Application Layer Functionality and Protocols-Layer 7

Network Architecture – Chapter 3

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Objectives

- Define the application layer as the source and destination of data for communication across networks.

- Explain the role of protocols in supporting communication between server and client processes.

- Describe the features, operation, and use of well-known TCP/IP application layer services (HTTP, DNS, SMTP).

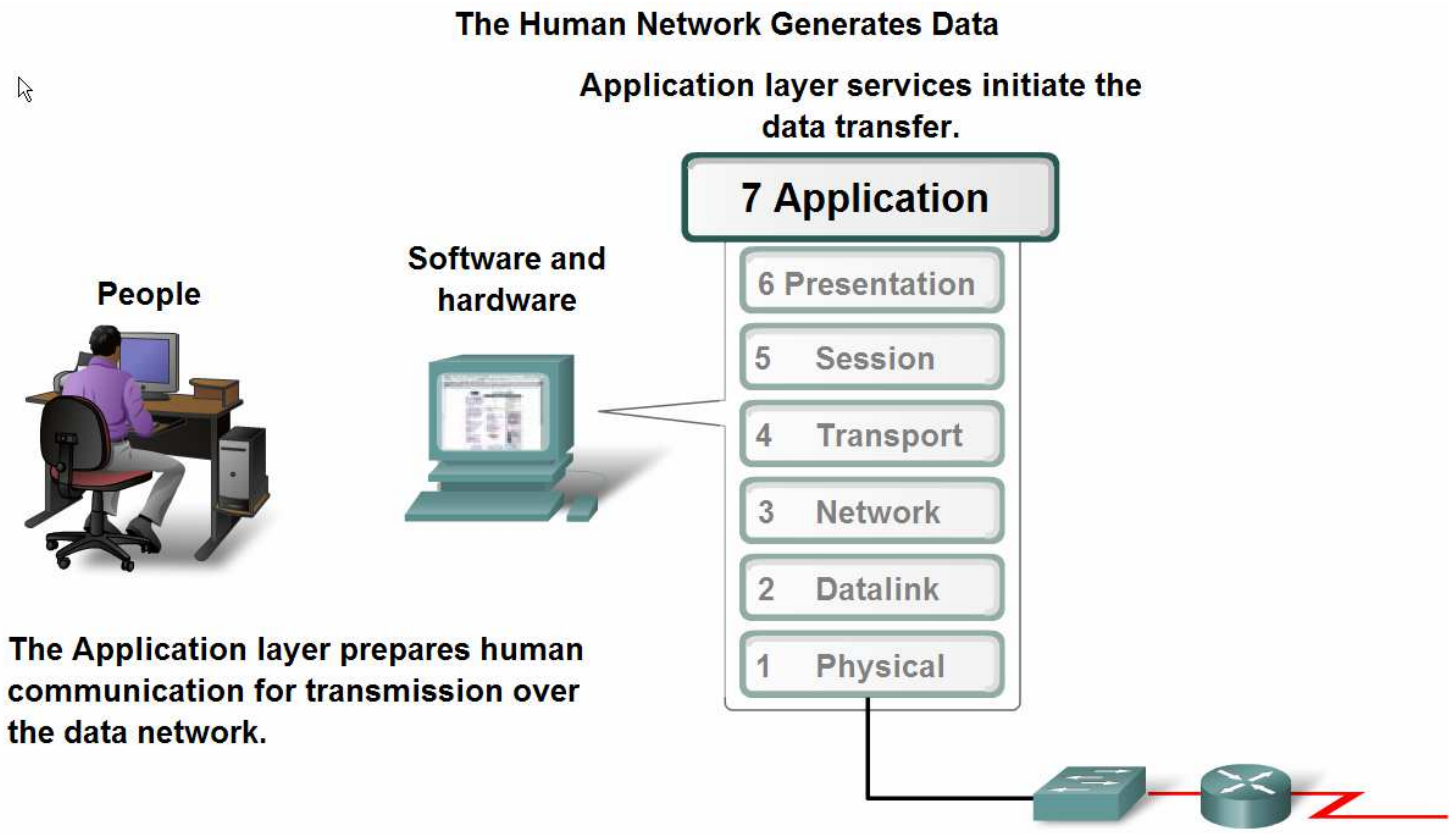# Applications – The Interface Between Human and Data Networks

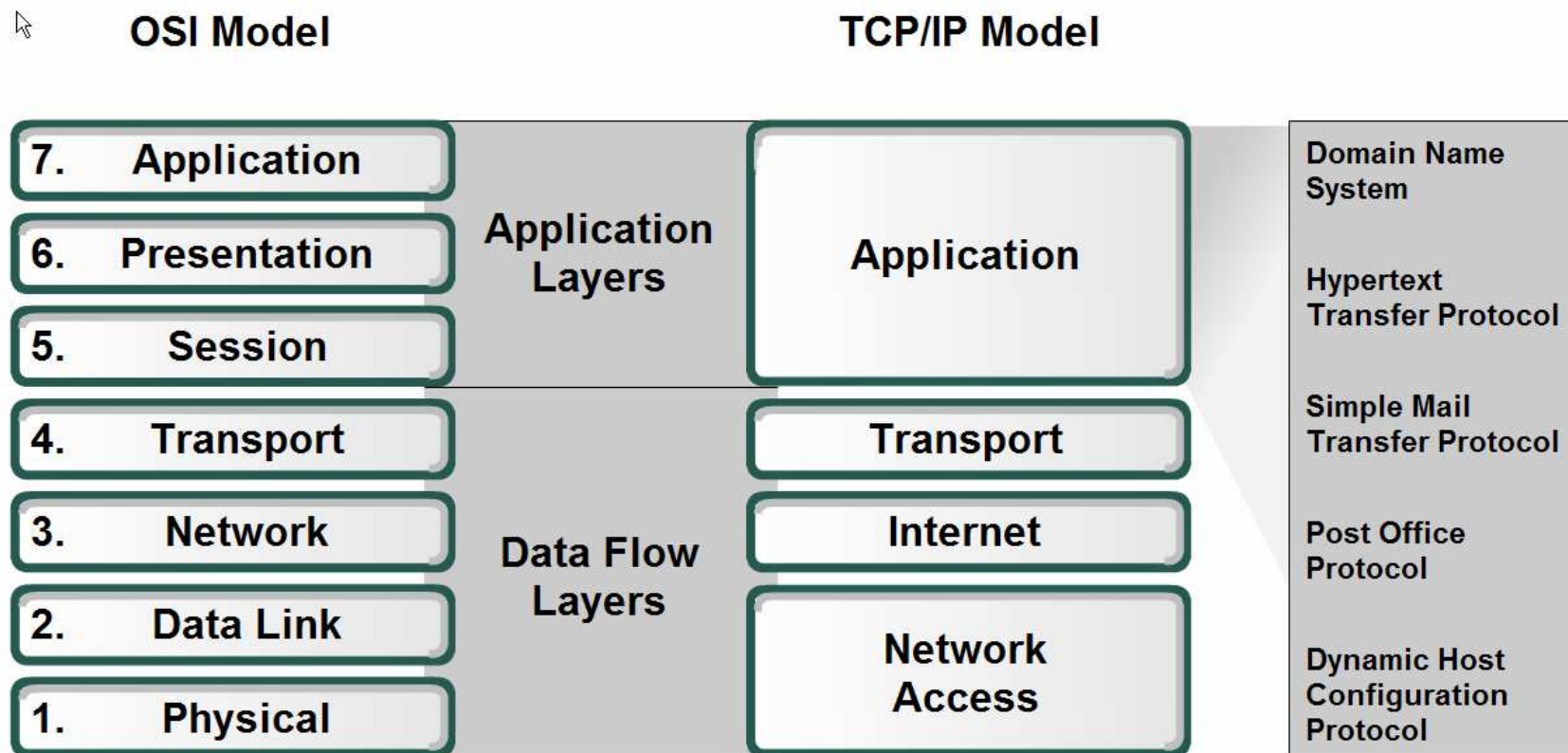- Applications provide the means for generating and receiving data that can be transported on the network

