

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

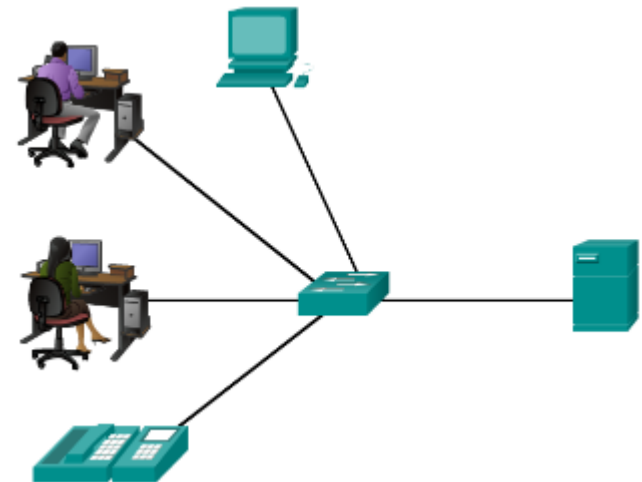
■ Local Area Networks

- 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



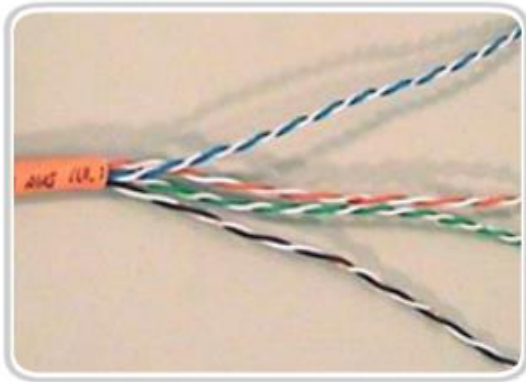
Fiber Optic



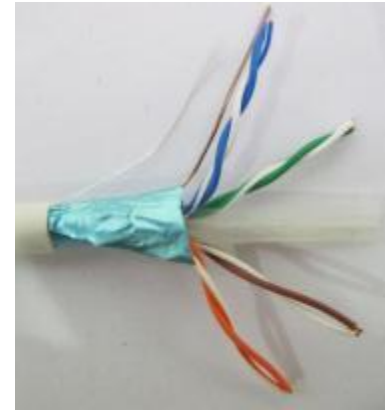
Wireless



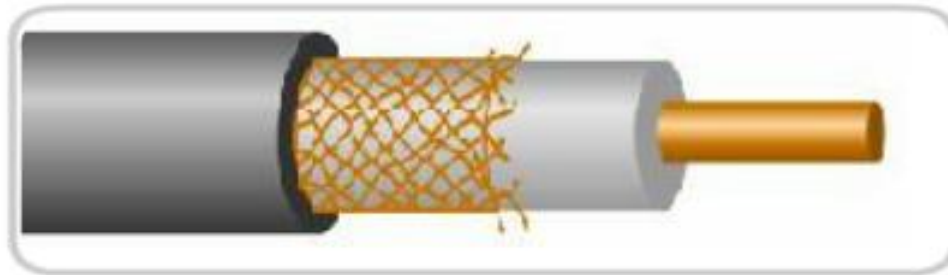
Copper Media



Unshielded Twisted
Pair (UTP) Cable

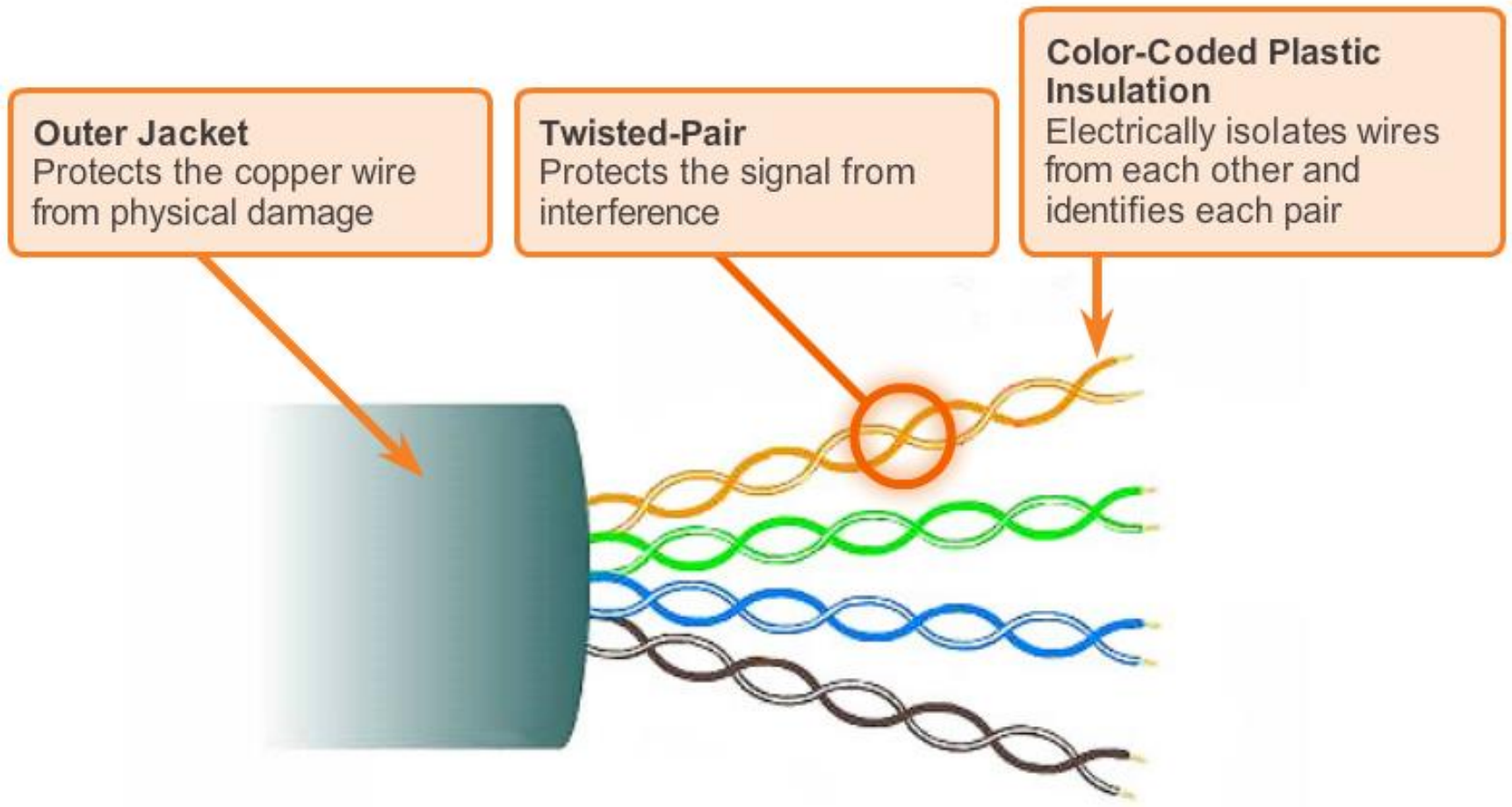


Shielded Twisted
Pair (STP) Cable



Coaxial Cable

UTP Cable

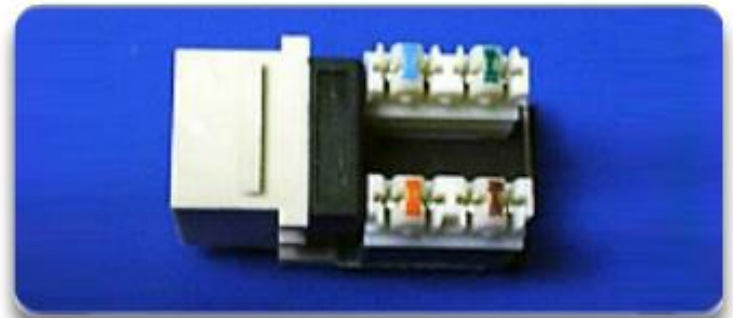


UTP Connectors

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.

