CCNA R&S: Introduction to Networks

Chapter 10:

The Application Layer

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Upon completion of this chapter you will be able to:

- Explain how the functions of the application layer, session layer, and presentation layer work together to provide network services to end user applications.
- Describe how common application layer protocols interact with end user applications.
- Describe, at a high level, common application layer protocols that provide Internet services to end-users, including WWW services and email.
- Describe application layer protocols that provide IP addressing services, including: DNS and DHCP.
- Describe the features and operation of well-known application layer protocols that allow for file sharing services, including: FTP, File Sharing Services, SMB protocol.
- Explain how data is moved across the network, from opening an application, to receiving data.
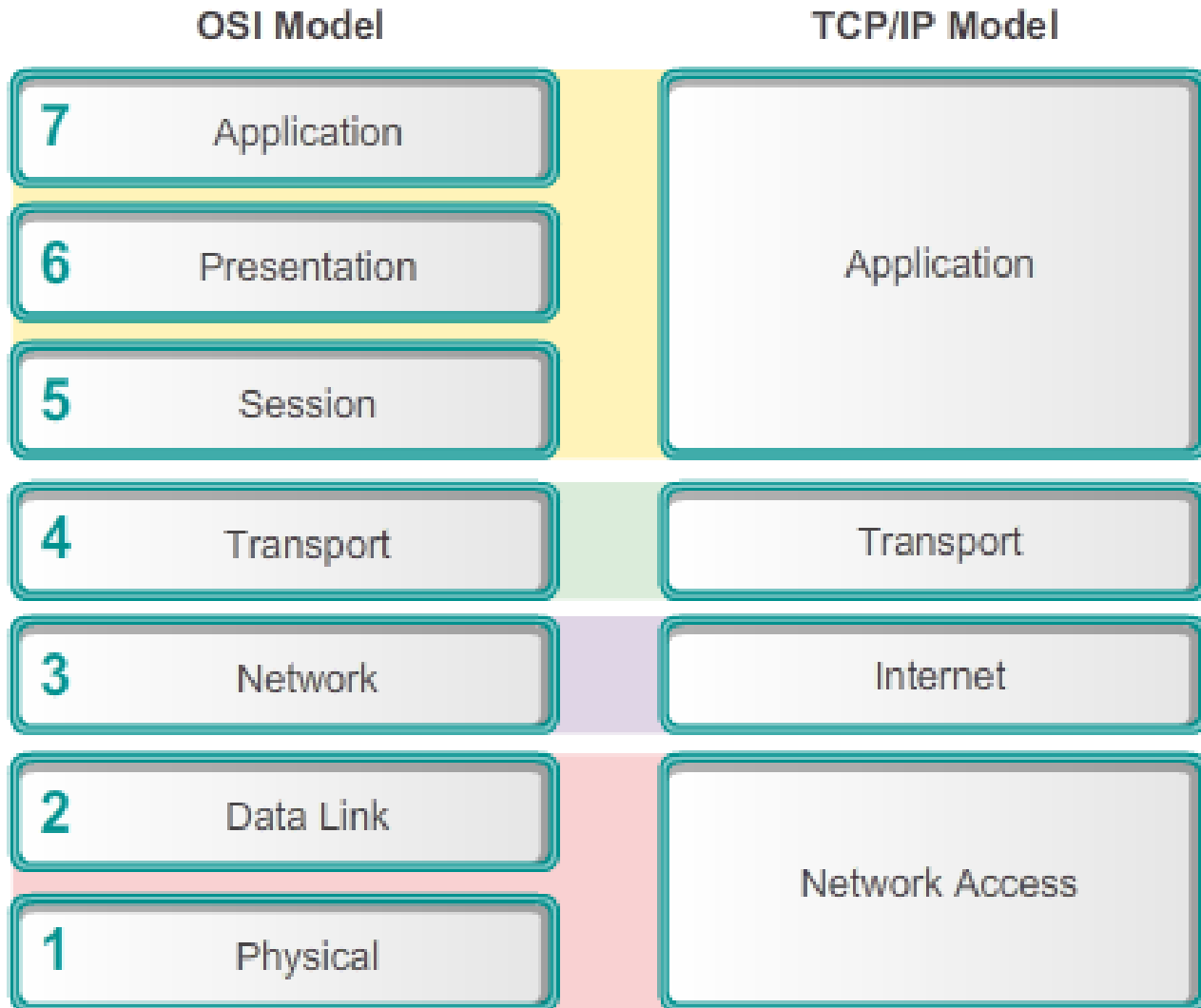
Instant Messaging

Podcasting

Weblog

Network applications…
- make communication in the workplace easier
- affect the amount of work completed on a daily basis
- reduce data communications time and costs

Comparing the OSI Model and TCP/IP Models

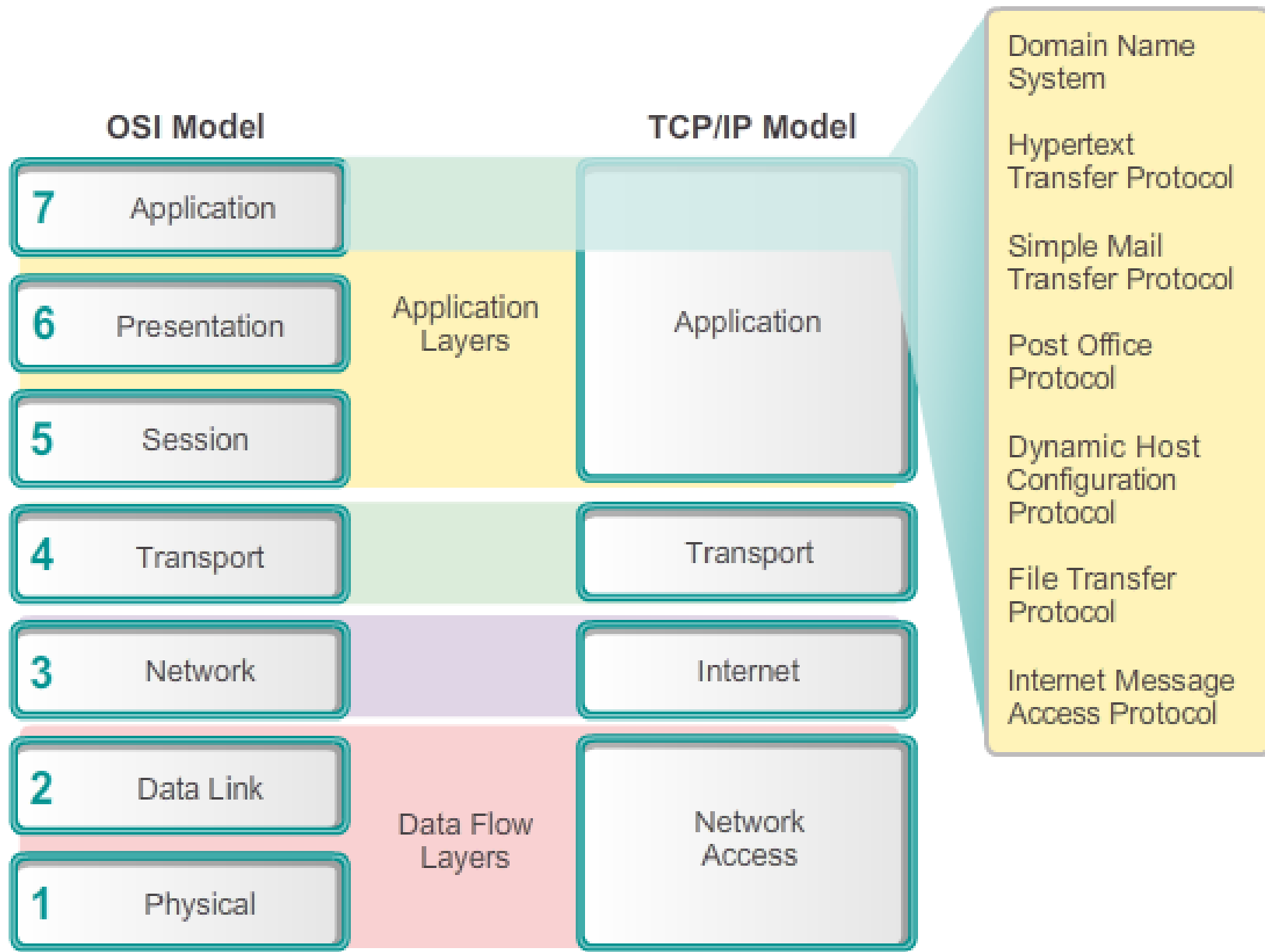| OSI Model	TCP/IP Model
7 Application	Application
6 Presentation	
5 Session	
4 Transport	Transport
3 Network	Internet
2 Data Link	Network Access
1 Physical	

The application layer is the top layer of both the OSI and TCP/IP models.

The TCP/IP application layer includes a number of protocols that provide specific functionality to a variety of end-user applications.

The functionality of the TCP/IP application layer protocols fit roughly into the framework of the top three layers of the OSI model: application, presentation and session layers.
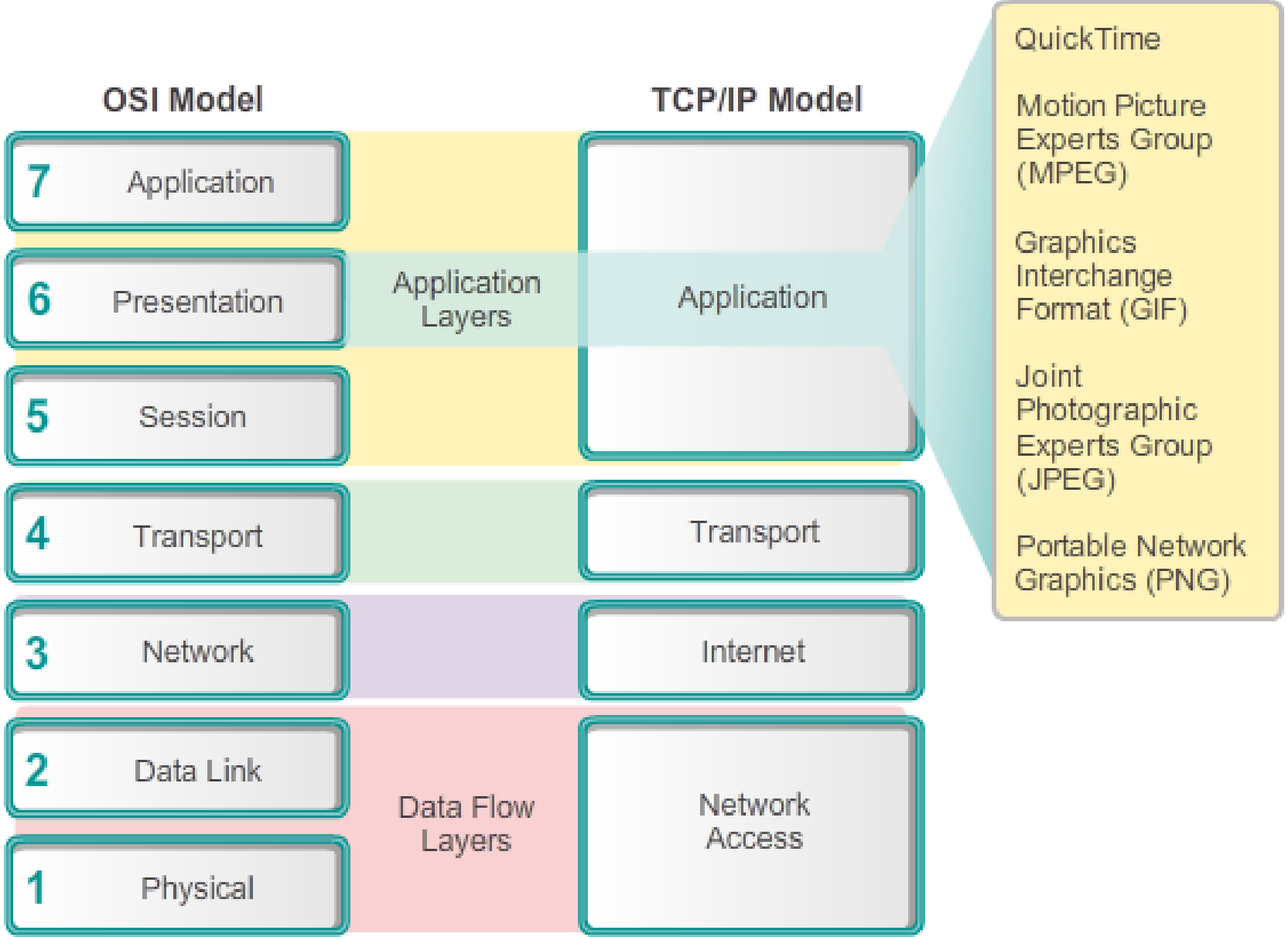
The OSI model Layers 5, 6, and 7 are used as references for application software developers and vendors to produce products, such as web browsers that need to access networks.

OSI Model

|	
7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data Link
1	Physical

Application Layers

Data Flow Layers

TCP/IP Model

Application

Transport

Internet

Network Access

Domain Name System

Hypertext Transfer Protocol

Simple Mail Transfer Protocol

Post Office Protocol

Dynamic Host Configuration Protocol

File Transfer Protocol

Internet Message Access Protocol

Application layer protocols are used to exchange data between programs running on the source and destination hosts

OSI Model

7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data Link
1	Physical

Application Layers

Data Flow Layers

TCP/IP Model

Application

Transport

Internet

Network Access

QuickTime

Motion Picture Experts Group (MPEG)

Graphics Interchange Format (GIF)

Joint Photographic Experts Group (JPEG)

Portable Network Graphics (PNG)

The presentation layer has three primary functions:

