



# CISCO CCNA1

## CCNA Routing and Switching: Introduction to Networks

## HOOFDSTUK 3

### Network Protocols and Communications

#### DE HOGESCHOOL MET HET NETWERK

Hogeschool PXL – Elfde-Liniestraat 24 – B-3500 Hasselt  
[www.pxl.be](http://www.pxl.be) - [www.pxl.be/facebook](http://www.pxl.be/facebook)

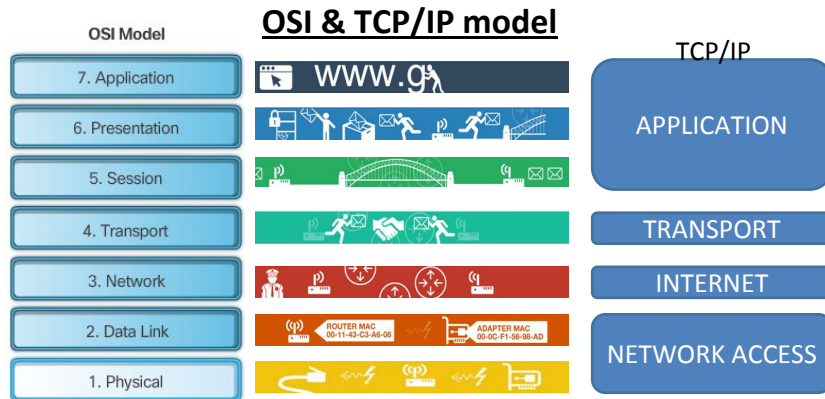


# CCNA1 - Overzicht

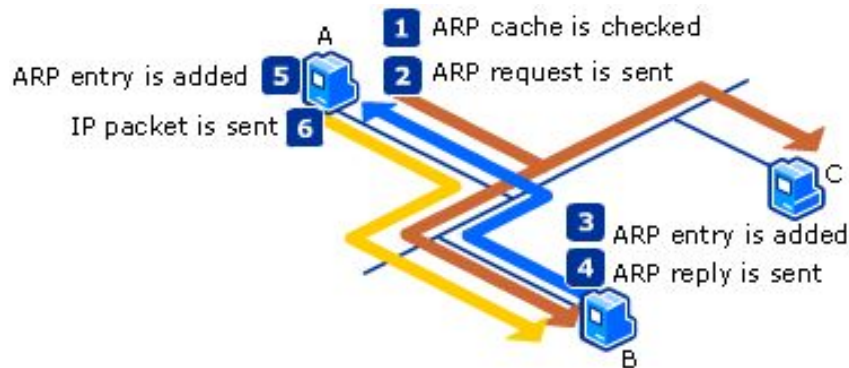
- OSI model en de belangrijkste (LAN) protocollen.
- Data Flow in een LAN  
(verklaring volgens het OSI model).
- IP en subnetting.
- Het toepassen en onderzoeken van bovenstaande 3 in Packettrace oefeningen.

# CCNA1 - Overzicht

## 1. OSI model en de belangrijkste (LAN) protocollen.



## 2. Data Flow in een LAN (verklaring volgens het OSI model)



## 3. IP en subnetting

# Situering hoofdstuk 3

In dit hoofdstuk worden het TCP/IP-model en het OSI-model besproken en in praktijk bekeken .

Het eerste deel van dit hoofdstuk (3.1 & 3.2) bespreek het OSI & TCP/IP model. Aan de hand van deze modellen worden verschillende items besproken; de meest gebruikte protocollen, adressering, data-flow, encapsulation, ... .

Het tweede deel (3.3) beschrijft de data transfer in een netwerk. Hoe worden te versturen gegevens opgebouwd en wat is het gebruik van network(IP)- en datalink (MAC) adres. (Dit komt nog uitgebreid aan bod in chapter 4,5,6)

## Doelstellingen:

- Ken en begrijp het OSI & TCP/IP model!
- Weet waar het model gebruikt wordt en waarom het zo belangrijk is.
- Ken en begrijp het proces van (de-) encapsulation. ( + PDU benamingen !)
- Ken en begrijp de meest voorkomende protocollen. Afkorting, omschrijving en situering in het OSI model. Dit komt in volgende hoofdstukken uitgebreid terug.
- Ken en begrijp het verschil tussen netwerk adressering (IP/logisch) en data-link adressering (MAC/fysisch). Wat gebeurt er bij datacommunicatie in éénzelfde netwerk t.o.v. in een remote network? (Dit komt in volgende hoofdstukken terug.)
- Gebruik packettracer als ondersteuning. De PT oefening omschrijft een eenvoudig netwerk, analyseer het netwerk a.d.h.v. het OSI model. Bekijk de 'events' in PT en bestudeer de protocollen.
- De slides in summary zijn zeer belangrijk. Dergelijke schema's ken je als netwerker als de binnenkant van je broekzak! Let op, leer niet enkel van buiten, maar BEGRIJP!

## Activity en PT:

- 3.2.2.5 Mapping the protocols
- 3.2.4.5 Identify layers and functions
- 3.3.1.5 Identify the PDU Layer
- 3.2.4.6 PT-Investigating the TCP/IP and OSI models in action

## Leertip:

Lees het hoofdstuk aandachtig en zorg dat je de activiteiten vlot kan. De samenvattende slides geven het hele hoofdstuk in één oogopslag.

**Zie leerpapier op blackboard!**

# Chapter 3: Network Protocols and Communications

Introduction to Networks v5.1



# Chapter Outline

3.0 Introduction

3.1 Rules of Communication

3.2 Network Protocols and  
Standards

3.3 Data Transfer in the Network

3.4 Summary

# Section 3.1:

## Rules of Communication

### 3.1.1: The Rules

## 3.1.1: The Rules

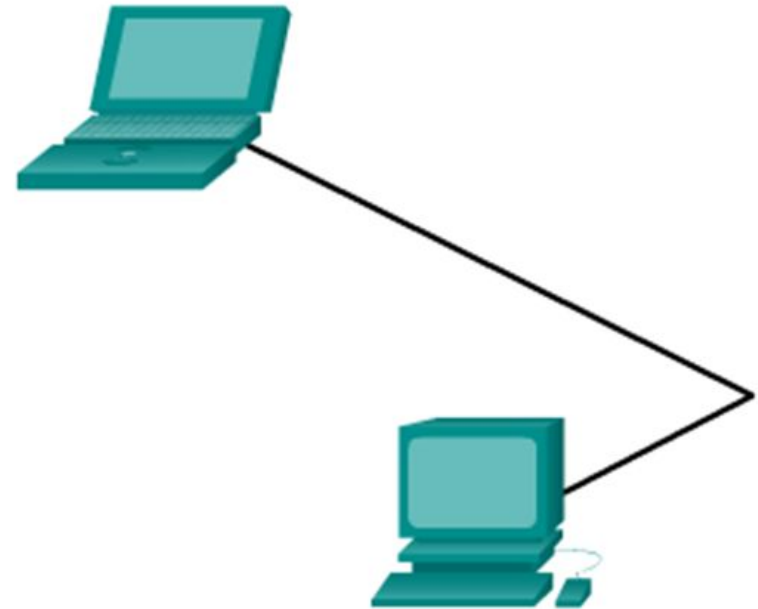
### 3.1.1.1 Communication Fundamentals



Human Communication



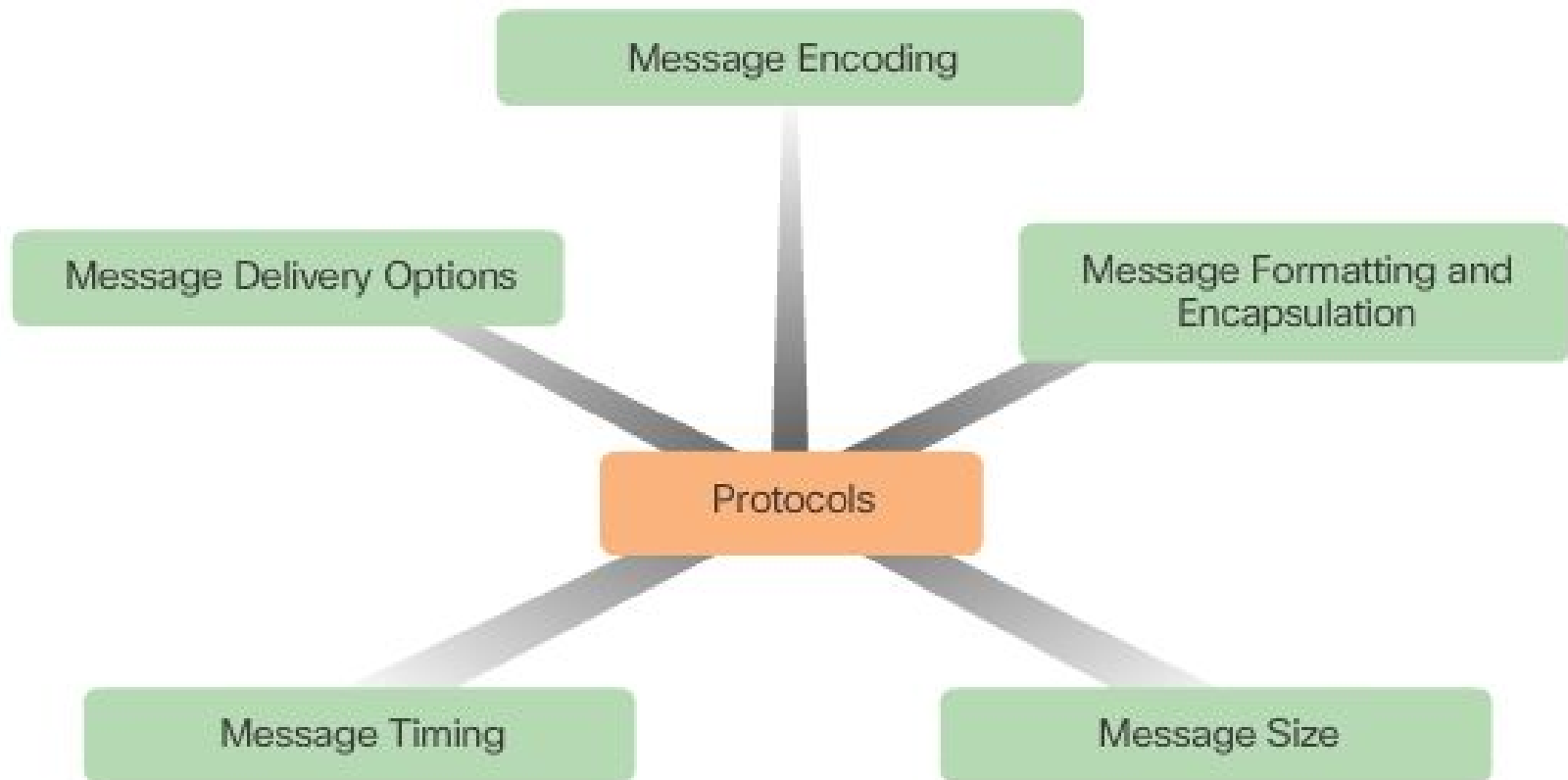
Computer Communication





## 3.1.1: The Rules

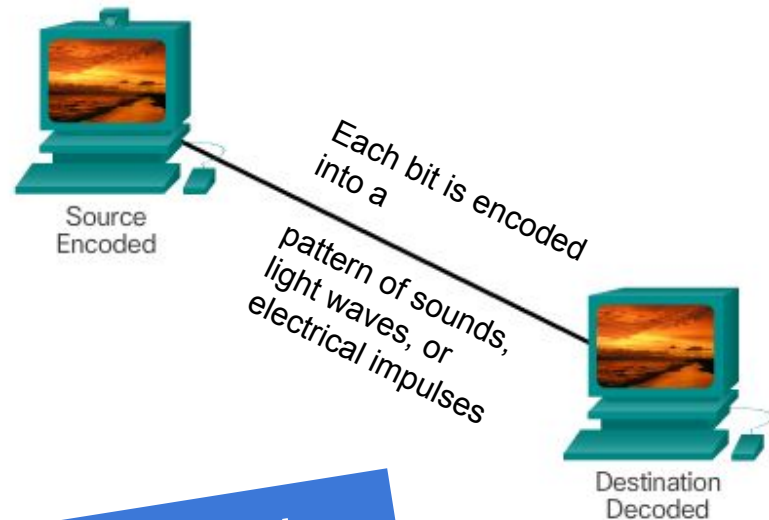
### 3.1.1.2 Rule Establishment



see next slides

## 3.1.1: The Rules

### 3.1.1.3 Message Encoding



see animation online

## 3.1.1: The Rules

### 3.1.1.4 Message Formatting and Encapsulation

a message must use  
a specific format and  
structure



letter is encapsulated in an envelope

Destination (physical / hardware address)	Source (physical / hardware address)	Start Flag (start of message indicator)	Recipient (destination identifier)	Sender (source identifier)	Encapsulated Data (bits)	End of Frame (end of message indicator)
Frame Addressing		Encapsulated Message				

see animation online

## 3.1.1: The Rules

### 3.1.1.5 Message Size

- The source host breaks a long message into individual pieces or frames that meet both the minimum and maximum size requirements.
- Each frame will also have its own addressing information.
- At the receiving host, the pieces are reconstructed to be processed and interpreted.