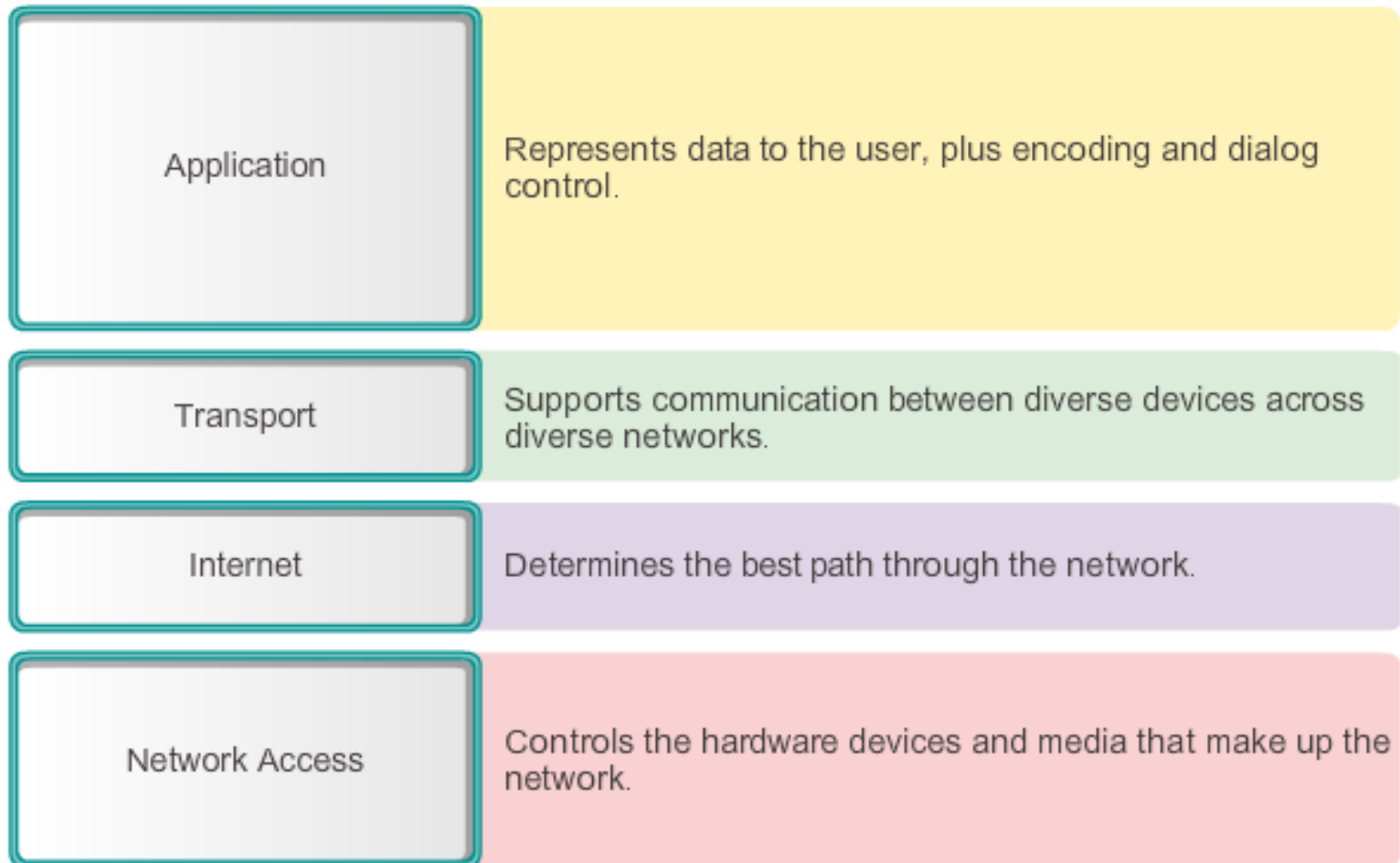
The OSI Reference Model

OSI Model

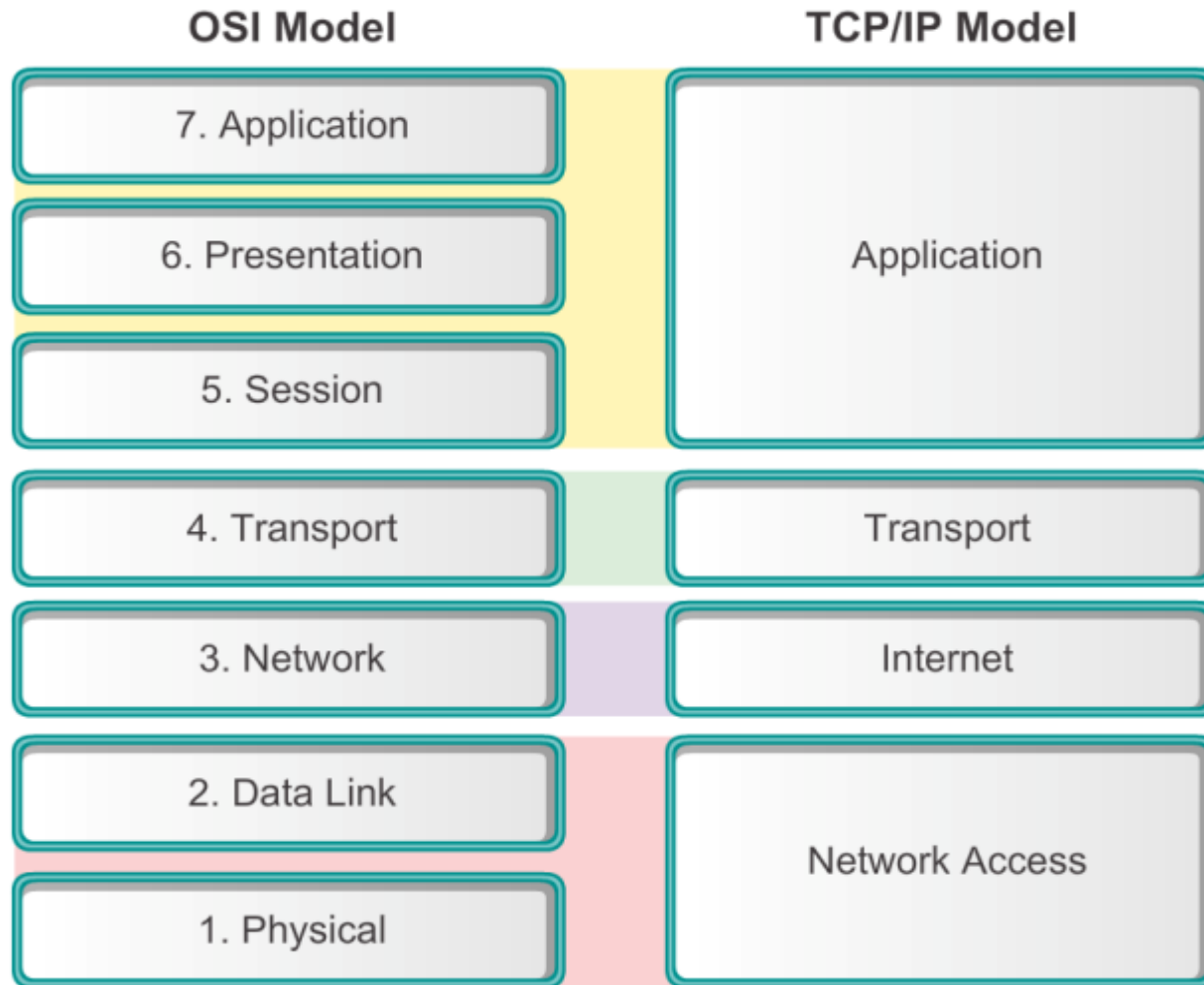


The TCP/IP Reference Model

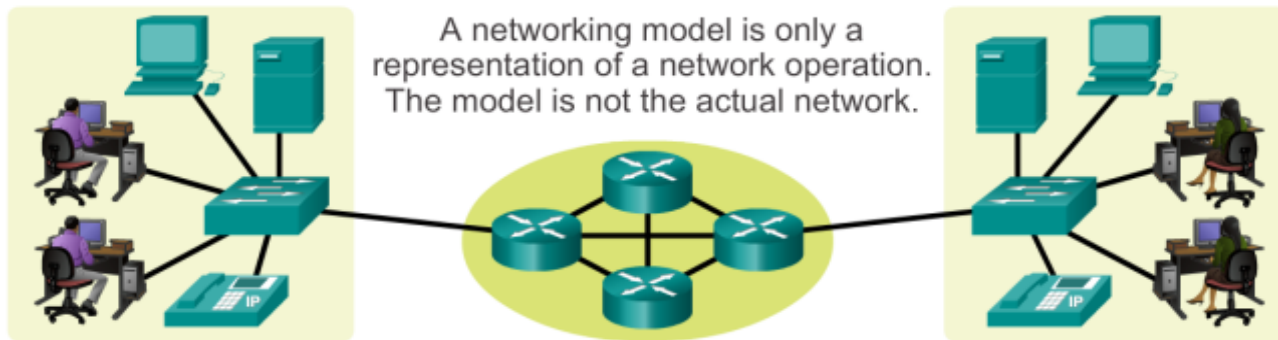
TCP/IP Model



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		

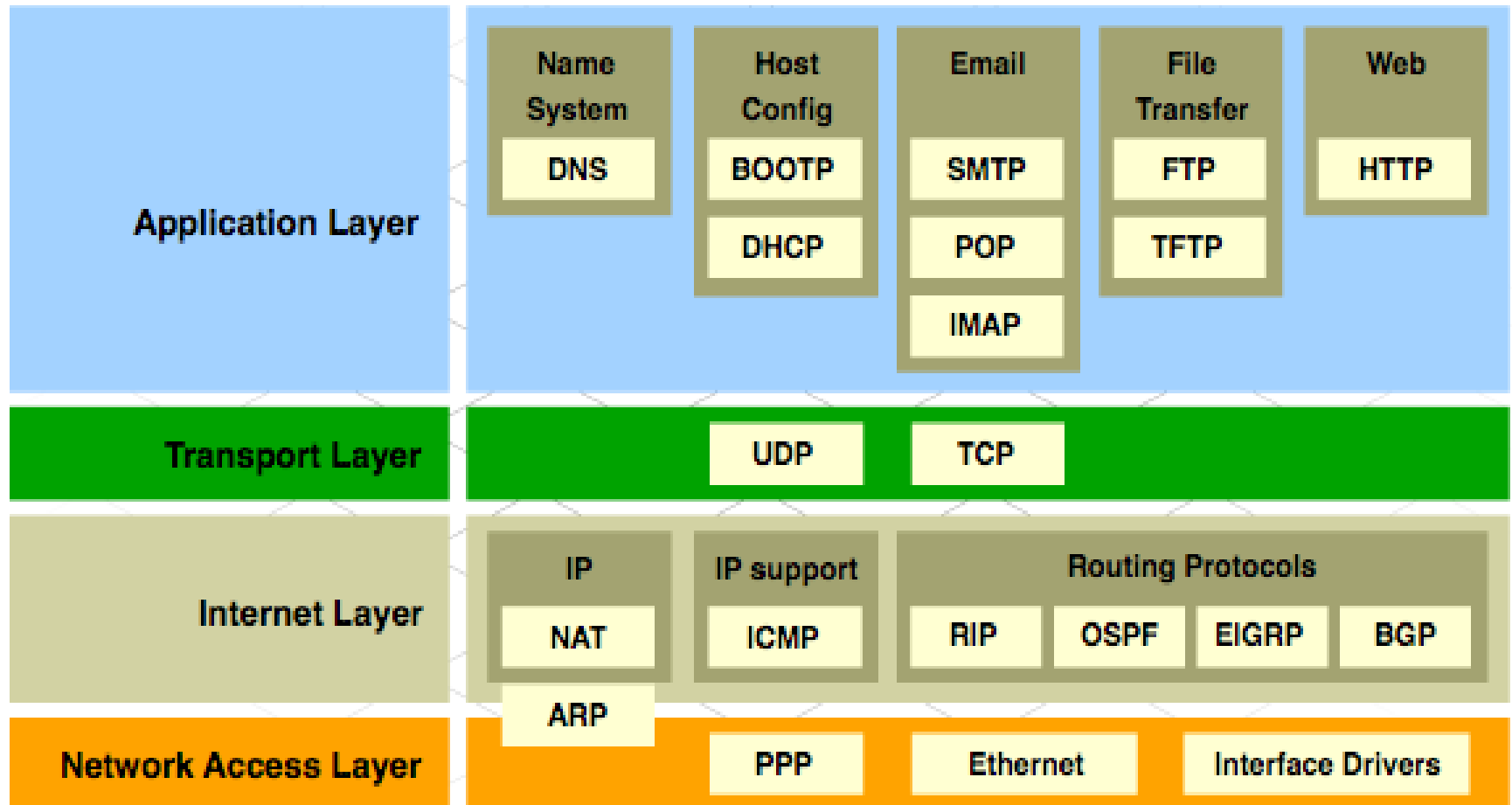
Establishing the Rules

- 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

