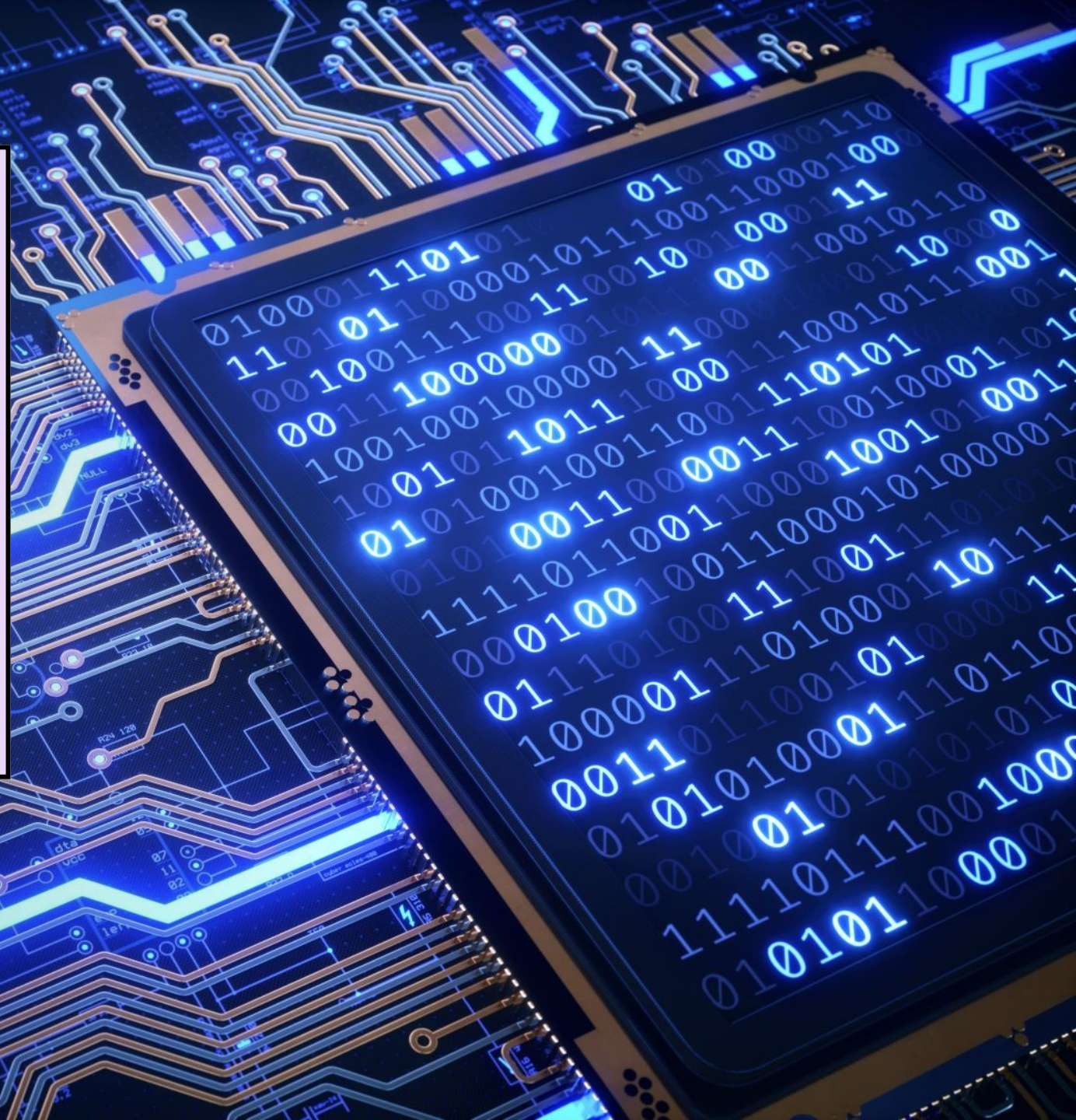


COMPUTER NETWORKS

APPLICATION LAYER



○ Topic of the day

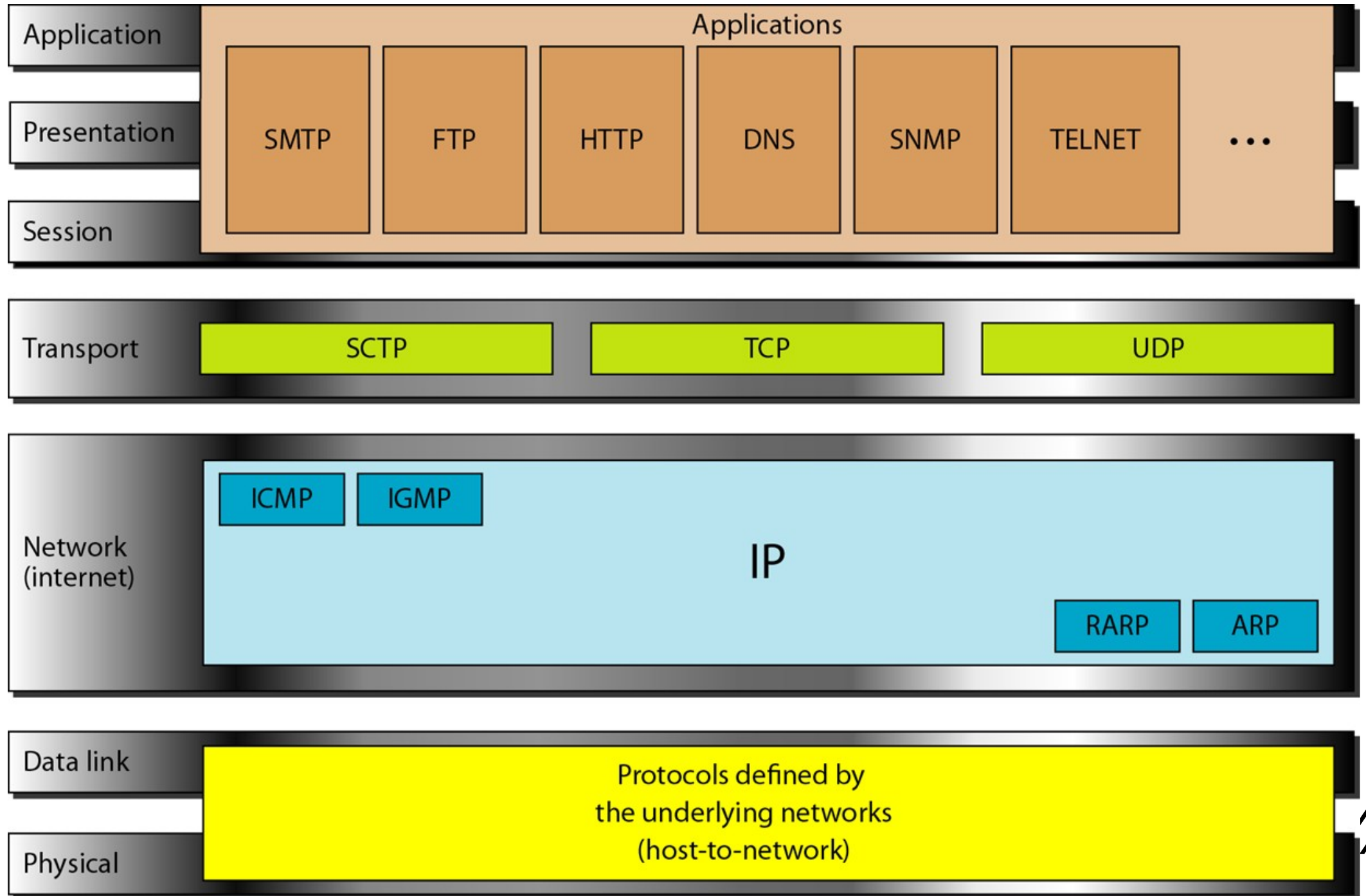
- TCP/IP vs OSI Model
- Application Layer
- Application Layer Protocols