### 3.1.1.6 Message Timing

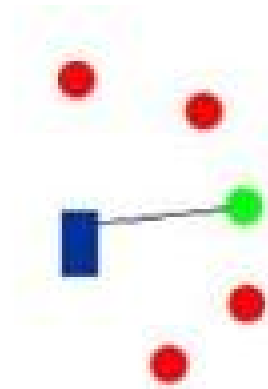
- Access Method → Do not talk at the same time
- Flow Control → Do not talk too fast
- Response Timeout → How long to wait for a response

## 3.1.1: The Rules

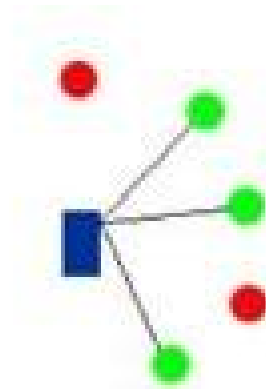
### 3.1.1.7 Message Delivery Options

- Unicast
- Multicast
- Broadcast

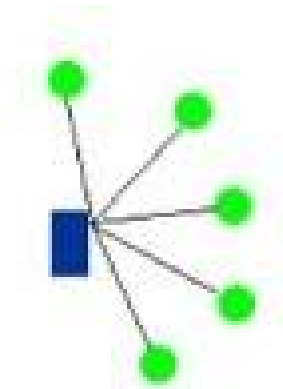
see animation online



Unicast



Multicast



Broadcast

# Section 3.2:

## Network Protocols and Standards

3.2.1: Protocols

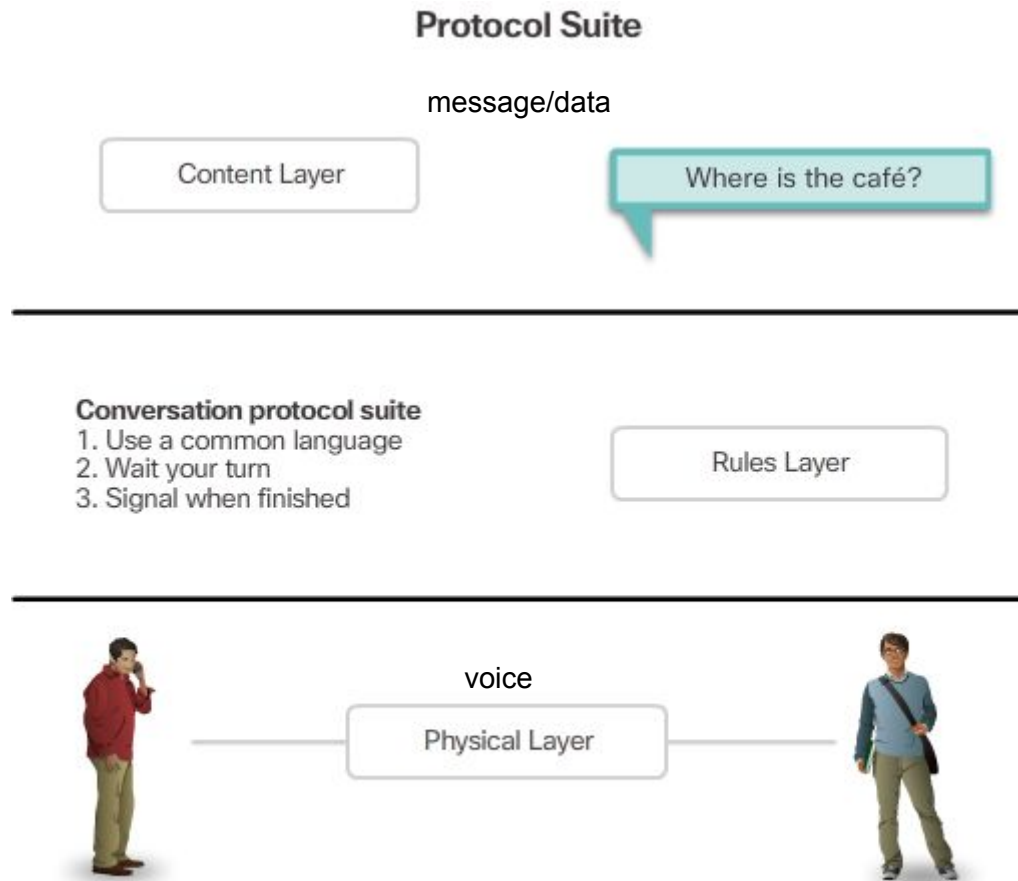
3.2.2: Protocol Suites

3.2.3: Standard Organizations

3.2.4: Reference Models

## 3.2.1: Protocols

### 3.2.1.1 Rules that Govern Communications



Protocol suites are sets of rules that work together to help solve a problem.

## 3.2.1: Protocols

### 3.2.1.2 Network Protocols

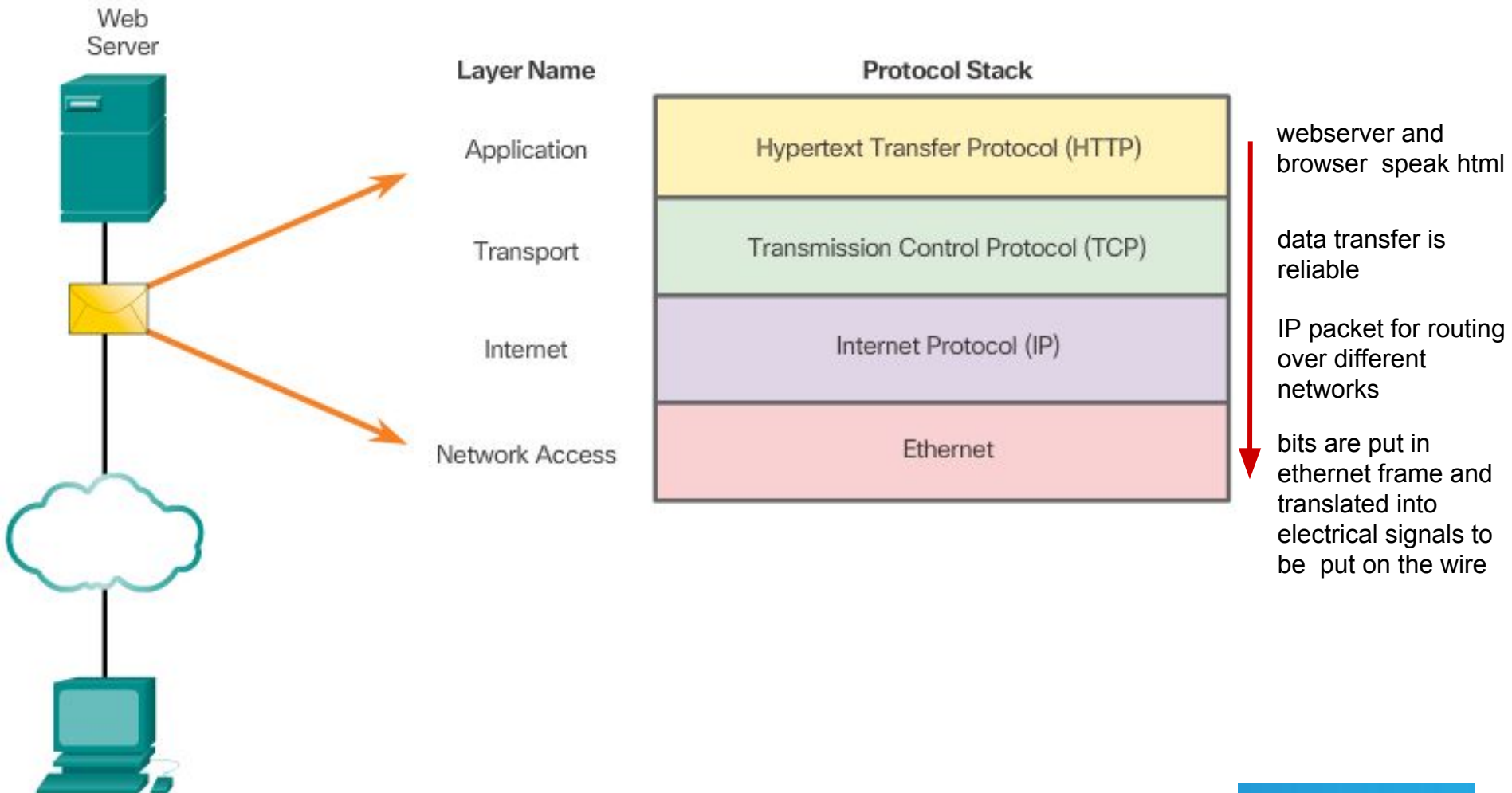
- The role of protocols
- How the message is formatted or structured
- The process by which networking devices share information about pathways with other networks
- How and when error and system messages are passed between devices
- The setup and termination of data transfer sessions



## 3.2.1: Protocols


### 3.2.1.3 Protocol Interaction

Interaction of protocols in communication between a web server and web client.



## 3.2.2: Protocol Suites

### 3.2.2.1 Protocol Suites and Industry Standards



Layer Name	TCP/IP	ISO	AppleTalk	Novell Netware
Application	HTTP DNS DHCP FTP	ACSE ROSE TRSE SESE	AFP	NDS
Transport	TCP UDP	TP0 TP1 TP2 TP3 TP4	ATP AEP NBP RTMP	SPX
Internet	IPv4 IPv6 ICMPv4 ICMPv6	CONP/CMNS CLNP/CLNS	AARP	IPX
Network Access	Ethernet    PPP    Frame Relay    ATM    WLAN			

## 3.2.2: Protocol Suites

### 3.2.2.2 Development of TCP/IP

2011

The first World IPv6 Day (June 8, 2011), many websites and Internet service providers around the world, including Google, Facebook, and Yahoo!, participated with more than 1,000 other companies for a worldwide trial of IPv6.