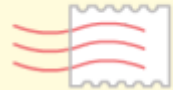


Message Formatting and Encapsulation

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

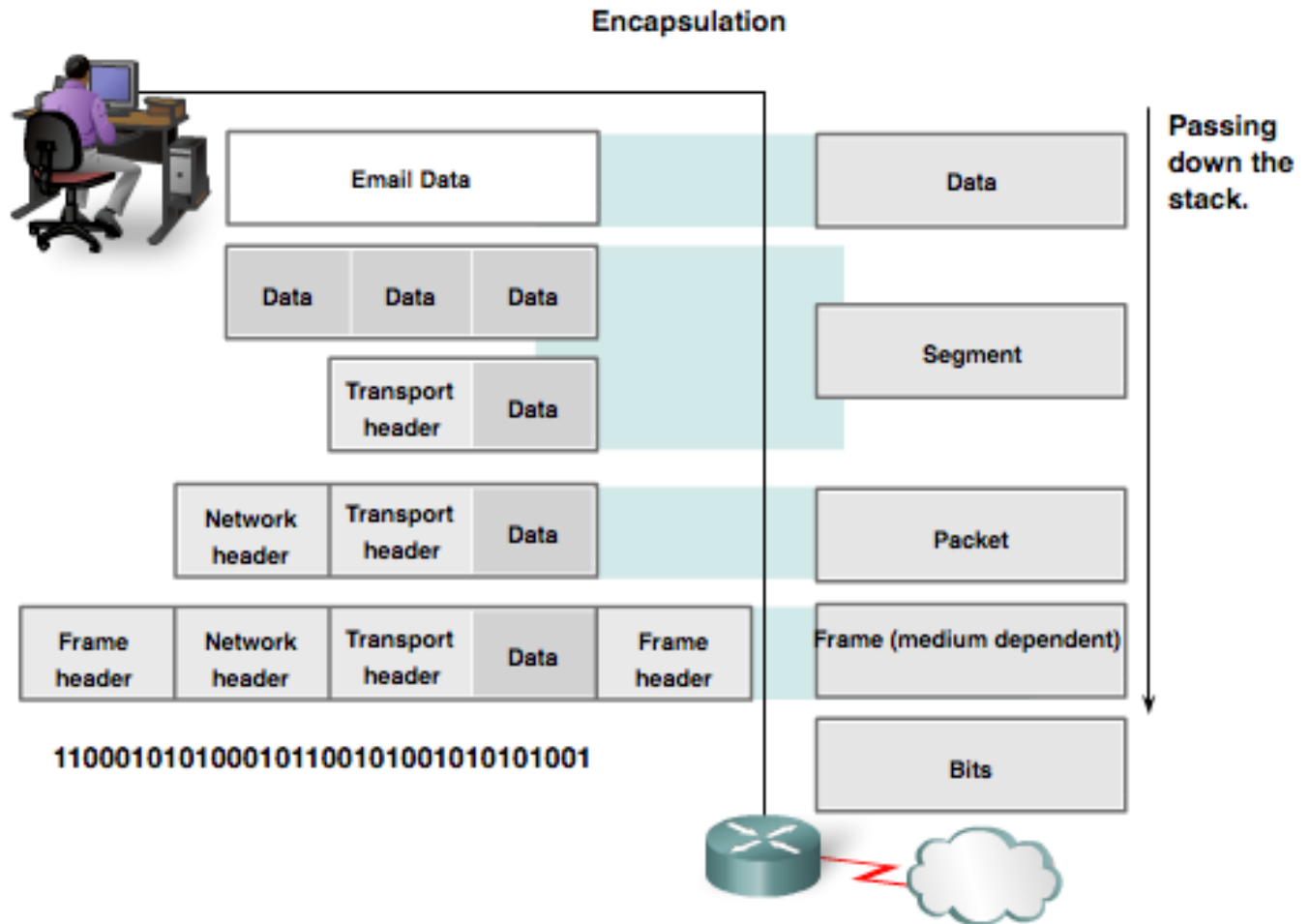
Sender
4085 SE Pine Street
Ocala, Florida 34471



Recipient
1400 Main Street
Canton, Ohio 44203

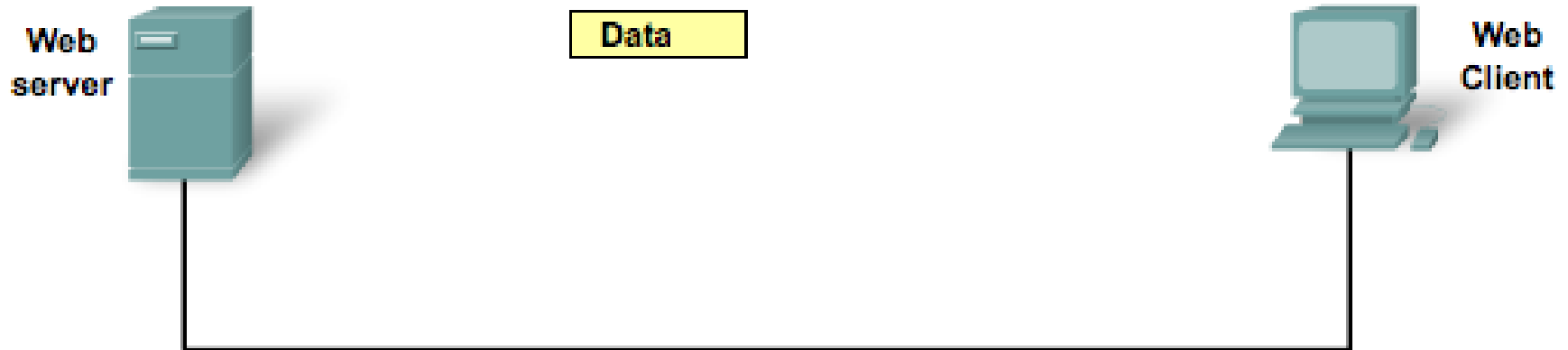
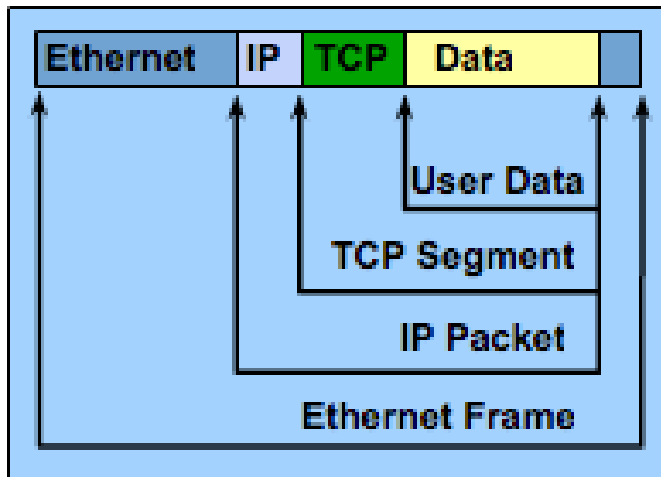
Protocol Data Units (PDUs)