Interfacing Human and Data Networks

The Application layer provides the interface to the network.
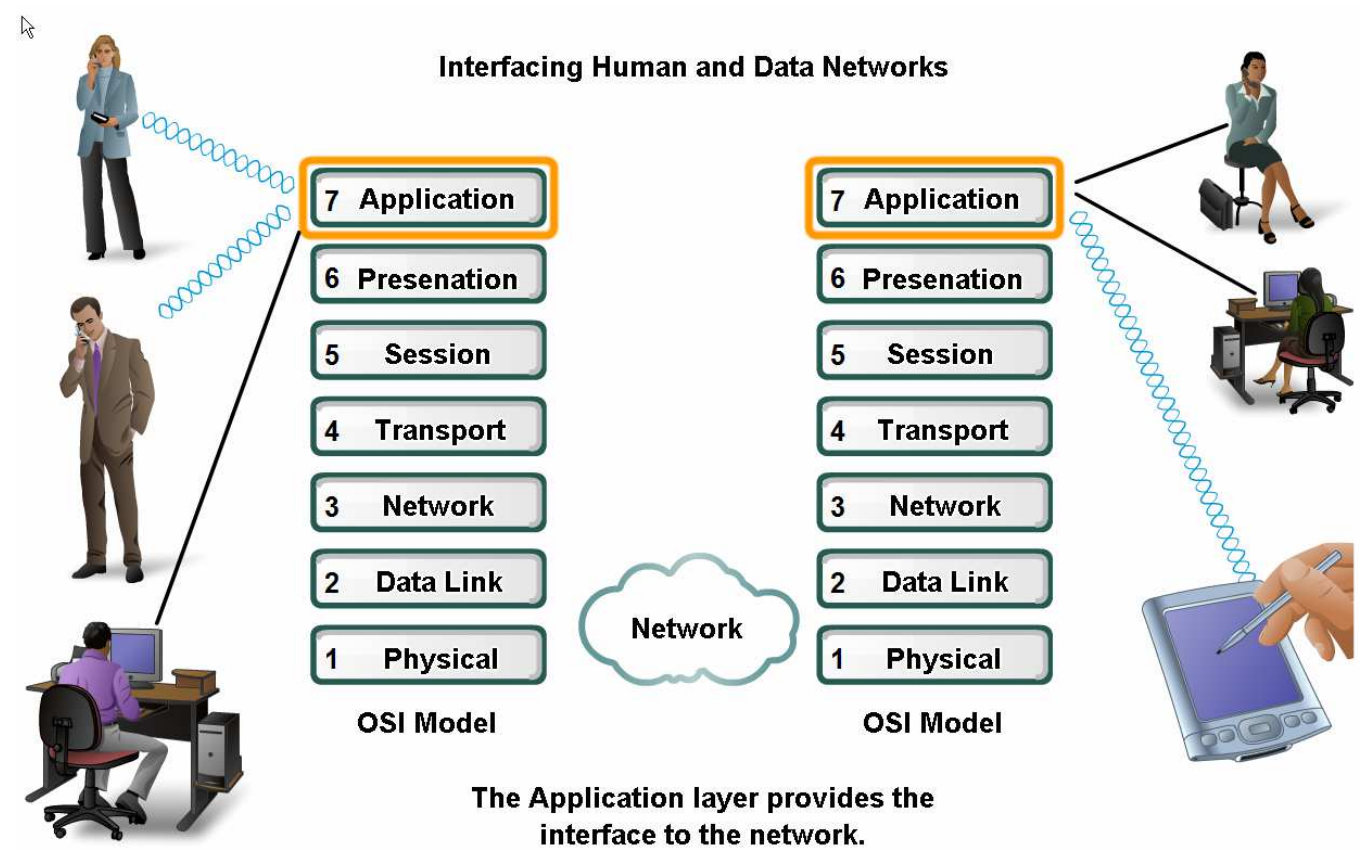
- Most of us experience the Internet through the **World Wide Web**, **e-mail services**, and **file-sharing programs**. These applications, and many others, provide the <u>human interface to the underlying network</u>, enabling us to send and receive information.

Applications – The Interface Between Human and Data Networks

Application layer is the layer that provides the **interface** between the applications we use to communicate and the underlying network over which our messages are transmitted.

The Human Network Generates Data

Application layer services initiate the data transfer.

People

Software and hardware

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

The Application layer prepares human communication for transmission over the data network.

Applications – The Interface Between Human and Data Networks

OSI Model		TCP/IP Model	
7. Application	Application Layers	Application	Domain Name System
6. Presentation			Hypertext Transfer Protocol
5. Session			
4. Transport	Data Flow Layers	Transport	Simple Mail Transfer Protocol
3. Network		Internet	Post Office Protocol
2. Data Link		Network Access	Dynamic Host Configuration Protocol
1. Physical			

TCP/IP Application layer protocols

- These protocols specify the <u>format</u> and <u>control information</u> necessary for many of the common Internet communication functions. Among these TCP/IP protocols are:

- Domain Name Service Protocol (DNS) is used to resolve Internet names to IP addresses.

- Hypertext Transfer Protocol (HTTP) is used to transfer files that make up the Web pages of the World Wide Web.

- Simple Mail Transfer Protocol (SMTP) is used for the transfer of mail messages and attachments.

- Telnet, a terminal emulation protocol, is used to provide remote access to servers and networking devices. (SSH)

- File Transfer Protocol (FTP) is used for interactive file transfer between systems.

- Domain Name System (DNS) - TCP/UDP Port 53

- Hypertext Transfer Protocol (HTTP) - TCP Port 80

- Simple Mail Transfer Protocol (SMTP) - TCP Port 25

- Post Office Protocol (POP) - TCP Port 110

- Telnet - TCP Port 23

- Dynamic Host Configuration Protocol - UDP Ports 67 and 68

- File Transfer Protocol (FTP) - TCP Ports 20 and 21

تأكيد

- The **functions** associated with the <u>Application layer protocols</u> *enable our human network to interface with the underlying data network.*

- Within the <u>Application layer</u>, there are *two forms* of software programs or processes that provide access to the network: **applications and services**.

1- Network-Aware Applications

- **Applications** are the software programs used by people to communicate over the network. Some end-user <u>applications are network-aware</u>, *meaning that they implement the Application layer protocols and are able to communicate directly with the lower layers of the protocol stack*. **E-mail clients** and **web browsers** are <u>examples</u> of these types of applications.

2- Application layer Services

Other programs may need the <u>assistance</u> of *Application layer services* to use network resources, like file transfer or network printer. These services are the programs that interface with the network and prepare the data for transfer.

Different types of data - whether it is text, graphics, or video - require *different network services* to ensure that it is properly prepared for processing by the functions occurring at the lower layers of OSI model.
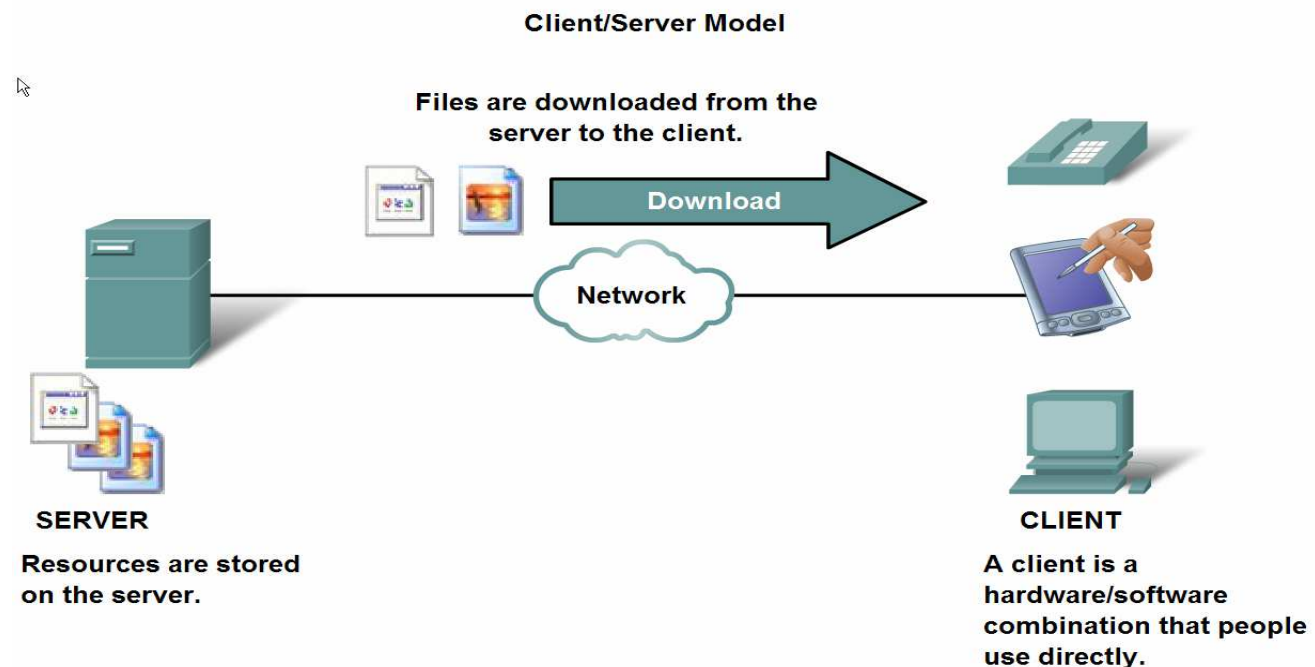
التأكيد على استخدام Protocols

- Each application or network service uses protocols which define the **standards and data formats** to be used. *Without protocols*, the data network would not have a common way to format and direct data.

