Introduction to Computer Networks

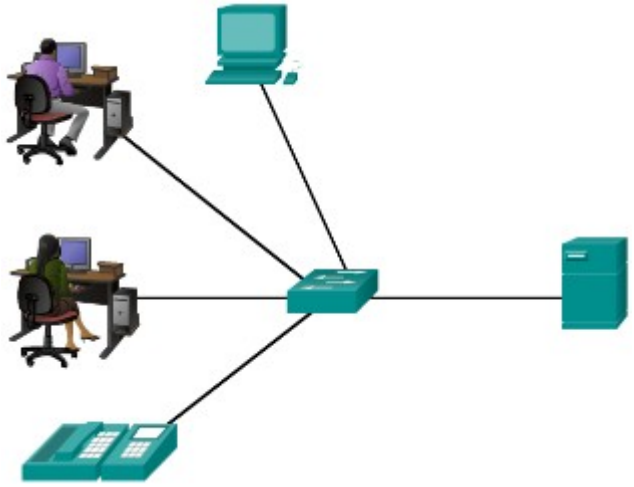
Slide Source: Cisco Networking

Networking Today

- Network has no boundary and supports the way we:
  - Learn
  - Communicate
  - Work
  - Play

LANs and WANs

- Local Area Networks
  - Spans across small geographical area
  - Interconnects end devices
  - Administrated by a single organization
  - Provide high speed bandwidth to internal devices
- WAN Area Networks
  - Interconnects LAN
  - Administrated by multiple service providers
  - Provide slower speed links between LANS
- Can you name more network types?

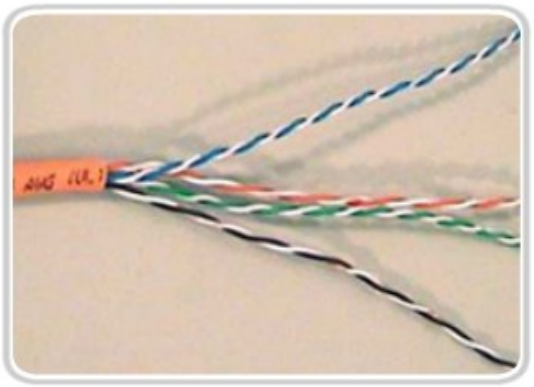


Network Components

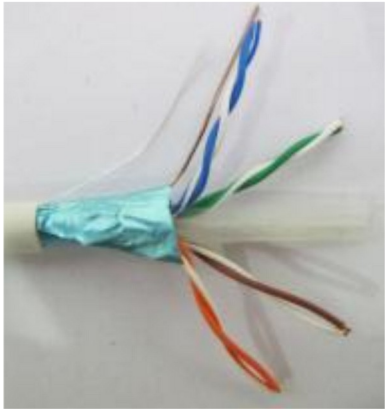
Network Components

- End Devices
  - Either the source or destination of a message
- Intermediary Network Devices
  - Connect multiple individual networks to form an internetwork
  - Connect the individual end devices to the network
- Network Media
  - Provide the pathway for data transmission
  - Interconnect devices

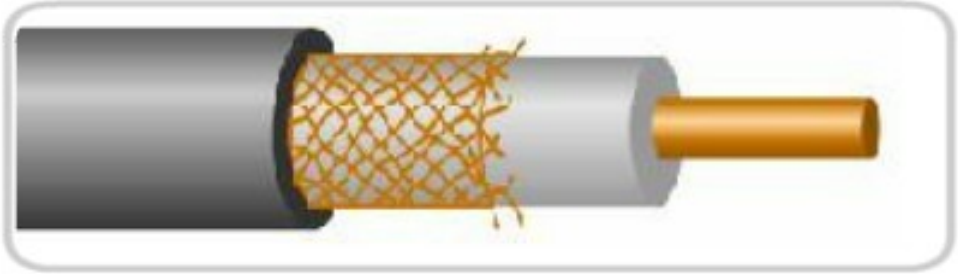
Copper Media



Unshielded Twisted Pair (UTP) Cable

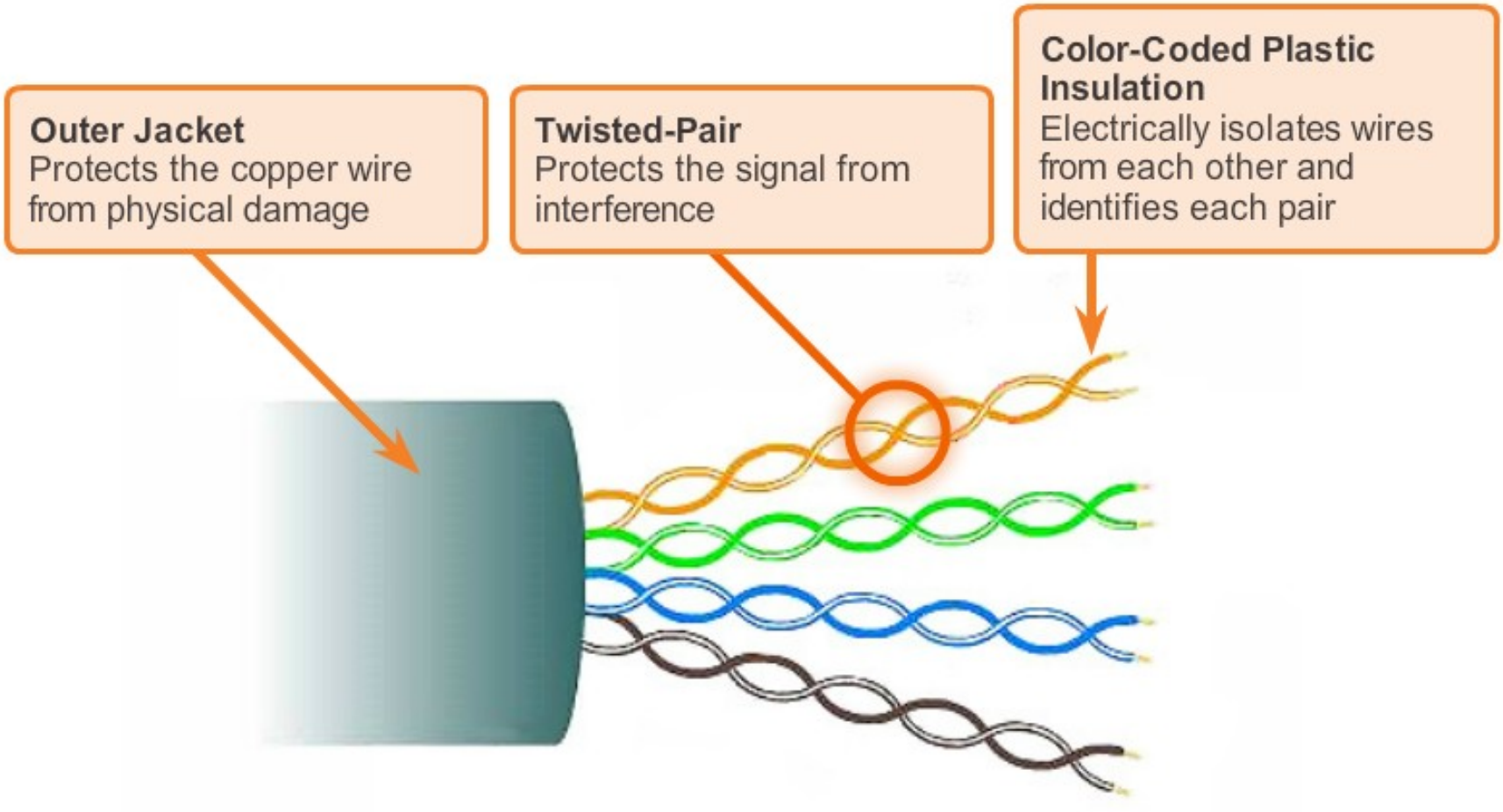


Shielded Twisted Pair (STP) Cable



Coaxial Cable

UTP Cable


Outer Jacket
Protects the copper wire from physical damage
Twisted-Pair
Protects the signal from interference
Color-Coded Plastic Insulation
Electrically isolates wires from each other and identifies each pair