- **Formats**, or presents, data from the source device into a compatible form for receipt by the destination device.
- **Compression** of the data in a way that can be decompressed by the destination device.
- **Encryption** of the data for transmission and the decryption of data upon receipt by the destination.
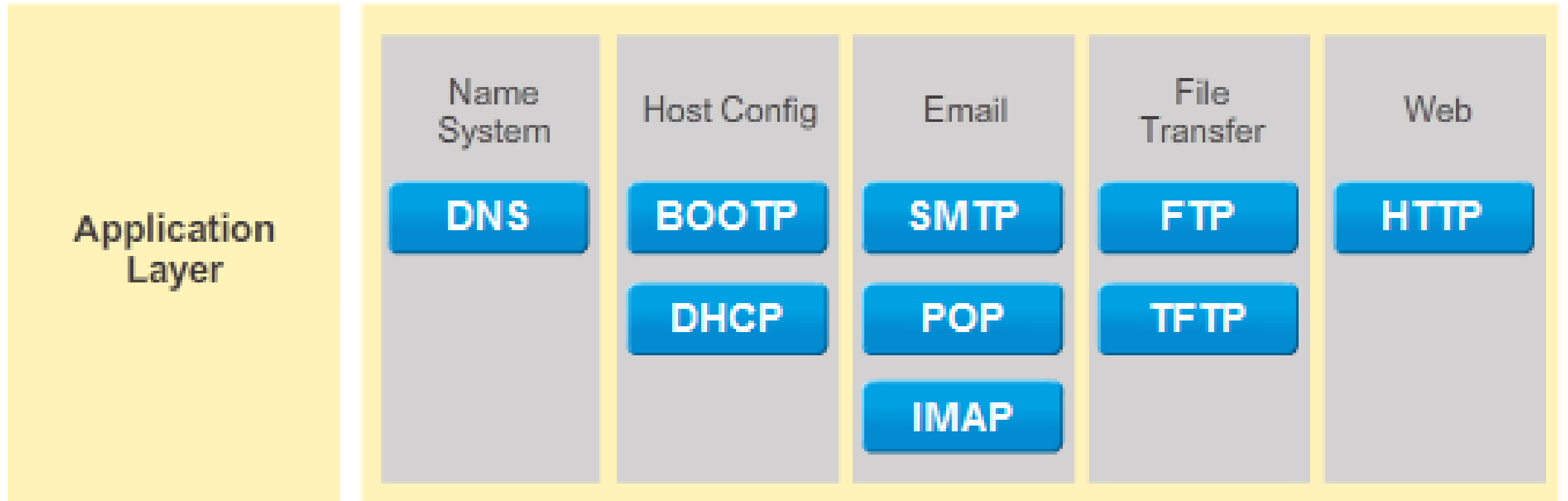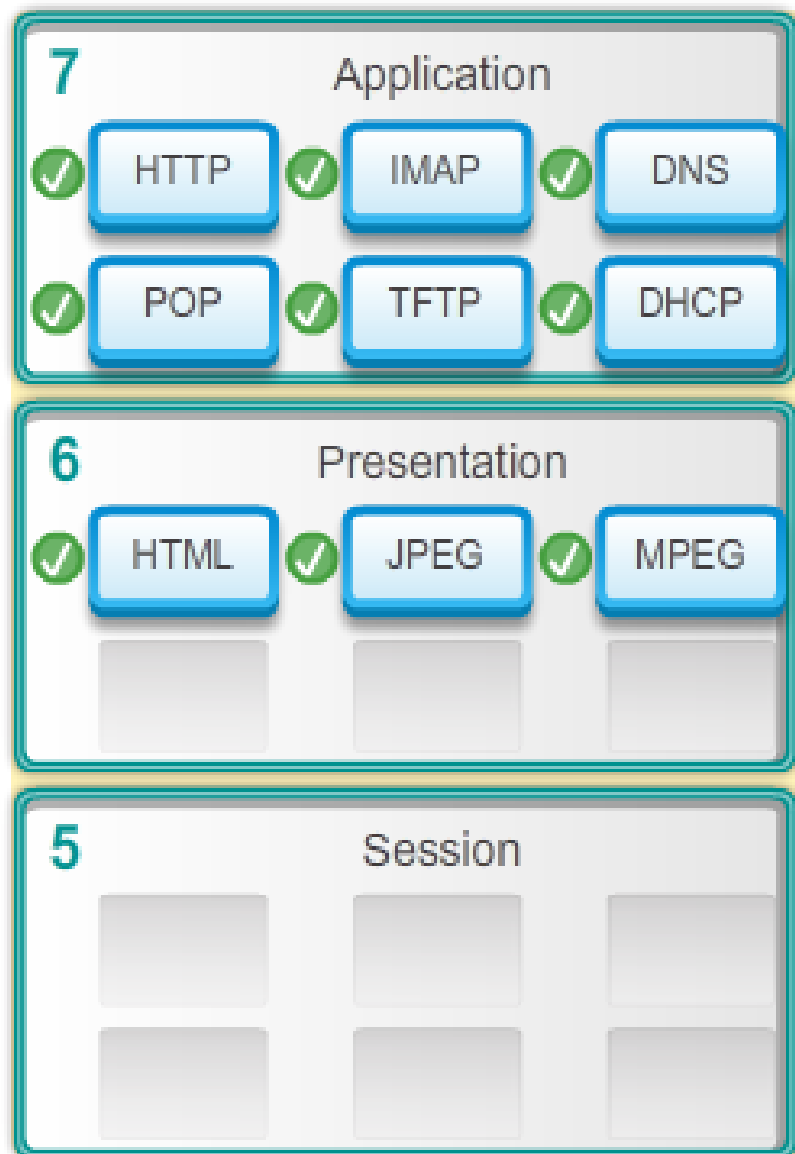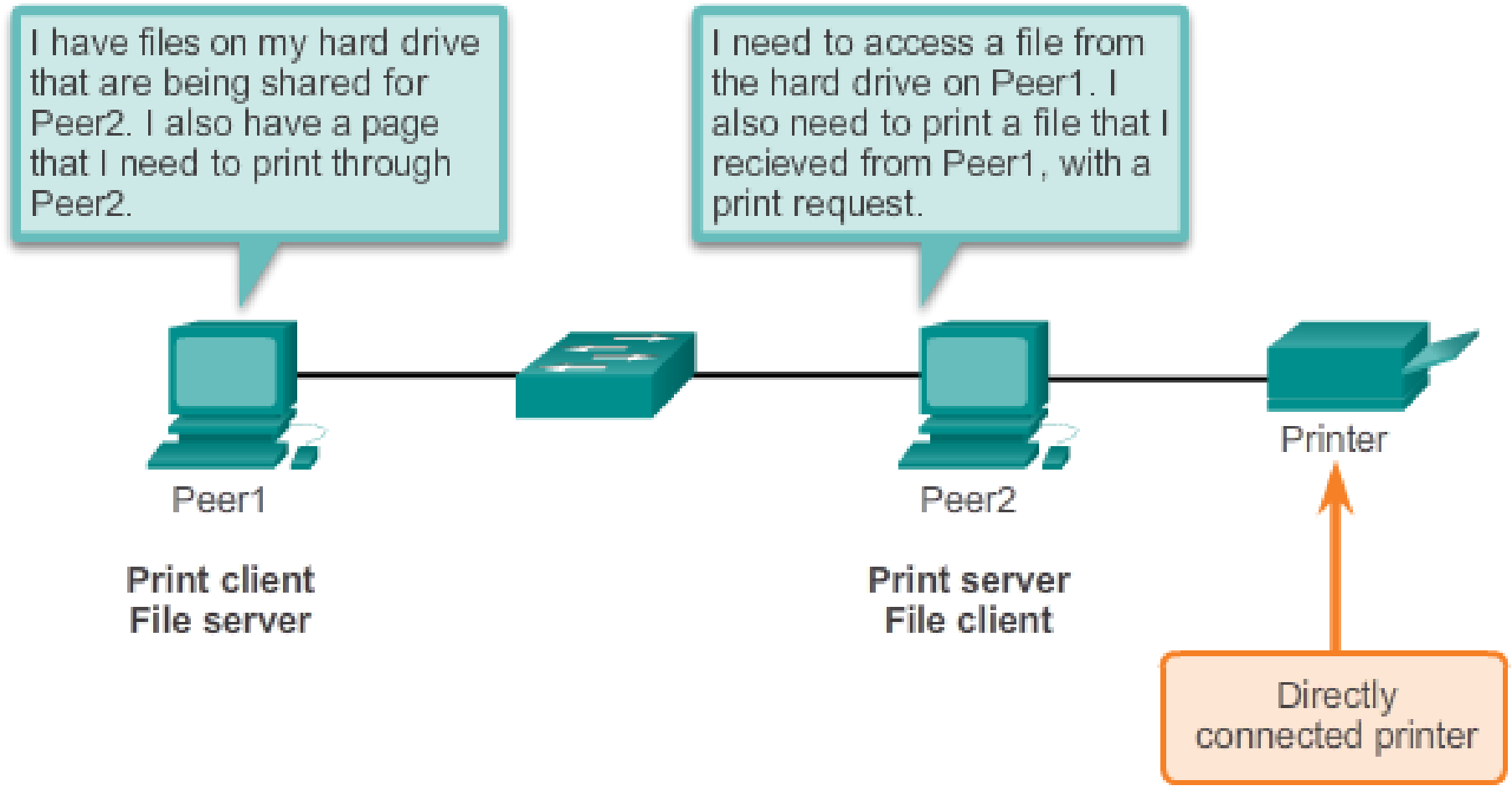
Peer-to-Peer Applications

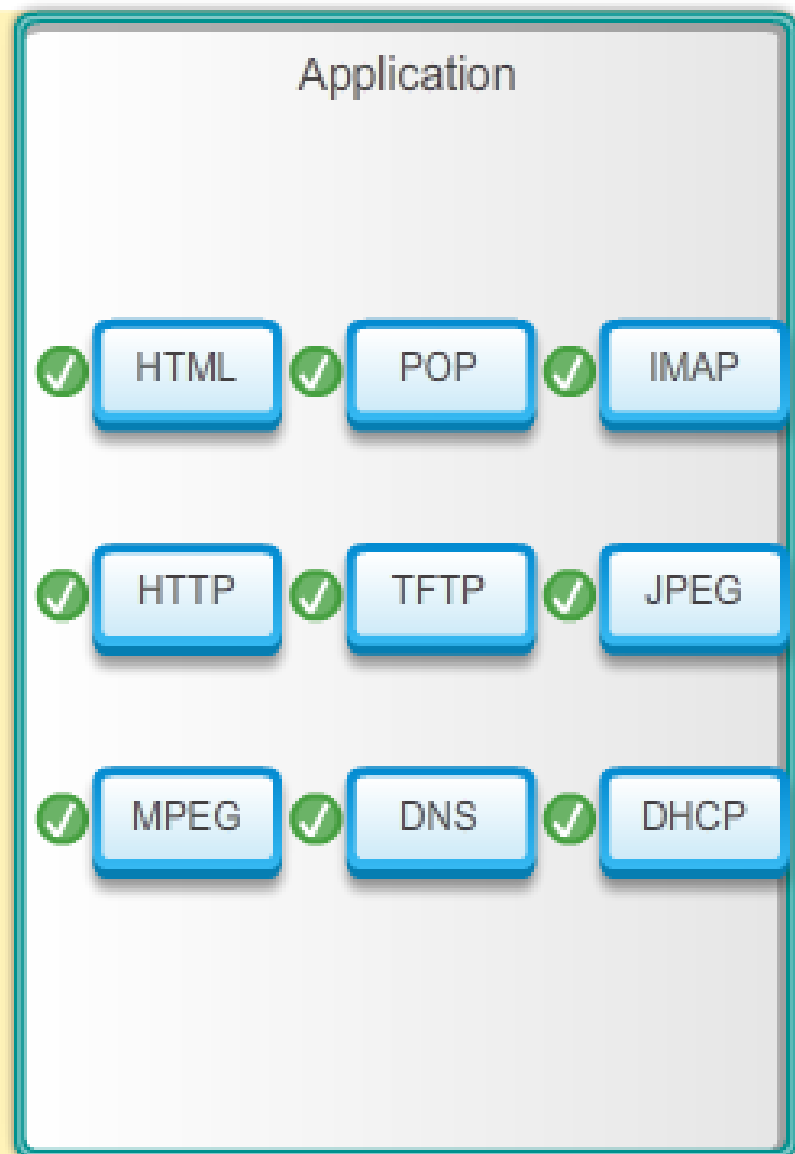Client and server in the same communication

Client and server

Instant Message

Meeting tonight.

I'll be there.

Good.

| Send | Receive |

Network

Client and server

Instant Message

Meeting tonight.

I'll be there.
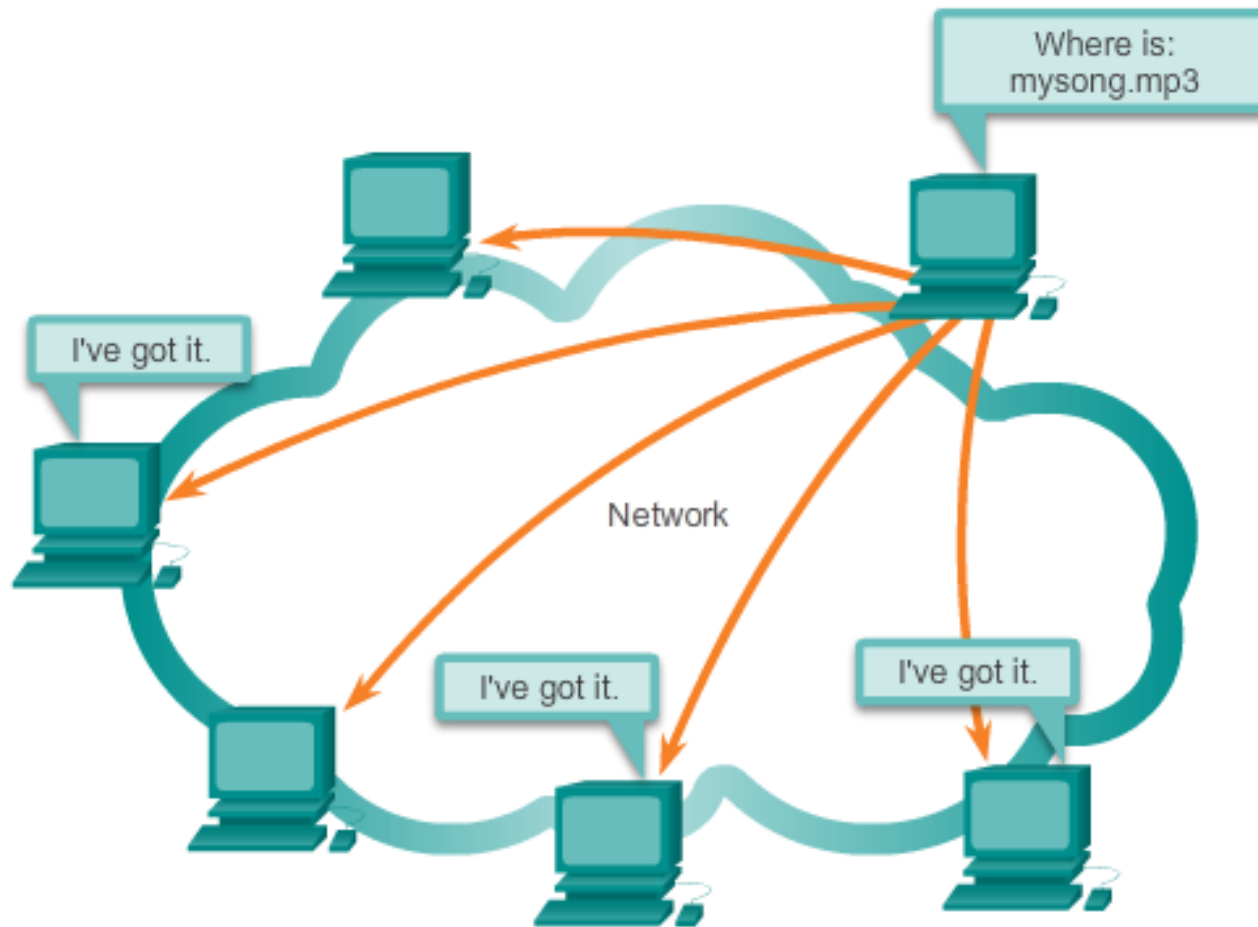
Good.

| Receive | Send |
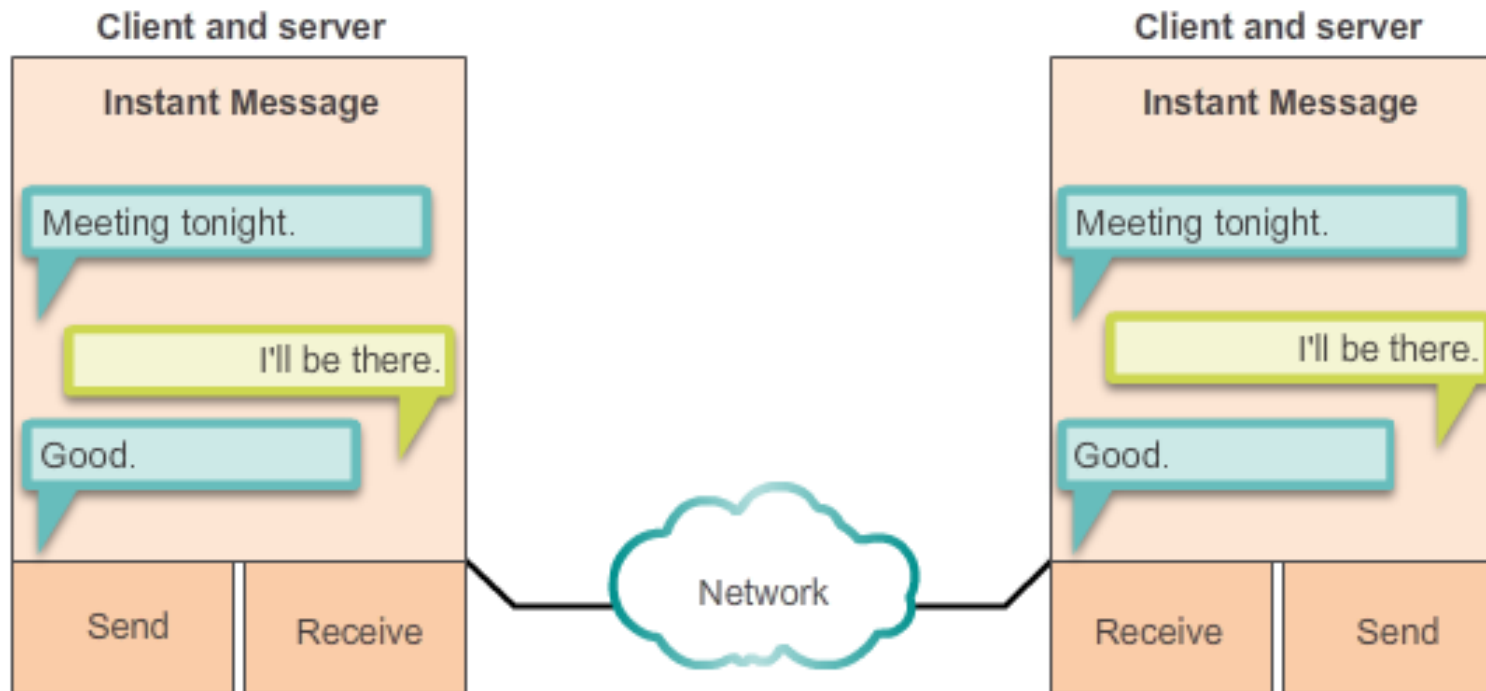
Both clients simultaneously
- Initiate a message
- Receive a message

A peer-to-peer (P2P) application allows a device to act as both a client and a server within the same communication, as shown in the figure.

