Chapter 10: Application Layer

Introduction to Networks

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Chapter 10: Objectives

By the end 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.

Chapter 10

10.1 Application Layer Protocols

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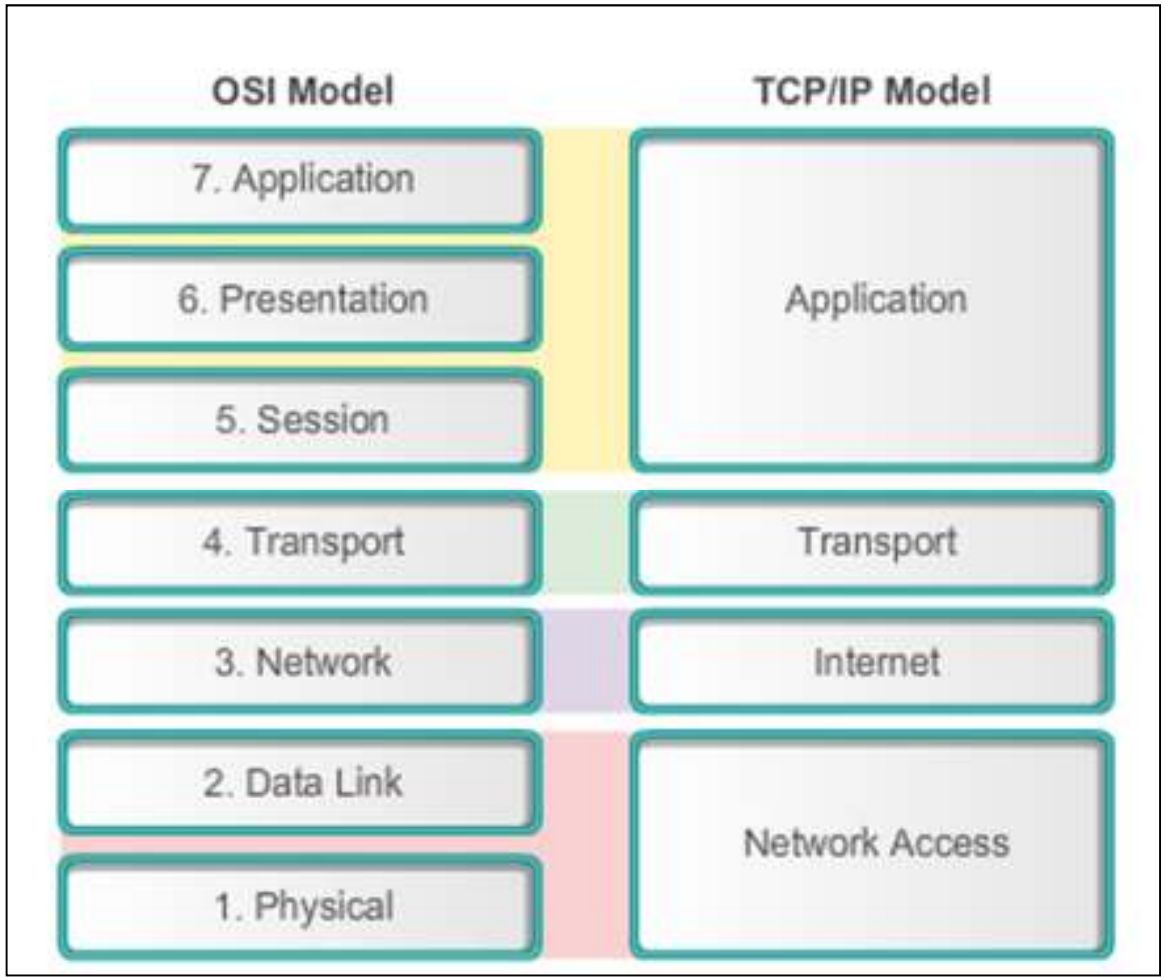
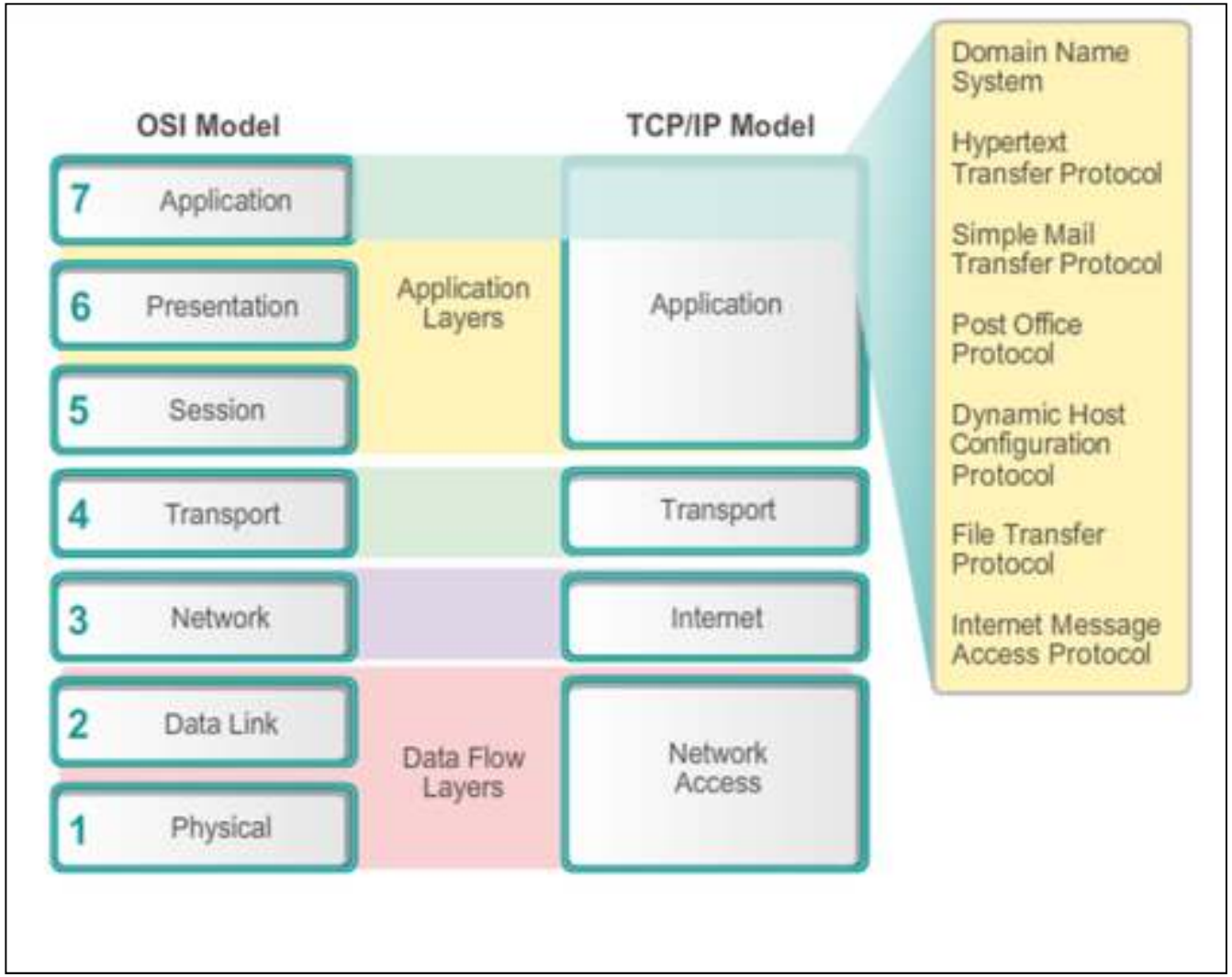
OSI and TCP/IP Models Revisited



The key parallels are in the transport and network layer.

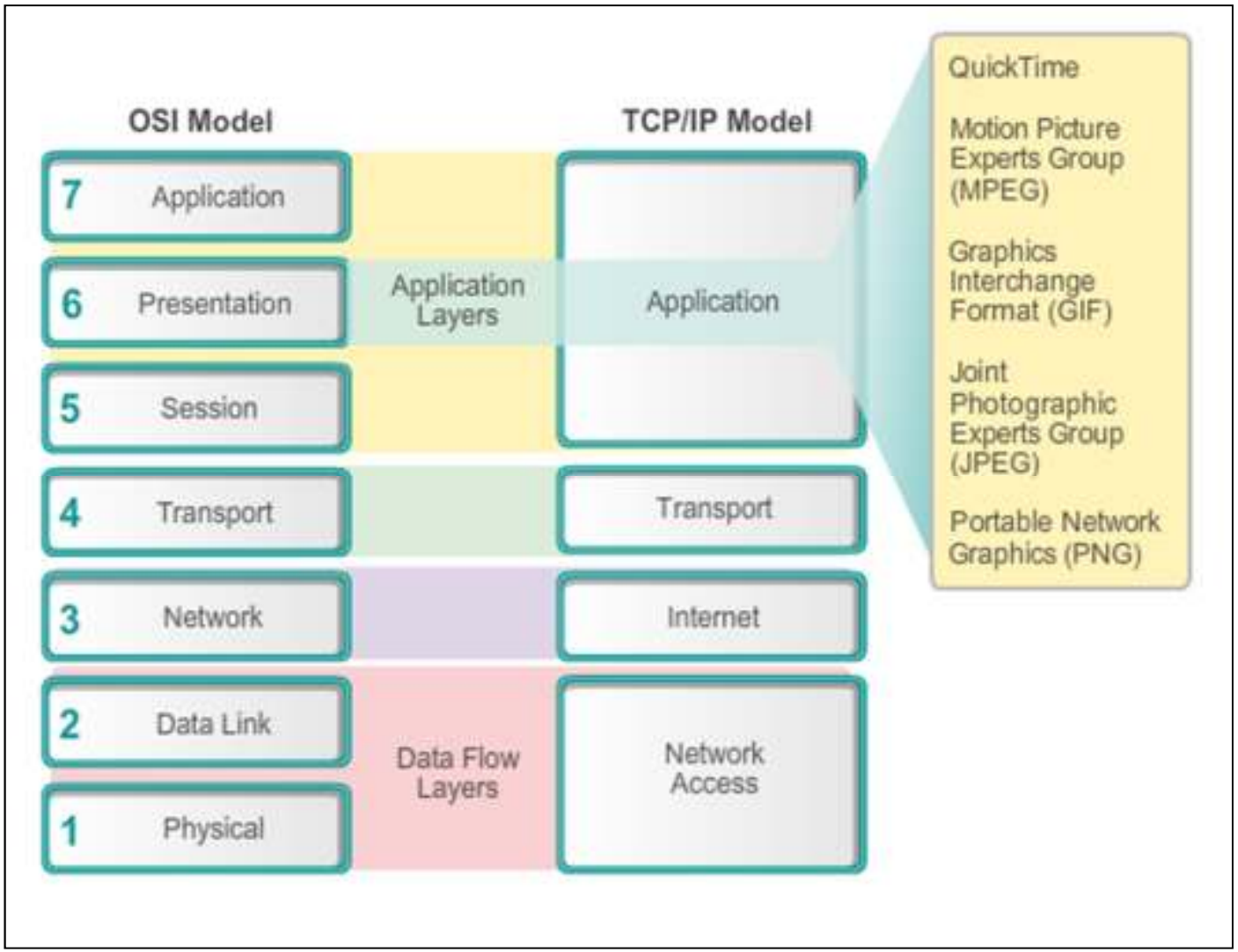
Application Layer



Presentation and Session Layers

- **Presentation layer**
  - Coding and conversion of application layer data
  - Data compression
  - Data encryption for the transmission and decryption of data upon receipt by the destination
- **Session layer**
  - Functions, creates, and maintains dialogs between source and destination applications
  - Handles the exchange of information to initiate dialogs, keep them active, and to restart sessions

Presentation and Session Layers (cont.)



