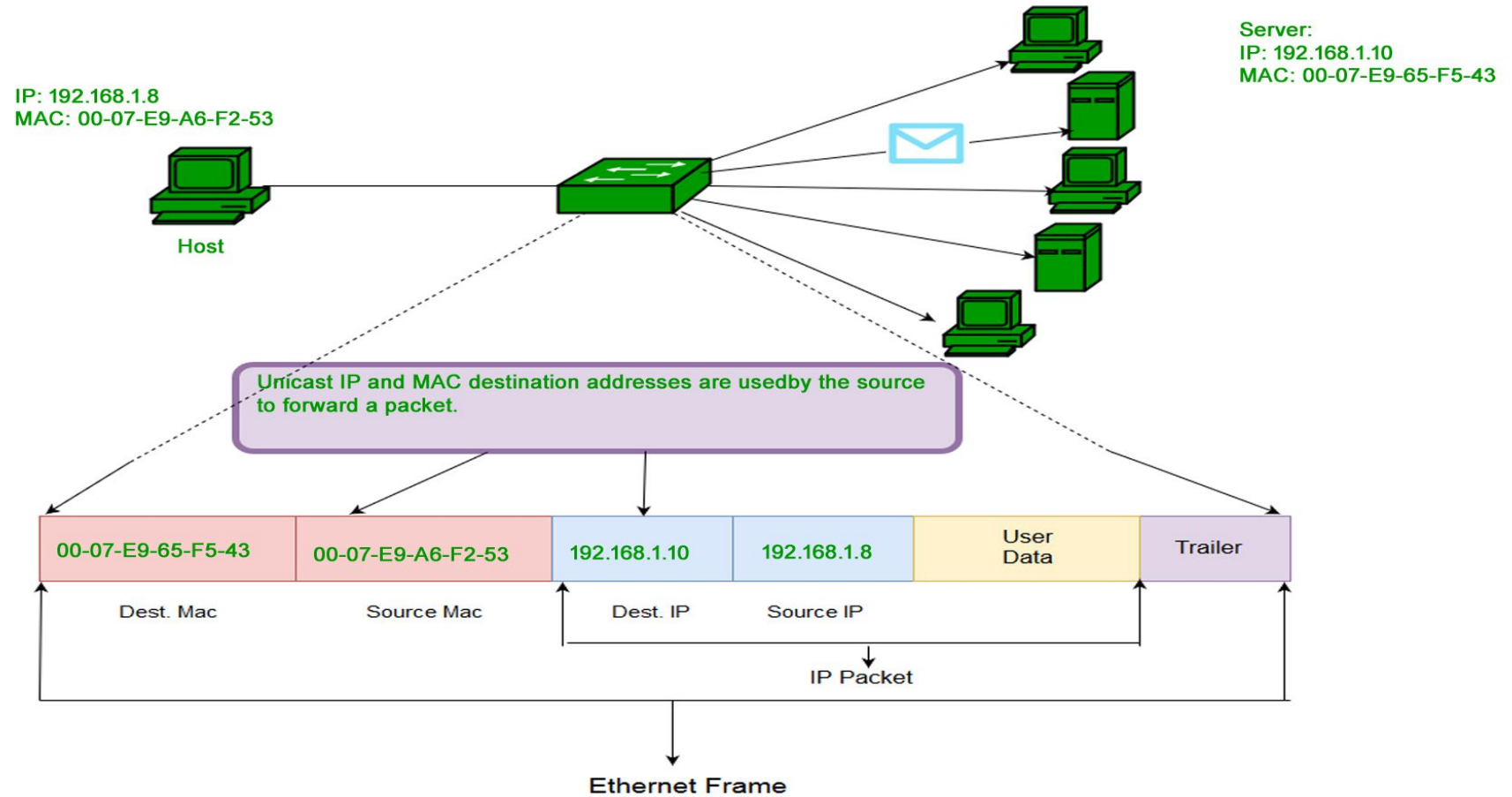
- A Unicast addressed frame is only sent out to the interface leading to a specific NIC.
- If the LSB (least significant bit) of the first octet of an address is set to **zero**, the frame is meant to reach only **one receiving NIC**.
- MAC Address of source machine is always Unicast.

1. Unicast (One-to-One)

- **The Analogy:** The teacher calls out a specific student's ID (e.g., "Roll No. 5, please stand up"). Only that specific student listens and responds.
- **Networking Fact:** The frame is sent to one specific NIC.
- **Technical Check:** The first octet's last bit is 0.
- **Real-World Example:** Your laptop sending a private document to a specific network printer.