Gnutella Supports P2P Applications

Where is: mysong.mp3

I've got it.

Network

I've got it.

I've got it.

Gnutella allows P2P applications to search for shared resources on peers.

With P2P applications, each computer in the network running the application can act as a client or a server for the other computers in the network running the application. Common P2P applications include:

- eDonkey
- eMule
- Shareaza
- BitTorrent
- Bitcoin
- LionShare

Some P2P applications are based on the **Gnutella protocol**. They enable people to share files on their hard disks with others. As shown in the figure,
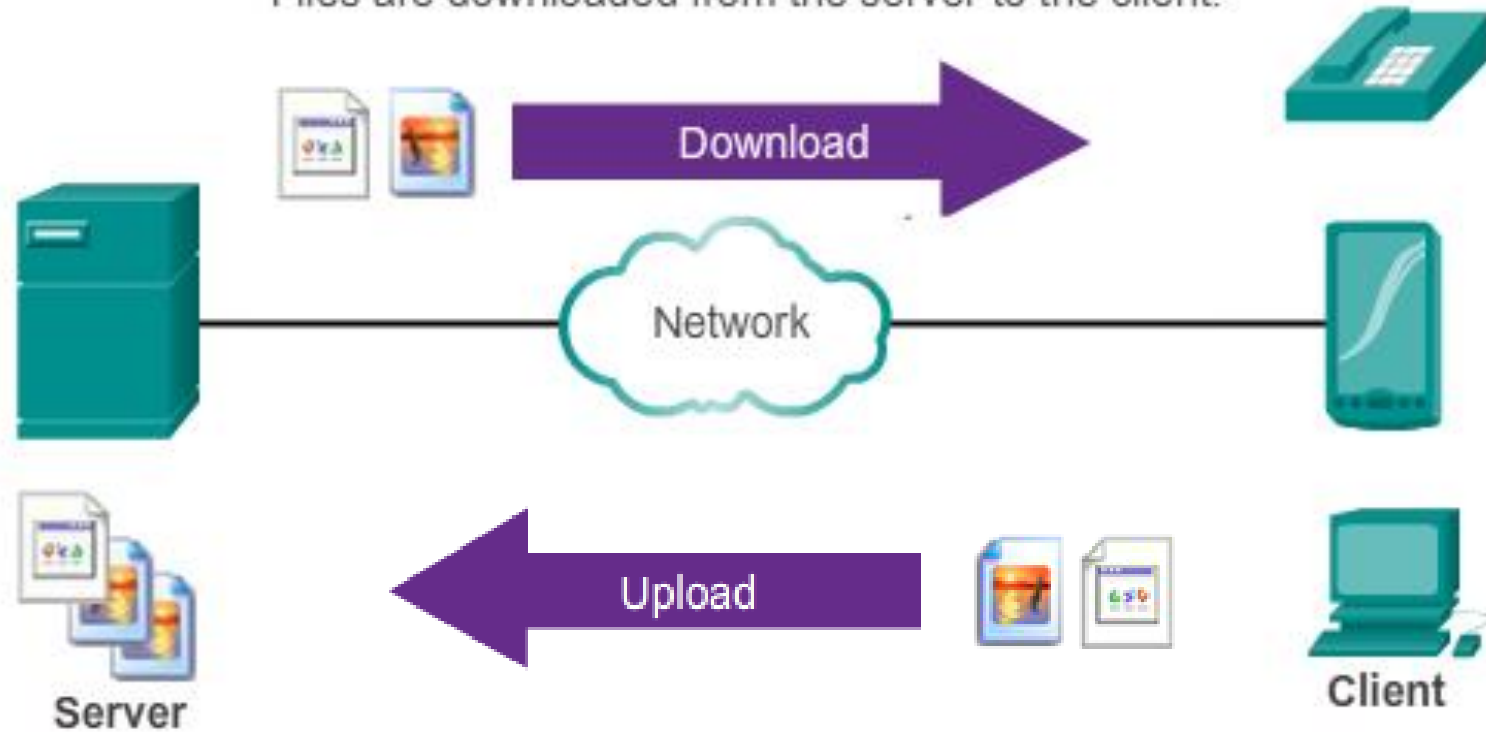
Researching Peer-to-Peer File Sharing

In this lab, you will complete the following objectives:
- Part 1: Identify P2P Networks, File Sharing Protocols, and Applications
- Part 2: Research P2P File Sharing Issues
- Part 3: Research P2P Copyright Litigations

Client/Server Model

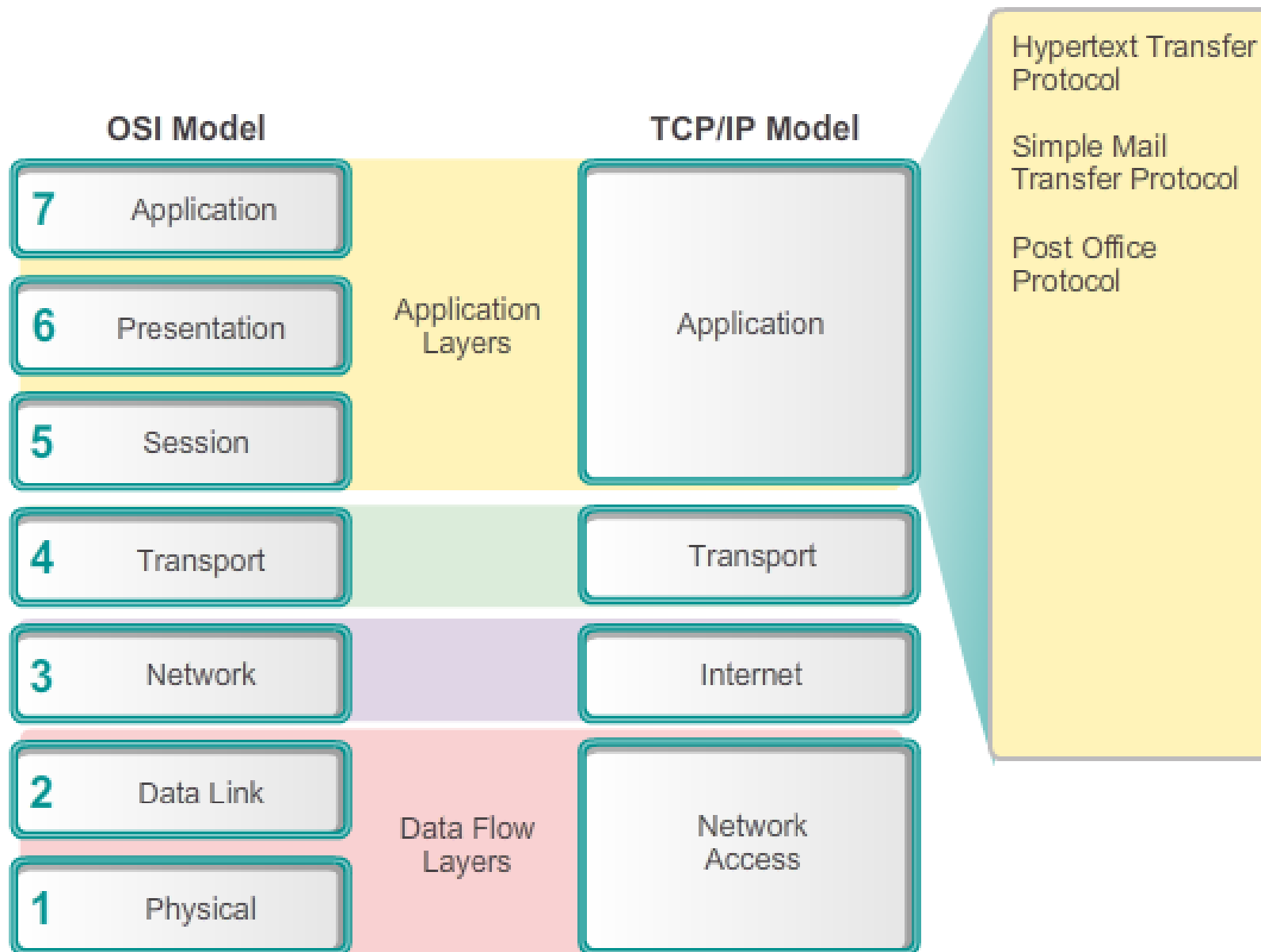Files are downloaded from the server to the client.

Download

Network

Upload

Server

Client

Resources are stored on the server.

A client is a hardware/software combination that people use directly.

OSI Model

7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data Link
1	Physical

Application Layers

Data Flow Layers

TCP/IP Model

Application

Transport

Internet

Network Access

Hypertext Transfer Protocol
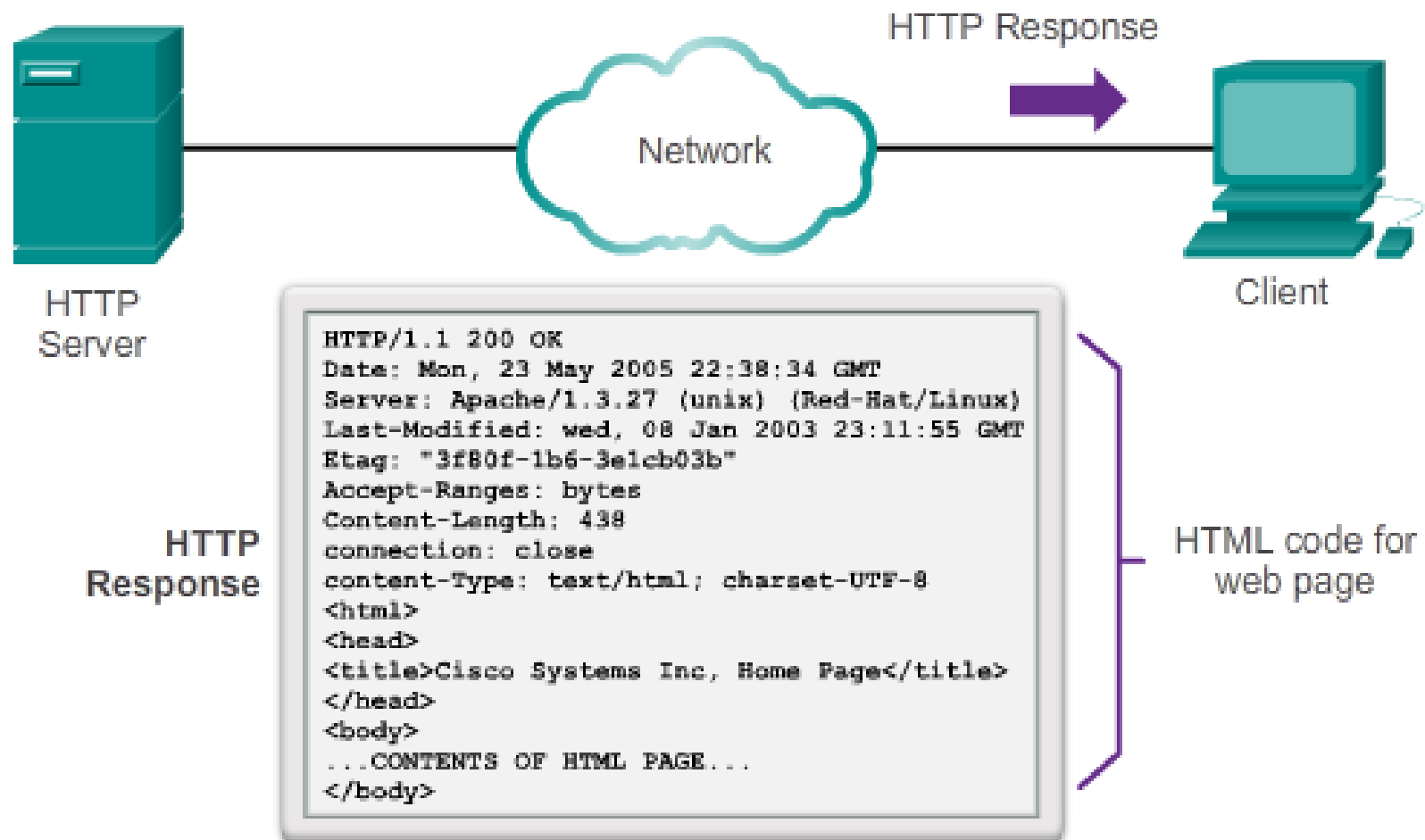
Simple Mail Transfer Protocol