UTP Connectors

RJ-45 UTP Plugs

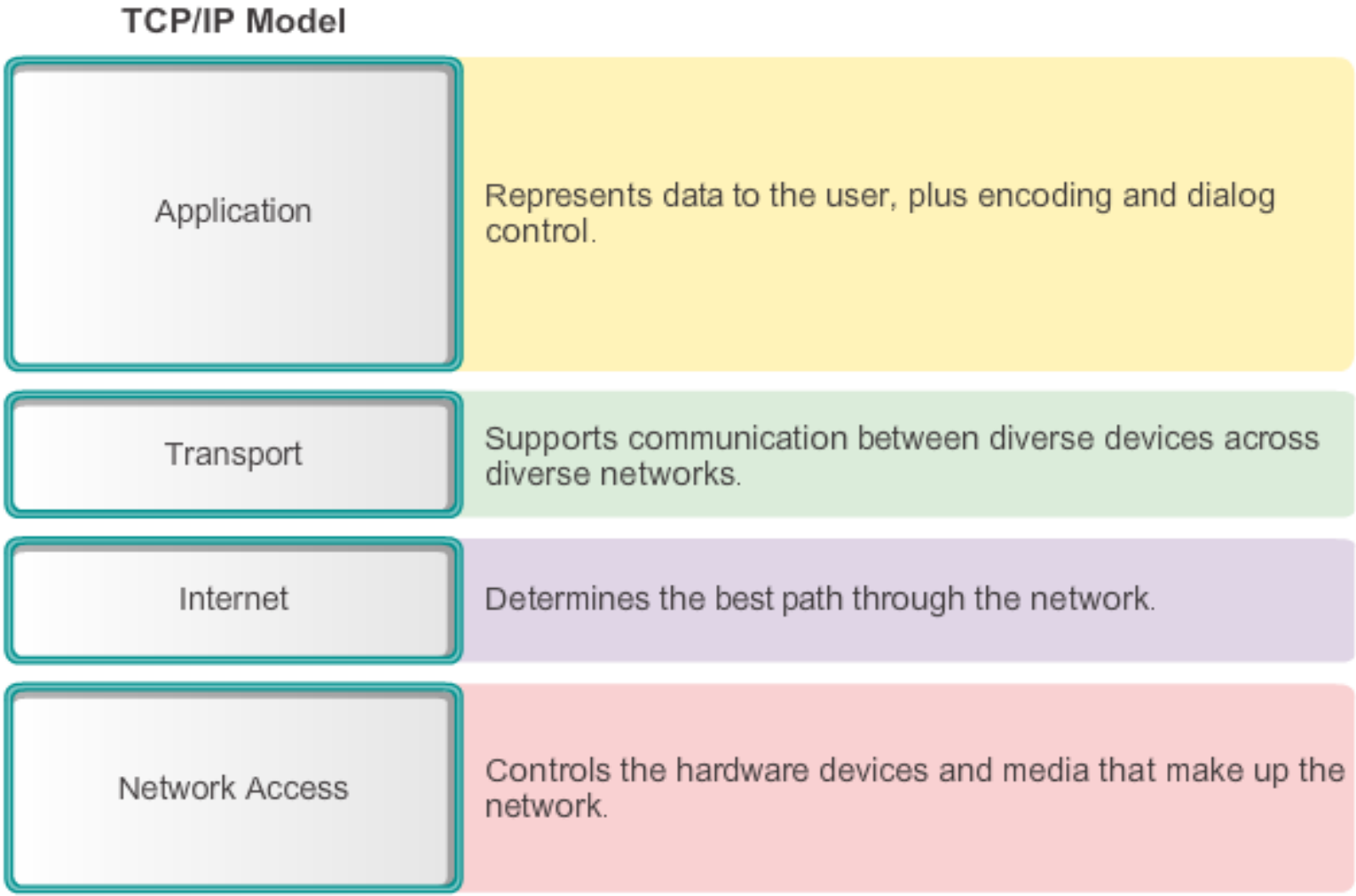
RJ-45 UTP Socket

Creation of Internet, Development of TCP/IP

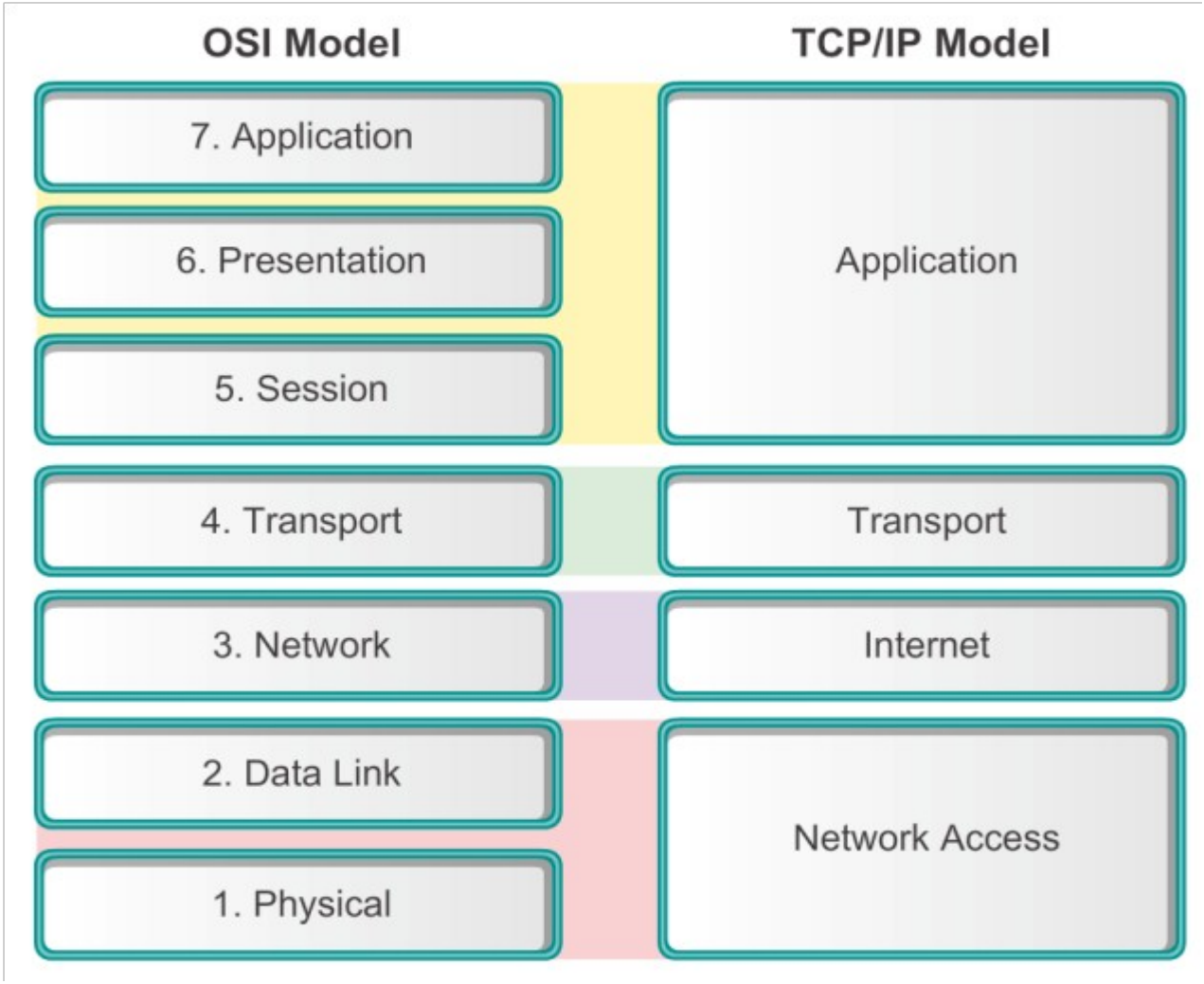
- The first packet switching network and predecessor to today's Internet was the Advanced Research Projects Agency Network (ARPANET), which came to life in 1969 by connecting mainframe computers at four locations.
- ARPANET was funded by the U.S. Department of Defense for use by universities and research laboratories. Bolt, Beranek and Newman (BBN) was the contractor that did much of the initial development of the ARPANET, including creating the first router known as an Interface Message Processor (IMP).
- In 1973, Robert Kahn and Vinton Cerf began work on TCP to develop the next generation of the ARPANET. TCP was designed to replace ARPANET's current Network Control Program (NCP).
- In 1978, TCP was divided into two protocols: TCP and IP. Later, other protocols were added to the TCP/IP suite of protocols including Telnet, FTP, DNS, and many others.

The OSI Reference Model

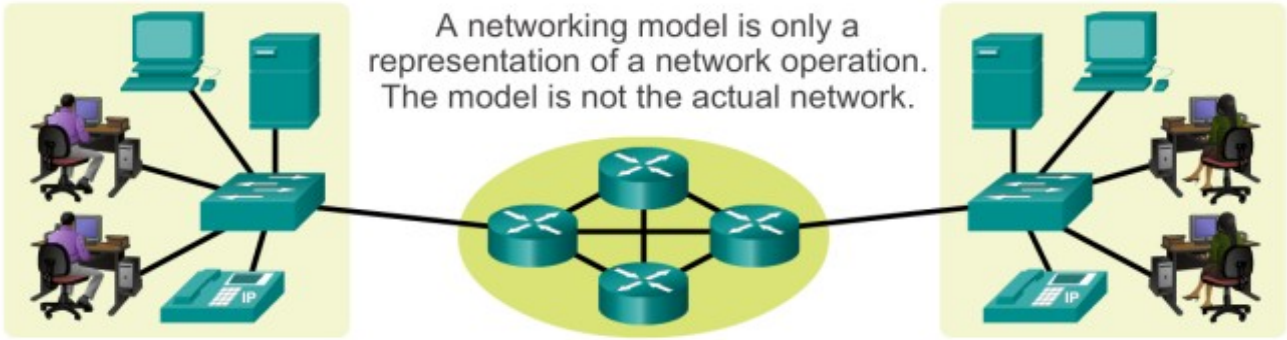
The TCP/IP Reference Model



Comparing the OSI and TCP/IP Models



Benefits of Using a Layered Model



OSI Model	TCP/IP Protocol Suite	TCP/IP Model
Application	HTTP, DNS, DHCP, FTP	Application
Presentation		
Session		
Transport	TCP, UDP	Transport
Network	IPv4, IPv6, ICMPv4, ICMPv6	Internet
Data Link	PPP, Frame Relay, Ethernet	Network Access
Physical		

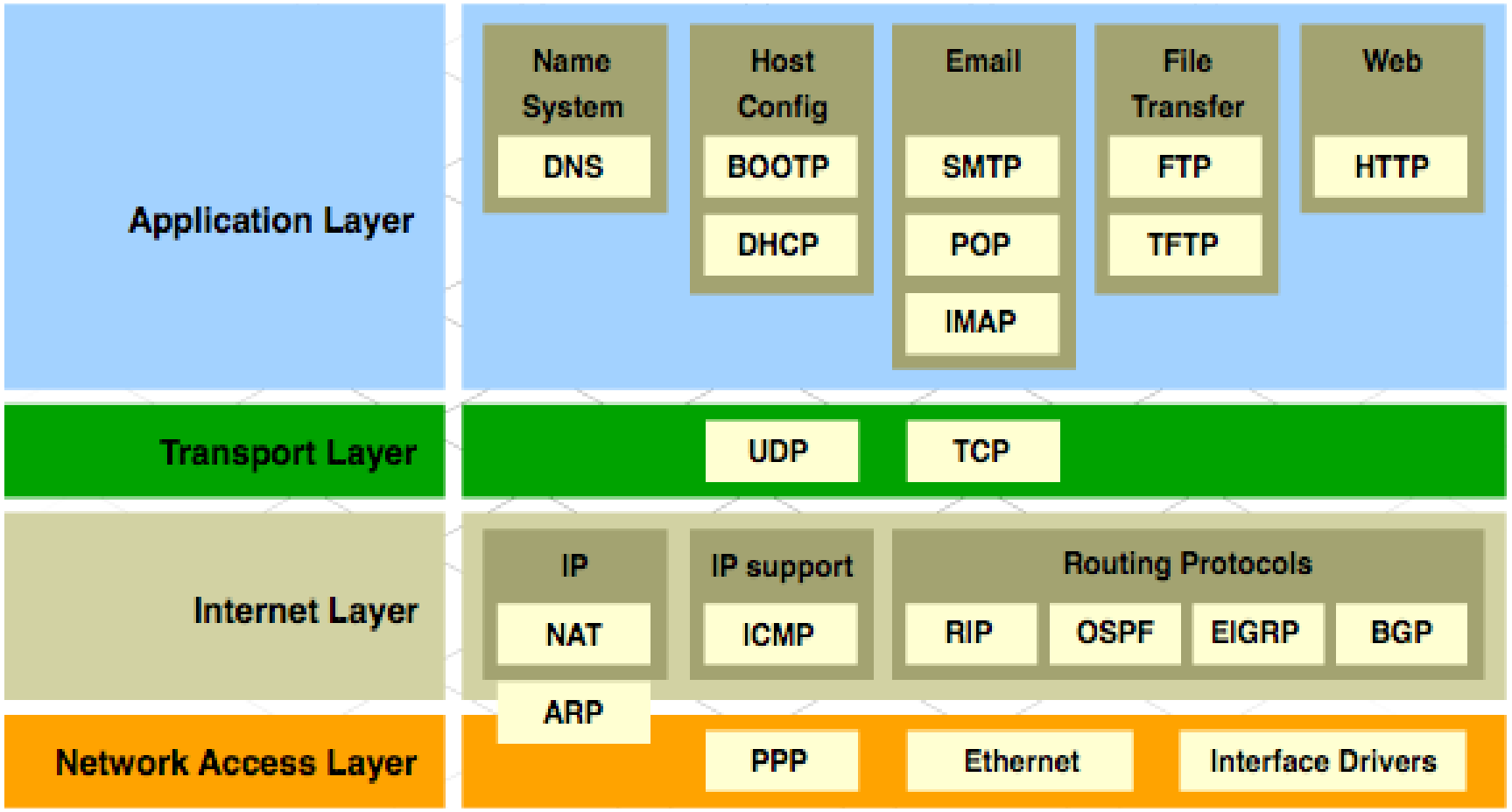
Establishing the Rules

- An identified sender and receiver
- Common language and grammar
- Speed and timing of delivery
- Confirmation or acknowledgment requirements

Network Protocols

- How the message is formatted or structured
- The process by which networking devices share information about pathways with other networks
- How and when error and system messages are passed between devices
- The setup and termination of data transfer sessions