○ TCP/IP Protocol Suite

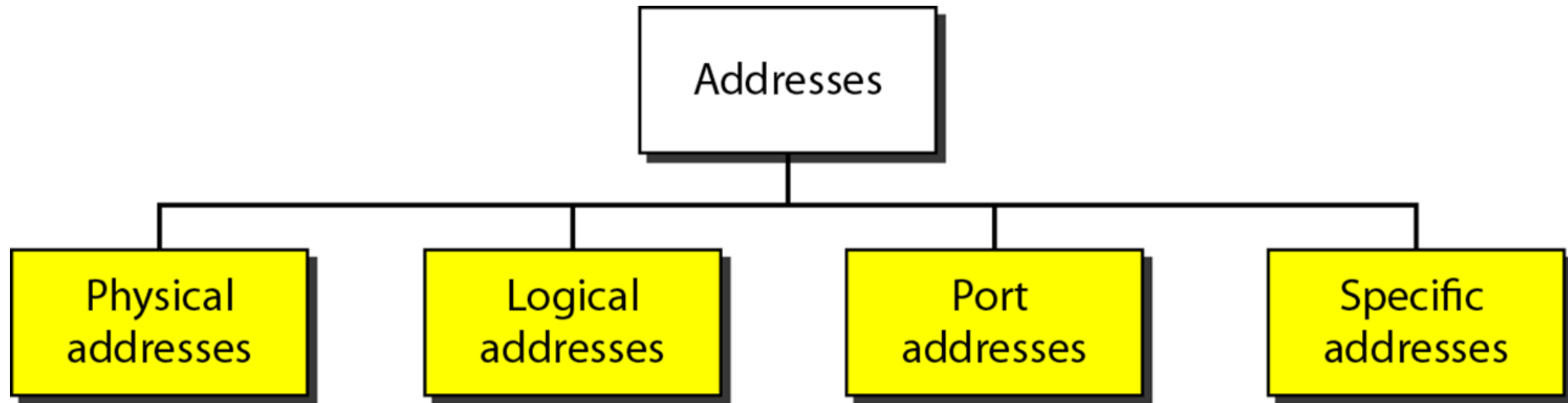
- The layers in the TCP/IP protocol suite do not exactly match those in the OSI model.
- The original TCP/IP protocol suite was defined as having four layers: host-to-network, internet, transport, and application.
- However, when TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers:
 - physical,
 - data link,
 - network,
 - transport, and
 - application.





○ Addressing

- Four levels of addresses are used in an internet employing the *TCP/IP* protocols:
 - physical (link) addresses,
 - logical (IP) addresses,
 - port addresses, and
 - specific addresses





Application layer

Processes

Specific
addresses

Transport layer

SCTP

TCP

UDP

Port
addresses

Network layer

IP and
other protocols

Logical
addresses

Data link layer

Underlying
physical
networks

Physical
addresses

Physical layer



○ Reading Assignment

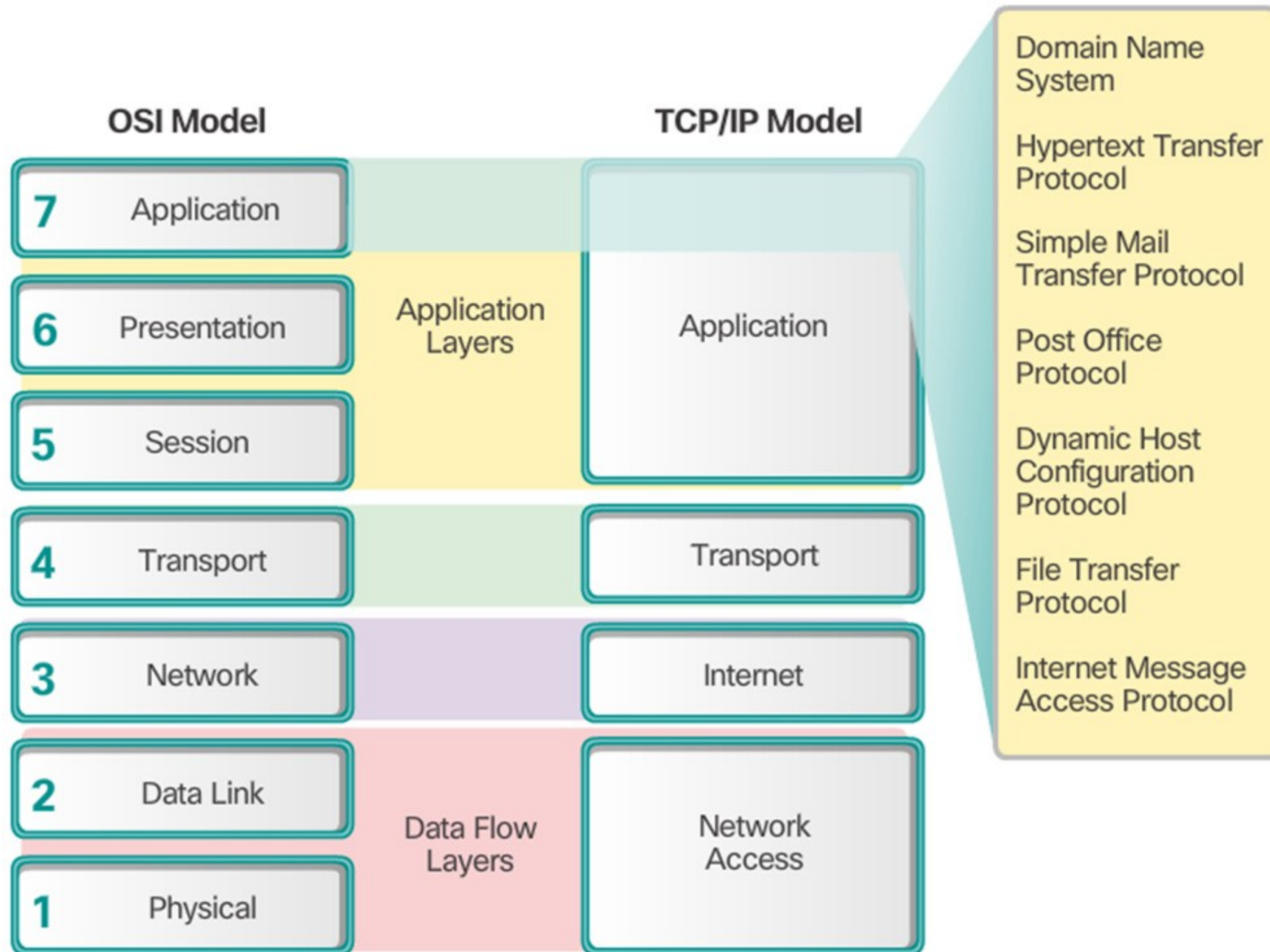
- Comparison between OSI and TCP/IP model.
- Addresses and its types.
- Different Addresses for different applications and networks.
- Cmd-> ipconfig/all