Post Office Protocol

Three application layer protocols that are involved in everyday work or play are:
- Hypertext Transfer Protocol (HTTP)
- Simple Mail Transfer Protocol (SMTP)
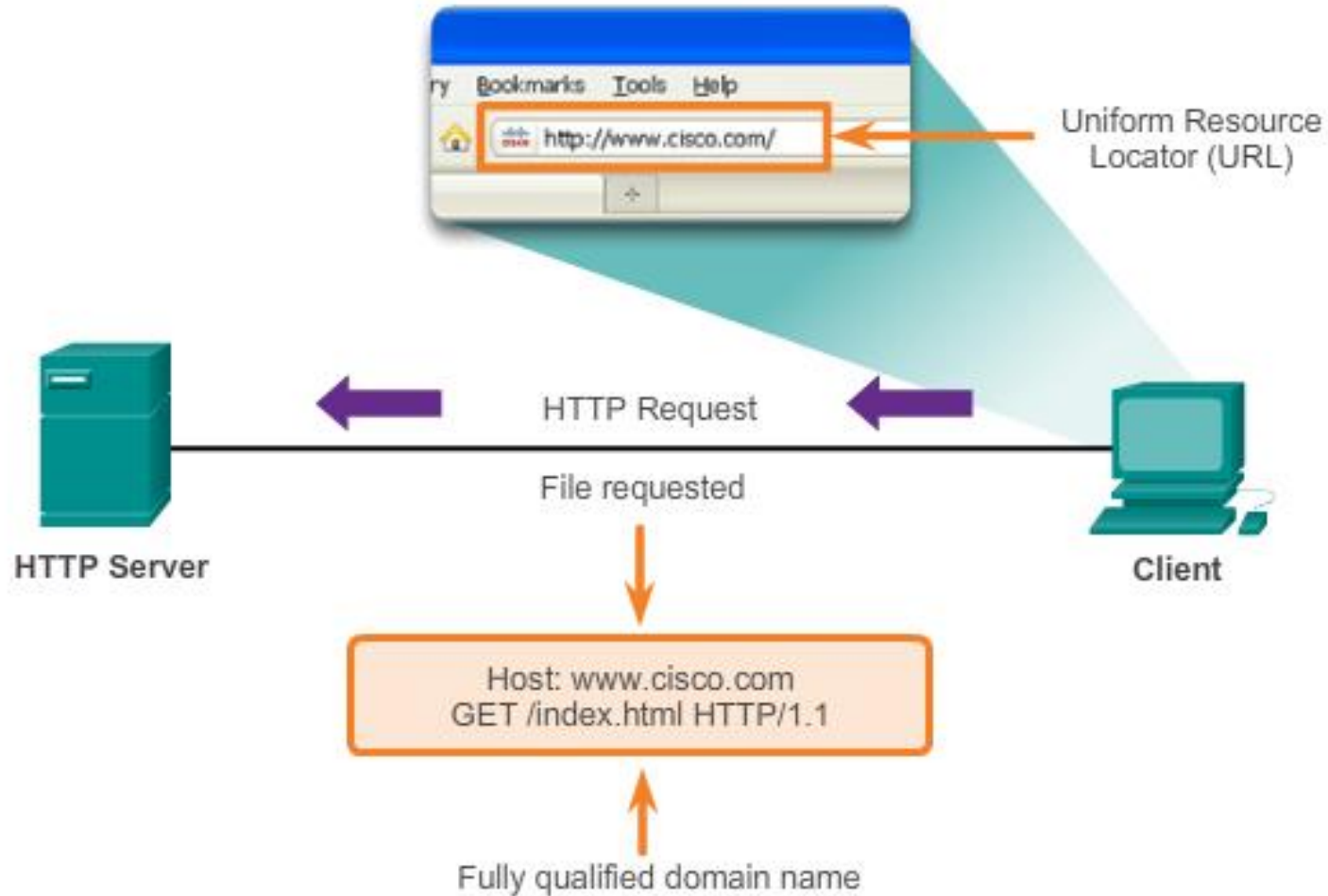- Post Office Protocol (POP)

HTTP Protocol Step 2

HTTP Server

HTTP Response

Network

HTTP Response

```
HTTP/1.1 200 OK
Date: Mon, 23 May 2005 22:38:34 GMT
Server: Apache/1.3.27 (unix) (Red-Hat/Linux)
Last-Modified: wed, 08 Jan 2003 23:11:55 GMT
Etag: "3f80f-1b6-3e1cb03b"
Accept-Ranges: bytes
Content-Length: 438
connection: close
content-Type: text/html; charset-UTF-8
<html>
<head>
<title>Cisco Systems Inc, Home Page</title>
</head>
<body>
...CONTENTS OF HTML PAGE...
</body>
```

Client

HTML code for web page

HTTP Protocol using GET

Uniform Resource Locator (URL)

HTTP Request

File requested

HTTP Server

Client

Host: www.cisco.com
GET /index.html HTTP/1.1

Fully qualified domain name

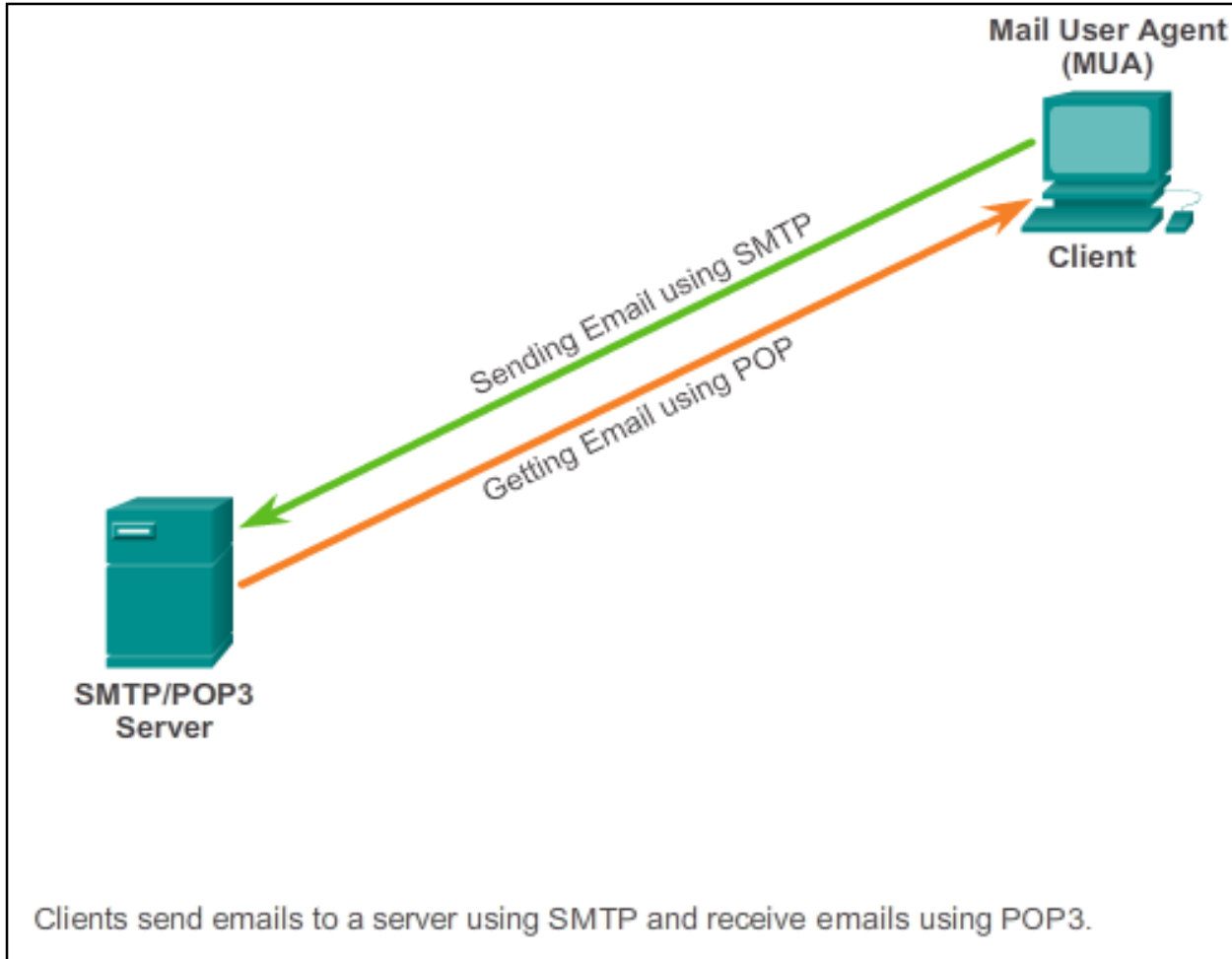Entering 'http://www.cisco.com' in the address bar of a web browser generates the HTTP 'GET' message.
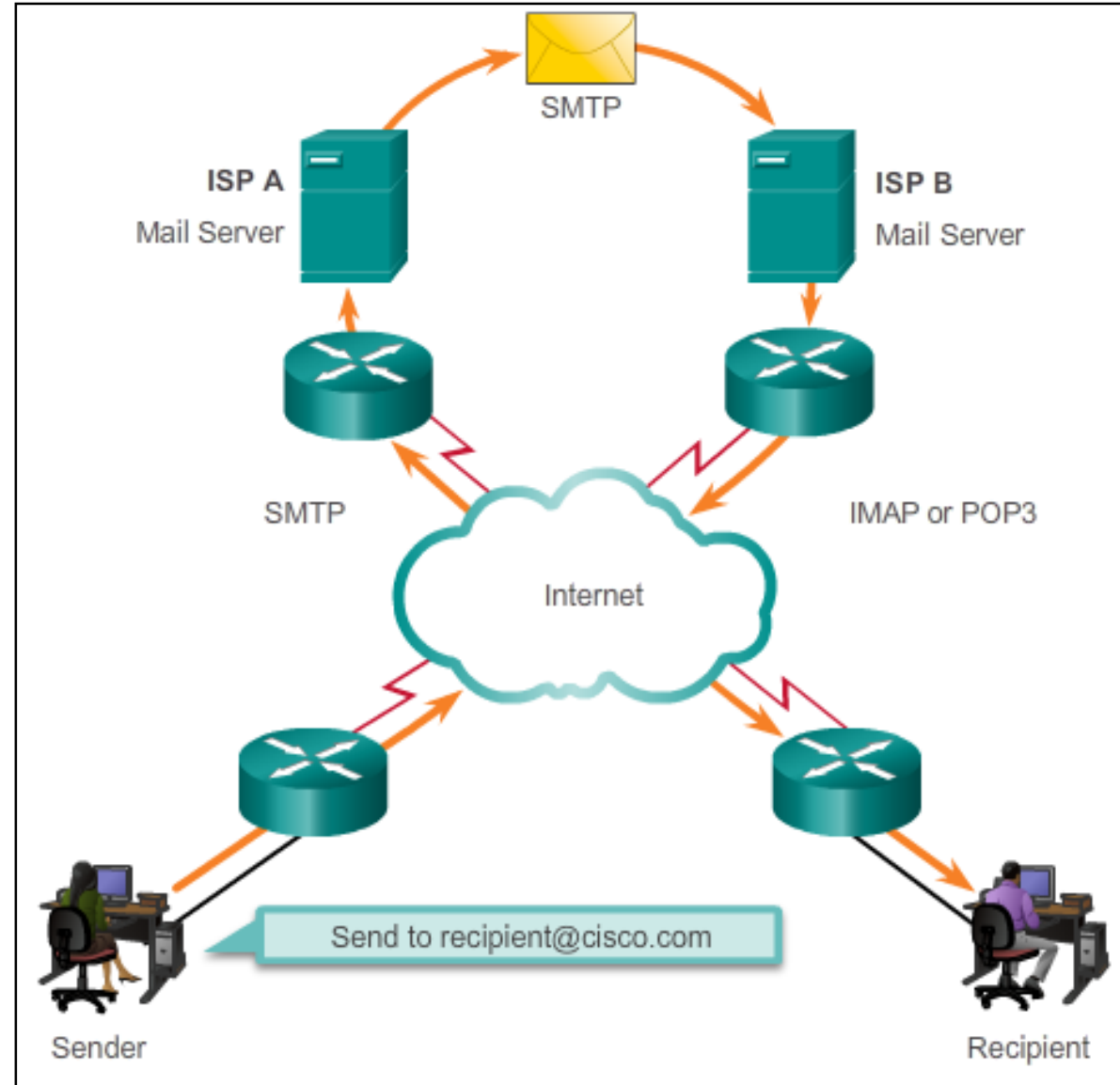
HTTPS uses the same client request-server response process as HTTP, but the data stream is encrypted with Secure Socket Layer (SSL) before being transported across the network. HTTPS creates additional load and processing time on the server due to the encryption and decryption of traffic.

Mail User Agent (MUA)

Client

Sending Email using SMTP

Getting Email using POP

SMTP/POP3 Server

Clients send emails to a server using SMTP and receive emails using POP3.