- The Application layer relies on the functions of the lower layers in order to complete the communication process. Within the Application layer, protocols specify:

- 1- what messages are exchanged between the source and destination hosts,

- 2- the syntax of the control commands,

- 3- the type and format of the data being transmitted,

- 4- and the appropriate methods for error notification and recovery.

The Client/Server model

- the device <u>requesting</u> the information is called a **client** and

- the device <u>responding</u> to the request is called a **server**.

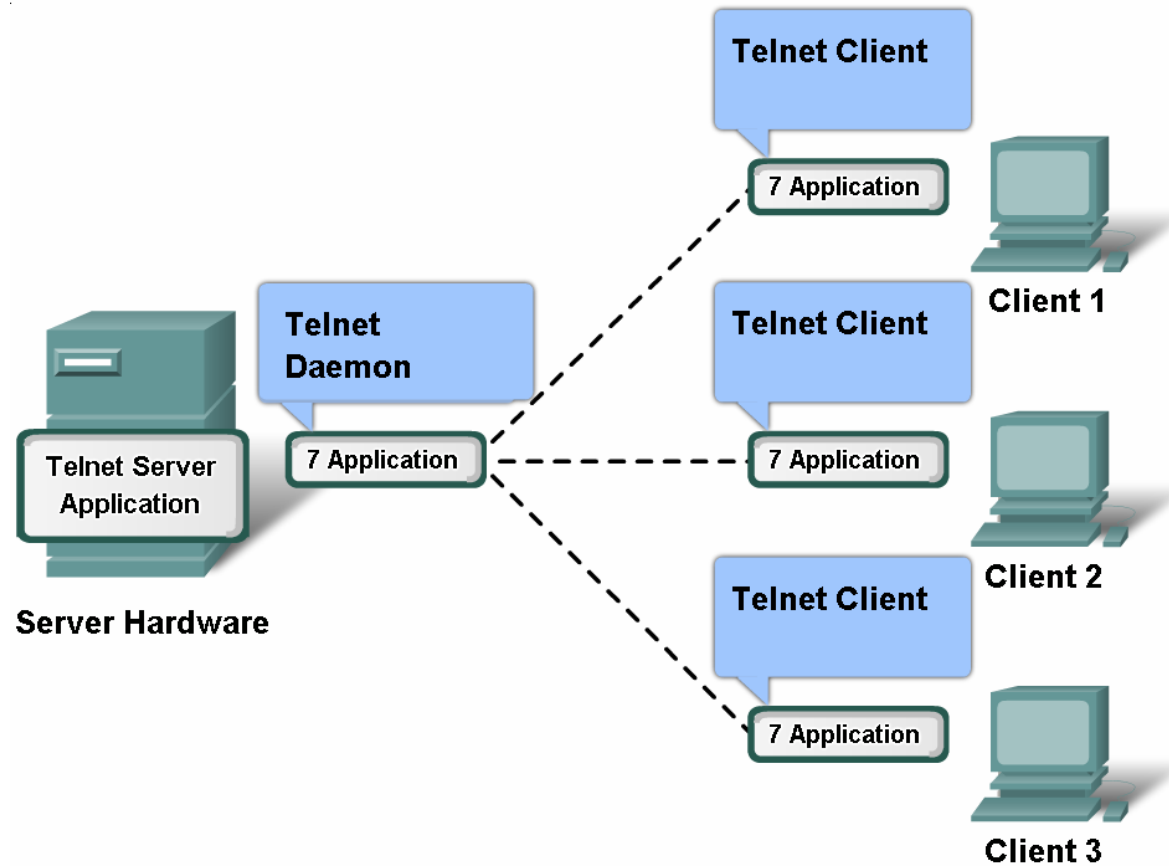- Client and server processes are considered to be in the Application layer. Advantages?

Client/Server Model

Files are downloaded from the server to the client.

Download

Network

SERVER
Resources are stored on the server.

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

Servers

- In a client/server network, the server runs a service, or process, sometimes called a server **daemon**. Like most services, daemons typically run in the background and are not under an end user's direct control.

- **Daemons** are described as "listening" for a request from a client, because they are programmed to respond whenever the server receives a request for the service provided by the daemon.

- Additionally, servers typically have multiple clients requesting information at the same time. For example, a **Telnet** server may have many clients requesting connections to it. These individual client requests must be handled simultaneously and separately for the network to succeed. The Application layer processes and services rely on *support from lower layer functions* to successfully manage the multiple conversations.

Server processes may support multiple clients.

Telnet Client

7 Application

Client 1

Telnet Daemon

Telnet Client

7 Application

7 Application

Client 2

Telnet Server Application

Server Hardware

Telnet Client

7 Application

Client 3

The Peer-to-Peer Model

- Peer-to-peer networking involves two distinct forms:

- 1- peer-to-peer network design and

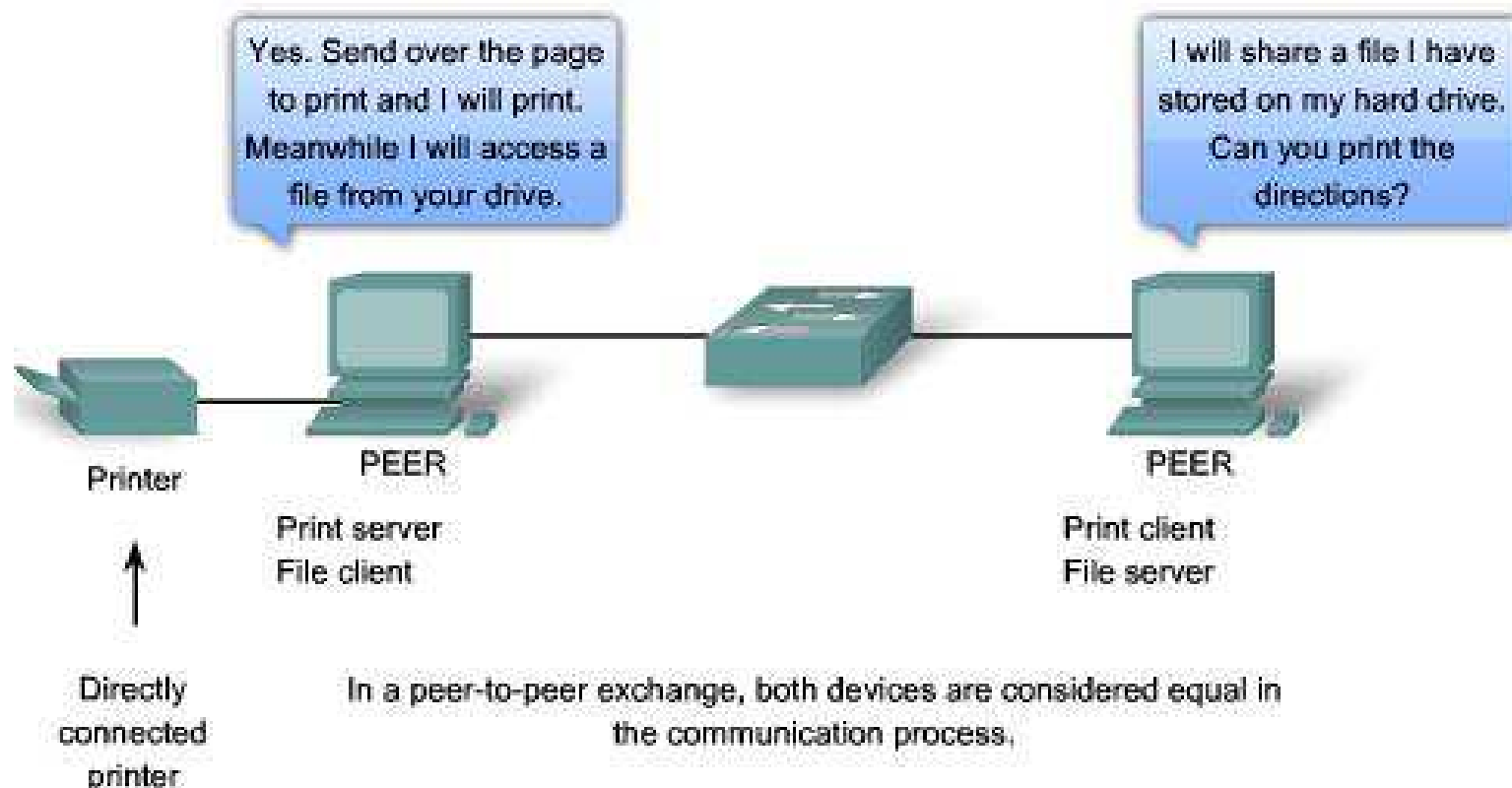- 2- peer-to-peer applications (P2P).