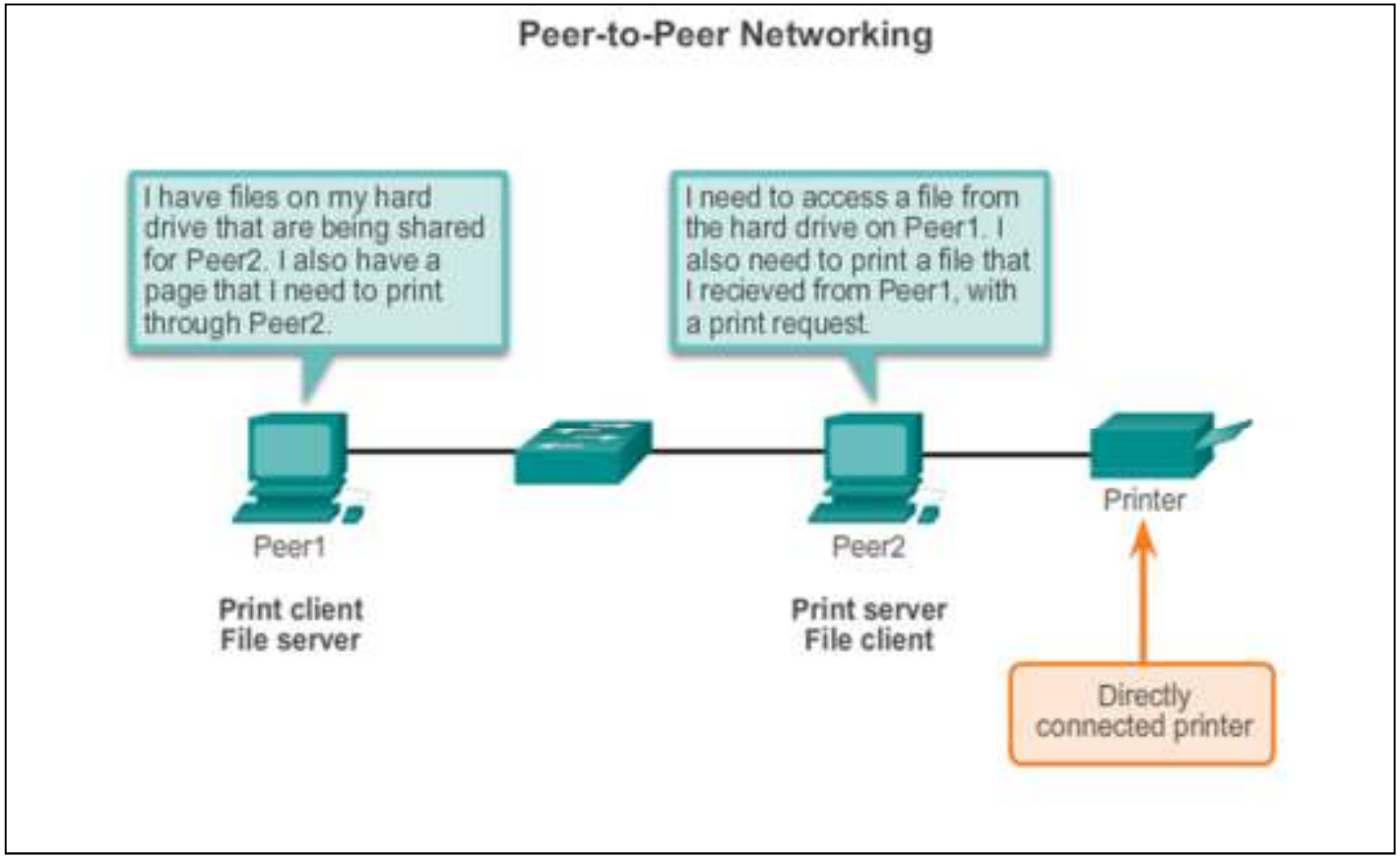
TCP/IP Application Layer Protocols

- **Domain Name Service Protocol (DNS)** – used to resolve Internet names to IP addresses
- **Telnet** – a terminal emulation protocol used to provide remote access to servers and networking devices
- **Bootstrap Protocol (BOOTP)** – a precursor to the DHCP protocol, a network protocol used to obtain IP address information during bootup
- **Dynamic Host Control Protocol (DHCP)** – used to assign an IP address, subnet mask, default gateway and DNS server to a host
- **Hypertext Transfer Protocol (HTTP)** – used to transfer files that make up the Web pages of the World Wide Web

TCP/IP Application Layer Protocols (cont.)

- **File Transfer Protocol (FTP)** - used for interactive file transfer between systems
- **Trivial File Transfer Protocol (TFTP)** - used for connectionless active file transfer
- **Simple Mail Transfer Protocol (SMTP)** - used for the transfer of mail messages and attachments
- **Post Office Protocol (POP)** - used by email clients to retrieve email from a remote server
- **Internet Message Access Protocol (IMAP)** – another protocol for email retrieval

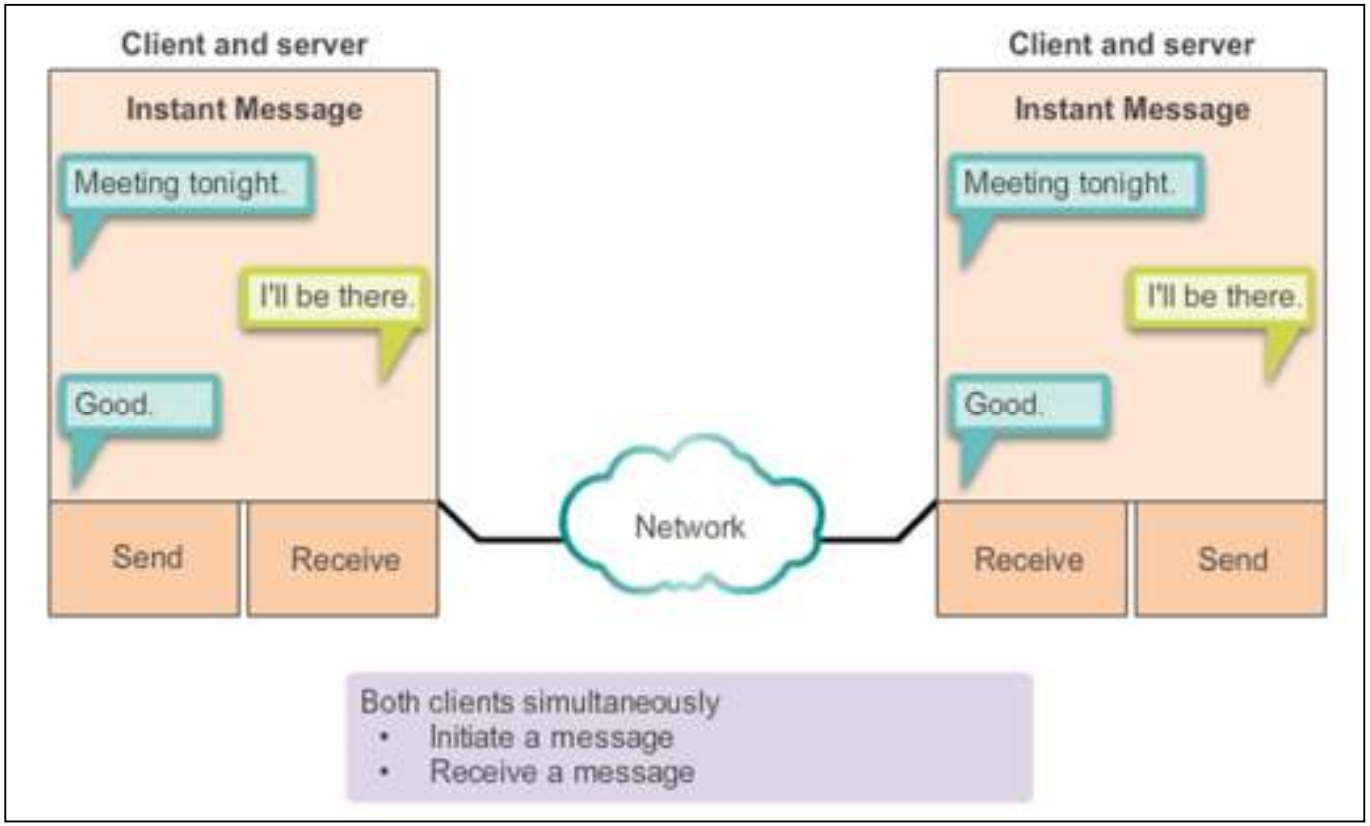
Peer-to-Peer Networks



Both devices are considered equal in the communication. The roles of client and server are set on a per request basis.

Peer-to-Peer Applications

Client and server in the same communication.

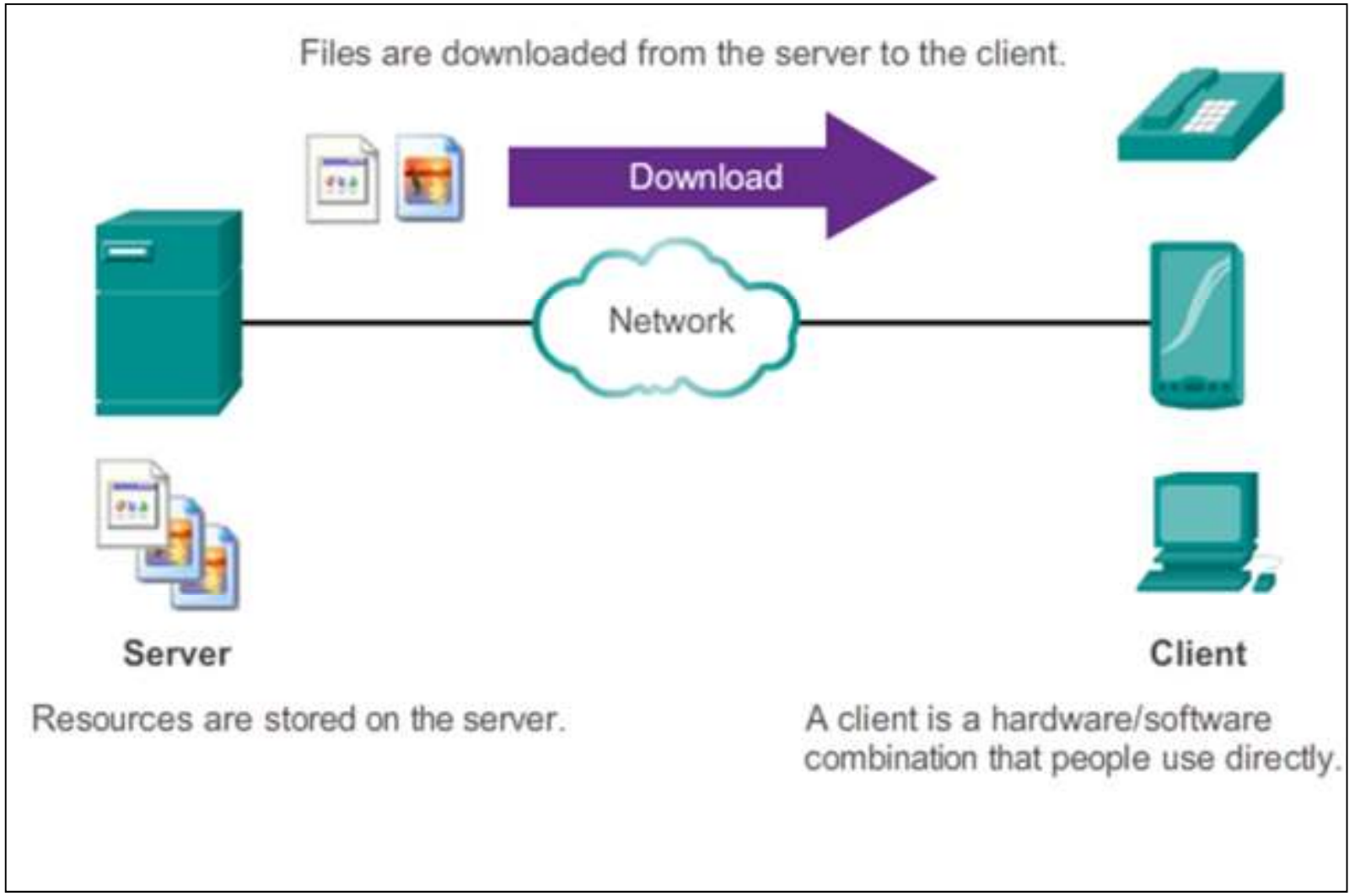


Both can initiate a communication and are considered equal in the communication process.

