



ADVANCED OPERATING SYSTEMS AND NETWORKS

Computer Science Engineering

Universidad Complutense de Madrid

1.1. IPv4 Review. DHCP

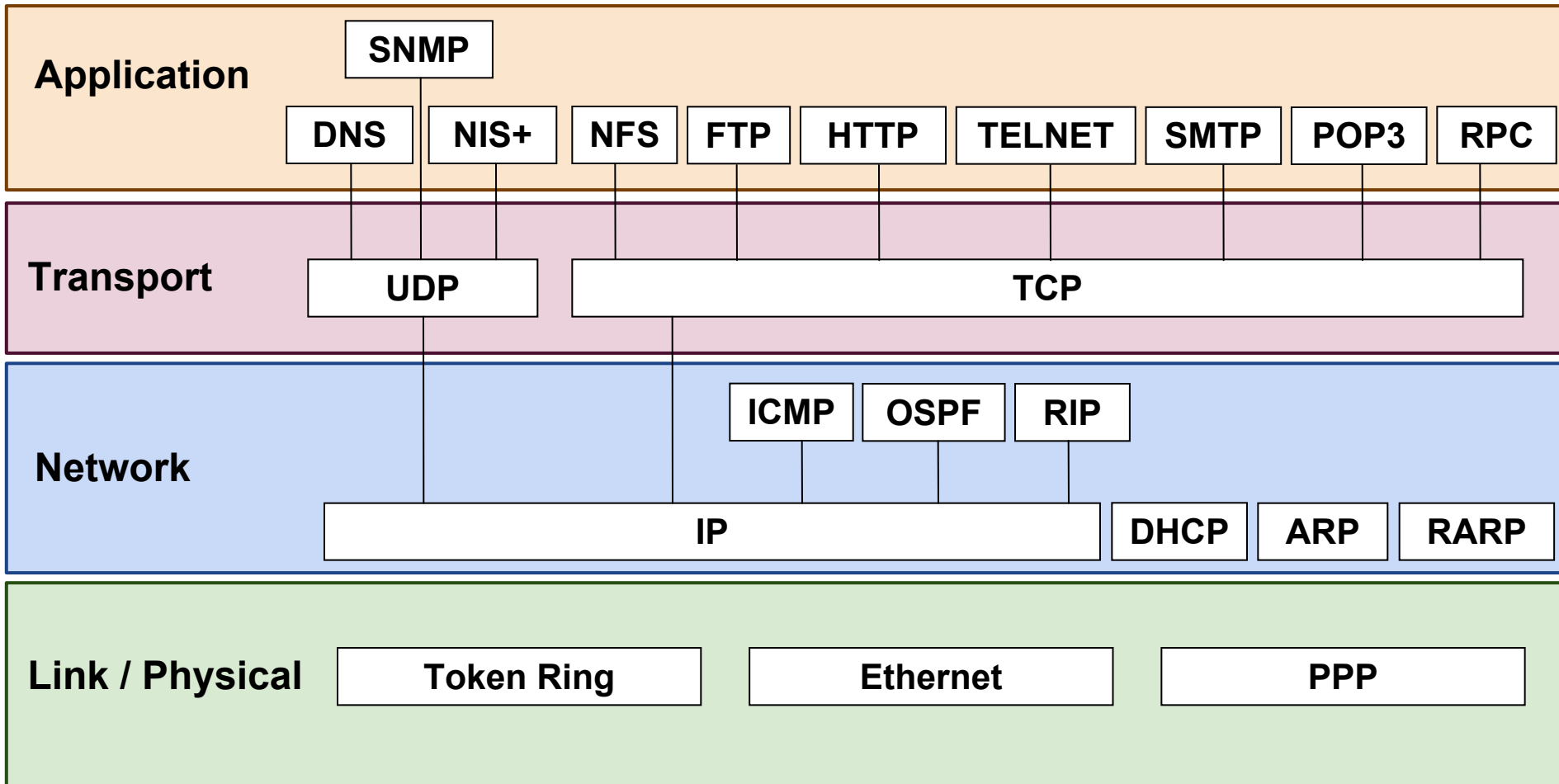
PROFESSORS:

Rubén Santiago Montero
Eduardo Huedo Cuesta

OTHER AUTHORS:

Rafael Moreno Vozmediano
Juan Carlos Fabero Jiménez

TCP/IP Architecture



IP (Internet Protocol)

Network Protocol in Internet

- Provides a basic service for packet delivery send packets between hosts even in different networks
- Connectionless, unreliable (“best effort”) protocol
 - No detection of lost packets
 - Packets may arrive out of order
 - No detection of duplicate packets