○ Application Layer

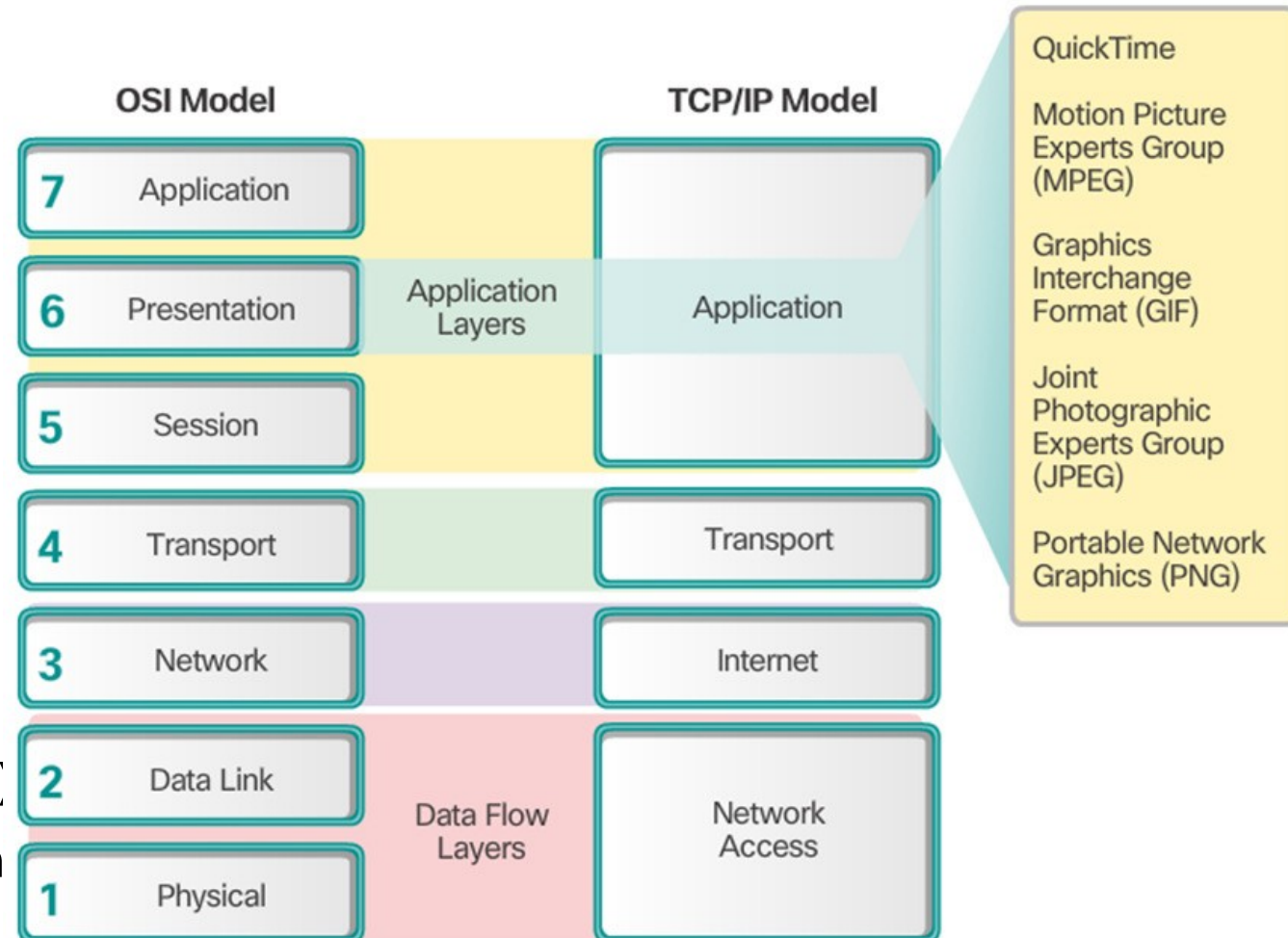
- The application layer is **closest to the end user**.
- Network applications enable users to **send and receive data** with ease.
- The application layer acts as **interface** between the applications and the underlying network.
- Application layer protocols help **exchange** data between programs running on the source and destination hosts.
- The TCP/IP application layer performs the functions of the upper three layers of the OSI model.
- Common application layer protocols include: HTTP, FTP, TFTP, DNS.





○ Presentation & Session Layer

- The presentation layer has three primary functions:
 - o Format data
 - o Compress data
 - o Encrypt data
- Common standards for video include QuickTime and Motion Picture Experts Group (MPEG).
- Common graphic image formats are:
 - Graphics Interchange Format (GIF)
 - Joint Photographic Experts Group (JPEG)
 - Portable Network Graphics (PNG) format



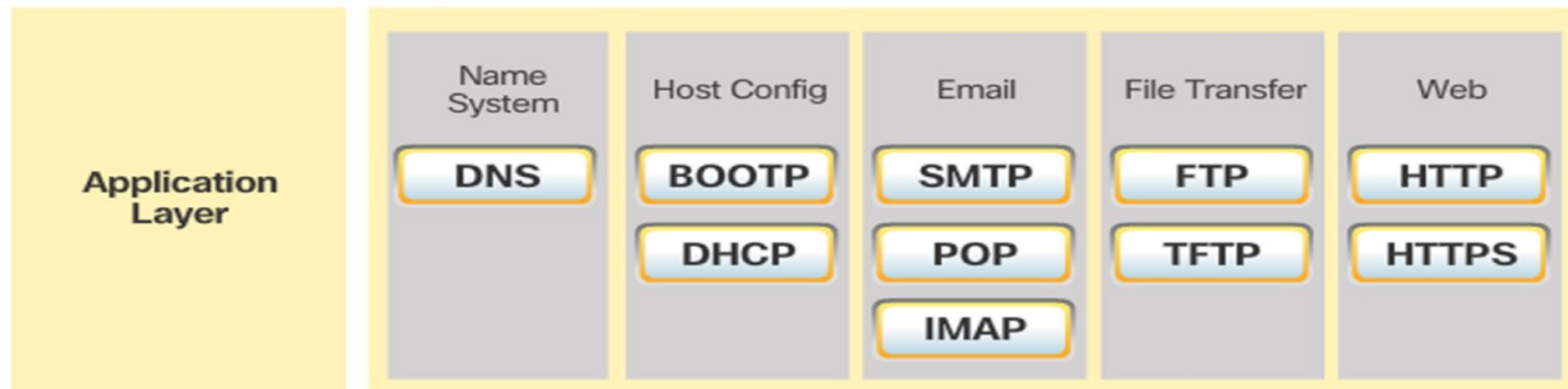
○ Presentation & Session Layer

- The session layer creates and maintains dialogs between source and destination applications.
- The session layer handles the exchange of information to initiate dialogs, keep them active, and to restart sessions that are disrupted or idle for a long period of time.



○ TCP/IP Application Layer

- TCP/IP application protocols specify the format and control information necessary for common Internet functions.
- Application layer protocols must be implemented in both the source and destination devices.
- Application layer protocols implemented on the source and destination host must be compatible to allow communication.





How Application Protocol Interact with End User Application?





Two important concepts:

- Application Layer:

- The first step for getting data on to the network.

- Application Software:

- The programs used to communicate over the network.

For example:

- When displaying a web page:

- The Application Layer uses the HTTP Protocol.
 - The Application Software is your browser.





Application Layer- Services & Ports

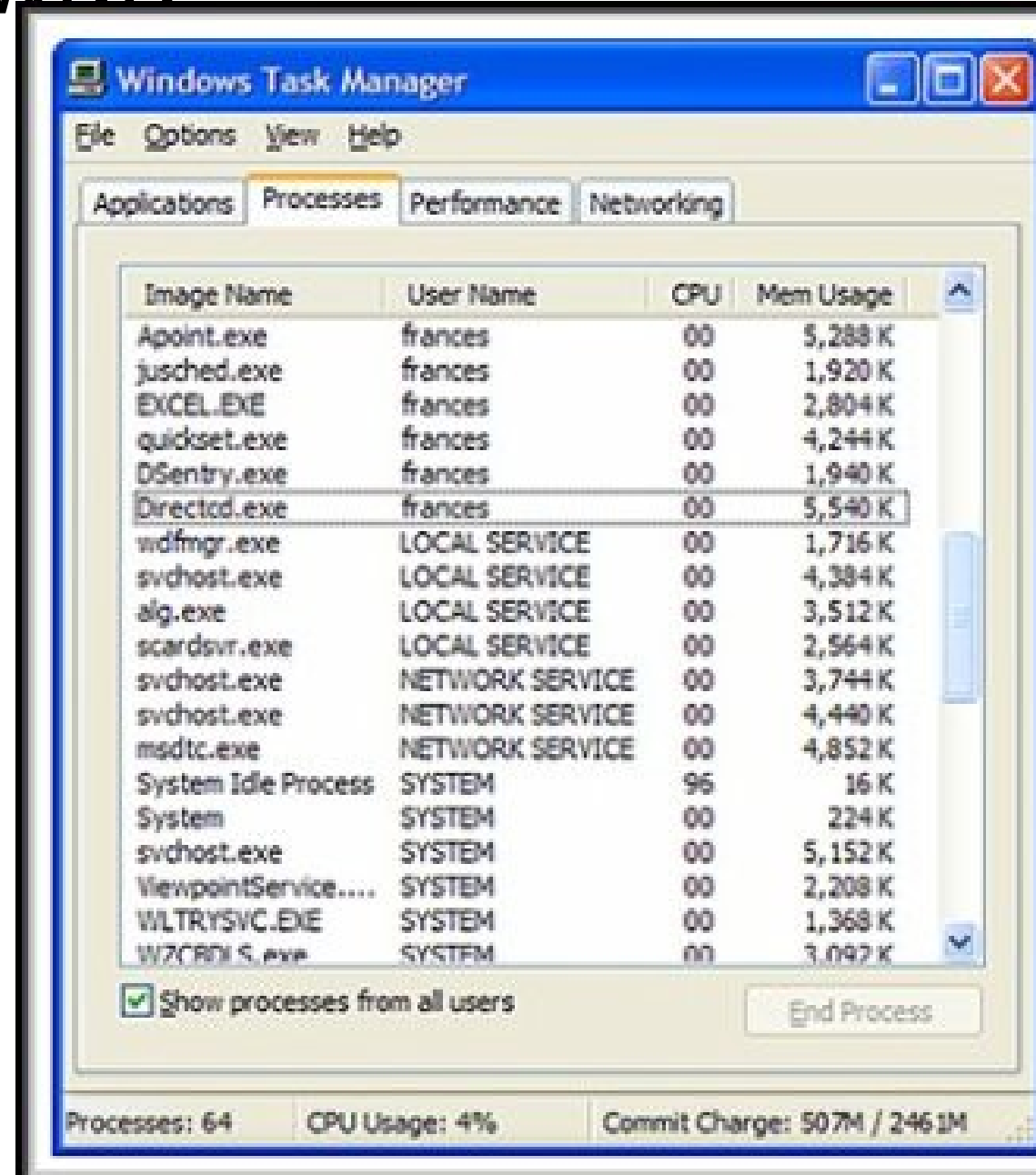
- **DNS** (Domain Name System)
Resolves Internet names (URLs) to IP Addresses, port 53
- **Telnet, SSH** (Terminal emulation, Secure shell)
access to servers and network devices, port 23, 22
- **SMTP** (Simple Mail Transfer Protocol)
Transfer of mail messages and attachments (outgoing), port 25
- **POP3, POP3S** (Post Office Protocol)
Transfer of mail messages and attachments (incoming), port 110, 995
- **IMAP**
Internet Message Access Protocol, port 143
- **DHCP** (Dynamic Host Configuration Protocol)
Assigns IP Addresses (IP, subnetmask) and other parameters (DNS, Gateway, ...) to hosts, port 67, 68
- **HTTP(s)** (Hypertext Transfer Protocol)
Transfer files that make up web pages, port 80, 443
- **FTP(S)** ((Secure) File Transfer Protocol)
Interactive file transfer between systems, port control:21,data:21 and 3713, data:989,990