TCP/IP Protocol Suite and Communication



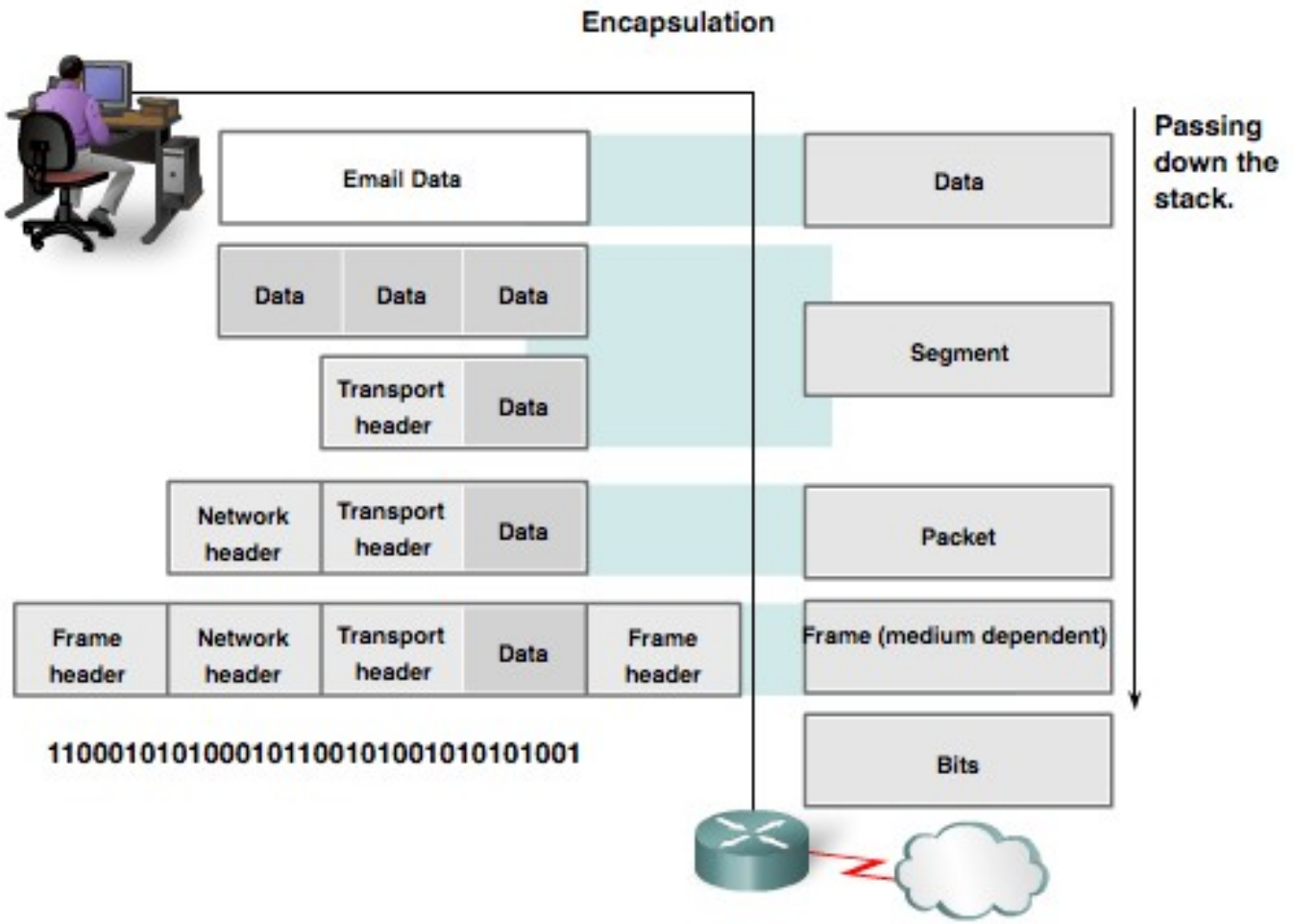
Message Formatting and Encapsulation

Example: Personal letter contains the following elements:

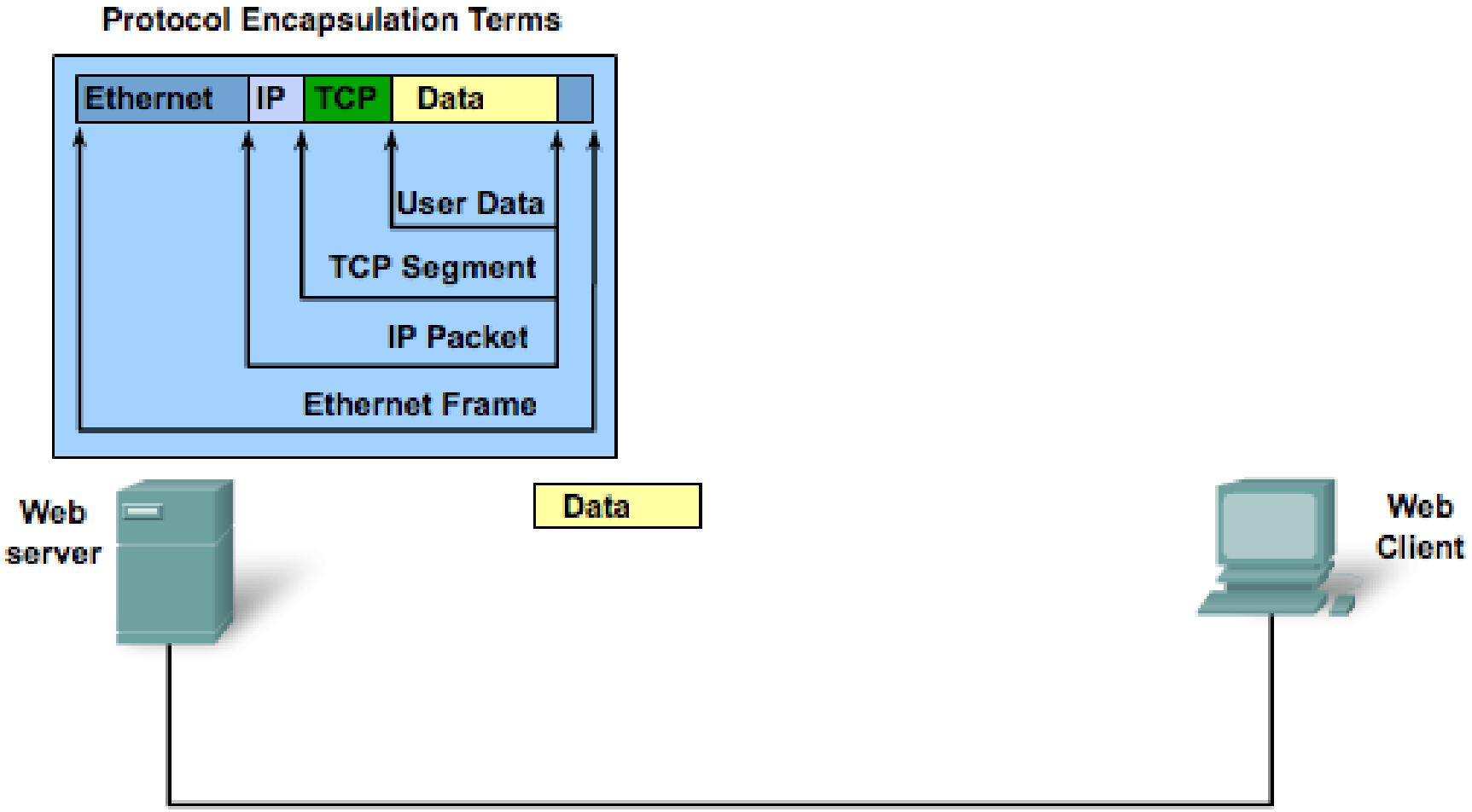
- Identifier of the recipient's location
- Identifier of the sender's location
- Salutation or greeting
- Recipient identifier
- The message content
- Source identifier
- End of message indicator

Protocol Data Units (PDUs)

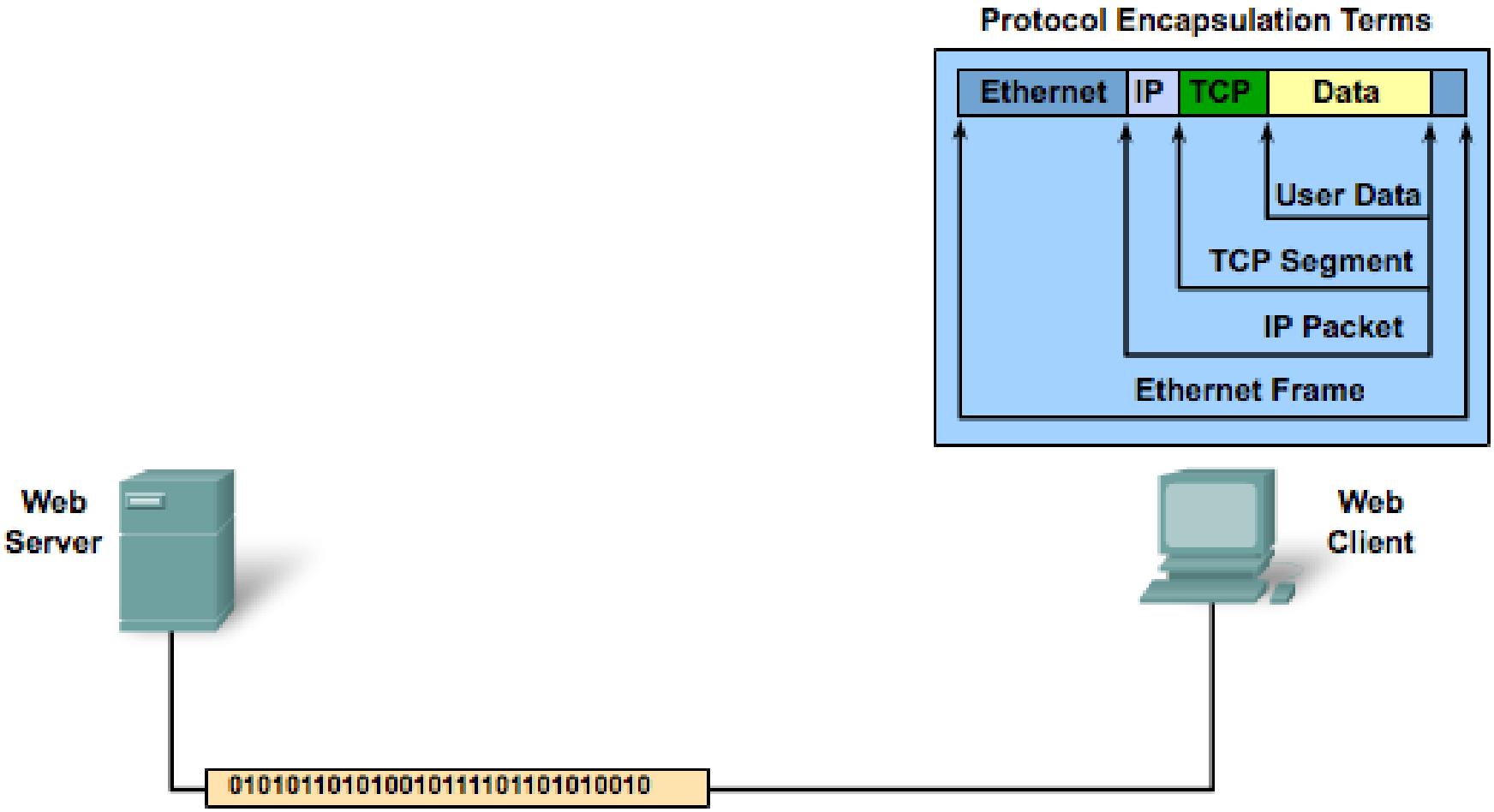
- Data
- Segment
- Packet
- Frame
- Bits



