Introduction to Computer Networks

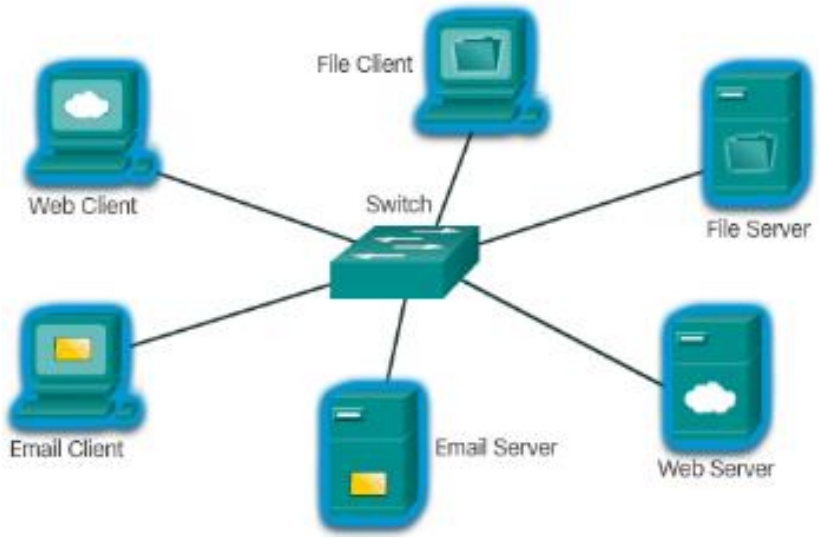
Slide Source: Cisco Networking

Networking Today

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

Providing Resources in a Network

- Networks of Many Sizes
  - Small Home / Office Networks
  - Medium to Large Networks
  - World Wide Network
- Clients and Servers
  - Clients request and display information
  - Servers provide information to other devices on the network
- Peer-to-Peer
  - Computers can be both server and client at the same time.
  - What are the advantages?
  - What are the disadvantages?



Network Components

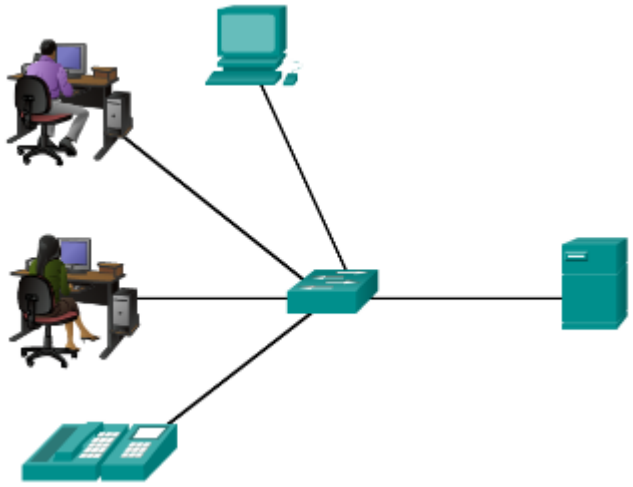
- End Devices
  - Either the source or destination of a message
  - Name some end devices
- Intermediary Network Devices
  - Connect multiple individual networks to form an internetwork
  - Connect the individual end devices to the network
  - Ensure data flows across the network
  - Provide connectivity
- Network Media
  - Provide the pathway for data transmission
  - Interconnect devices
  - Name the three types of media

Network Components

- Network Representations
  - What do the symbols represent?
- Topology Diagrams
  - Physical
  - Logical

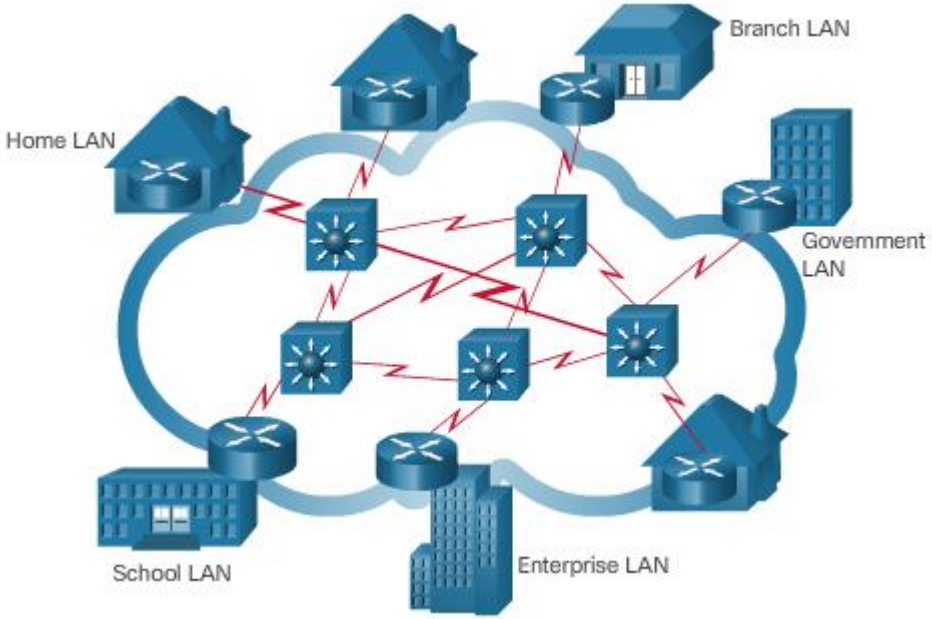
LANs and WANs

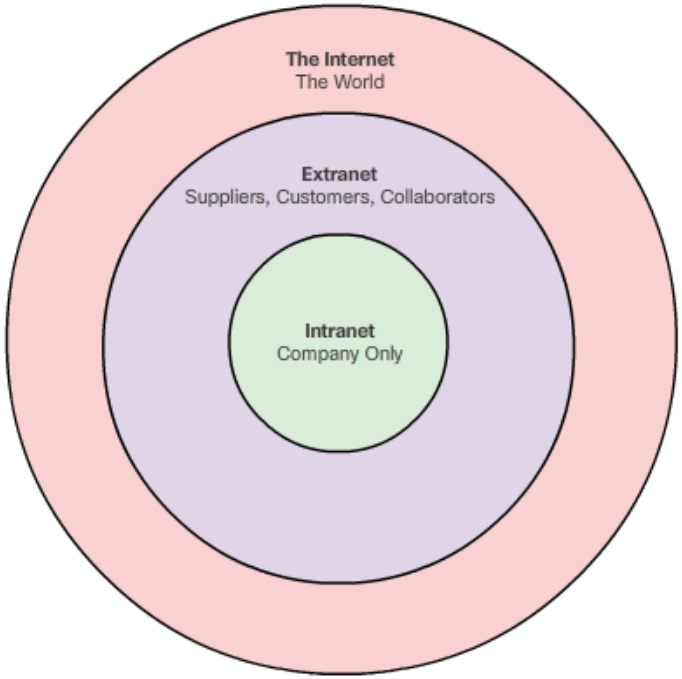
- Local Area Networks
  - Spans across small geographical area
  - Interconnects end devices
  - Administrated by a single organization
  - Provide high speed bandwidth to internal devices
- WAN Area Networks
  - Interconnects LAN
  - Administrated by multiple service providers
  - Provide slower speed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



The Internet, Intranets, and Extranets

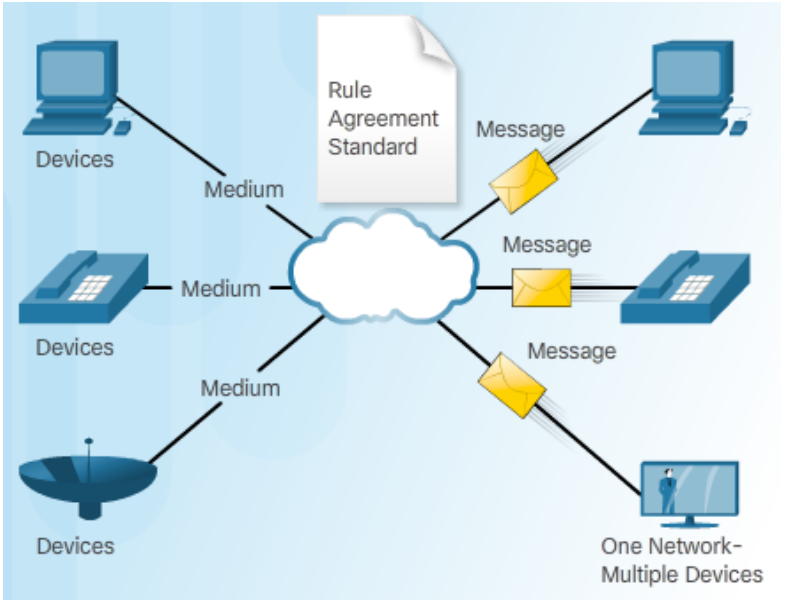
- The Internet
  - Worldwide collection of interconnected networks
  - Not owned by any individual or group
- Intranets and Extranets



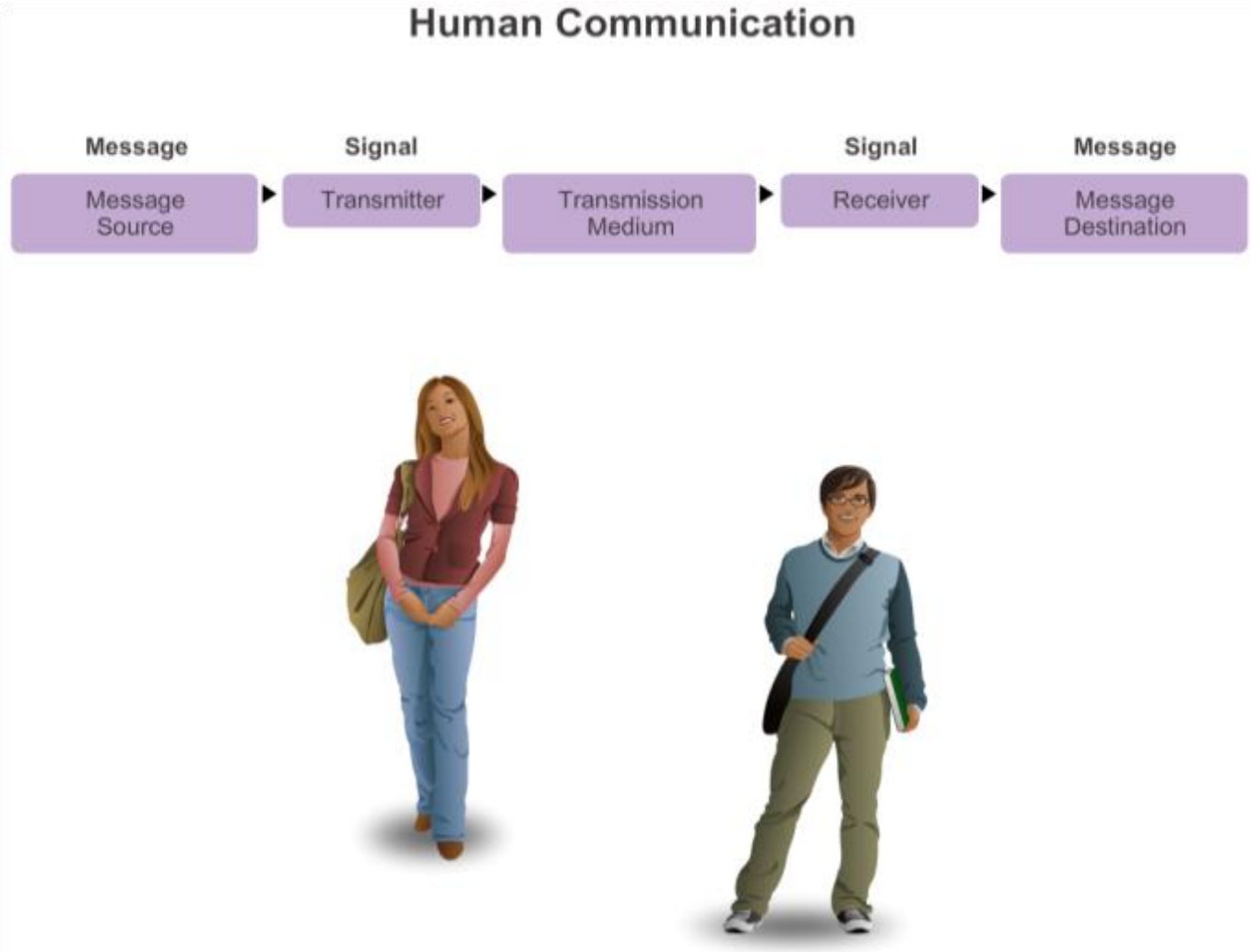


Converged Networks

- Traditional Separate Networks
  - Each network with its own rules and
- The Converging Network
  - Capable of delivering data, voice, and video over the same network infrastructure



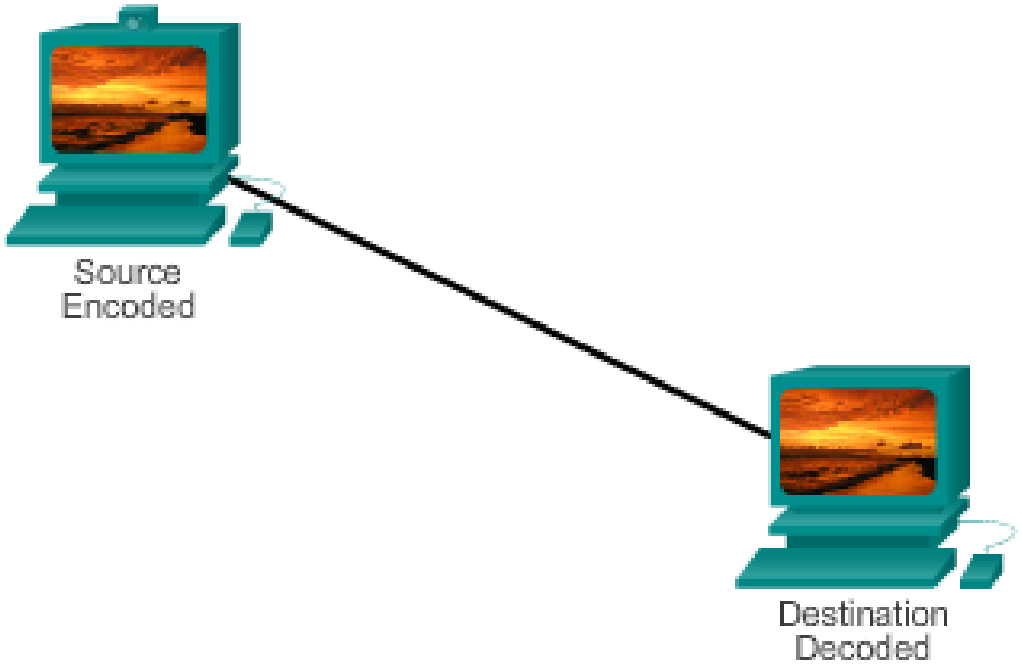
What is Communication?



Establishing the Rules

- An identified sender and receiver
- Agreed upon method of communicating (face-to-face, telephone, letter, photograph)
- Common language and grammar
- Speed and timing of delivery
- Confirmation or acknowledgment requirements

Message Encoding



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

Message Size

An overview of the segmenting process:

- The size restrictions of frames require the source host to break a long message into individual pieces (or segments) that meet both the minimum and maximum size requirements.
- Each segment is encapsulated in a separate frame with the address information, and is sent over the network.
- At the receiving host, the messages are de-encapsulated and put back together to be processed and interpreted.

Message Timing

- Access Method
- Flow Control
- Response Timeout

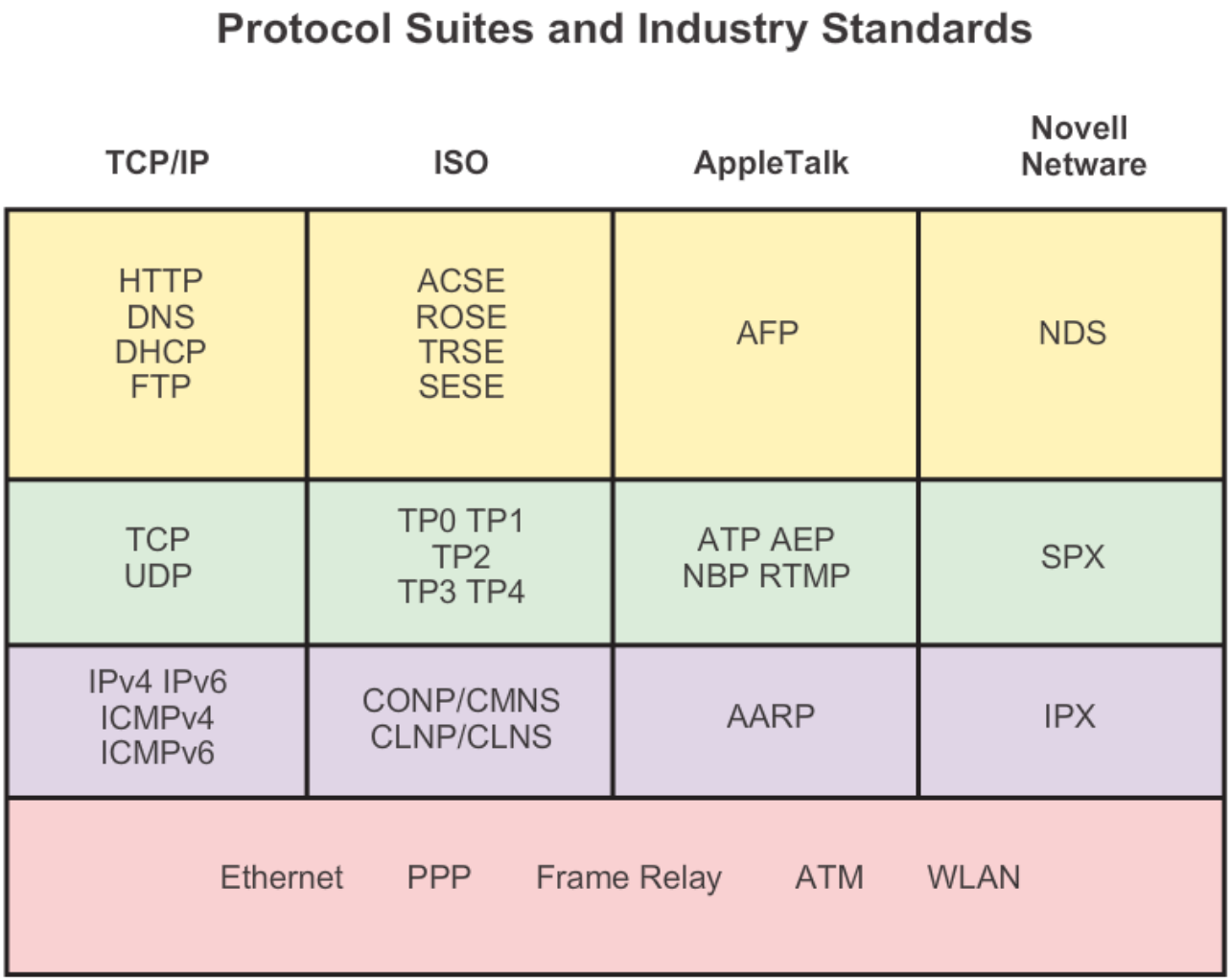
Network Protocols

- 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

Interaction of Protocols

- Application Protocol – Hypertext Transfer Protocol (HTTP)
- Transport Protocol – Transmission Control Protocol (TCP)
- Internet Protocol – Internet Protocol (IP)
- Network Access Protocols – Data link & physical layers