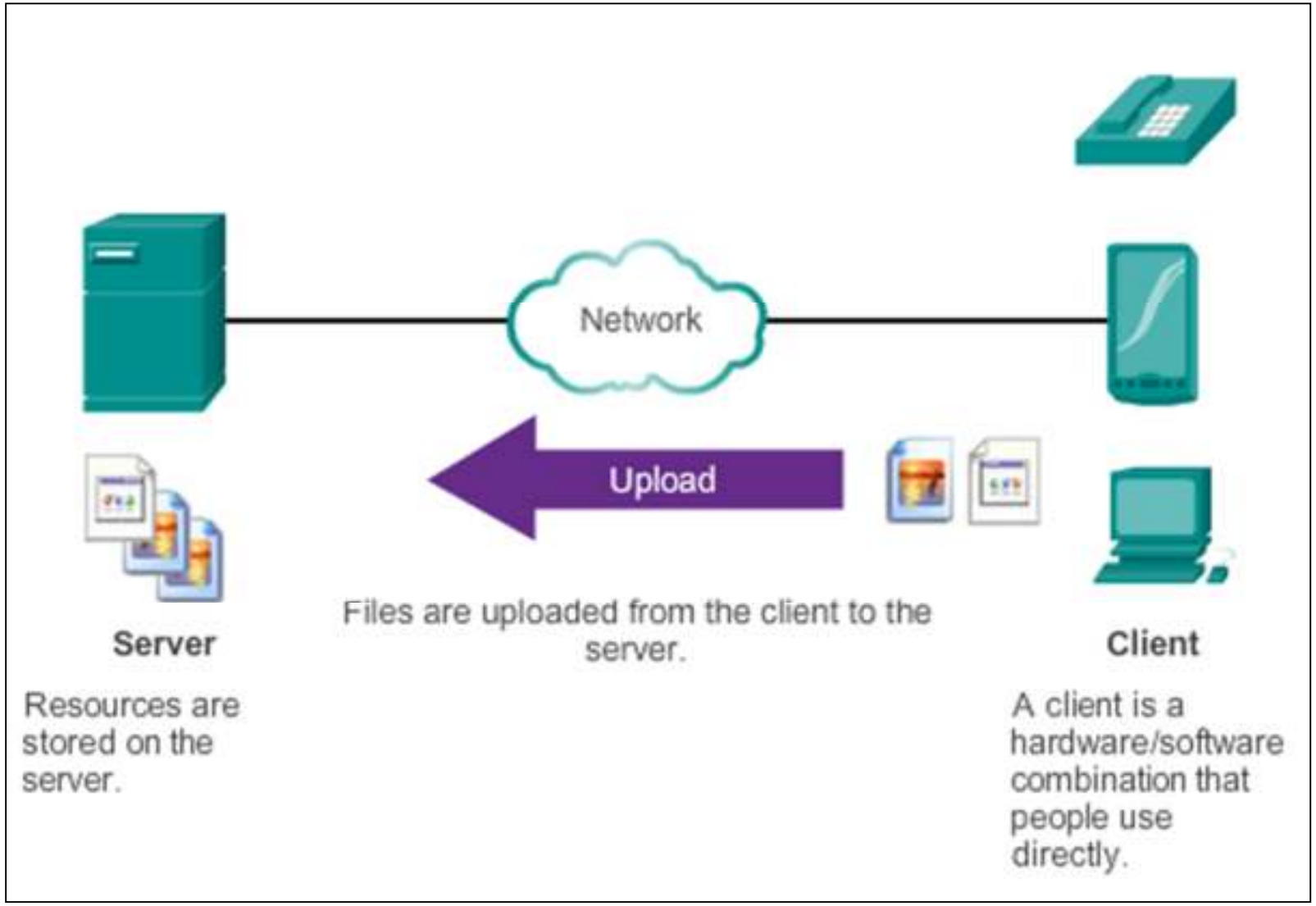
Common P2P Applications

- 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 which enables people to share files on their hard disks with others

Client-Server Model



Client-Server Model



10.2 Well-Known Application Layer Protocols and Services

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Application Layer Protocols Revisited

Three application layer protocols involved in everyday work or play include:

- **HTTP** to browse the web.
- **Simple Mail Transfer Protocol (SMTP)** to enable users to send email.
- **Post Office Protocol (POP**) to enable users to receive email.

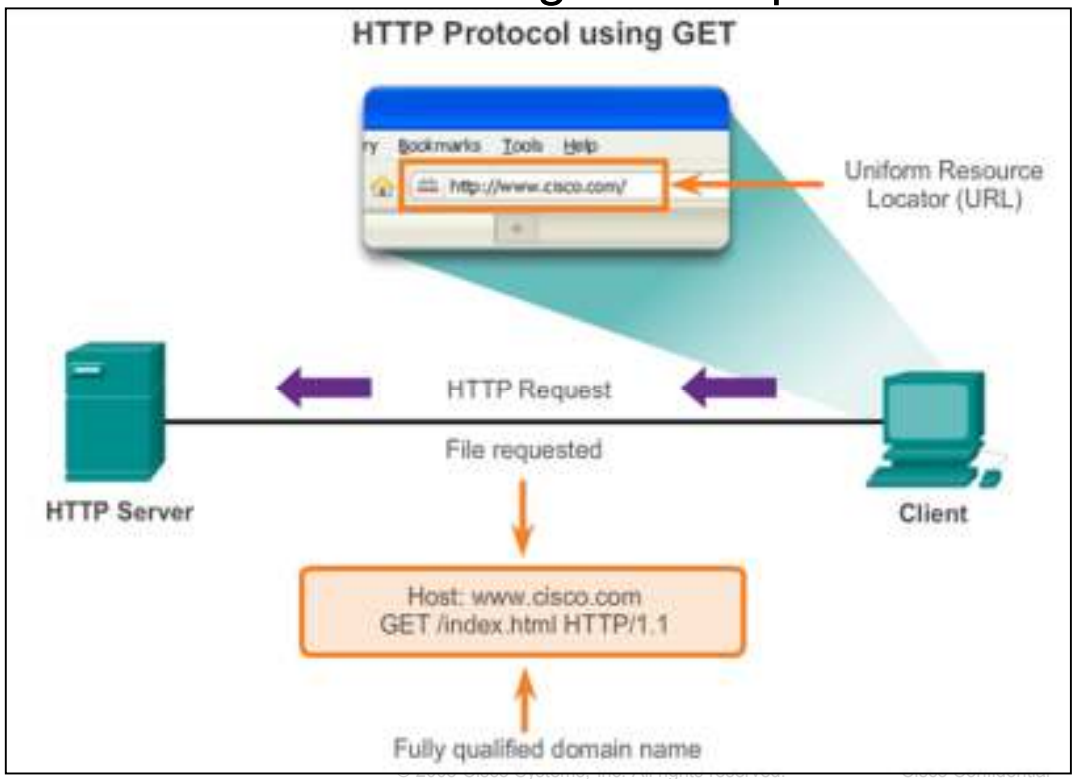
Hypertext Transfer Protocol and Hypertext Markup Language

Example URL: http://www.cisco.com/index.html

1. First, the browser interprets the three parts of the URL:
   - **http** (the protocol or scheme)
   - **www.cisco.com** (the server name)
   - **index.html** (the specific file name requested)
2. Browser checks with a name server to convert **www.cisco.com** into a numeric address
3. Using the HTTP protocol requirements sends a GET request to the server and asks for the file **index.html**
4. Server sends the HTML code for this web page
5. Browser deciphers the HTML code and formats the page

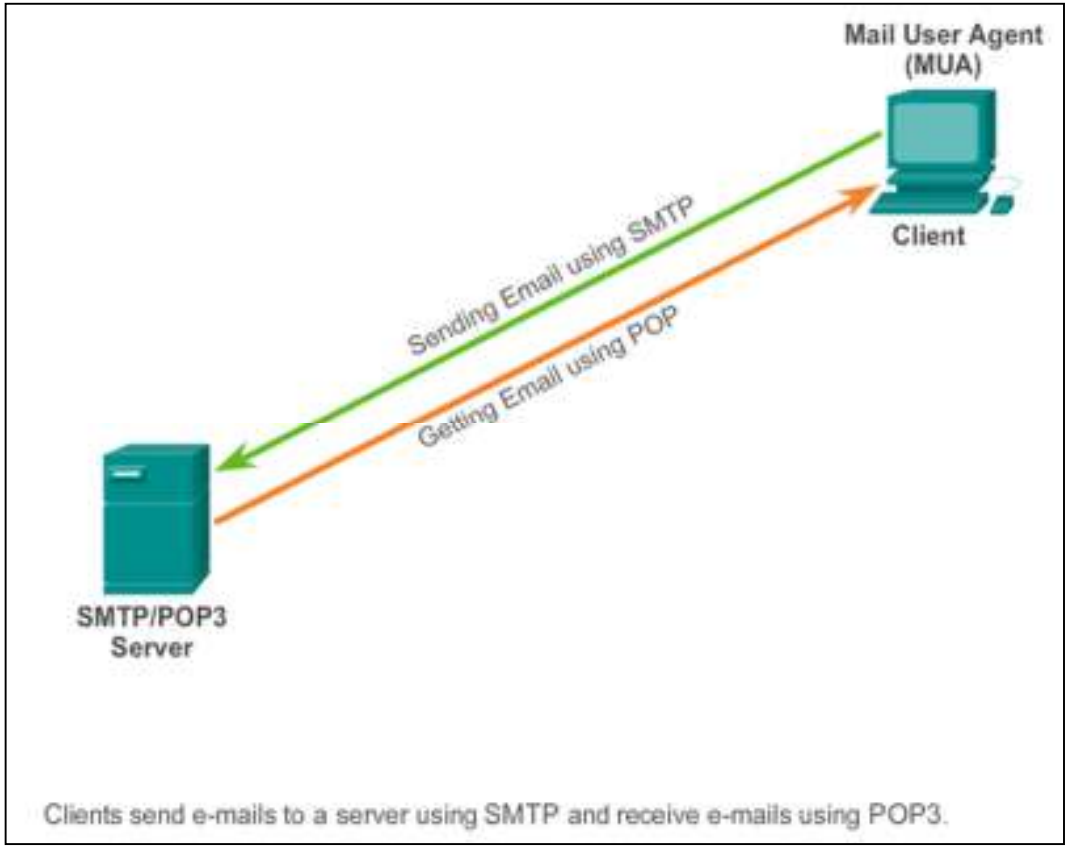
HTTP and HTTPS

- Developed to publish and retrieve HTML pages
- Used for data transfer
- Specifies a request/response protocol
- Three common message types are GET, POST, and PUT
- GET is a client request for data
- POST and PUT are used to send messages that upload data to the web server

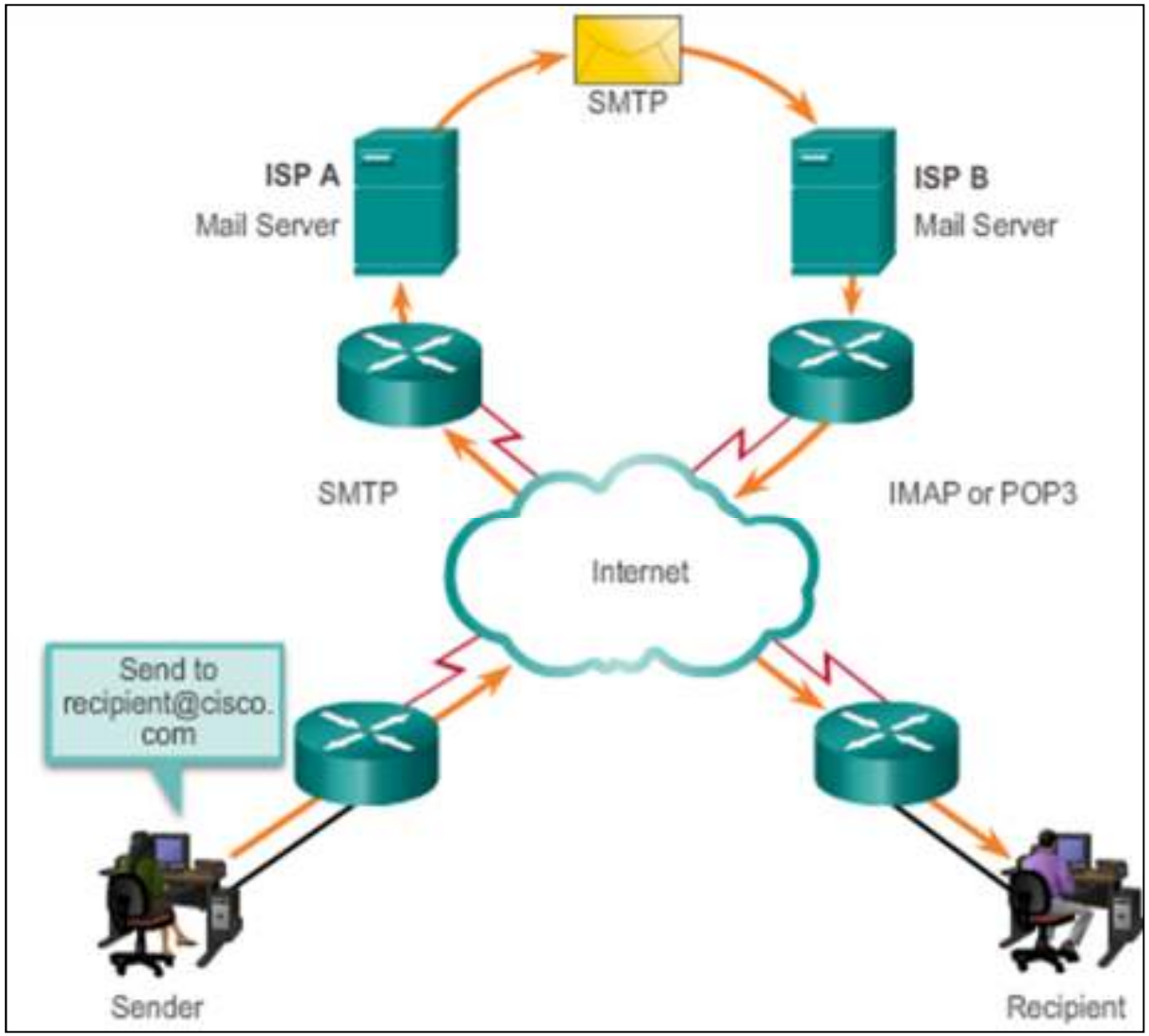


SMTP, POP, and IMAP

- Typically use an application called a Mail User Agent (email client)
- Allows messages to be sent
- Places received messages into the client's mailbox
- SMTP - Send email from either a client or a server
- POP - Receive email messages from an email server
- IMAP - Internet Message Access Protocol
- Email client provides the functionality of both protocols within one application



SMTP, POP, and IMAP (cont.)



SMTP, POP, and IMAP (cont.)