○ Application Layer Software

- Within the Application layer, there are two forms of software programs or processes that provide access to the network:

- Applications
- Services



- Application layer protocols are used by both the source and destination devices during a communication session.
- The application layer protocols implemented on the source and destination host must **match**.
- The Application Layer uses protocols that are implemented within applications and services.
 - **Applications** provide people a way to create messages.
 - Application layer **services** establish an interface to the network.
 - **Protocols** provide the rules and formats that govern how data is treated



Client Server Model – Traditional

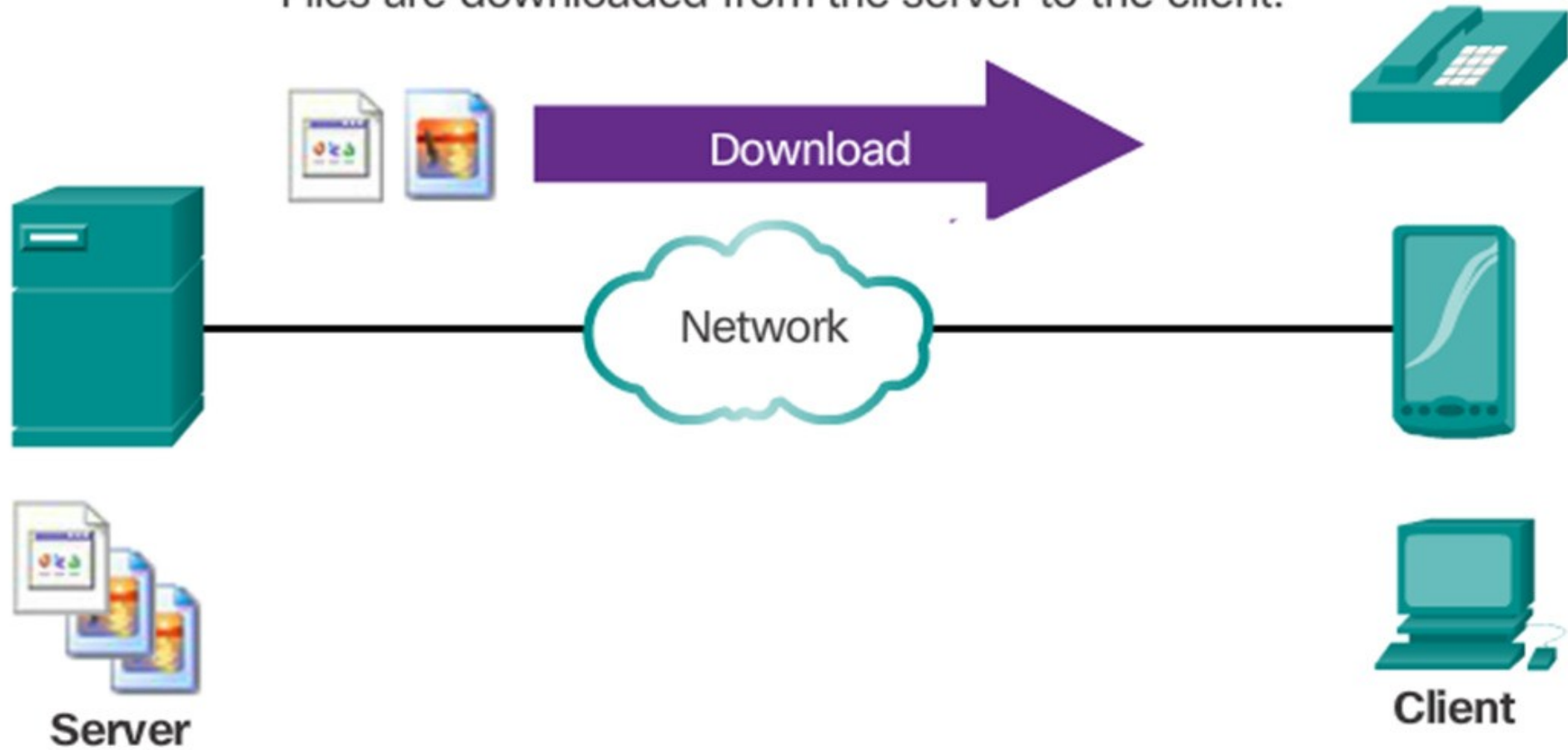
○ Paradigm

- The device requesting the information is called a **client**.
- The device responding to the request is called a **server**.
- Client and server processes are considered to be in the **application layer**.
- The client initiates the exchange by requesting data from the server.
- The server responds by sending one or more streams of data to the client.
- Application layer protocols describe the format of the requests and responses between clients and servers.
- The contents of the data exchange will depend of the application in use.
- Email is an example of a Client-Server interaction.
- Several traditional services using this paradigm includes World Wide Web (www) and its vehicle HyperText Transfer Protocol (HTTP), File Transfer Protocol FTP, Secure Shell SSH etc.



Client/Server Model

Files are downloaded from the server to the client.