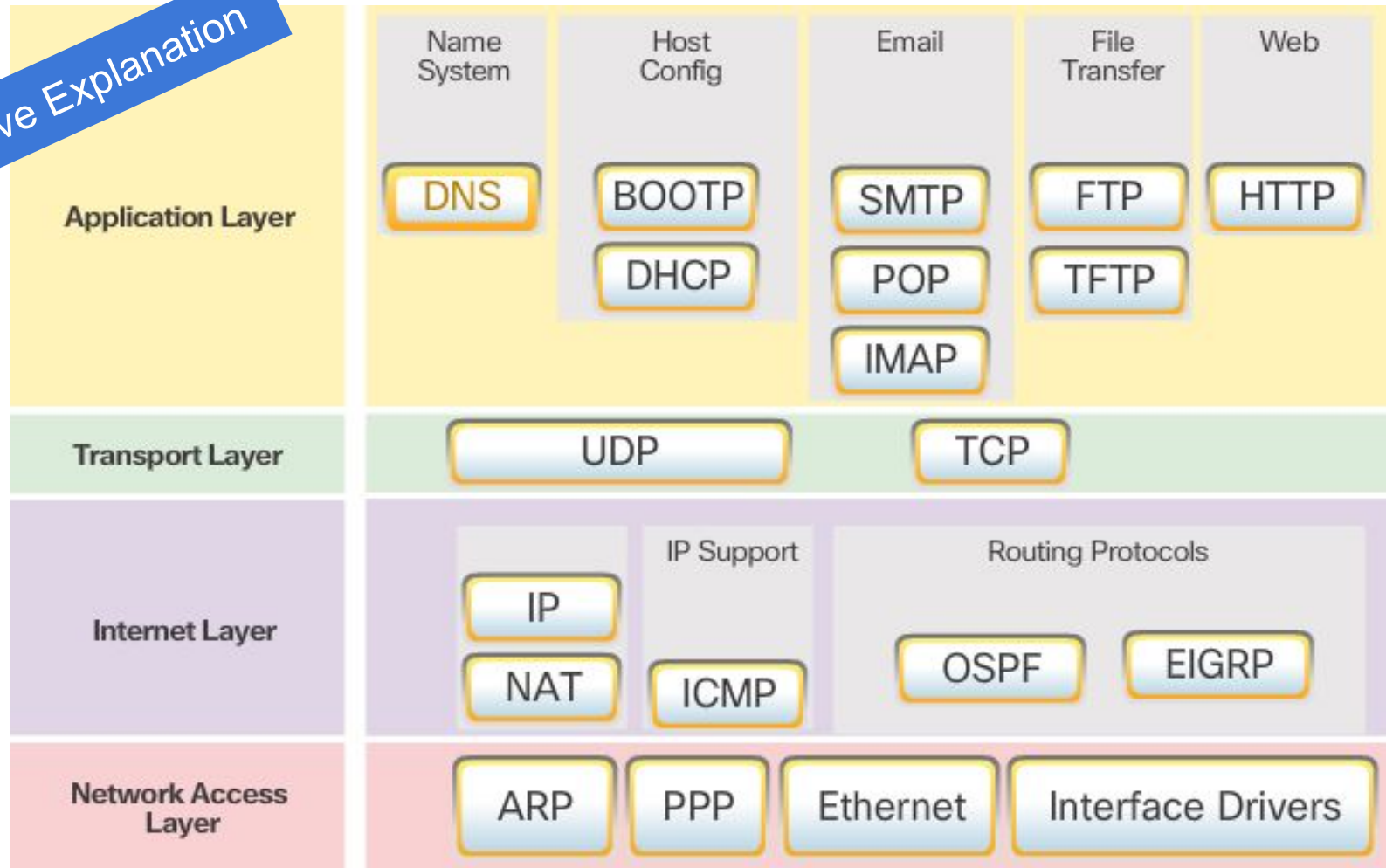


@Home

## 3.2.2: Protocol Suites

### 3.2.2.3 TCP/IP Protocol Suite

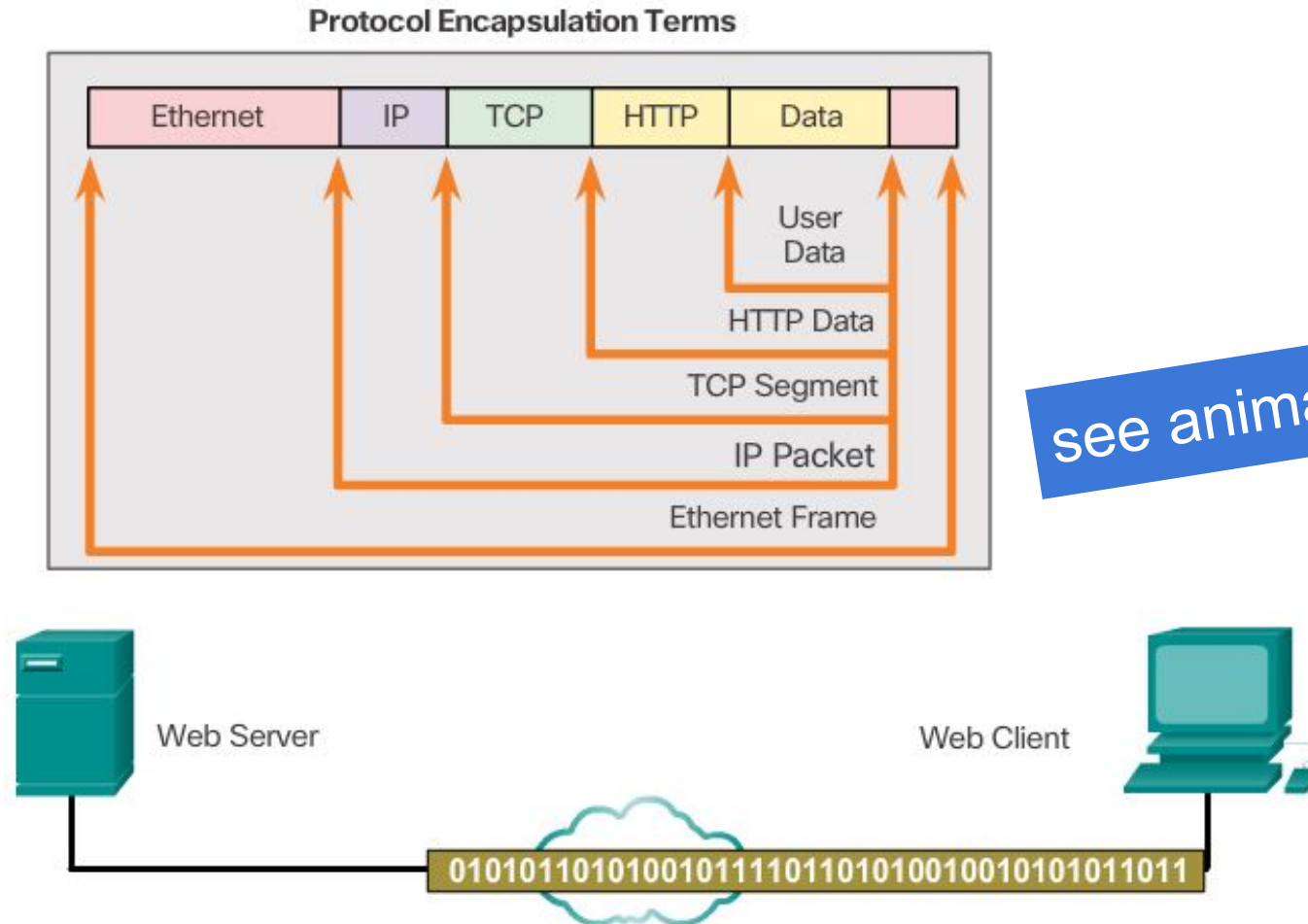
Interactive Explanation



## 3.2.2: Protocol Suites

### 3.2.2.4 TCP/IP Communication Process

#### Protocol Operation - Sending a Message



see animation online

## 3.2.2: Protocol Suites

### 3.2.2.5 Activity - mapping the protocols

#### Activity - Protocols and Layers

Drag the protocol or standard to the TCP/IP layer name as described.

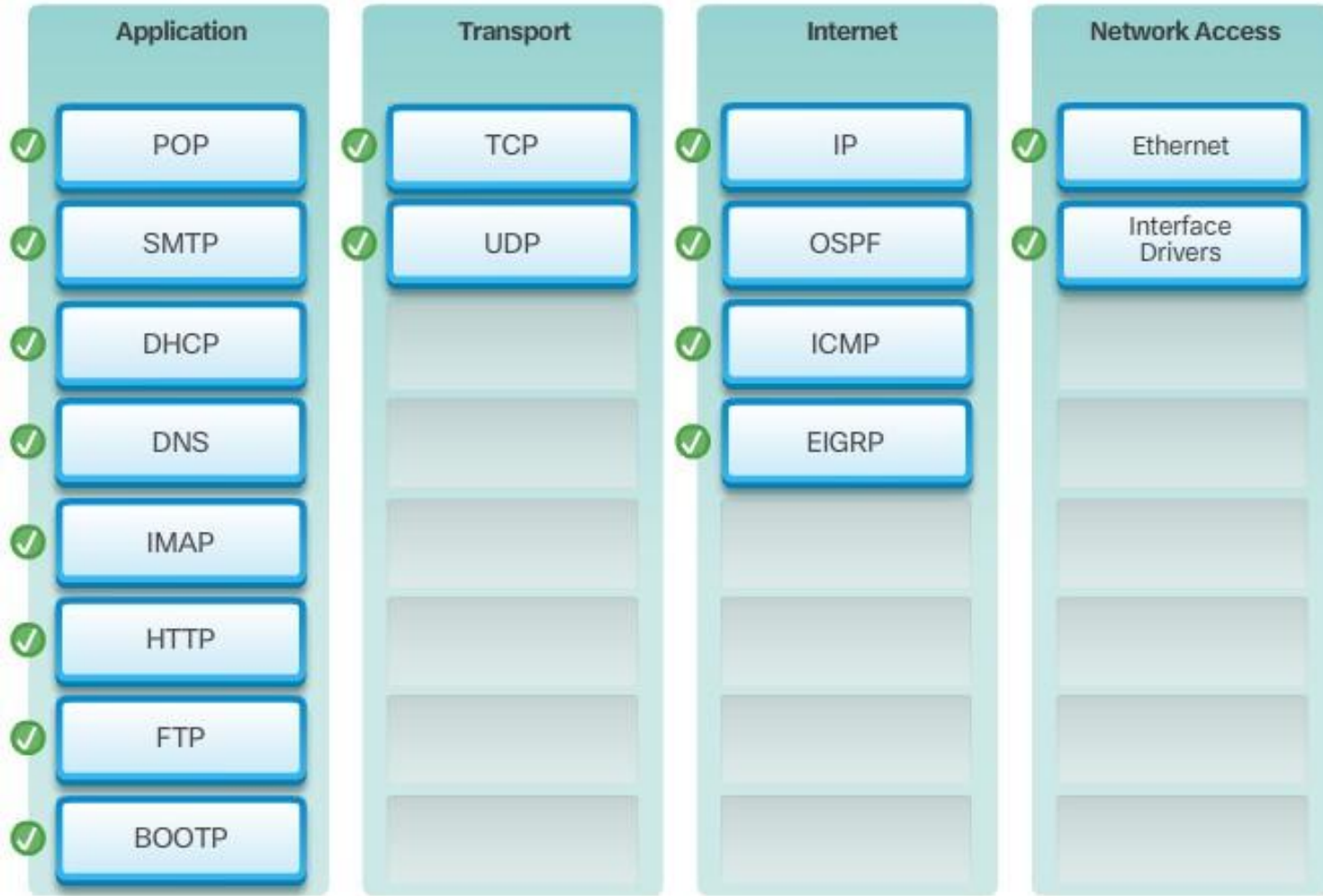
Ethernet	IP
POP	SMTP
Interface Drivers	OSPF
TCP	DHCP
DNS	IMAP
UDP	ICMP
HTTP	FTP
EIGRP	BOOTP

Application	Transport	Internet	Network Access

CheckReset

## 3.2.2: Protocol Suites

### 3.2.2.5 Activity - mapping the protocols





## 3.2.3: Standard Organizations

### 3.2.3.1 Open Standards

### 3.2.3.2 Internet Standards

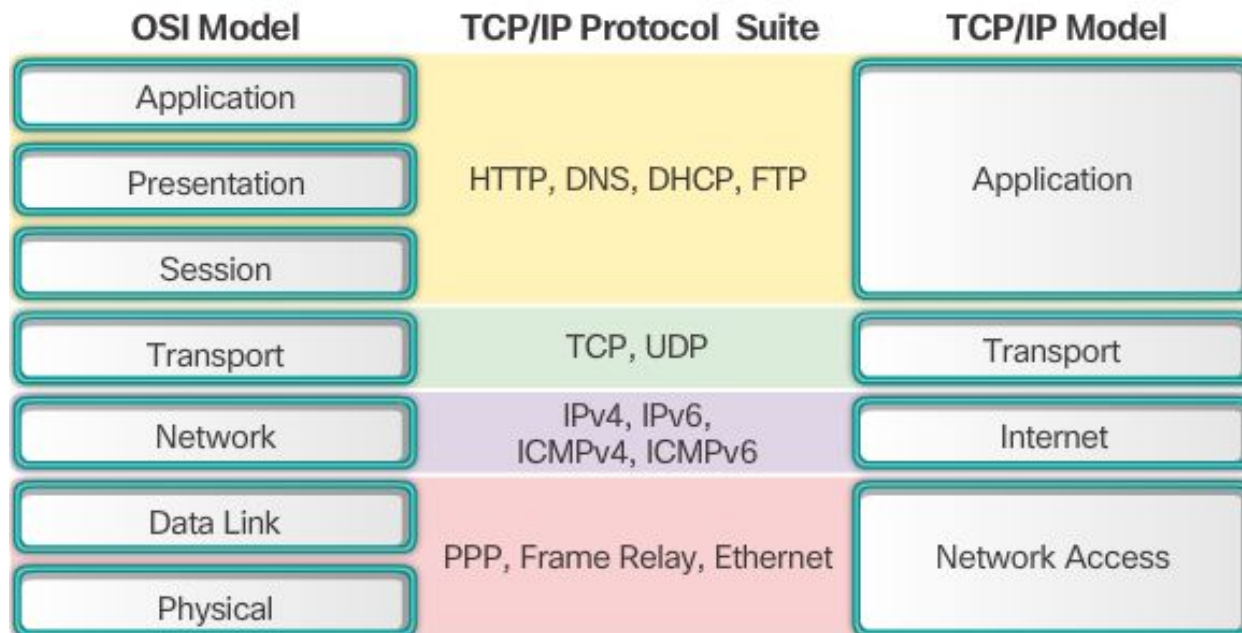
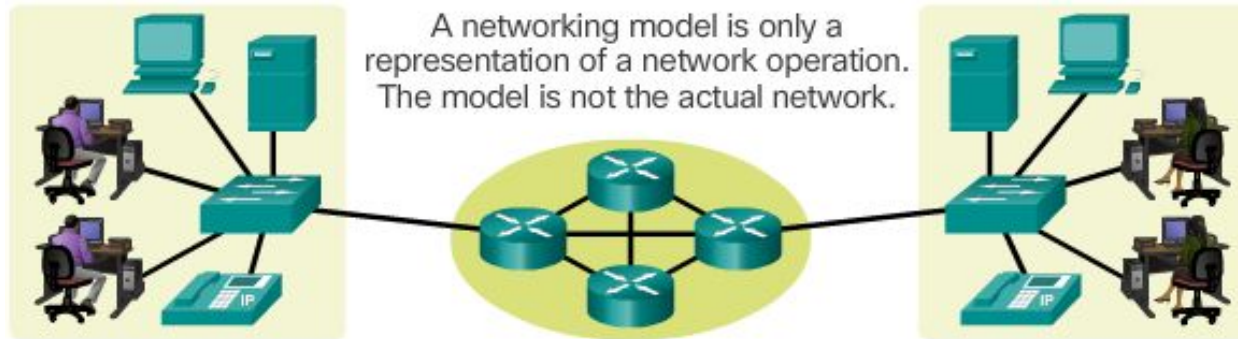
### 3.2.3.3 Electronics and Communications Standard Organizations





## 3.2.4: Reference Models

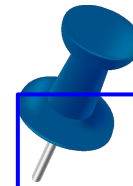
### 3.2.4.1 The Benefits of Using a Layered Model



## 3.2.4: Reference Models

### 3.2.4.2 The OSI Reference Model

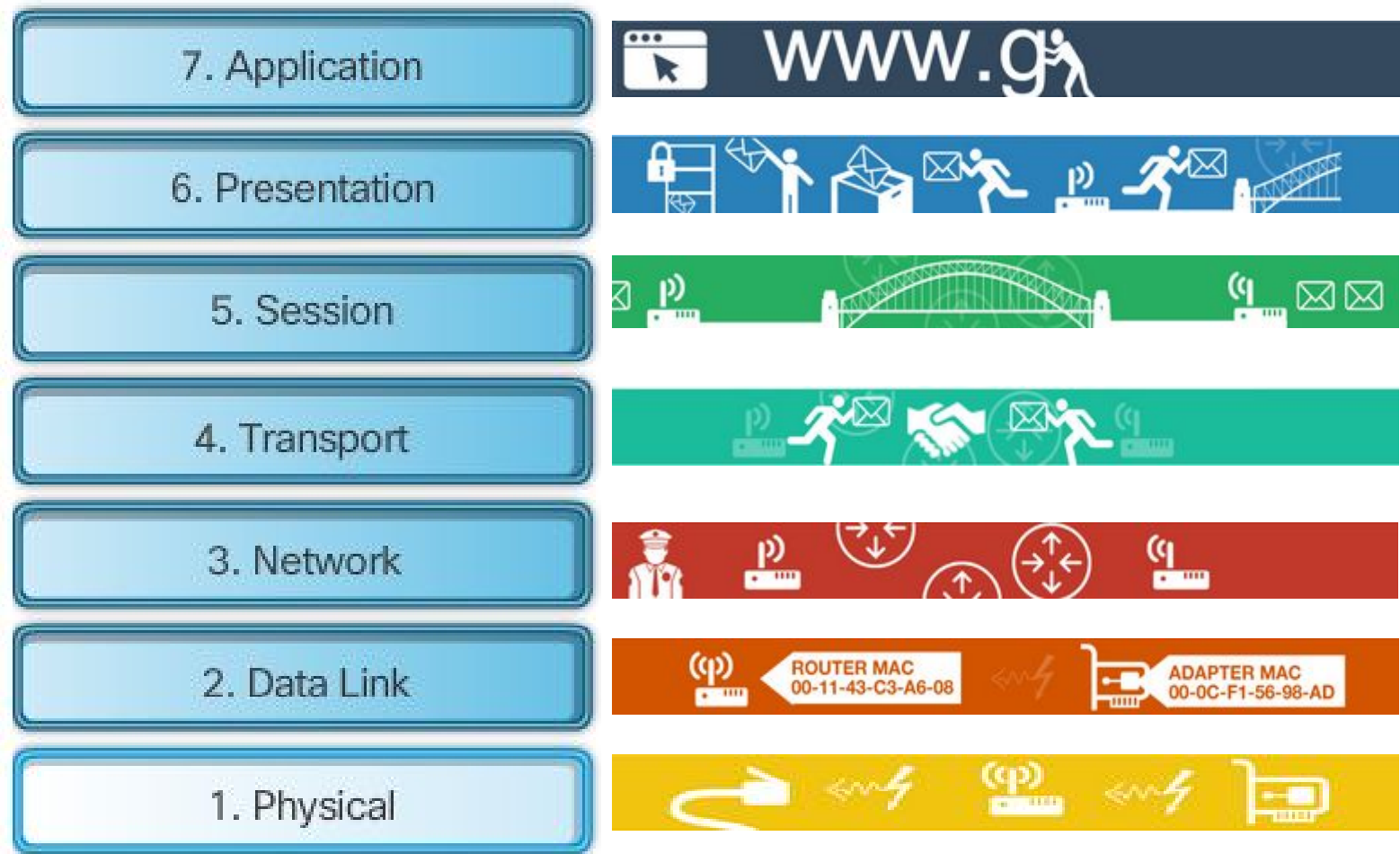
OSI Model



All  
People  
Seem  
To  
Need  
Data  
Protocols

# 3.2.4.2 The OSI Reference Model

## OSI Model



## 3.2.4: Reference Models

### 3.2.4.2 The OSI Reference Model



- mechanical, electrical, functional
- physical connections
- transmitting bits ( to and from a network device)
- PDU: Bit