Basic Functions

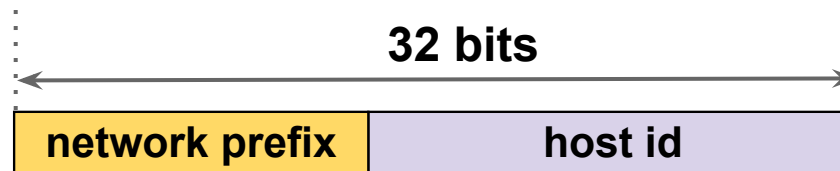
- **Addressing**
 - Global addressing scheme
- **Datagram fragmentation and reassembly**
 - Division of packets into smaller fragments to be accepted by the network
- **Datagram forwarding**
 - Packet forwarding based on routing table information
 - Protocols to create routing tables (RIP, OSPF, BGP)

size of packet > MTU
- DF (dont fragment)=1 => rejection (ICMP msg)
- DF=0 =>fragmentation

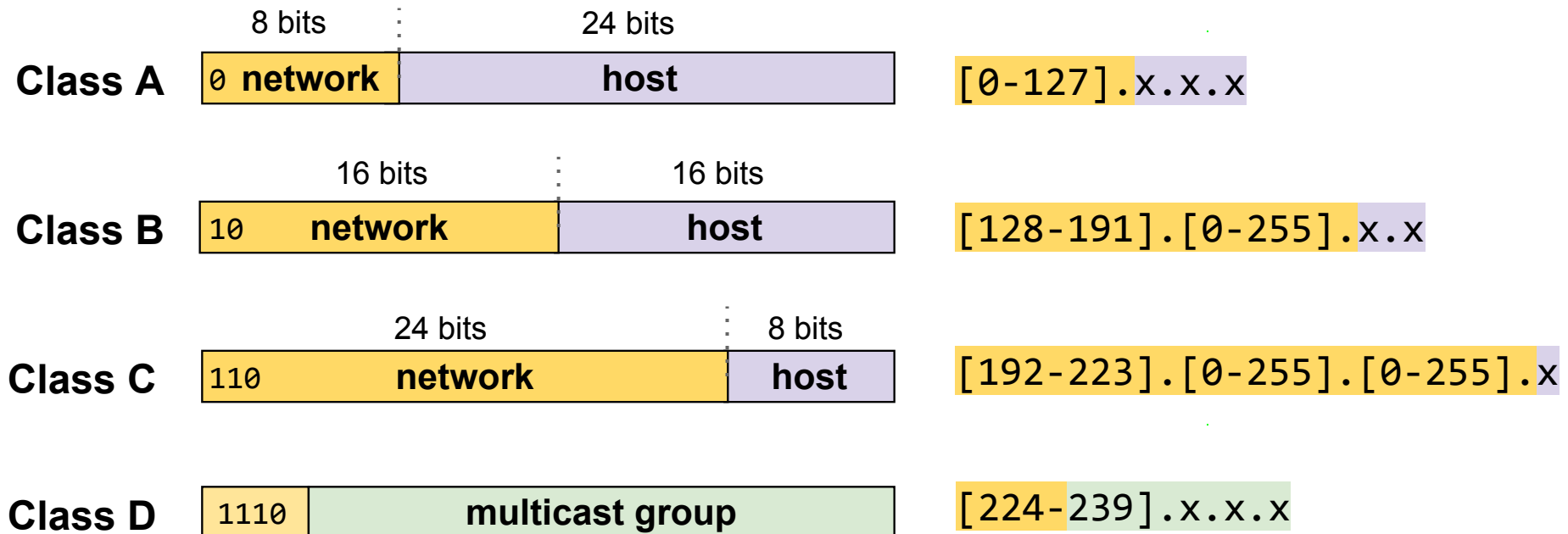
IP: Addressing

Structure and Notation

- An IPv4 address has 32 bits (4 bytes)
- Represented in “dotted decimal notation” (e.g. 10.0.0.1)