Peer-to-Peer Network

- two or more computers are connected via a network and can share resources (such as printers and files) without having a *dedicated server*. Every connected end device (known as a peer) <u>can function as either a server or a client</u>. One computer might assume the role of server for *one transaction* while simultaneously serving as a client for another. The roles of client and server are set on a per request basis.

- characteristics of peer-to-peer networks?

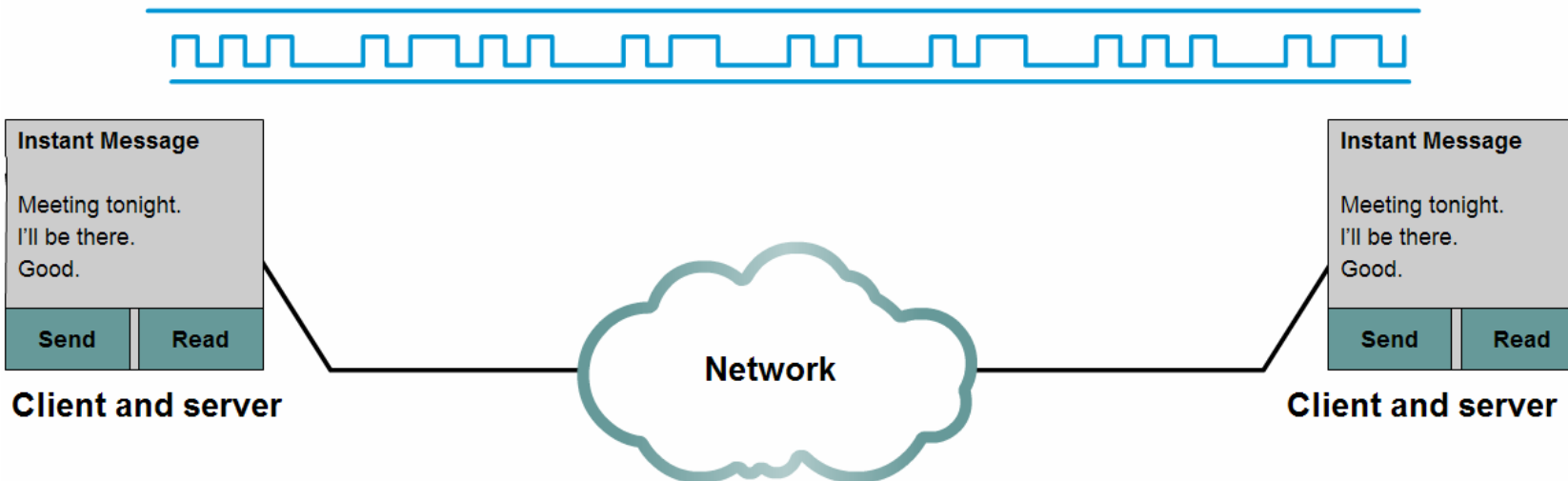# Peer-to-Peer Applications properties

- allows a device to <u>act as both a client and a server within the same communication</u>.

- In this model, every client is a server and every server a client. Both can initiate a communication and are considered equal in the communication process. *(can be used in client-server networks)*

Peer-to-Peer Networking

In a peer-to-peer exchange, both devices are considered equal in the communication process.

Peer-to-Peer Applications

Client and server in the same communication

Instant Message

Meeting tonight.
I'll be there.
Good.

| Send | Read |

Client and server

Network

Instant Message

Meeting tonight.
I'll be there.
Good.

| Send | Read |

Client and server

Both clients:
- Initiate a message
- Receive a message

Both clients simultaneously:
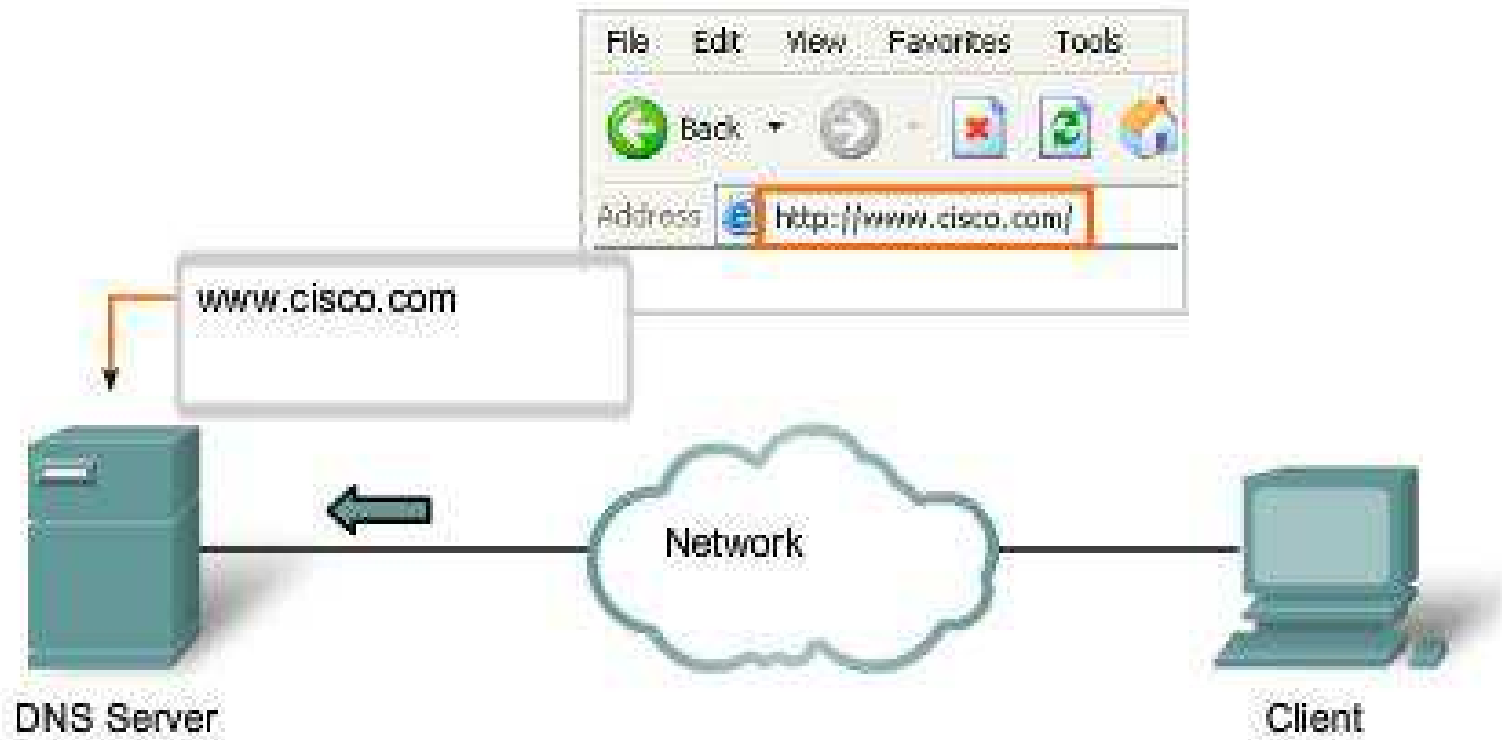- Send
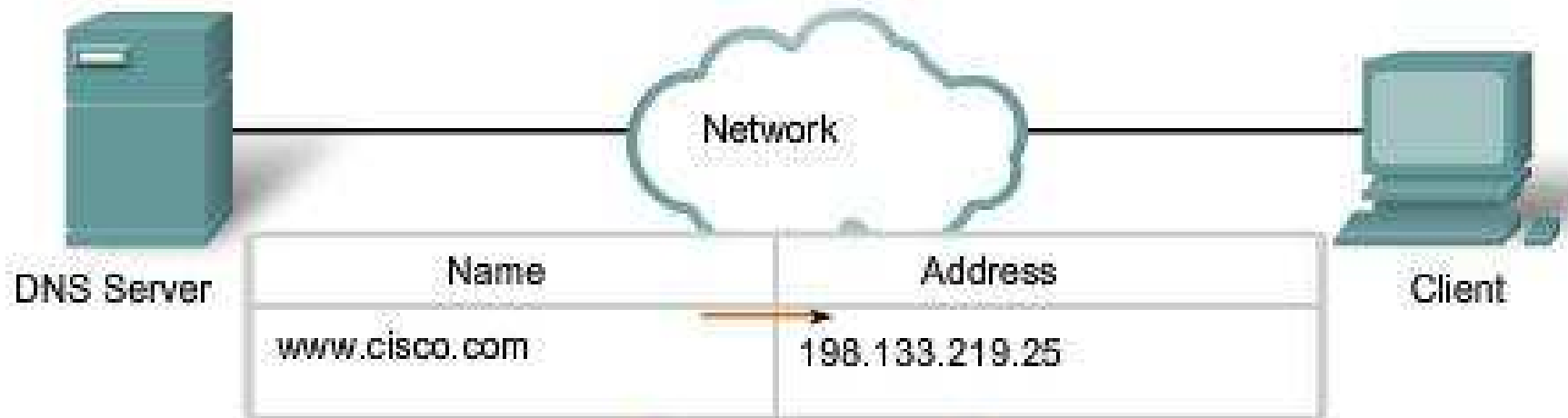- Receive