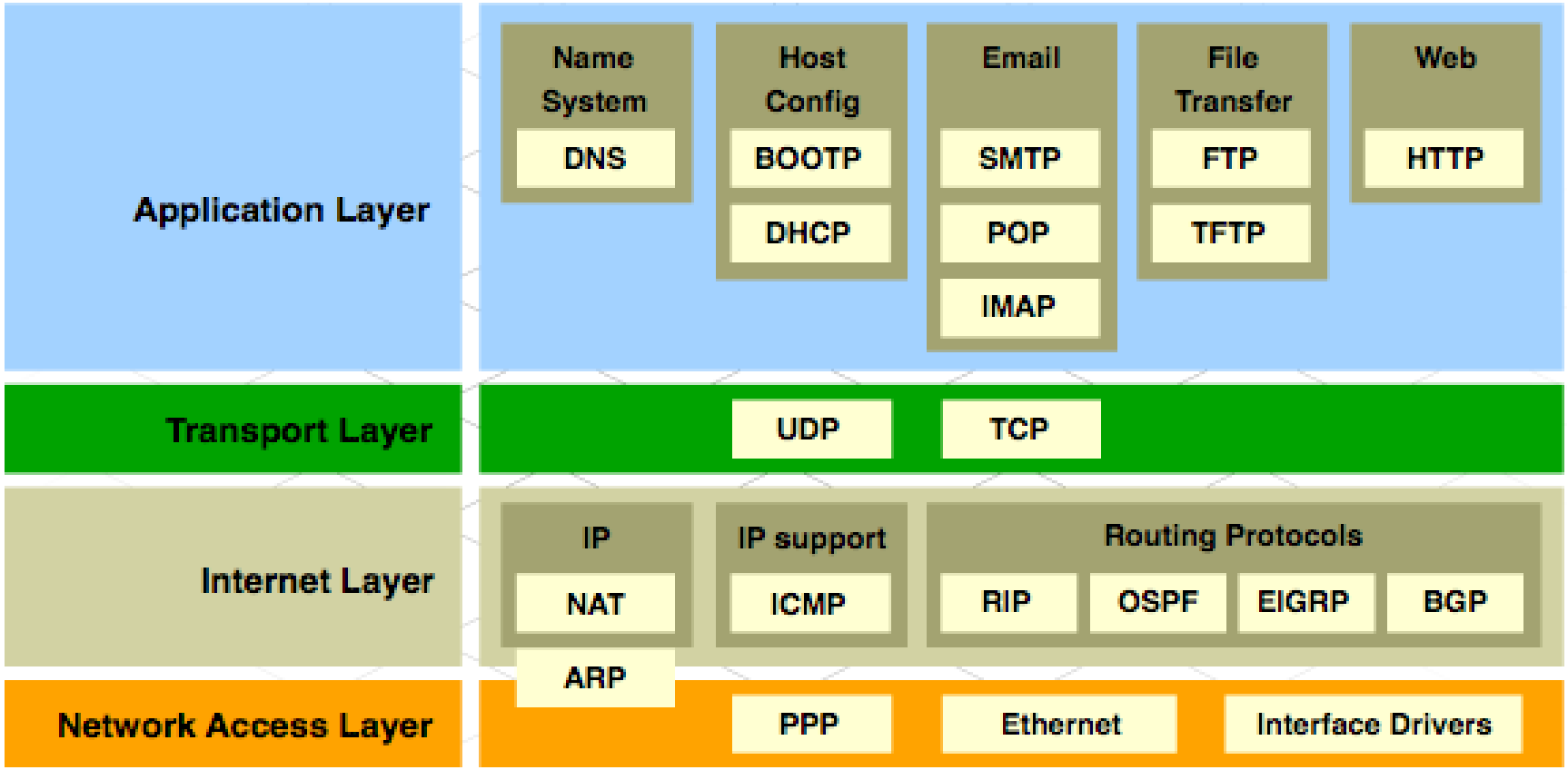
Protocol Suites and Industry Standards



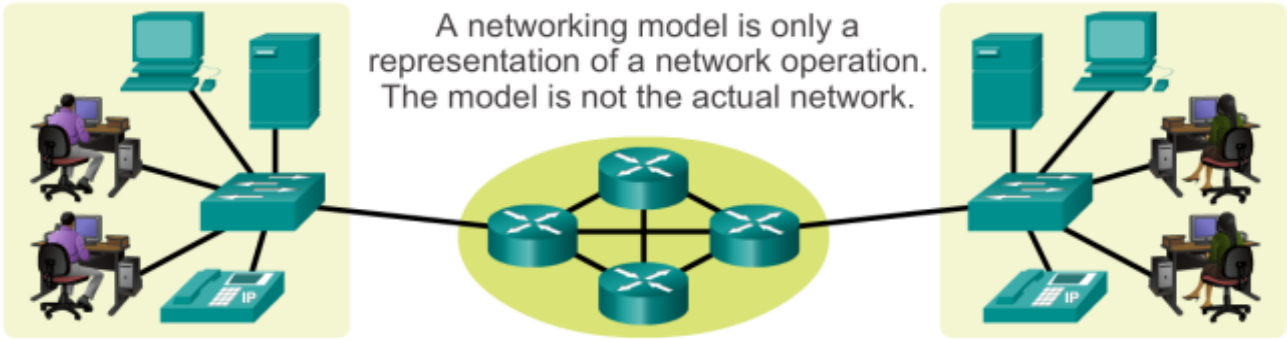
Creation of Internet, Development of TCP/IP

- 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.

TCP/IP Protocol Suite and Communication



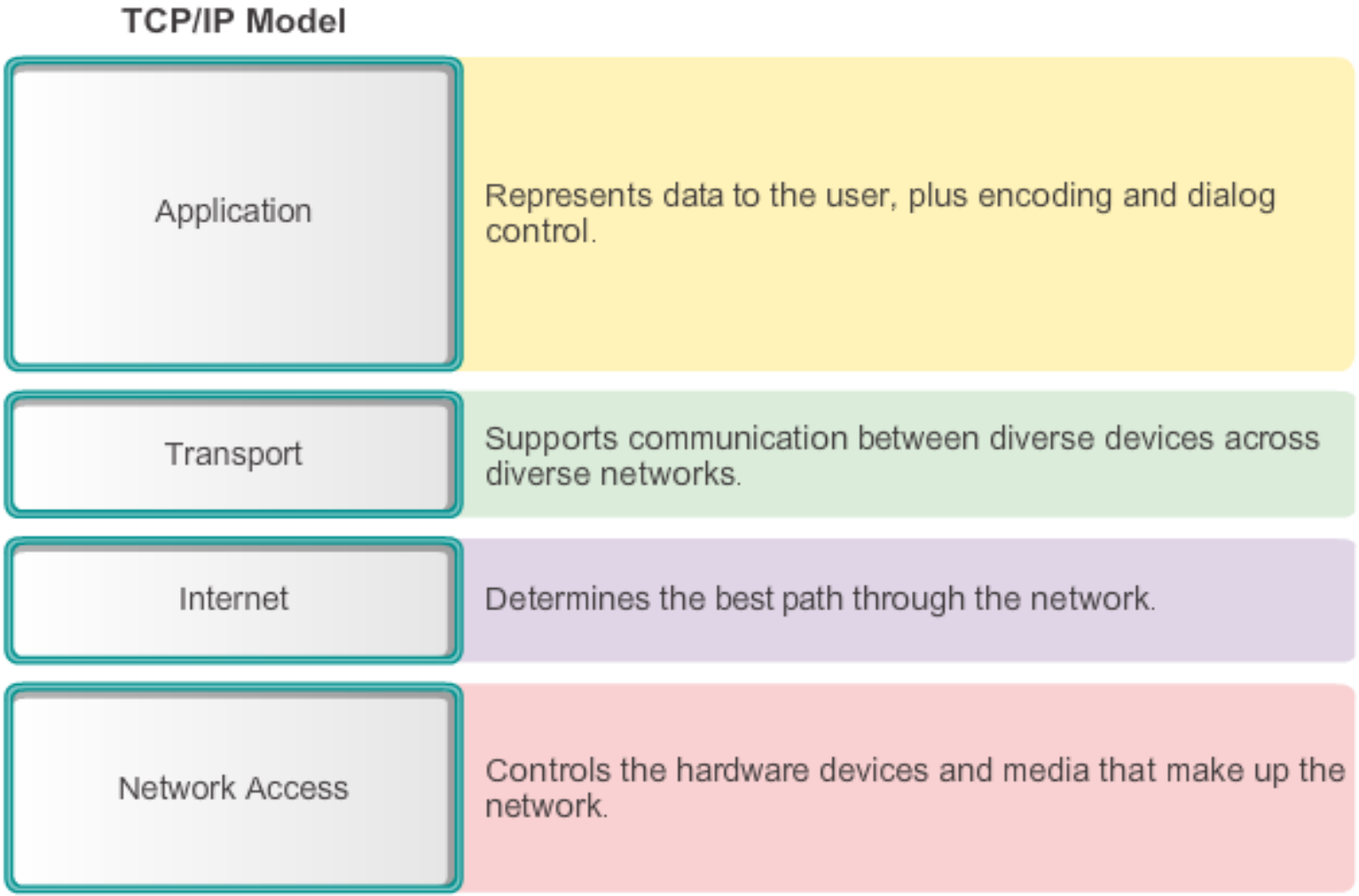
Benefits of Using a Layered Model



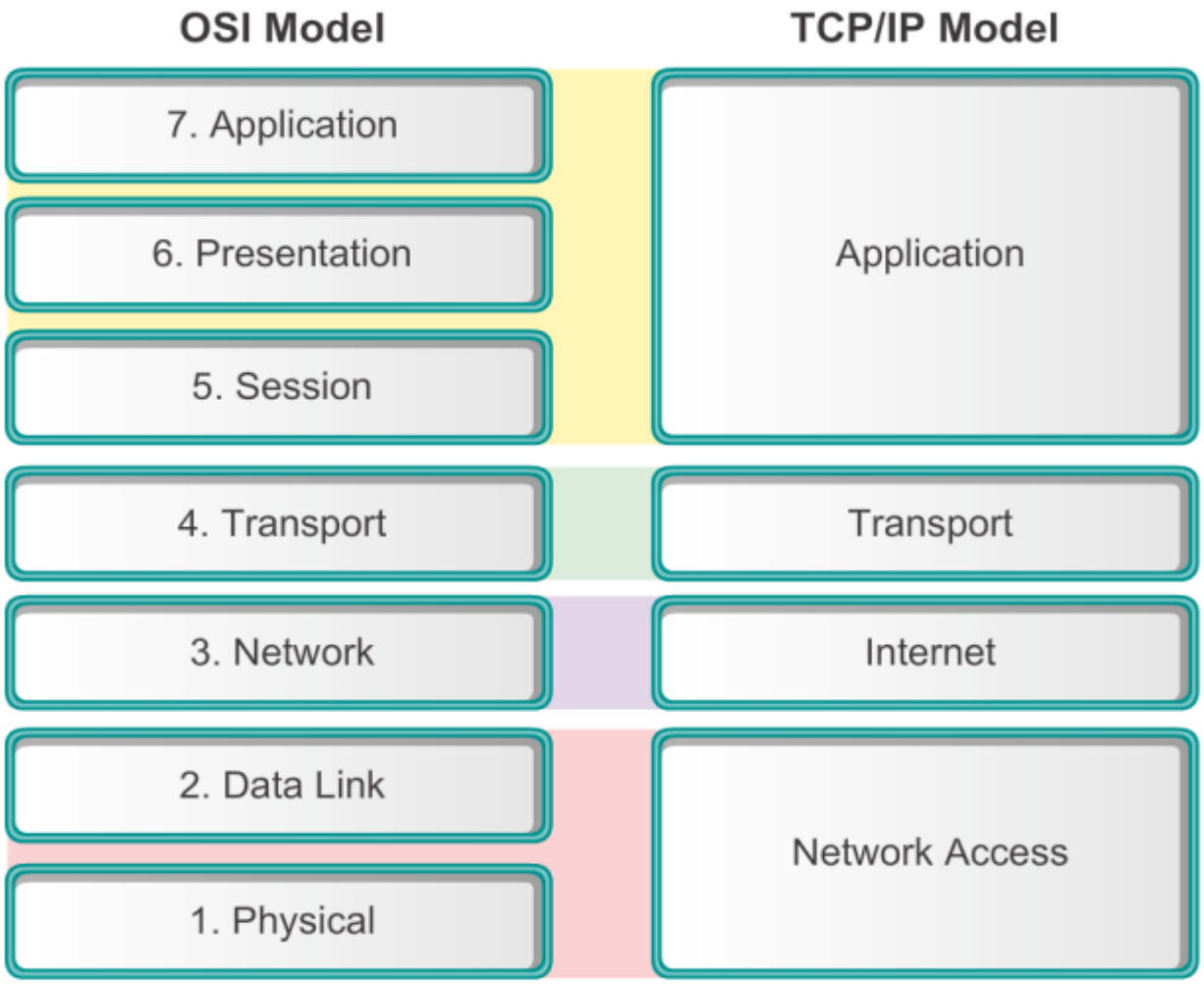
OSI Model	TCP/IP Protocol Suite	TCP/IP Model
Application	HTTP, DNS, DHCP, FTP	Application
Presentation		
Session		
Transport	TCP, UDP	Transport
Network	IPv4, IPv6, ICMPv4, ICMPv6	Internet
Data Link	PPP, Frame Relay, Ethernet	Network Access
Physical		

The OSI Reference Model

The TCP/IP Reference Model

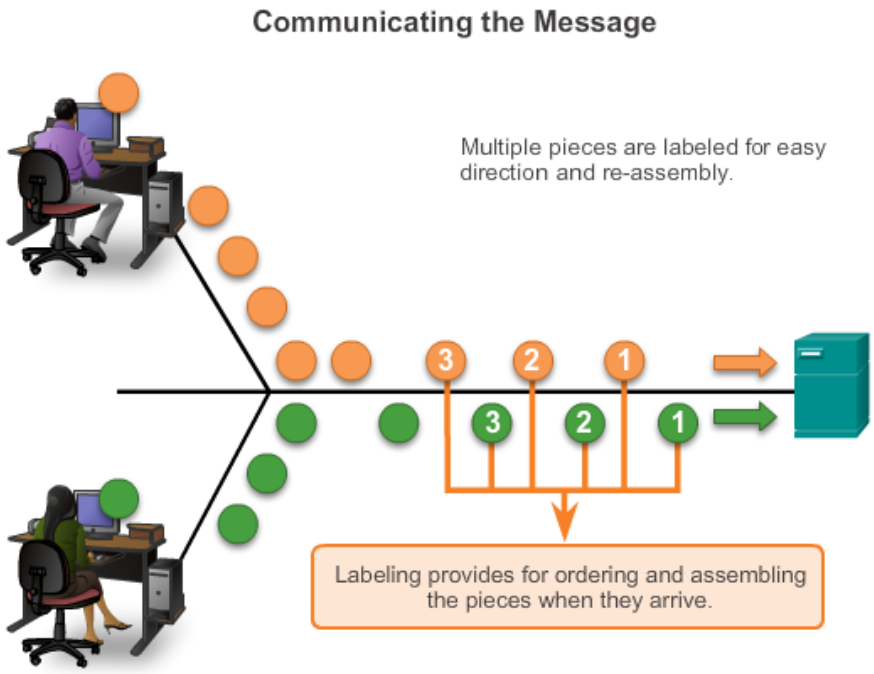


Comparing the OSI and TCP/IP Models



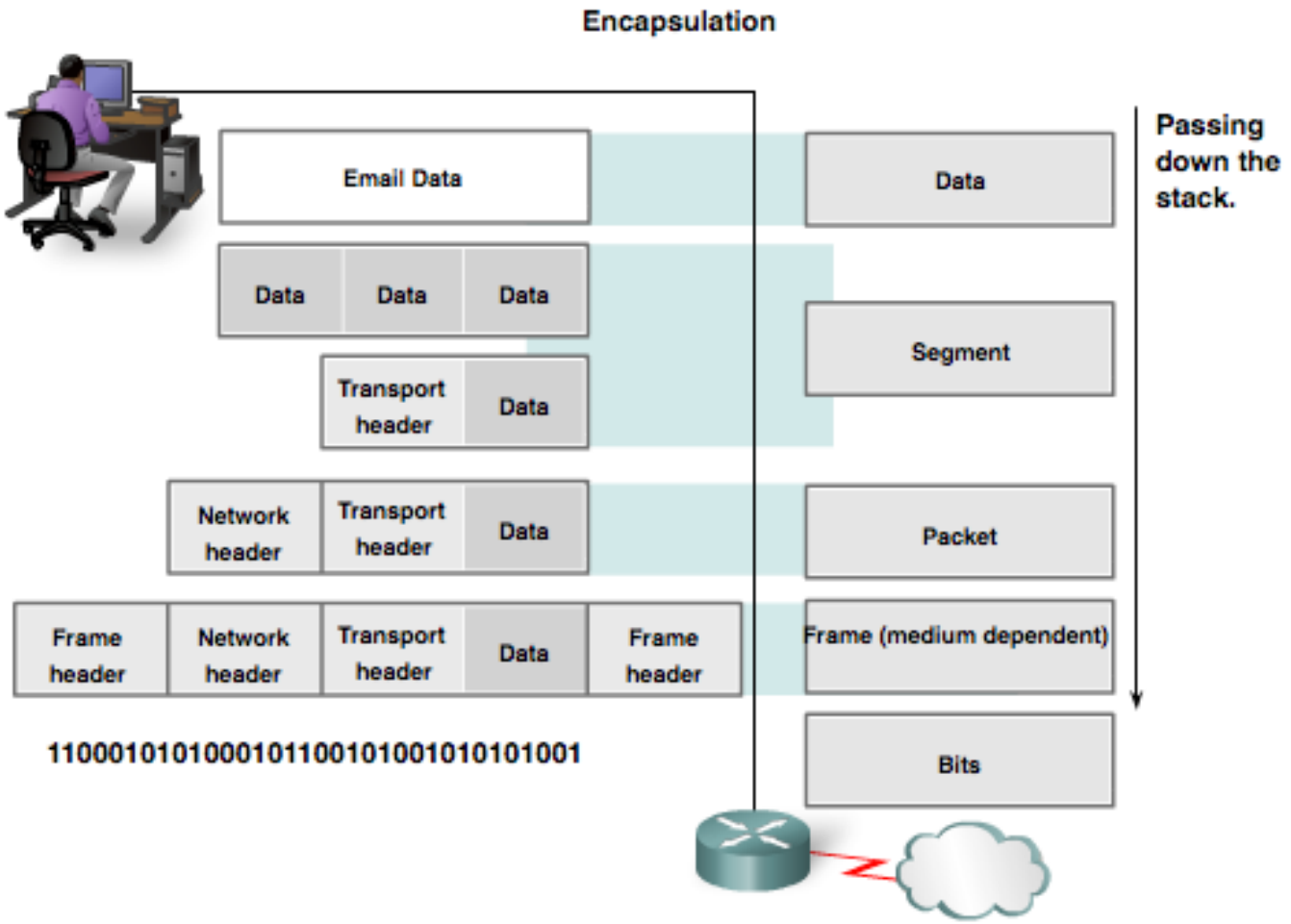
Communicating the Messages

- Segmenting message benefits
  - Different conversations can be interleaved
  - Increased reliability of network communications
- Segmenting message disadvantage
  - Increased level of complexity