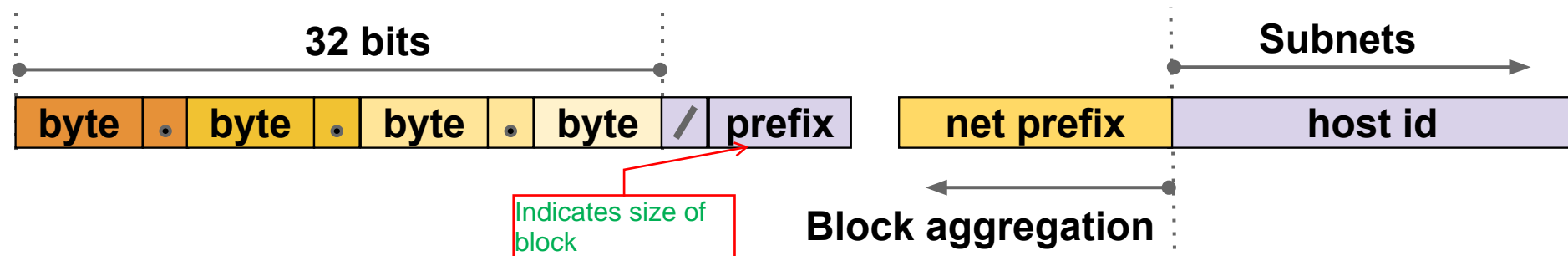
Classful Addressing



IP: Addressing

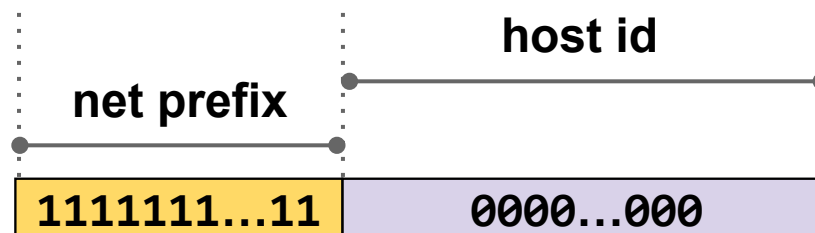
CIDR (Classless Inter Domain Routing)

- Tries to alleviate the address exhaustion problem
- Removes fixed structure based on classes
- Address space divided in blocks of arbitrary size
- Represented in “CIDR notation”, including network prefix length after a slash



Network Mask

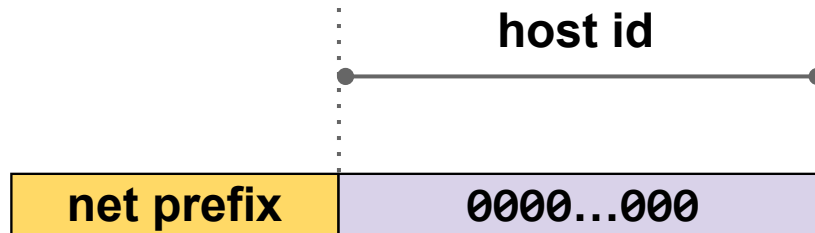
- Used to determine network prefix of an IP address (logical AND)
- Represented in dotted decimal or CIDR notation



IP: Addressing

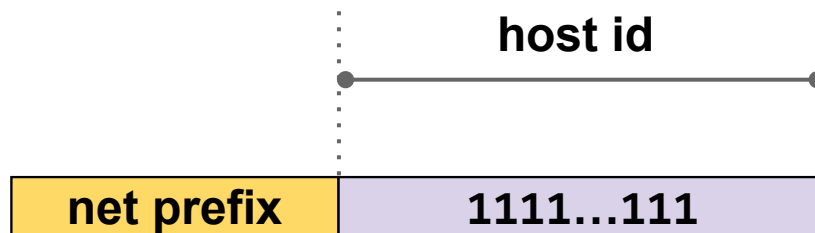
Network Addresses

- Used to represent a whole network in routing tables
- Never used as a target address and never assigned to a host



Broadcast Addresses

- Used to send a packet to all the hosts in a network



Loopback Addresses


- Addresses for local loop
- Format: 127.x.y.z (usually 127.0.0.1)