Physical + Data Link (OSI) = Network Access (TCP/IP)

## 3.2.4: Reference Models

### 3.2.4.2 The OSI Reference Model

OSI Model



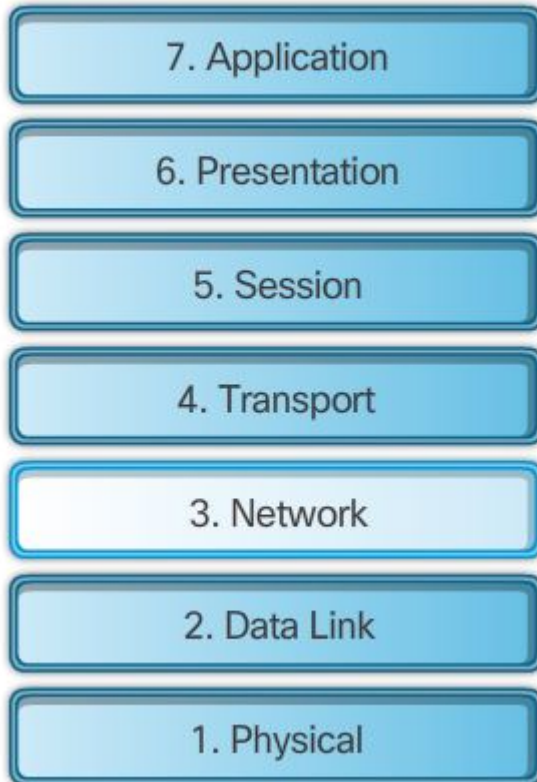
- Methods for exchanging data frames between devices over a common media.
- Physical addressing
- MAC address
- Switch
- Ethernet frames
- PDU: Frame

Physical + Data Link (OSI) = Network Access (TCP/IP)

## 3.2.4: Reference Models

### 3.2.4.2 The OSI Reference Model

#### OSI Model



- “services to exchange the individual pieces of data over the network between identified end devices”
- path determination
- Logical addressing
- IP address
- Router
- IP packet
- PDU: Packet

Network (OSI) = Internet (TCP/IP)

## 3.2.4: Reference Models

### 3.2.4.2 The OSI Reference Model

#### OSI Model



- transfer, and reassemble the data for individual communications between the end devices.
- End-to-end communication and reliability
- services to segment
- Ports
- TCP, UDP segments
- PDU: Segment

Transport (OSI) = Transport (TCP/IP)



## 3.2.4: Reference Models

### 3.2.4.2 The OSI Reference Model



#### OSI Model



- Service to presentation
- Controls the dialogues and data exchange
- Interhost communication
- establishes, manages and terminates sessions between the local and the remote application
- eg. cookie session and php session
- PDU: Data

Session + Presentation + Application (OSI) = Application (TCP/IP)



## 3.2.4: Reference Models

### 3.2.4.2 The OSI Reference Model

OSI Model



- Data representation
  - different computers might have different representations of characters
  - eg. ASCII vs EBCDIC
- Data compression (image, audio, video)
- Data encryption
- PDU: Data

Session + Presentation + Application (OSI) = Application (TCP/IP)

## 3.2.4: Reference Models

### 3.2.4.2 The OSI Reference Model

OSI Model

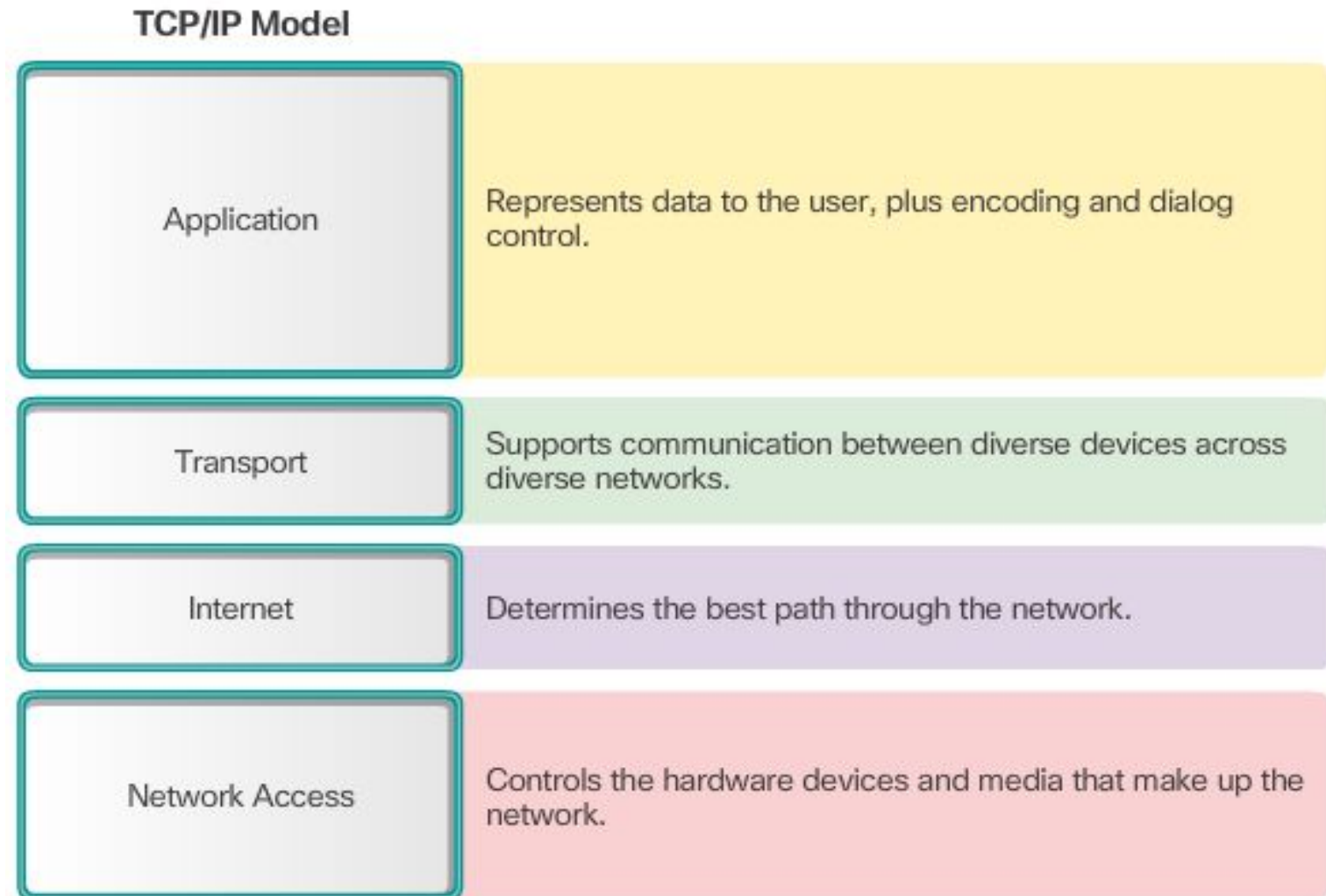


- Protocols used for process-to-process communications
- Application data
- PDU: Data

Session + Presentation + Application (OSI) = Application (TCP/IP)

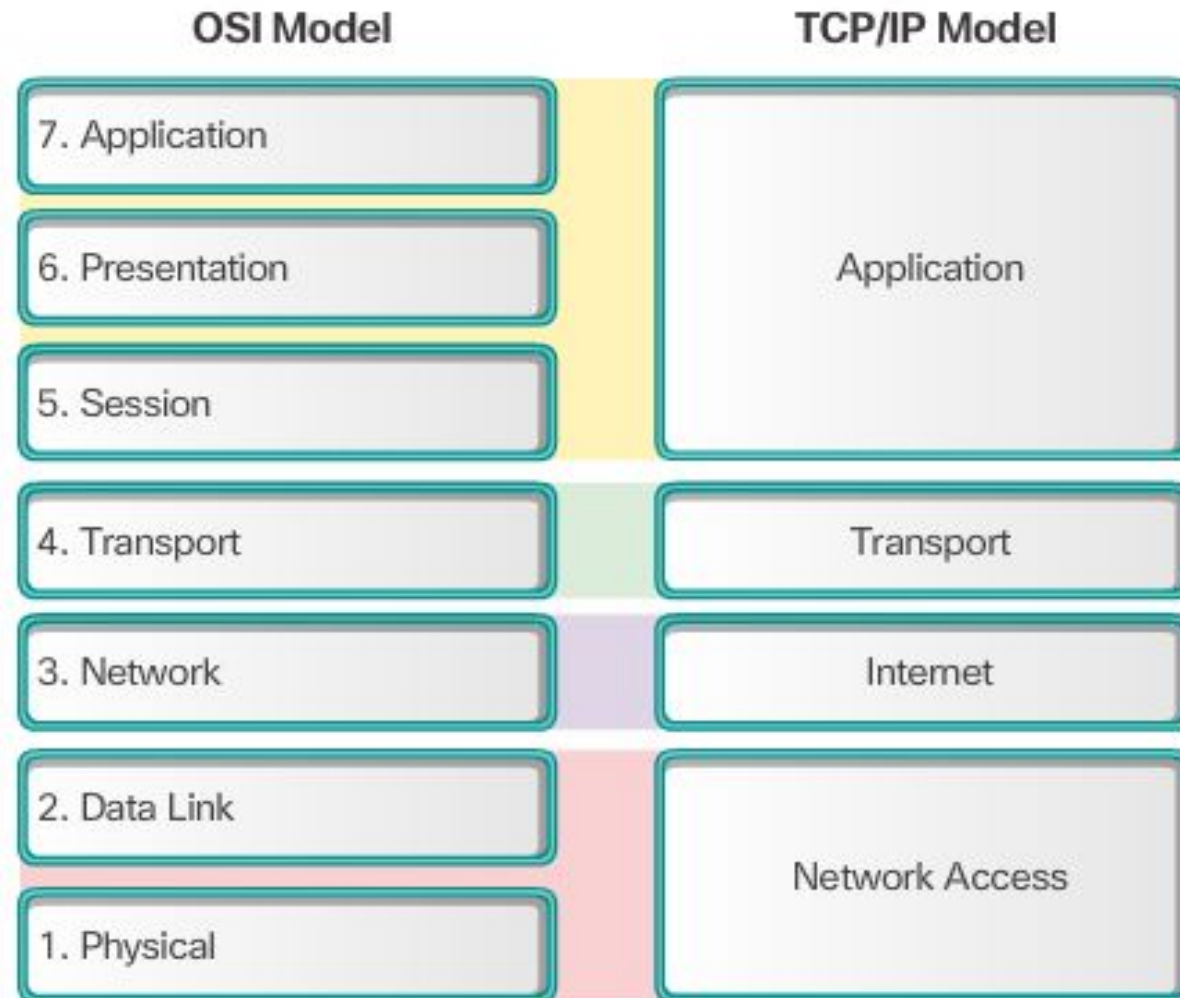
## 3.2.4: Reference Models

### 3.2.4.3 The TCP/IP Protocol Model



## 3.2.4: Reference Models

### 3.2.4.4 OSI Model and TCP/IP Model Comparison



## 3.2.4: Reference Models

### 3.2.4.5 Activity - Identify Layers and functions

Layers	OSI Layer Functional Descriptions
7 Application	<input type="text"/> Segments, transfers and reassembles data
6 Presentation	<input type="text"/> Exchanges frames between devices
5 Session	<input type="text"/> Contains protocols used for process-to-process communications
4 Transport	<input type="text"/> Provides a data path or route
3 Network	<input type="text"/> Bit transmission
2 Data Link	
1 Physical	

## 3.2.4: Reference Models

### 3.2.4.5 Activity - Identify Layers and functions

#### OSI Layer Functional Descriptions

✓	Transport	Segments, transfers and reassembles data
✓	Data Link	Exchanges frames between devices
✓	Application	Contains protocols used for process-to-process communications
✓	Network	Provides a data path or route
✓	Physical	Bit transmission



## 3.2.4: Reference Models

### 3.2.4.6 PT – Investigating the TCP/IP and OSI Models in Action

Packet Tracer

Packet Tracer | Investigating the TCP/IP and OSI Models in Action

2950T 24 SW-A

2950T 24 SW-B

PC-PT C2

PC-PT C3

PC-PT C4

PC-PT D1

PC-PT D2

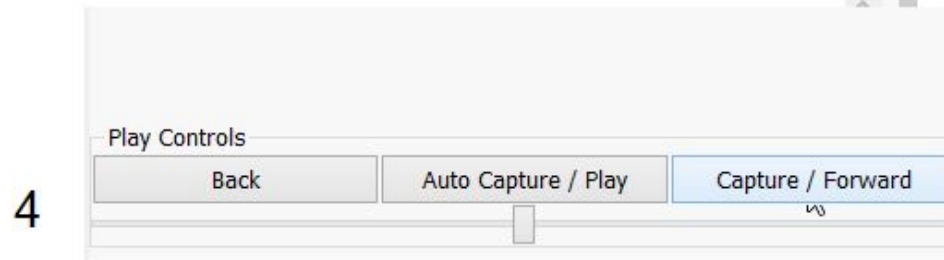
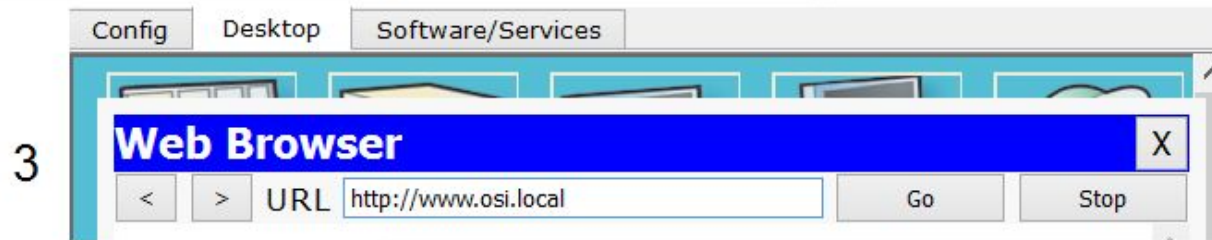
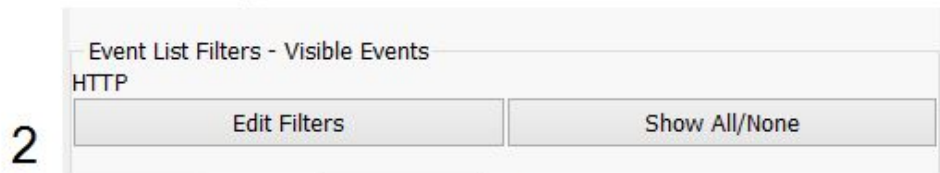
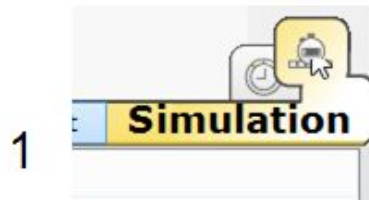
Devices Fast Forward Time