DNS Services and Protocol

Resolving DNS Addresses

DNS Server — Network — Client

Resolving DNS Addresses

The name is easy for people to use.

File   Edit   View   Favorites   Tools

Back

Address   http://www.cisco.com/

Network

DNS Server

Client

Resolving DNS Addresses

File	Edit	View	Favorites	Tools

Back ▾

Address http://www.cisco.com/

www.cisco.com

Network

DNS Server

Client

Network

DNS Server | Name | Address | Client

www.cisco.com | 198.133.219.25
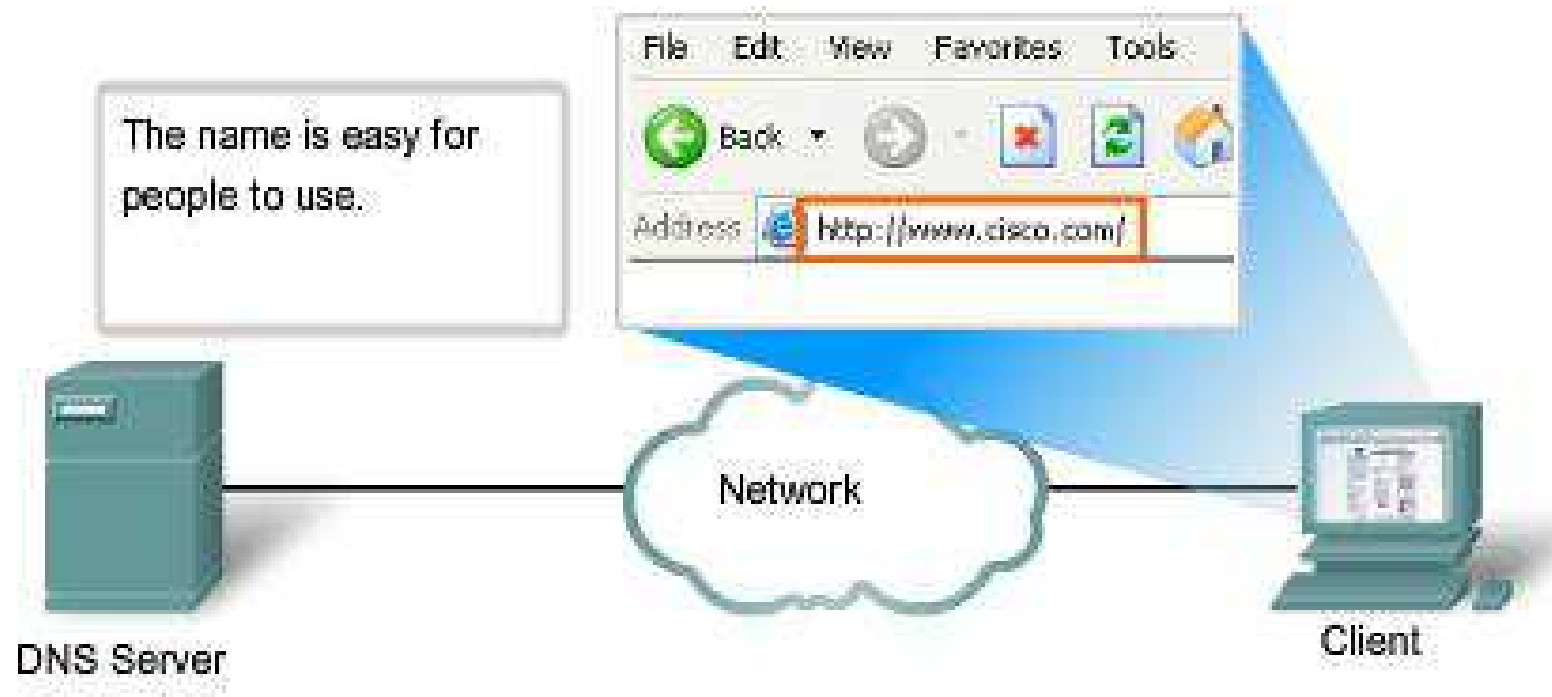
The DNS server matches the human address with the numeric address.

The devices use numbers.