IP: Addressing

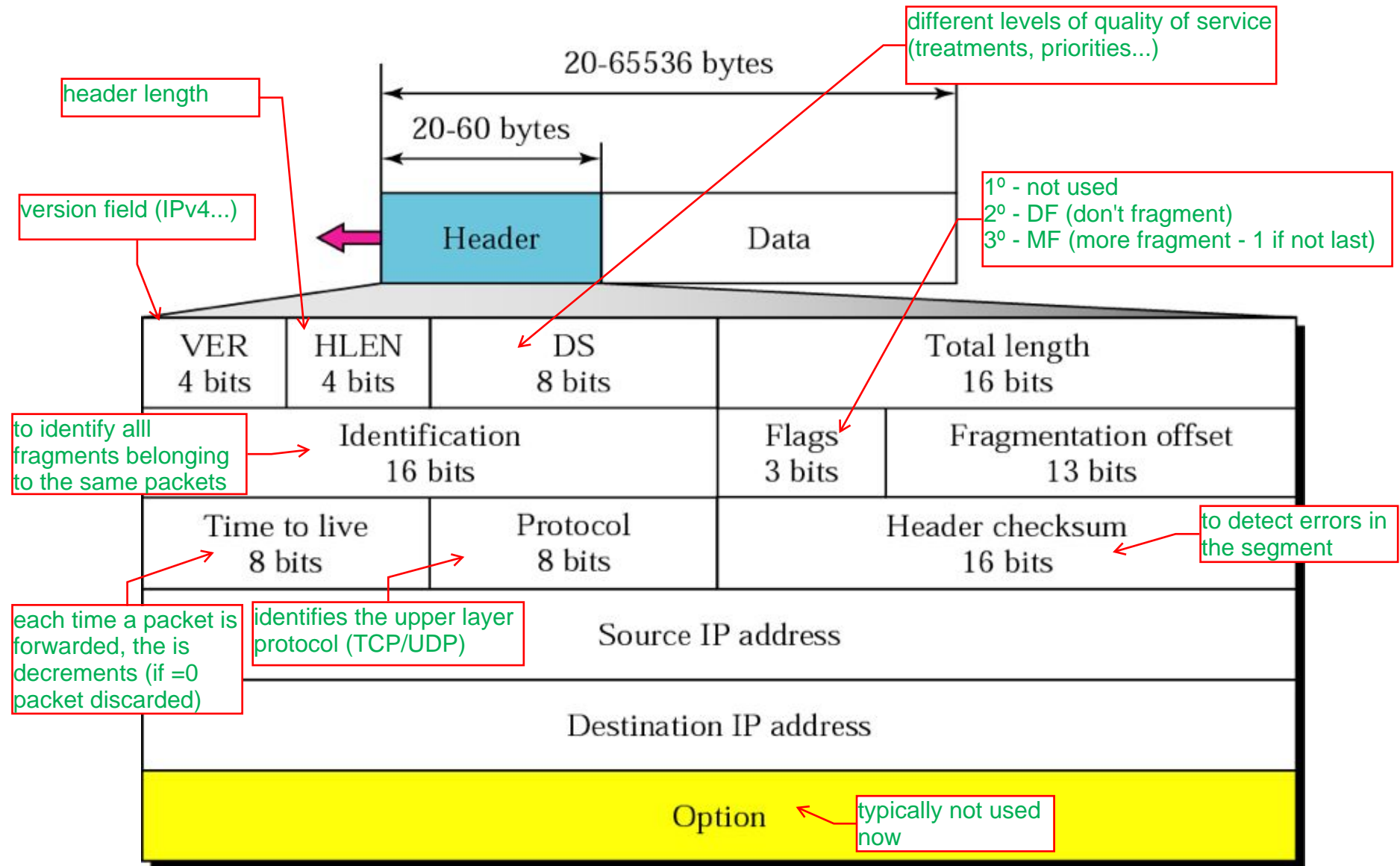
Private Addresses

- Set of addresses reserved for private use
- Not valid for use in Internet *You need an address translation protocol to use these in the internet*
- Ranges for private IP addresses are the following:
 - 10.0.0.0 – 10.255.255.255 ~ 1 class-A private network
 - 172.16.0.0 – 172.31.255.255 ~ 16 class-B private networks
 - 192.168.0.0 – 192.168.255.255 ~ 256 class-C private networks

Multicast Addresses (224.0.0.0/4) - RFC 1112

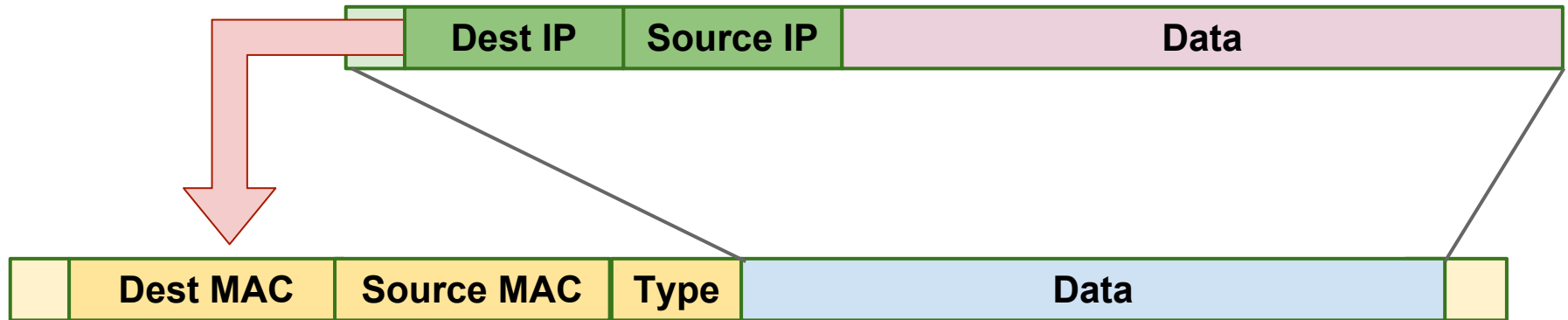
- Logically identify a group of hosts in the network segment. Examples:
 - 224.0.0.1 (all hosts)
 - 224.0.0.2 (all routers)
 - 224.0.0.251 (mDNS)
- Relation to link layer (Ethernet - type 0x0800, RFC 7042 - Section 2.1.1)
 - IP: 224.0.0.1  23 bits
 - MAC: 01:00:5E:00:00:01