Scenario 0

## 3.2.4: Reference Models

### 3.2.4.6 PT – Investigating the TCP/IP and OSI Models in Action

*Step1: Generate data traffic*





## 3.2.4: Reference Models

### 3.2.4.6 PT – Investigating the TCP/IP and OSI Models in Action

*Step2: Check it out: OSI in packet tracer ...*

**PDU Information at Device: Web Client**

At Device: Web Client  
Source: Web Client  
Destination: HTTP CLIENT

OSI Model	Outbound PDU Details
<b>In Layers</b>	<b>Out Layers</b>
Layer7	Layer 7: HTTP
Layer6	Layer6
Layer5	Layer5
Layer4	Layer 4: TCP Src Port: 1025, Dst Port: 80
Layer3	Layer 3: IP Header Src. IP: 192.168.1.1, Dest. IP: 192.168.1.254
Layer2	Layer 2: Ethernet II Header 0060.47CA.4DEE >> 0001.96A9.401D
Layer1	Layer 1: Port(s):

# 3.2.4: Reference Models

## 3.2.4.6 PT – Investigating the TCP/IP and OSI Models in Action

Step3: View the HTTP protocol

Event List

Vis.	Time(sec)	Last Devi	At Device	Type	Info
	0.006	--	Web C...	HTTP	
	0.007	--	Web C...	HTTP	
	0.008	Web Cli...	Web S...	HTTP	

PDU Information at Device:

OSI Model

Outbound PDU Details

At Device: Web Client  
Source: Web Client  
Destination: HTTP CLIENT

In Layers

Layer7

Layer6

Layer5

Layer4

Layer3

Layer2

Layer1

Out Layers

Layer 7: HTTP

Layer6

Layer5

Layer 4: TCP Src Port: 1025, Dst Port: 80

Layer 3: IP Header Src. IP: 192.168.1.1, Dest. IP: 192.168.1.254

Layer 2: Ethernet II Header 0060.47CA.4DEE >> 0001.96A9.401D

Layer 1: Port(s):

OSI Model

Outbound PDU Details

PDU Formats

Ethernet II

0 4 8 14 19 31 bytes

PREAMBLE: 101010...1011

DEST MAC: 0001.96A9.401D

SRC MAC: 0060.47CA.4DEE

TYPE: 0x800

DATA (VARIABLE LENGTH)

FCS: 0x0

IP

0 4 8 16 19 31 Bits

4 IHL DSCP: 0x0 TL: 122

ID: 0x4 0x2 0x0

TTL: 128 PRO: 0x6 CHKSUM

SRC IP: 192.168.1.1

DST IP: 192.168.1.254

OPT: 0x0 0x0

DATA (VARIABLE LENGTH)

TCP

0 16 31 Bits

SRC PORT: 1025 DEST PORT: 80

SEQUENCE NUM: 1

ACK NUM: 1

OFF. RES. PSH + WINDOW

## 3.2.4: Reference Models

### 3.2.4.6 PT – Investigating the TCP/IP and OSI Models in Action

*Step4: View the other protocols (DNS, ARP, TCP)*

The screenshot displays a network simulation interface. On the left, a table lists captured packets with columns for visibility, time, source device, destination device, protocol type, and information. The 'Type' column has 'DNS', 'ARP', 'DNS', 'DNS', and 'TCP' circled in red. Below the table are 'Reset Simulation' and 'Constant Delay' (checked) buttons.

On the right, the 'Outbound PDU Details' tab is active, showing the following information:

- At Device: Web Client
- Source: Web Client
- Destination: Broadcast

Below this, the 'In Layers' and 'Out Layers' sections are shown. The 'Out Layers' section highlights the details for Layer 2 and Layer 1:

**Layer 2: Ethernet II Header**  
0060.47CA.4DEE >>  
FFFF.FFFF.FFFF ARP Packet Src.  
IP: 192.168.1.1, Dest. IP:  
192.168.1.254

**Layer 1: Port(s): FastEthernet0**

1. The ARP process constructs a request for the target IP address.
2. The device encapsulates the PDU into an Ethernet frame.

