CELEBAL TECHNOLOGY INTERNSHIP (CSI)

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Research and Development Document

Title: Basics of MAC Addressing and Functionality of ARP & RARP

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1. Introduction

Communication in networks involves two key identifiers: IP addresses and MAC addresses. While IP addresses help identify a host logically in an internetwork, actual data transfer at the link layer uses MAC addresses. Address resolution protocols like ARP and RARP play a critical role in bridging these two addressing schemes.

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2. MAC Addressing

2.1 Structure of MAC Address

- A MAC address is a **48-bit hardware address**, usually displayed in hexadecimal format.
- Example: 00:1A:2B:3C:4D:5E
- Consists of:
    - **OUI (Organizationally Unique Identifier):** First 24 bits, assigned by IEEE to manufacturers.
    - **NIC-specific:** Last 24 bits, assigned uniquely by the manufacturer.

2.2 Types of MAC Addresses

- **Unicast MAC Address:** Identifies a single unique NIC.
- **Multicast MAC Address:** Targets a group of devices.
- **Broadcast MAC Address:** FF:FF:FF:FF:FF:FF used to communicate with all devices on a LAN.

2.3 Functions and Role in Networking

- Enables **device identification** on Ethernet networks.
- Assists in **frame forwarding** within LAN.
- Used in **switching**, **bridging**, and **network access control**.

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3. Address Resolution Protocol (ARP)

3.1 Purpose and Need

- ARP is essential for mapping **IP addresses to MAC addresses** in a local network.
- Without ARP, devices wouldn’t know the link-layer address of the recipient.

3.2 Working of ARP

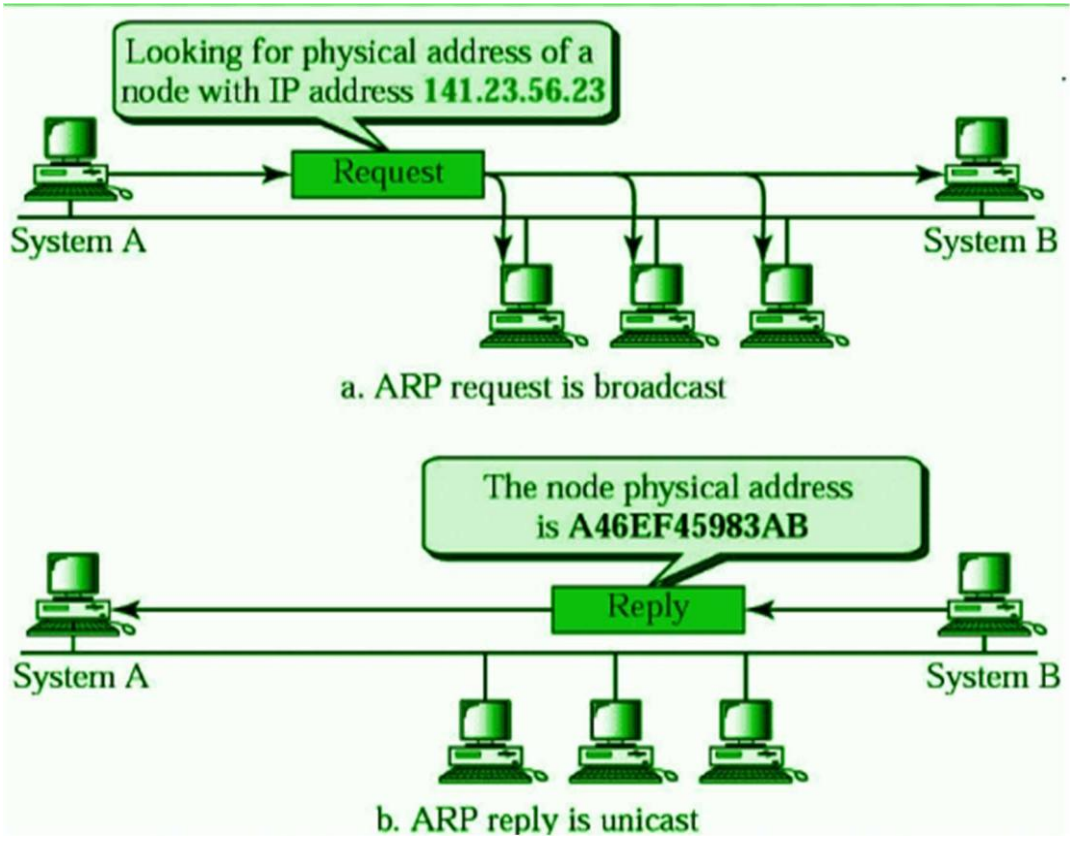
1. Host A wants to communicate with Host B (IP known, MAC unknown).
2. Host A sends a **broadcast ARP request** on the LAN.
3. Host B responds with its **MAC address**.
4. Host A caches this mapping for future use (ARP cache).

3.3 ARP Packet Format

- **Hardware Type:** Ethernet = 1
- **Protocol Type:** IPv4 = 0x0800
- **Hardware Size:** 6 bytes (MAC)
- **Protocol Size:** 4 bytes (IP)
- **Opcode:** 1 for request, 2 for reply

3.4 Types of ARP

- **Standard ARP:** Basic IP-to-MAC mapping.
- **Proxy ARP:** A router responds to ARP requests on behalf of another device.
- **Gratuitous ARP:** A host sends ARP request for its own IP to detect duplicates or update others' ARP tables.