IP: Datagram Format



ARP (Address Resolution Protocol)

Target: To establish the correspondence between IP and MAC addresses



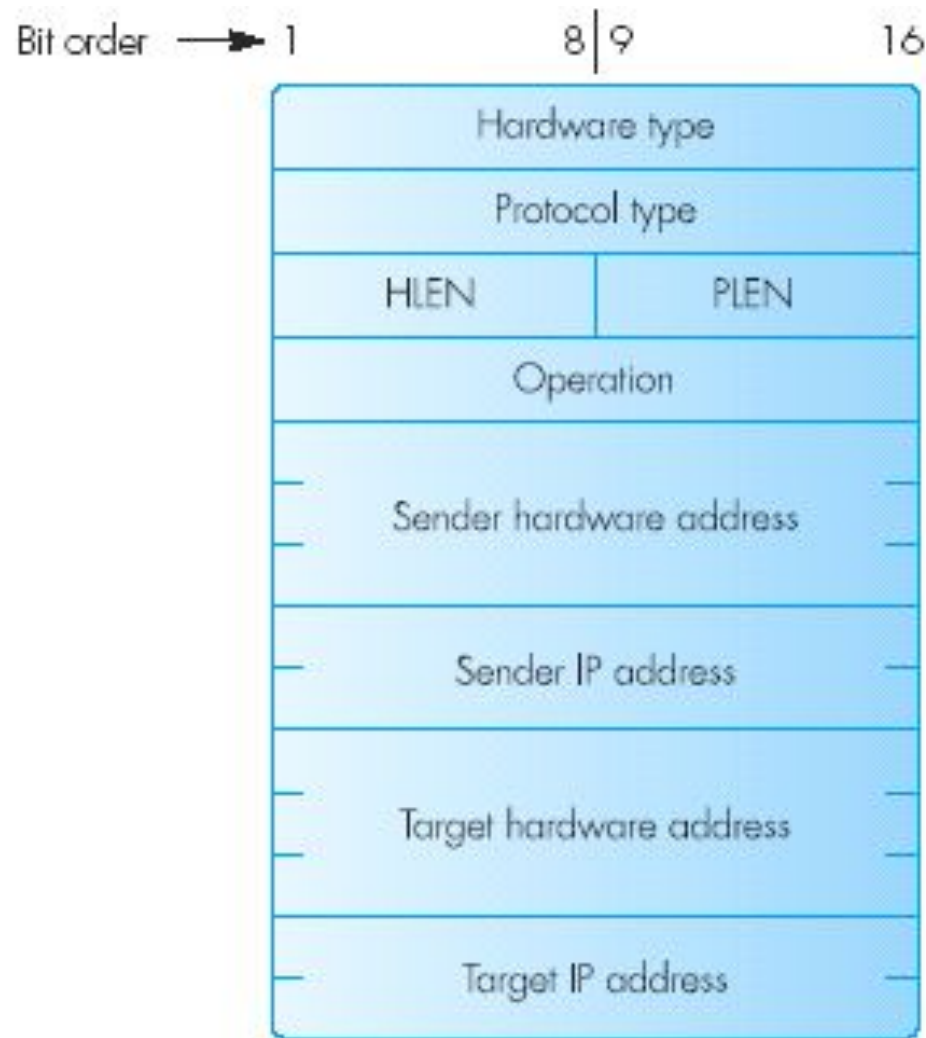
ARP Table

- Temporarily keeps IP-to-MAC address associations

Net to Media Table

Device	IP Address	Mask	Flags	Phys Addr
le0	147.96.48.203	255.255.255.255		00:00:b4:c3:c8:f4
le0	147.96.37.196	255.255.255.255		00:a0:24:57:78:3e
le0	147.96.48.217	255.255.255.255		00:20:18:2f:1d:60

ARP (Address Resolution Protocol)