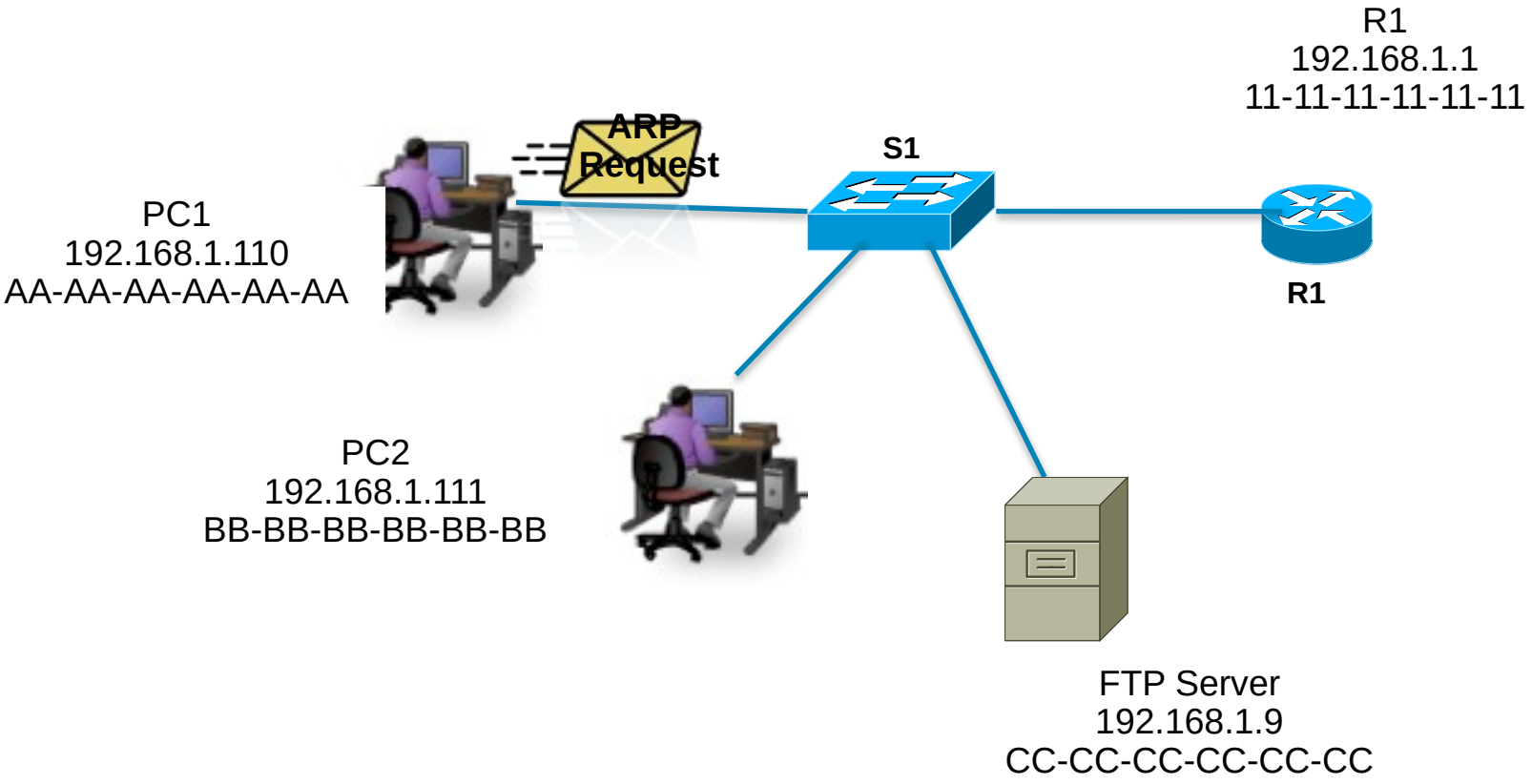
Protocol Encapsulation



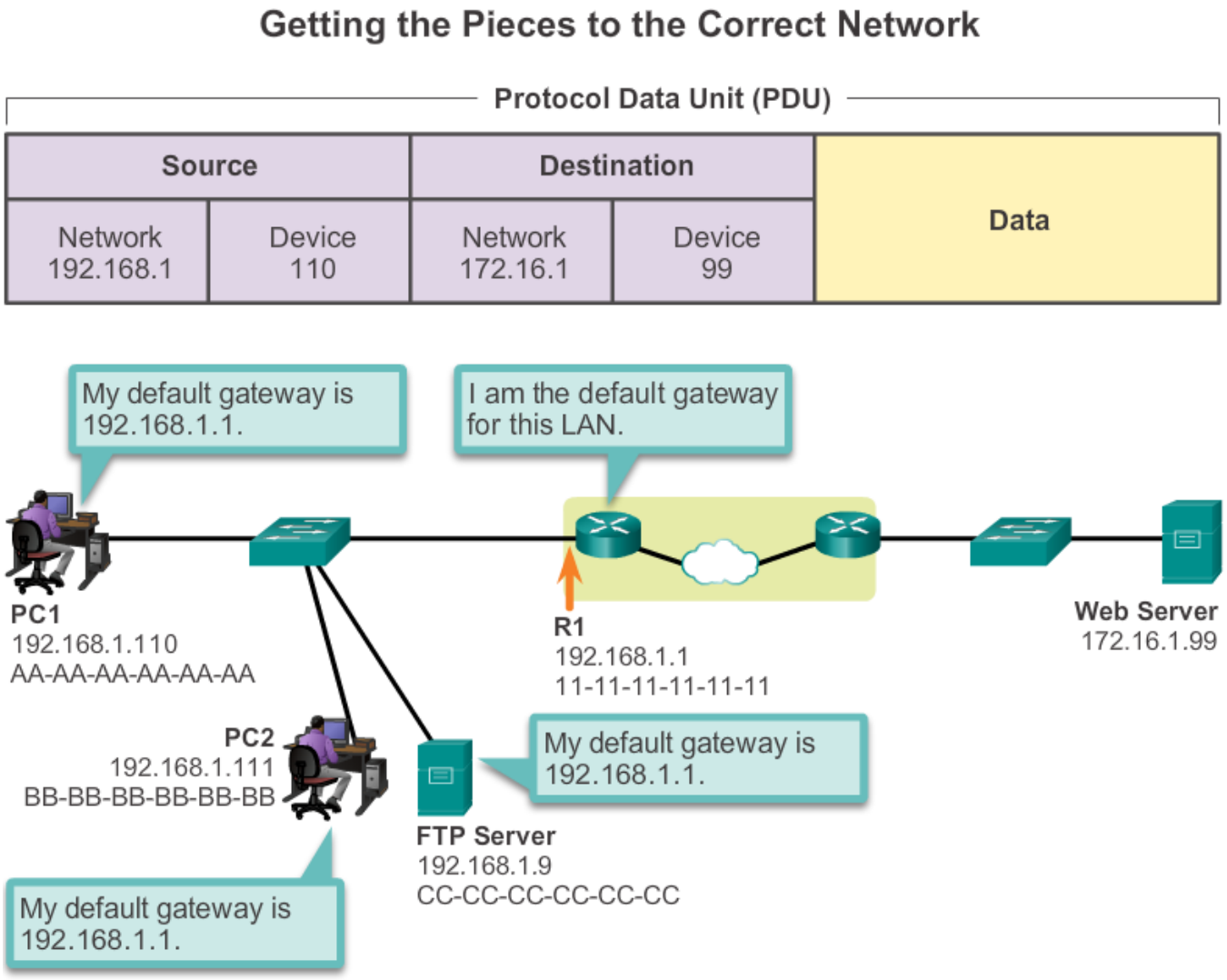
Protocol De-encapsulation



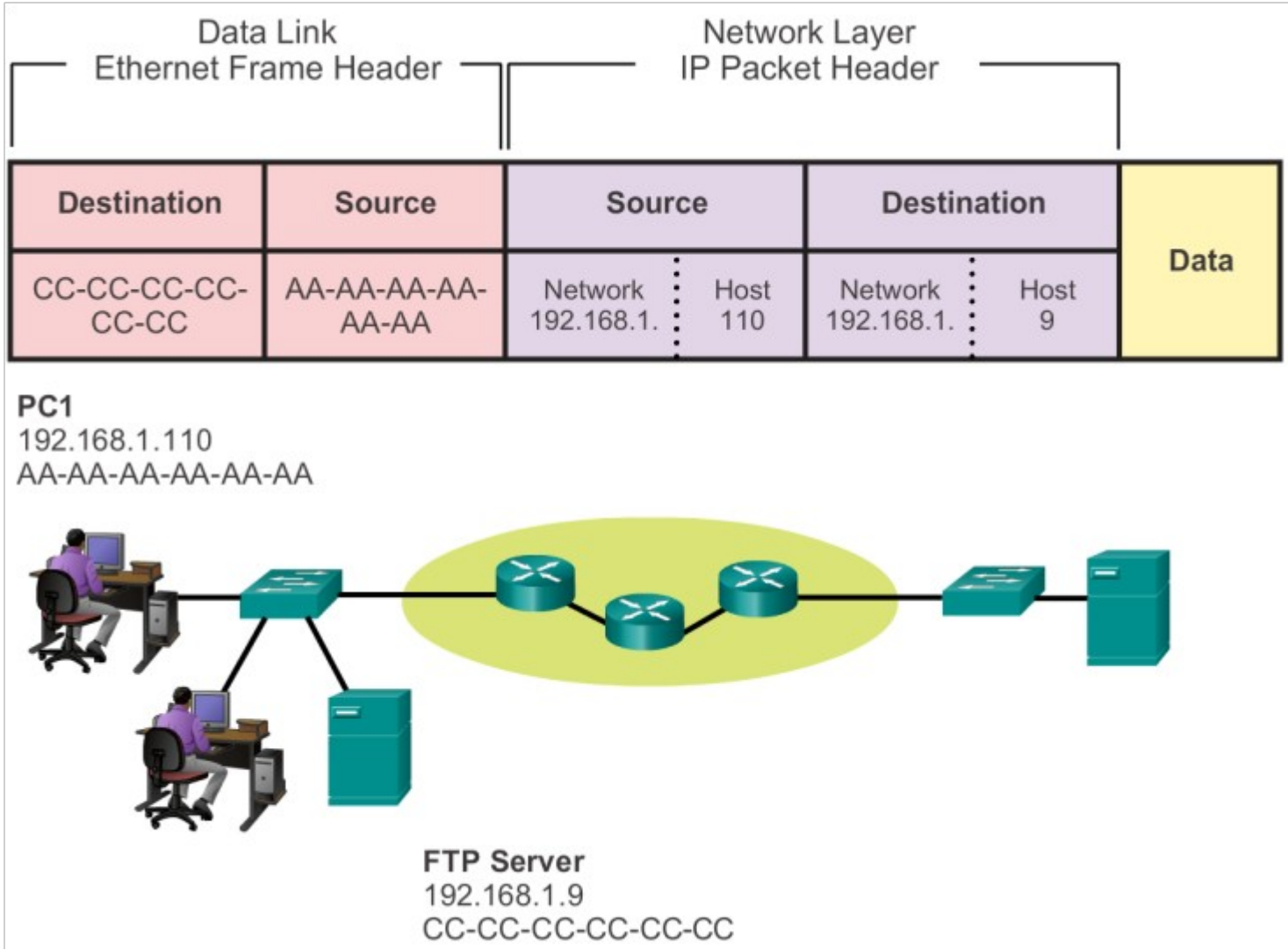
MAC and IP Addresses



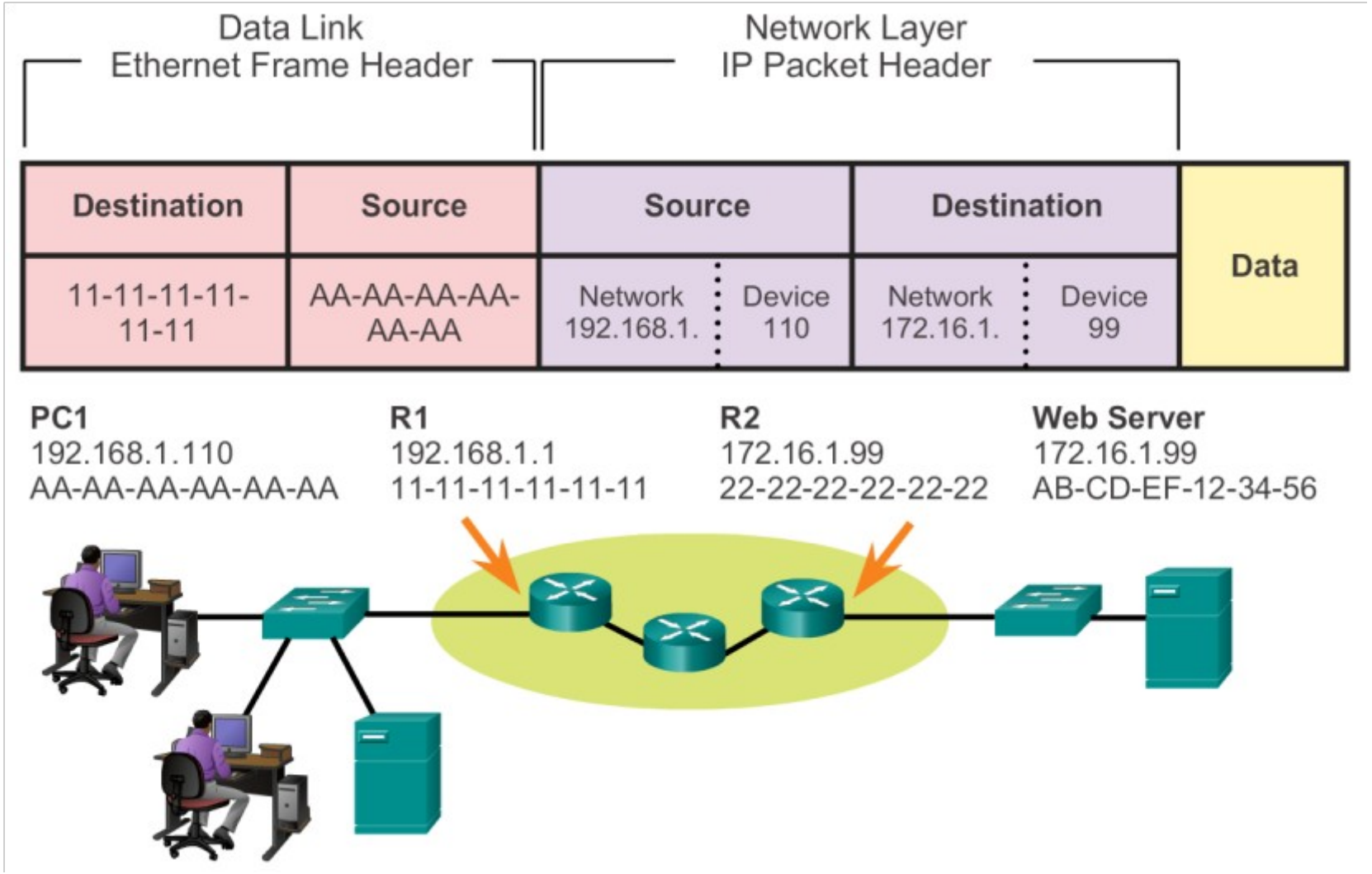
Default Gateway



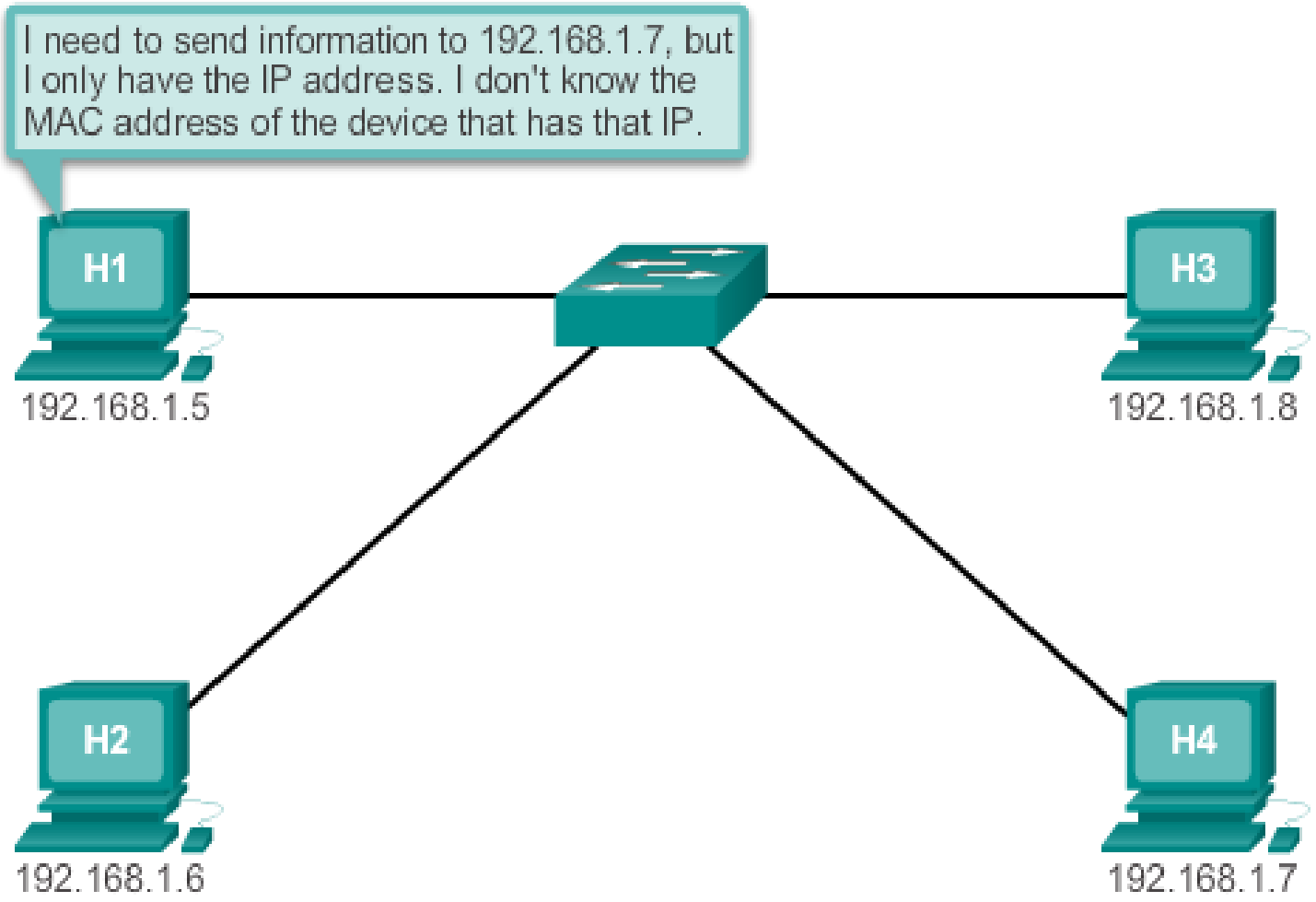
Communicating with Device / Same Network



Communicating Device / Remote Network



Address Resolution Protocol (ARP)



ARP Operation

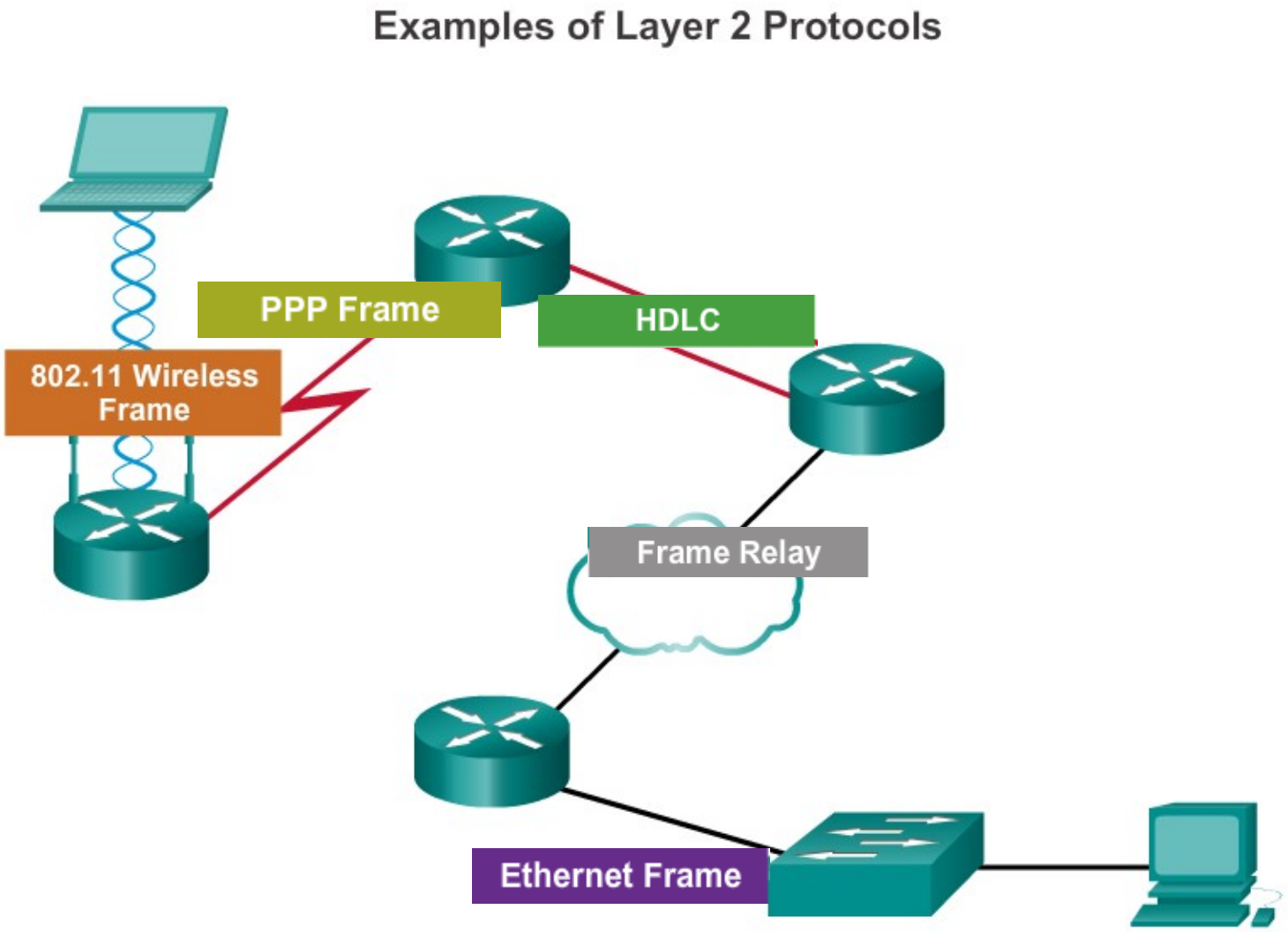