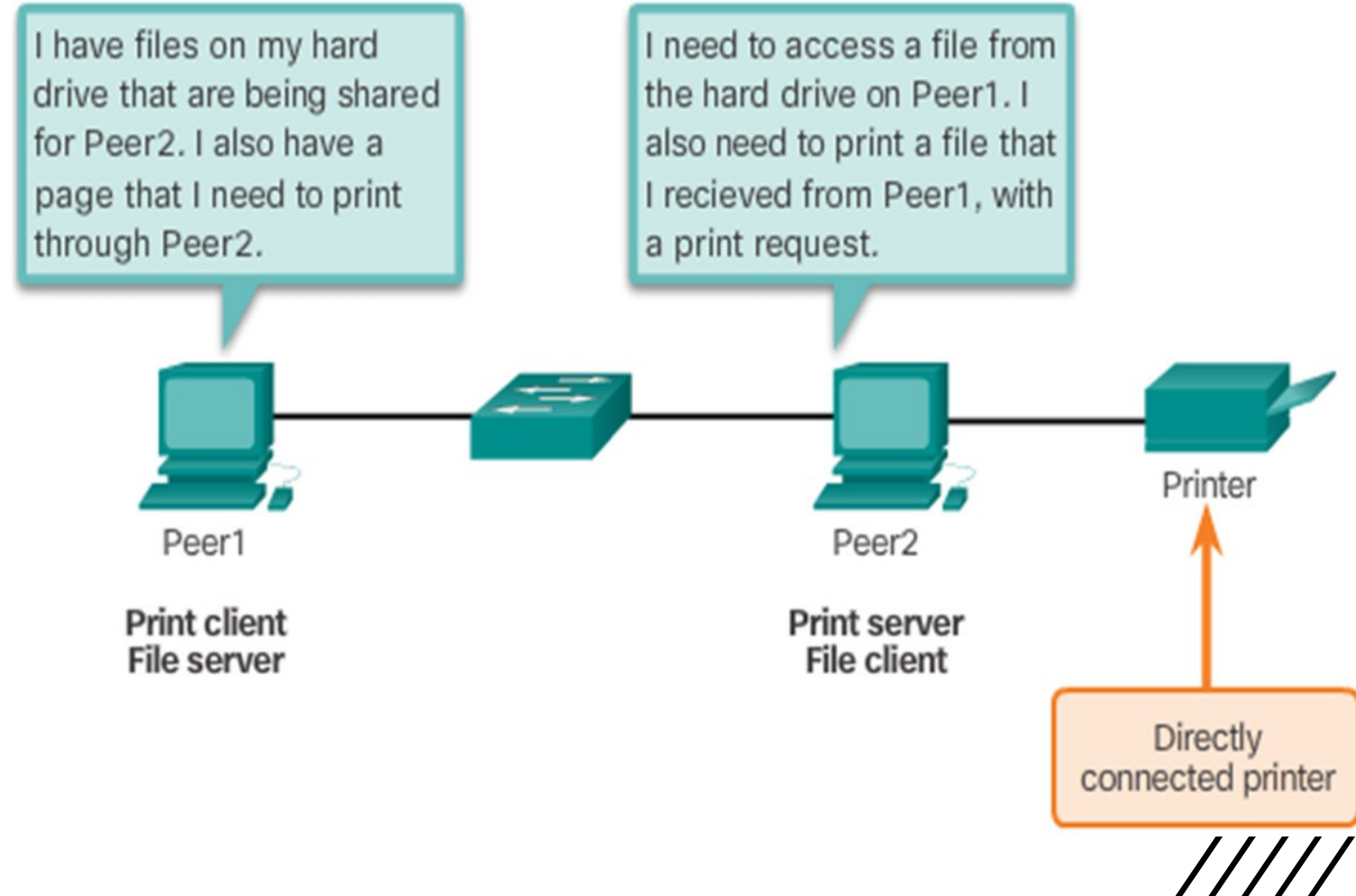
Resources are stored on the server.

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



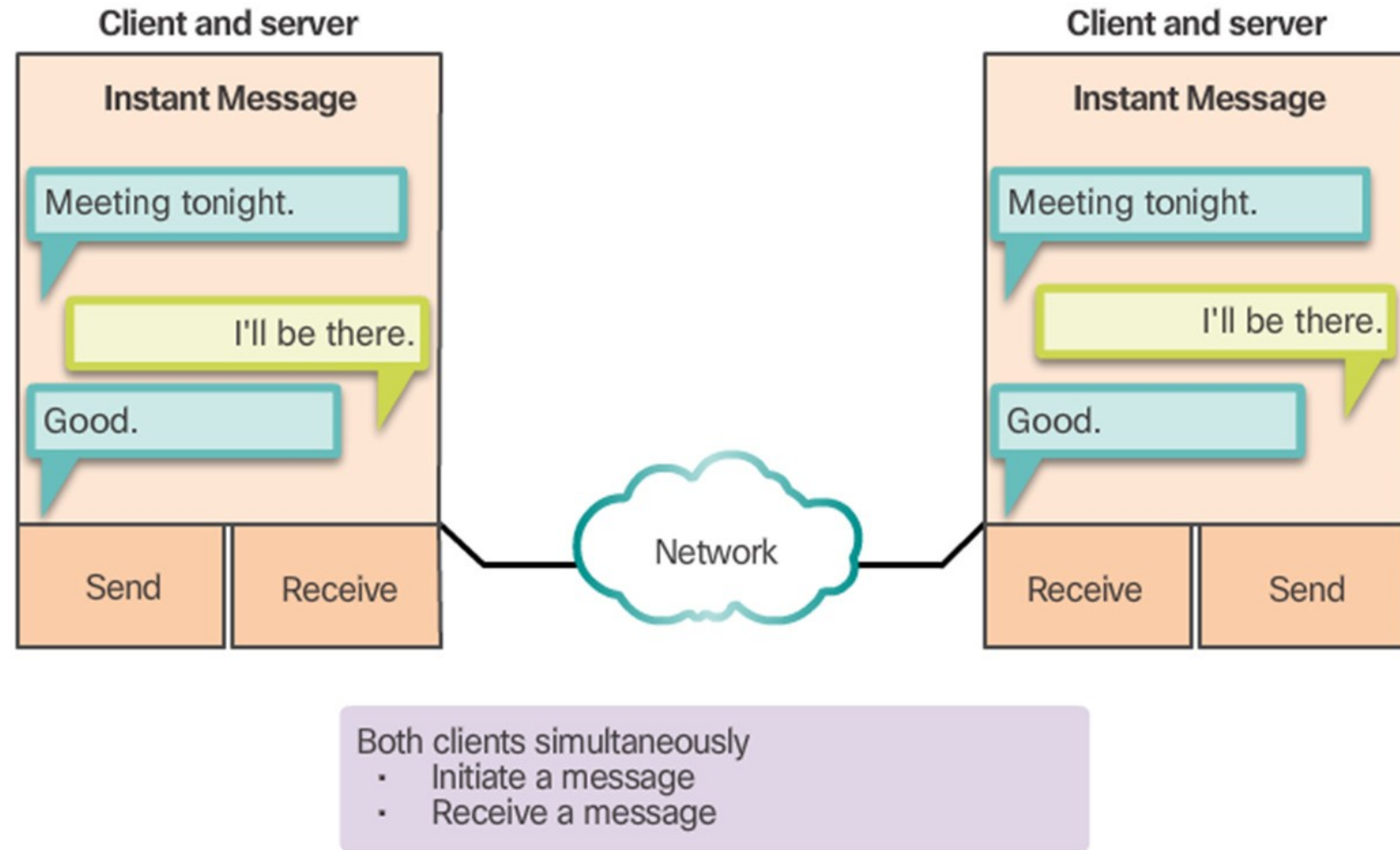
Peer-to-Peer Model - New Paradigm

- In the peer-to-peer (P2P) networking model, the data is accessed without the use of a dedicated server.
- Two or more computers can be connected to a P2P network to share resources.
- Every connected end device (a peer) can function as both a server and a client.
- The roles of client and server are set on a per request basis.