# Section 3.3:

## Data Transfer in the Network

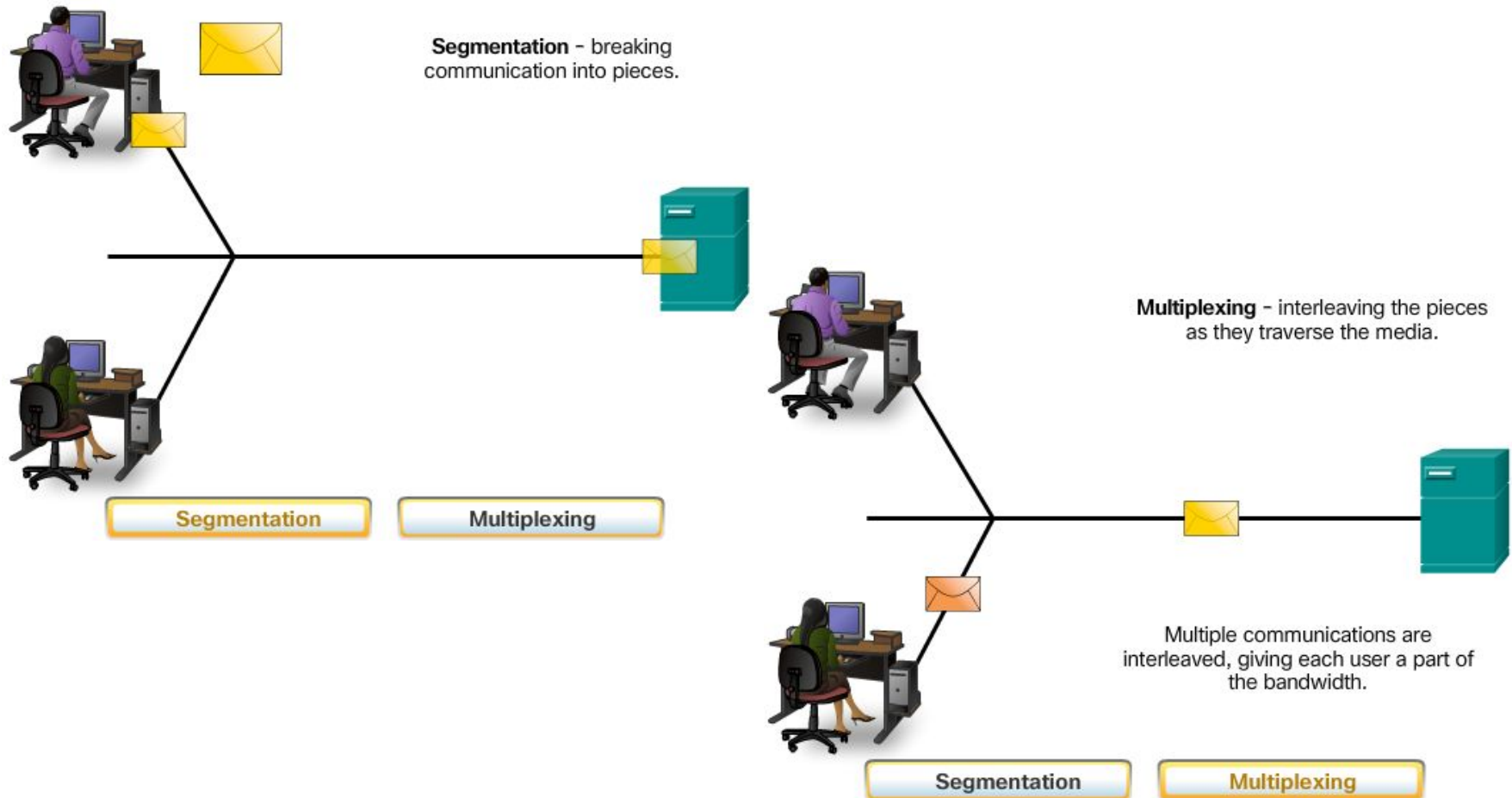
3.3.1: Data Encapsulation

3.3.2: Data Access

## 3.3.1: Data Encapsulation

### 3.3.1.1 Message Segmentation

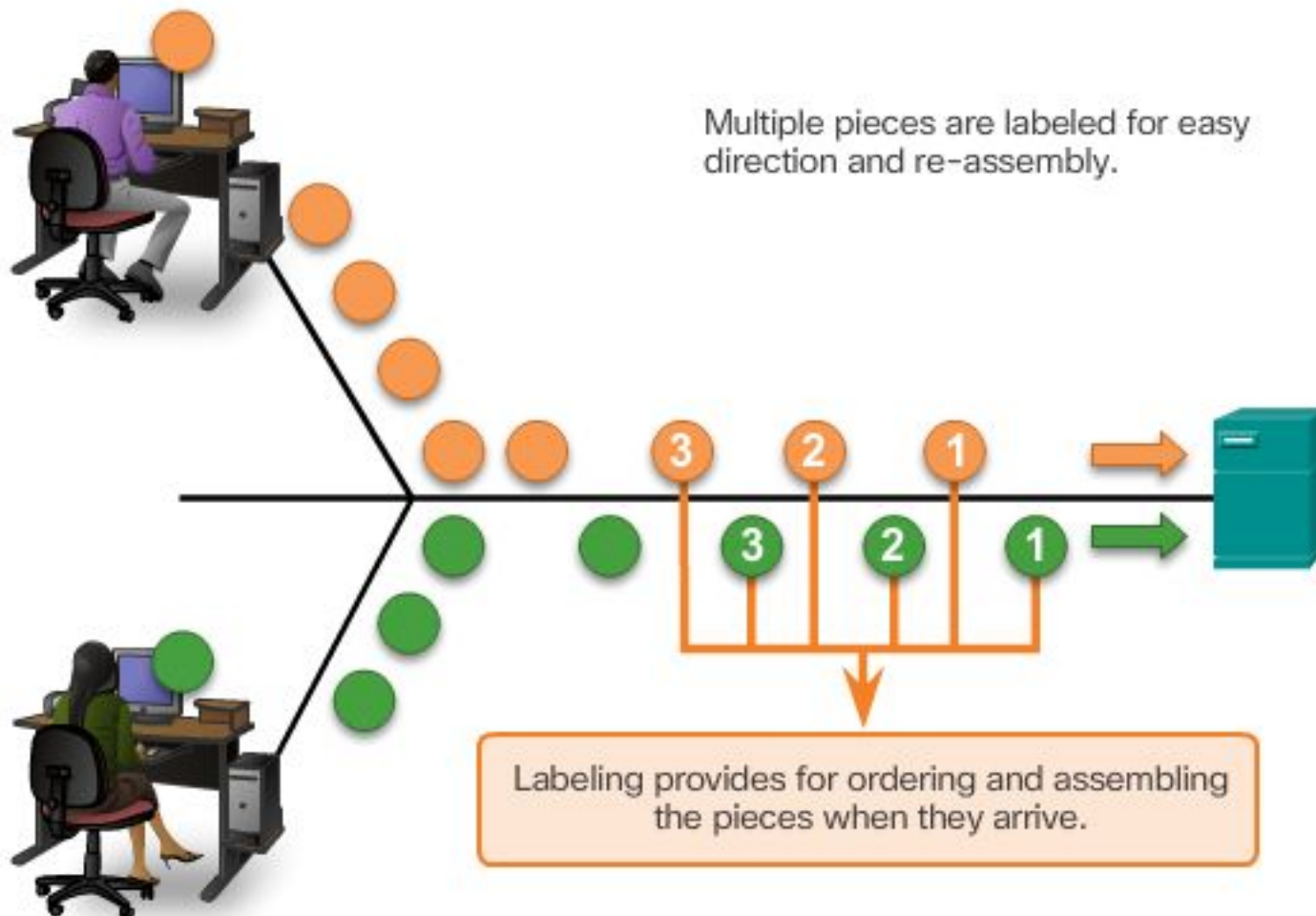
#### Communicating the Message



## 3.3.1: Data Encapsulation

### 3.3.1.1 Message Segmentation (cont.)

Communicating the Message

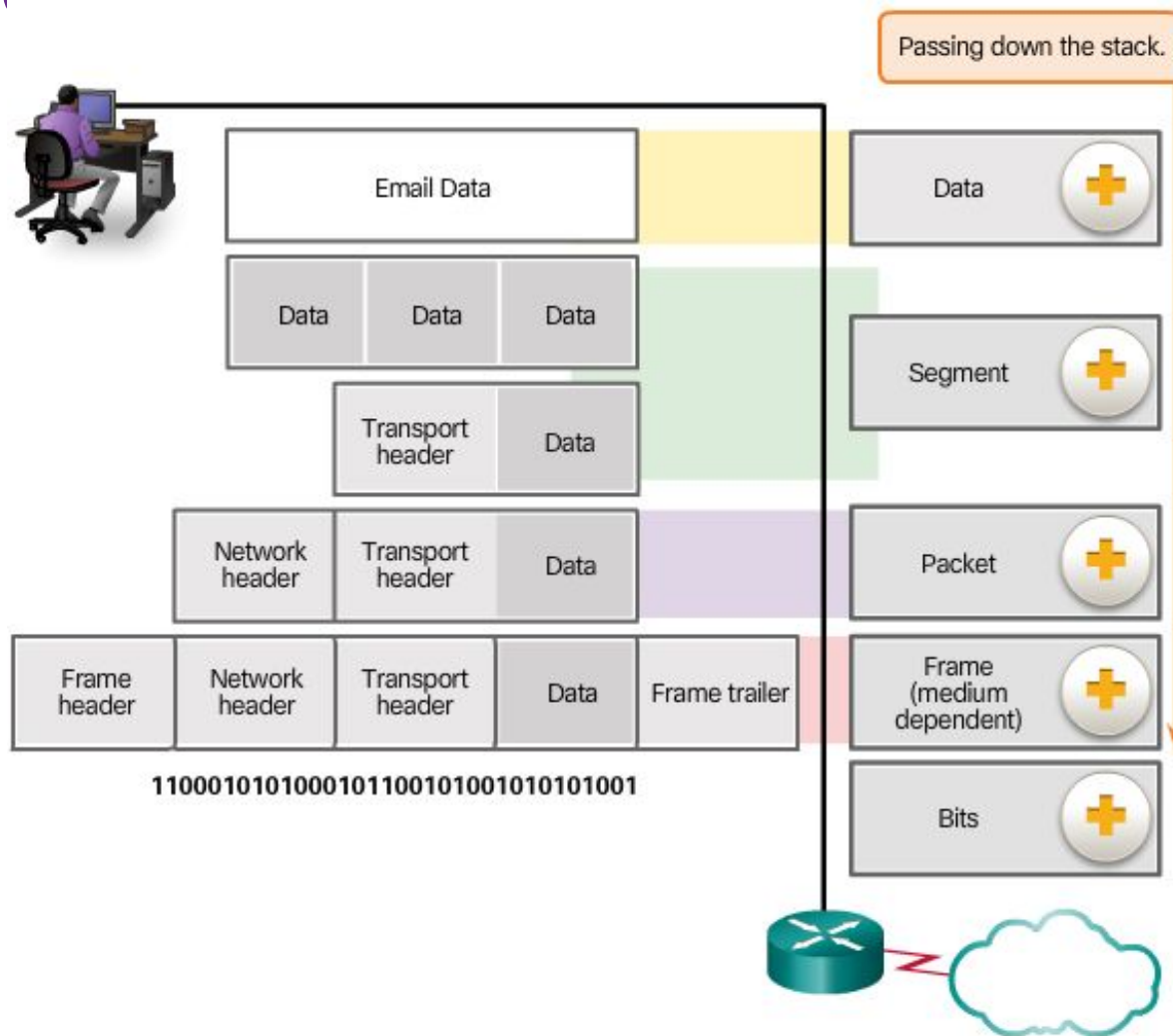


# 3.3.1: Data Encapsulation

## 3.3.1.2 Protocol Data Units

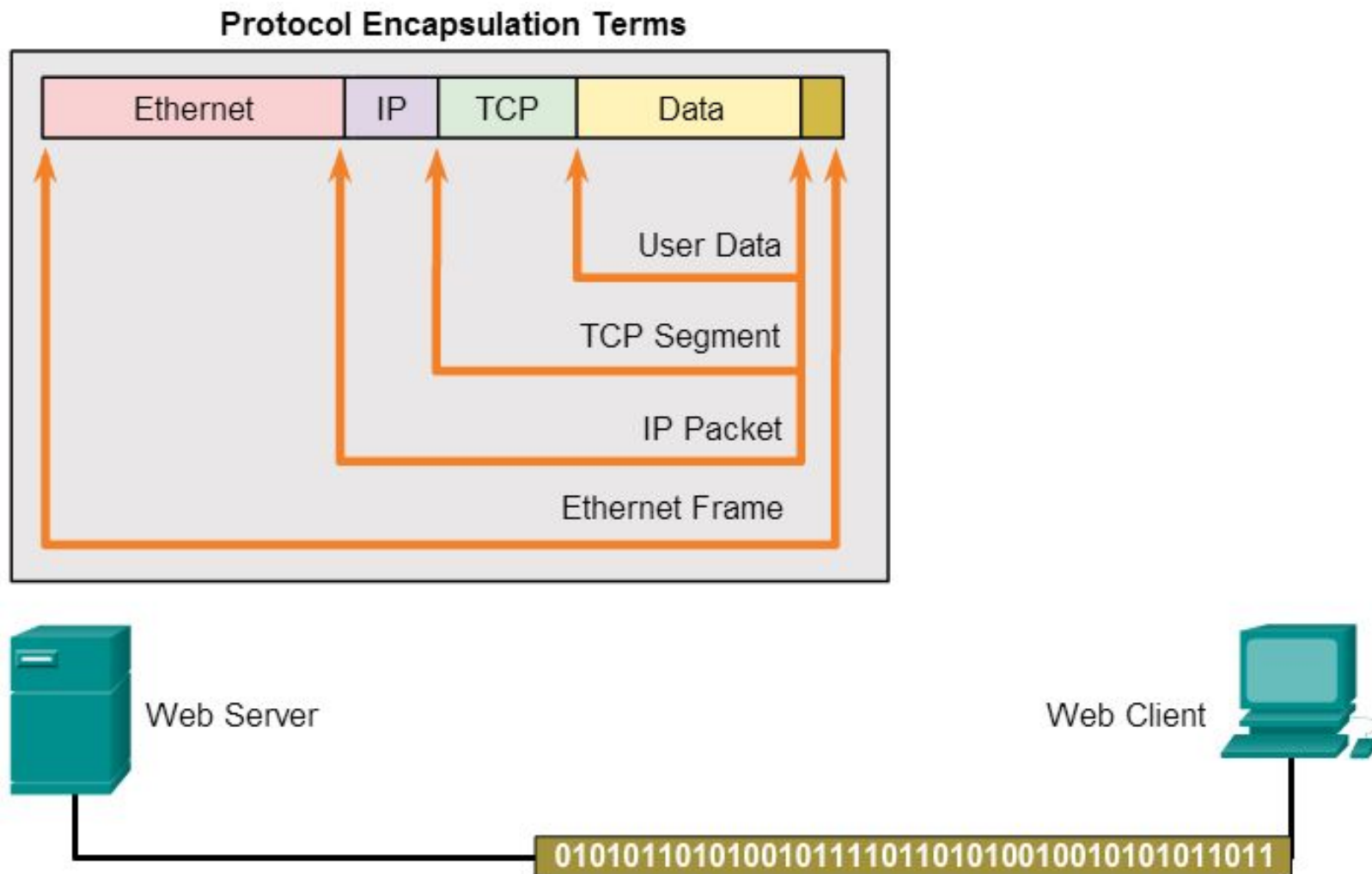
### Encapsulation

- Data
- Segment
- Packet
- Frame
- Bits



## 3.3.1: Data Encapsulation

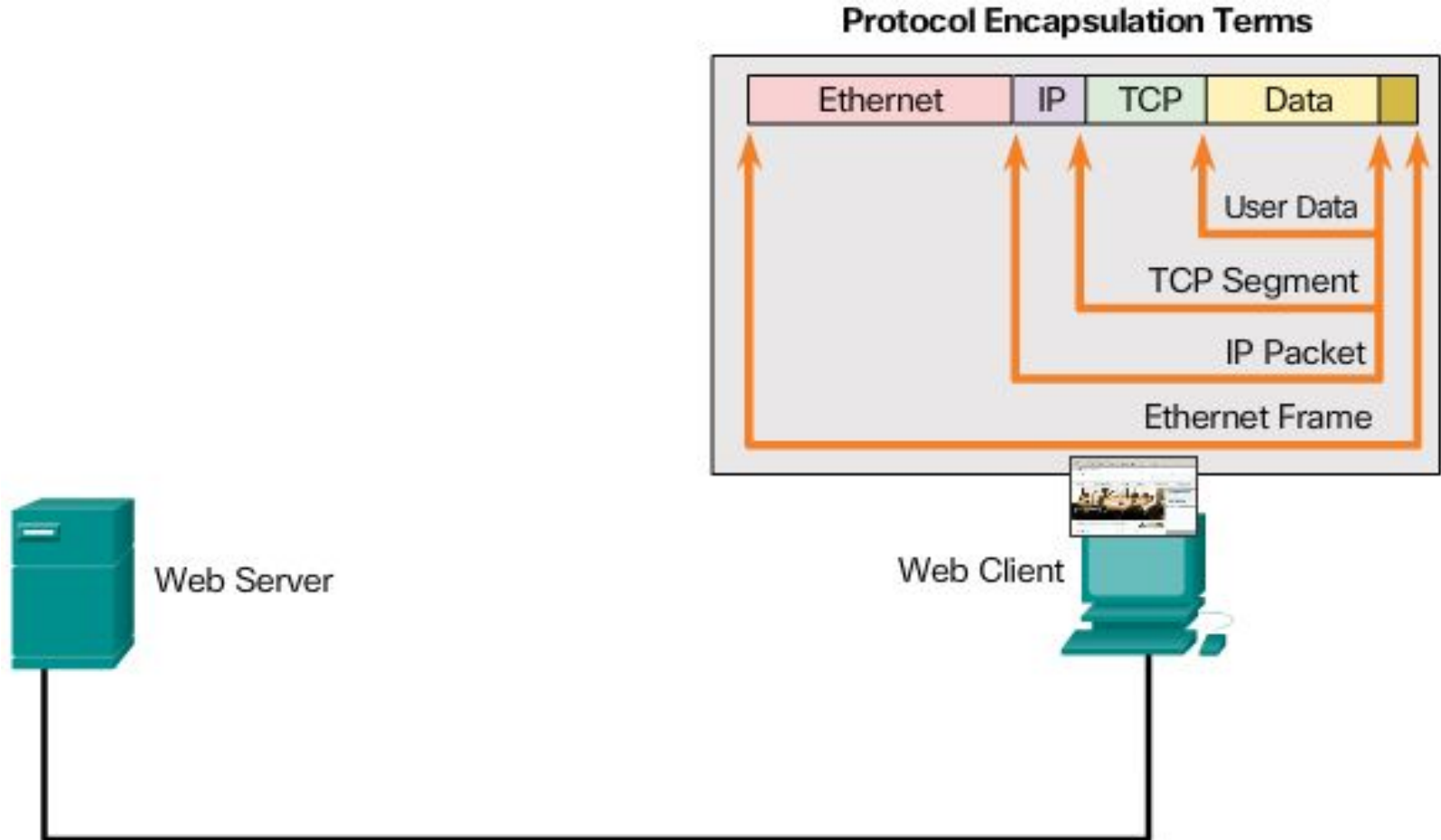
### 3.3.1.3 Encapsulation Example





## 3.3.1: Data Encapsulation

### 3.3.1.4 De-Encapsulation

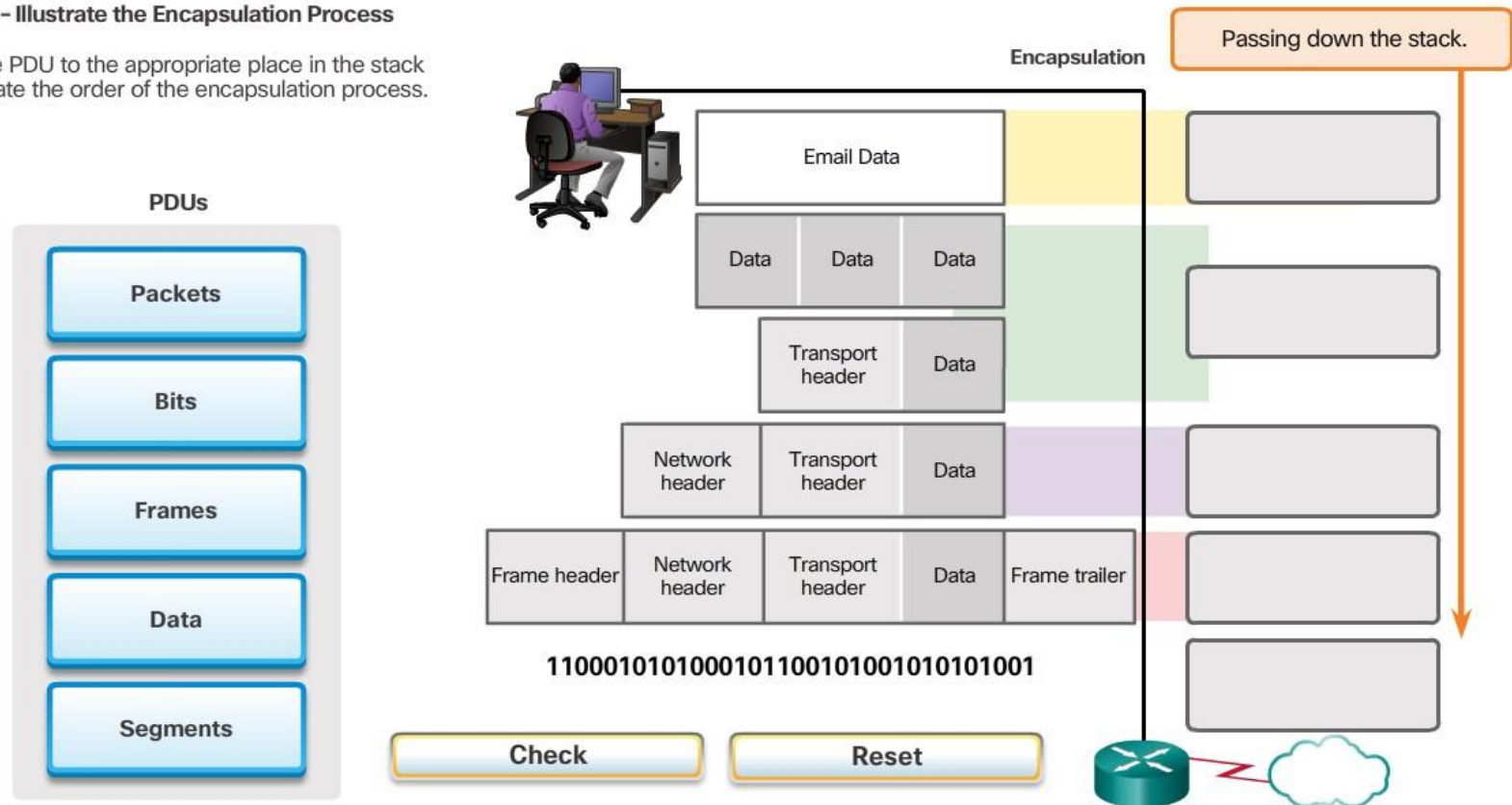


## 3.3.1: Data Encapsulation

### 3.3.1.5 Activity – Identify the PDU Layer

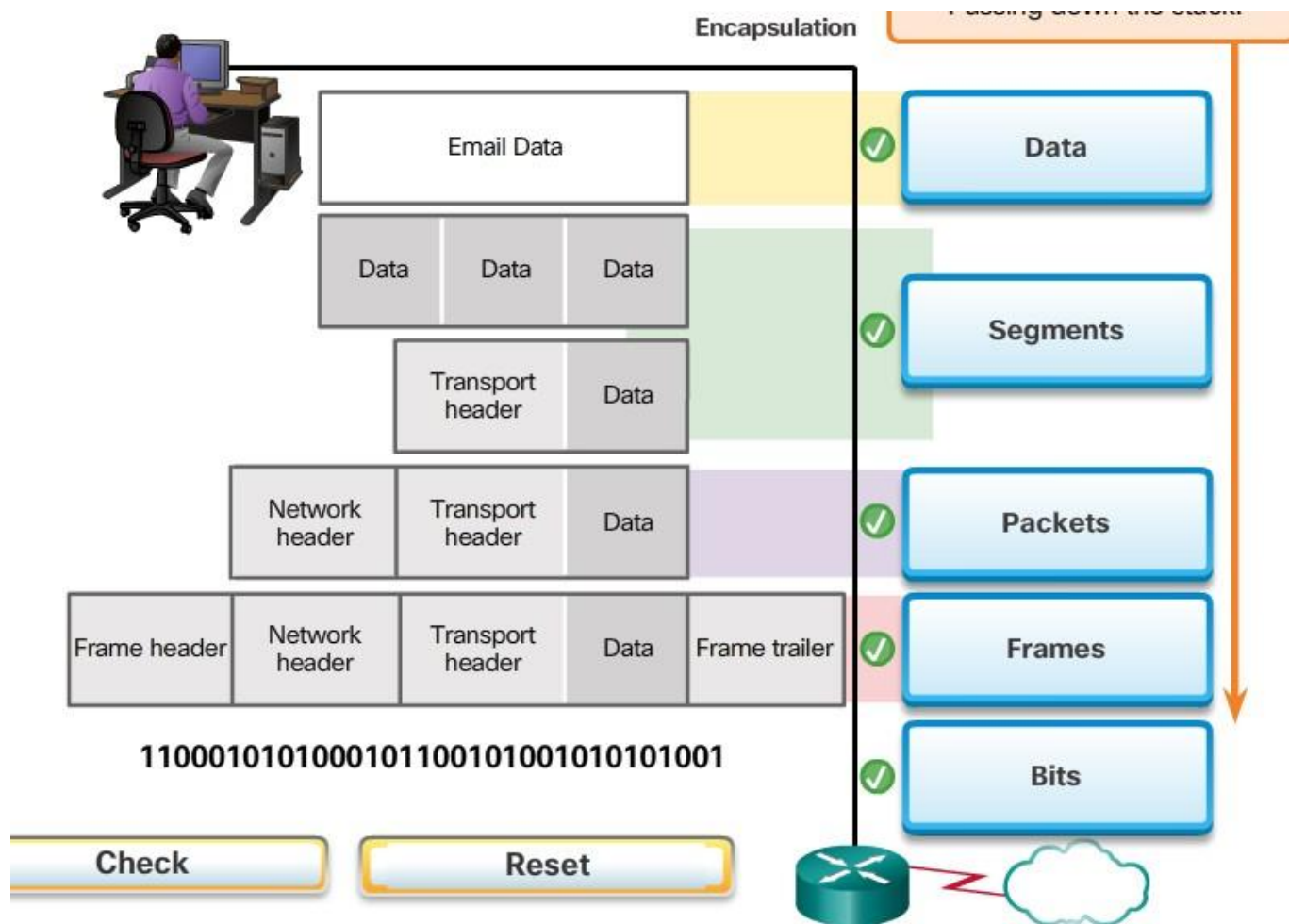