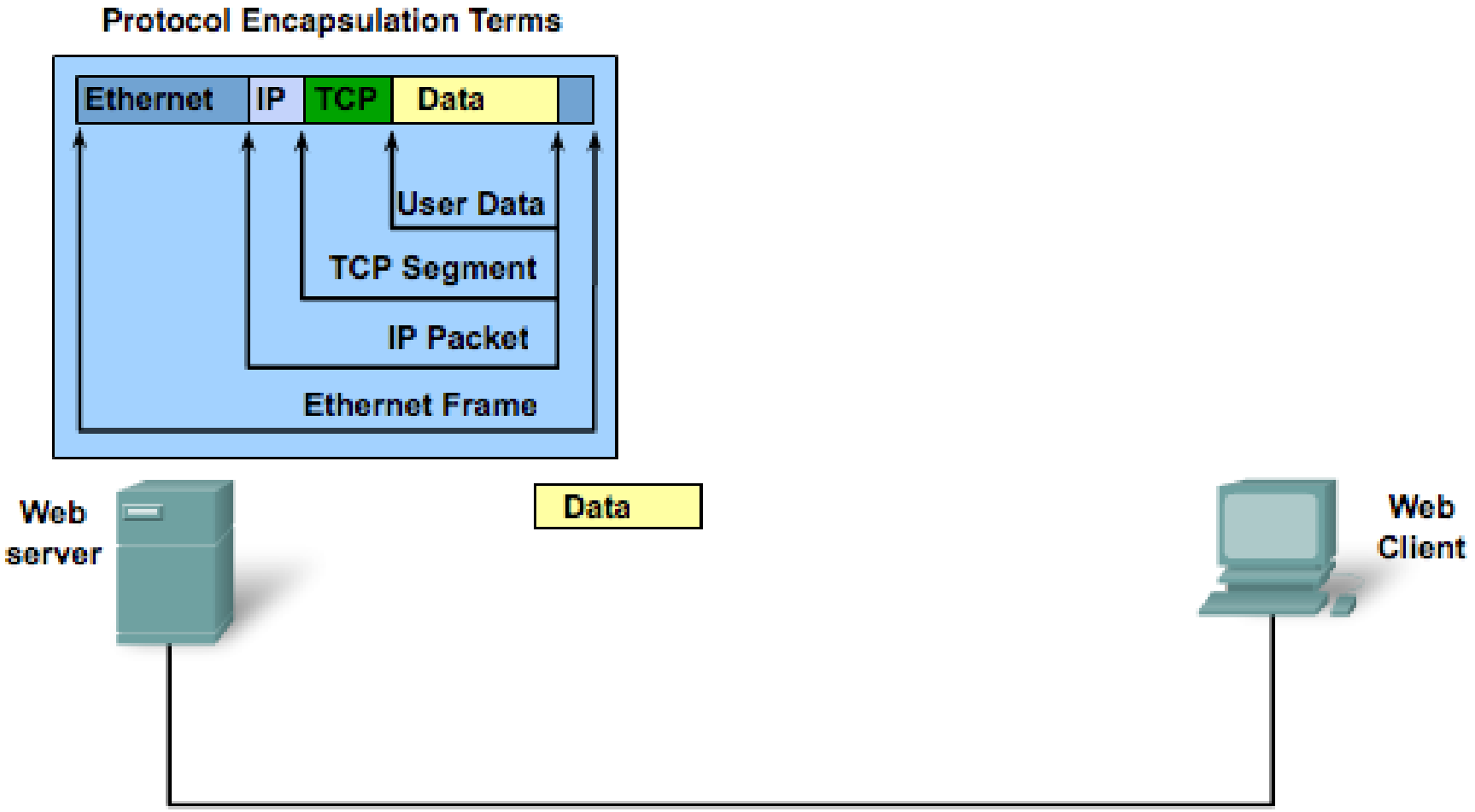


Protocol Data Units (PDUs)

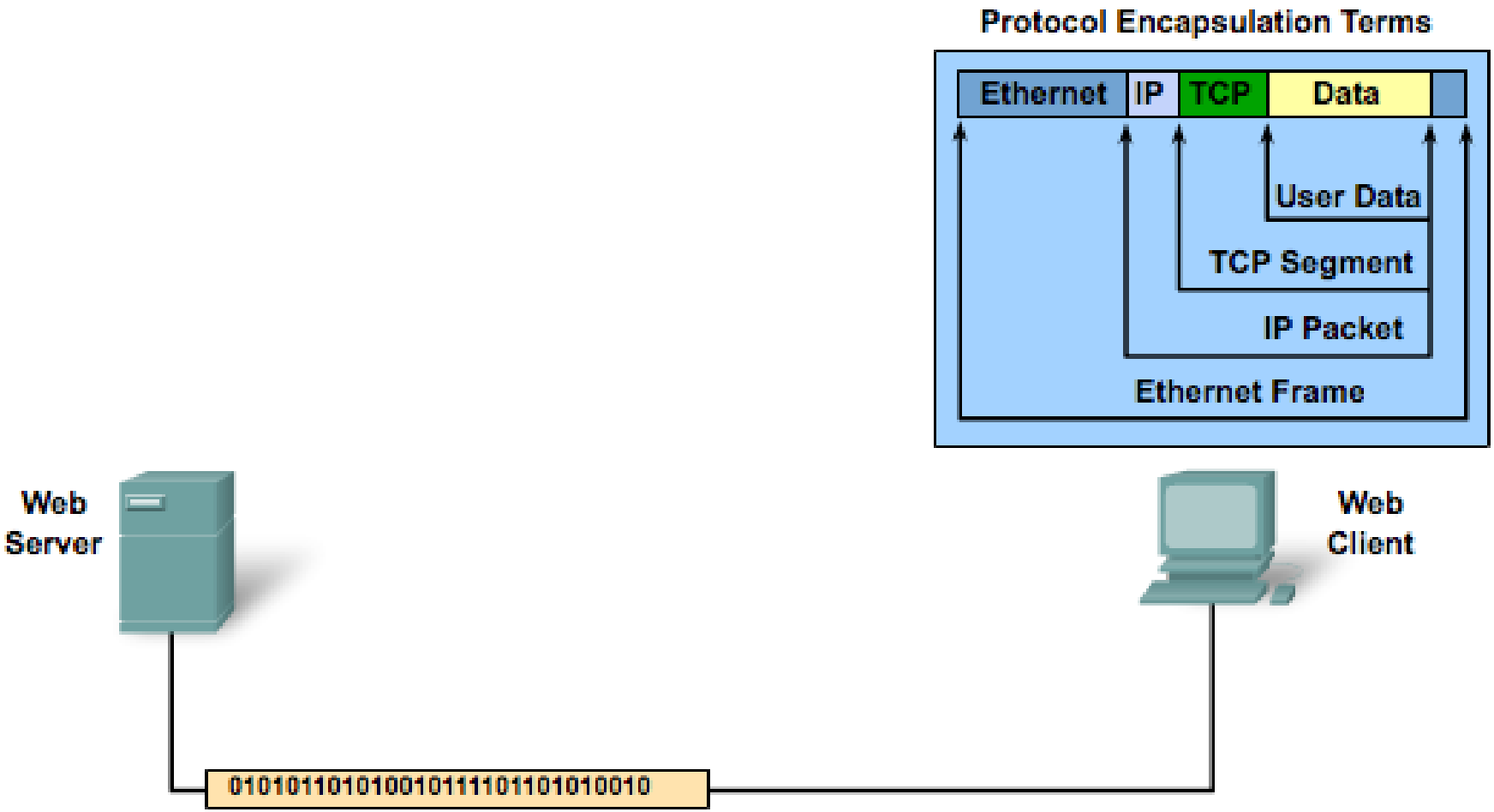
- Data
- Segment
- Packet
- Frame
- Bits