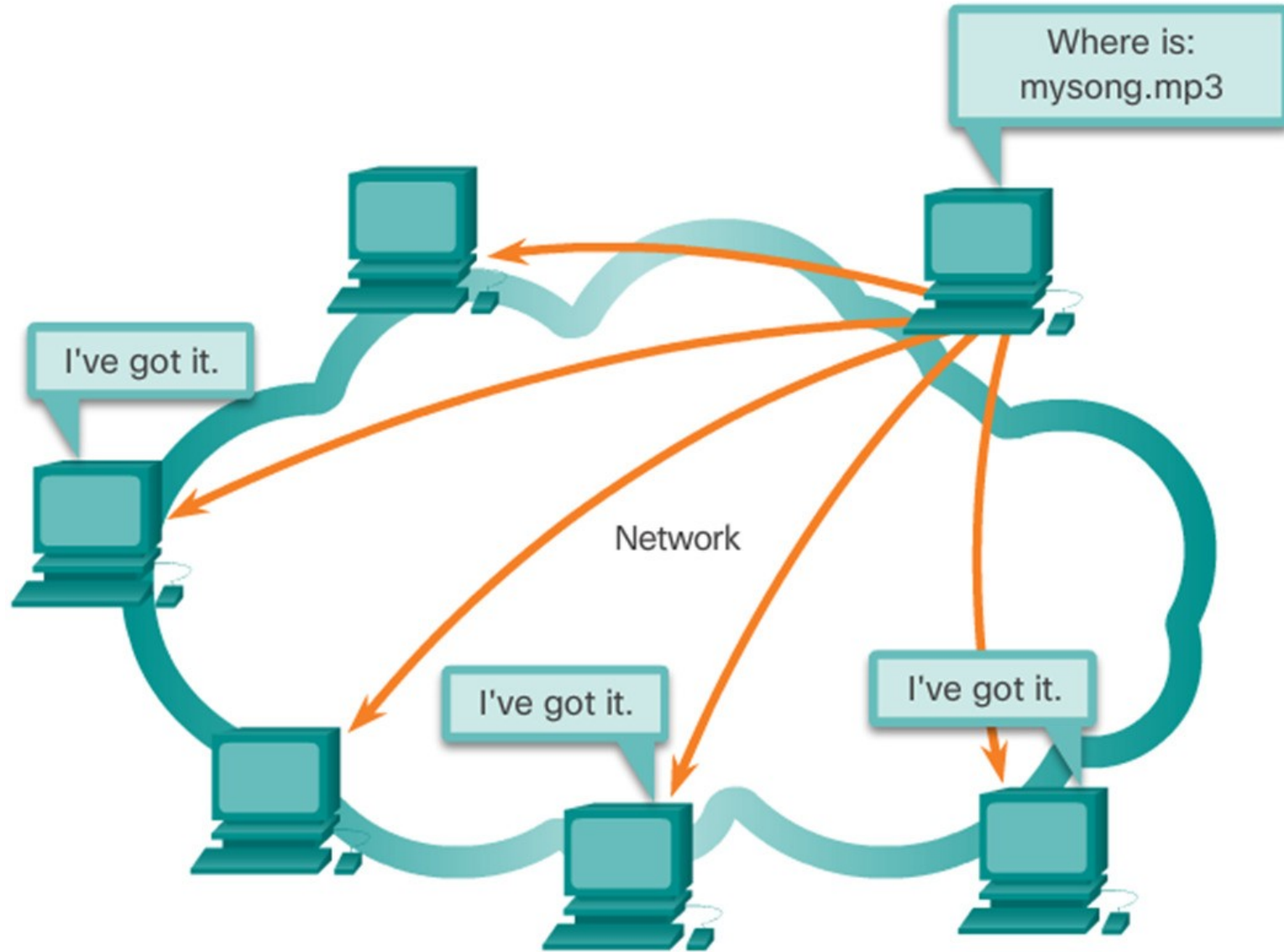




- Some P2P applications use a hybrid system.
- In hybrid P2P, resource sharing is decentralized.
- Indexes that point to resource locations are stored in a centralized directory.
- In a hybrid system, each peer accesses an index server to get the location of a resource stored on another peer.



- Common P2P networks include: eDonkey, G2, BitTorrent, Bitcoin, Skype.
- Many P2P applications allow users to share pieces of many files with each other at the same time.
- A small torrent file contains information about the location of other users and tracker computers.
- Trackers are computers keeping track of the files hosted by users.
- This technology is called BitTorrent.
- There are many BitTorrent clients, including BitTorrent, uTorrent, Frostwire, and qBittorrent.