SMTP

ISP A
Mail Server

ISP B
Mail Server

SMTP

IMAP or POP3

Internet

Send to recipient@cisco.com

Sender

Recipient
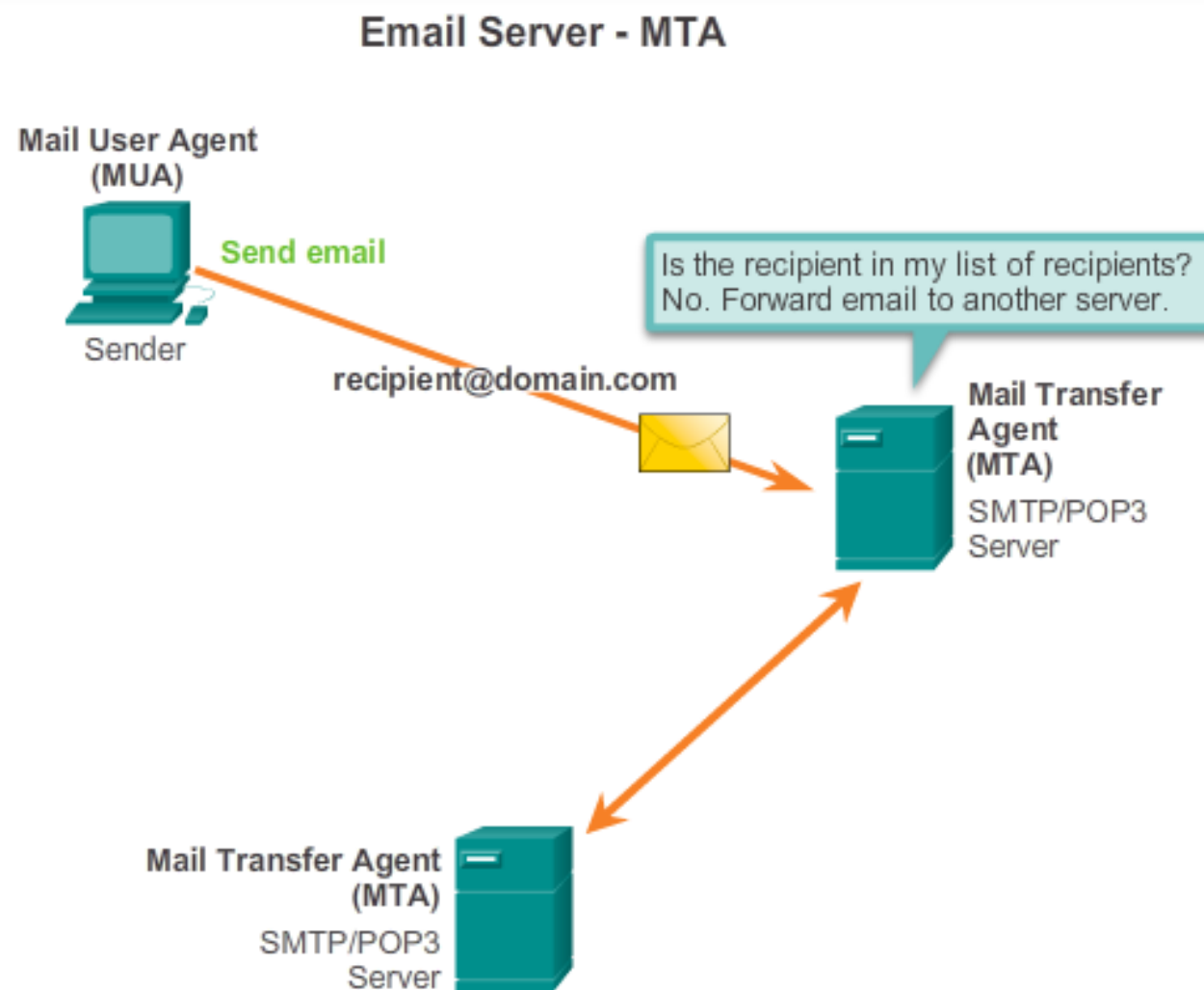
Email is a store-and-forward method of sending, storing, and retrieving electronic messages across a network. Email messages are stored in databases on mail servers. ISPs often maintain mail servers that support many different customer accounts.
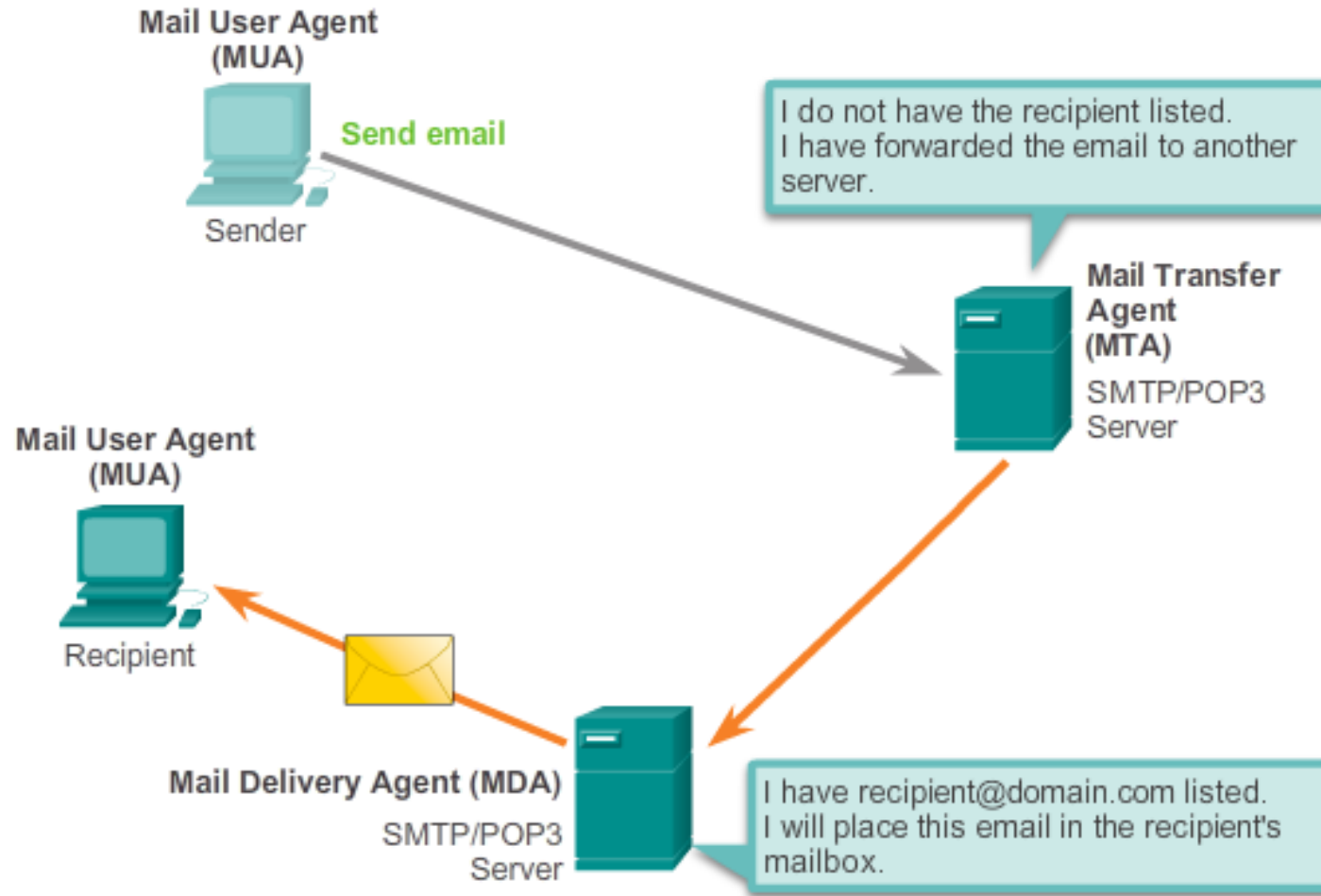
Email Server - MTA

Mail User Agent (MUA)

Send email

Sender

recipient@domain.com

Is the recipient in my list of recipients? No. Forward email to another server.

Mail Transfer Agent (MTA)

SMTP/POP3 Server

Mail Transfer Agent (MTA)

SMTP/POP3 Server

The Mail Transfer Agent process governs email handling between servers and clients.

Simple Mail Transfer Protocol (SMTP) transfers mail reliably and efficiently. For SMTP applications to work properly, the mail message must be formatted properly and SMTP processes must be running on both the client and server.

SMTP message formats require a message **header** and a message **body**. While the message body can contain any amount of text, the message header must have a properly formatted recipient email address and a sender address. Any other header information is optional.

Email Server - MDA

The Mail Delivery Agent process governs delivery of email between servers and clients.
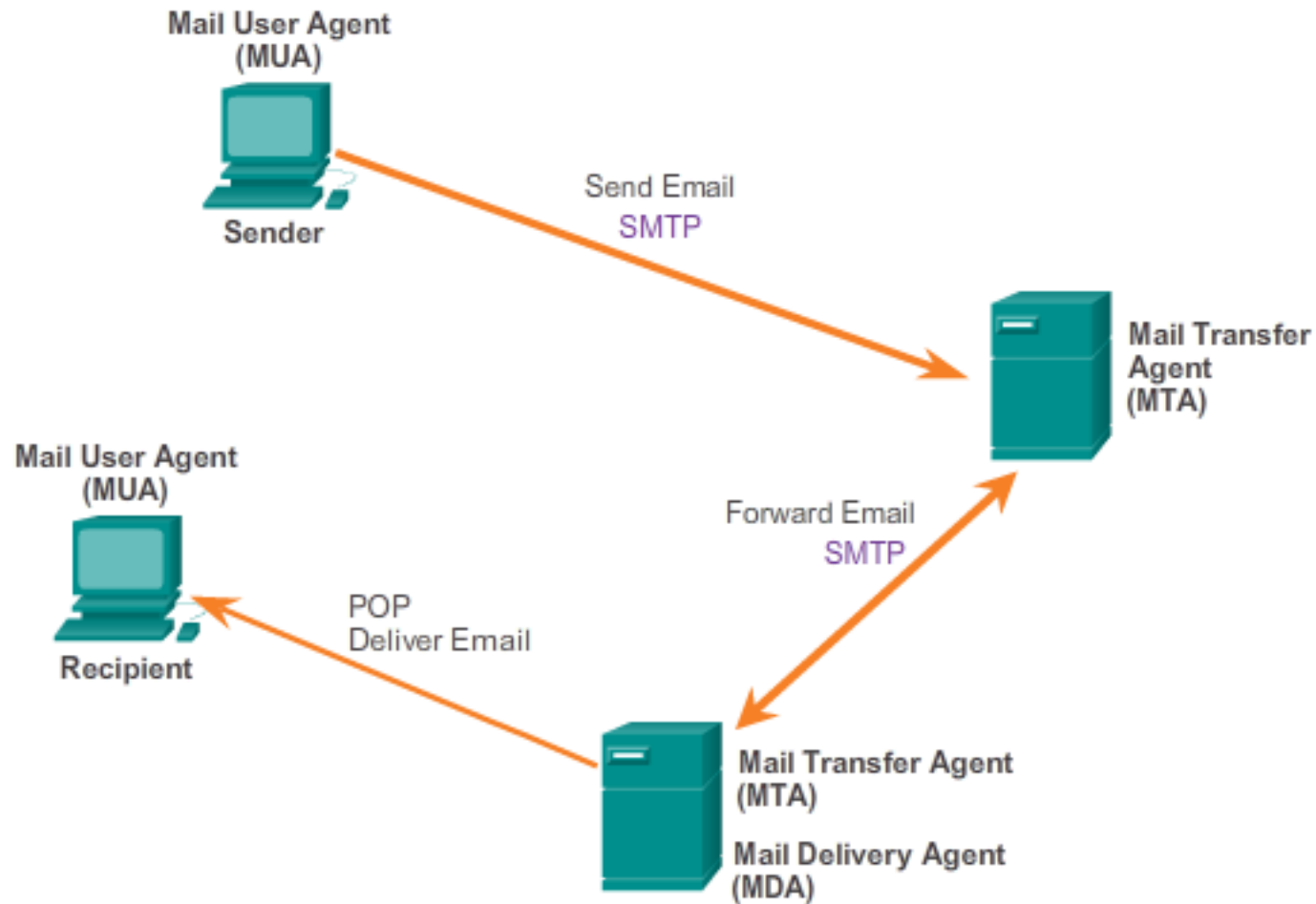
Post Office Protocol (POP) enables a workstation to retrieve mail from a mail server. With POP, mail is downloaded from the server to the client and then deleted on the server.

The server starts the POP service by passively listening on TCP port 110 for client connection requests. When a client wants to make use of the service, it sends a request to establish a TCP connection with the server. When the connection is established, the POP server sends a greeting. The client and POP server then exchange commands and responses until the connection is closed or aborted.

Email Server - MDA

Mail User Agent
(MUA)

Sender

Send Email
SMTP

Mail Transfer
Agent
(MTA)

Mail User Agent
(MUA)

Recipient

POP
Deliver Email

Forward Email
SMTP

Mail Transfer Agent
(MTA)

Mail Delivery Agent
(MDA)

SMTP is used to send emails from clients to server, and to forward emails between email servers.

POP is used to deliver email.

Internet Message Access Protocol (IMAP) is another protocol that describes a method to retrieve email messages. However, unlike POP, when the user connects to an IMAP-capable server, copies of the messages are downloaded to the client application. The original messages are kept on the server until manually deleted. Users view copies of the messages in their email client software.

Users can create a file hierarchy on the server to organize and store mail. That file structure is duplicated on the email client as well. When a user decides to delete a message, the server synchronizes that action and deletes the message from the server.
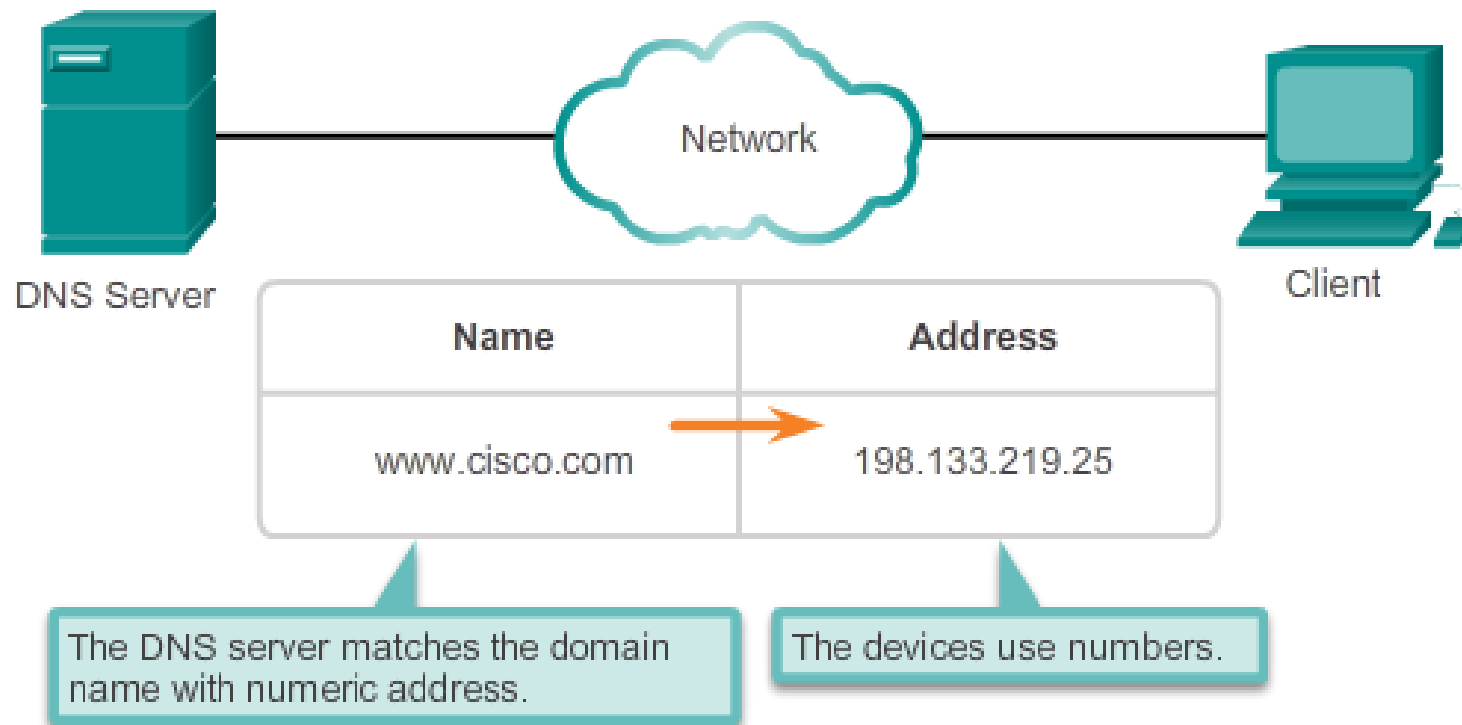
Web and Email

In this activity, you will configure HTTP and email services using the simulated server in Packet Tracer. You will then configure clients to access the HTTP and email services.

Resolving DNS Addresses Step 2

DNS Server

Network

Client

Name	Address
www.cisco.com	198.133.219.25

The DNS server matches the domain name with numeric address.

The devices use numbers.