#### Activity – Illustrate the Encapsulation Process

Drag the PDU to the appropriate place in the stack to illustrate the order of the encapsulation process.



## 3.3.1: Data Encapsulation

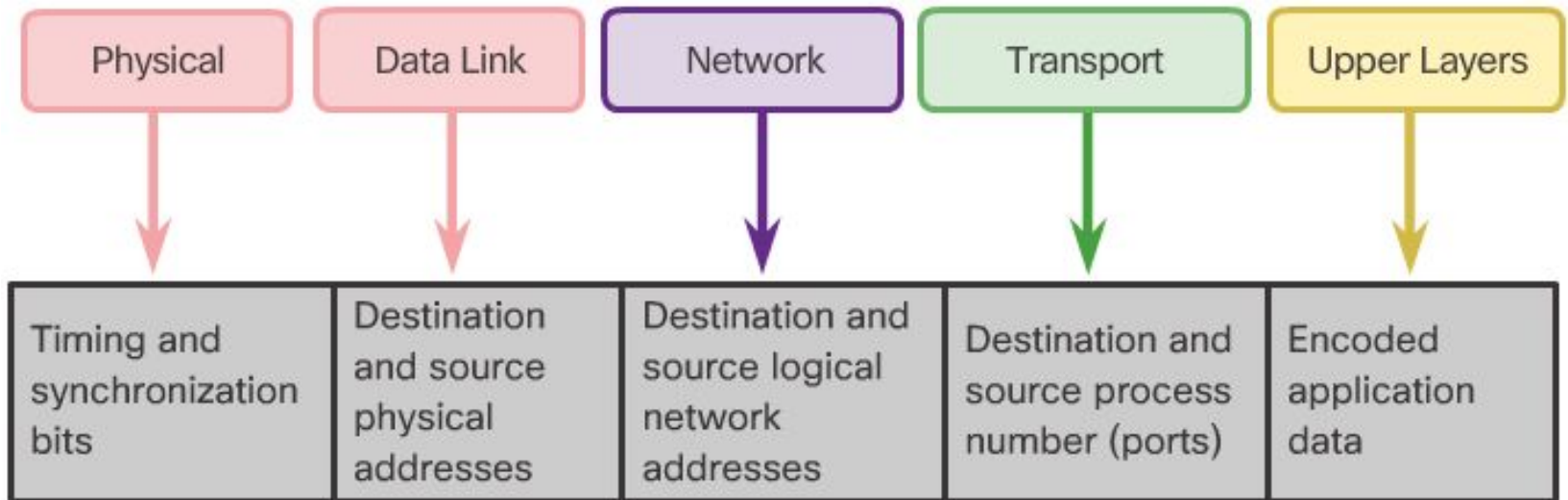
### 3.3.1.5 Activity – Identify the PDU Layer



## 3.3.2: Data Access

### 3.3.2.1 Network Addresses

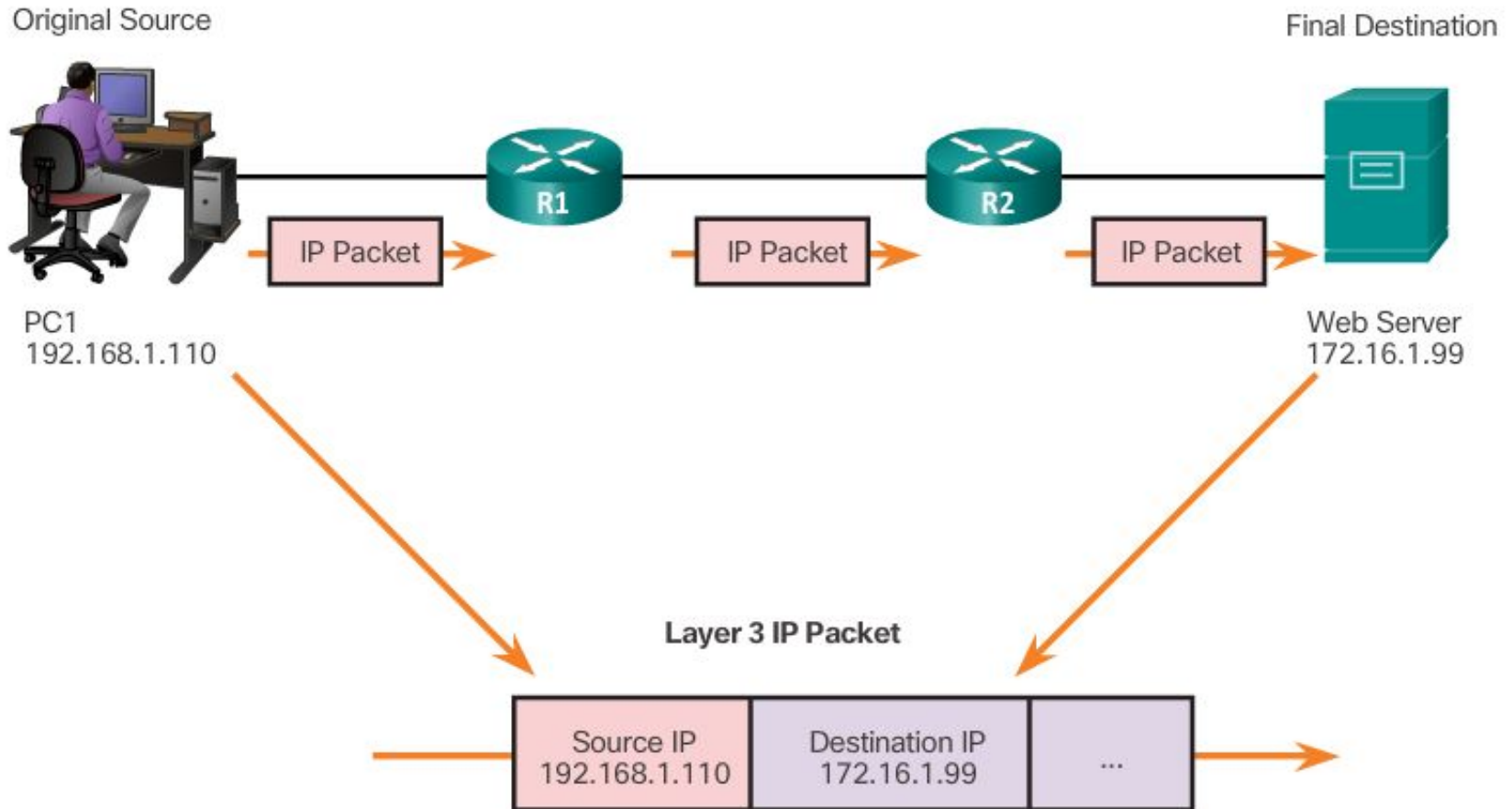
#### Network Addresses and Data Link Addresses



## 3.3.2: Data Access

### 3.3.2.1 Network Addresses (cont.)

#### Layer 3 Network Addresses

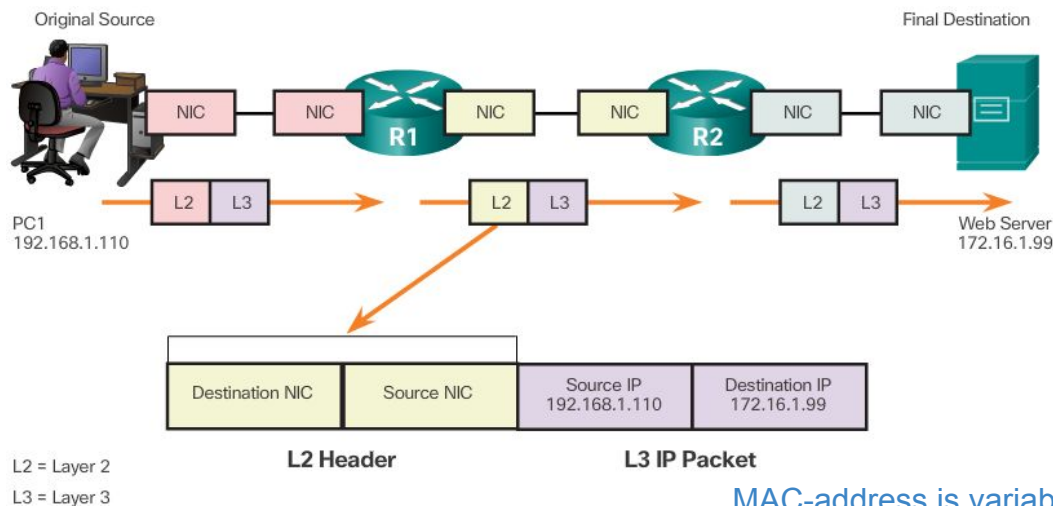
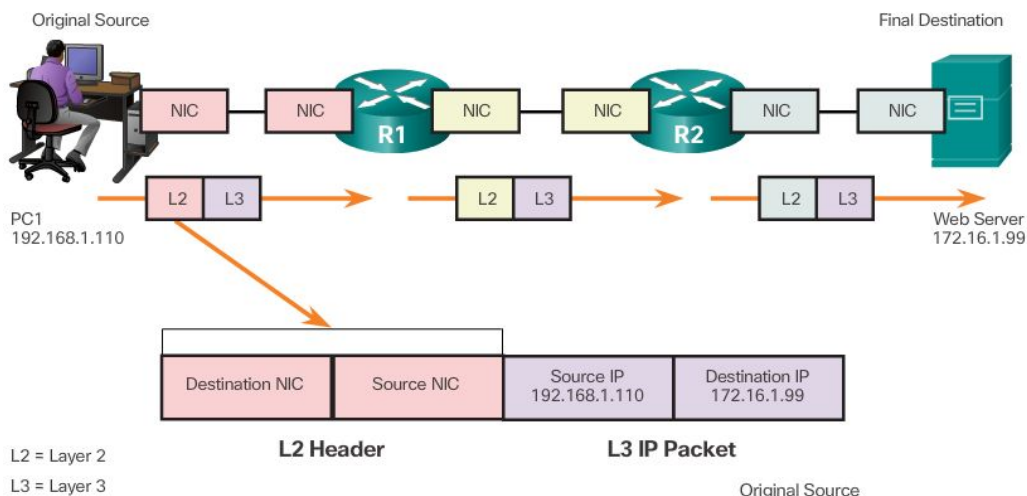


IP-address is fixed

# 3.3.2: Data Access

## 3.3.2.2 Data Link Address

### Layer 2 Data Link Addresses



MAC-address is variable

## 3.3.2: Data Access

### 3.3.2.2 Data Link Addresses

#### Network Address

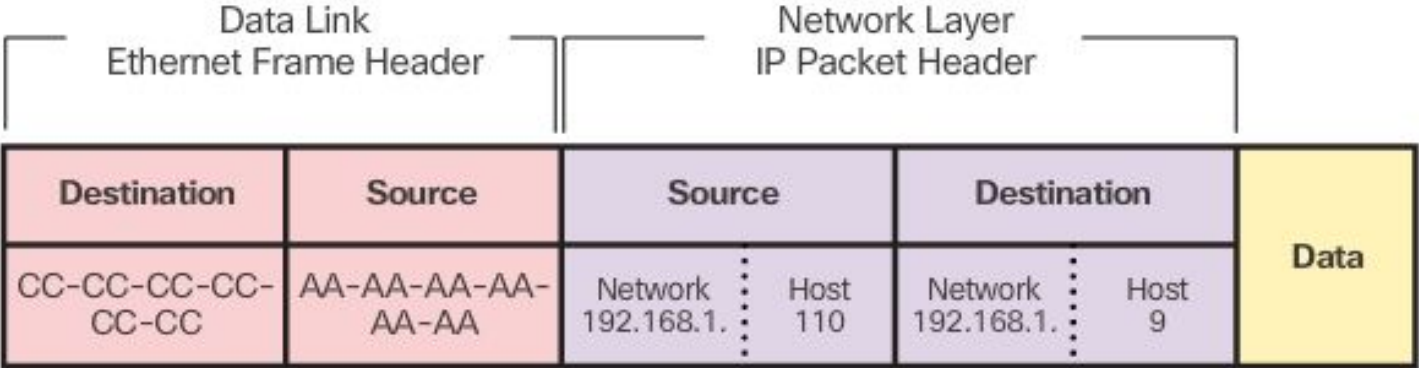
- Source IP address
- Destination IP address
- Responsible for delivering the IP packet from the original source to the final destination, either on the same network or to a remote network.