Types of MAC Address:

1. Unicast:



Types of MAC Address:

2. Multicast:

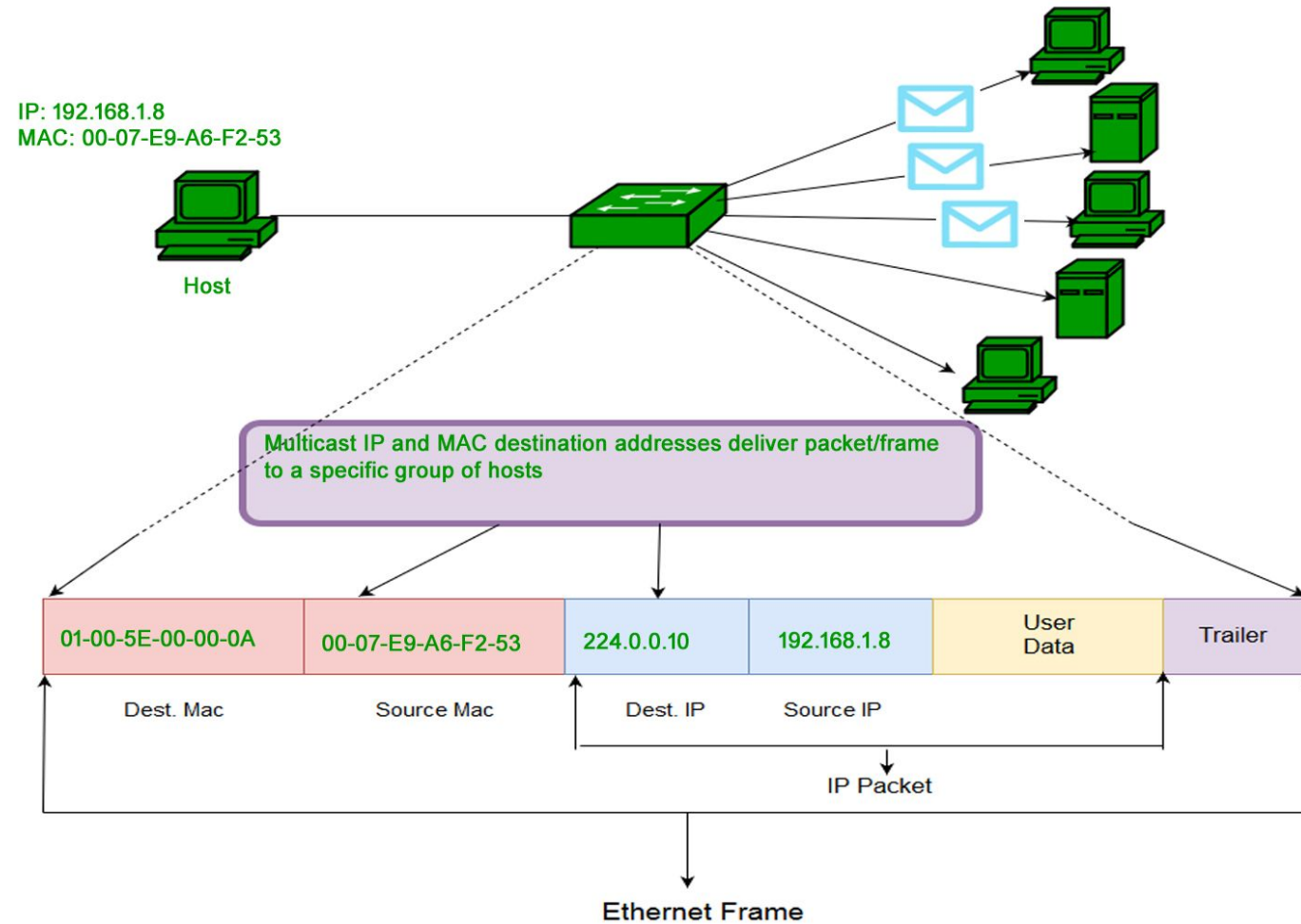
- The multicast address allows the source to send a frame to a group of devices.
- In Layer-2 (Ethernet) Multicast address, LSB (least significant bit) of the **first octet of an address is set to one.**
- IEEE has allocated the address block 01-80-C2-xx-xx-xx (01-80-C2-00-00-00 to 01-80-C2-FF-FF-FF) for group addresses for use by standard protocols.