DNS Message Format

DNS uses the same message format for:
_____
- all types of client queries and server responses
- error messages
- the transfer of resource record information between servers

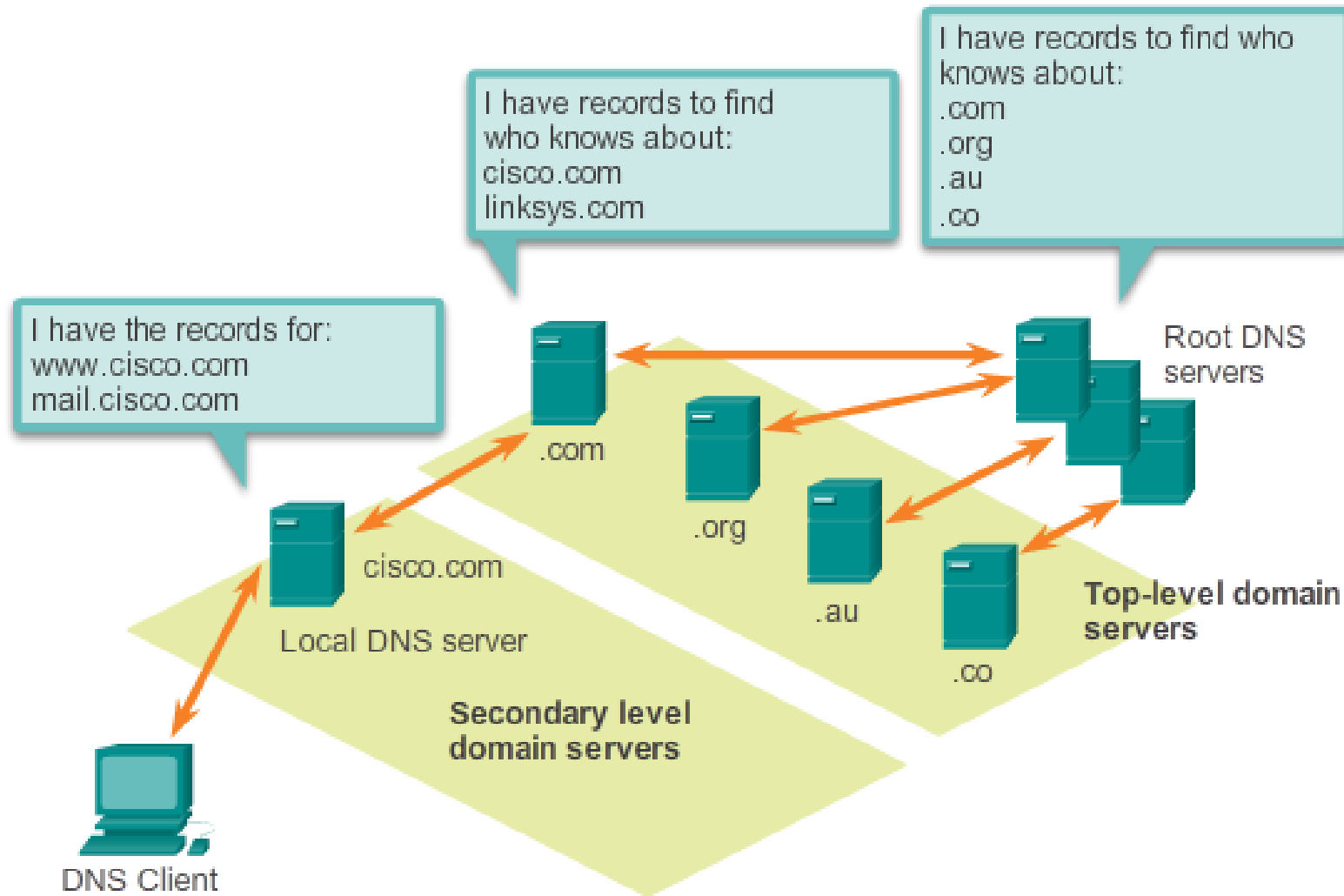| Header	
Question	The question for the name server
Answer	Resource Records answering the question
Authority	Resource Records pointing toward an authority
Additional	Resource Records holding additional information

The DNS server stores different types of resource records used to resolve names. These records contain the name, address, and type of record.
Some of these record types are:
- A - An end device address
- NS - An authoritative name server
- CNAME - The canonical name (or Fully Qualified Domain Name) for an alias; used when multiple services have the single network address, but each service has its own entry in DNS
- MX - Mail exchange record; maps a domain name to a list of mail exchange servers for that domain

When a client makes a query, the server's BIND process first looks at its own records to resolve the name. If it is unable to resolve the name using its stored records, it contacts other servers to resolve the name.
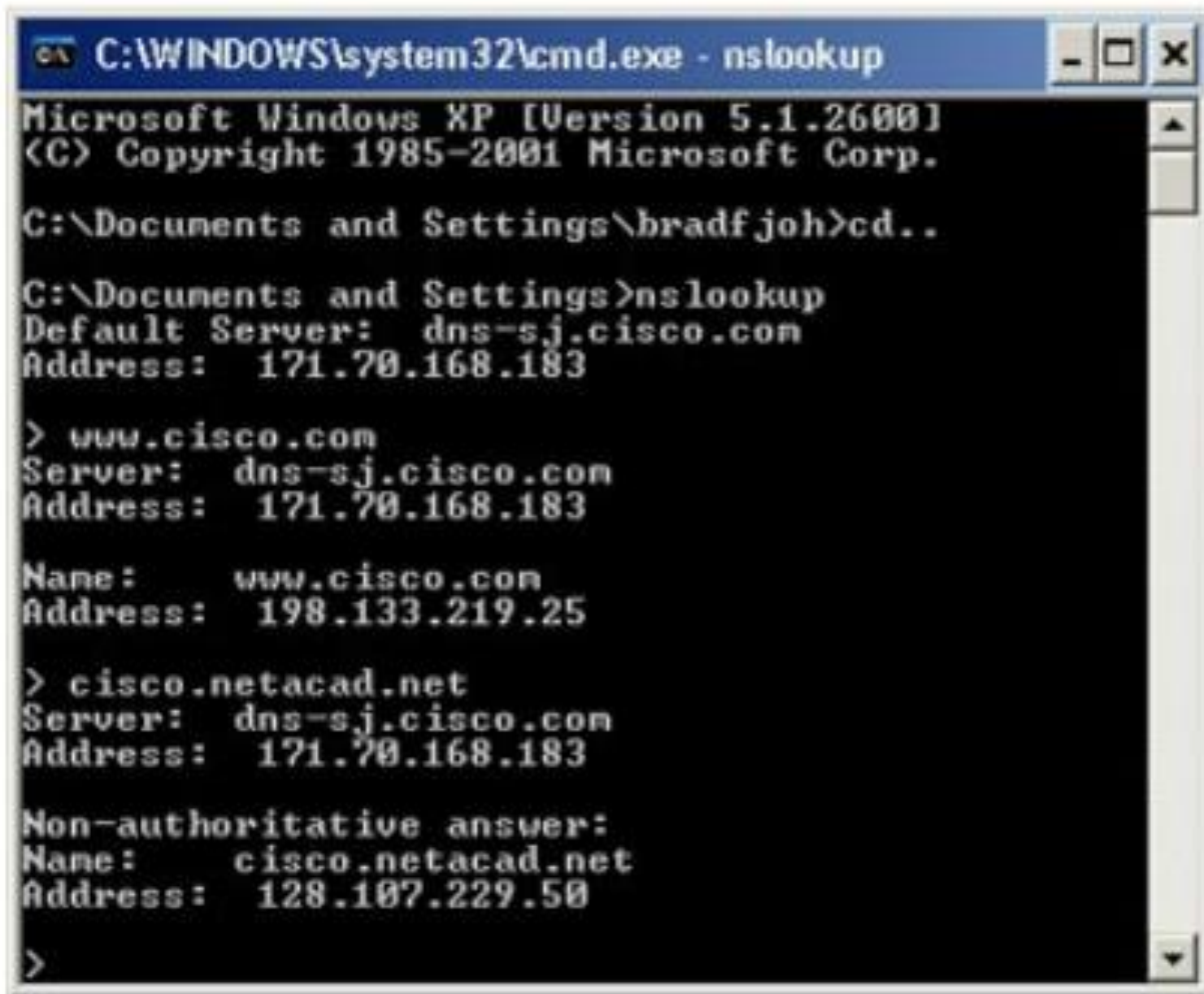
I have records to find who knows about:
cisco.com
linksys.com

I have records to find who knows about:
.com
.org
.au
.co

I have the records for:
www.cisco.com
mail.cisco.com

.com

Root DNS servers

.org

cisco.com

Local DNS server

.au

.co

Top-level domain servers

Secondary level domain servers

DNS Client

A hierarchy of DNS servers contains the resource records that match names with addresses.

- The naming structure is broken down into small, manageable zones.
- Each DNS server maintains a specific database file and is only responsible for managing name-to-IP mappings for that small portion of the entire DNS structure.
- When a DNS server receives a request for a name translation that is not within its DNS zone, the DNS server forwards the request to another DNS server within the proper zone for translation.

```
C:\WINDOWS\system32\cmd.exe - nslookup

Microsoft Windows XP [Version 5.1.2600]
<C> Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\bradfjoh>cd..

C:\Documents and Settings>nslookup
Default Server:  dns-sj.cisco.com
Address:  171.70.168.183

> www.cisco.com
Server:  dns-sj.cisco.com
Address:  171.70.168.183

Name:      www.cisco.com
Address:  198.133.219.25

> cisco.netacad.net
Server:  dns-sj.cisco.com
Address:  171.70.168.183

Non-authoritative answer:
Name:      cisco.netacad.net
Address:  128.107.229.50

>
```

Computer operating systems also have a utility called nslookup that allows the user to manually query the name servers to resolve a given hostname. This utility can also be used to troubleshoot name resolution issues and to verify the current status of the name servers.

In the figure, when the nslookup command is issued, the default DNS server configured for your host is displayed. In this example, the DNS server is dns-sj.cisco.com which has an address of 171.70.168.183.

Using the `nslookup` Command

Enter the 'nslookup' command to begin a manual query of the name servers.

```
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation.  All rights reserved.

c:\>
```

Enter the 'nslookup' command to begin a manual query of the name servers.

```
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation.  All rights reserved.

c:\> nslookup
Default Server:   UnKnown
Address:   10.10.10.1
```

The output lists the name and IP address of the closest name server. In this case, the user is in a home network behind a router firewall. The address is the router.
 You are now in nslookup mode. Enter the domain name 'www.cisco.com'.

As in Windows, you can directly query the DNS servers by simply adding the domain name to the 'nslookup' command. Enter 'nslookup www.google.com'.

```
user@cisconetacad$nslookup www.google.com
Server:         127.0.1.1
Address:     127.0.1.1#53

Non-authoritative answer:
Name:     www.google.com
Address: 74.125.225.209
Name:     www.google.com
Address: 74.125.225.210
Name:     www.google.com
Address: 74.125.225.211
Name:     www.google.com
Address: 74.125.225.212
Name:     www.google.com
Address: 74.125.225.208

user@cisconetacad$
```

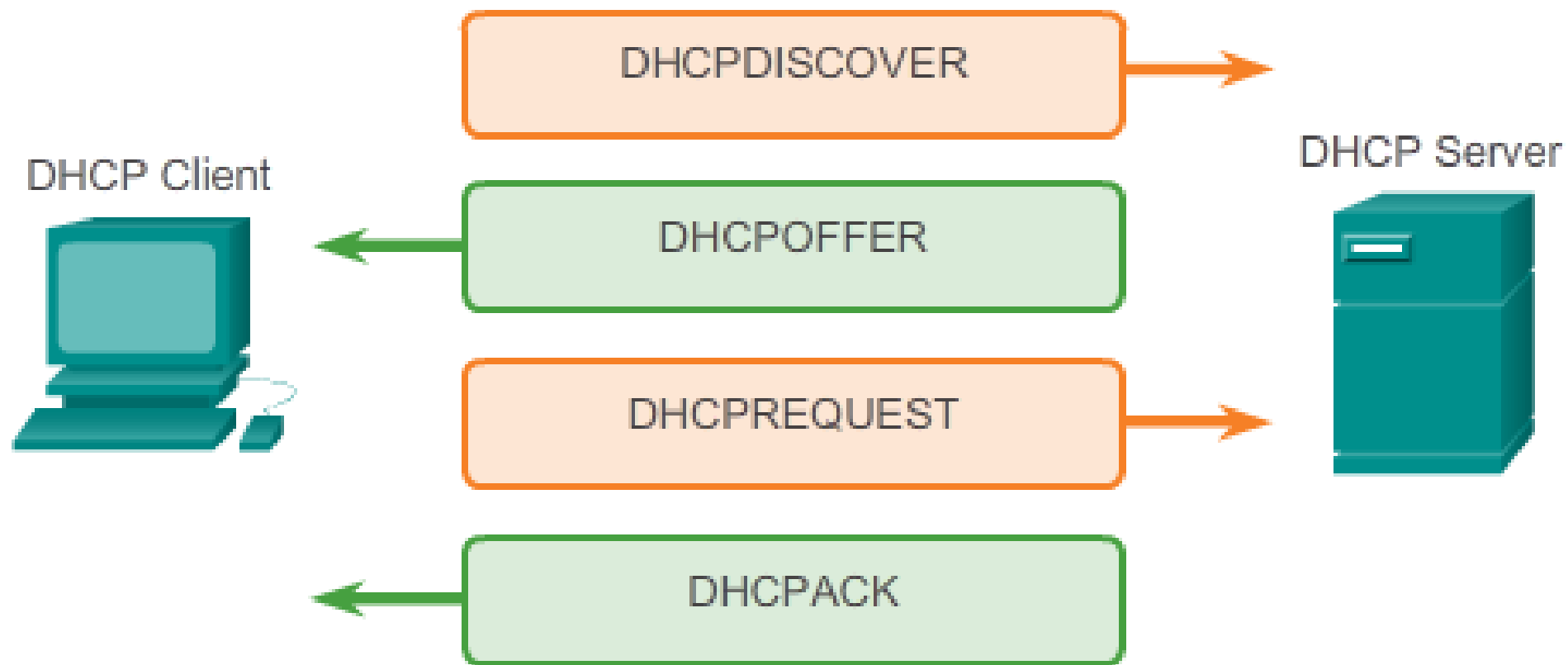**You successfully used the nslookup command to verify the status of domain names.**
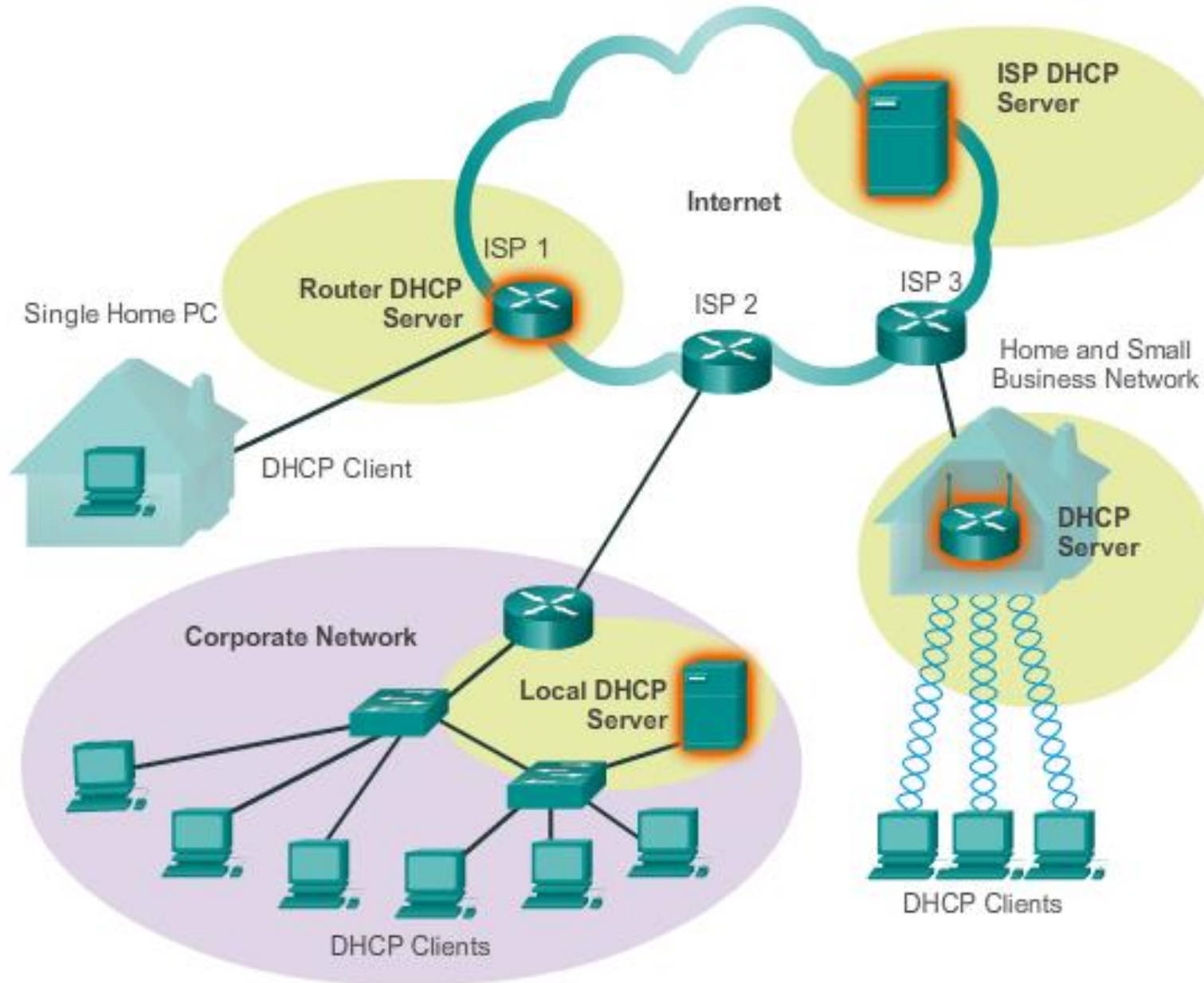
DHCP allows a host to obtain an IP address dynamically when it connects to the network. The DHCP server is contacted and an address requested. The DHCP server chooses an address from a configured range of addresses called a pool and assigns (leases) it to the host for a set period.