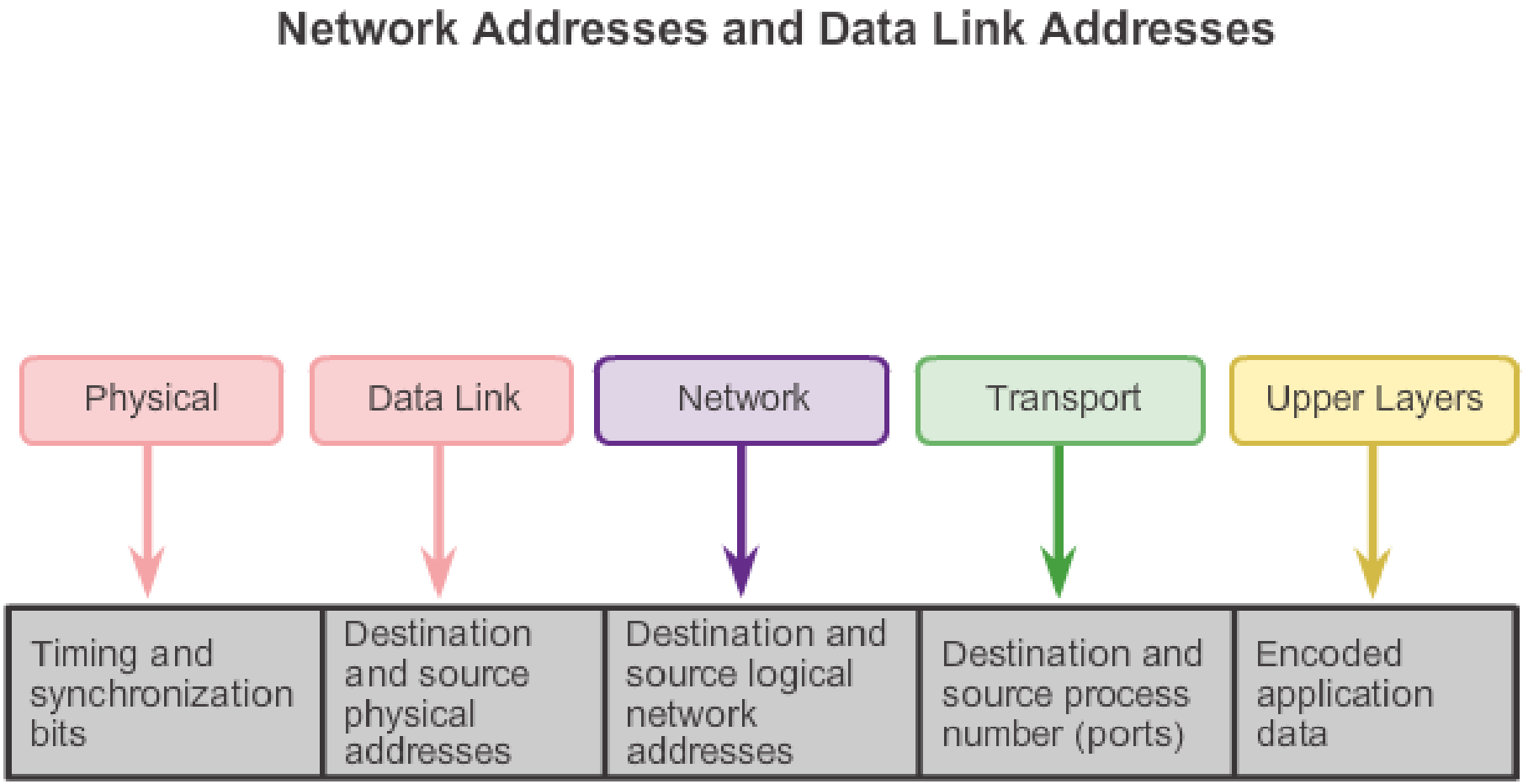
Protocol Encapsulation



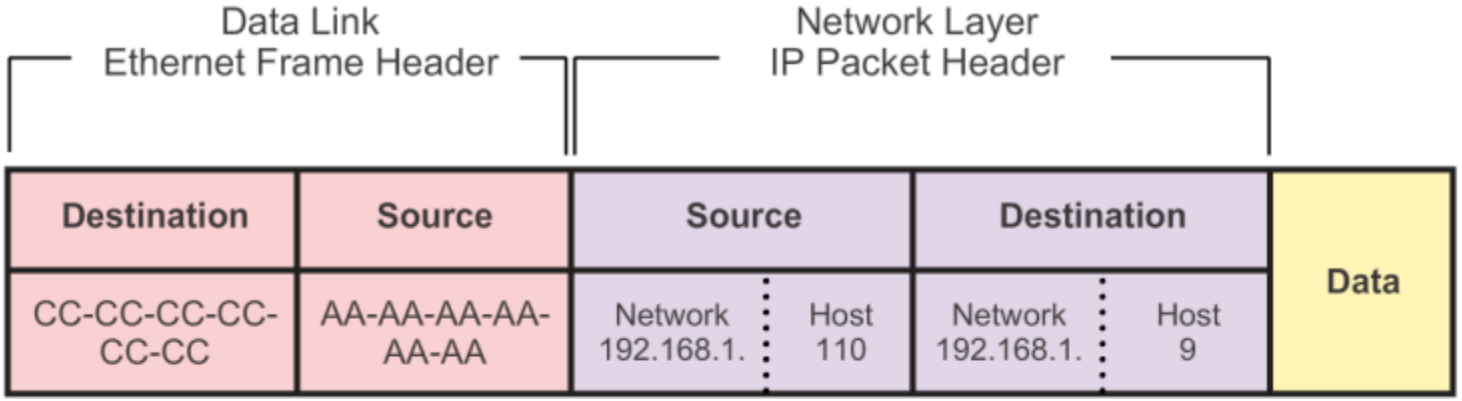
Protocol De-encapsulation



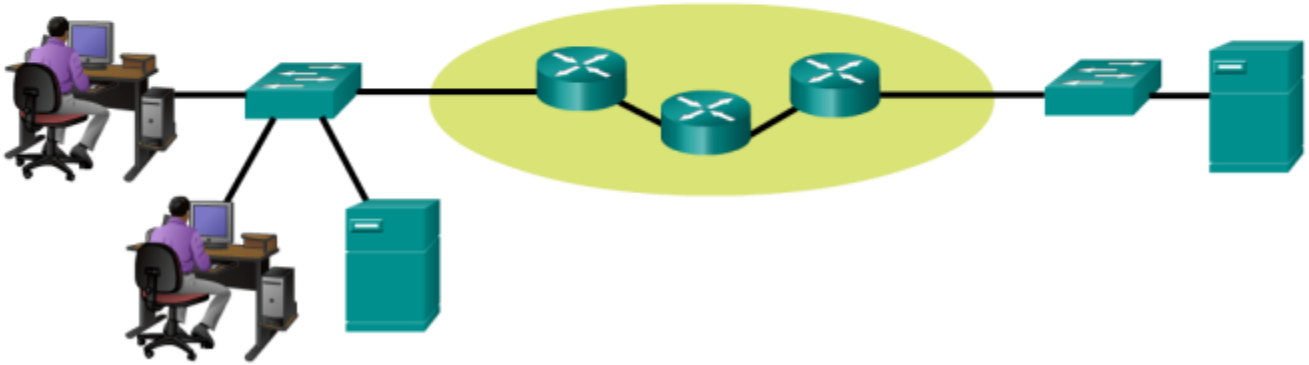
Accessing Local Resources



Communicating with Device / Same Network

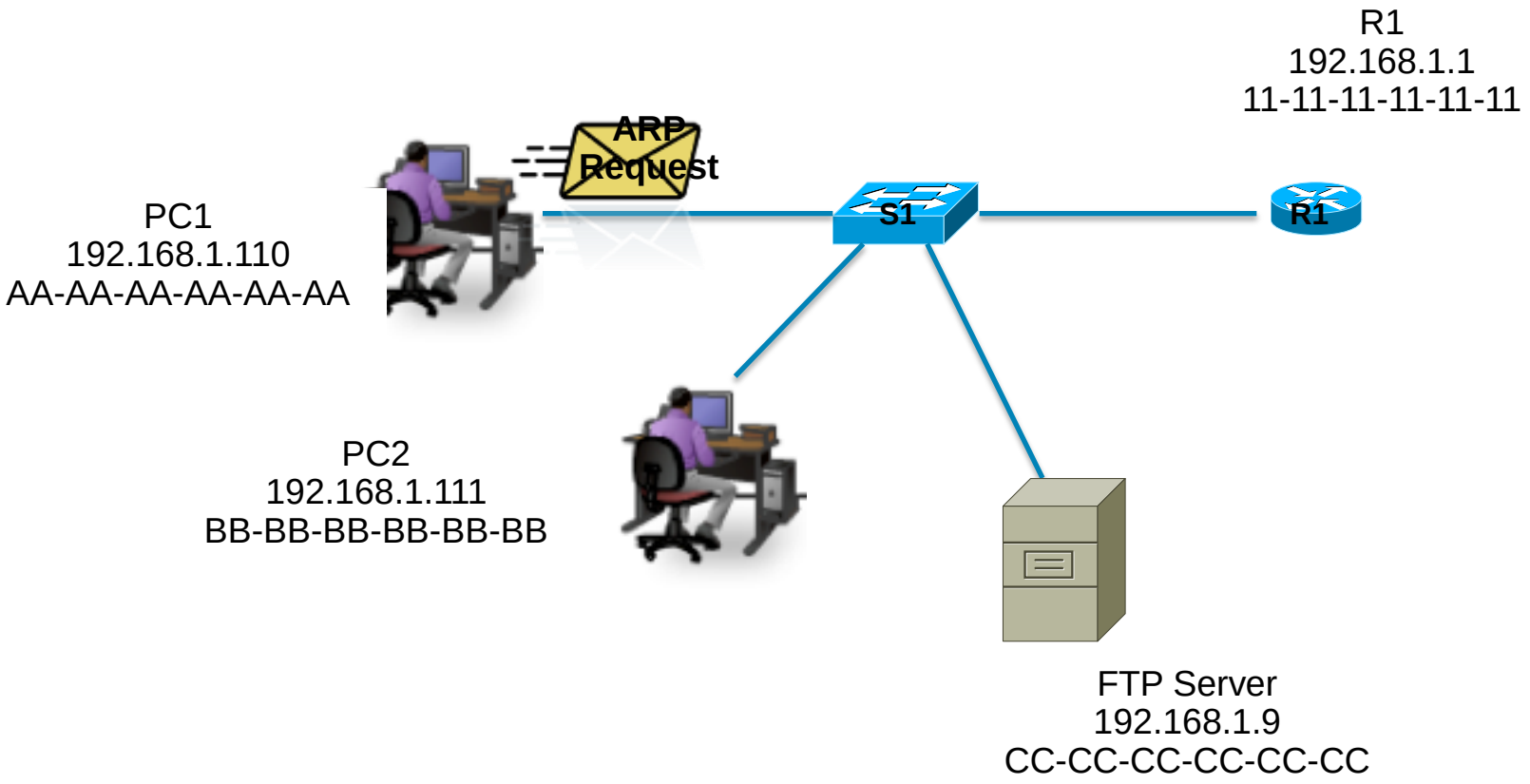


PC1
192.168.1.110
AA-AA-AA-AA-AA-AA

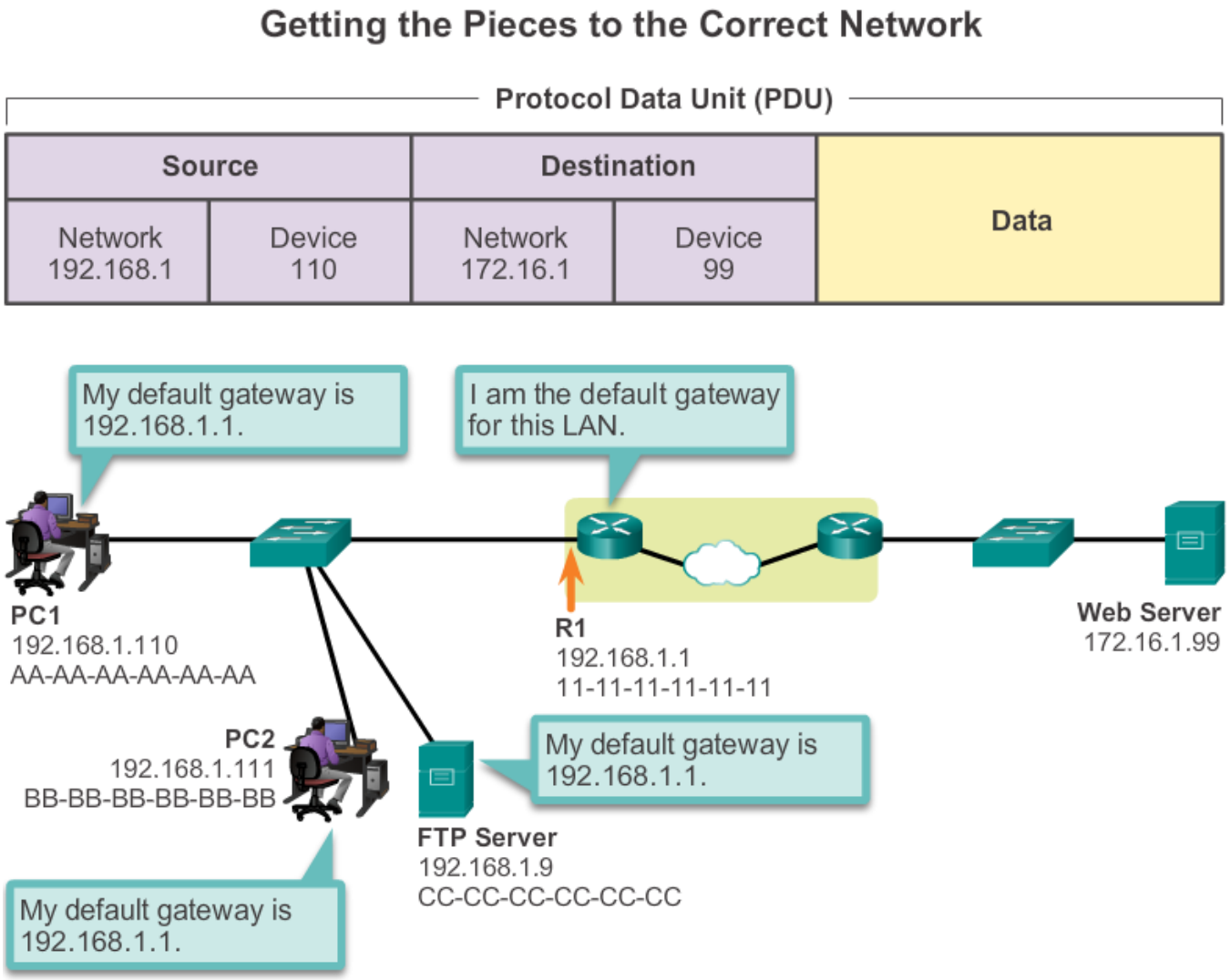


FTP Server
192.168.1.9
CC-CC-CC-CC-CC-CC

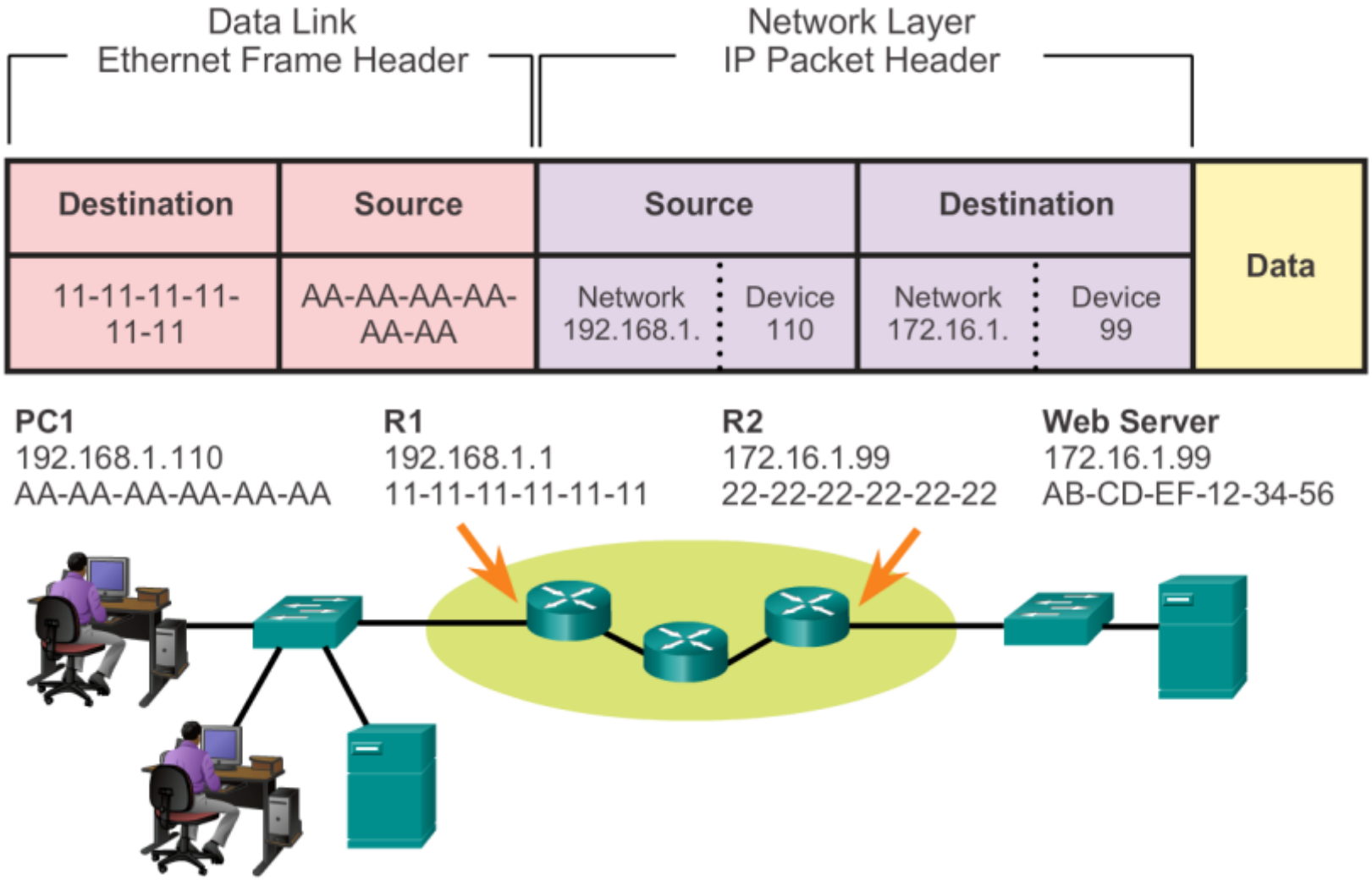
MAC and IP Addresses



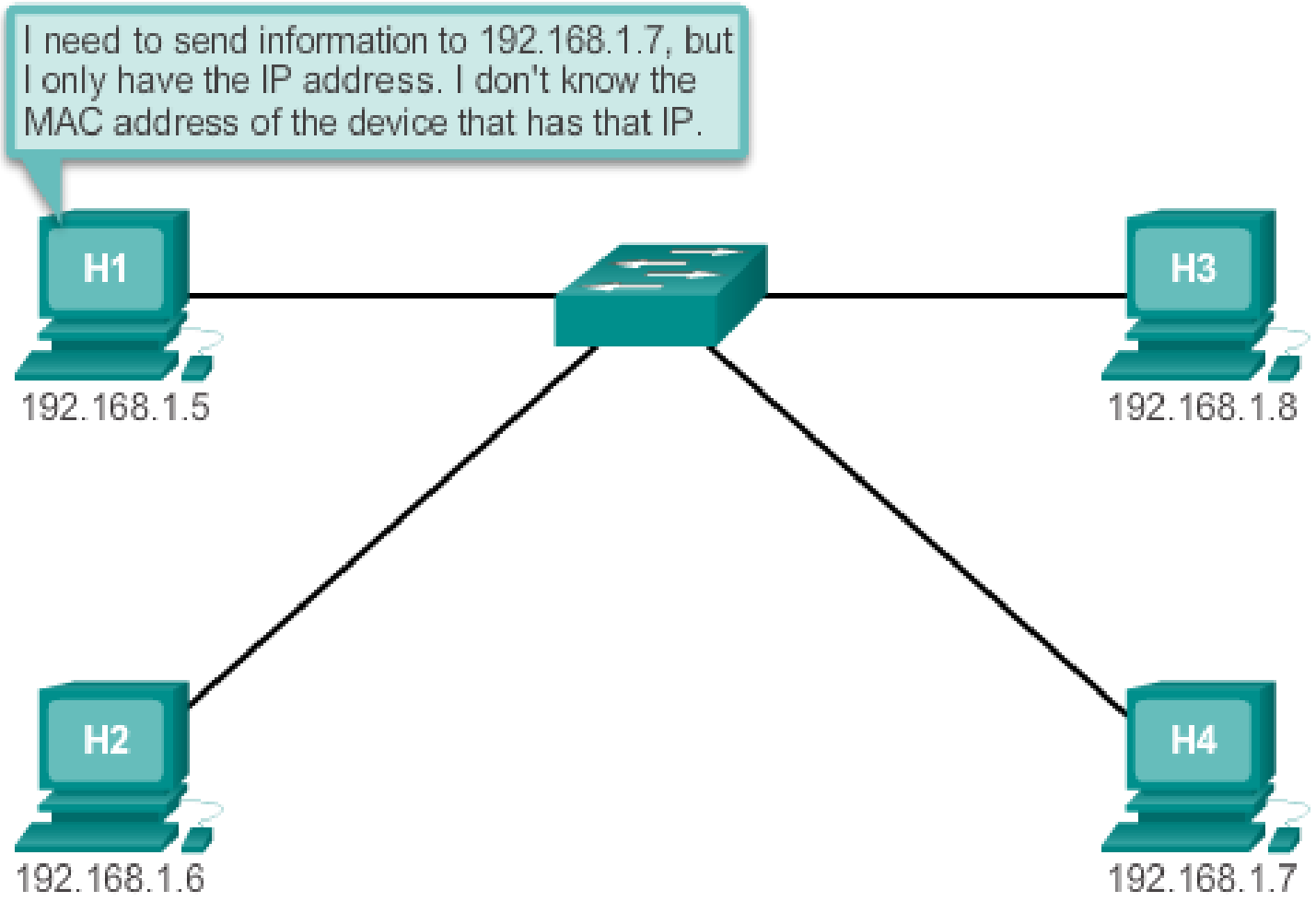
Default Gateway



Communicating Device / Remote Network



Introduction to ARP



ARP Functions/Operation

ARP Table

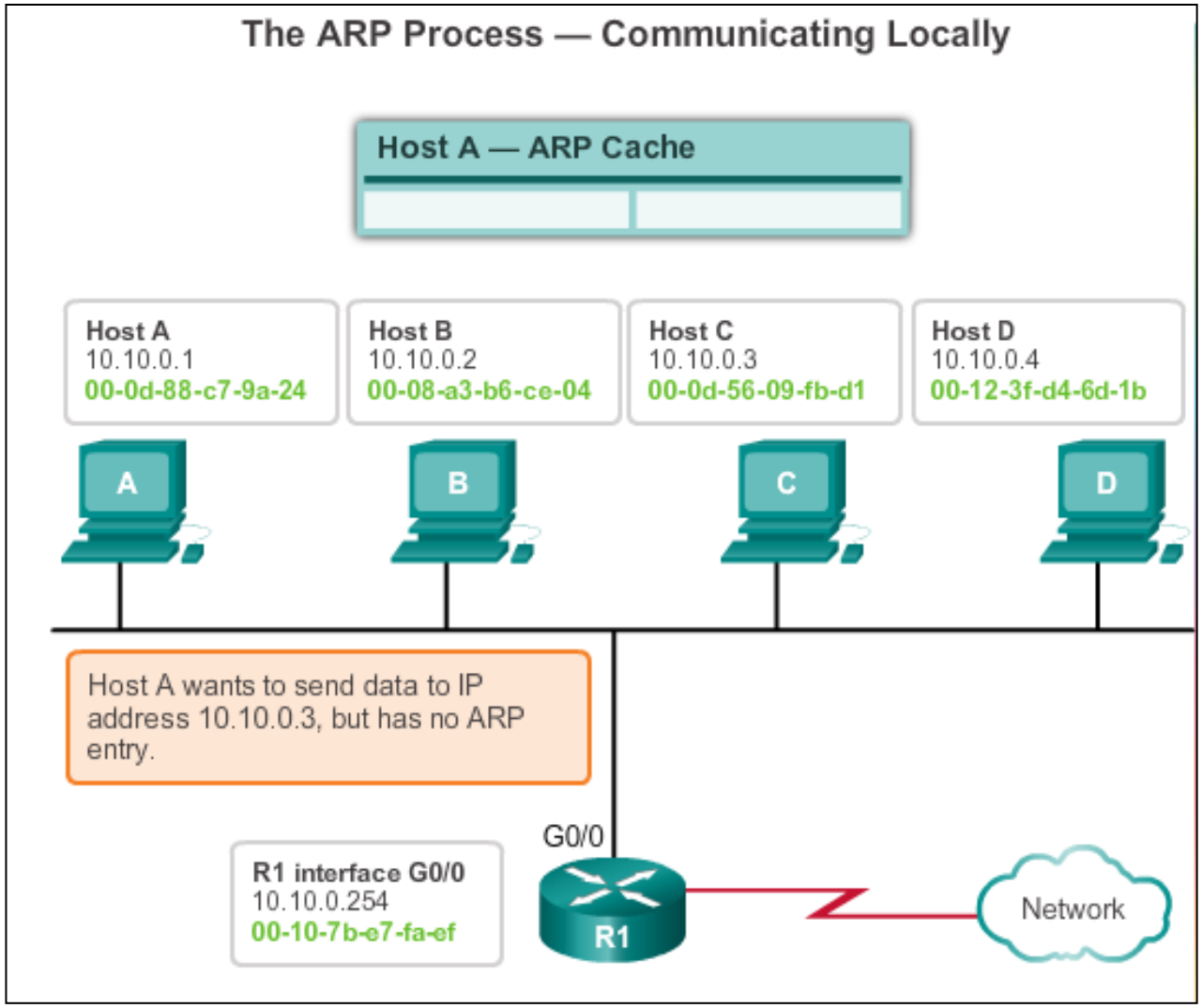
- Used to find the data link layer address that is mapped to the destination IPv4 address.
- As a node receives frames from the media, it records the source IP and MAC address as a mapping in the ARP table.

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.

Note: Static map entries can be entered in an ARP table, but this is rarely done.

ARP Operation

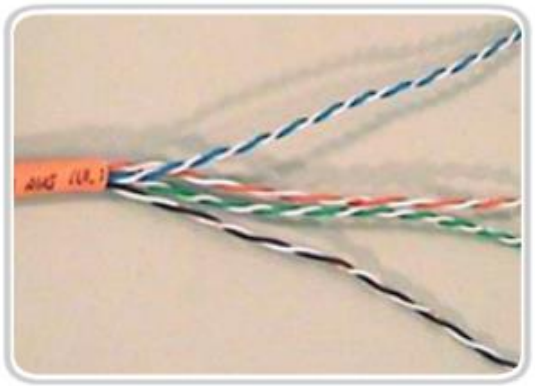


Physical Layer Fundamental Principles

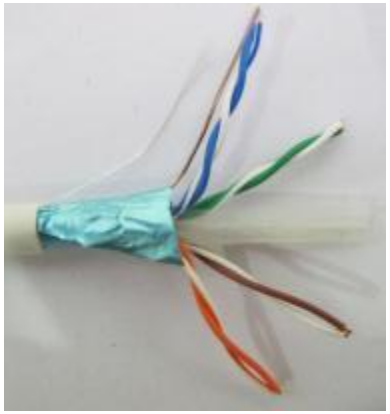
Media	Physical Components	Frame Encoding Technique	Signalling Method
Copper Cable	• UTP • Coaxial • Connectors • NICs • Ports • Interfaces	• Manchester Encoding • Non-Return to Zero (NRZ) techniques • 4B/5B codes are used with Multi-Level Transition Level 3 (MLT-3) signaling • 8B/10B • PAM5	• Changes in the electromagnetic field • Intensity of the electromagnetic field • Phase of the electromagnetic wave
Fiber Optic Cable	• Single-mode Fiber • Multimode Fiber • Connectors • NICs • Interfaces • Lasers and LEDs • Photoreceptors	• Pulses of light • Wavelength multiplexing using different colors	• A pulse equals 1. • No pulse is 0.
Wireless Media	• Access Points • NICs • Radio • Antennae	• DSSS (direct-sequence spread-spectrum) • OFDM (orthogonal frequency division multiplexing)	• Radio waves