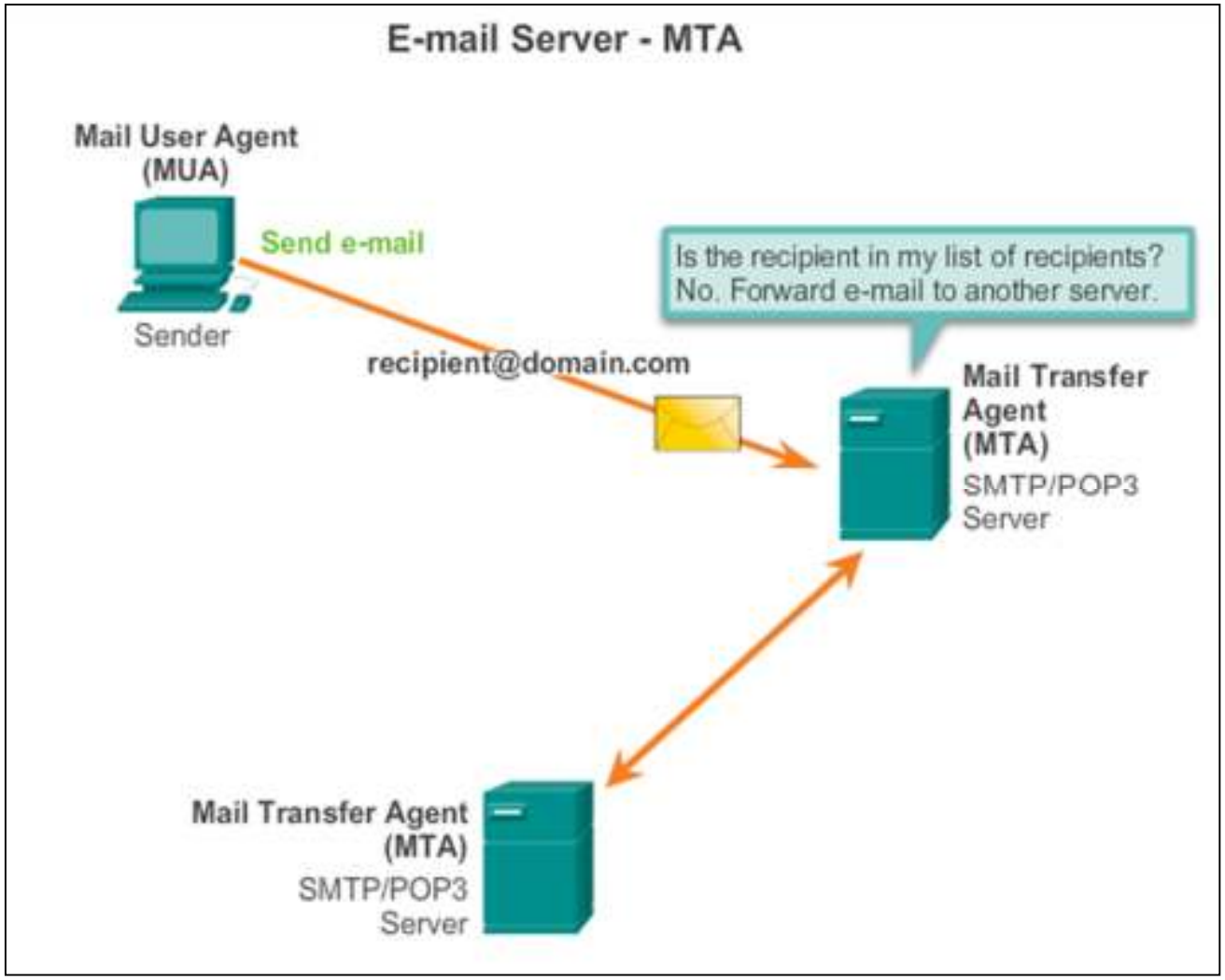
Simple Mail Transfer Protocol (SMTP)

- transfers mail
- message must be formatted properly
- SMTP processes must be running on both the client and server
- message header must have a properly formatted recipient email address and a sender
- uses port 25

Post Office Protocol (POP)

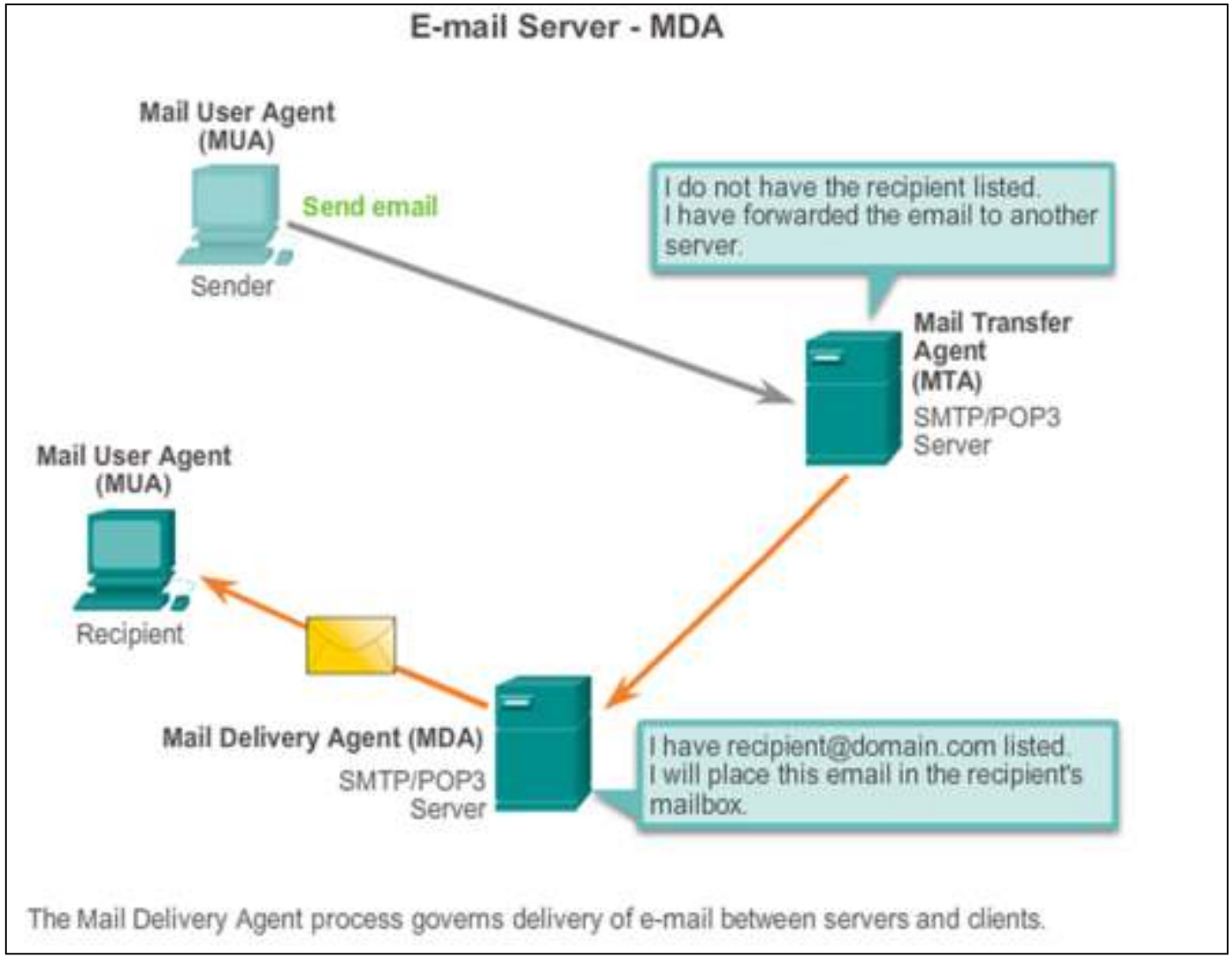
- enables a workstation to retrieve mail from a mail server
- mail is downloaded from the server to the client and then deleted on the server
- uses port 110
- POP does not store messages
- POP3 is desirable for an ISP, because it alleviates their responsibility for managing large amounts of storage for their email servers

SMTP, POP, and IMAP (cont.)



The Mail Transfer Agent process governs e-mail handling between servers and clients.

SMTP, POP, and IMAP (cont.)



SMTP, POP, and IMAP (cont.)

- MDA accepts a piece of email from MTA and performs the actual delivery.
- MDA receives all the inbound mail from the MTA and places it into mailboxes.
- MDA can also resolve final delivery issues, such as virus scanning, spam filtering, and return-receipt handling.

SMTP, POP, and IMAP (cont.)

Simple Mail Transfer Protocol (SMTP)

- Transfers mail reliably and efficiently

Post Office Protocol (POP)

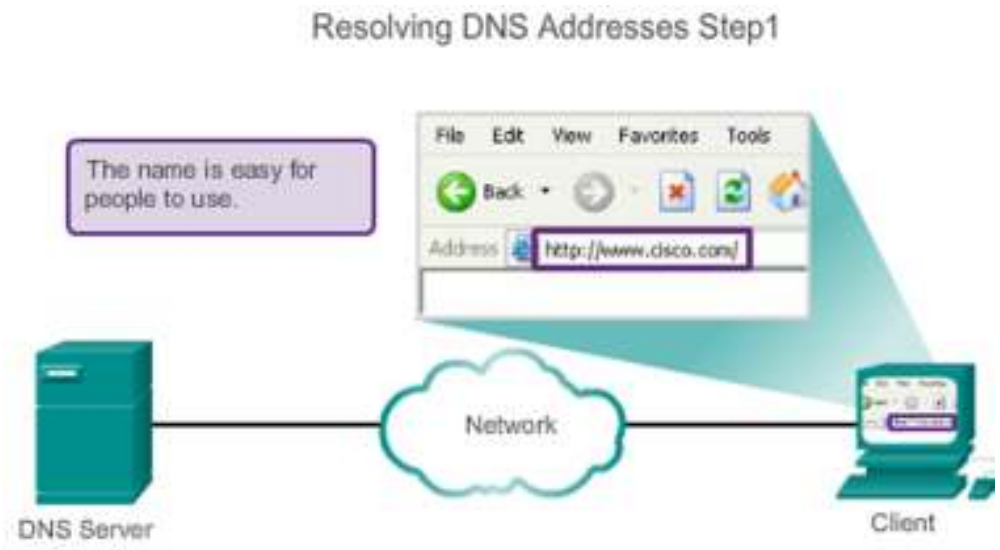
- Enables a workstation to retrieve mail from a mail server
- With POP, mail is downloaded from the server to the client and then deleted on the server

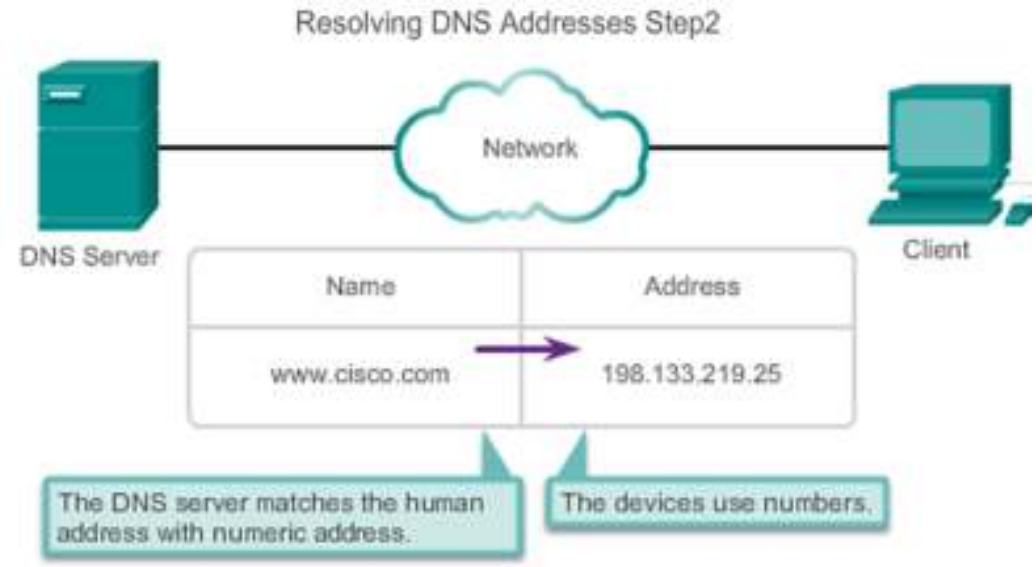
Internet Message Access Protocol (IMAP)

- Another protocol that to retrieves email messages
- Unlike POP, when the user connects to an IMAP-capable server, copies of the messages are downloaded to the client application
- Original messages are kept on the server until manually deleted

Domain Name Service

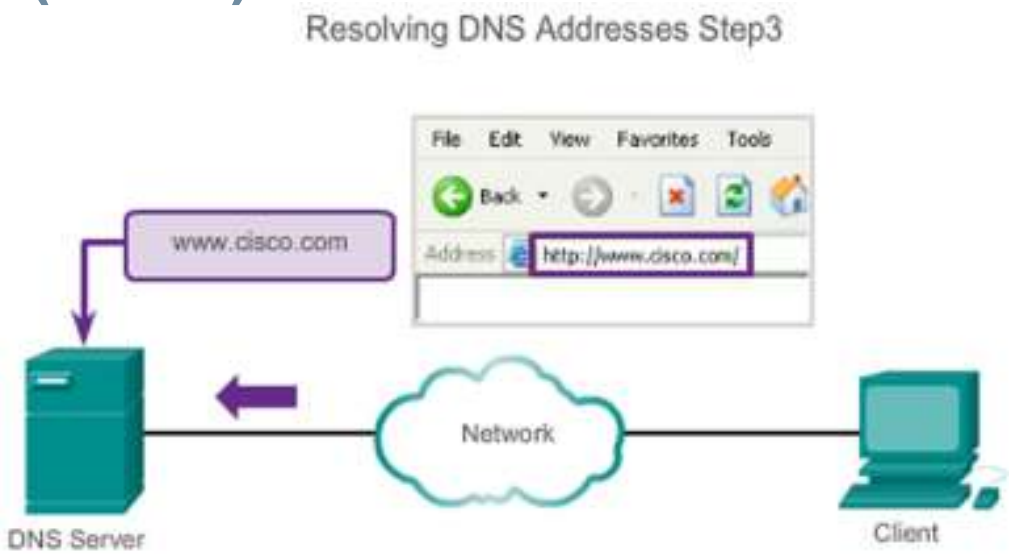
A human legible name is resolved to its numeric network device address by the DNS protocol.