- Data
- Segment
- Packet
- Frame
- Bits

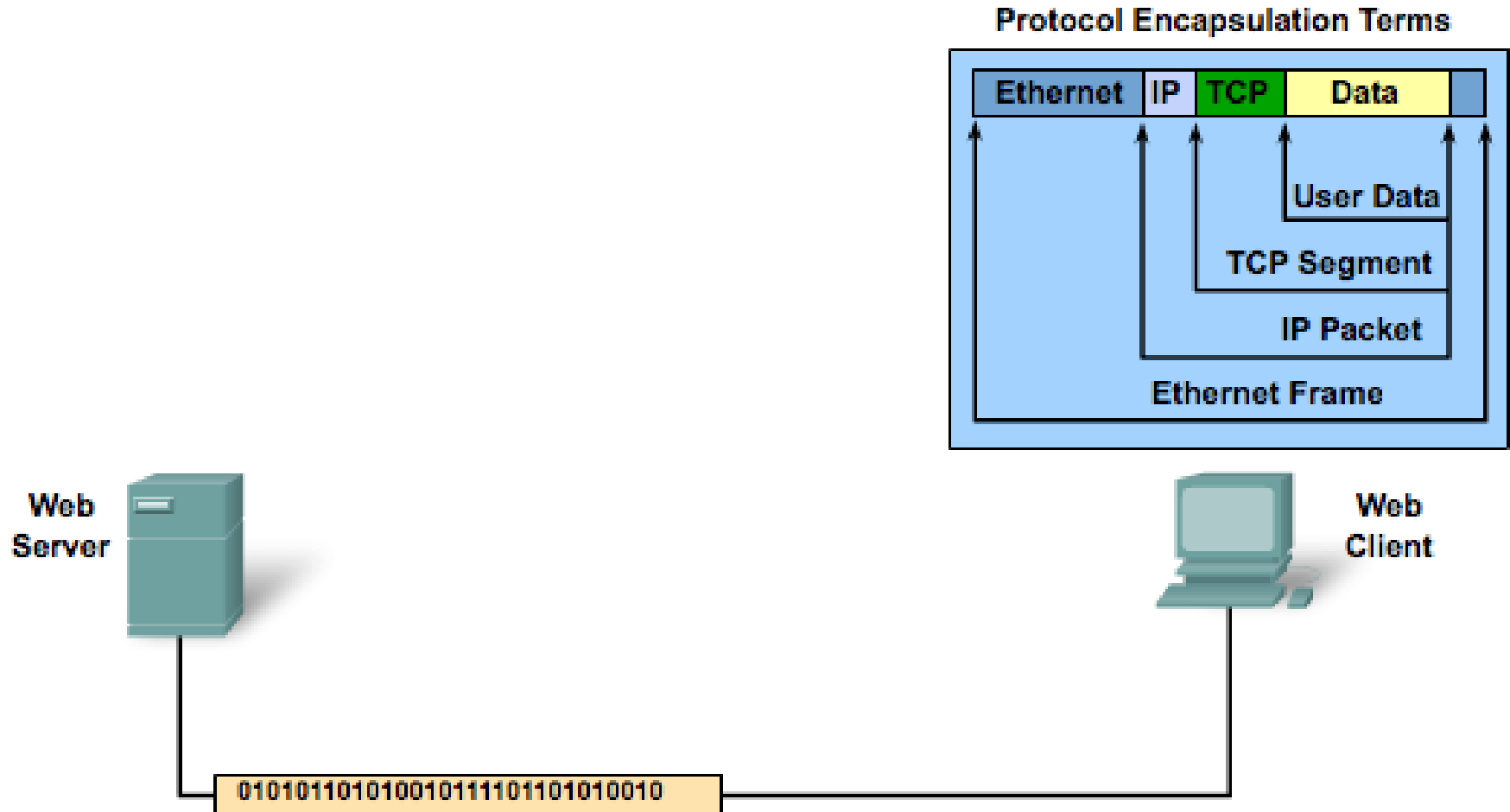


Protocol Encapsulation

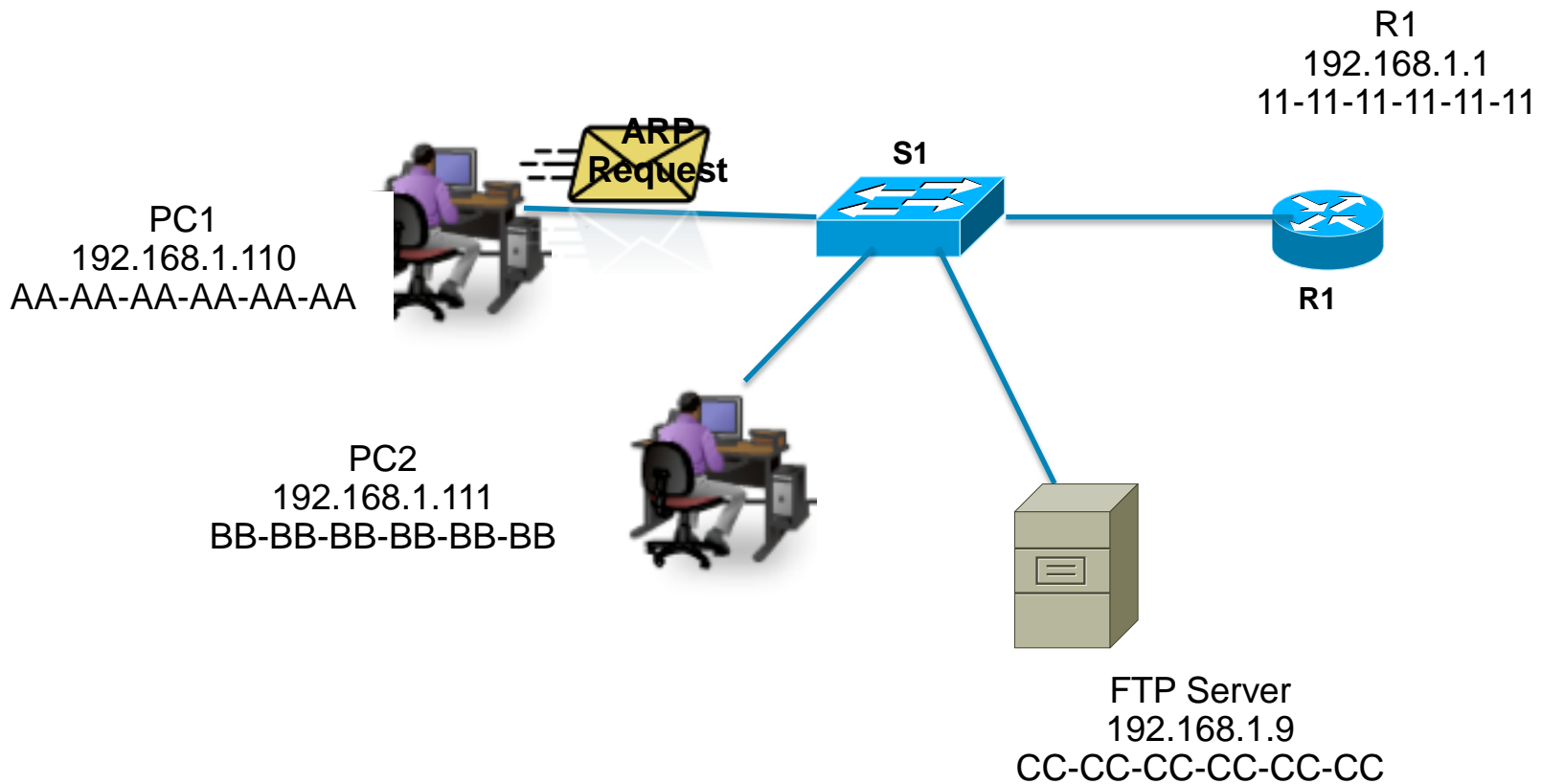
Protocol Encapsulation Terms



Protocol De-encapsulation



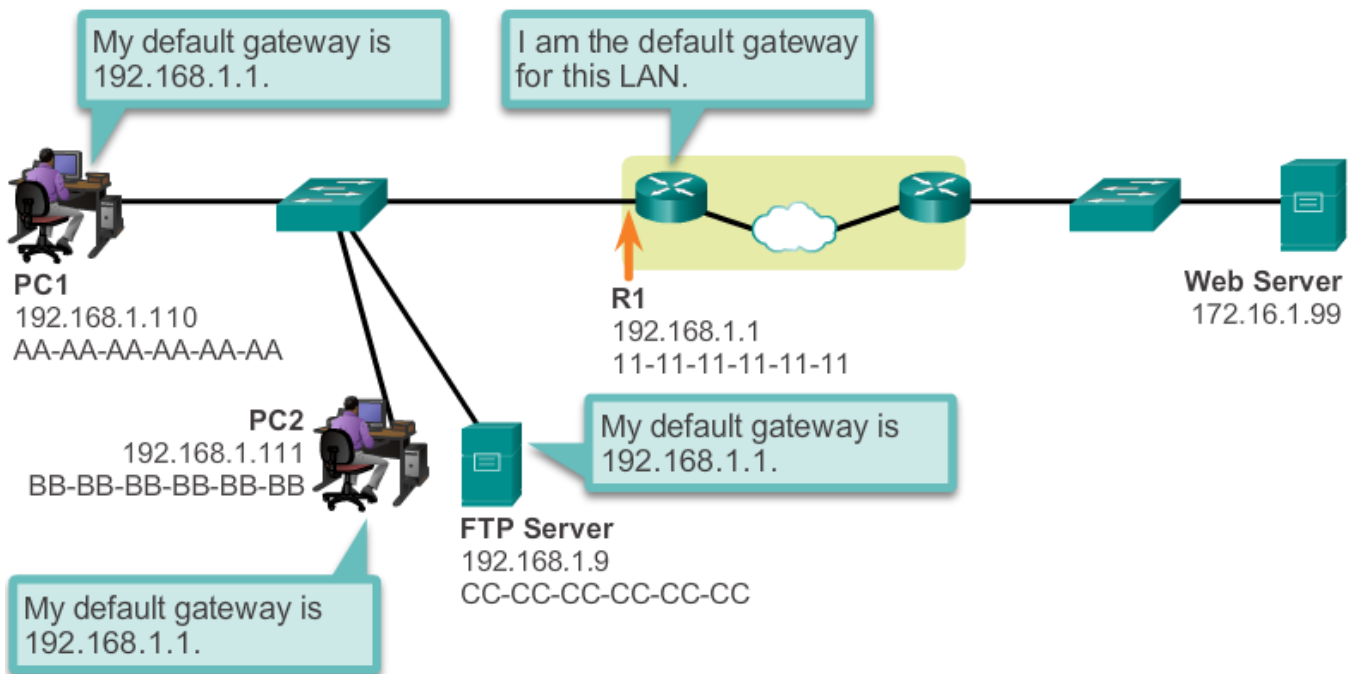
MAC and IP Addresses



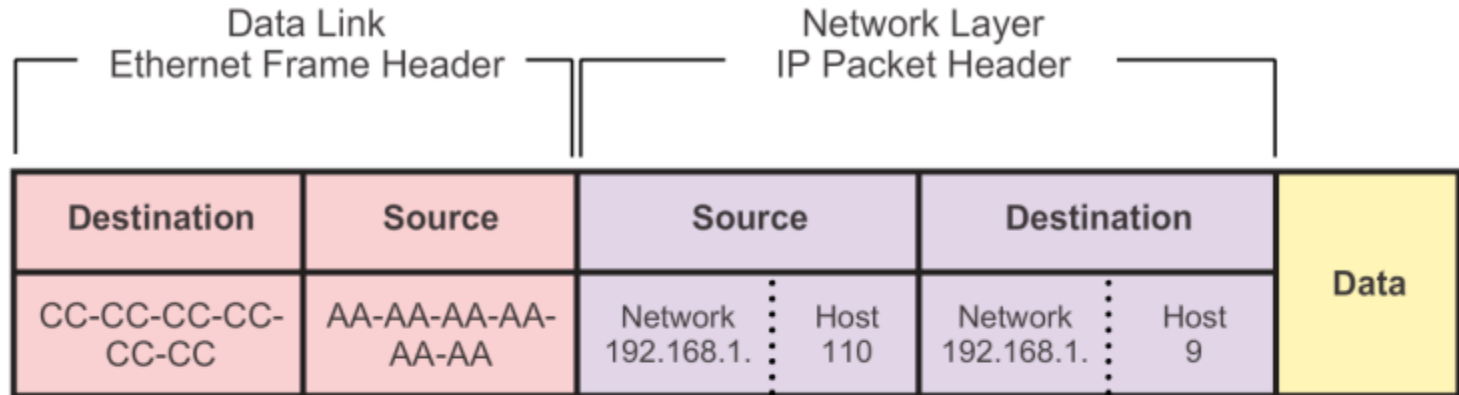
Default Gateway

Getting the Pieces to the Correct Network

Protocol Data Unit (PDU)				
Source		Destination		Data
Network 192.168.1	Device 110	Network 172.16.1	Device 99	



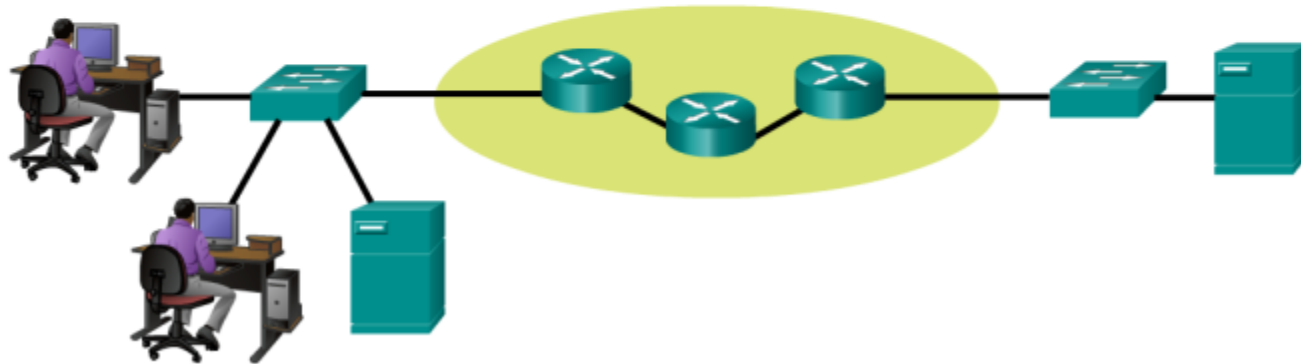
Communicating with Device / Same Network