#### Data Link Address

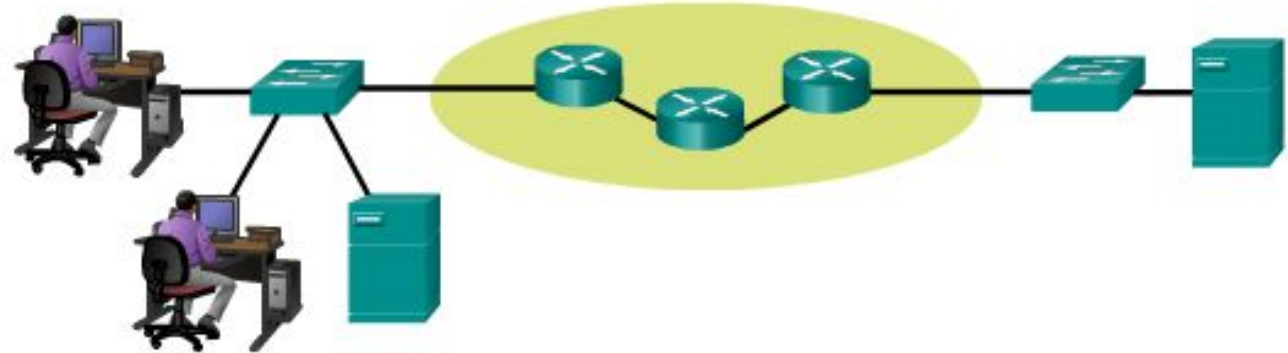
- Source data link address
- Destination data link address
- Responsible for delivering the data link frame from one network interface card (NIC) to another NIC on the same network

# 3.3.2: Data Access

## 3.3.2.3 Devices on the 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



## 3.3.2: Data Access

### 3.3.2.3 Devices on the Same Network (cont.)

- Role of the Network Layer Addresses

Network portion of the IP Address – The left-most part of the address that indicates which network the IP address is a member.

Host portion – The remaining part of the address that identifies a specific device on the network.

- Source IP address – The IP address of the sending device
- Destination IP address – The IP address of the receiving device

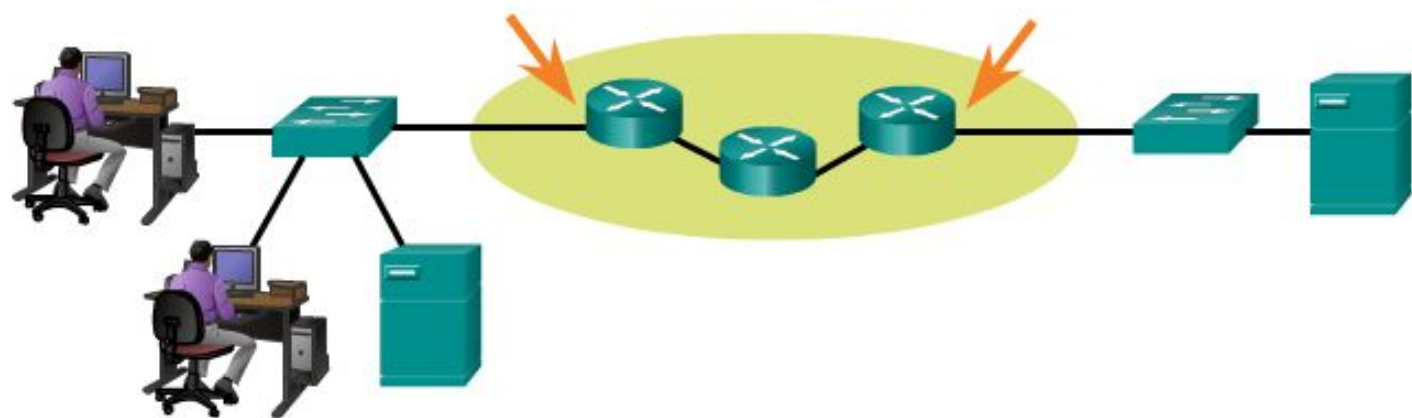
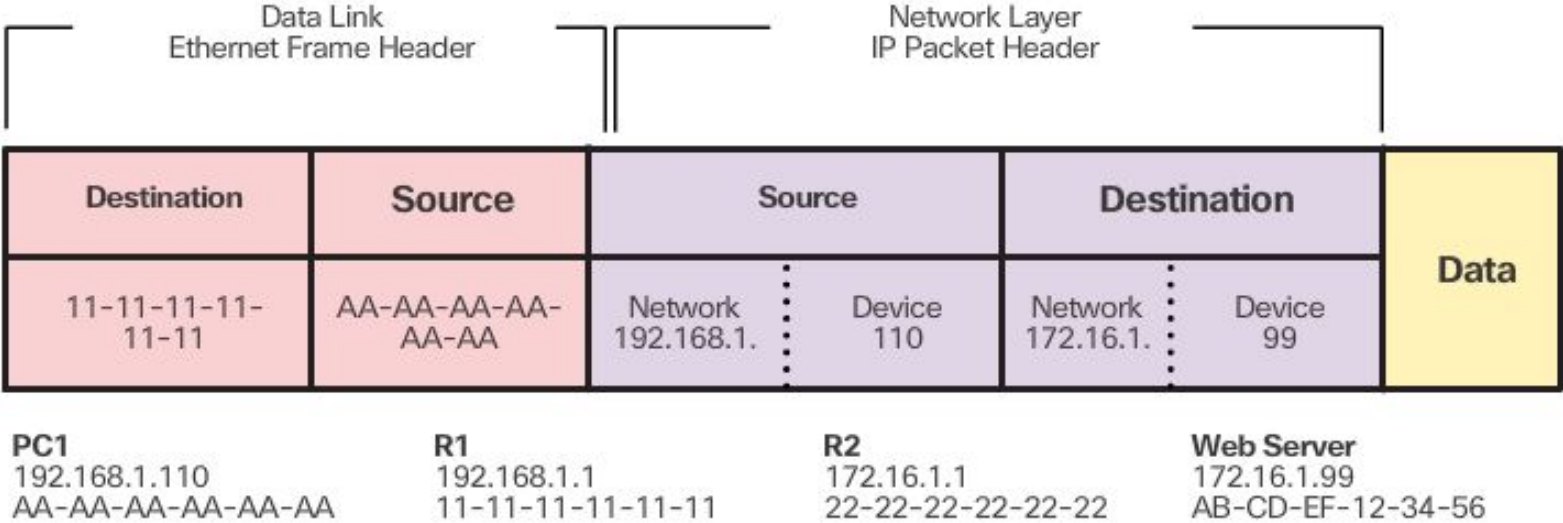
- Role of the Data Link Layer Addresses

Source MAC address – This is the data link address, or the Ethernet MAC address, of the sending device.

Destination MAC address – When the receiving device is on the same network as the sending device, this is the data link address of the receiving device.

# 3.3.2: Data Access

## 3.3.2.4 Devices on a Remote Network



## 3.3.2: Data Access

### 3.3.2.4 Devices on a Remote Network (cont.)

#### Role of the Network Layer Addresses

- The source and destination IP addresses will represent hosts on different networks indicated by the different network portions of the source and destination addresses.

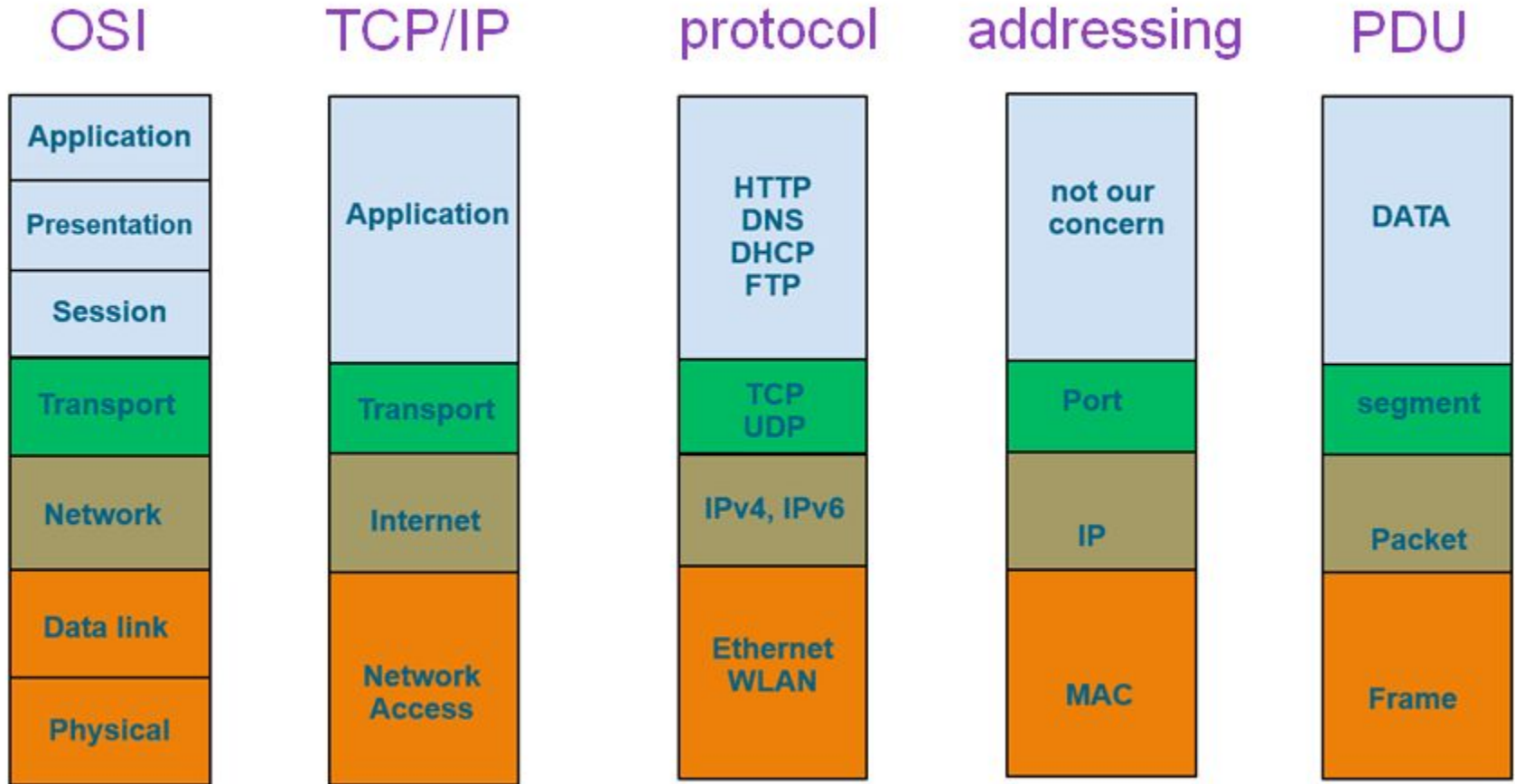
#### Role of the Data Link Layer Addresses

- Destination MAC address - When the receiving device is on a different network from the sending device, the sending device uses the Ethernet MAC address of the default gateway or router.

# Section 3.4: Summary

- 3.0 Introduction
- 3.1 Rules of Communication
- 3.2 Network Protocols and Standards
- 3.3 Data Transfer in the Network

# 3.4 Summary



# 3.4 Summary

	Layer	Functions	TCP/IP Model	Encapsulation <small>Practical Data Units (PDUs)</small>	Protocols	Applications
Host Layers	Application	Network Processes & Applications Network Services to Applications, Terminal emulation	Application	Data	FTP	Web browsers
	Presentation	Data formatting, encrypting, compression & presentation Concerned with data structures			HTTP	E-mail applications
	Session	Manages communication sessions Class of service, Data expedition			SMTP	Domain Name Servers
	Transport	Error correction before retransmission Establishes logical end-to-end connection (sessions) Flow control	Transport	Segment	DNS	Trivial file transfer
Communications Layers					TFTP	
					TCP	
					UDP	
						Devices
	Network	Determines best path for data transfer (routing)	Internet	Packet	IP ICMP ARP RARP	Router
	Data Link	Handles error notification, network topology Prepares packets ( <b>datagrams</b> ) for physical transmission	Network	Frame		Bridges Switches NIC
	Physical	Activates and maintains physical links between systems Binary transmission	Access	Bit		Hub Repeater Concentrator

## 3.4 Summary

### Data access

- Layer 2 addressing
  - MAC address (NIC)
  - Communicate on the same network (till gateway)
- Layer 3 addressing
  - IP address
  - Communicate on different network (through gateway)