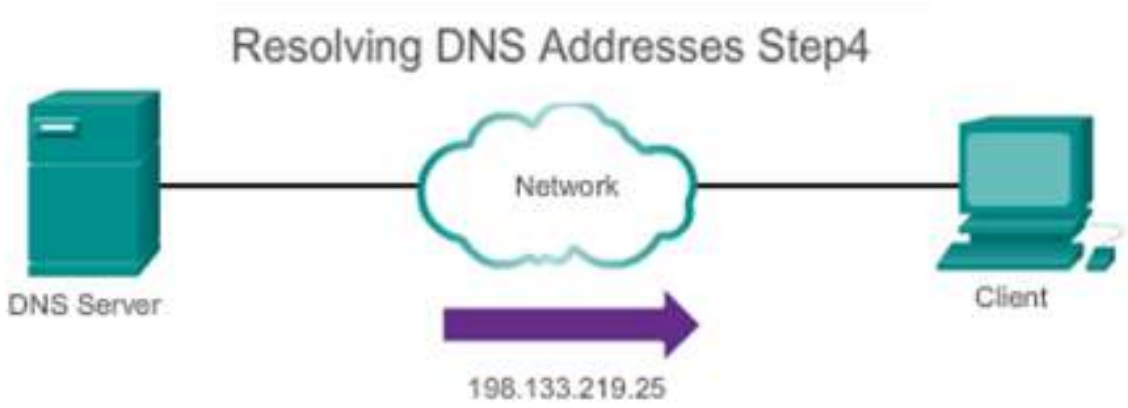




Domain Name Service (cont.)

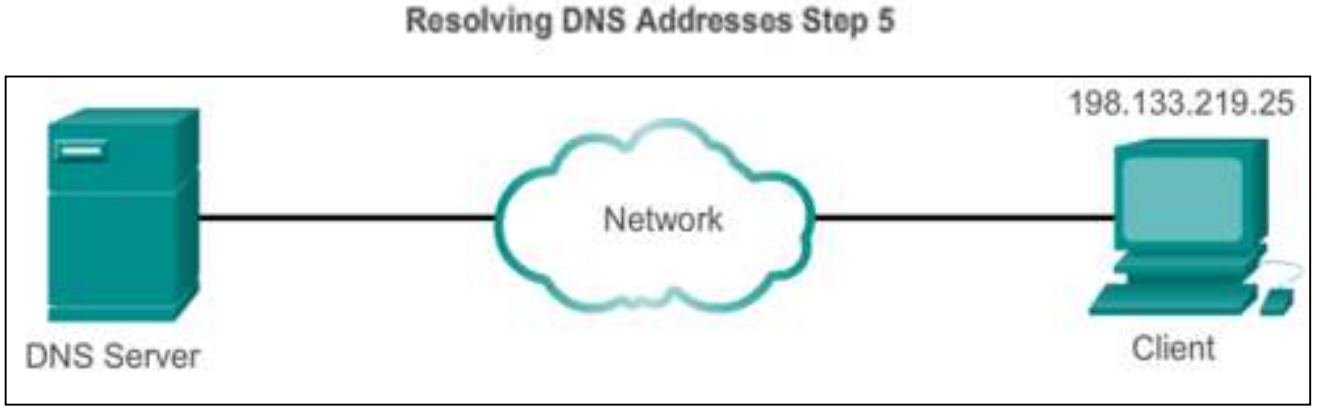
A human legible name is resolved to its numeric network device address by the DNS protocol.





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

Domain Name Service (cont.)



A domain name is resolved to its numeric network device address by the DNS protocol.

DNS Message Format

- DNS server stores different types of resource records used to resolve names
- Contains the name, address, and type of record.
- Record types are:
  - **A** – An end device address
  - **NS** – An authoritative name server
  - **CNAME** – The canonical 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
- Unable to resolve the name using its stored records, contacts other servers.
- Server temporarily stores the numbered address that matches the name in cache memory.
- Windows **ipconfig /displaydns** displays all cached DNS.

DNS Hierarchy

Examples top-level domains:

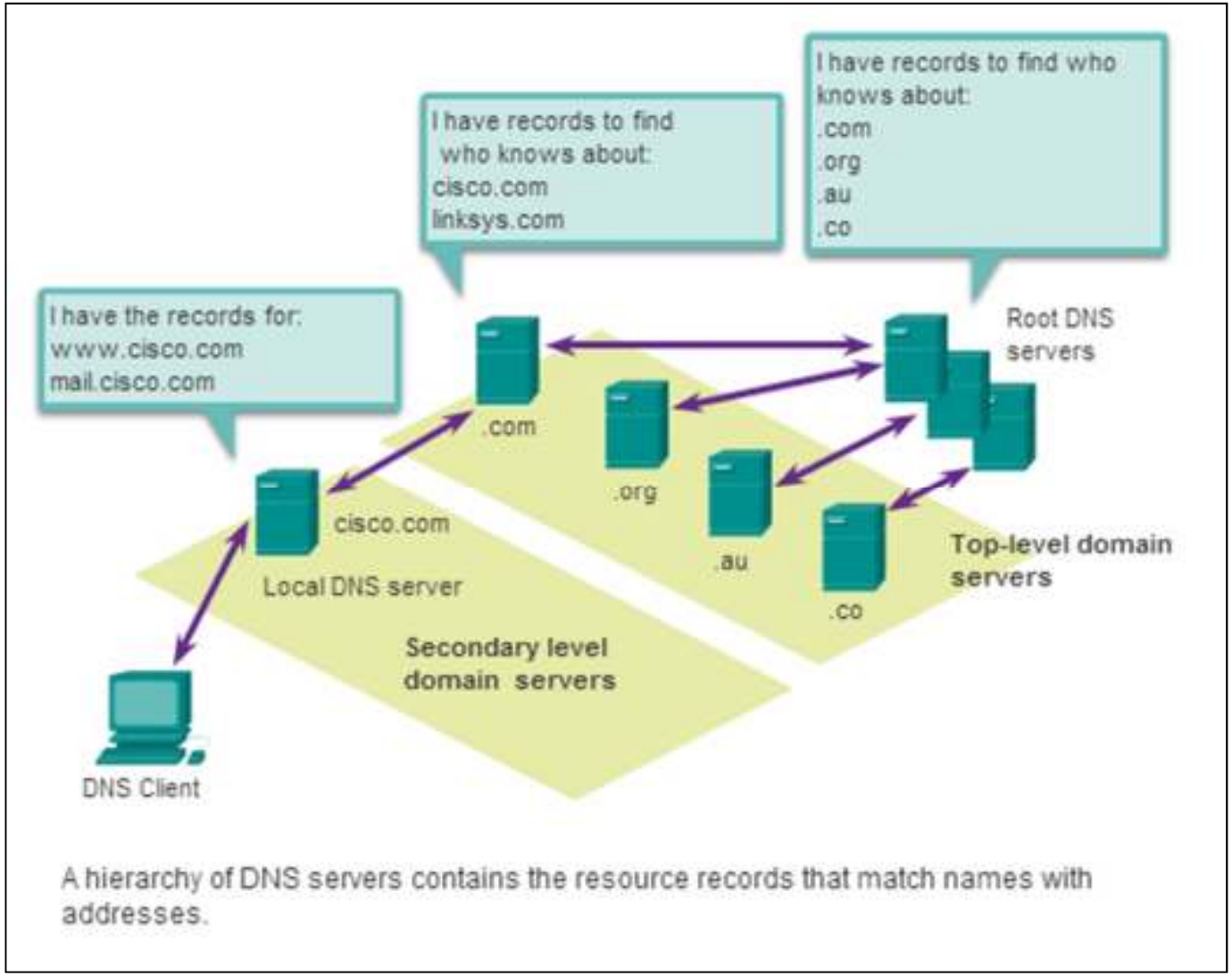
.au - Australia

.co - Colombia

.com - business or industry

.jp - Japan

.org - non-profit organization



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

nslookup

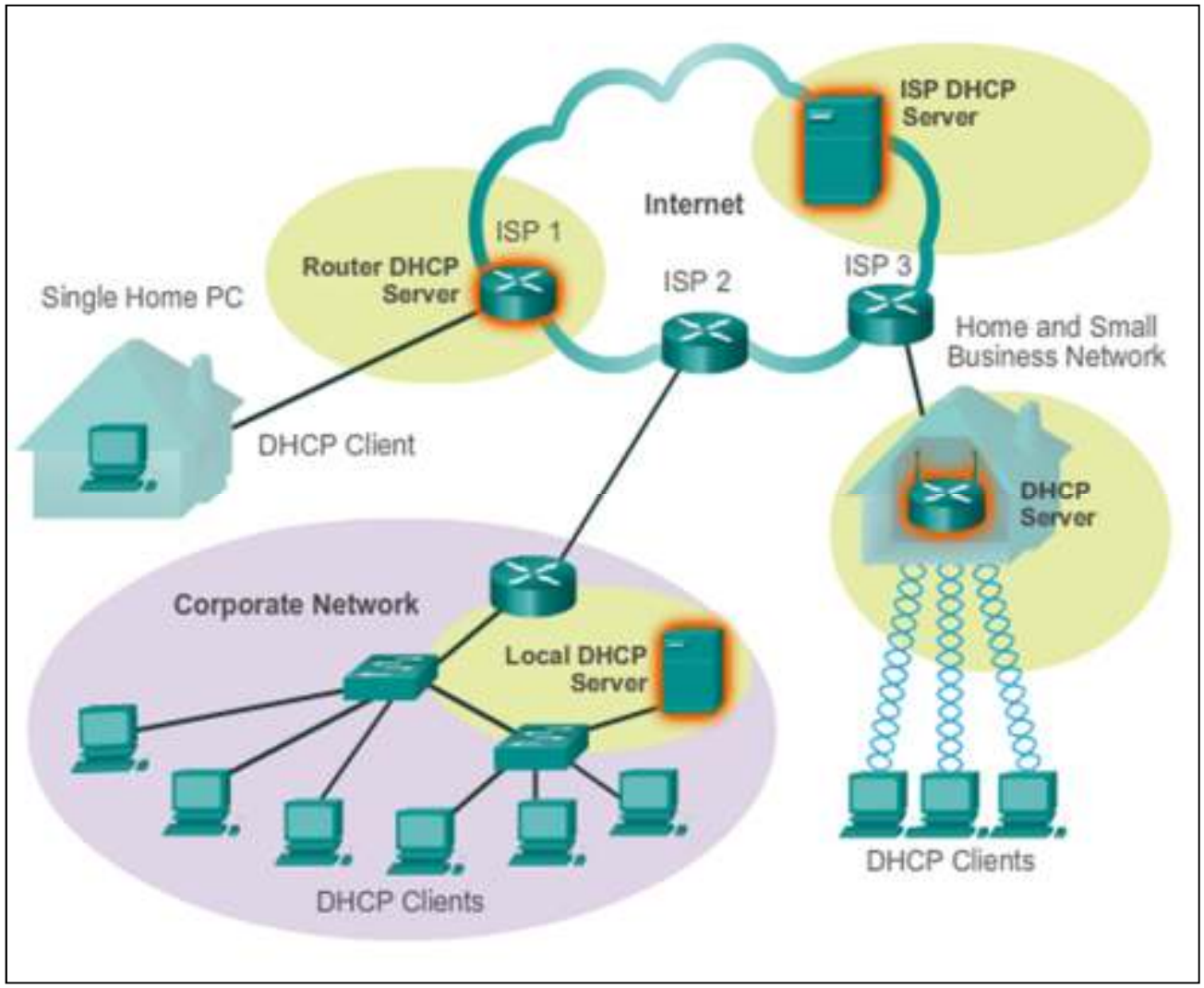
- Operating system utility called nslookup allows the user to manually query the name servers to resolve a given host name
- Utility can be used to troubleshoot name resolution issues and to verify the current status of the name servers

```
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

>
```