PC1

192.168.1.110

AA-AA-AA-AA-AA-AA

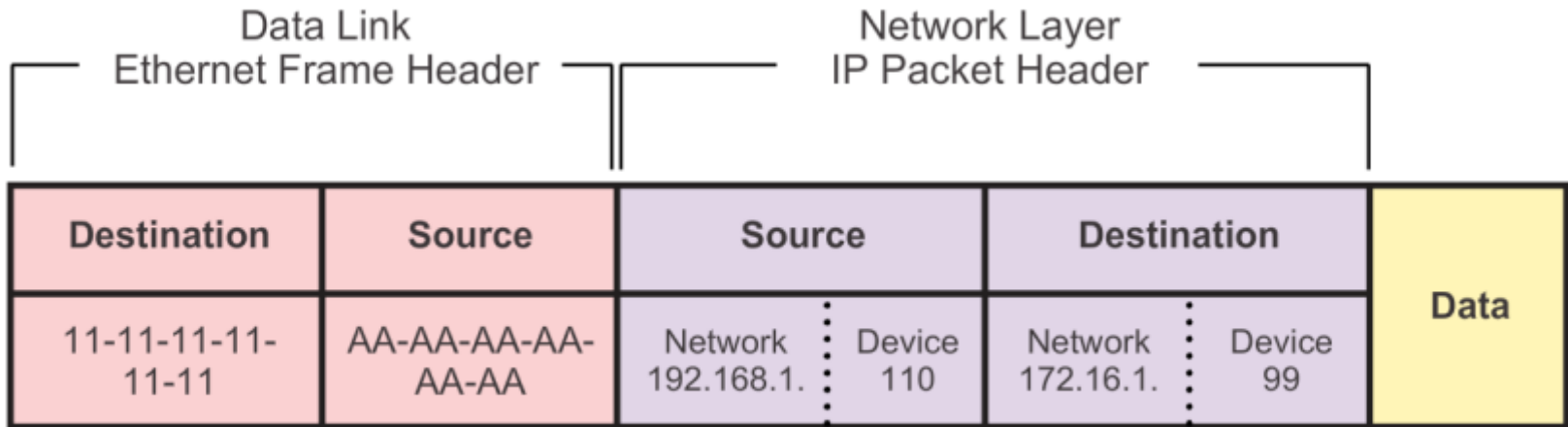


FTP Server

192.168.1.9

CC-CC-CC-CC-CC-CC

Communicating Device / Remote Network

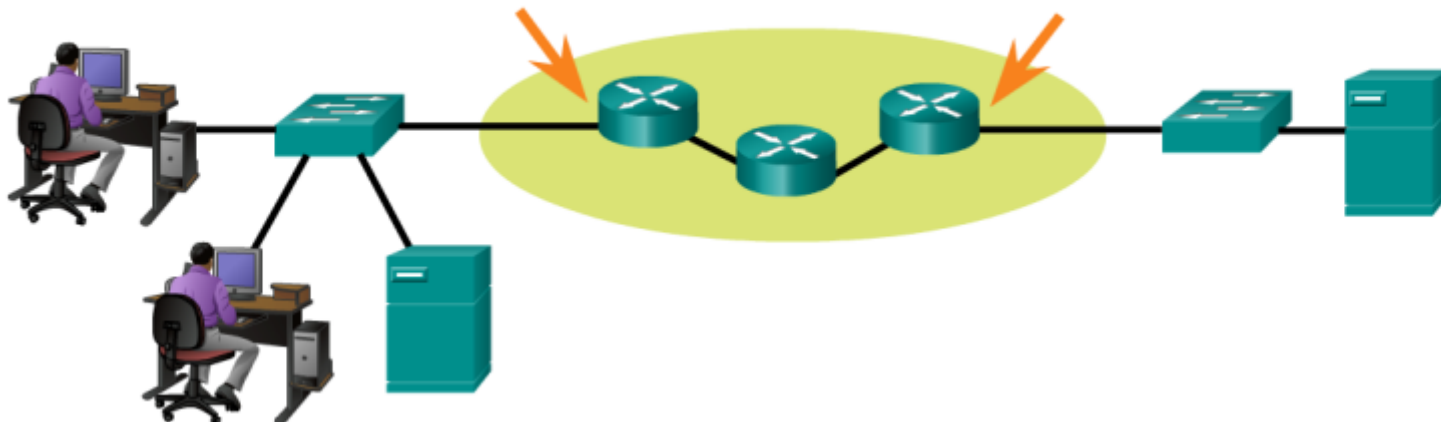


PC1
192.168.1.110
AA-AA-AA-AA-AA-AA

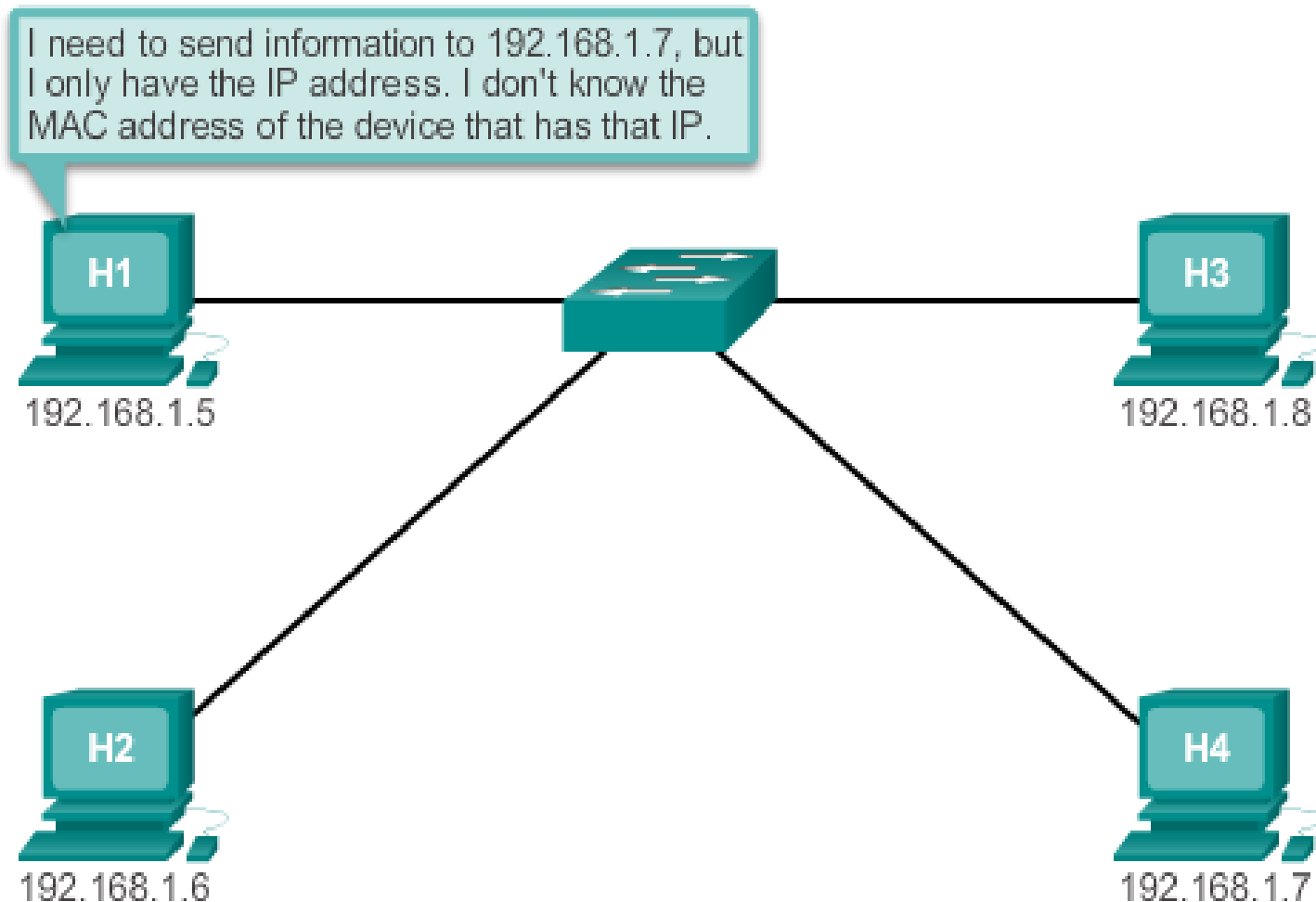
R1
192.168.1.1
11-11-11-11-11-11

R2
172.16.1.99
22-22-22-22-22-22

Web Server
172.16.1.99
AB-CD-EF-12-34-56



Address Resolution Protocol (ARP)



ARP Operation

ARP Table

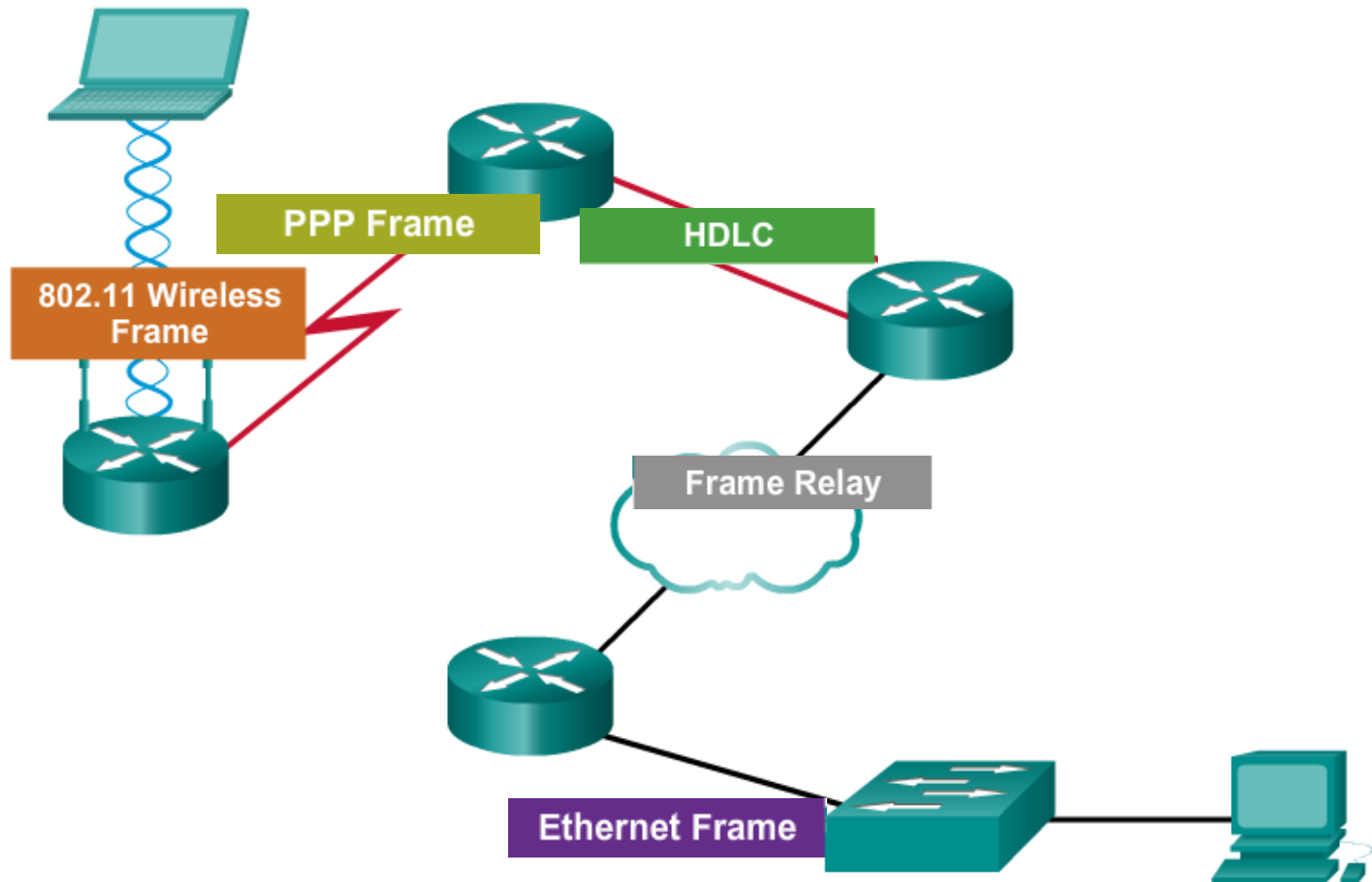
- Maps data link layer address to destination IPv4 address.
- As a node receives frames from the media, it records the source IP and MAC address as a mapping in the ARP table.