Copper Cabling

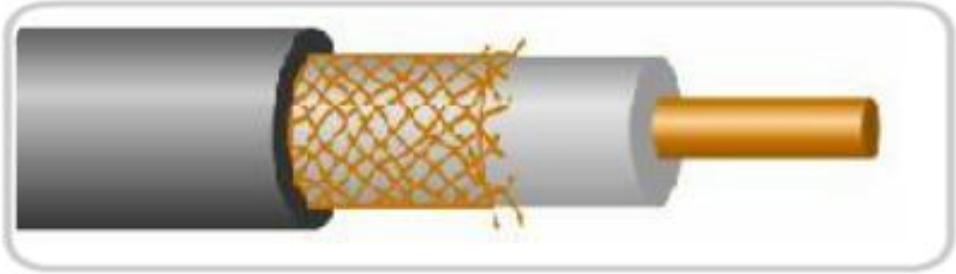
Copper Media



Unshielded Twisted Pair (UTP) Cable



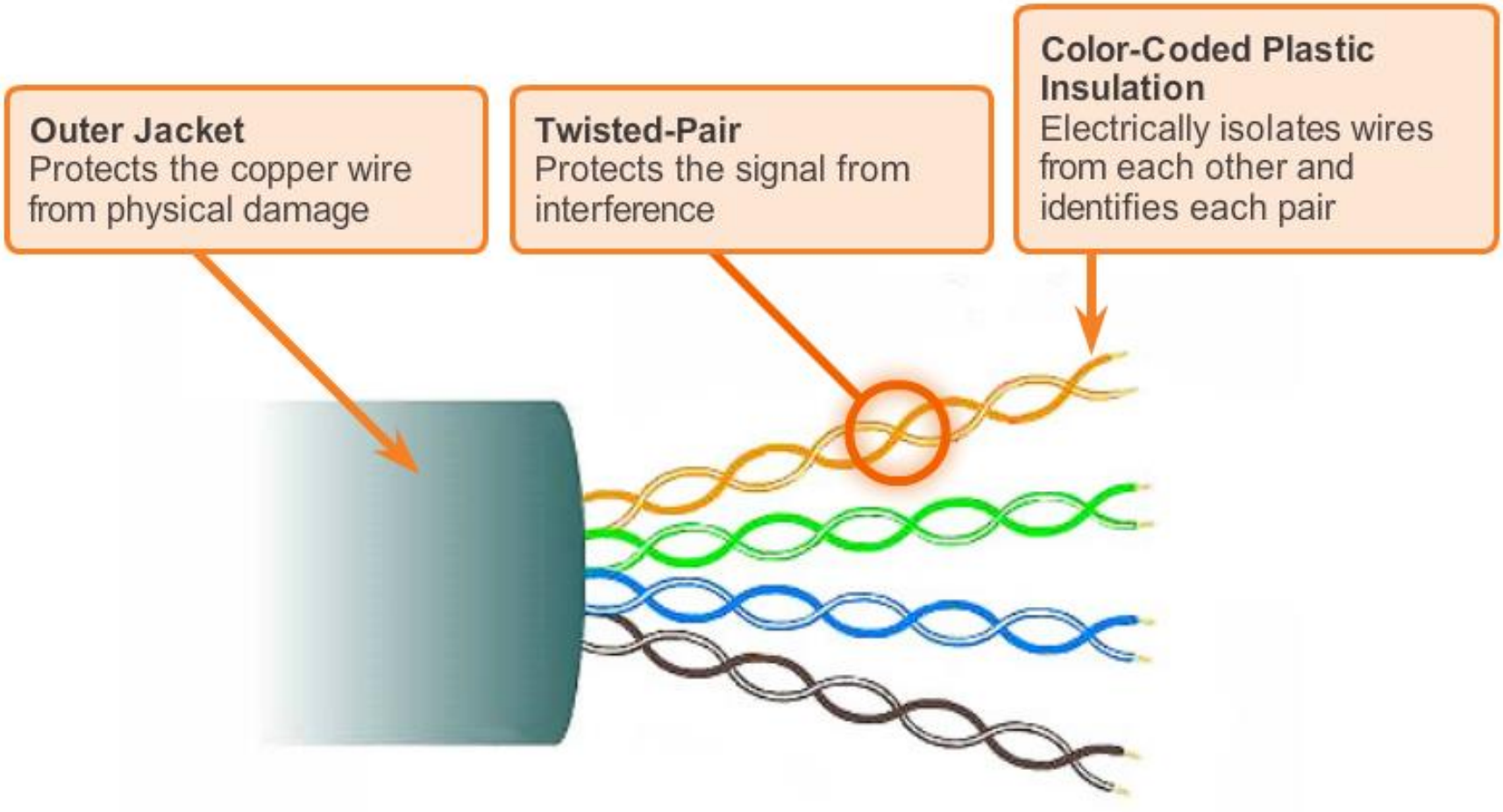
Shielded Twisted Pair (STP) Cable



Coaxial Cable

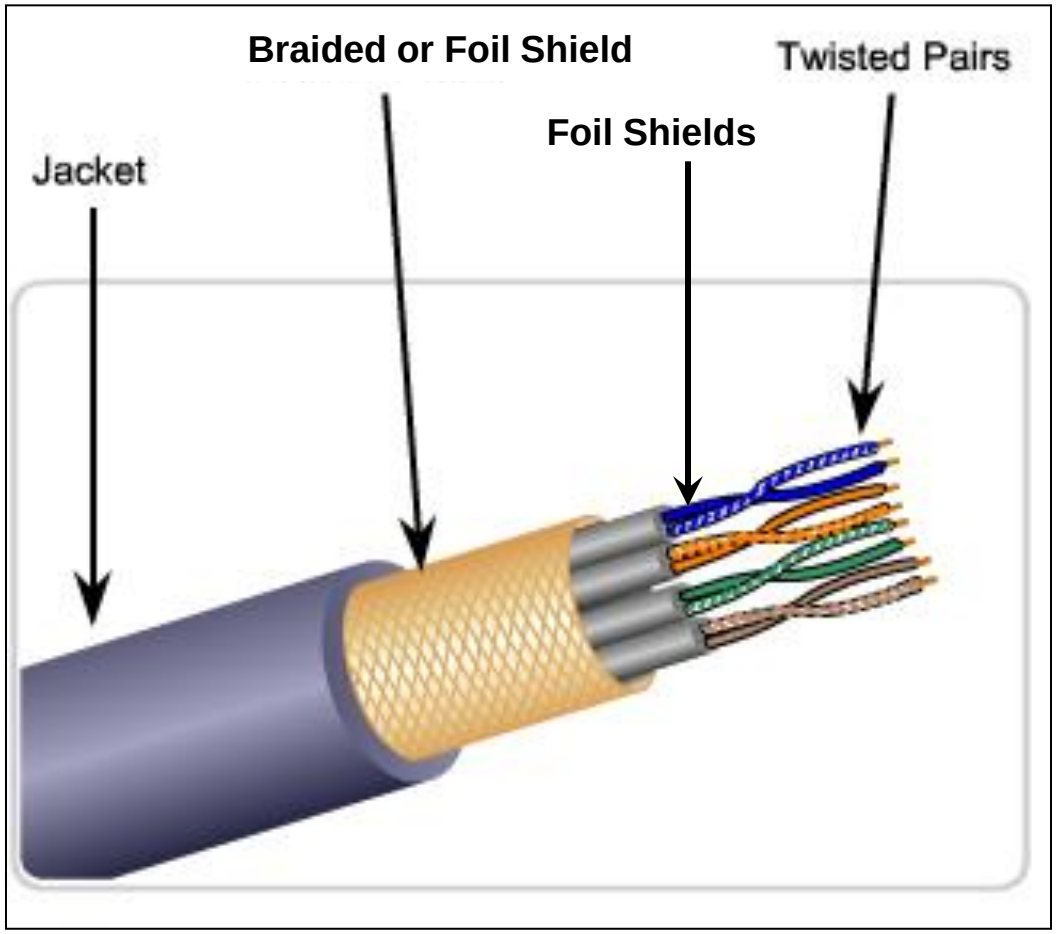
Copper Cabling

UTP Cable



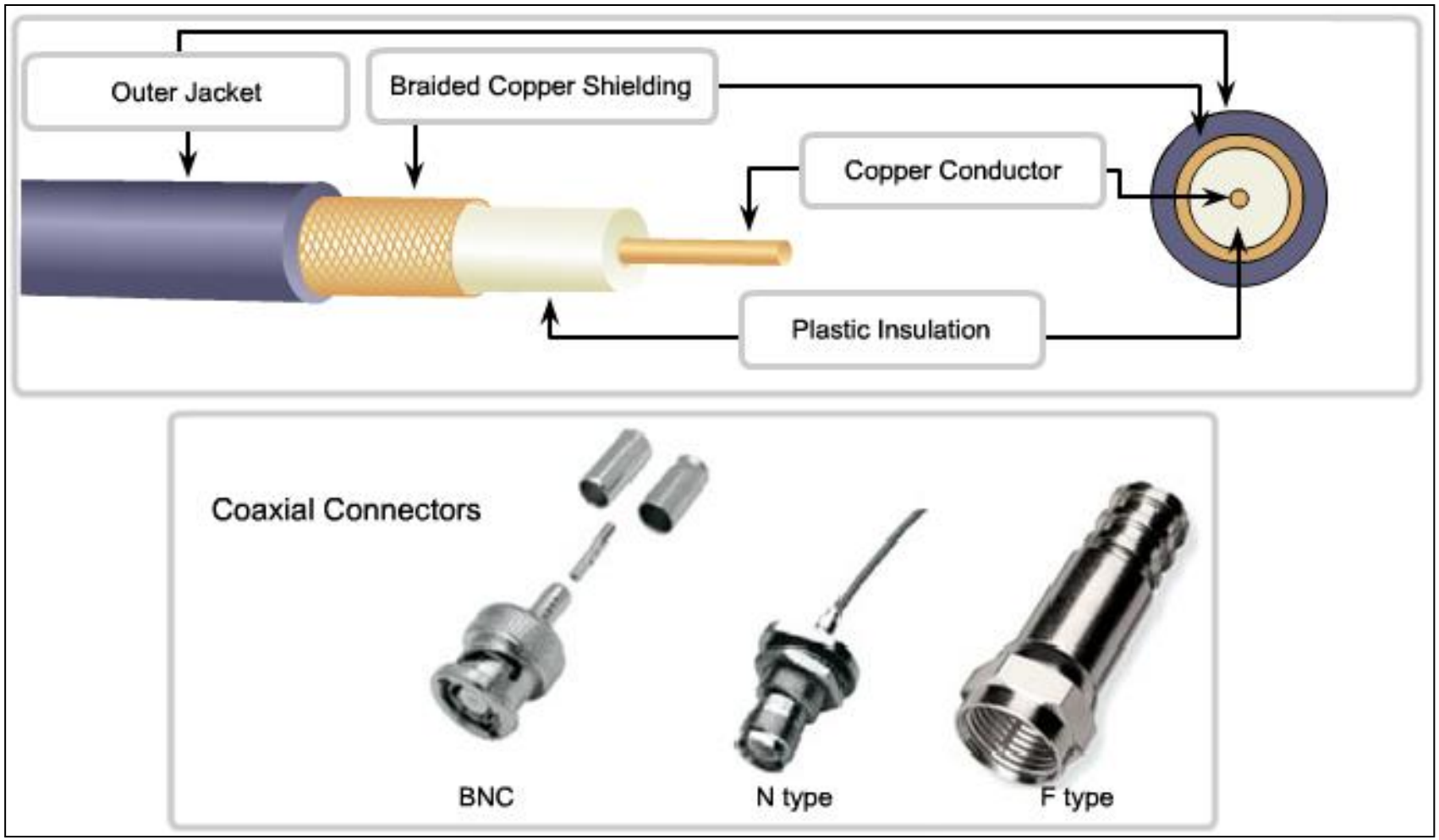
Copper Cabling

STP Cable



Copper Cabling

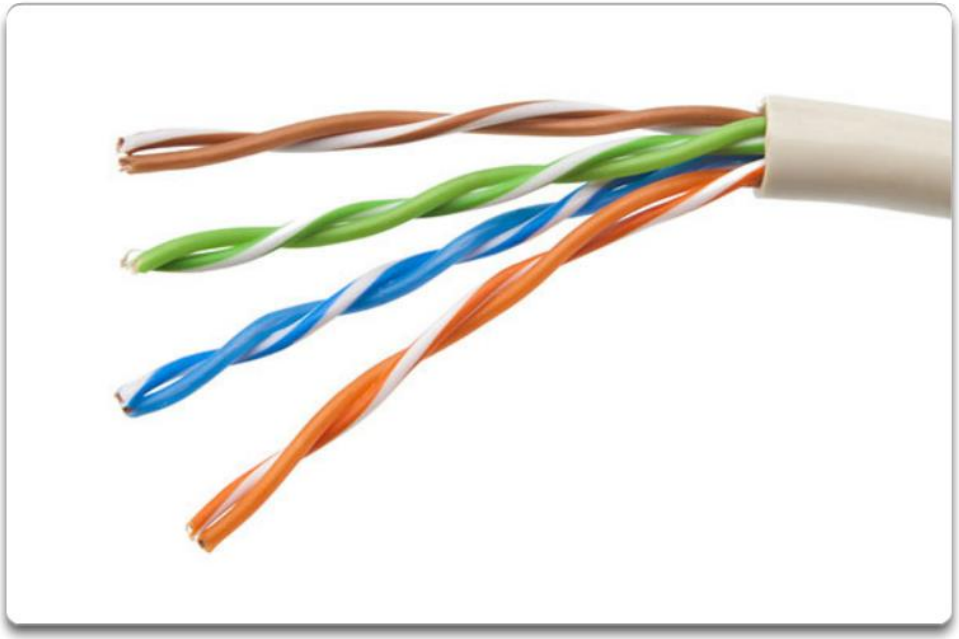
Coaxial Cable



UTP Cabling

UTP cable does not use shielding to counter the effects of EMI and RFI. Instead, cable designers have discovered that they can limit the negative effect of crosstalk by:

- Cancellation
- Varying the number of twists per wire pair



UTP Cabling

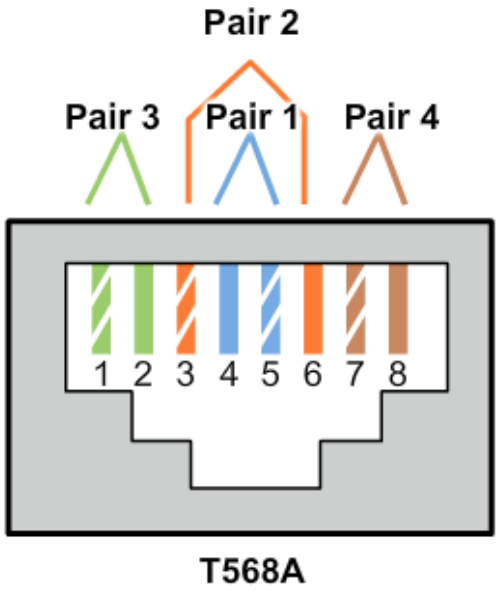
UTP Connectors

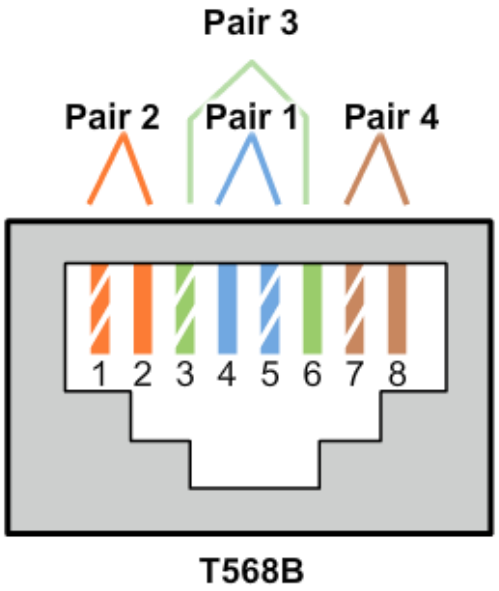
RJ-45 UTP Plugs

RJ-45 UTP Socket

UTP Cabling

Types of UTP Cable



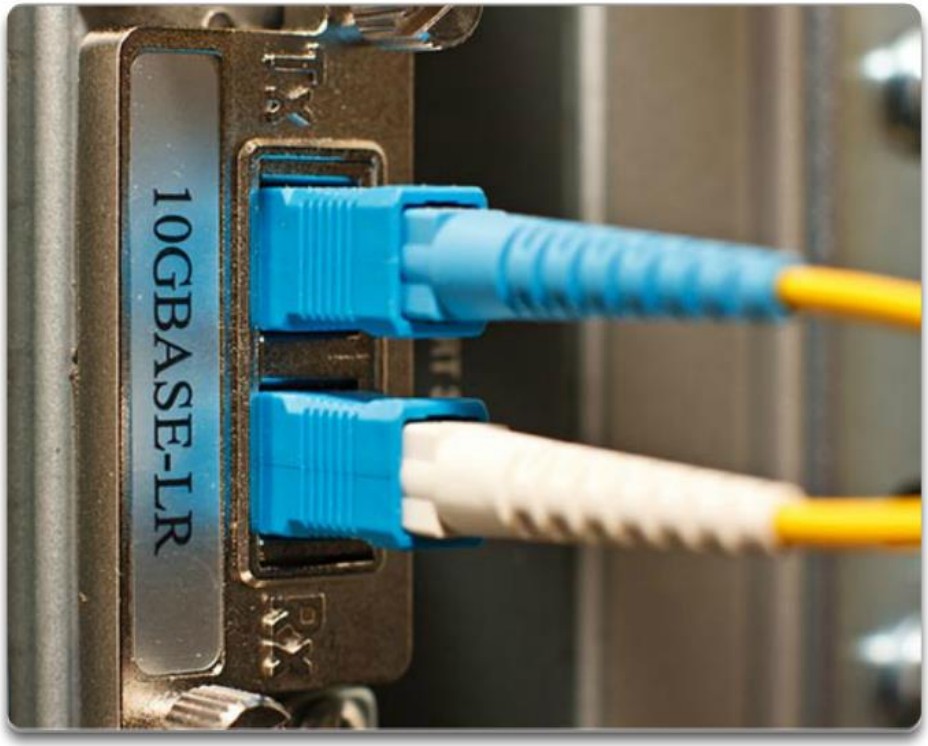


Cable Type	Standard	Application
Ethernet Straight-through	Both ends T568A or both ends T568B	Connects a network host to a network device such as a switch or hub.
Ethernet Crossover	One end T568A, other end T568B	• Connects two network hosts • Connects two network intermediary devices (switch to switch, or router to router)
Rollover	Cisco proprietary	Connects a workstation serial port to a router console port, using an adapter.

Properties of Fiber Optic Cabling

Fiber-optic cabling is now being used in four types of industry:

- Enterprise Networks
- Fiber-to-the-home (FTTH) and Access Networks
- Long-Haul Networks
- Submarine Networks



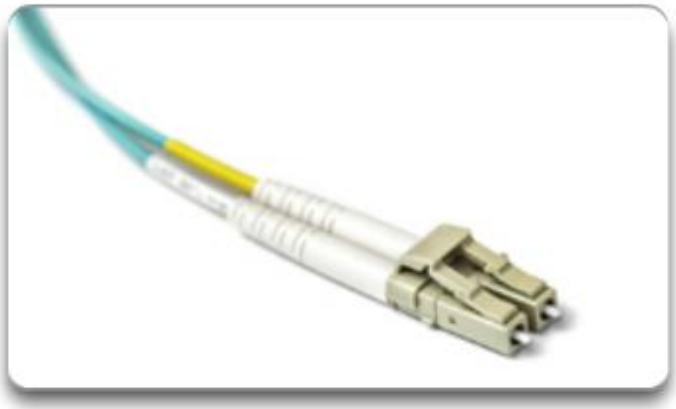
Fiber Optic Cabling

Network Fiber Connectors

ST Connectors

SC Connectors

LC Connector



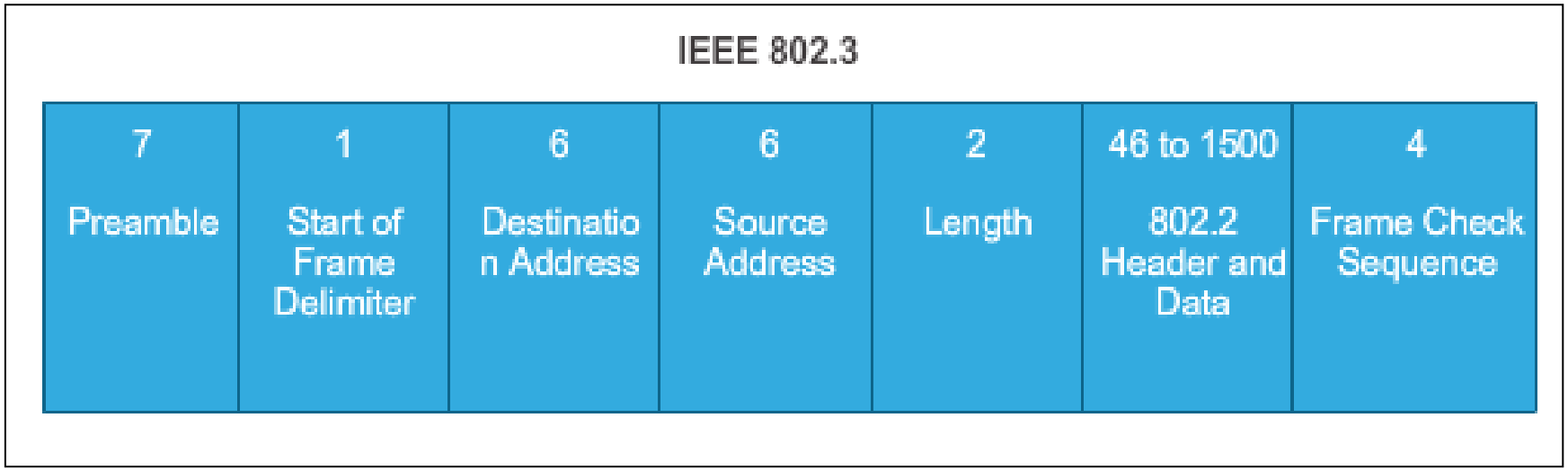
Duplex Multimode LC Connectors

Types of Wireless Media

	• IEEE 802.11 standards
	• Commonly referred to as Wi-Fi.
	• Uses CSMA/CA
	• Variations include:
	  • 802.11a: 54 Mbps, 5 GHz
	  • 802.11b: 11 Mbps, 2.4 GHz
	  • 802.11g: 54 Mbps, 2.4 GHz
	  • 802.11n: 600 Mbps, 2.4 and 5 GHz
	  • 802.11ac: 1 Gbps, 5 GHz
	  • 802.11ad: 7 Gbps, 2.4 GHz, 5 GHz, and 60 GHz

	• IEEE 802.15 standard • Supports speeds up to 3 Mb/s • Provides device pairing over distances from 1 to 100 meters.
	• IEEE 802.16 standard • Provides speeds up to 1 Gbps • Uses a point-to-multipoint topology to provide wireless broadband access.