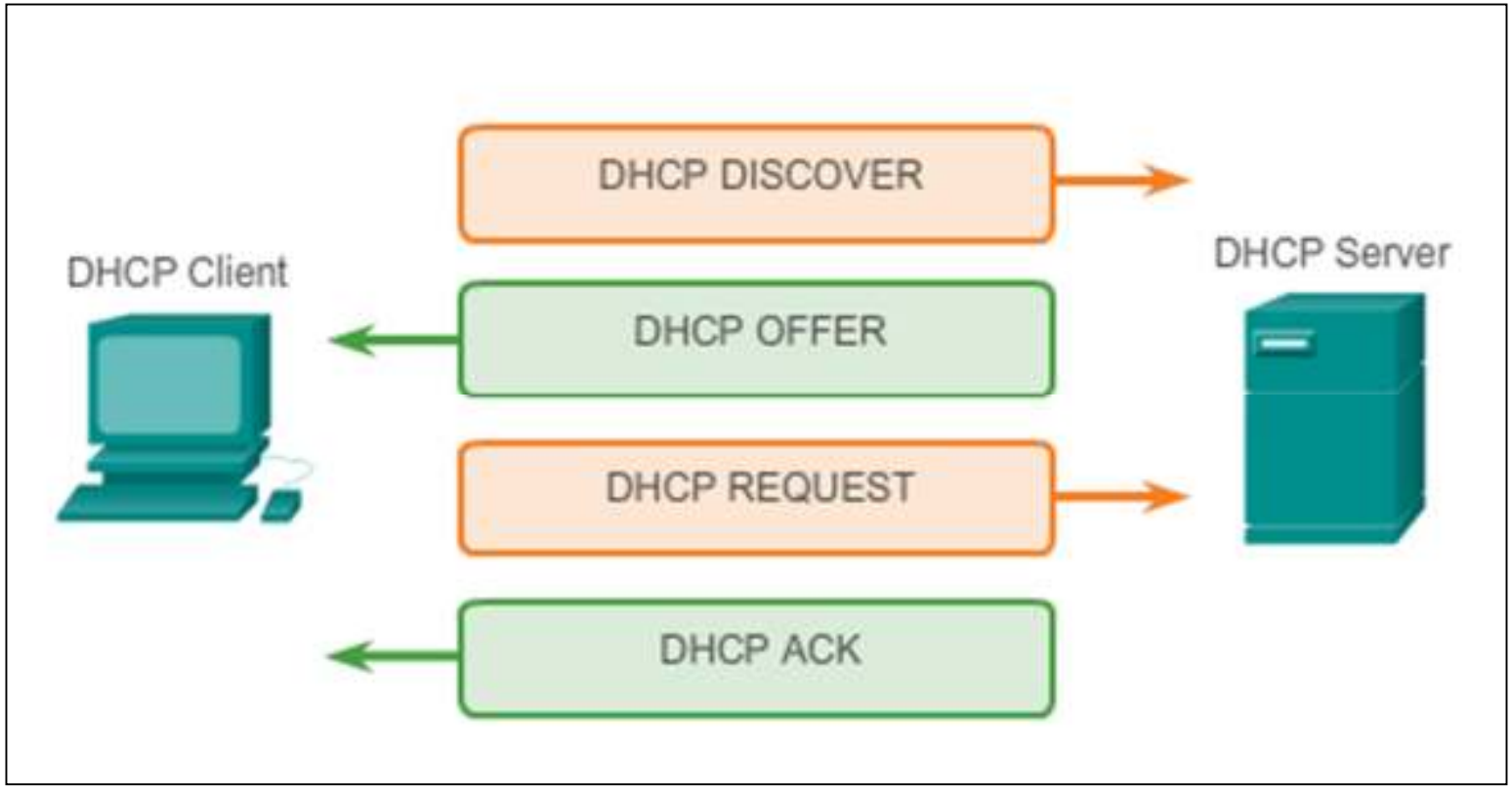
Dynamic Host Configuration Protocol

- DHCP allows a host to obtain an IP address dynamically.
- DHCP server is contacted and address requested - chooses address from a configured range of addresses called a pool and “leases” it to the host for a set period.
- DHCP used for general purpose hosts such as end user devices, and static addressing is used for network devices such as gateways, switches, servers and printers.

Dynamic Host Configuration Protocol (cont.)



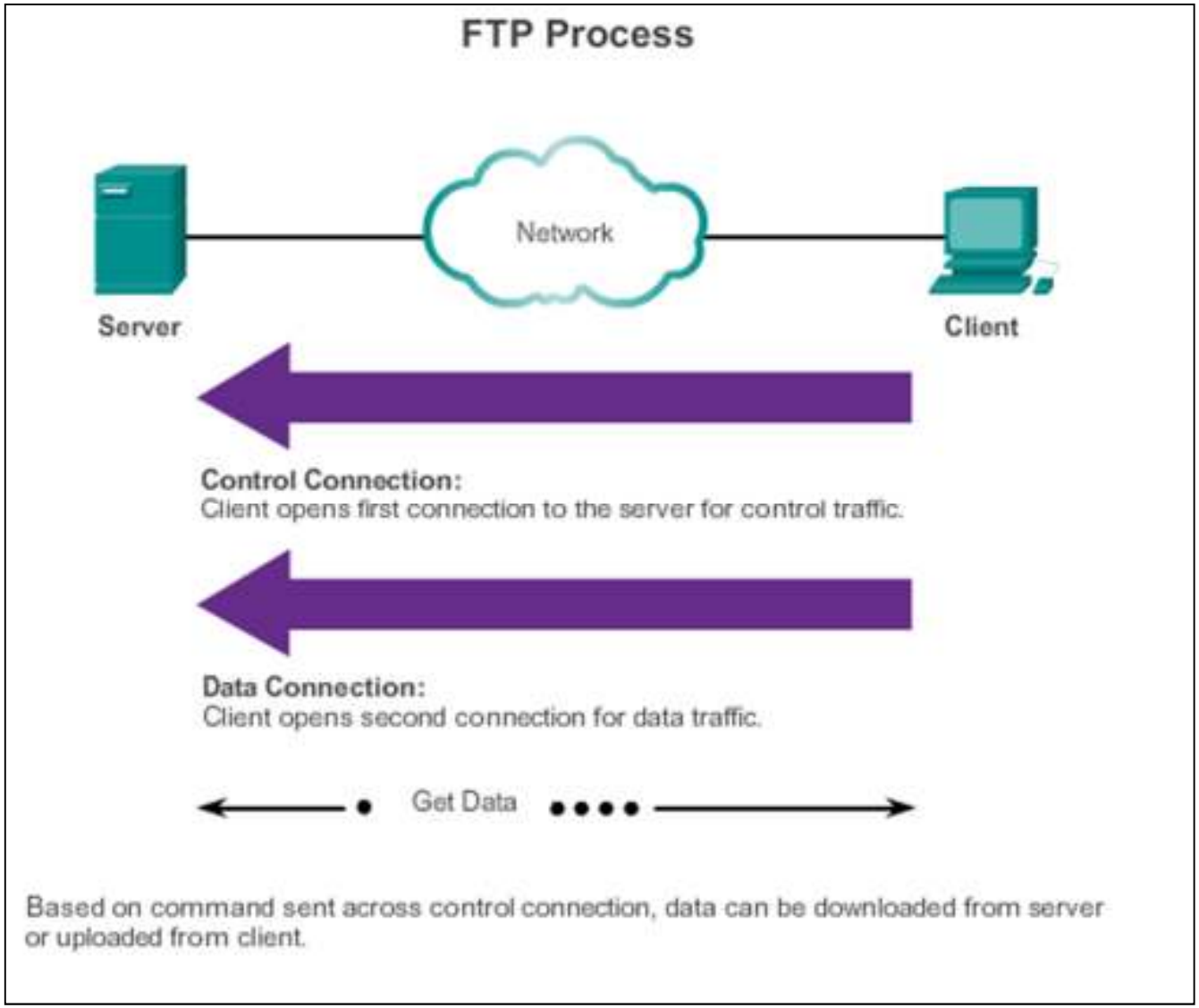
DHCP Operation



File Transfer Protocol

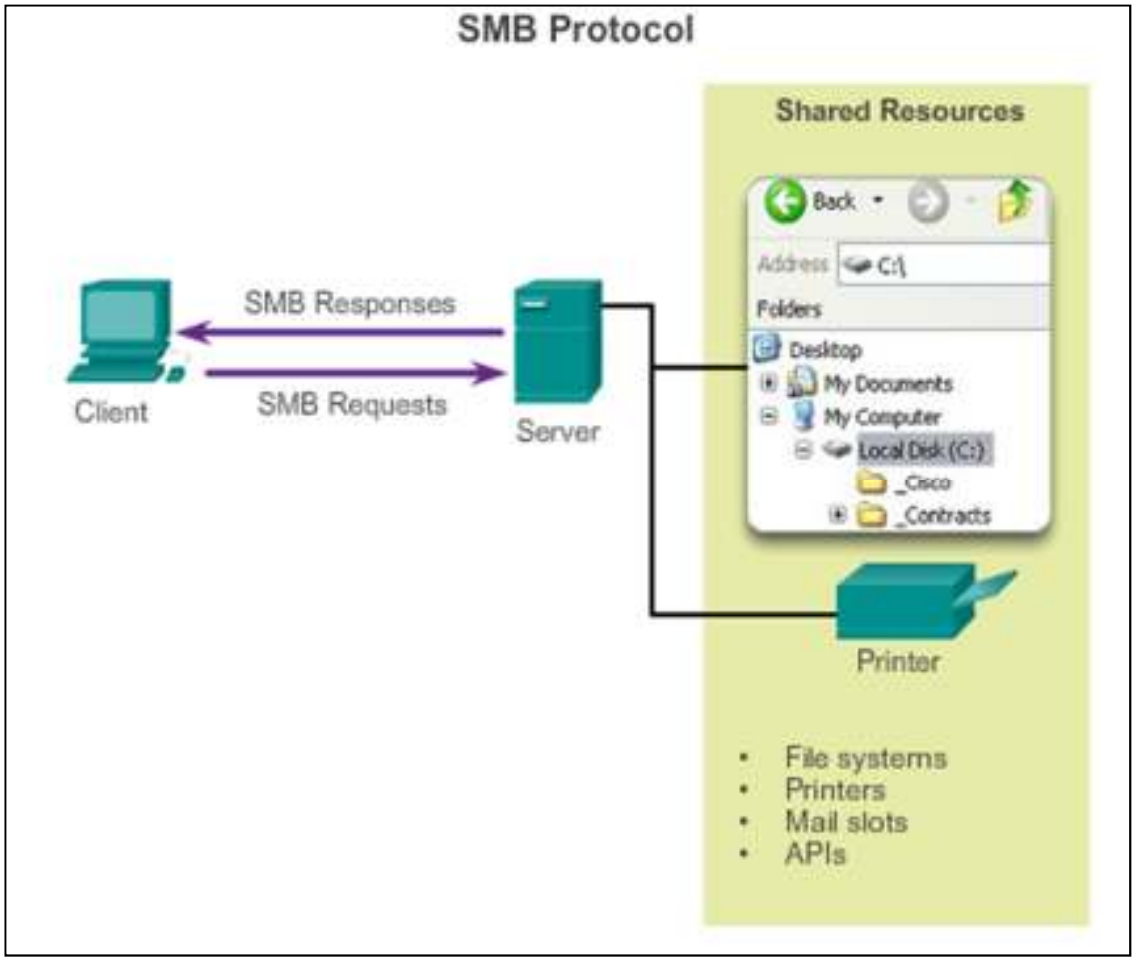
- FTP allow data transfers between a client and a server.
- FTP client is an application that runs on a computer that is used to push and pull data from a server running an FTP daemon.
- To successfully transfer data, FTP requires two connections between the client and the server, one for commands and replies, the other for the actual file transfer.

File Transfer Protocol (cont.)