ARP Request

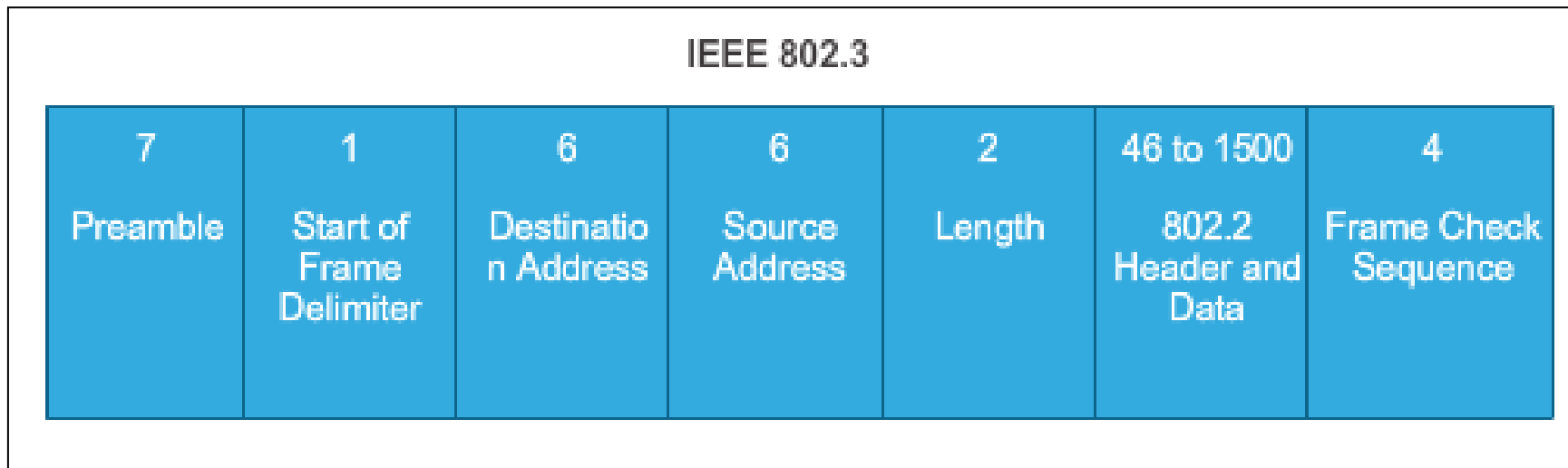
- Layer 2 broadcast to all devices on the Ethernet LAN.
- The node that matches the IP address in the broadcast will reply.
- If no device responds to the ARP request, the packet is dropped because a frame cannot be created.

LAN and WAN Frames

Examples of Layer 2 Protocols



Ethernet Frame format



Preamble and Start Frame Delimiter Fields –

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

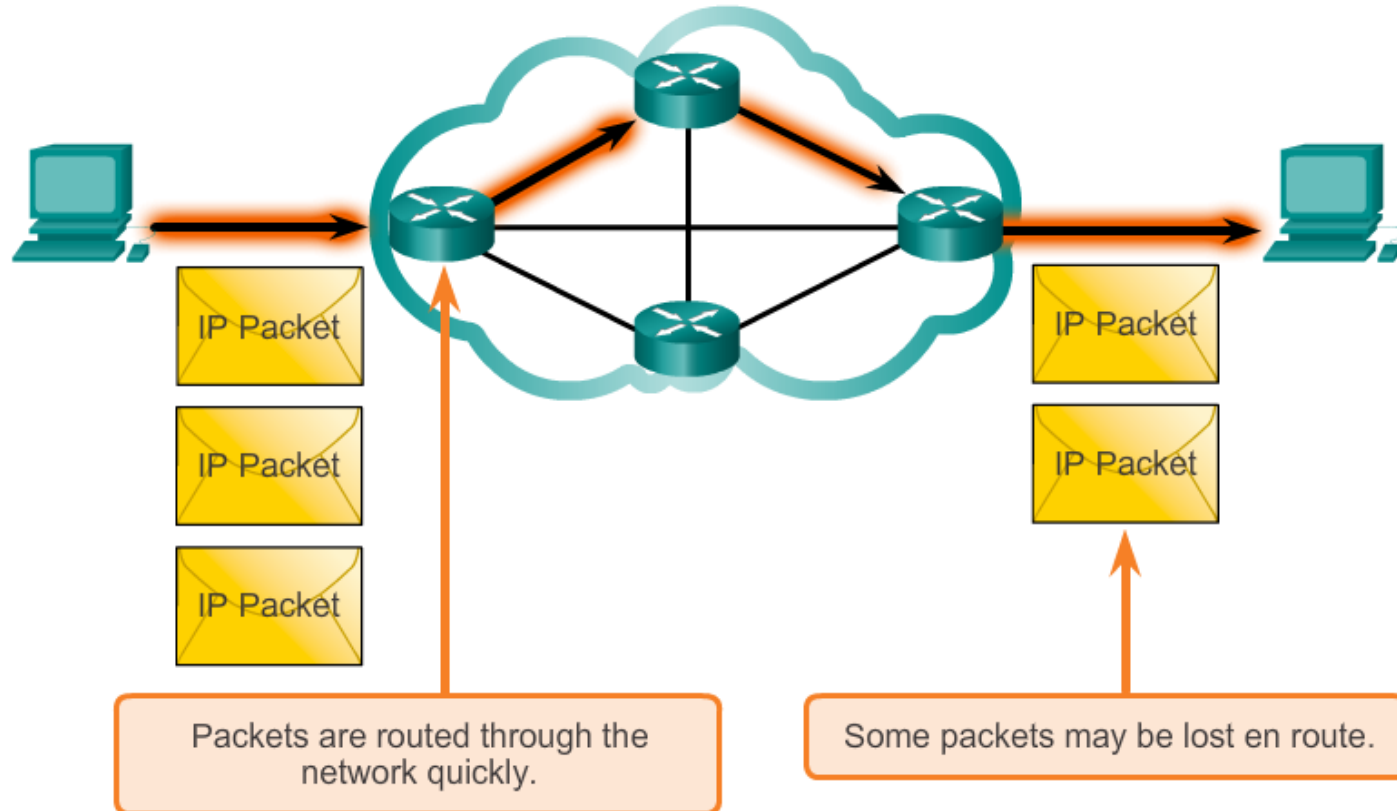
The network layer, or OSI Layer 3, provides services to allow end devices to exchange data across the network. To accomplish this end-to-end transport, the network layer uses four basic processes:

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

Network Layer Protocols

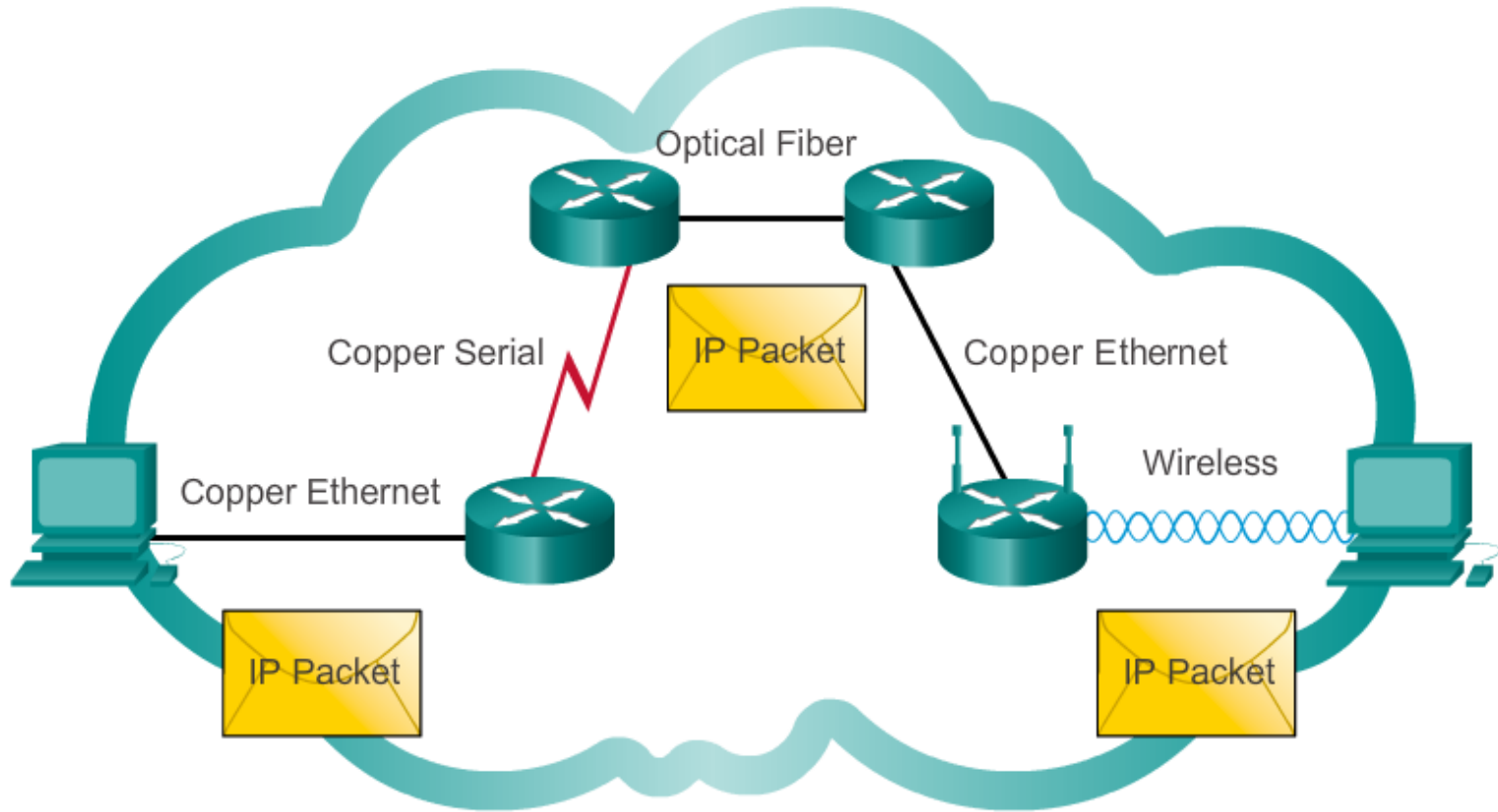
- IP version 4 (IPv4)
- IP version 6 (IPv6)