ARP Table

- Maps data link layer address to destination IPv4 address.
- As a node receives frames from the media, it records the source IP and MAC address as a mapping in the ARP table.

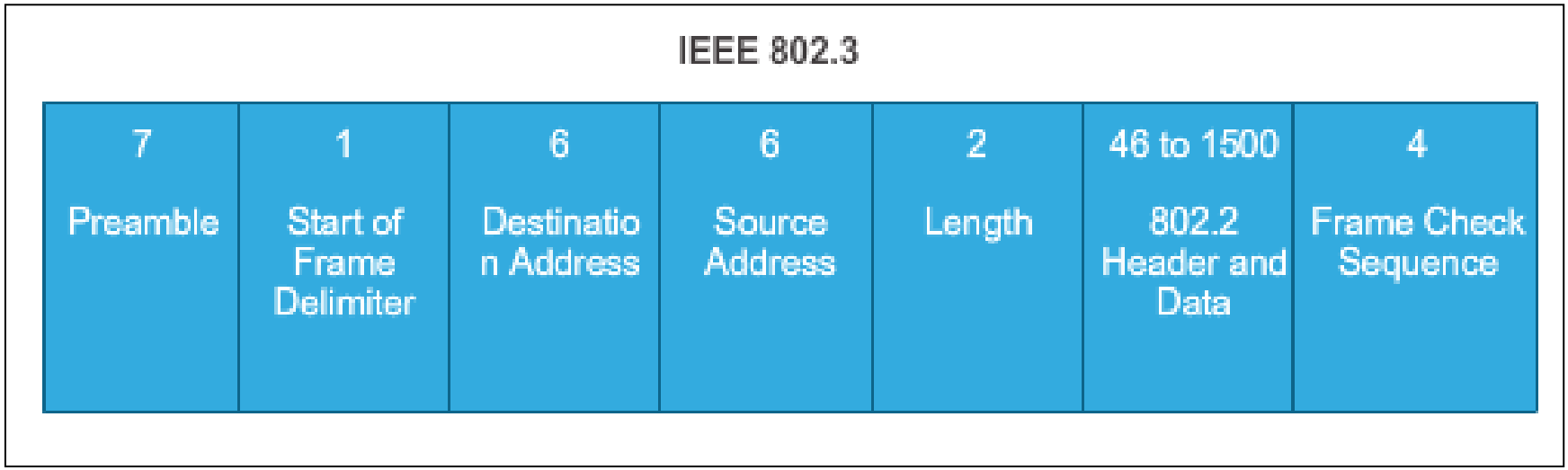
ARP Request

- Layer 2 broadcast to all devices on the Ethernet LAN.
- The node that matches the IP address in the broadcast will reply.
- If no device responds to the ARP request, the packet is dropped because a frame cannot be created.