Introduction to the Ethernet Frame

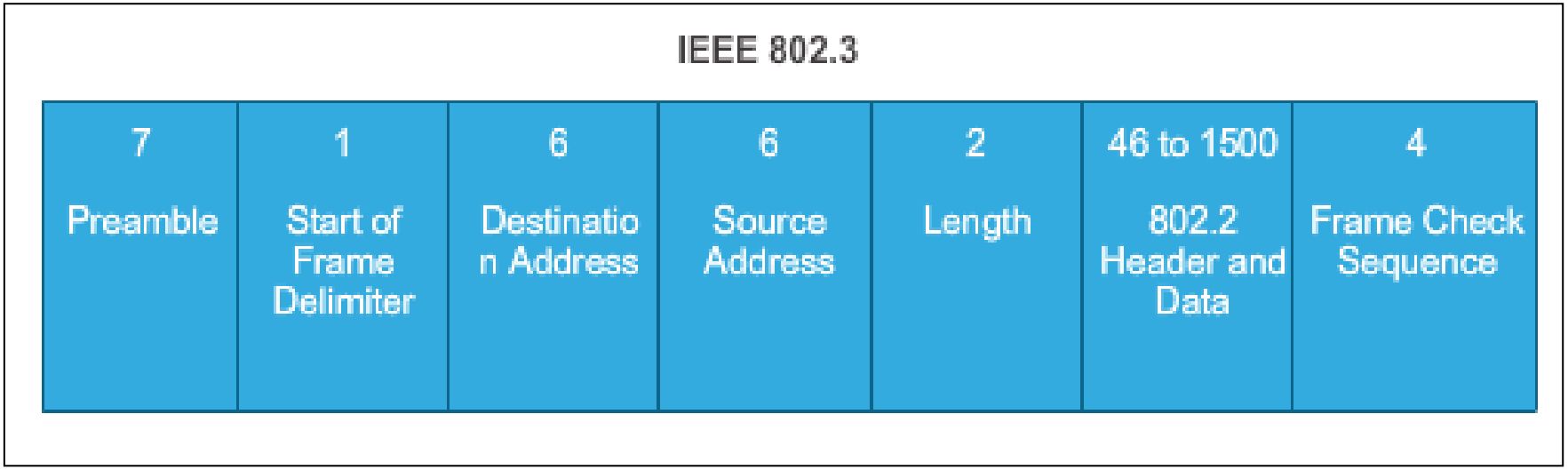


Preamble and Start Frame Delimiter Fields – Used for synchronization between the sending and receiving devices.

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

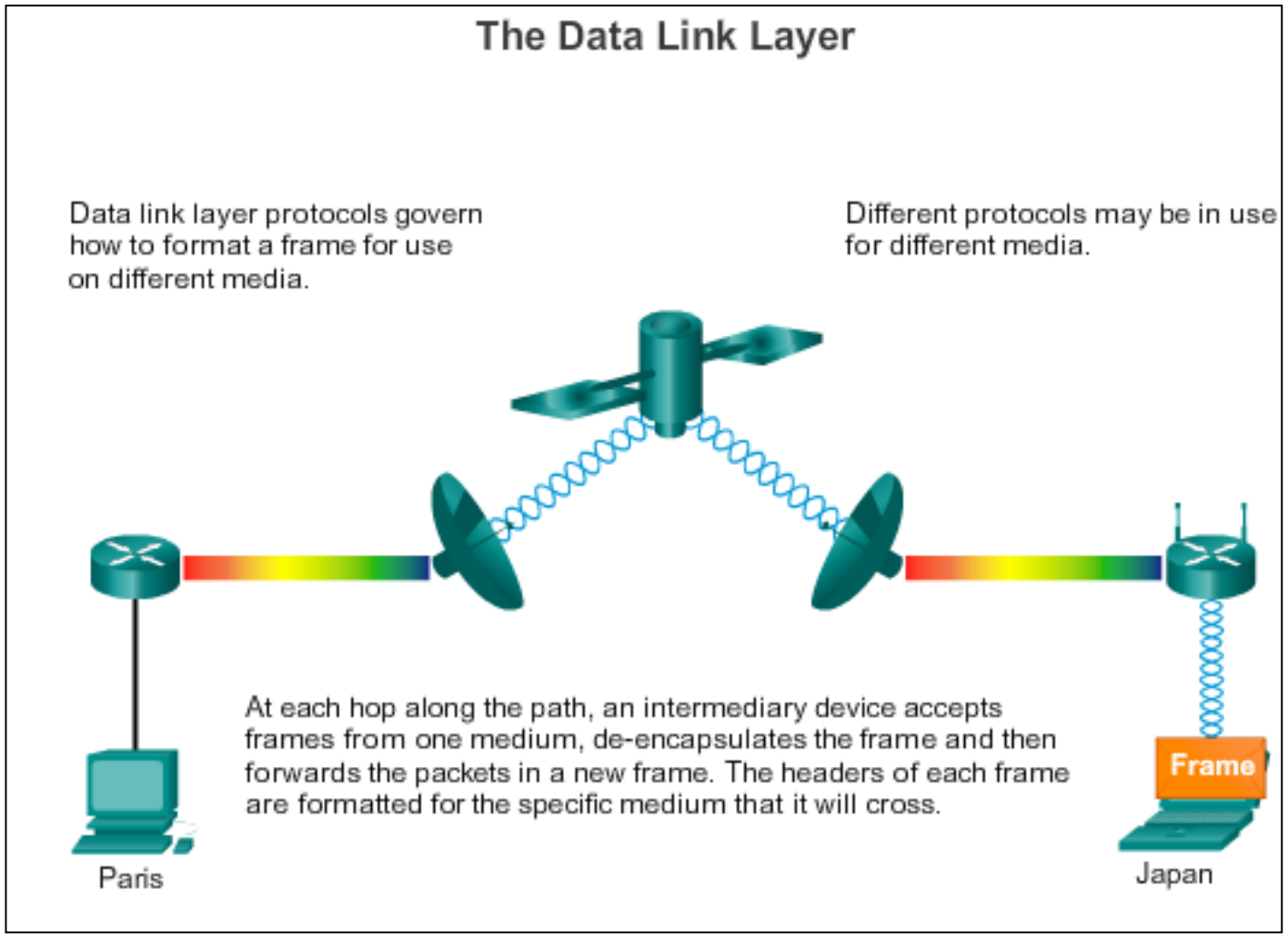
Data and Pad Fields – Contains the encapsulated data from a higher layer, an IPv4 packet.

Introduction to the Ethernet Frame (cont.)

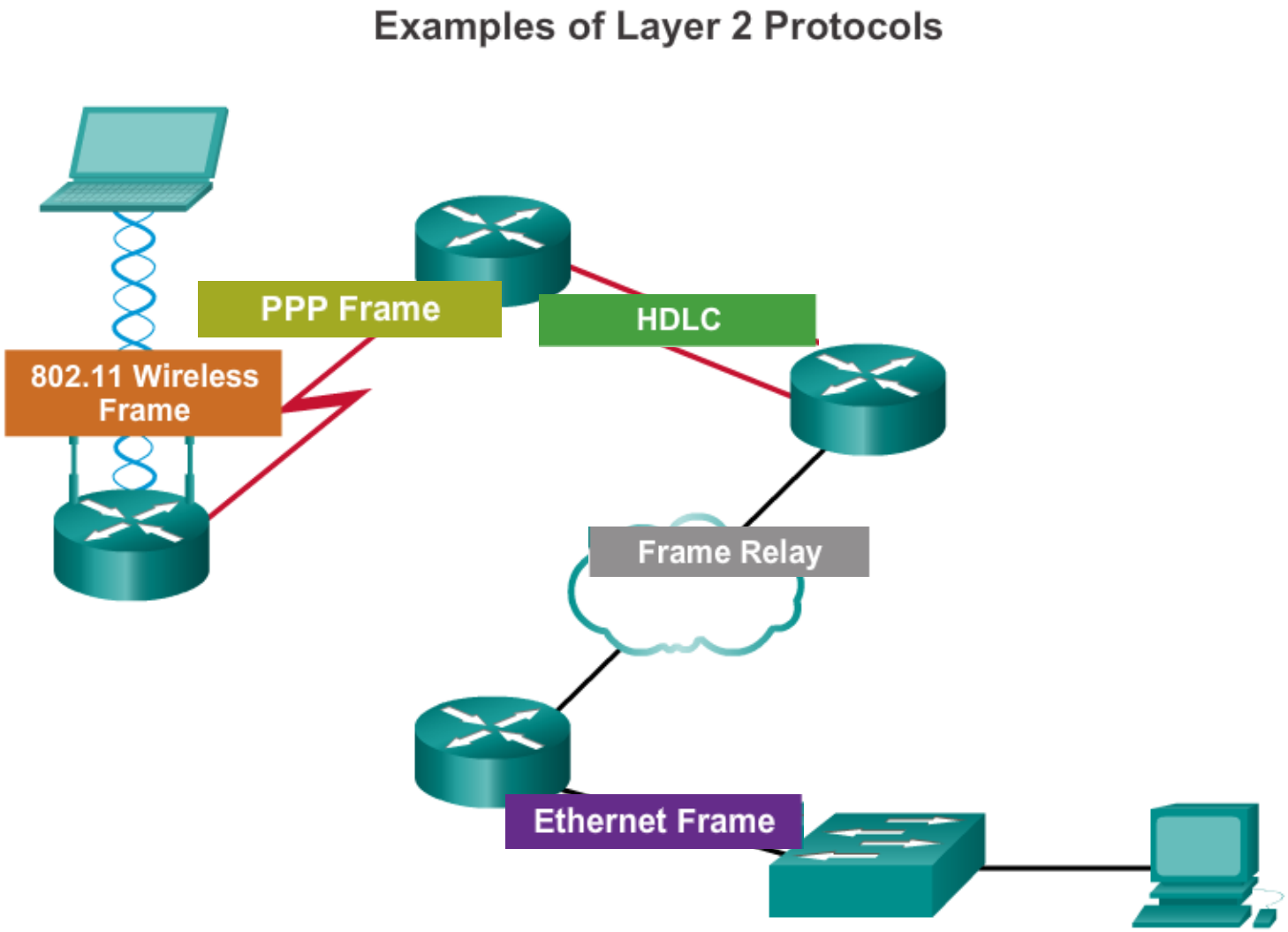


Frame Check Sequence Field
Used to detect errors in a frame with cyclic redundancy check (4 bytes); if calculations match at source and receiver, no error occurred.

End-to-End Connectivity, MAC, and IP (cont.)



LAN and WAN Frames



The Network Layer

Start

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:

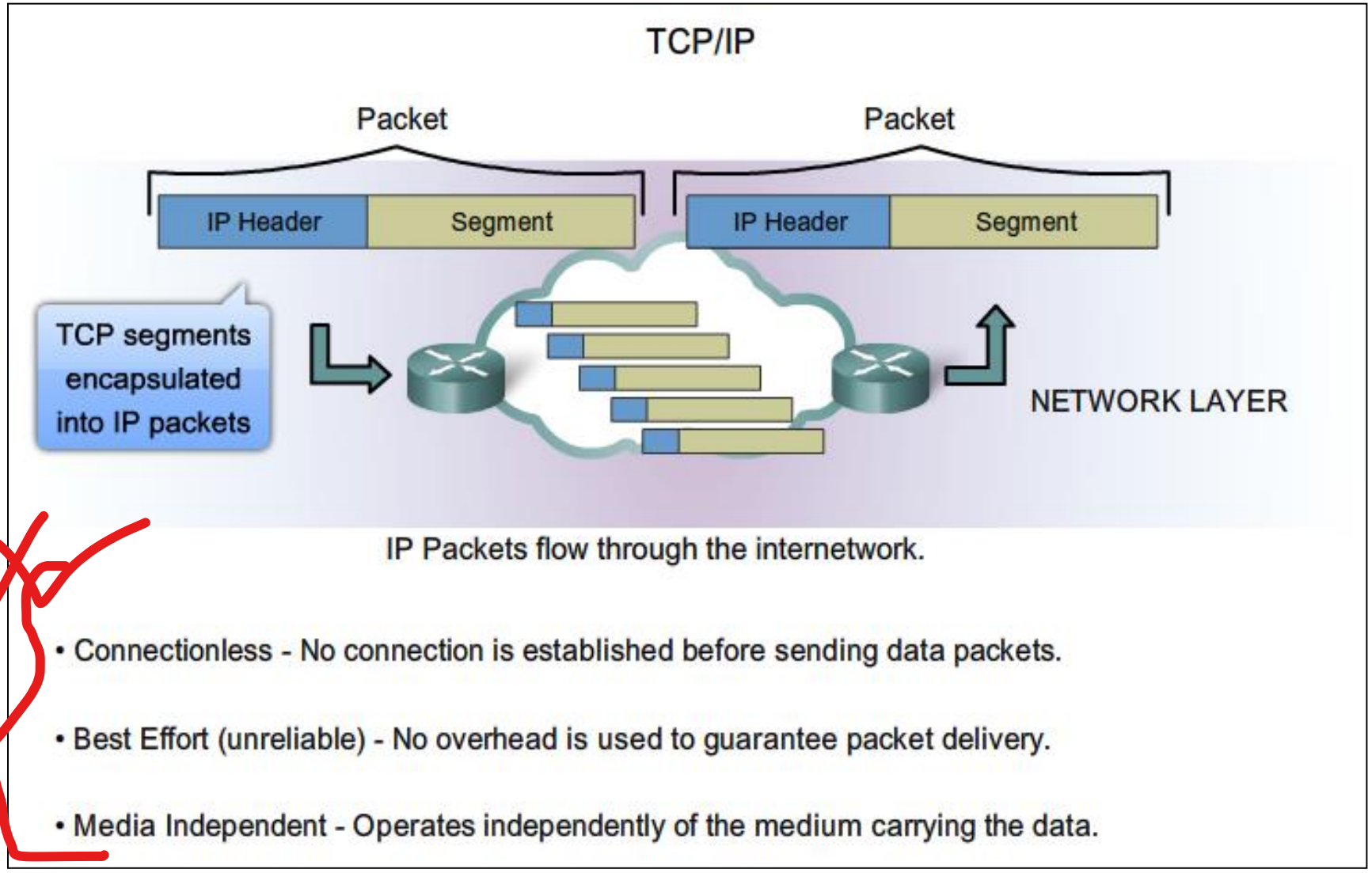
- Addressing end devices
- Encapsulation
- Routing
- De-encapsulating

Network Layer Protocols

Common network layer protocols include:

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

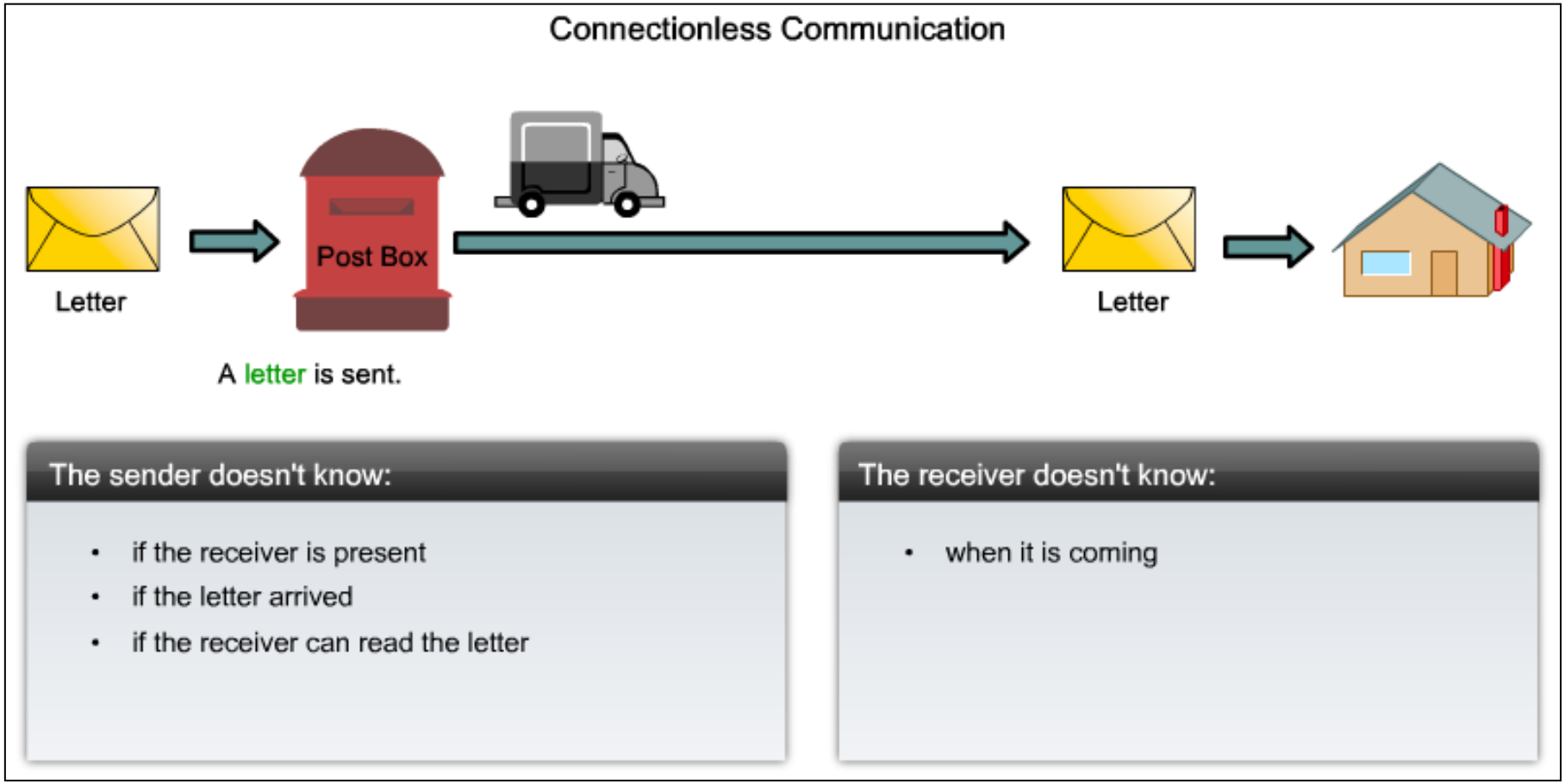
IP Components



IP Packets flow through the internetwork.