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4. Reverse Address Resolution Protocol (RARP)

4.1 Purpose and Need

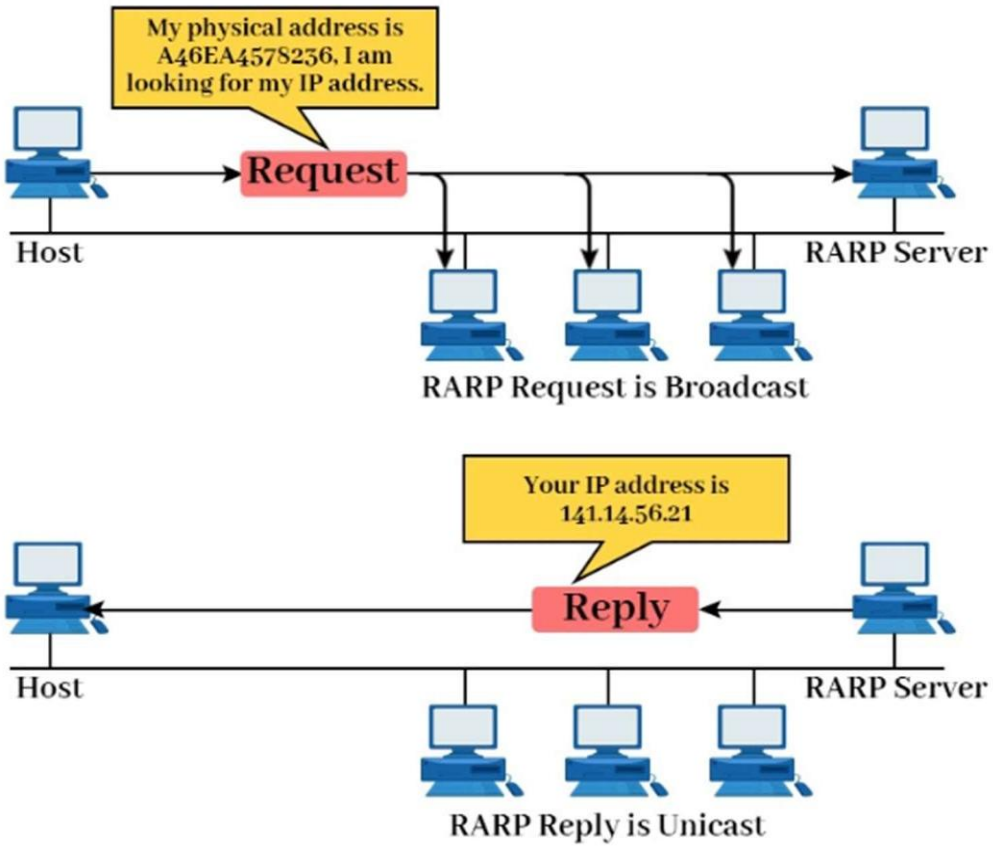
- RARP is used to obtain the **IP address from a known MAC address**.
- Typically used by diskless workstations on boot.

4.2 Working of RARP

1. Client broadcasts a RARP request with its MAC.
2. A **RARP server** responds with the appropriate IP address.
3. Client configures itself using the received IP.

4.3 Limitations and Deprecation

- Requires dedicated server support.
- Not scalable in modern dynamic networks.
- **Replaced by BOOTP and DHCP**, which offer more configuration options.



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5. Inverse ARP (InARP)

- **Used in Frame Relay and ATM** networks.
- Opposite of ARP: used when MAC/DLCI is known, but IP is unknown.

- Device learns peer's IP by sending InARP request over an established virtual circuit.

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6. Proxy ARP

- Allows a **router to reply to ARP requests** intended for another device.
- Used when two devices are on separate networks but appear to be on the same subnet.
- Ensures transparent communication without the sender knowing the actual IP route.

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7. Gratuitous ARP

- A device sends an **ARP request for its own IP address**.
- Functions:
    - Check for **IP conflicts** (duplicate IPs).
    - Update other hosts' ARP tables (e.g., after IP or MAC changes).

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8. Comparative Summary of ARP Mechanisms

Protocol	**Direction**	**Purpose**	**Current Usage**
ARP	IP → MAC	Resolve MAC for a known IP	Actively used
RARP	MAC → IP	Retrieve IP from a known MAC	Deprecated (use DHCP)
Proxy ARP	IP → MAC	Router answers ARP for another device	Niche use
Gratuitous ARP	Self-check	Conflict detection / ARP table updates	Common in modern OS
InARP	DLCI → IP	Peer IP discovery over Frame Relay/ATM	Rare use

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9. Use Cases in Modern Networks

- **ARP** is still integral to IPv4 LAN communication.
- **Gratuitous ARP** is used by operating systems and routers to ensure address uniqueness.
- **Proxy ARP** can help in legacy inter-networking scenarios.
- **RARP/InARP** are largely obsolete but useful for historical and academic knowledge.

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10. Conclusion

The functionality of MAC addressing and protocols like ARP and RARP form the backbone of low-level network communications. While ARP is still crucial in IPv4-based systems, protocols like RARP have been phased out due to more robust alternatives like DHCP. Understanding these protocols enables network engineers and researchers to build and troubleshoot communication systems effectively.

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11. References

- GeeksforGeeks: ARP, Reverse ARP, RARP, InARP, Proxy ARP, and Gratuitous ARP
- RFC 826 – An Ethernet Address Resolution Protocol