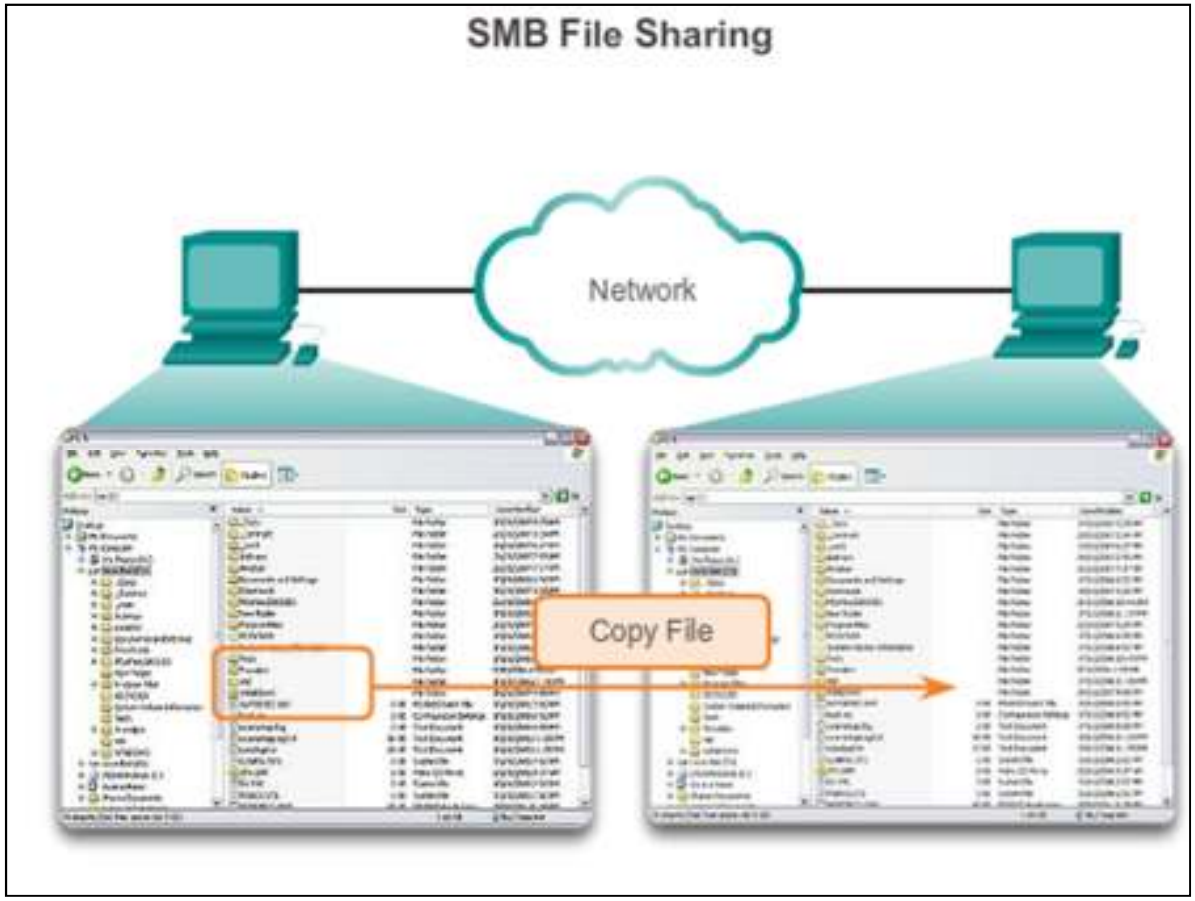
Server Message Block

- Clients establish a long term connection to servers.
- After the connection is established, the user can access the resources on the server as if the resource is local to the client host.



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

Server Message Block (cont.)



A file may be copied from PC to PC with Windows Explorer using the SMB protocol.

10.3 The Message Heard Around the World

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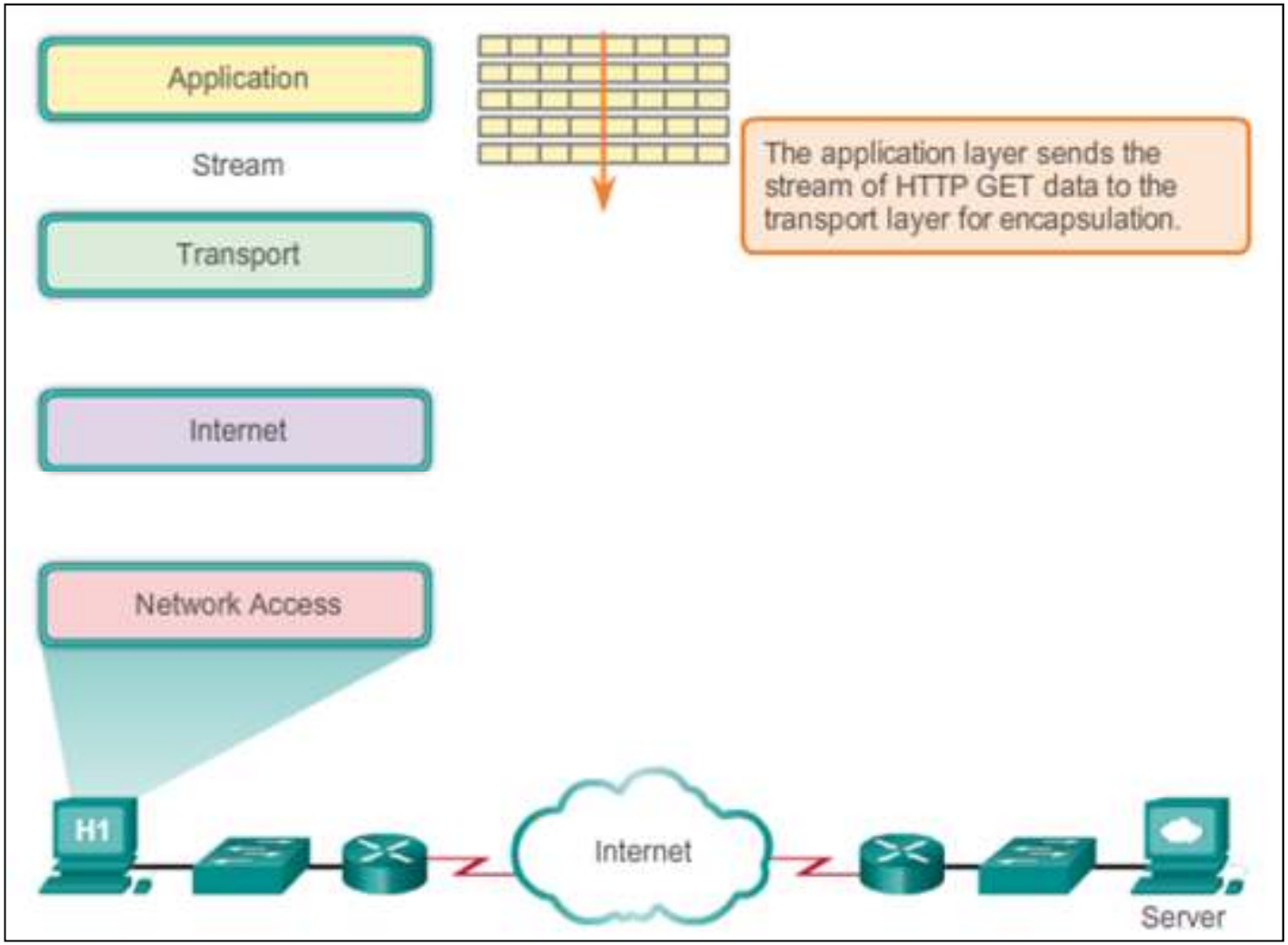
Move It!

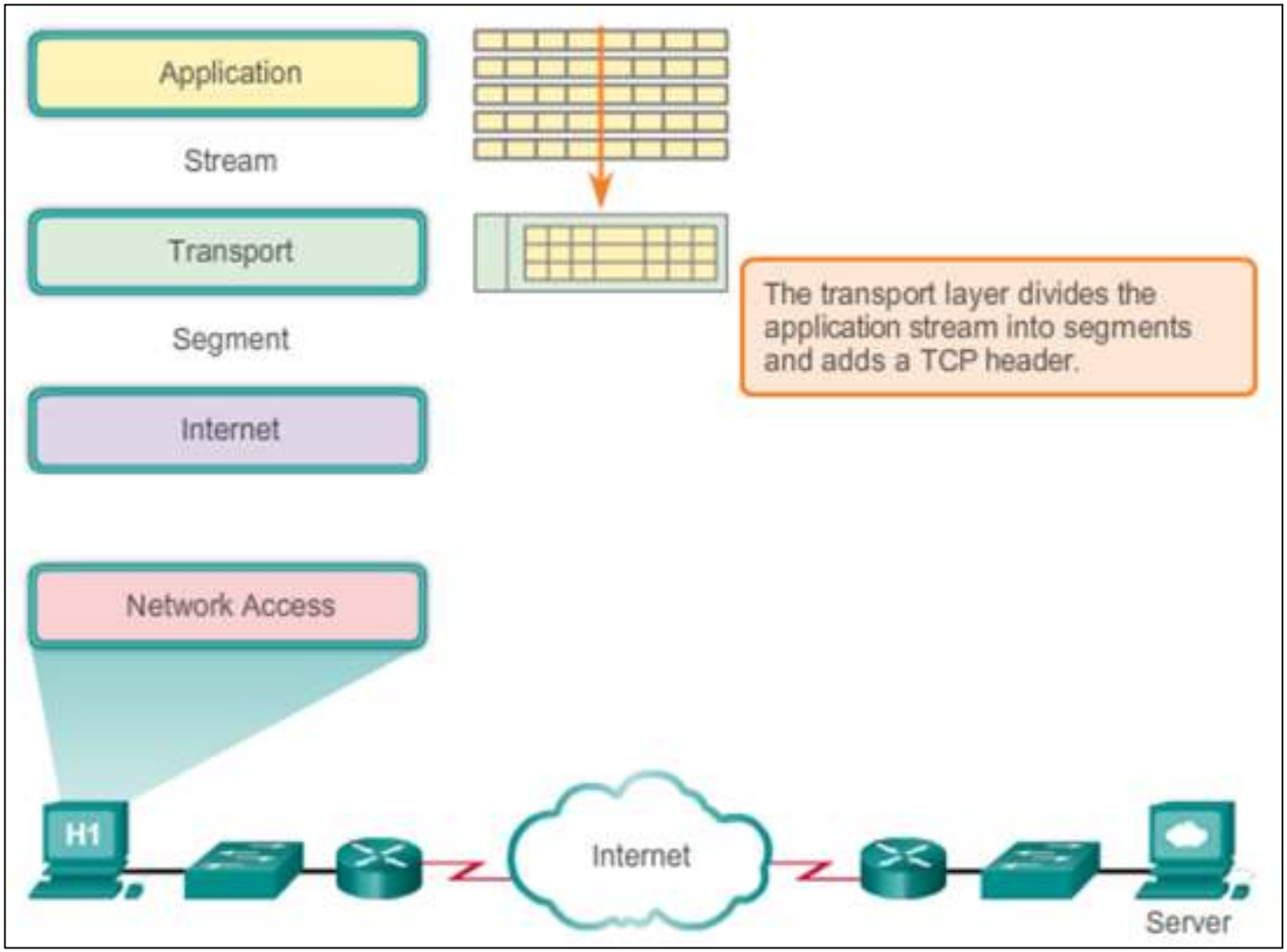
The Internet of Things

Move It!