Multicast (One-to-Many)

- **The Analogy:** The teacher says, "All students in the Football Club, please come to the field." Not everyone goes — only a specific group listens and acts.
- **Networking Fact:** The frame is sent to a group of devices that have "subscribed" to a service.
- **Technical Check:** The first octet's last bit is 1.
- **Real-World Example:** A video conference call (Zoom/Teams) where only the participants receive the video stream.

Types of MAC Address:

2. Multicast:



Types of MAC Address:

3. Broadcast:

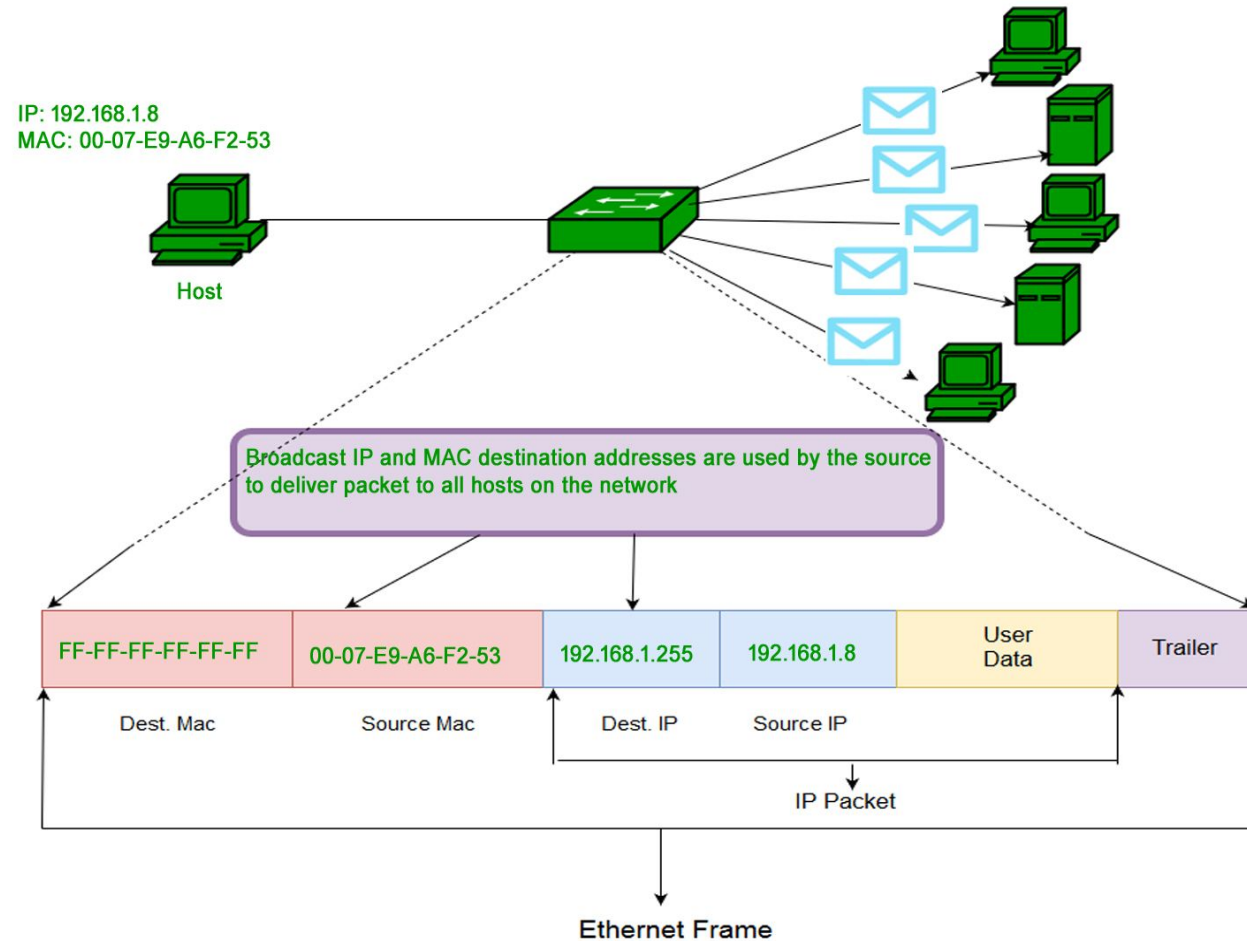
- Similar to Network Layer, Broadcast is also possible on the underlying layer(Data Link Layer).
- Ethernet frames with ones in all bits of the destination address (FF-FF-FF-FF-FF-FF) are referred to as the broadcast addresses.
- Frames that are destined with MAC address FF-FF-FF-FF-FF-FF will reach every computer belonging to that LAN segment.