Best Effort Delivery



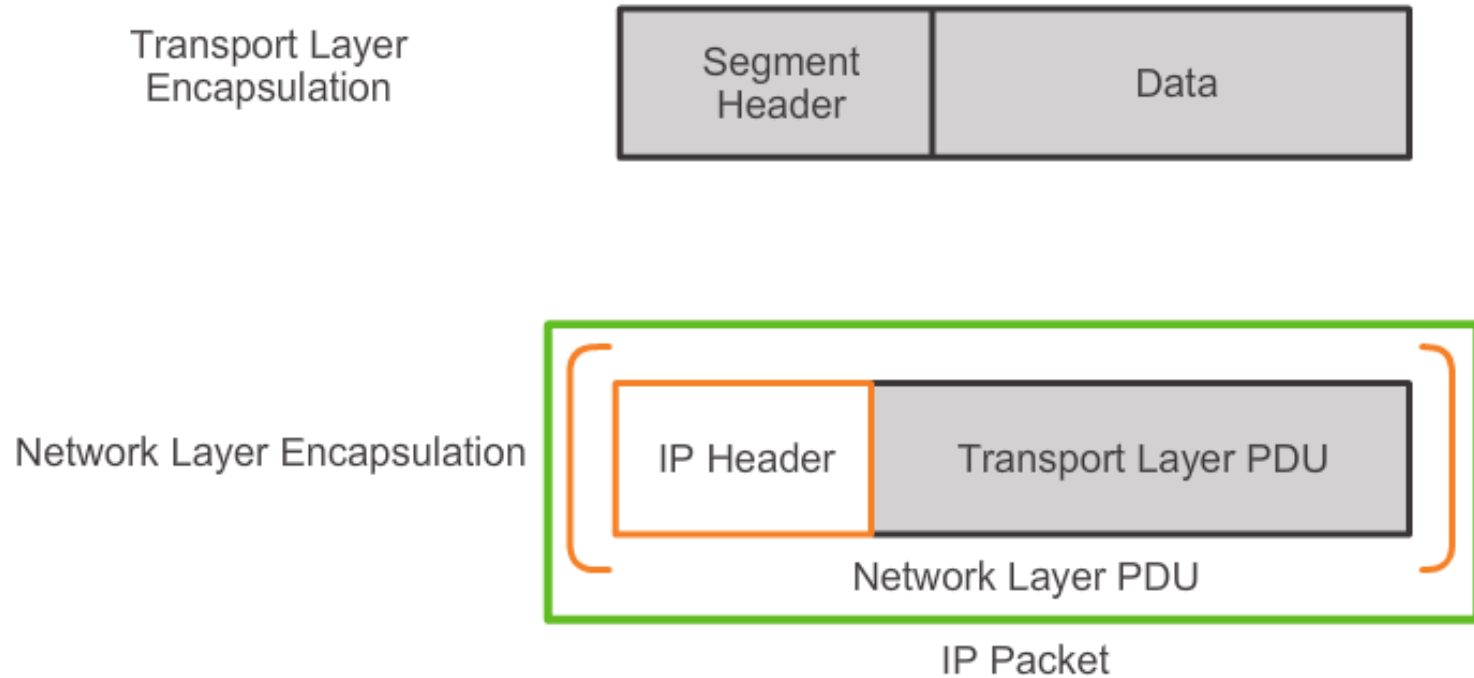
As an unreliable network layer protocol, IP does not guarantee that all sent packets will be received. Other protocols manage the process of tracking packets and ensuring their delivery.

IP – Media Independent



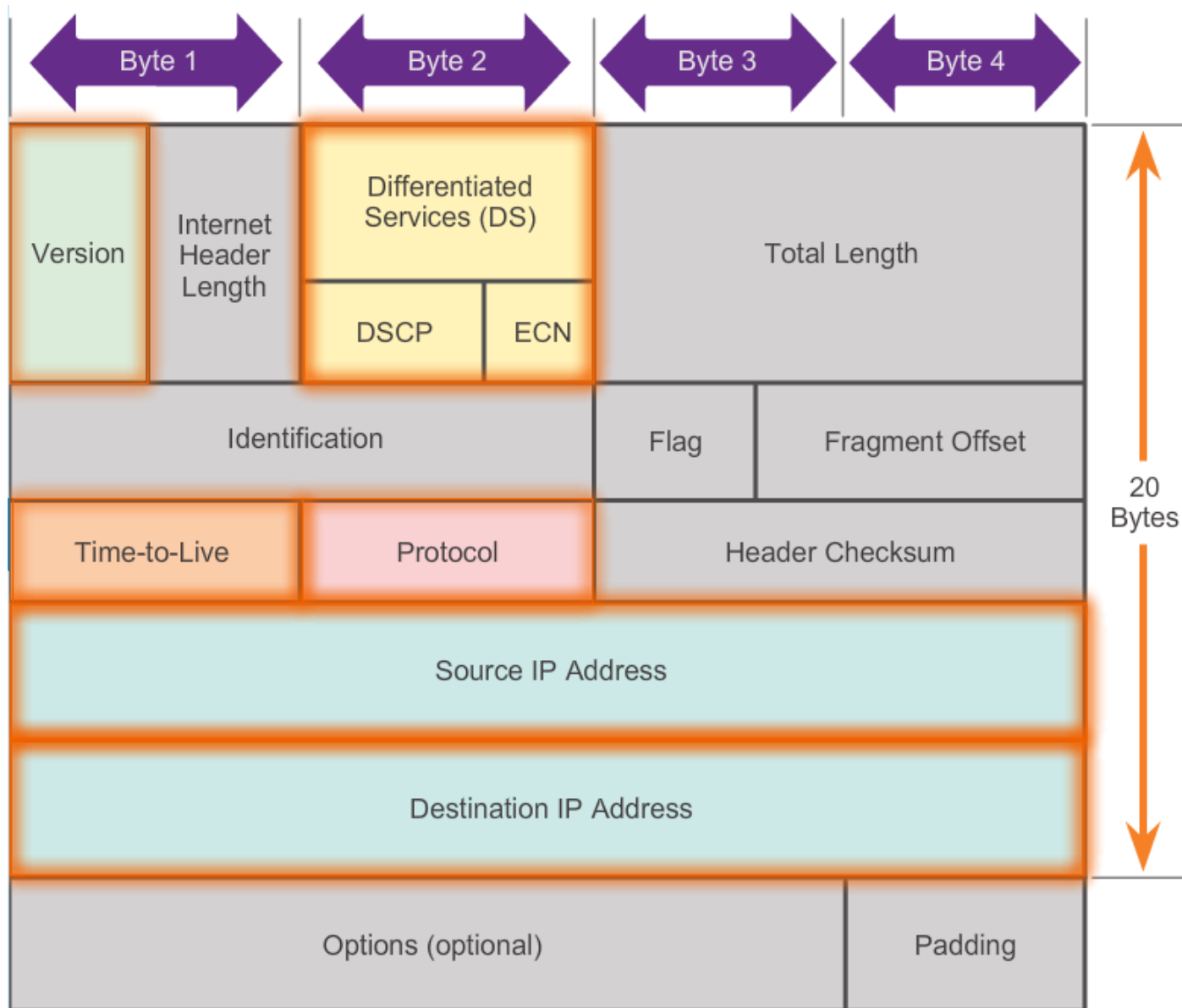
IP packets can travel over different media.

Encapsulating IP

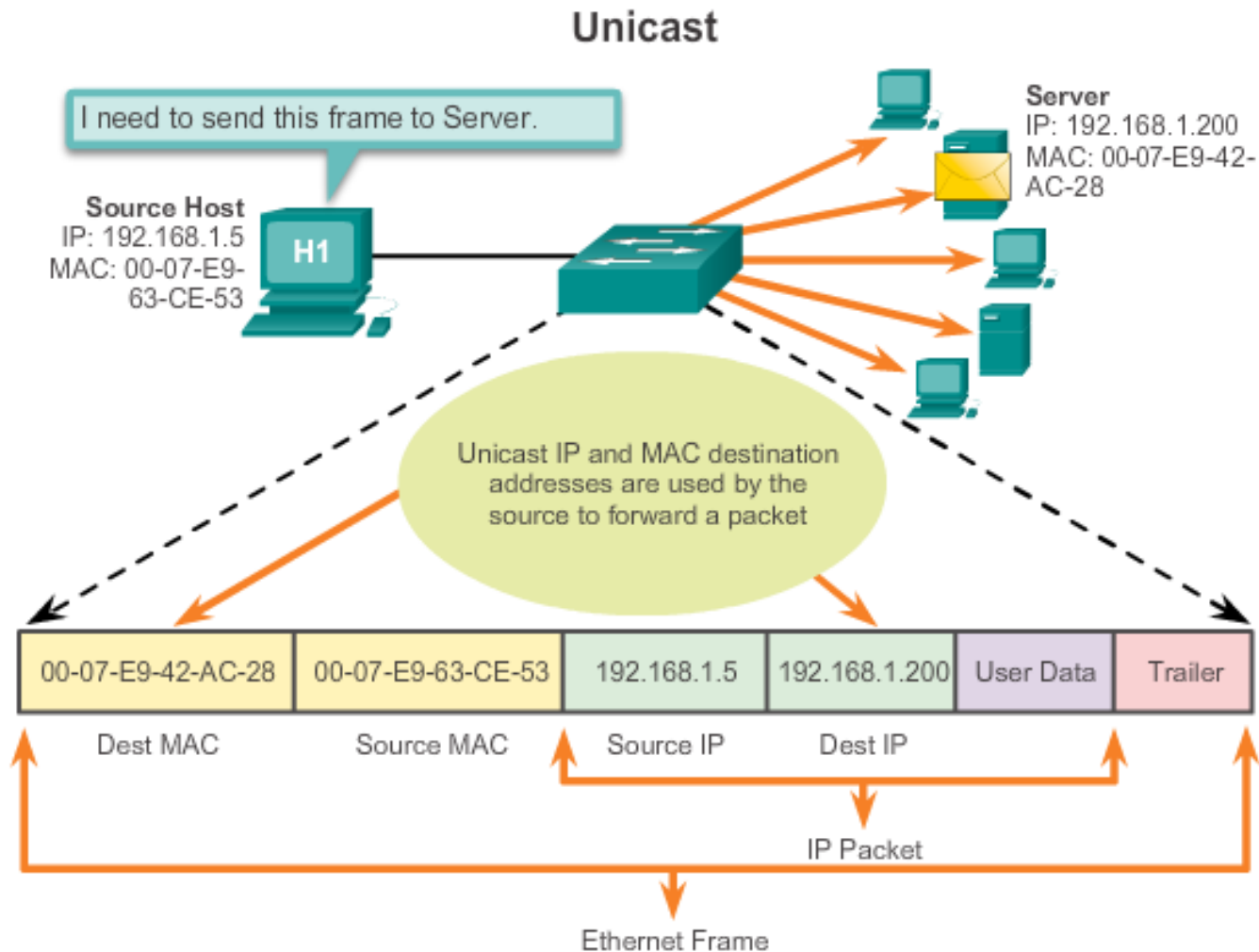


The network layer adds a header so packets can be routed through complex networks and reach their destination. In TCP/IP based networks, the network layer PDU is the IP packet.