Network

DNS Server

Client

198.133.219.25
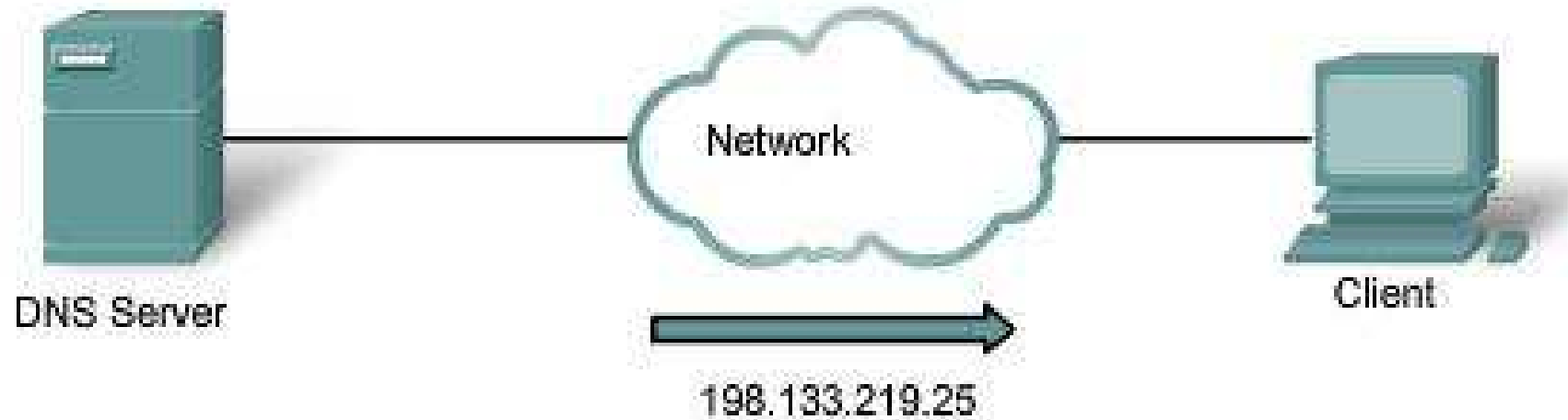
The number is returned back to the client for use in making requests of the server.
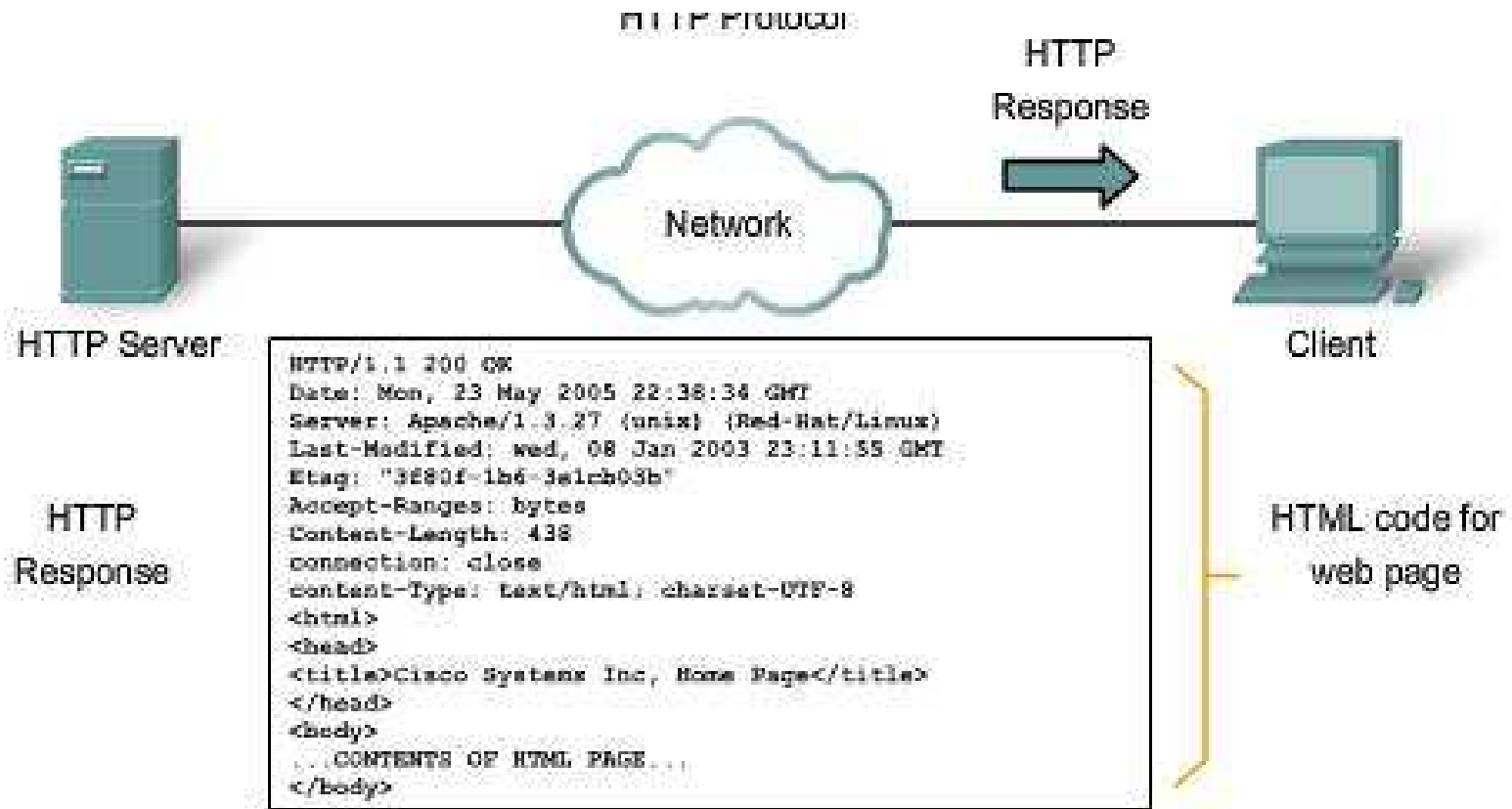
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DNS Server

Network

Client
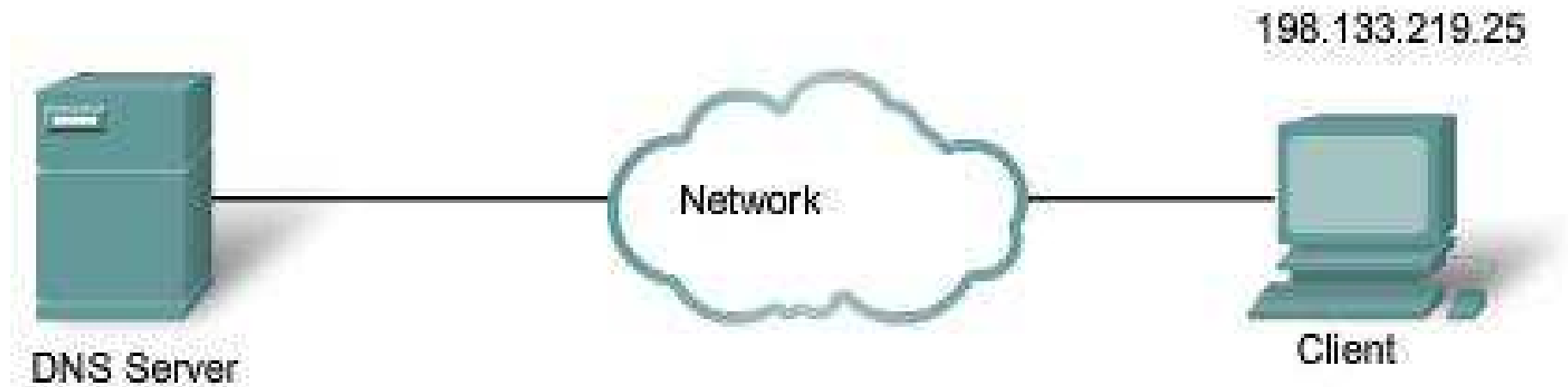
A human legible name is resolved to its numeric network device address by the DNS protocol.