LAN and WAN Frames



Ethernet Frame format



Preamble and Start Frame Delimiter Fields – Used for synchronization between the sending and receiving devices.

Length/Type Field – Defines the exact length of the frame's data field; describes which protocol is implemented.

Data and Pad Fields – Contains the encapsulated data from a higher layer, an IPv4 packet.

The Network Layer

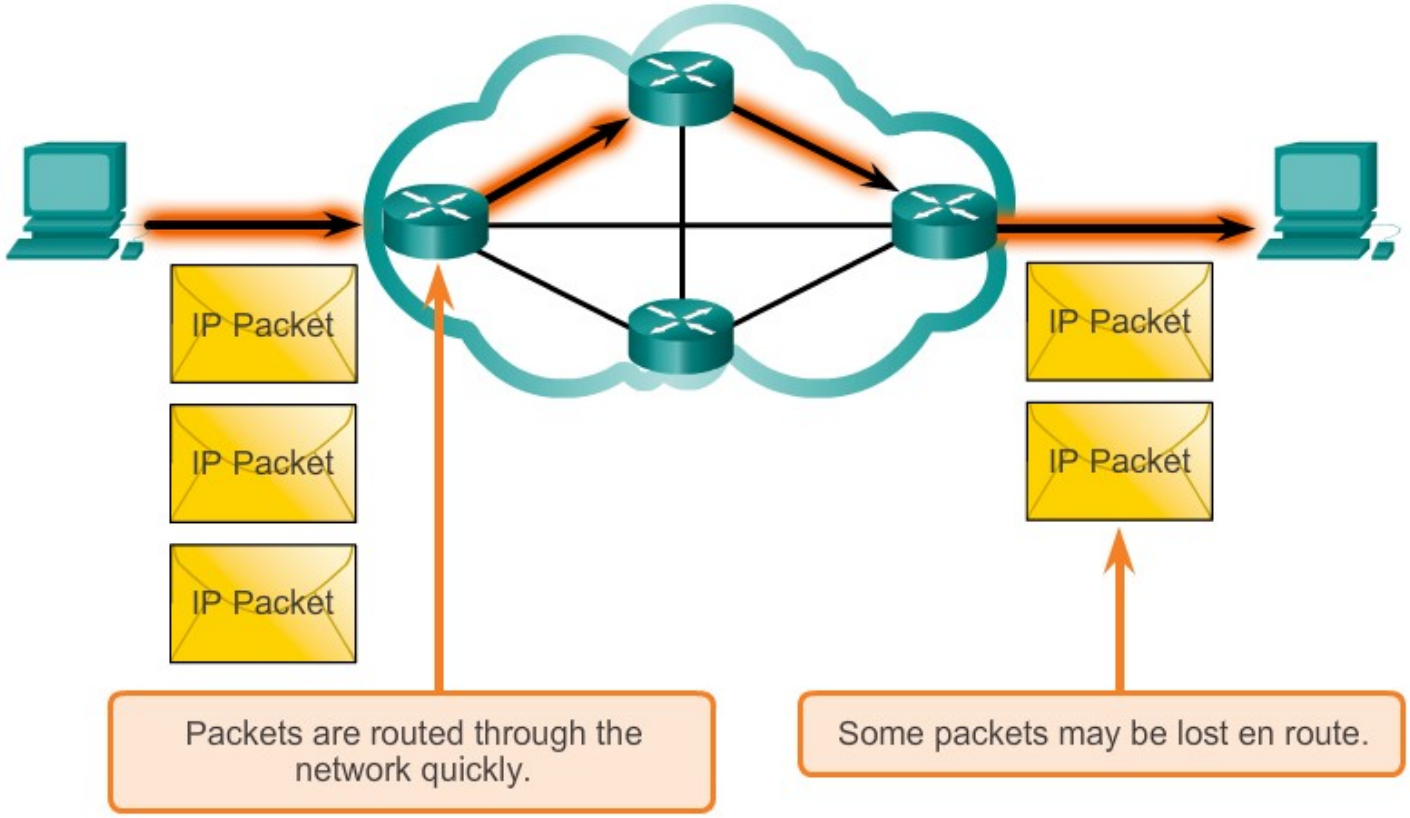
The network layer, or OSI Layer 3, provides services to allow end devices to exchange data across the network. To accomplish this end-to-end transport, the network layer uses four basic processes:

- Addressing end devices
- Encapsulation
- Routing
- De-encapsulating

Network Layer Protocols

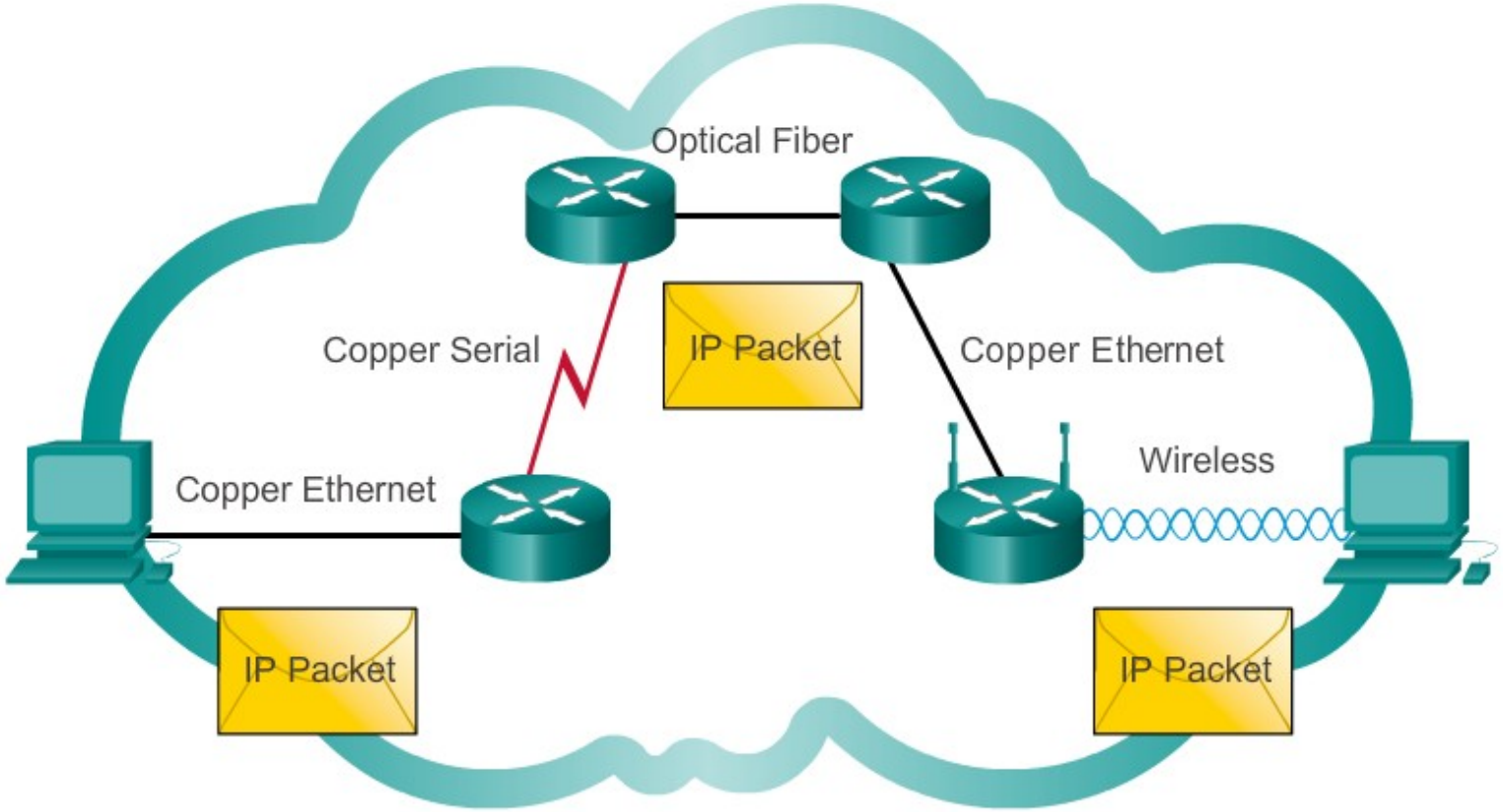
- IP version 4 (IPv4)
- IP version 6 (IPv6)

Best Effort Delivery



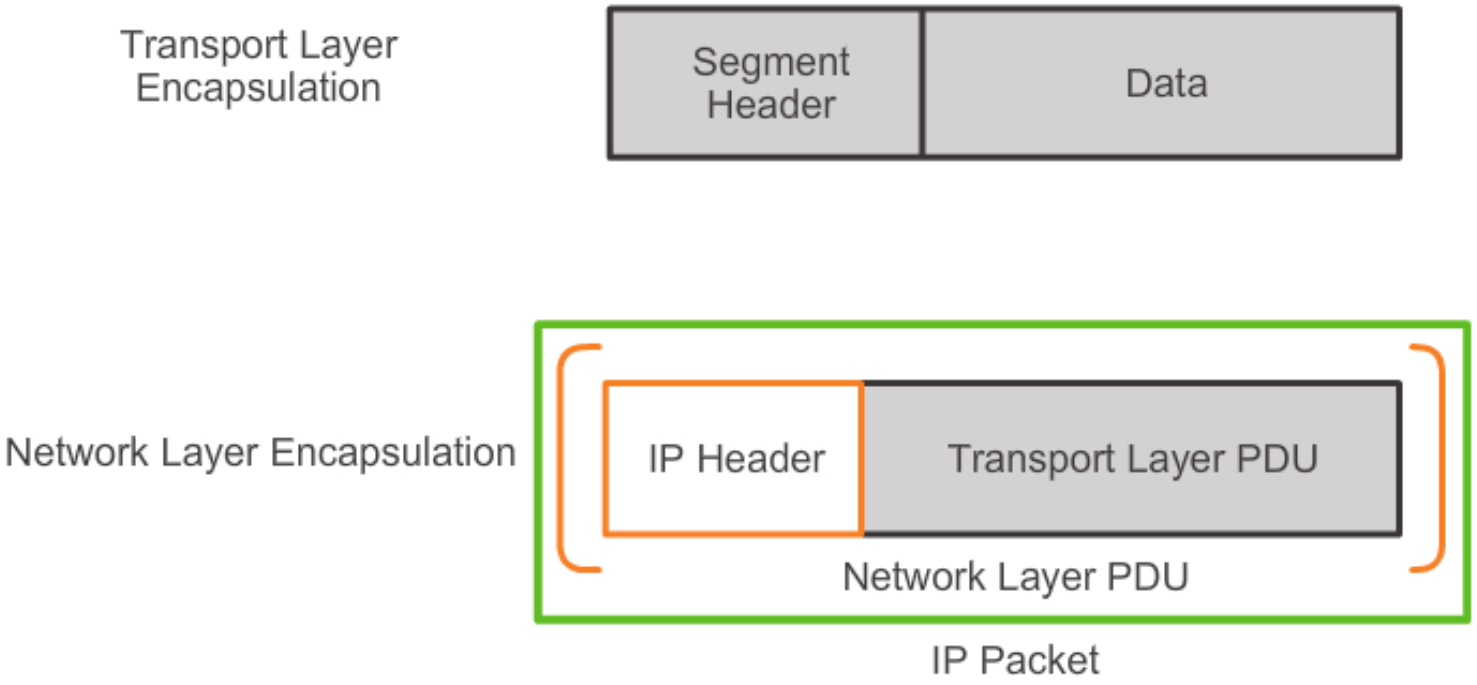
As an unreliable network layer protocol, IP does not guarantee that all sent packets will be received. Other protocols manage the process of tracking packets and ensuring their delivery.