- Connectionless - No connection is established before sending data packets.
- Best Effort (unreliable) - No overhead is used to guarantee packet delivery.
- Media Independent - Operates independently of the medium carrying the data.

IP - Connectionless



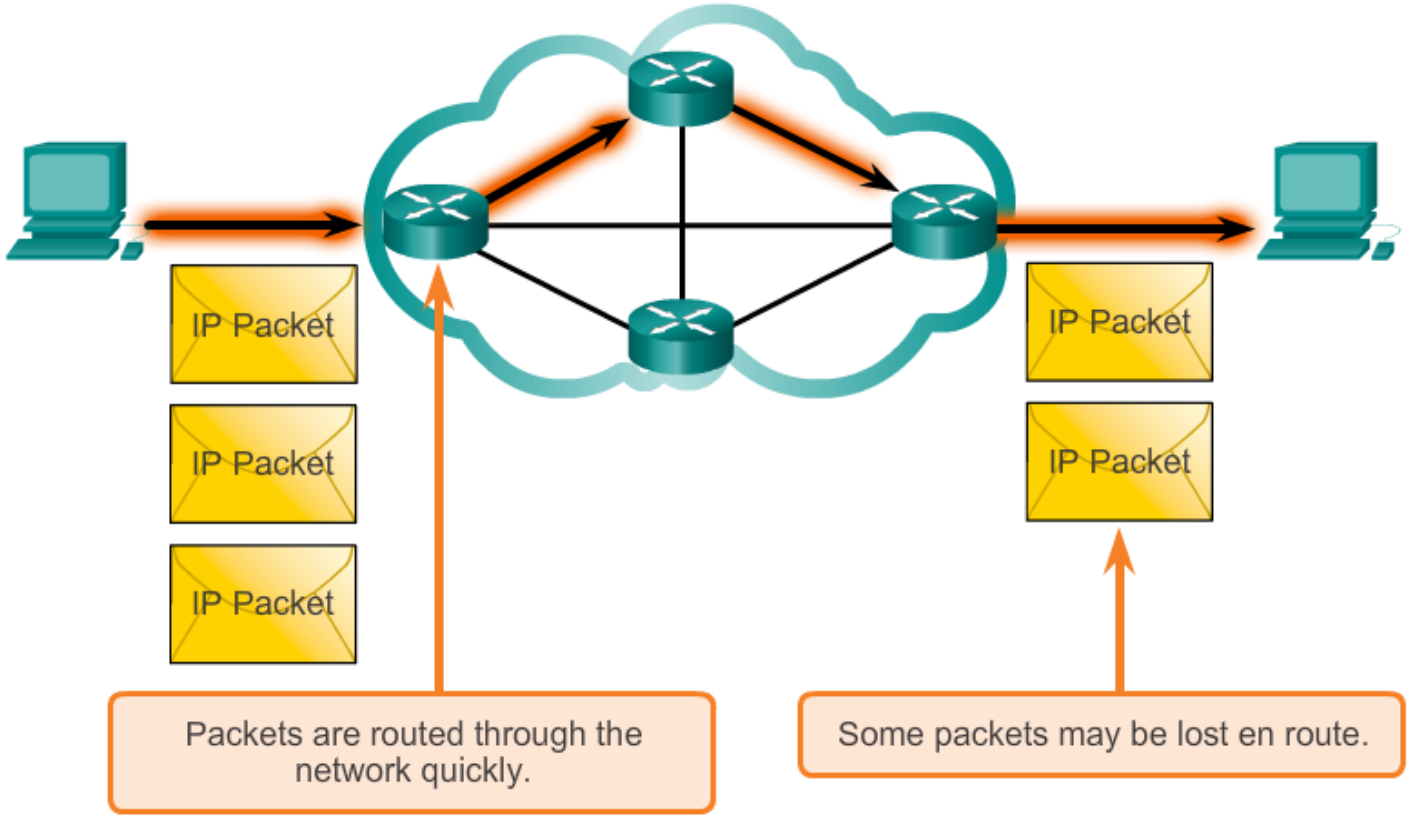
The sender doesn't know:

- if the receiver is present
- if the letter arrived
- if the receiver can read the letter

The receiver doesn't know:

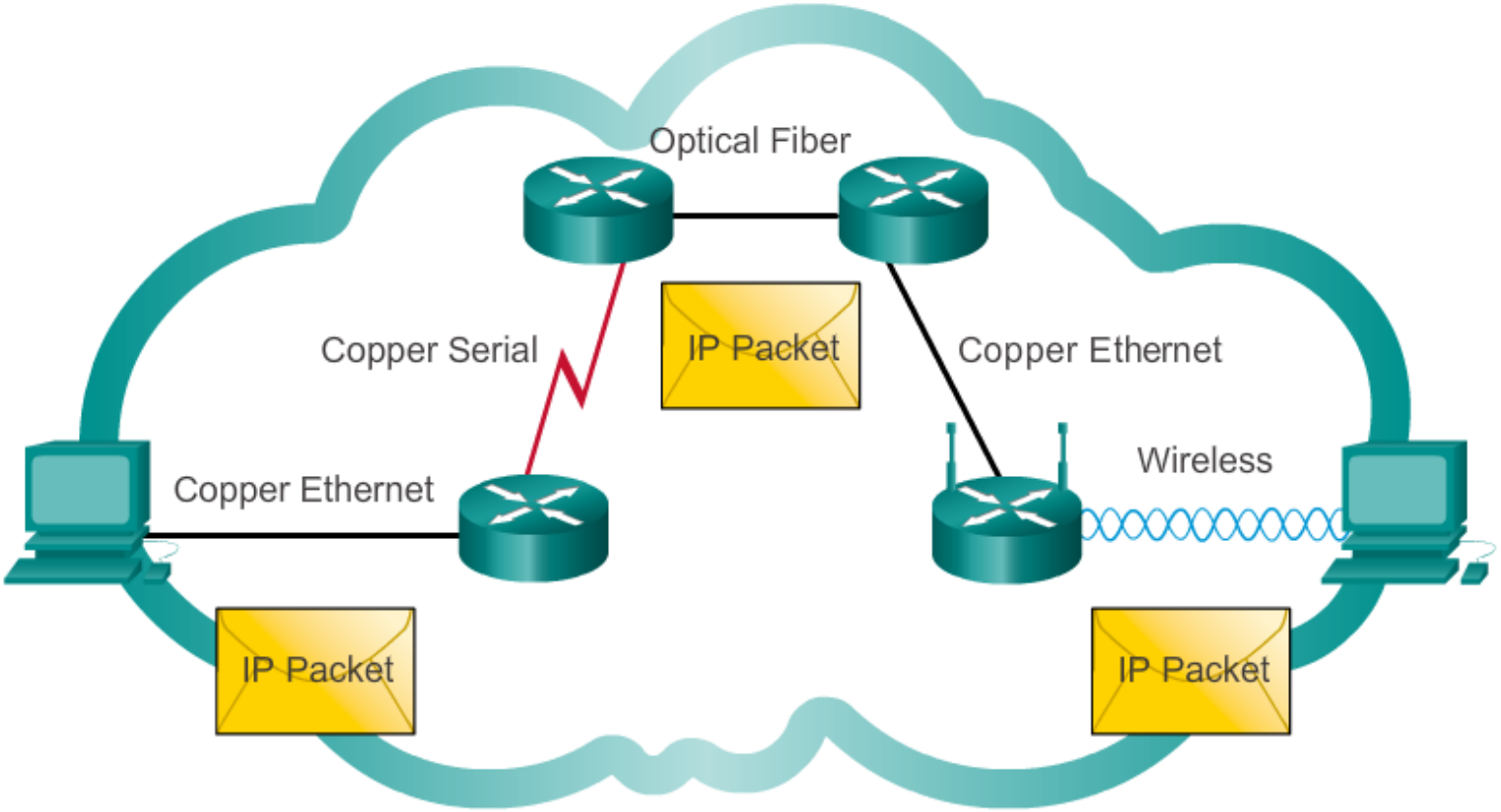
- when it is coming

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.

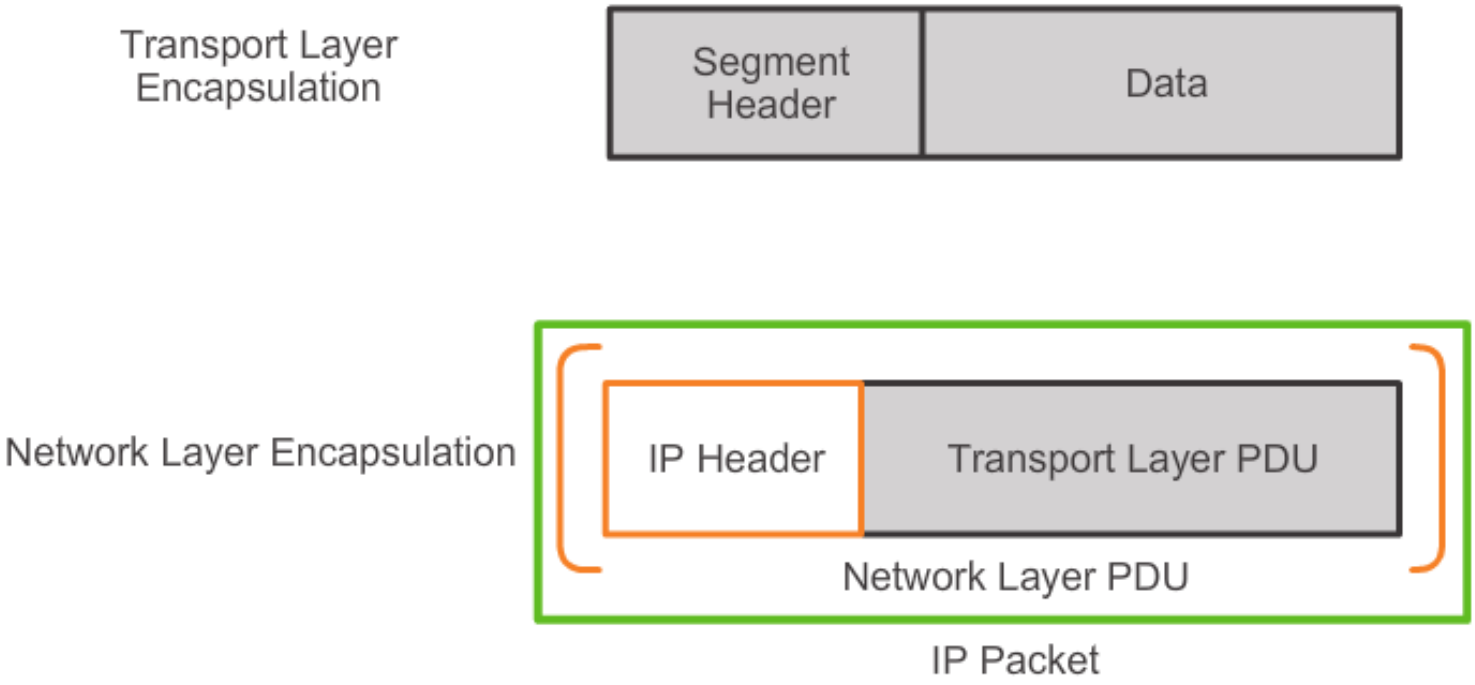
IP – Media Independent



IP packets can travel over different media.

IPv4 Packet

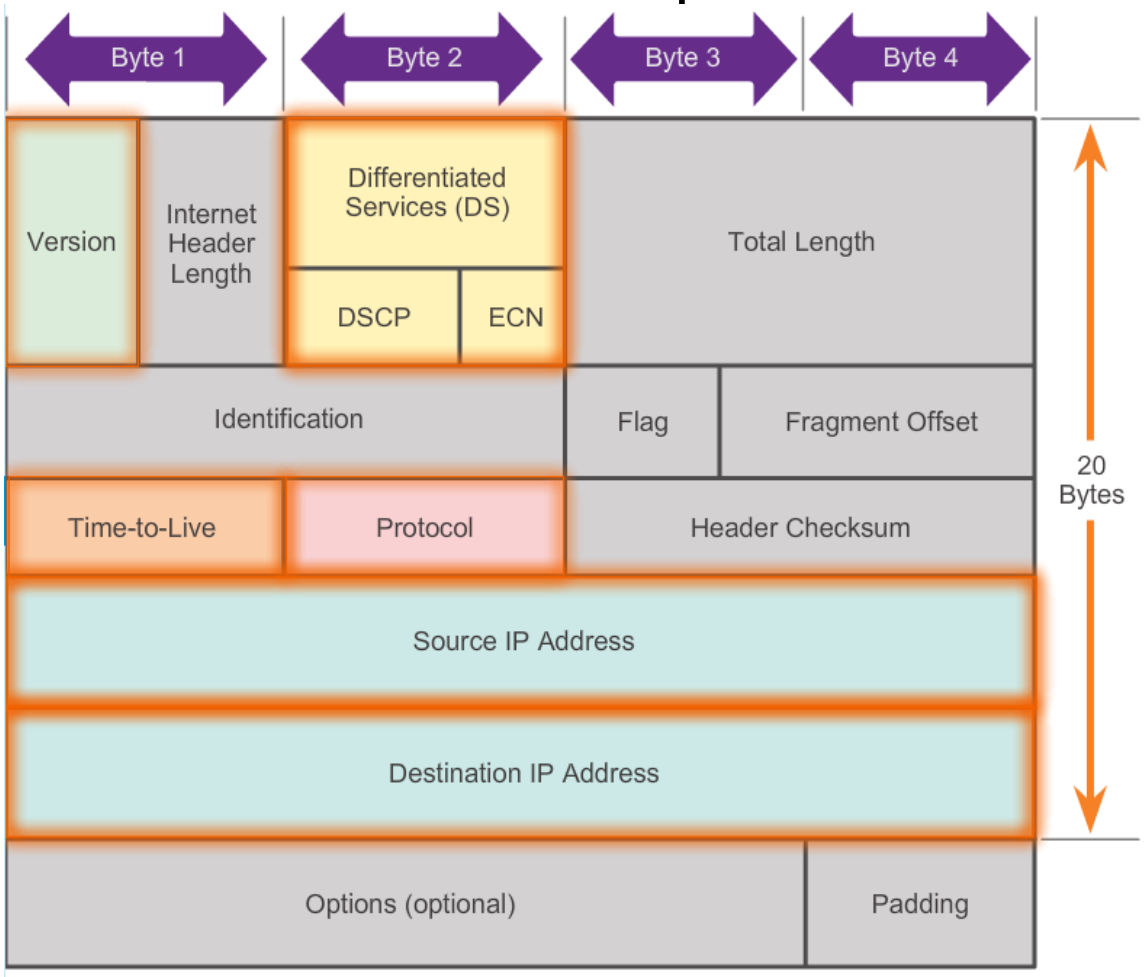
Encapsulating IP



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.