WWW Service and HTTP Protocol

HTTP Protocol

HTTP Server — Network — Client

HTTP Server Network

Request a page

Client

```
Bookmarks   Tools   Help
   http://www.cisco.com/
```

HTTP Protocol

HTTP
Response

Network

HTTP Server

Client

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>
```

HTML code for
web page

In response to the request, the HTTP server returns code for a web page.

WWW Service and HTTP Protocol
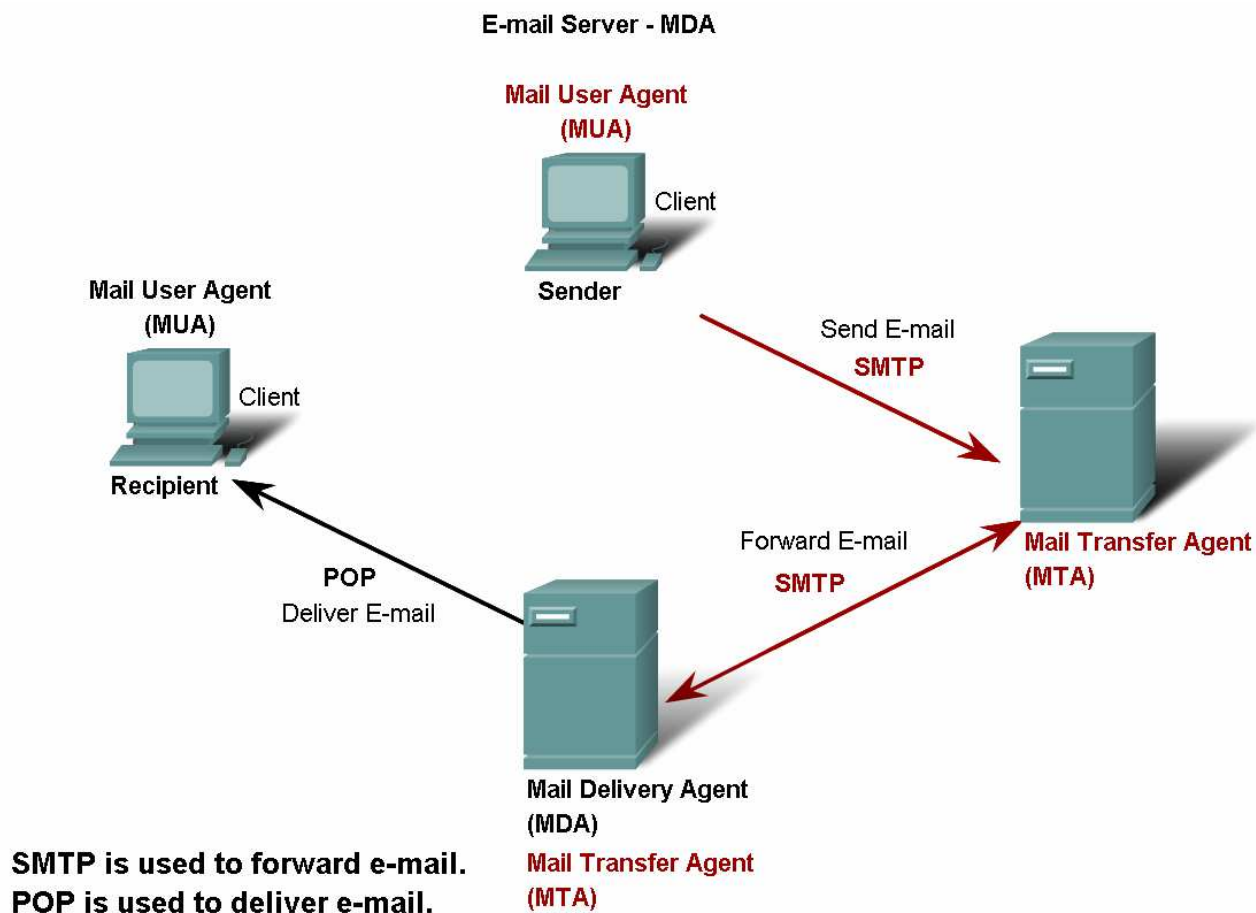

HTTP Protocol

HTTP Server

Network

Client
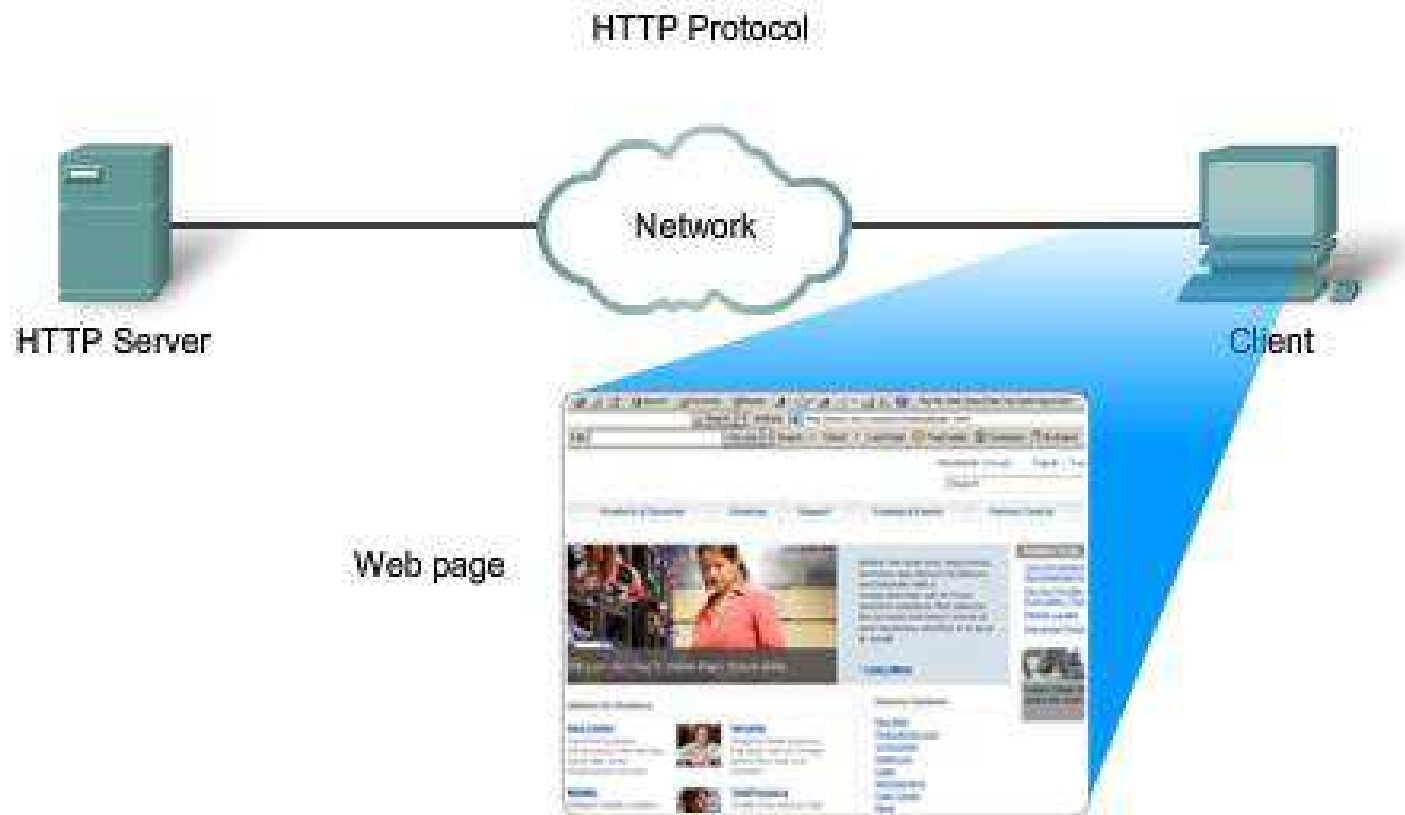
Web page

The browser interprets the HTML code and displays a web page.

- When a web address (or URL) is typed into a web browser, the web browser establishes a connection to the web service running on the server using the HTTP protocol. URLs (or Uniform Resource Locator) and URIs (Uniform Resource Identifier) are the names most people associate with web addresses.

- Web browsers are the client applications our computers use to connect to the World Wide Web and access resources stored on a web server. As with most server processes, the web server runs as a background service and makes different types of files available.

- In order to access the content, web clients make connections to the server and request the desired resources. The server replies with the resources and, upon receipt, the browser interprets the data and presents it to the user.

- Browsers can interpret and present many data types, such as plain text or Hypertext Markup Language (HTML, the language in which web pages are constructed). Other types of data, however, may require another service or program, typically referred to as plug-ins or add-ons. To help the browser determine what type of file it is receiving, the server specifies what kind of data the file contains.

- To better understand how the web browser and web client interact, we can examine how a web page is opened in a browser. For this example, we will use the URL: http://www.cisco.com/web-server.htm.

- First, the browser interprets the three parts of the URL:

- 1. http (the protocol or scheme)

- 2. www.cisco.com (the server name)

- 3. web-server.htm (the specific file name requested).

- The browser then checks with a name server to convert www.cisco.com into a numeric address, which it uses to connect to the server. Using the HTTP protocol requirements, the browser sends a GET request to the server and asks for the file web-server.htm. The server in turn sends the HTML code for this web page to the browser. Finally, the browser deciphers the HTML code and formats the page for the browser window.

- For secure communication across the Internet, the HTTP Secure (HTTPS) protocol is used for accessing or posting web server information. HTTPS can use authentication and encryption to secure data as it travels between the client and server.

E-mail Services and SMTP/POP Protocols

E-mail Services and SMTP/POP Protocols