IP – Media Independent



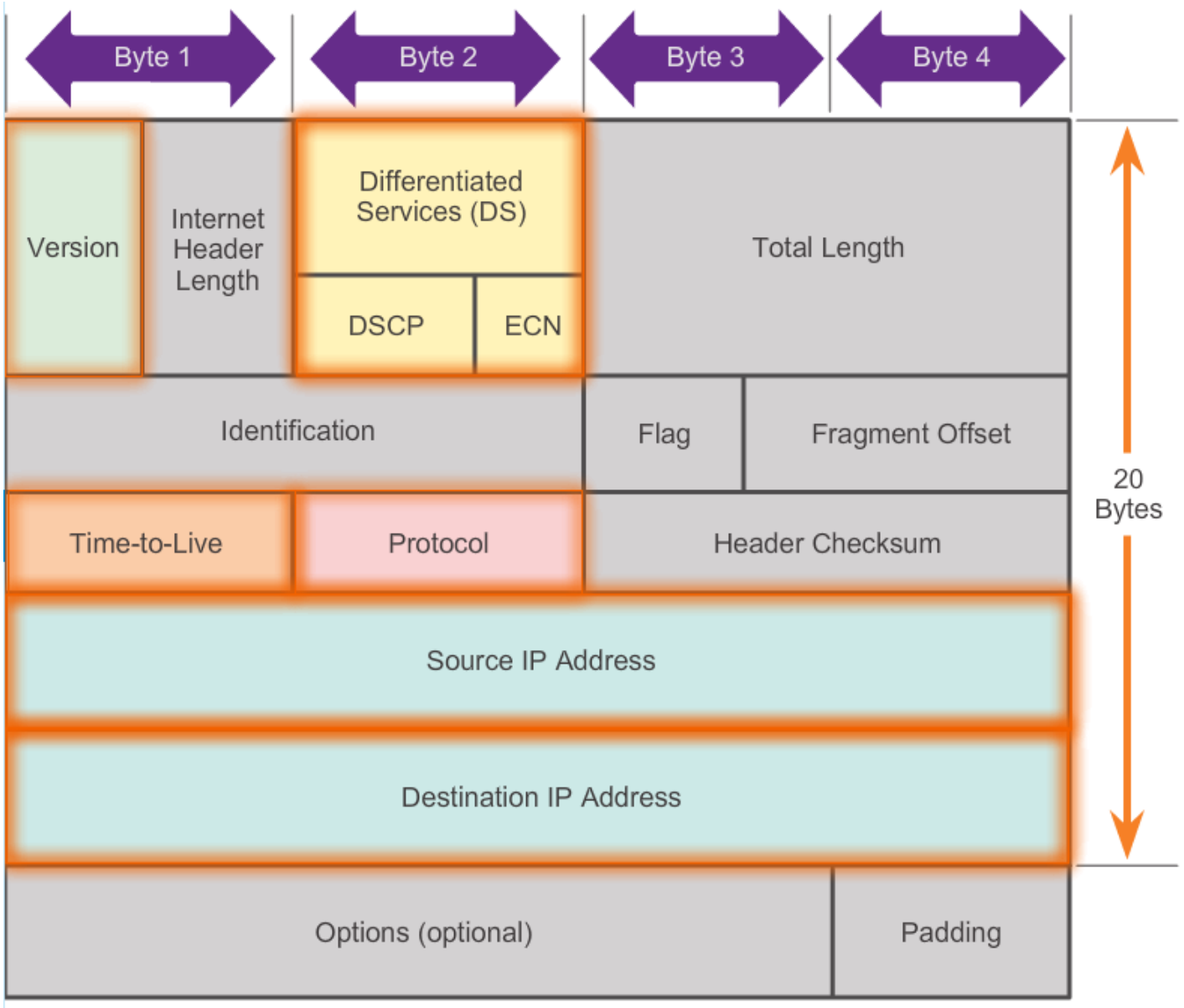
IP packets can travel over different media.

Encapsulating IP

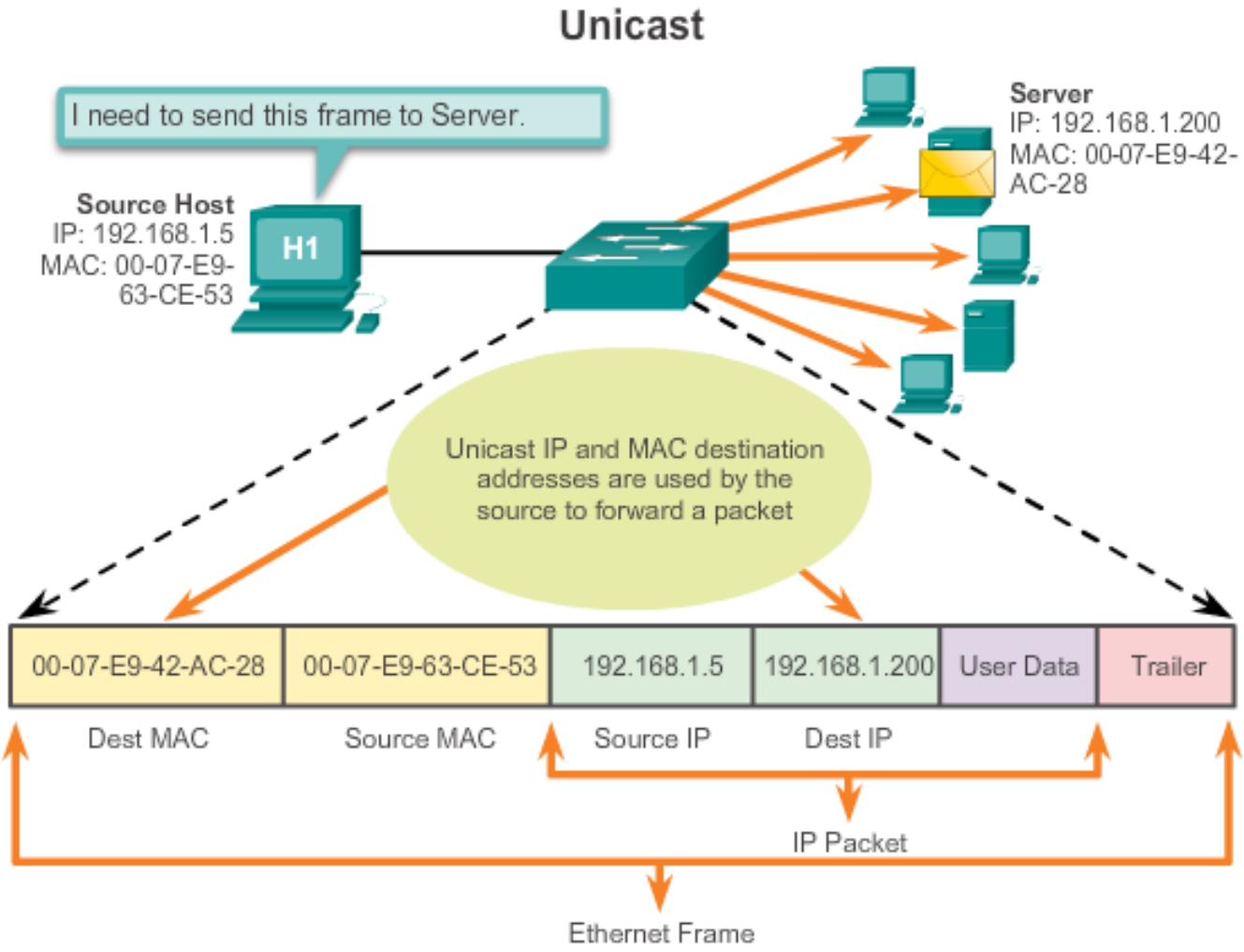


The network layer adds a header so packets can be routed through complex networks and reach their destination. In TCP/IP based networks, the network layer PDU is the IP packet.