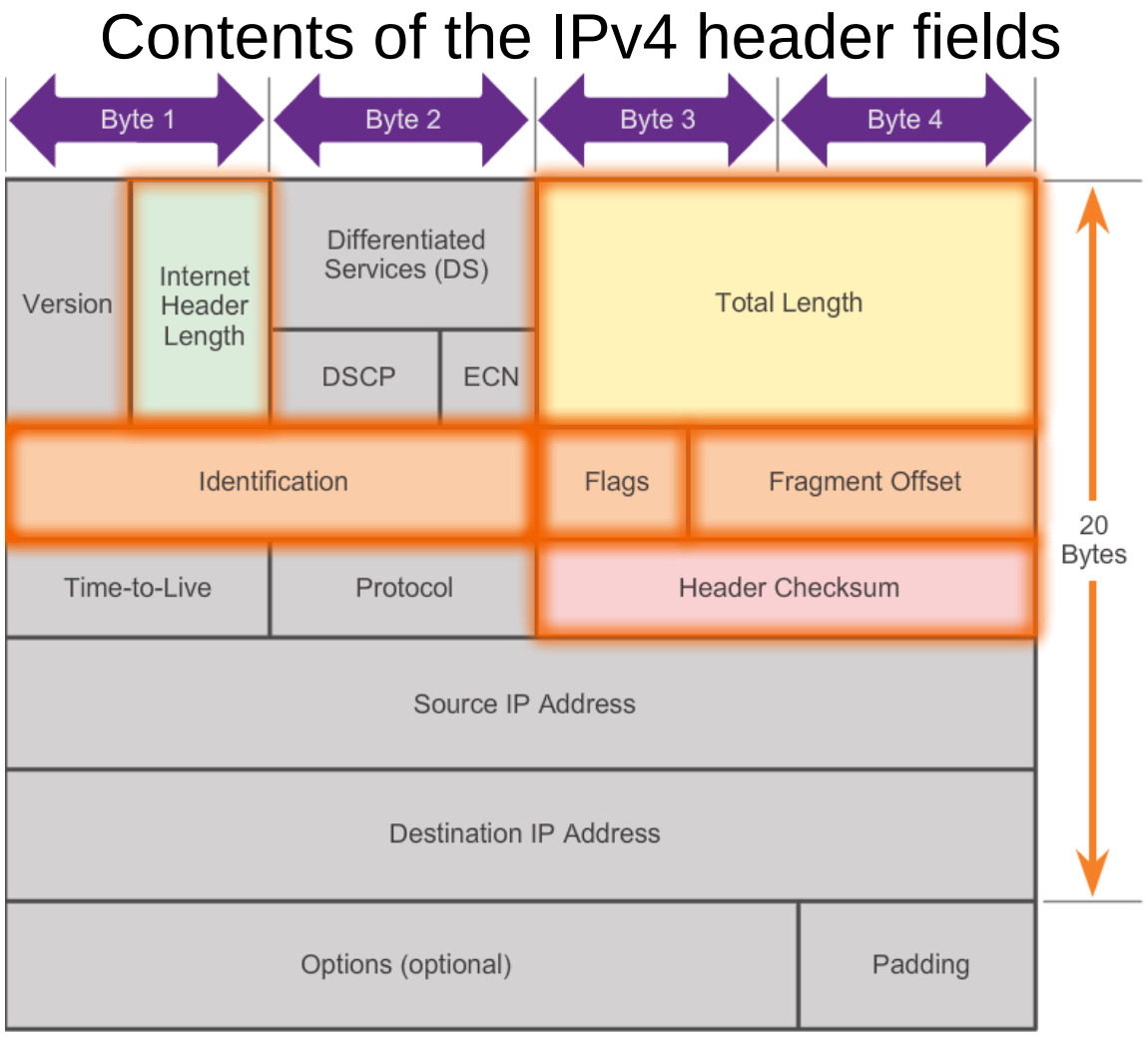
IPv4 Packet Header

Contents of the IPv4 packet header



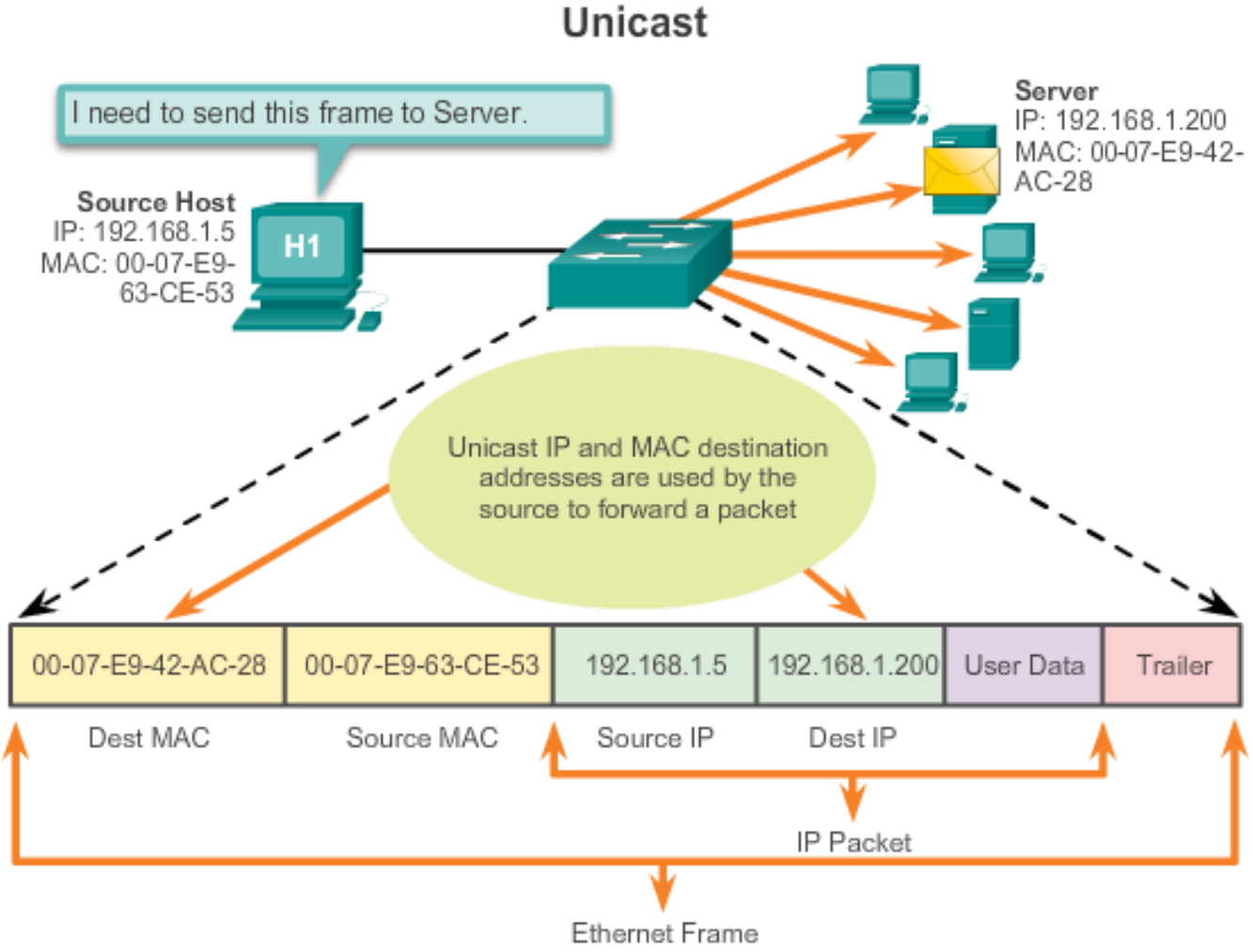
IPv4 Packet

IPv4 Header Fields

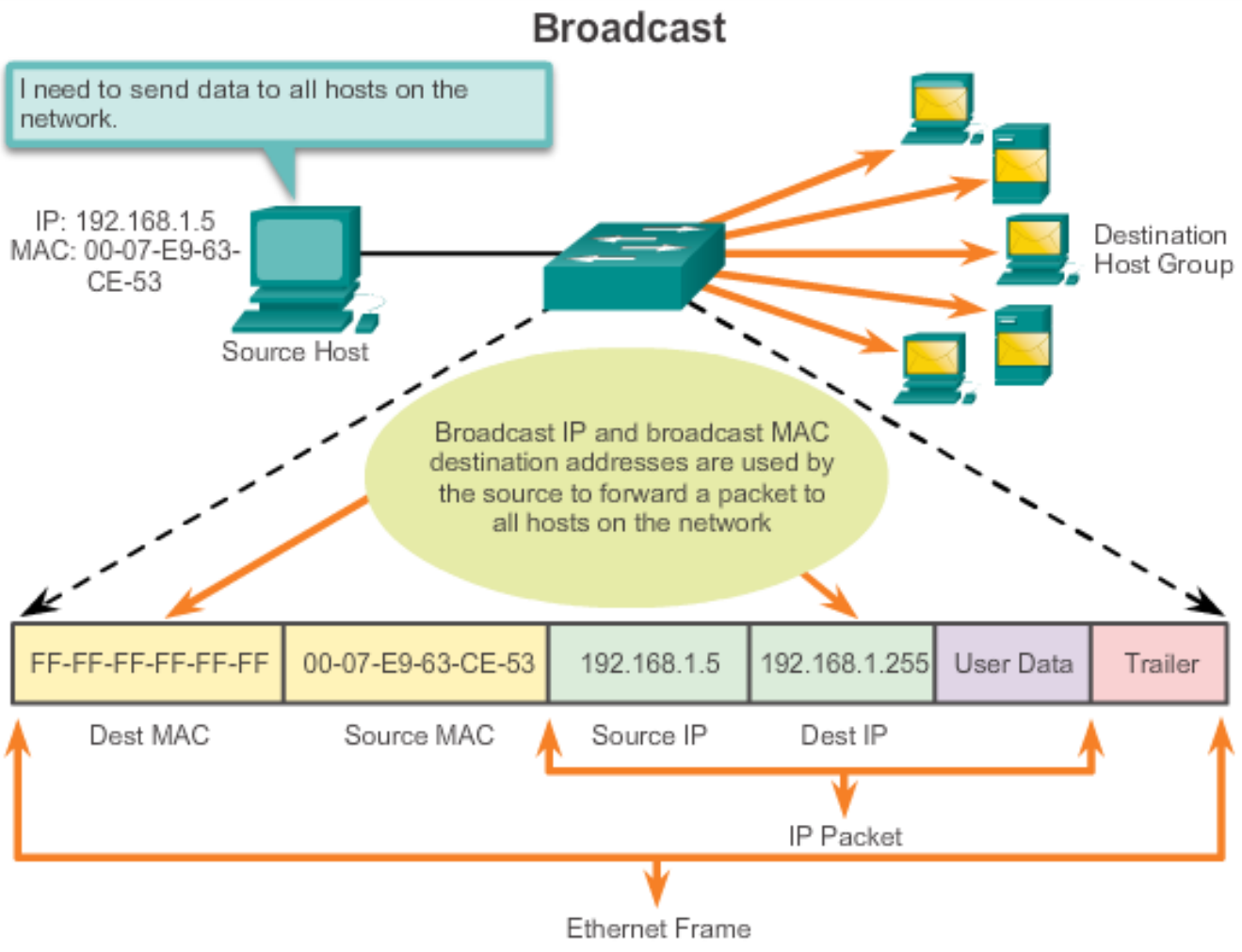


Unicast Address

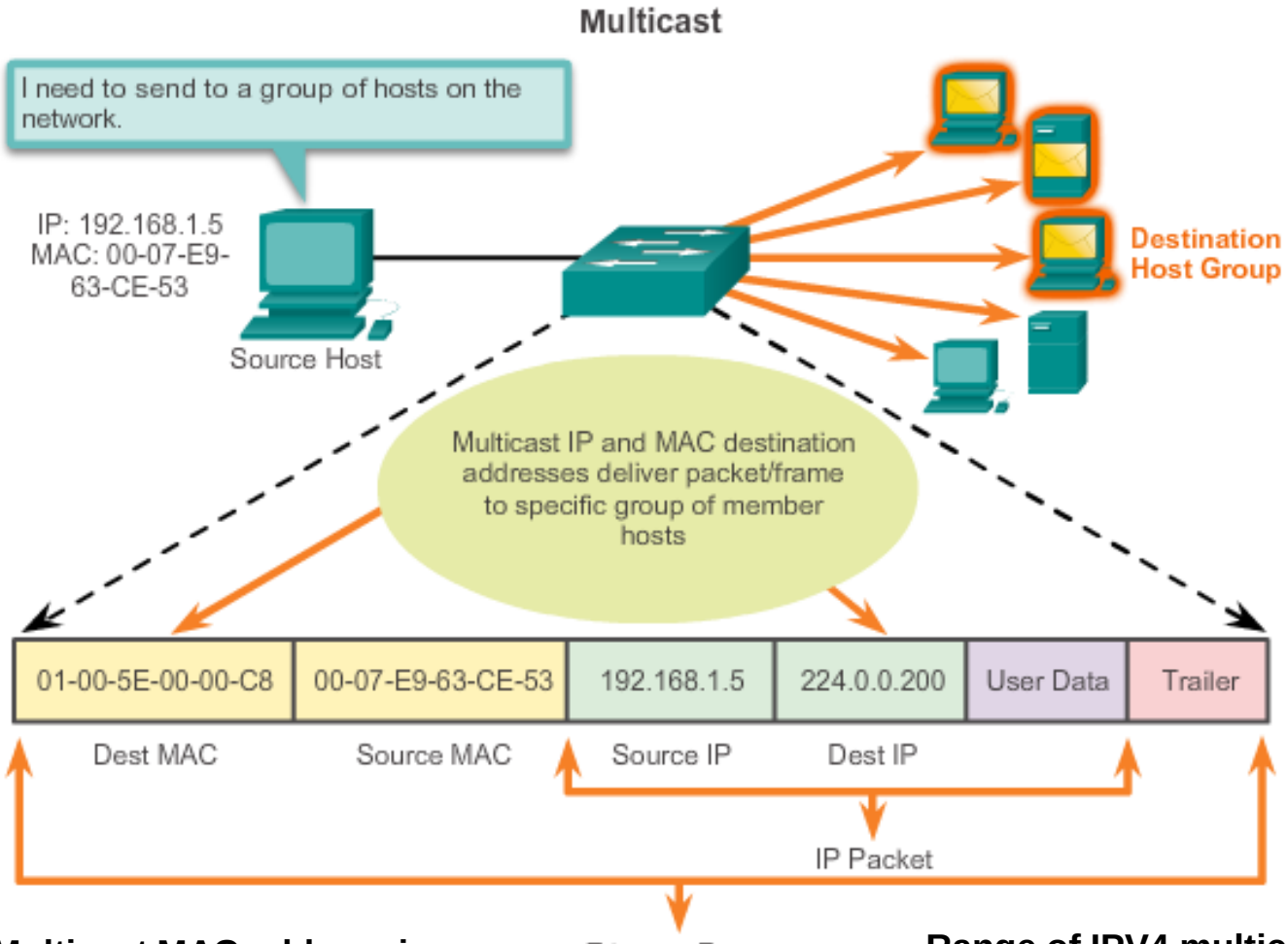
(From Not Covered)



Broadcast MAC Address



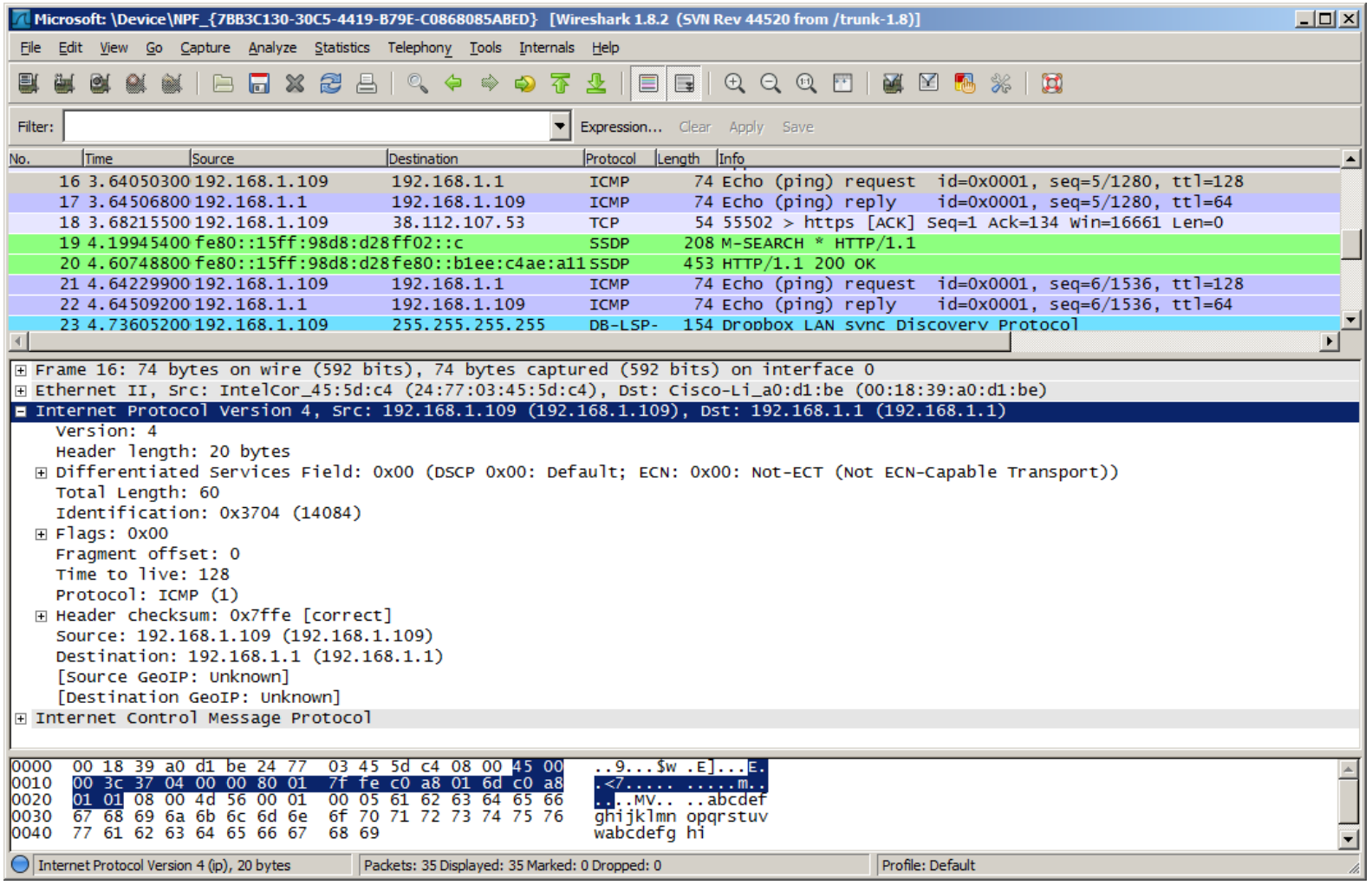
Multicast Address



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 Packet Tracer



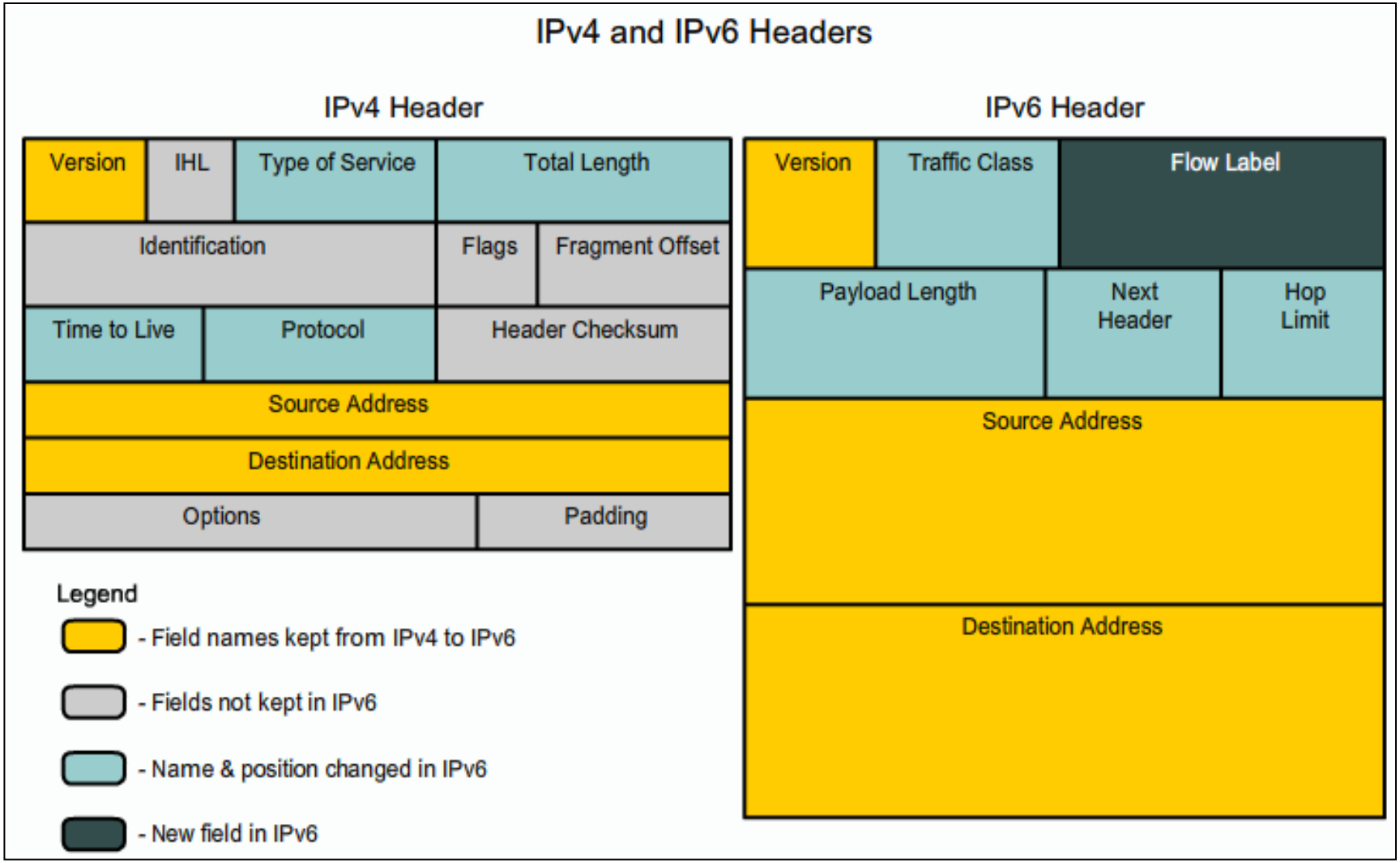
Limitations of IPv4

- 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

Encapsulating IPv6



IPv6 Packet Header