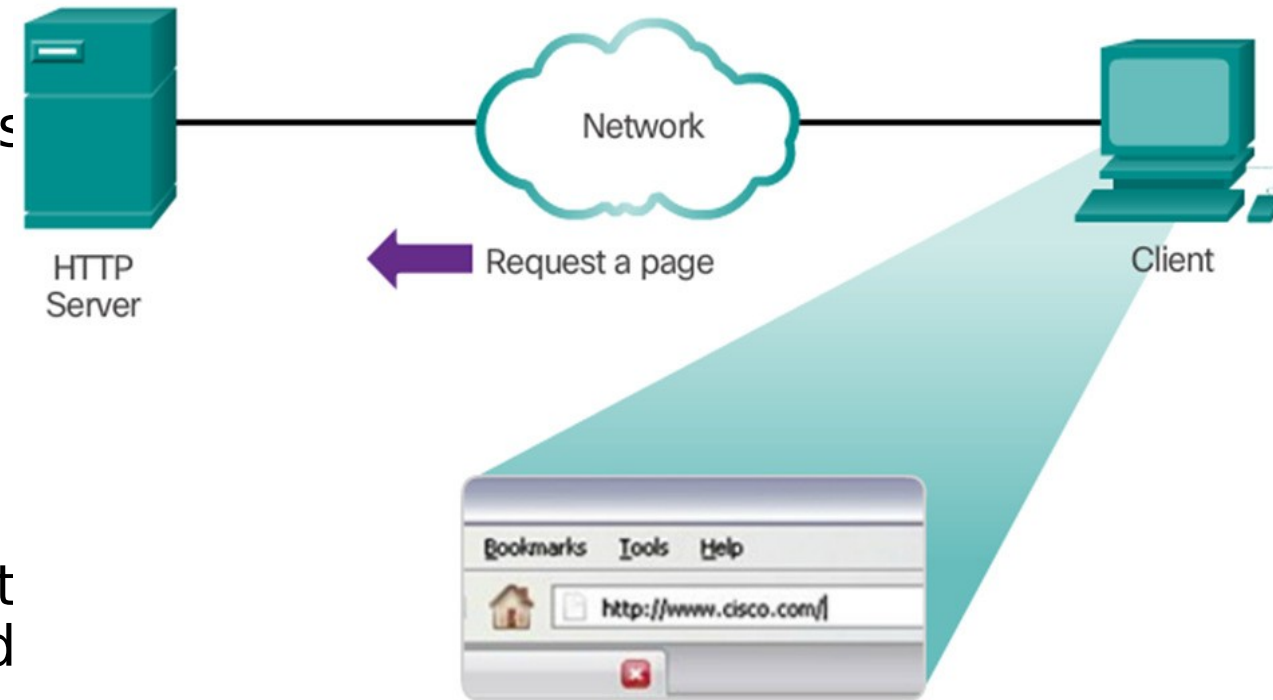


Well Known Protocols & their Working

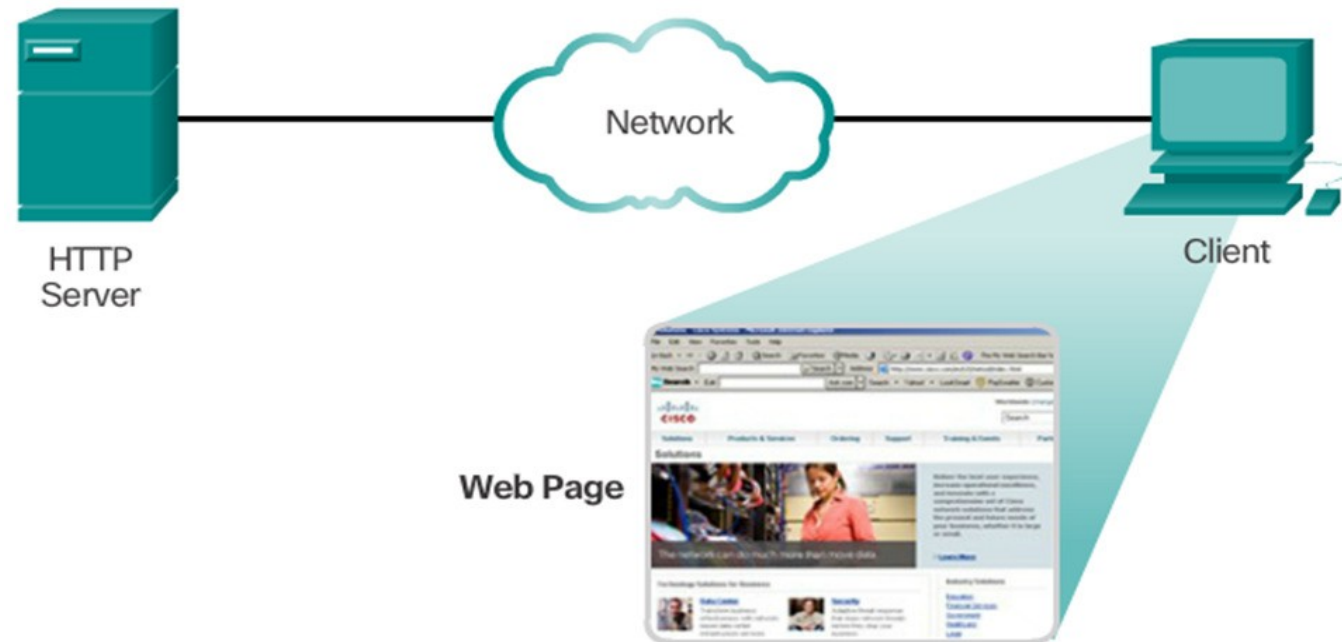
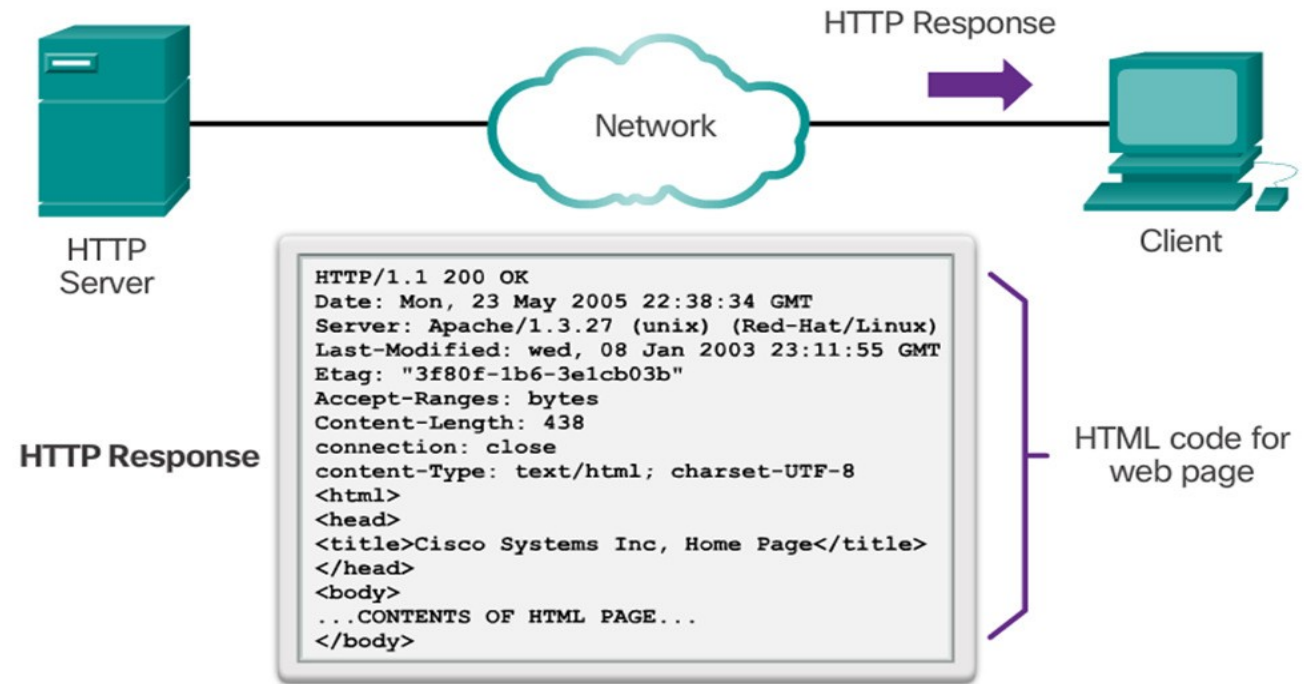


HTTP & HTML

- A web address or uniform resource locator (URL) is a reference to a web server.
- A URL allows a web browser to establish a connection to that web server.
- URLs and Uniform Resource Identifier (URIs) are the names most people associate with web addresses.
- The URL `http://cisco.com/index.html` has three basic parts:
 - o **http** (the protocol or scheme)
 - o **www.cisco.com** (the server name)
 - o **index.html** (the specific filename requested)
- Using DNS, the server name portion of the URL is then translated to the associated address before the server can be contacted.



- The browser sends a GET request to the server's IP address and asks for the **index.html** file.
- The server sends the requested file to the client.
- The **index.html** was specified in the URL and contains the HTML code for this web page.
- The browser processes the HTML code and formats the page for the browser window based on the code in the file.



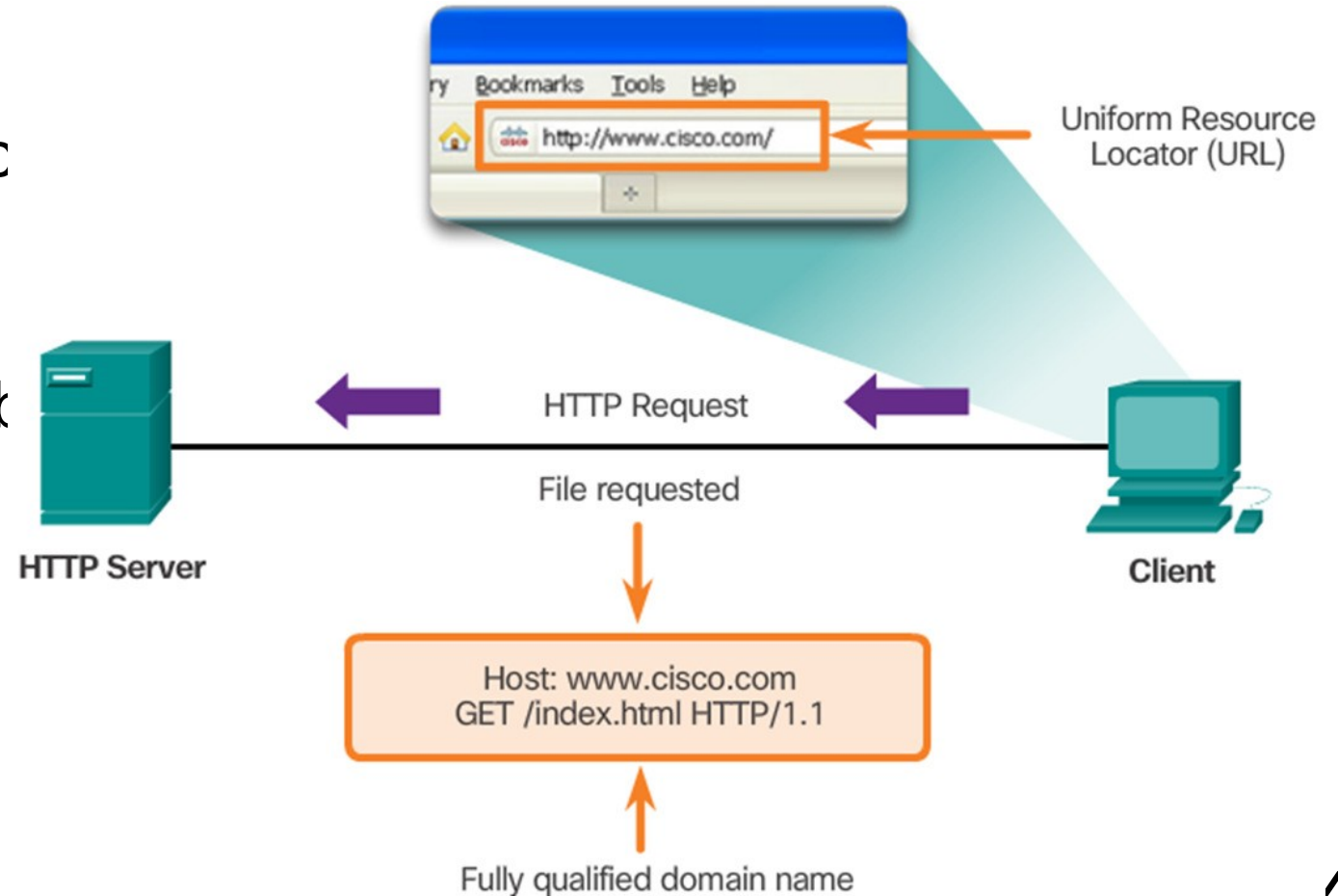
○ HTTP & HTTPS

- **HTTP**

- o Is a request/response protocol
- o Has three common message types: GET, POST, PUT.
- o Is not secure. Messages can be intercepted.
- o port 80