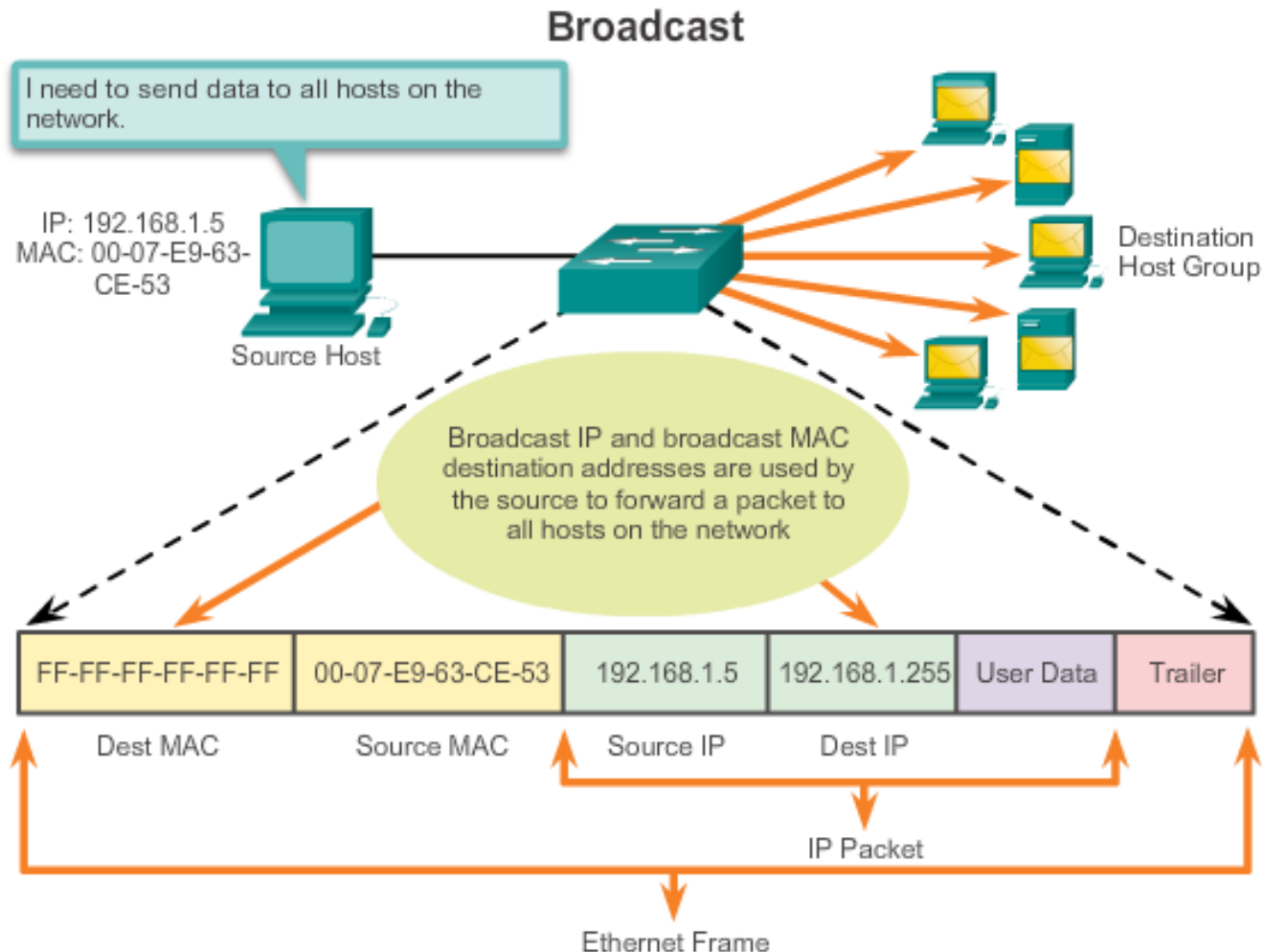
IPv4 Packet Header



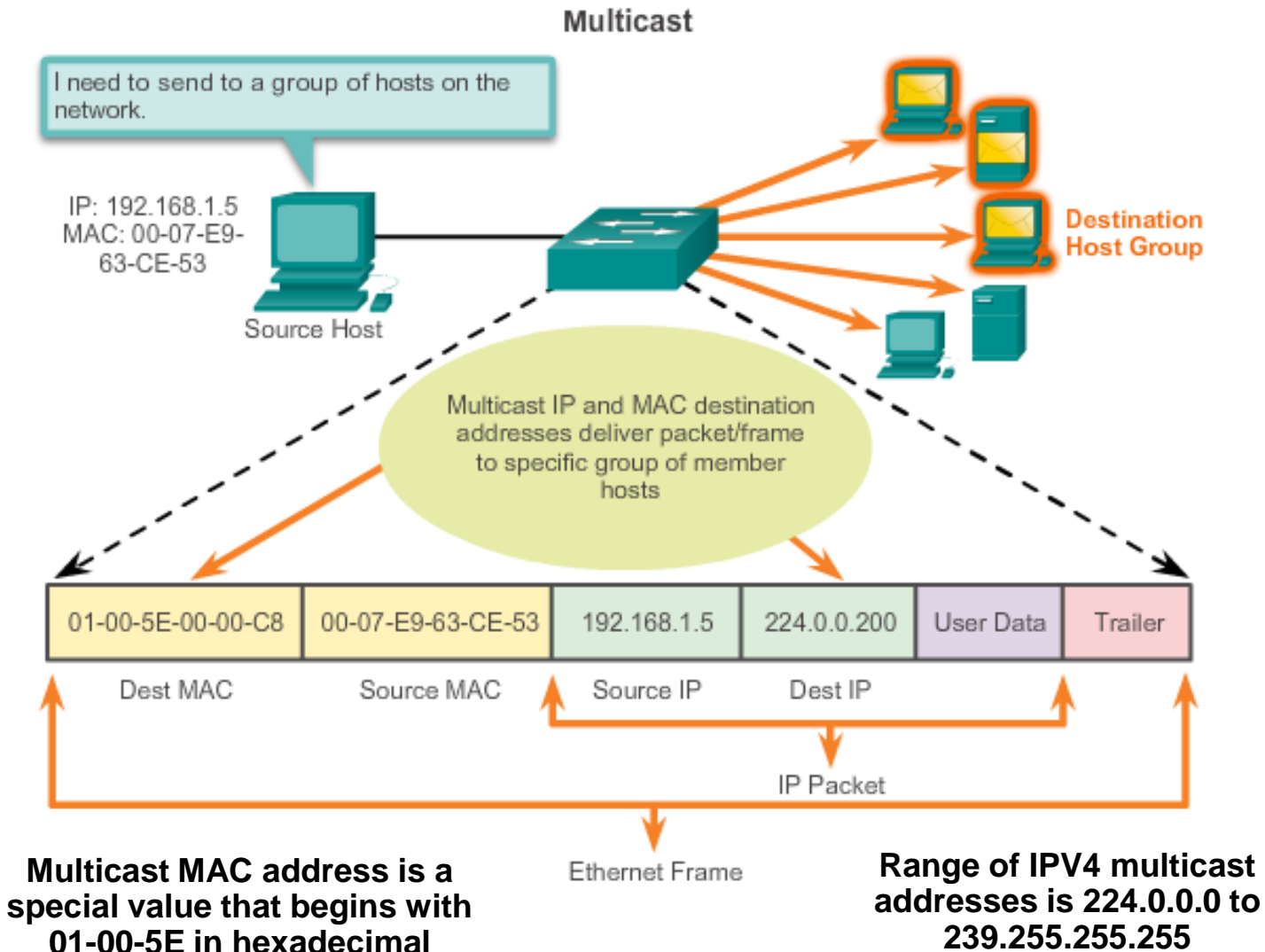
Unicast Address



Broadcast Address



Multicast Address



Sample IPv4 Headers in Wireshark

Microsoft: \\Device\\NPF_{7B83C130-30C5-4419-B79E-C0868085ABED} [Wireshark 1.8.2 (SVN Rev 44520 from /trunk-1.8)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
16	3.64050300	192.168.1.109	192.168.1.1	ICMP	74	Echo (ping) request id=0x0001, seq=5/1280, ttl=128
17	3.64506800	192.168.1.1	192.168.1.109	ICMP	74	Echo (ping) reply id=0x0001, seq=5/1280, ttl=64
18	3.68215500	192.168.1.109	38.112.107.53	TCP	54	55502 > https [ACK] Seq=1 Ack=134 win=16661 Len=0
19	4.19945400	fe80::15ff:98d8:d28ff02::c		SSDP	208	M-SEARCH * HTTP/1.1
20	4.60748800	fe80::15ff:98d8:d28ff02::b1ee:c4ae:a11		SSDP	453	HTTP/1.1 200 OK
21	4.64229900	192.168.1.109	192.168.1.1	ICMP	74	Echo (ping) request id=0x0001, seq=6/1536, ttl=128
22	4.64509200	192.168.1.1	192.168.1.109	ICMP	74	Echo (ping) reply id=0x0001, seq=6/1536, ttl=64
23	4.73605200	192.168.1.109	255.255.255.255	DB-LSP-	154	Dropbox LAN svnc Discoverv Protocol

Frame 16: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0

Ethernet II, Src: IntelCor_45:5d:c4 (24:77:03:45:5d:c4), Dst: Cisco-Li_a0:d1:be (00:18:39:a0:d1:be)

Internet Protocol Version 4, Src: 192.168.1.109 (192.168.1.109), Dst: 192.168.1.1 (192.168.1.1)

- Version: 4
- Header length: 20 bytes
- Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
- Total Length: 60
- Identification: 0x3704 (14084)
- Flags: 0x00
- Fragment offset: 0
- Time to live: 128
- Protocol: ICMP (1)
- Header checksum: 0x7ffe [correct]
- Source: 192.168.1.109 (192.168.1.109)
- Destination: 192.168.1.1 (192.168.1.1)
- [Source GeoIP: Unknown]
- [Destination GeoIP: Unknown]

Internet Control Message Protocol

Offset	Hex	ASCII
0000	00 18 39 a0 d1 be 24 77 03 45 5d c4 08 00 45 00	..9...\$w .E]...E.
0010	00 3c 37 04 00 00 80 01 7f fe c0 a8 01 6d c0 a8	..<7.... ..m..
0020	01 01 08 00 4d 56 00 01 00 05 61 62 63 64 65 66	...MV.. ..abcder
0030	67 68 69 6a 6b 6c 6d 6e 6f 70 71 72 73 74 75 76	ghijklmn opqrstuv
0040	77 61 62 63 64 65 66 67 68 69	wab cdefg hi

Internet Protocol Version 4 (IP), 20 bytes | Packets: 35 Displayed: 35 Marked: 0 Dropped: 0 | Profile: Default

Limitations of IPv4

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



IPv6

- [illegible]

IPv4 and IPv6 Headers

IPv4 and IPv6 Headers





IPv4 Header

Version	IHL	Type of Service	Total Length	
Identification			Flags	Fragment Offset
Time to Live	Protocol		Header Checksum	
Source Address				
Destination Address				
Options			Padding	

IPv6 Header

Version	Traffic Class	Flow Label	
Payload Length		Next Header	Hop Limit
Source Address			
Destination Address			

Legend

-  - Field names kept from IPv4 to IPv6
-  - Fields not kept in IPv6
-  - Name & position changed in IPv6
-  - New field in IPv6

IPv6 Packet Header