HLEN = Hardware address length

PLEN = IP address length

Operation = 1 ARP request

= 2 ARP response

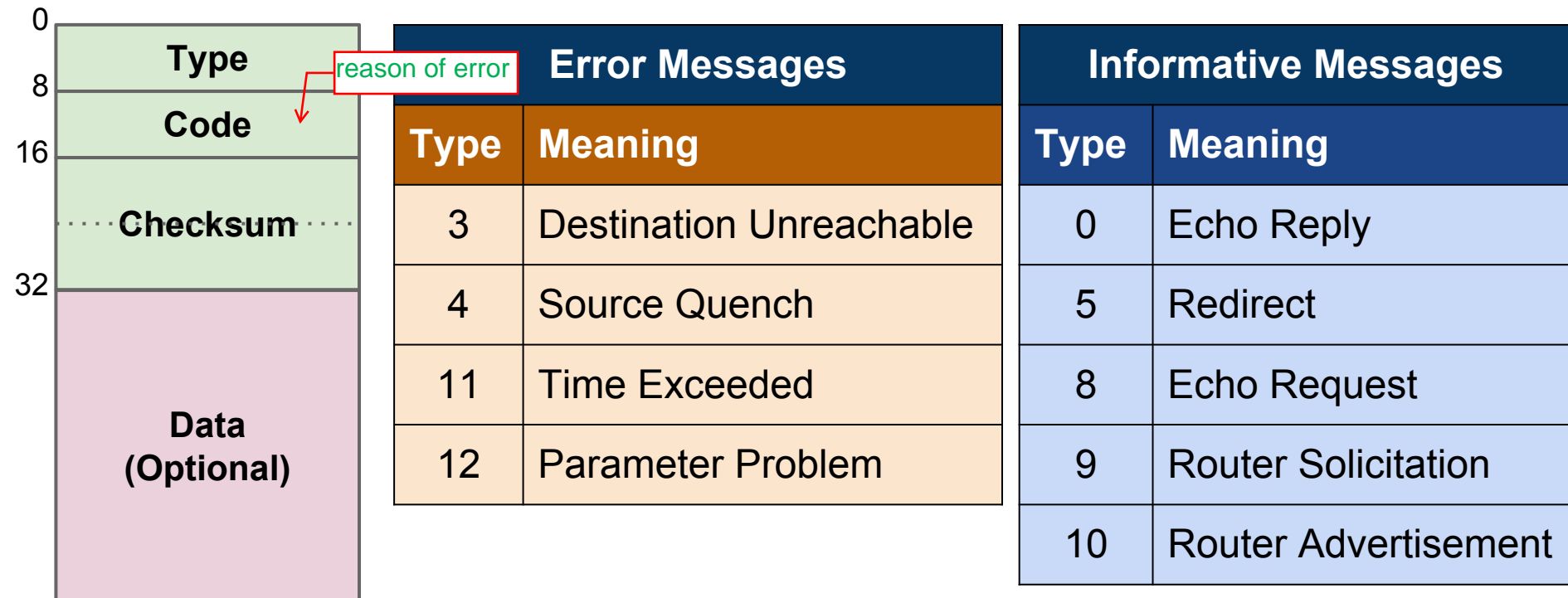
= 3 RARP request

= 4 RARP response

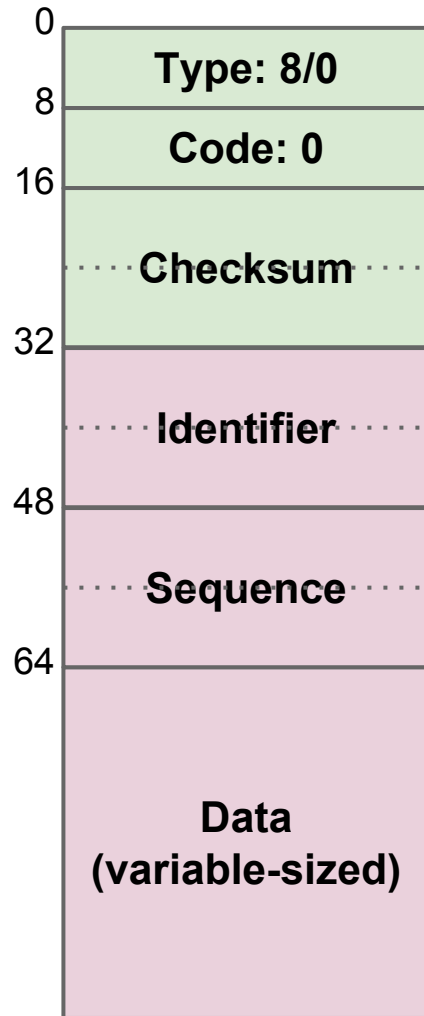
ICMP (Internet Control Message Protocol)

Characteristics

- Protocol for the exchange of control messages in the network
- Messages can be classified in two types:
 - **Error**, generated in response to errors in IP operations
 - **Informative**, used for diagnostics or control purposes (e.g. presence or status of a given system)