When a DHCP-configured device boots up or connects to the network, the client broadcasts a DHCP discover (DHCPDISCOVER) message to identify any available DHCP servers on the network. A DHCP server replies with a DHCP offer (DHCPOFFER) message, which offers a lease to the client. The offer message contains the IP address and subnet mask to be assigned, the IP address of the DNS server, and the IP address of the default gateway. The lease offer also includes the duration of the lease.

DHCP and DNS Servers

In this activity, you will configure and verify static IP addressing and DHCP addressing. You will then configure a DNS server to map IP addresses to the website names.

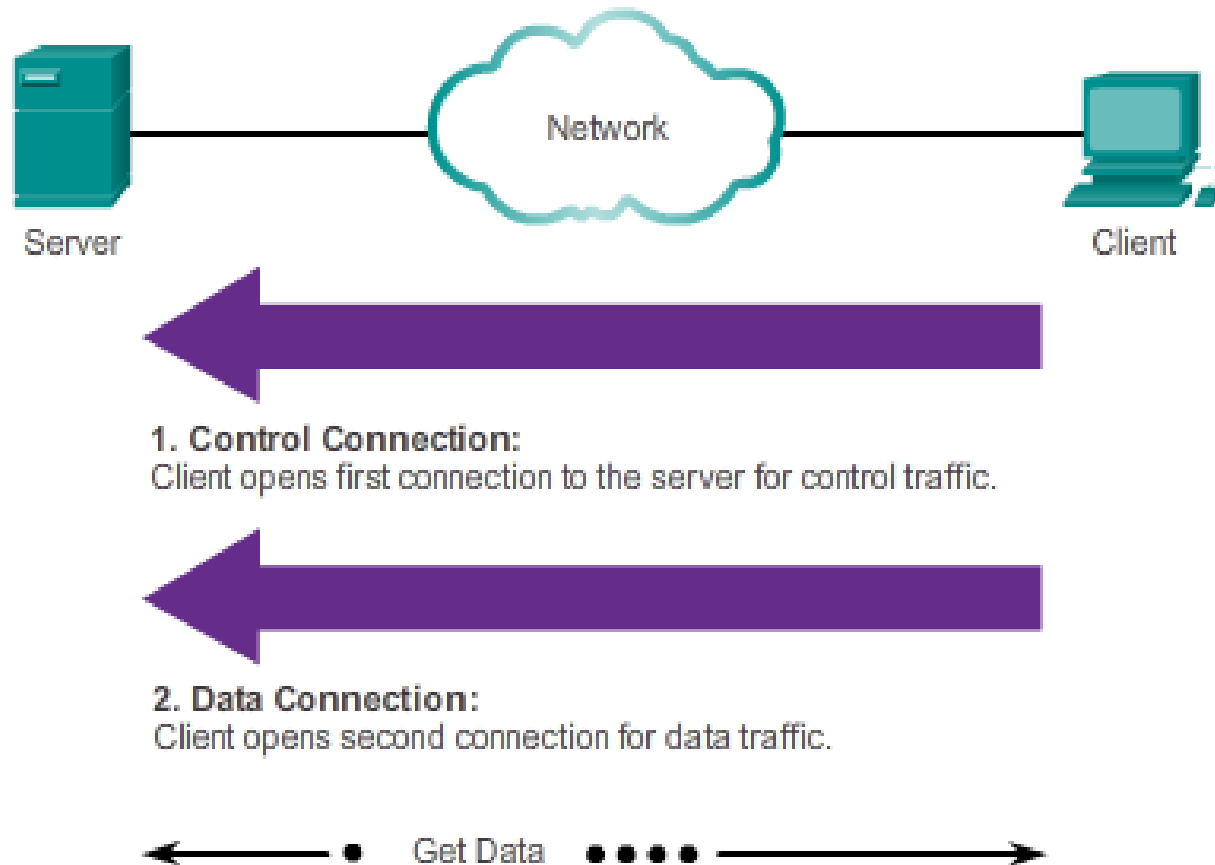## Observing DNS Resolution

In this lab, you will complete the following objectives:

- Part 1: Observe the DNS Conversion of a URL to an IP Address
- Part 2: Observe DNS Lookup Using the nslookup Command on a Web Site
- Part 3: Observe DNS Lookup Using the nslookup Command on Mail Servers

FTP Process

Server

Network

Client

1. Control Connection:
Client opens first connection to the server for control traffic.

2. Data Connection:
Client opens second connection for data traffic.

Get Data

Based on commands sent across control connection, data can be downloaded from server or uploaded from client.

As the figure illustrates, to successfully transfer data, FTP requires two connections between the client and the server, one for commands and replies, the other for the actual file transfer:

- The client establishes the first connection to the server for control traffic, consisting of client commands and server replies.
- The client establishes the second connection to the server for the actual data transfer. This connection is created every time there is data to be transferred.

The data transfer can happen in either direction. The client can download (pull) data from the server or, the client can upload (push) data to the server.

In this activity, you will configure FTP services. You will then use the FTP services to transfer files between clients and the server.
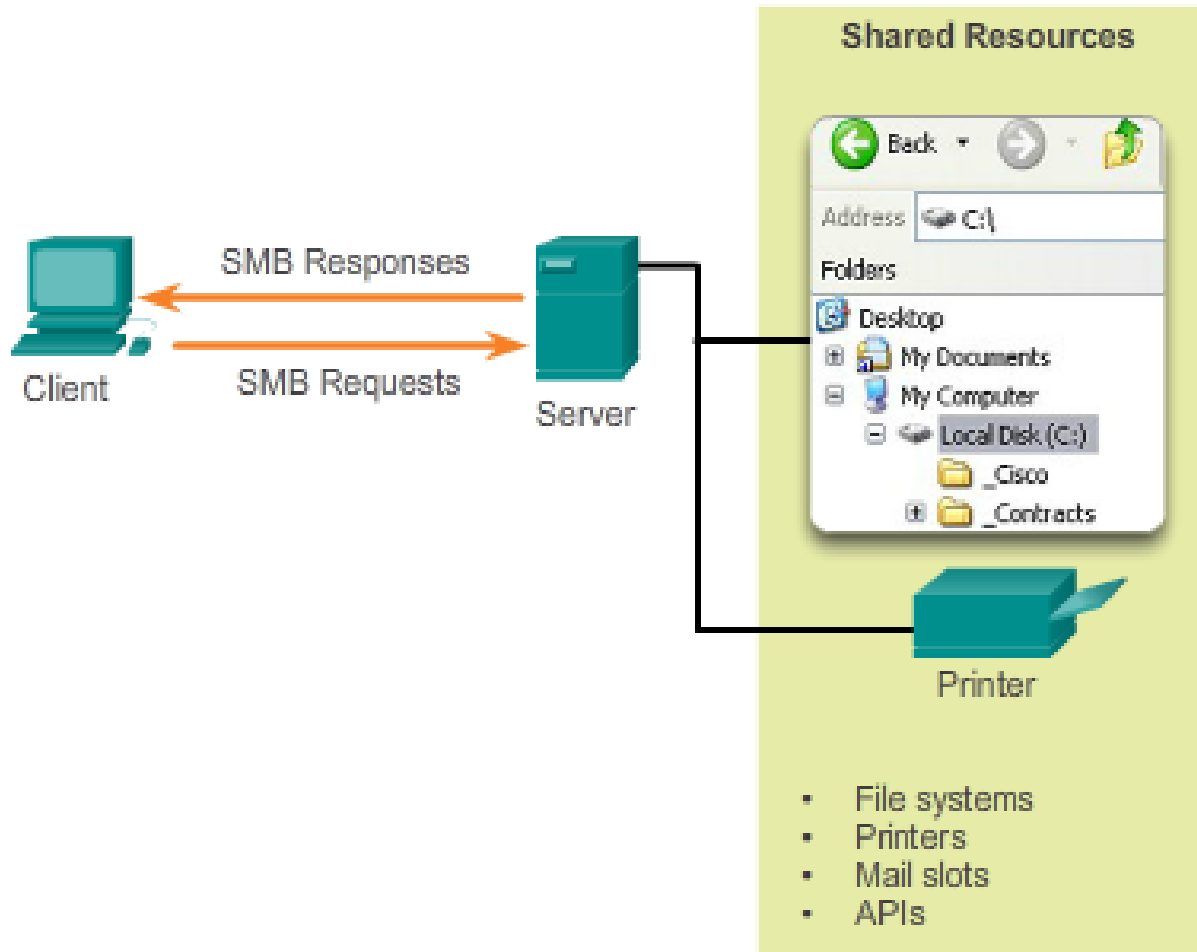
Exploring FTP

In this lab, you will complete the following objectives:
- Part 1: Use FTP from a Command Prompt
- Part 2: Download an FTP File Using WS_FTP LE
- Part 3: Use FTP in a Browser

SMB Protocol

Shared Resources

Back ▾

Address: C:\

Folders

- Desktop
  - My Documents
  - My Computer
    - Local Disk (C:)
      - _Cisco
      - _Contracts

Printer

- File systems
- Printers
- Mail slots
- APIs

SMB is a client-server, request-response protocol. Servers can make their resources available to clients on the network.

Client

SMB Responses

SMB Requests

Server

SMB messages can:

- Start, authenticate, and terminate sessions
- Control file and printer access
- Allow an application to send or receive messages to or from another device

SMB File Sharing

A file may be copied from PC to PC with Windows Explorer using the SMB protocol.
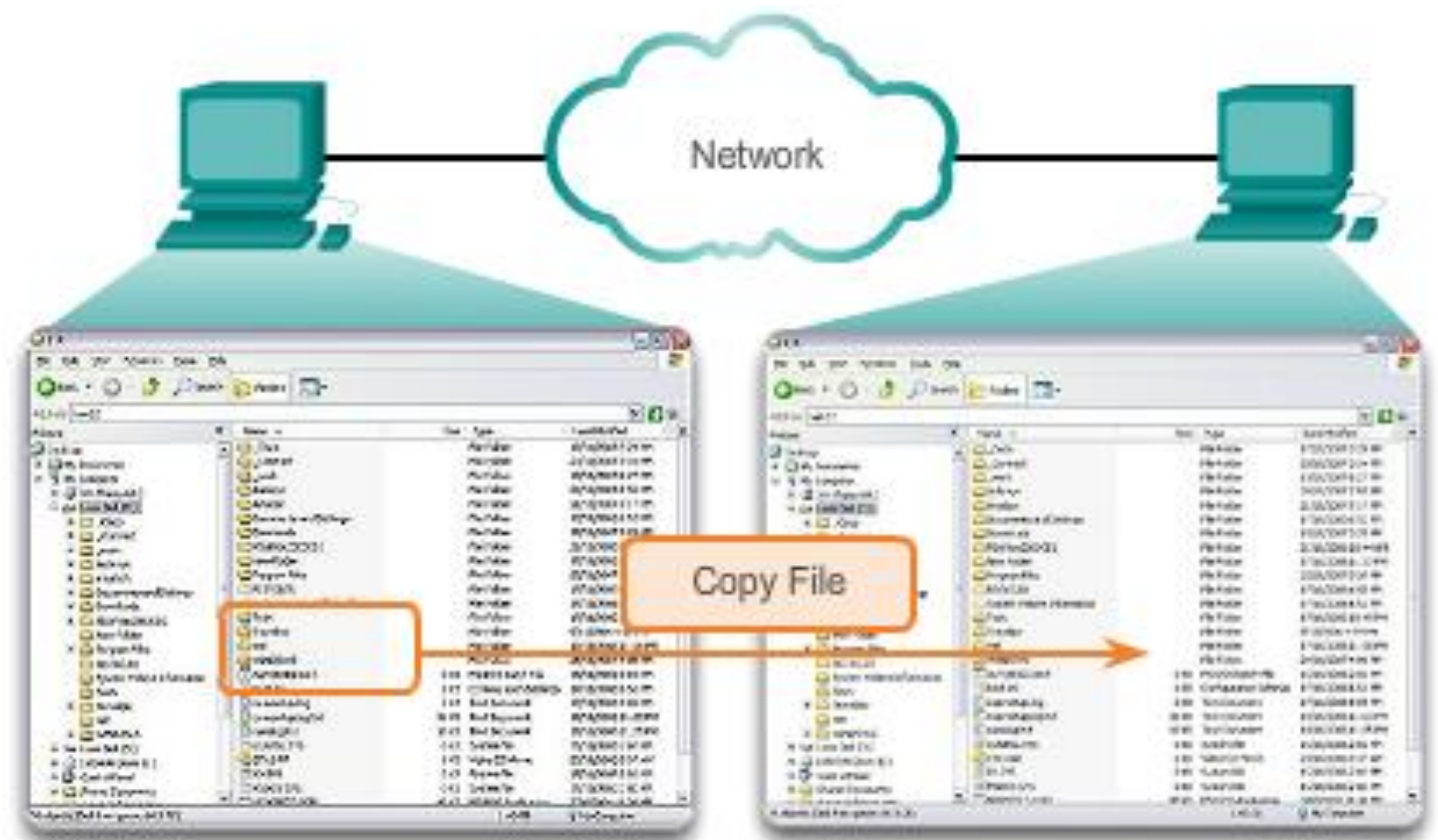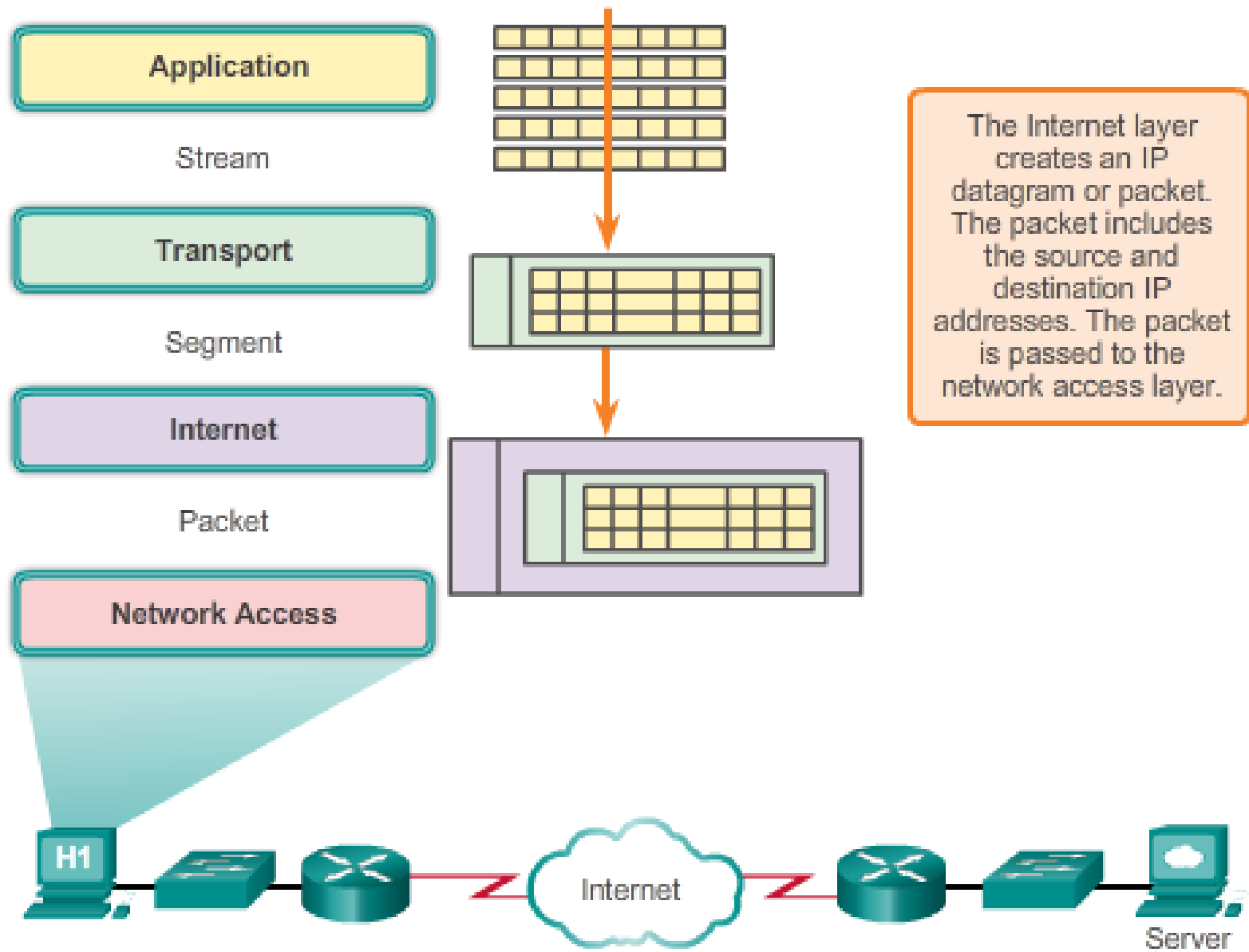
Using smart-tagging and advanced connectivity to digitize unintelligent products - from bikes and bottles, to refrigerators and cars - and connect them to the Internet, will allow people and companies to interact in new and almost unimaginable ways. Objects will be able to collect, receive and send information to users and other connected objects. As shown in the figure, this new wave in Internet development is known as the Internet of Things!