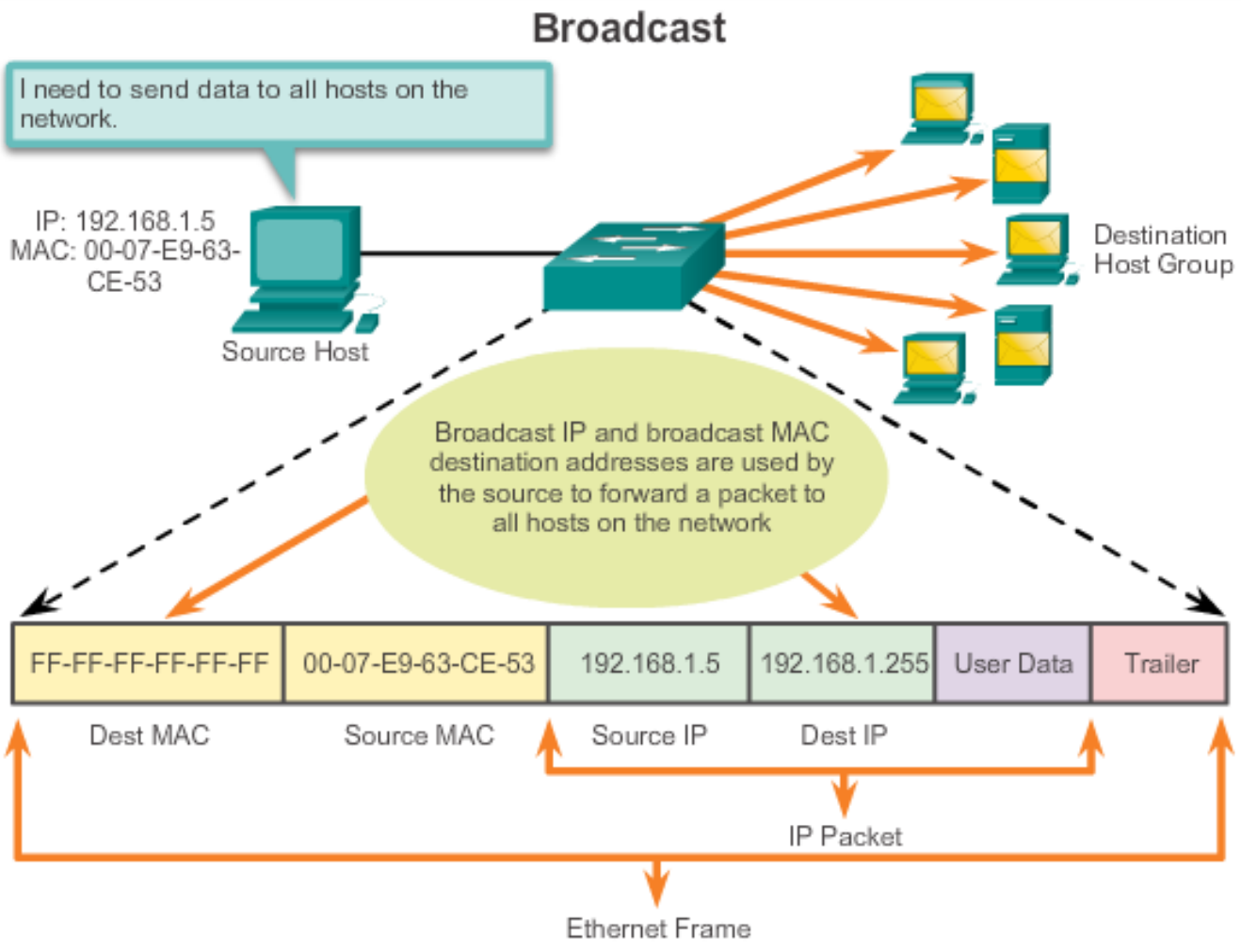
IPv4 Packet Header



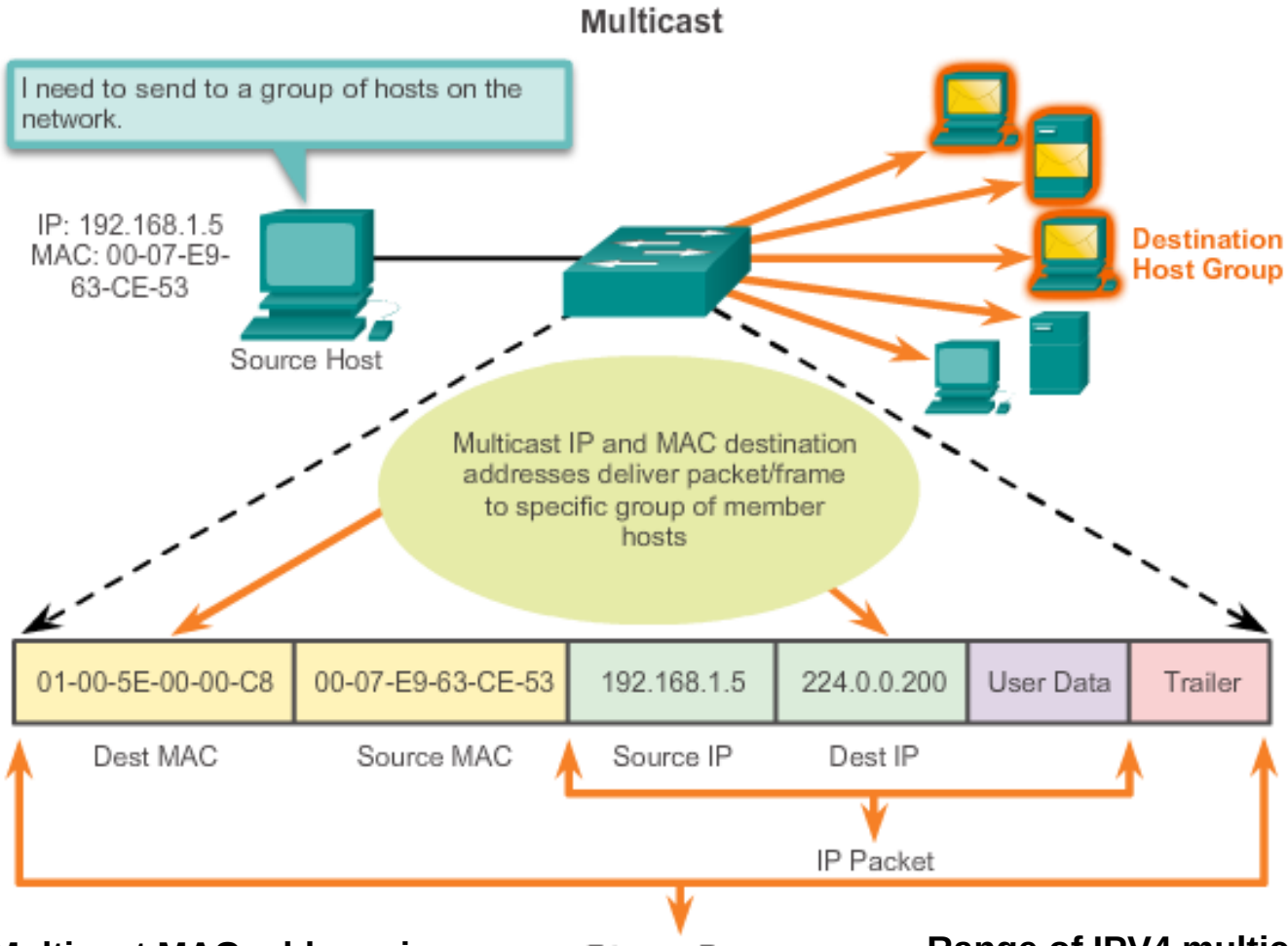
Unicast Address



Broadcast Address



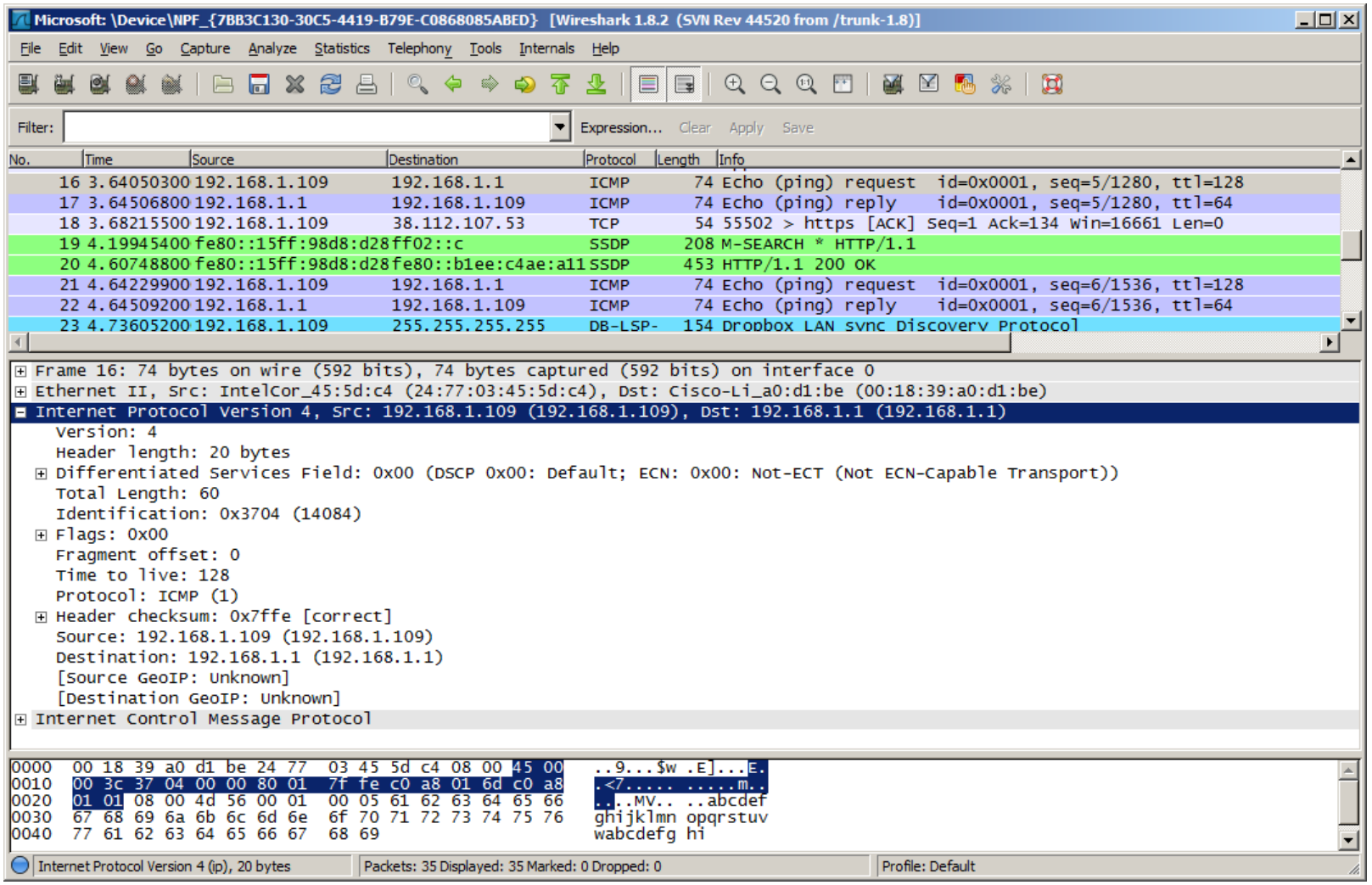
Multicast Address



Multicast MAC address is a special value that begins with 01-00-5E in hexadecimal

Range of IPV4 multicast addresses is 224.0.0.0 to 239.255.255.255

Sample IPv4 Headers in Wireshark



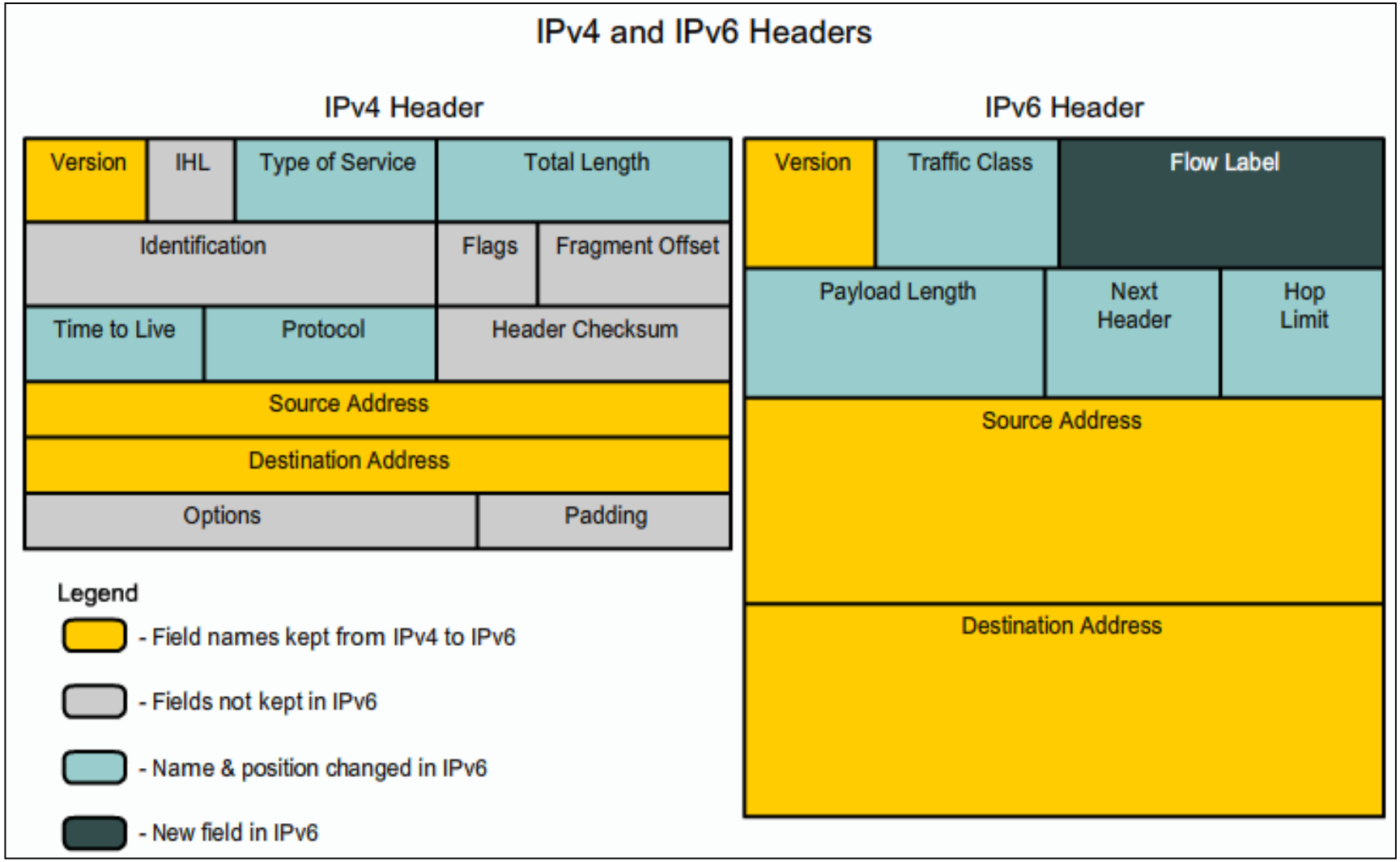
Limitations of IPv4

- IP Address depletion
- Internet routing table expansion
- Lack of end-to-end connectivity

IPv6

- Increased address space
- Improved packet handling
- Eliminates the need for NAT
- Integrated security
- 4 billion IPv4 addresses
  4,000,000,000
- 340 undecillion IPv6 addresses
  340,000,000,000,000,000,000,000,000,000,000,000,000

IPv4 and IPv6 Headers



IPv6 Packet Header