- E-mail, the most popular network service. Yet to run on a computer or other end device, e-mail requires several applications and services. Two example Application layer protocols are Post Office Protocol (POP) and Simple Mail Transfer Protocol (SMTP). As with HTTP, these protocols define client/server processes.

- When people compose e-mail messages, they typically use an application called a **Mail User Agent (MUA)**, or e-mail client. The MUA allows messages to be sent and places received messages into the client's mailbox, both of which are distinct processes.

- In order to receive e-mail messages from an e-mail server, the e-mail client can use POP. Sending e-mail from either a client or a server uses message formats and command strings defined by the SMTP protocol. Usually an e-mail client provides the functionality of both protocols within one application.

E-mail Client (MUA)

Mail User Agent
(MUA)

Send E-mail

Client

SMTP Protocol

Get E-mail

POP Protocol

SMTP/POP3
Server
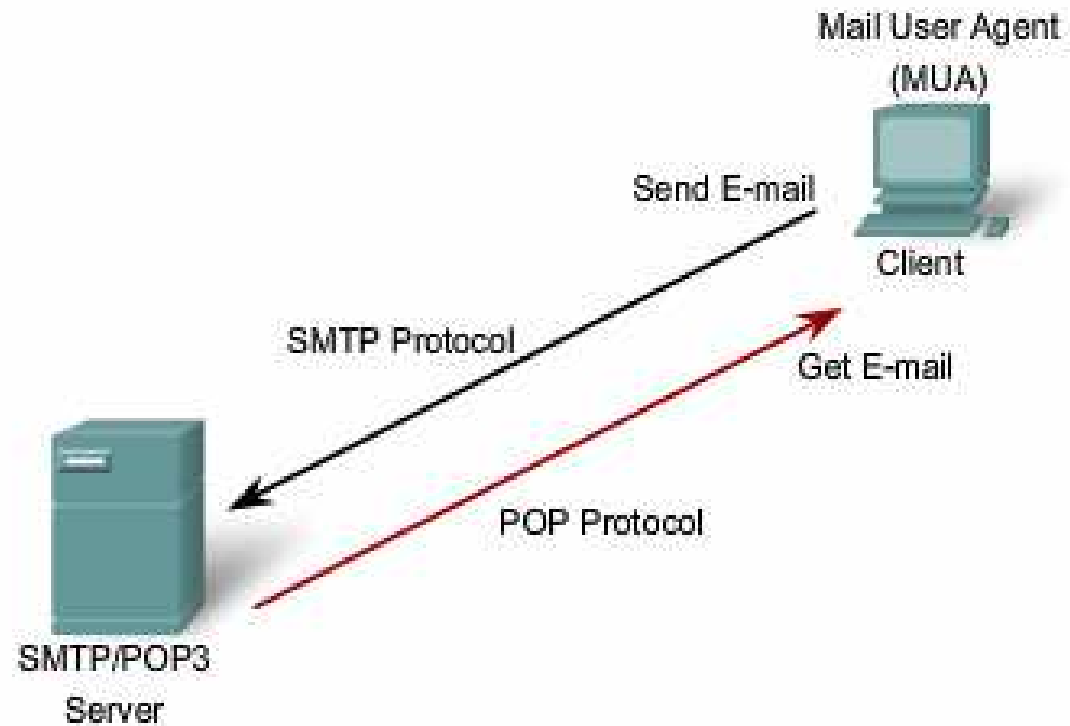
Clients send e-mails to a server using SMTP and receive e-mails using POP3.

E-mail Server Processes - MTA and MDA

- The e-mail server operates two separate processes:

- Mail Transfer Agent (MTA)

- Mail Delivery Agent (MDA)

- The Mail Transfer Agent (MTA) process is used to forward e-mail. The MTA receives messages from the MUA or from another MTA on another e-mail server. Based on the message header, it determines how a message has to be forwarded to reach its destination. If the mail is addressed to a user whose mailbox is on the local server, the mail is passed to the MDA. If the mail is for a user not on the local server, the MTA routes the e-mail to the MTA on the appropriate server.
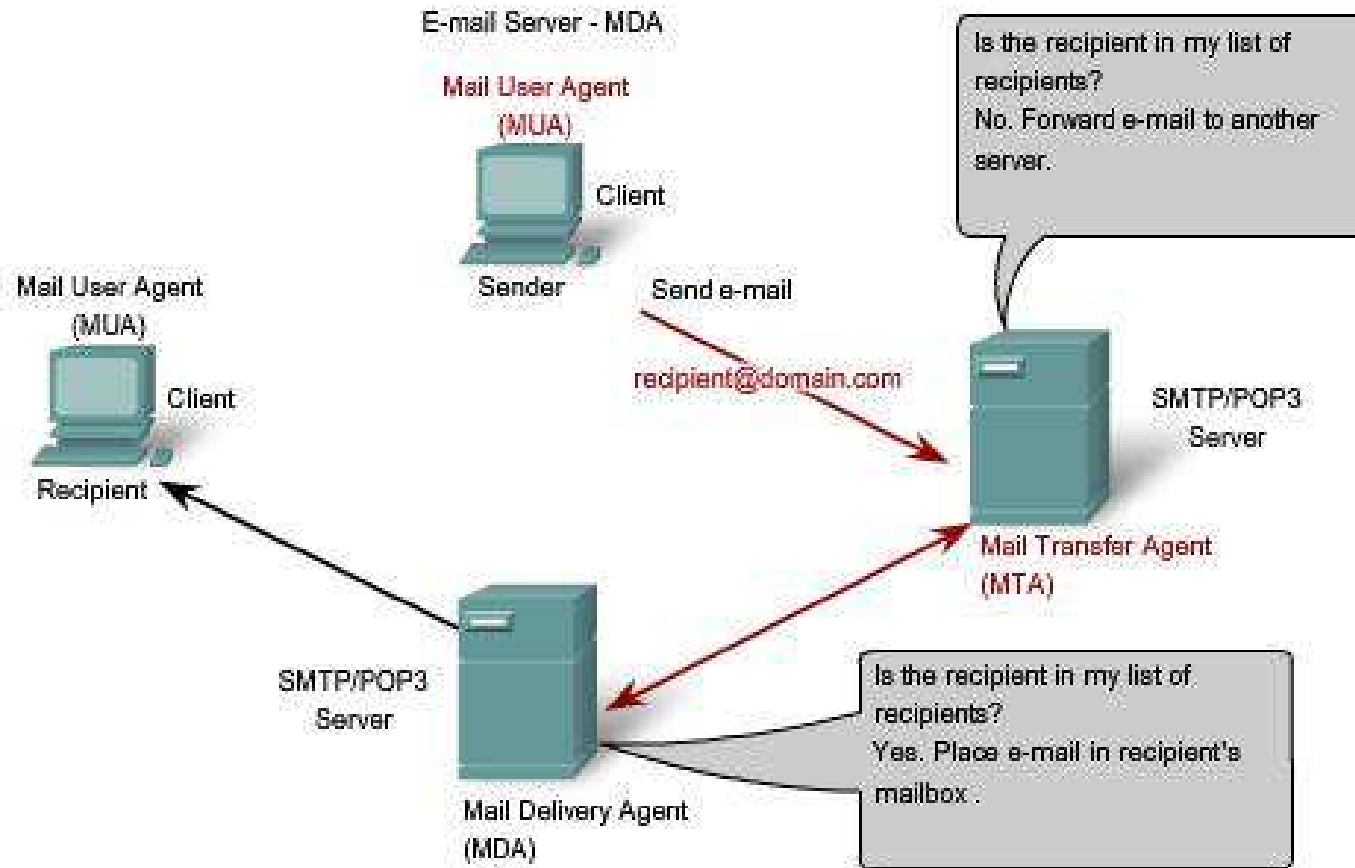
The Mail Delivery Agent process governs delivery of e-mail between servers and clients.

- The Mail Delivery Agent (MDA) accepts a piece of e-mail from a Mail Transfer Agent (MTA) and performs the actual delivery. The MDA receives all the inbound mail from the MTA and places it into the appropriate users' mailboxes. The MDA can also resolve final delivery issues, such as virus scanning, spam filtering, and return-receipt handling.

Home Works

- File Transfer Protocol (FTP)

- The Dynamic Host Configuration Protocol (DHCP)

- The Server Message Block (SMB)

- A small home network has been installed to interconnect three computers together for <u>gaming</u> and <u>file sharing</u>. **(Application Model?)**

Chapter Quiz

- 1.Which three layers of the O S I model make up the Application Layer of the TCP/IP model? (Choose three.)
A.data link
B.network
C.transport
D.session
E.presentation
F.application

- 2.What protocol is used to transfer web pages from server to client?
  A.HTML
  B.SMTP
  C.HTTP
  D.SSH
  E.Telnet
  F.POP

- 4.Which protocols use authentication and encryption to secure data traveling between the client and server? (Choose two.)
A.HTTP
B.DNS
C.HTTPS
D.SMTP
E.SSH

- 8.A network administrator is troubleshooting failed access to www.cisco.com. Typing the IP address of the web server into the browser successfully brings up the web page. What Application Layer protocol is responsible for the failure?
A.DHCP
B.DNS
C.CDP
D.HTTP
E.HTTPS
F.SSL