Application

Stream

Transport

Segment

Internet

Network Access

The transport layer divides the application stream into segments and adds a TCP header.
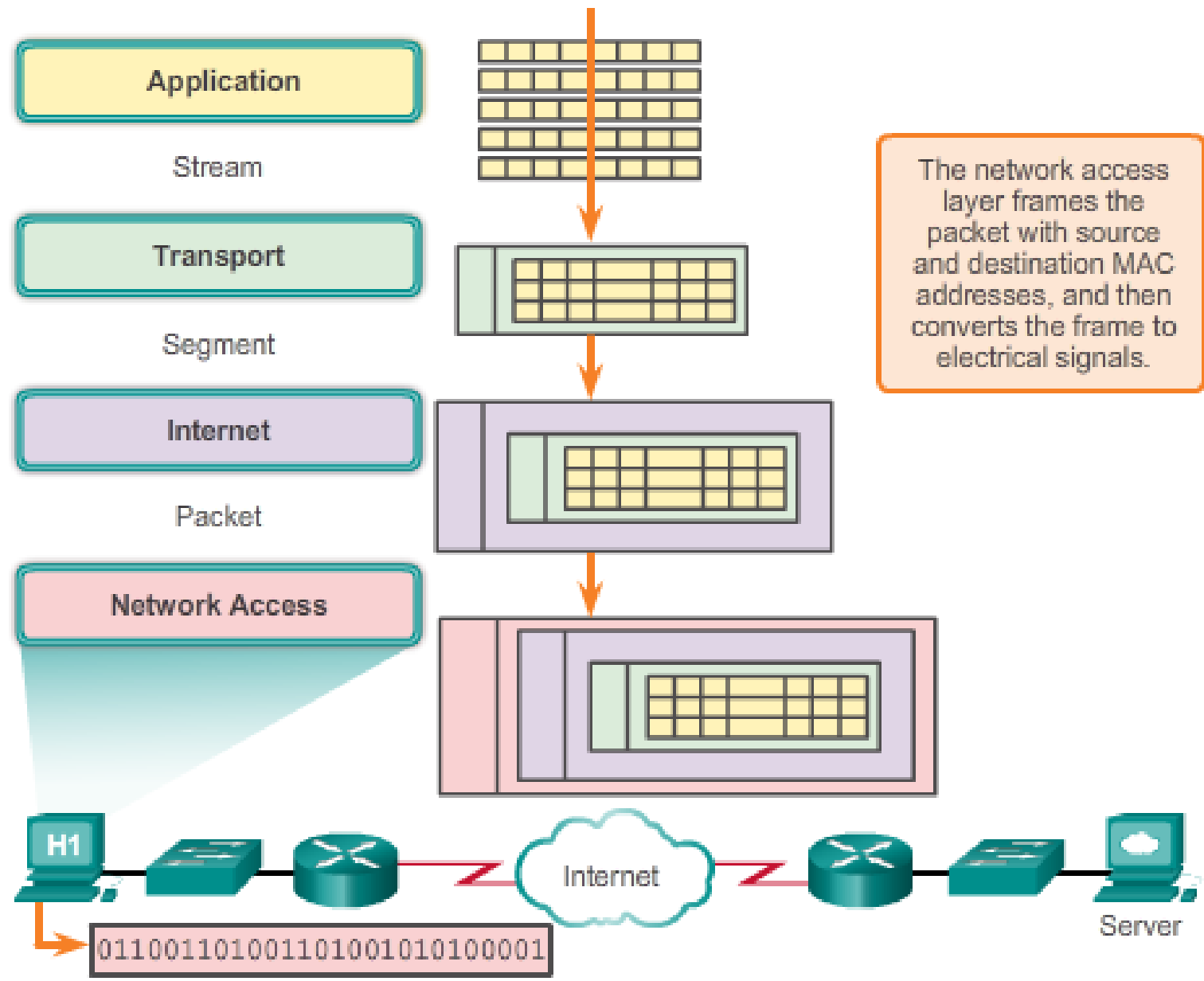
H1

Internet
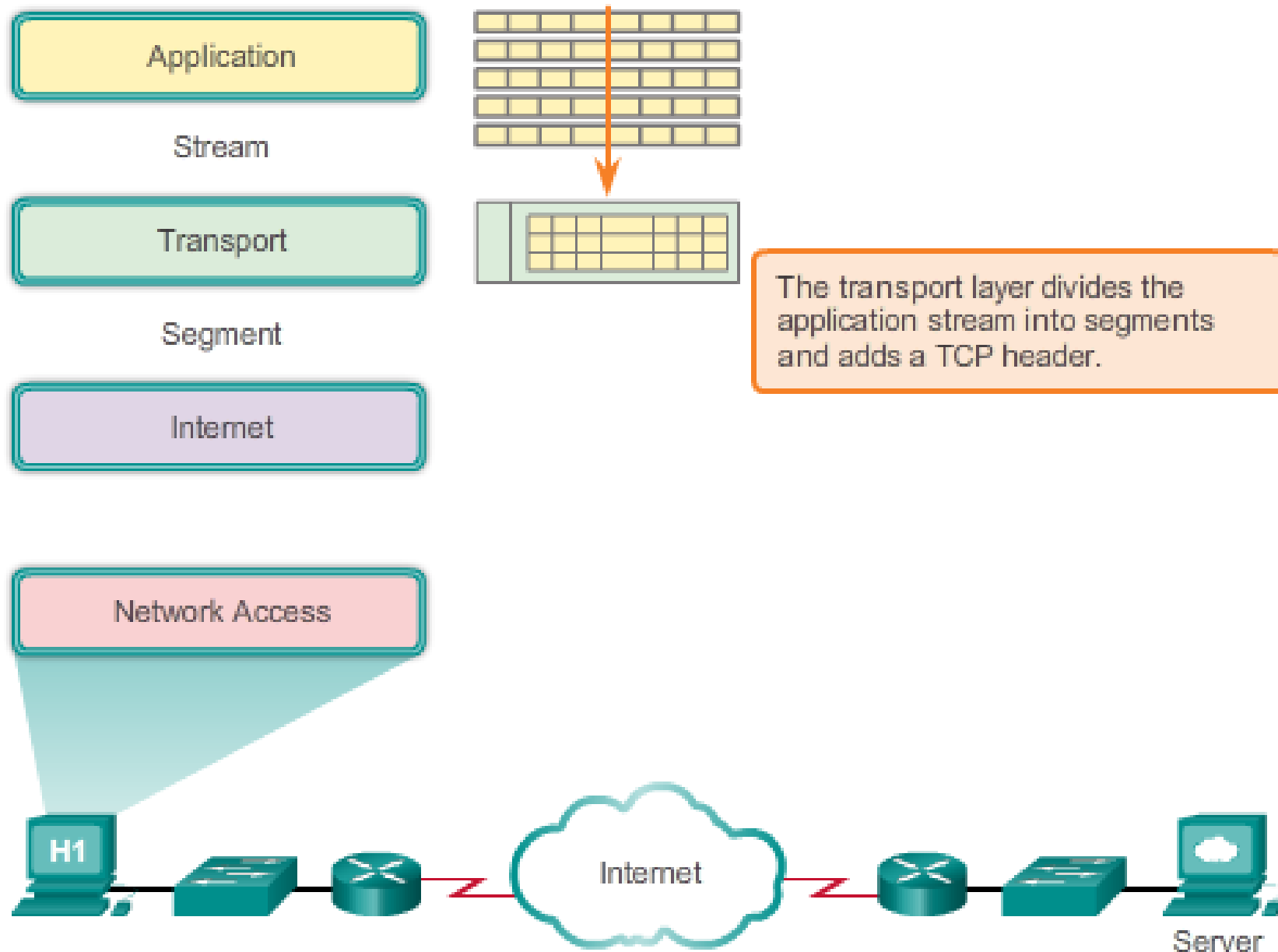
Server

When an application sends a request to a server application, the message is built by the application layer, but is then passed down through all the various layer functionalities on the client for delivery. As it moves through the stack each lower layer encapsulates the data with a header that contains the protocols of communication for that layer.

Application

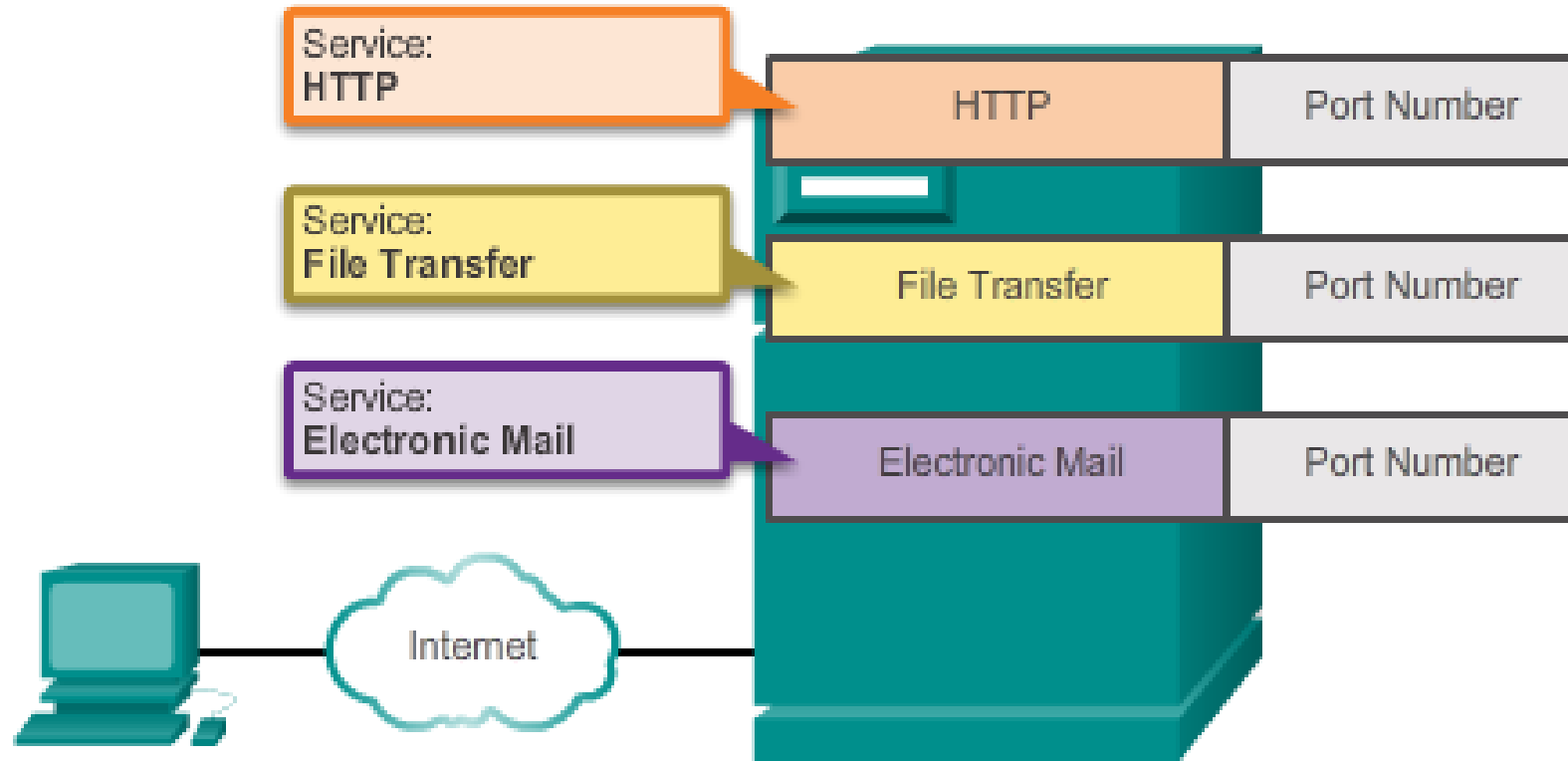Stream

Transport

Segment

Internet

Packet

Network Access

The Internet layer creates an IP datagram or packet. The packet includes the source and destination IP addresses. The packet is passed to the network access layer.

H1

Internet

Server

Application

Stream

Transport

Segment

Internet

Packet

Network Access

The network access layer frames the packet with source and destination MAC addresses, and then converts the frame to electrical signals.

H1

Internet

Server

01100110100110100101010100001

10.3.1.5 Getting the Data to the Right Application

Service:
HTTP

| HTTP | Port Number |

Service:
File Transfer

| File Transfer | Port Number |

Service:
Electronic Mail

| Electronic Mail | Port Number |

Internet

At the end device, the service port number directs the data to the correct conversation.

As shown in the figure, recall that at the transport layer, information contained in the PDU header identifies the specific process or service running on the destination host device that will act on the data. Hosts, whether they are clients or servers on the Internet, can run multiple network applications simultaneously. People using PCs often have an email client running at the same time as a web browser, an instant messaging program, some streaming media, and perhaps even a game. All these separately running programs are examples of individual processes.

An entertaining resource to help you visualize networking concepts is the animated movie "Warriors of the Net" by TNG Media Lab.

http://www.bing.com/videos/search?q=warriors%20of%20the%20net&FORM=BVLH1#view=detail&mid=46AFE91FF2936DFF2E8946AFE91FF2936DFF2E89

To view the video, Warriors of the Net, go to:
http://www.warriorsofthe.net

Class Activity

Network applications use protocols to facilitate data communication...

- POP
- IMAP
- HTTP
- FTP

...and the list goes on!

Multiuser - Tutorial

Multiuser - Implement Services

Thanks for your attention!!