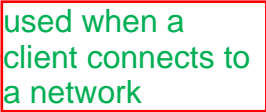





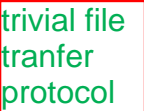



ICMP: Echo Request/Reply

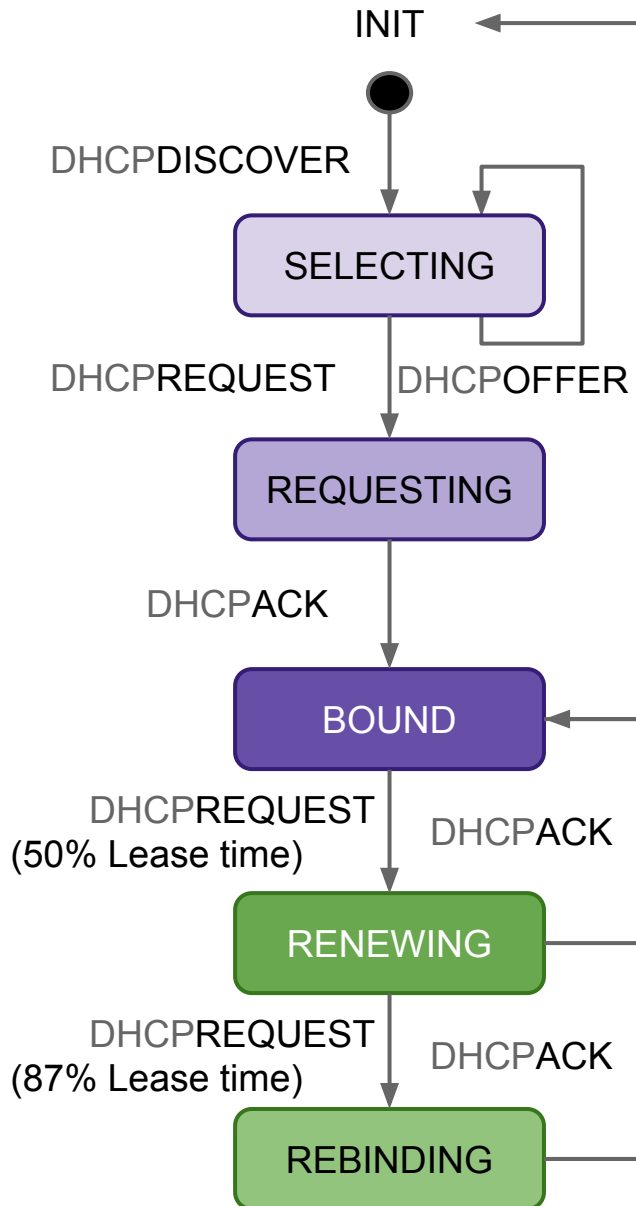


- Used to check if a host is reachable
- Format
 - **Identifier**: To establish correspondence between request and reply (same identifier)
 - **Sequence**: Also used to establish correspondence when multiple consecutive requests are sent with the same identifier
 - **Data**: A given number of random bytes
- The ping command sends Echo Request messages and waits for Echo Reply messages

DHCP (Dynamic Host Configuration Protocol)

- Provides automatic configuration of network parameters 
 - IP address and network mask
 - Default router
 - DNS servers
 - Other network parameters and services
- **History**
 - RARP (Reverse ARP) is only useful in the network segment and just provides IP addresses
 - BOOTP (Bootstrap Protocol) solves RARP limitations, but only supports static configurations (similar to DHCP in static configuration)
- **Characteristics (RFC 2131)** 
 - Based on BOOTP
 - Client/server protocol over UDP using ports 67 for server and 68 for client (client port is not ephemeral) 
 - Error control based on checksums, timeouts and retransmissions
 - TFTP protocol to transfer files with additional information or boot images 
 - DHCP Relay Agent for servers/clients in different networks