Broadcast (One-to-All)

- **The Analogy:** The teacher stands at the front and announces, "The school is closed tomorrow!" Every single student in the room must hear and process this information.
- **Networking Fact:** The frame is sent to every device on the local network segment.
- **Technical Check:** All 48 bits are 1 (Address: FF:FF:FF:FF:FF:FF).
- **Real-World Example:** A new device joining the Wi-Fi and shouting, "Is there a DHCP server here to give me an IP?"

Types of MAC Address

3. Broadcast :



Summary

Type	Communication Mode	Destination	Bit Rule (1st Octet)
Unicast	One-to-One	Specific Device	Ends in 0 (Even)
Multicast	One-to-Many	Specific Group	Ends in 1 (Odd)
Broadcast	One-to-All	Everyone	All Fs (All 1s)

Don't get confused

Don't get confused by binary. Just look at the **second digit** of the MAC address."

- If the 2nd digit is **Even** (0, 2, 4, 6, 8, A, C, E), it is **Unicast**.
- If the 2nd digit is **Odd** (1, 3, 5, 7, 9, B, D, F), it is **Multicast**.

MAC Cloning & Spoofing

- **What is MAC Cloning?**
- **Definition:** MAC Cloning (or Spoofing) is a technique used to change the factory-assigned MAC address of a network interface on a software level.
- **The Concept:** While the **Physical MAC** is "burned" into the hardware, the Operating System (Windows, Linux, Android) allows you to "mask" it with a different address.
- **Key Distinction:** * **MAC Spoofing:** Changing your PC's MAC to any random address.
 - **MAC Cloning:** Specifically copying the MAC address of *another* authorized device.

Why do we use MAC Cloning? (Practical Use Cases)

- **A. Internet Service Provider (ISP) Requirements**
- Many ISPs register the MAC address of the first device you connect to their cable/modem.
- **The Problem:** If you buy a new router, the ISP won't recognize it and will block the internet.
- **The Solution:** You "Clone" your old PC's MAC address into the new router's settings so the ISP thinks it's still the same device.

Bypassing MAC Filtering

- Administrators often use **MAC Whitelisting** to allow only specific devices on a Wi-Fi network.
- An unauthorized user can "sniff" an authorized MAC address from the air and clone it to gain access.

Privacy & Security

- **Anti-Tracking:** Public Wi-Fi (Airports/Hotels) tracks your movement using your MAC address. Modern smartphones (Android/iOS) use **MAC Randomization** (a form of spoofing) to protect user privacy.

How is it Done? (Technical Implementation)

- Go to Device Manager > Network Adapters.
- Right-click your adapter > Properties > Advanced.
- Look for Locally Administered Address or Network Address.
- Enter the 12-digit Hexadecimal value.

How is it Done? (Technical Implementation)

- **B. On Linux (Command Line)**

- Students love the CLI approach. Show them these commands:

```
# Bring the interface down
```

```
sudo ifconfig eth0 down
```

```
# Change the MAC
```

```
sudo ifconfig eth0 hw ether 00:11:22:33:44:55
```

```
# Bring the interface up
```

```
sudo ifconfig eth0 up
```

Disadvantages of MAC Cloning

- **MAC Flapping:** Causes network instability as the Switch gets confused between two ports sharing the same MAC.
- **IP Conflicts:** DHCP servers may assign the same IP to both devices, leading to "Duplicate IP" errors and loss of internet.
- **Security Risk:** Allows attackers to bypass **MAC Filtering** and impersonate trusted users.
- **Identity Theft:** Illegal activities performed by a "cloner" are logged against the original owner's hardware ID.
- **Troubleshooting Failure:** Makes it impossible for Network Admins to identify which physical device is faulty or causing high traffic.
- **License Deactivation:** Software tied to a specific hardware ID (Node-locked) may stop working if the MAC is changed.
- **Audit Issues:** Prevents accurate hardware inventory and tracking during IT audits.

“Thank You”