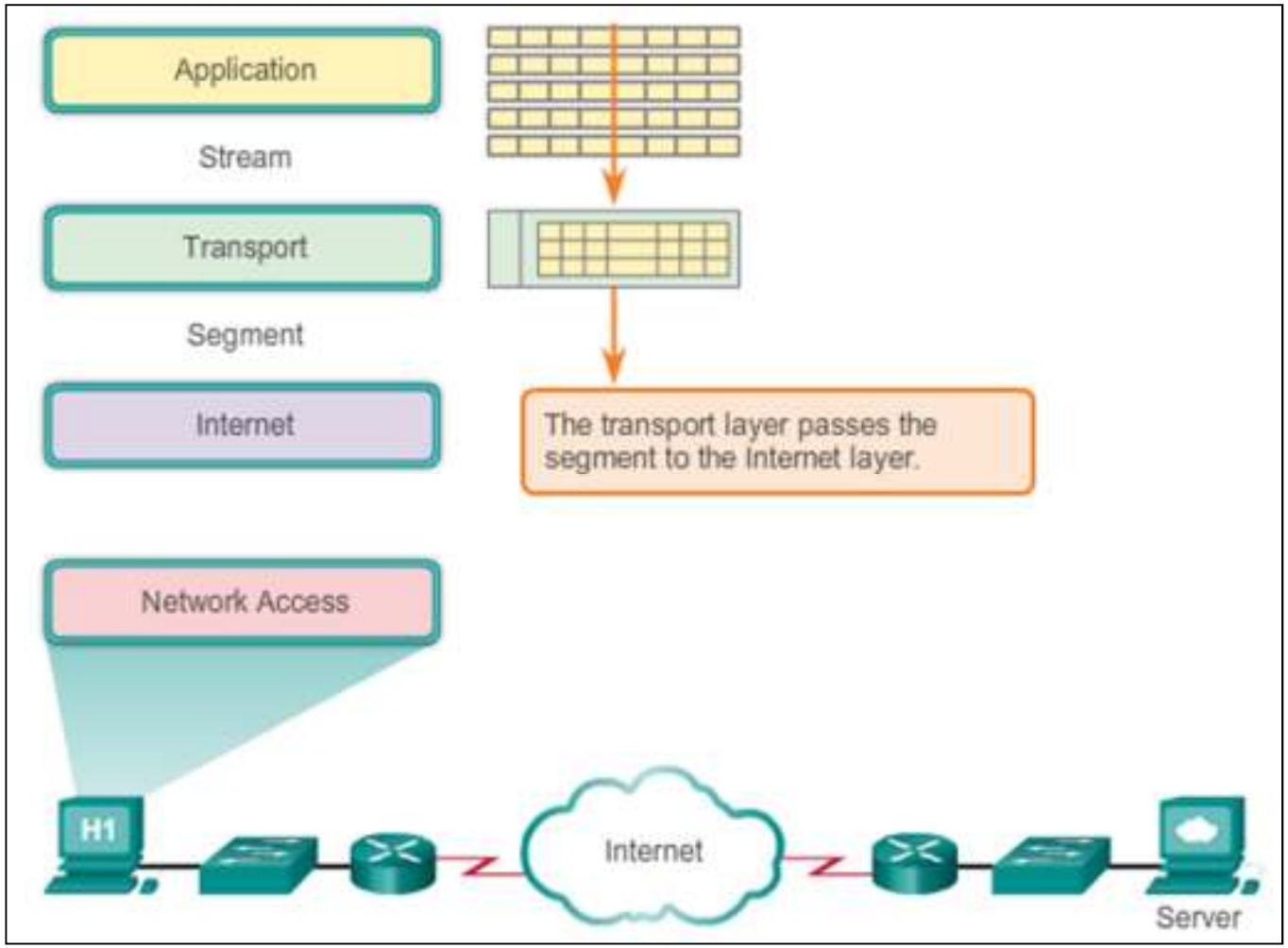
Message Travels Through a Network



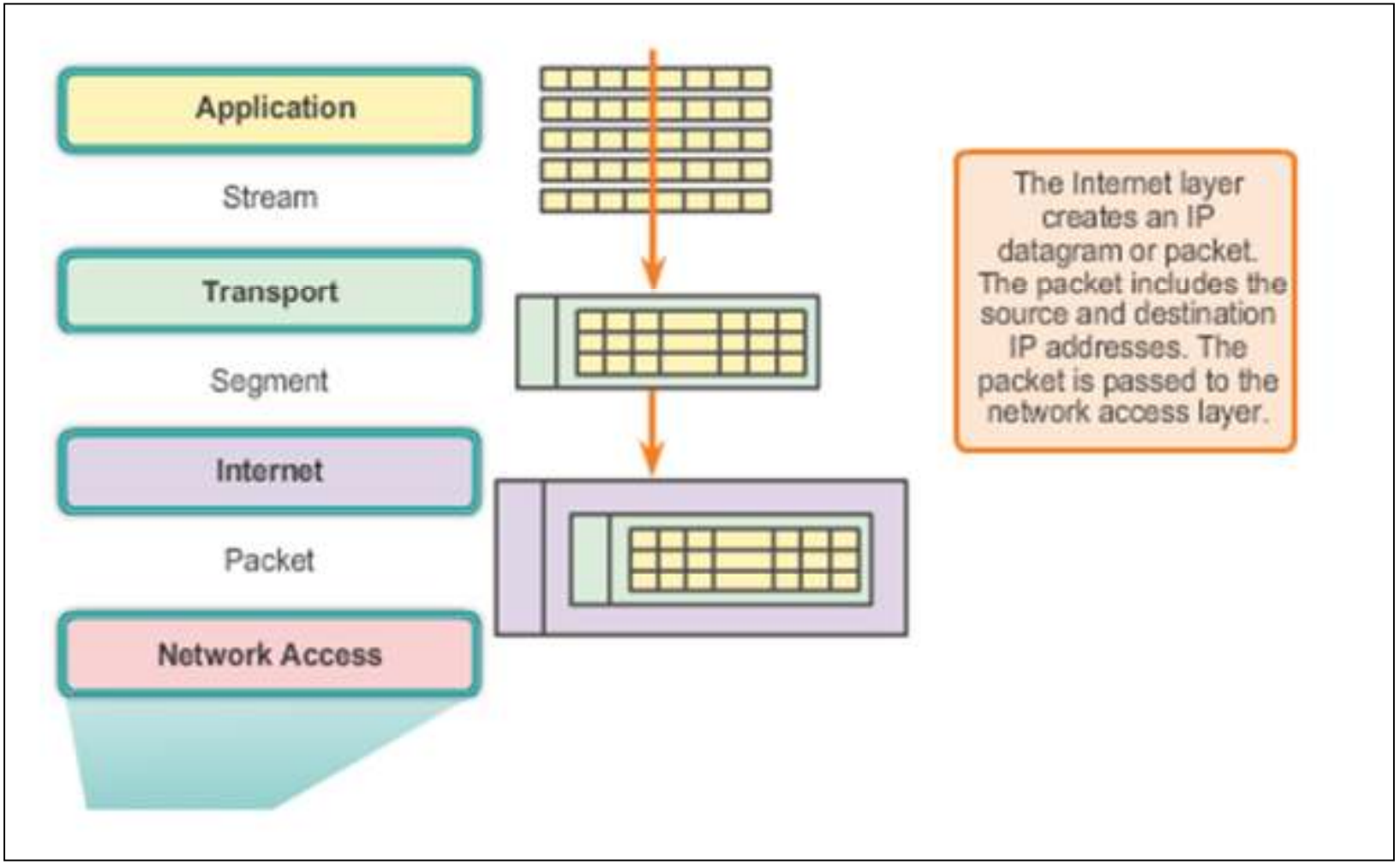
Message Travels Through a Network (cont.)



Message Travels Through a Network (cont.)

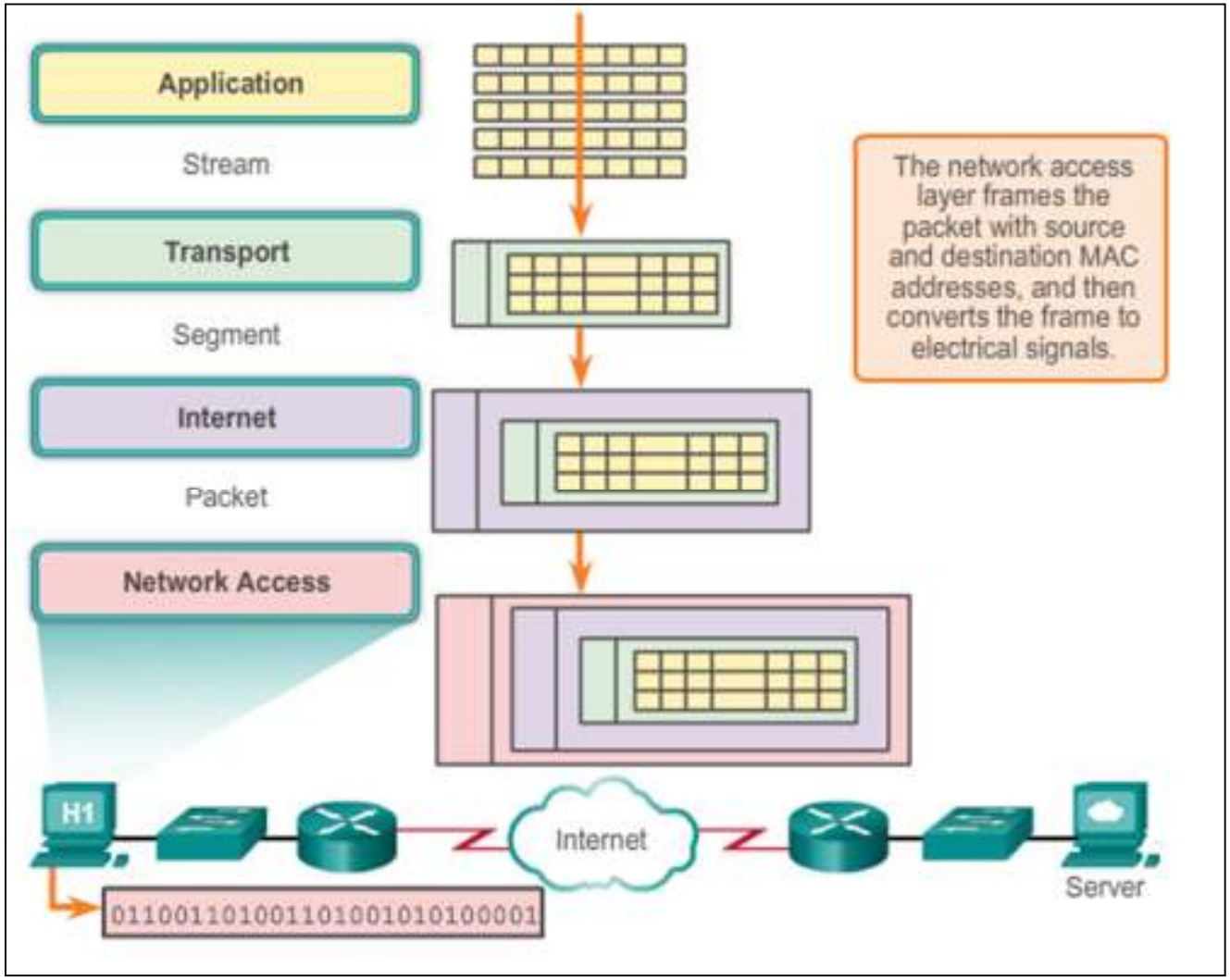


Getting the Data to the End Device

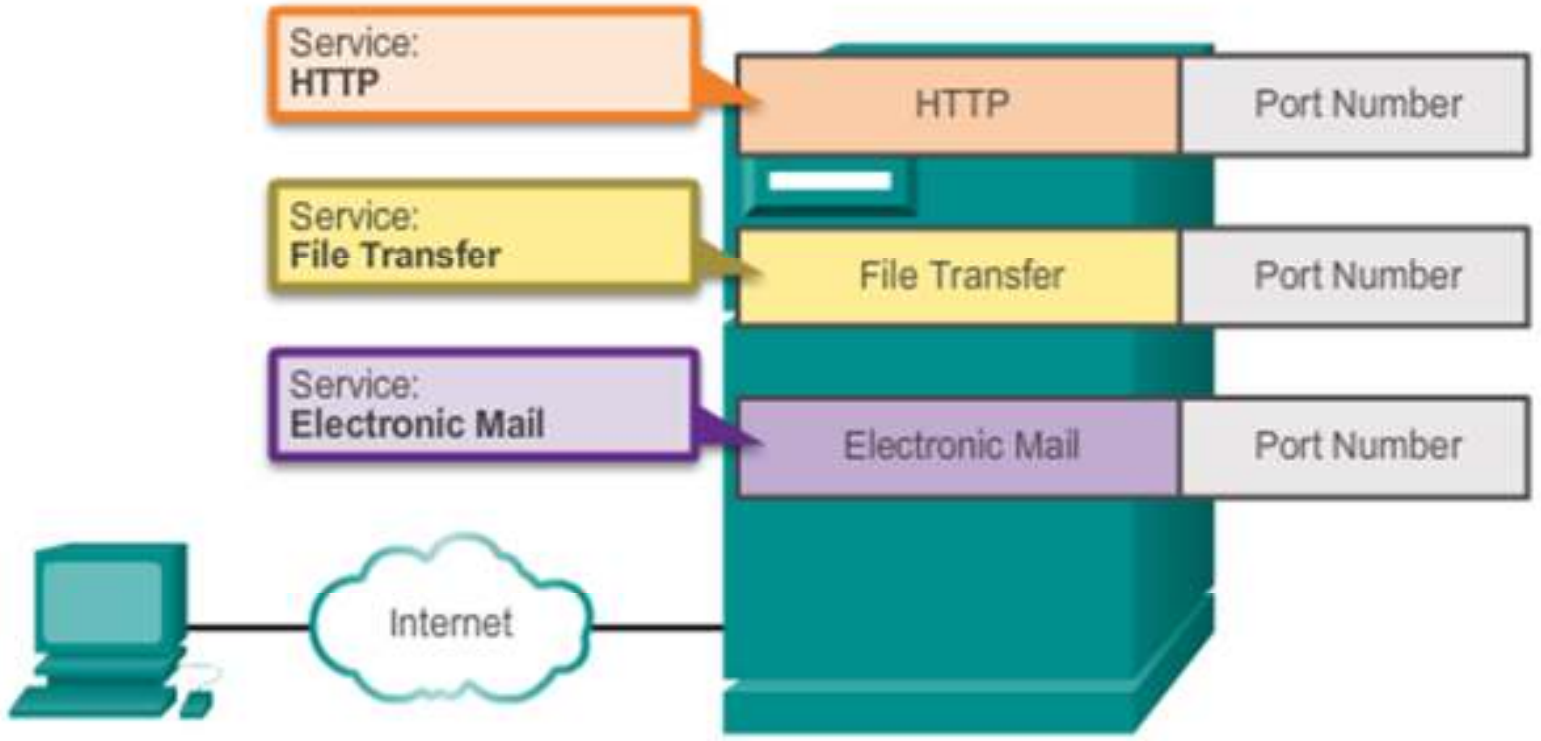


Move It!

Getting the Data through the Internetwork



Getting the Data to the Right Application



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

Summary

- Applications are computer programs with which the user interacts and which initiate the data transfer process at the user's request.
- Services are background programs that provide the connection between the application layer and the lower layers of the networking model.
- Protocols provide a structure of agreed-upon rules and processes that ensure services running on one particular device can send and receive data from a range of different network devices.
- HTTP supports the delivery of web pages to end devices.
- SMTP, POP, and IMAP support sending and receiving email.

Summary

- SMB and FTP enable users to share files.
- P2P applications make it easier for consumers to seamlessly share media.
- DNS resolves the human legible names used to refer to network resources into numeric addresses usable by the network
- All of these elements work together, at the application layer.
- The application layer enables users to work and play over the Internet.