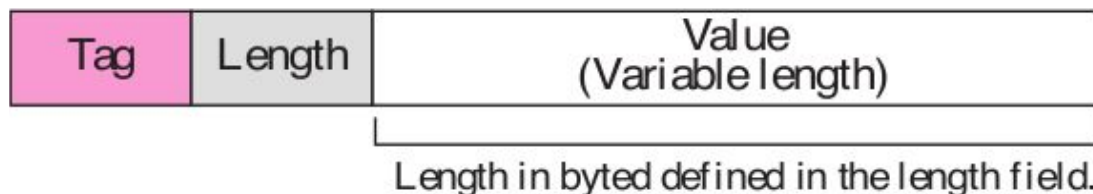
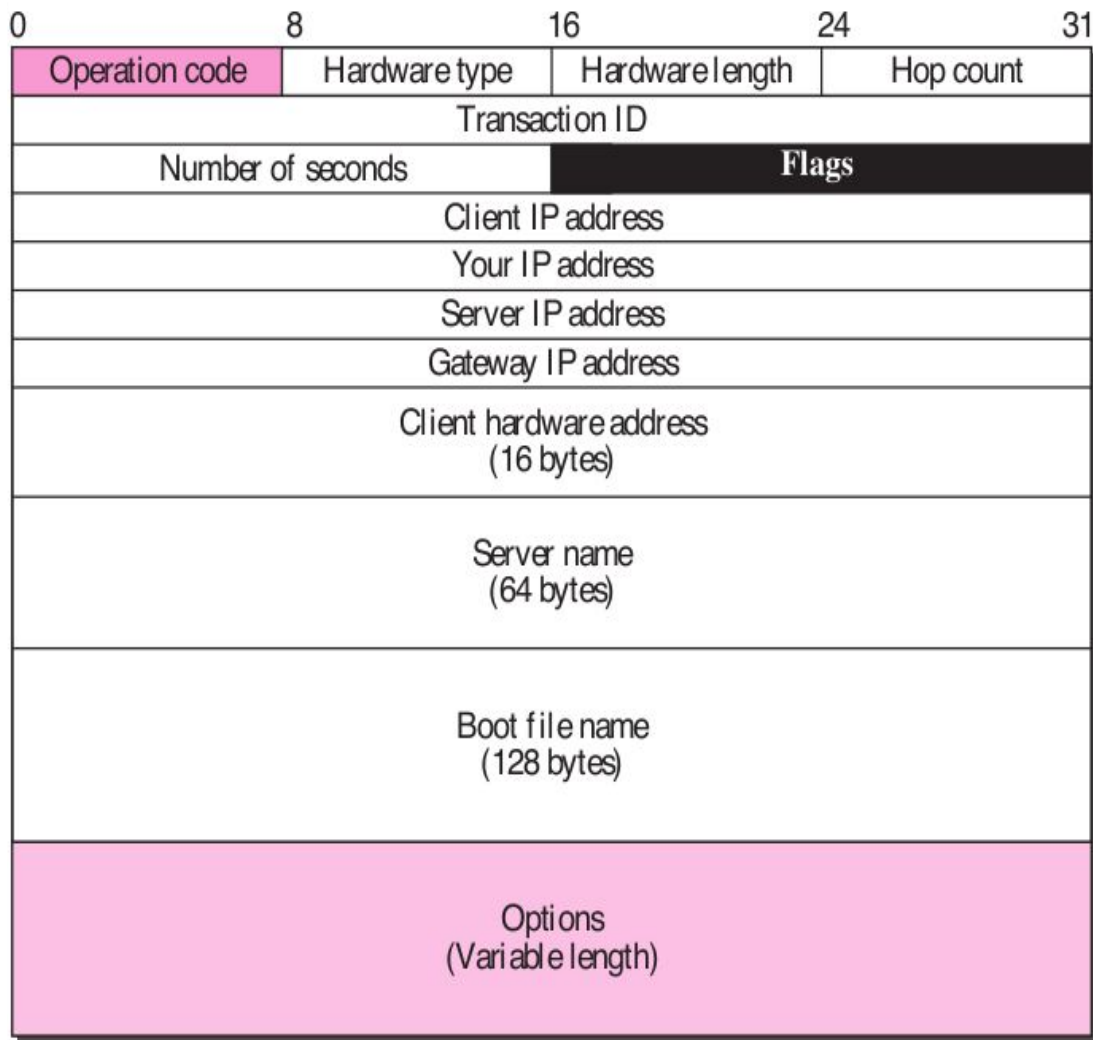
DHCP: State Diagram



- **DHCPDISCOVER:** Client broadcast to locate available servers (may contain the last assigned address and suggested lease time)
- **DHCPOFFER:** Reply from servers, with an offer of configuration parameters (possibly more than one)
- **DHCPREQUEST:** Client broadcast to request an offer or extend a lease, specifying the selected server as an option (Server Identifier, code 54)
- **DHCPACK:** Server broadcast to confirm and commit the offer, including the definitive parameters and lease duration
- **DHCPRELEASE:** Client message to inform the server that the use of the IP address has finalized and cancelling remaining lease (not mandatory)

DHCP: Message Format

Taken from the BOOTP protocol



Opcode: 0x01 (request), 0x02 (reply)

Hw type - length: 1 - 6 for Ethernet

Trans. ID: Correspondence between request and reply

Your IP: Offered by the server

Server name - Boot file name:
BOOTP compatibility

Options: Configuration information (RFC 2132)

- DNS servers
- Hostname
- TCP/IP (MTU, TTL...)
- Servers for NTP, SMTP, POP3...
- DHCP extensions (DHCP Message Type, Server ID, Client ID, TFTP Server, Lease Time...)