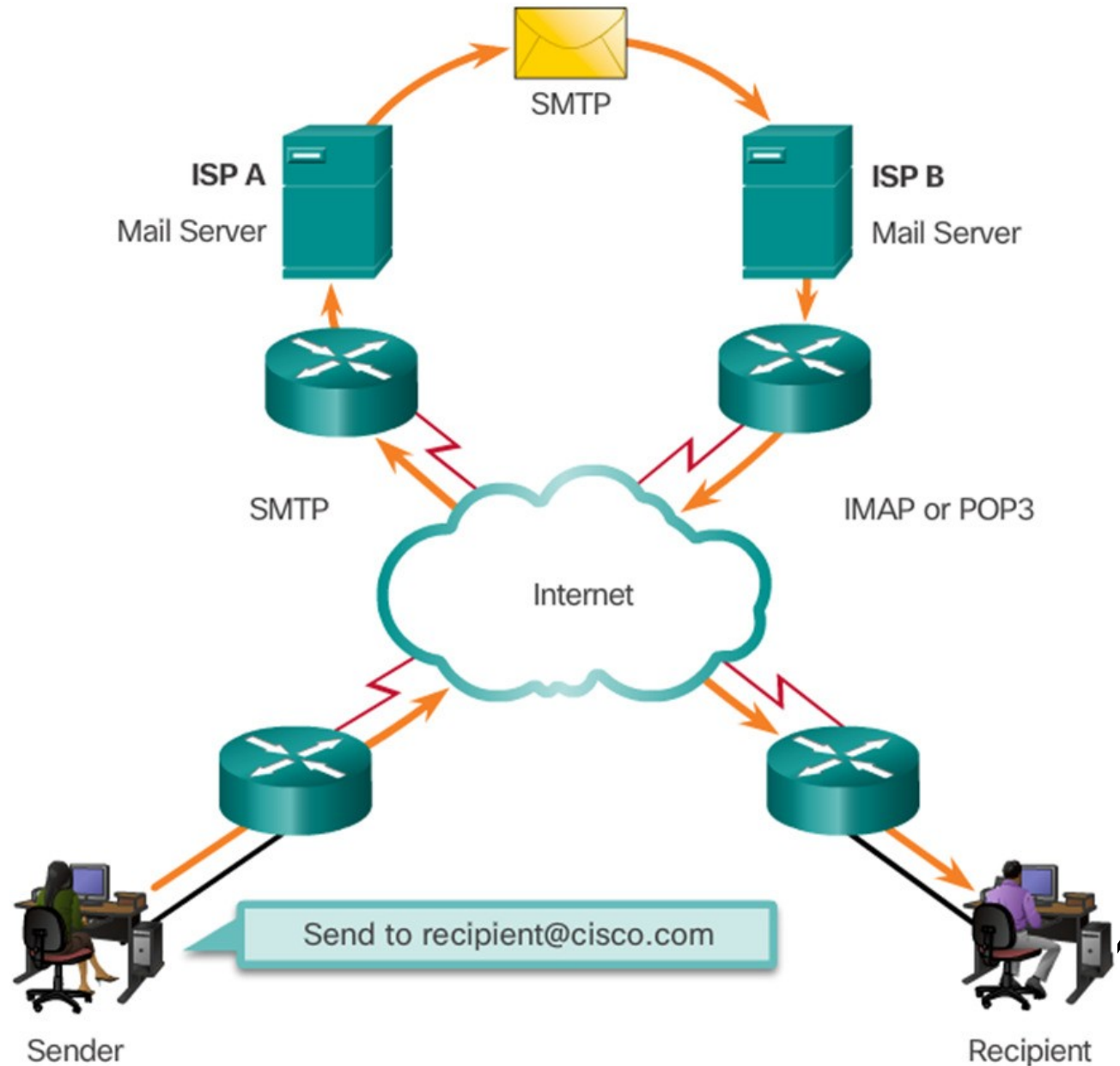
- **HTTPS**

- o uses authentication and encryption to secure data.
- o port 443



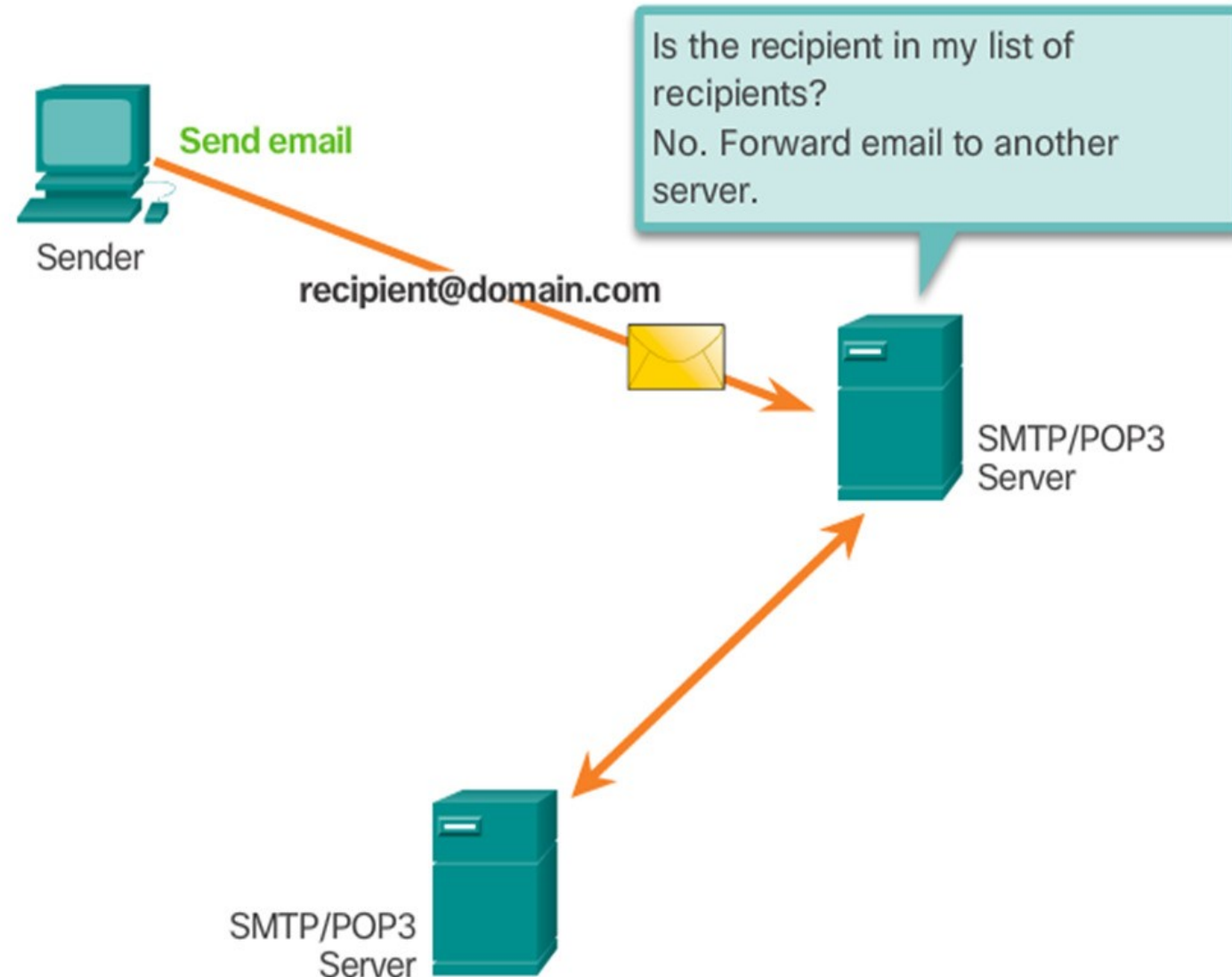
Email Protocol

- Email is a store-and-forward method of sending, storing, and retrieving electronic messages.
- Email messages are stored in databases on mail servers.
- Email clients communicate with mail servers to send and receive email.
- Mail servers communicate with other mail servers to transport messages from one domain to another.
- Email clients do not communicate directly when sending email.
- Email relies on three separate protocols for operation: SMTP (sending), POP (retrieving), IMAP (retrieving).



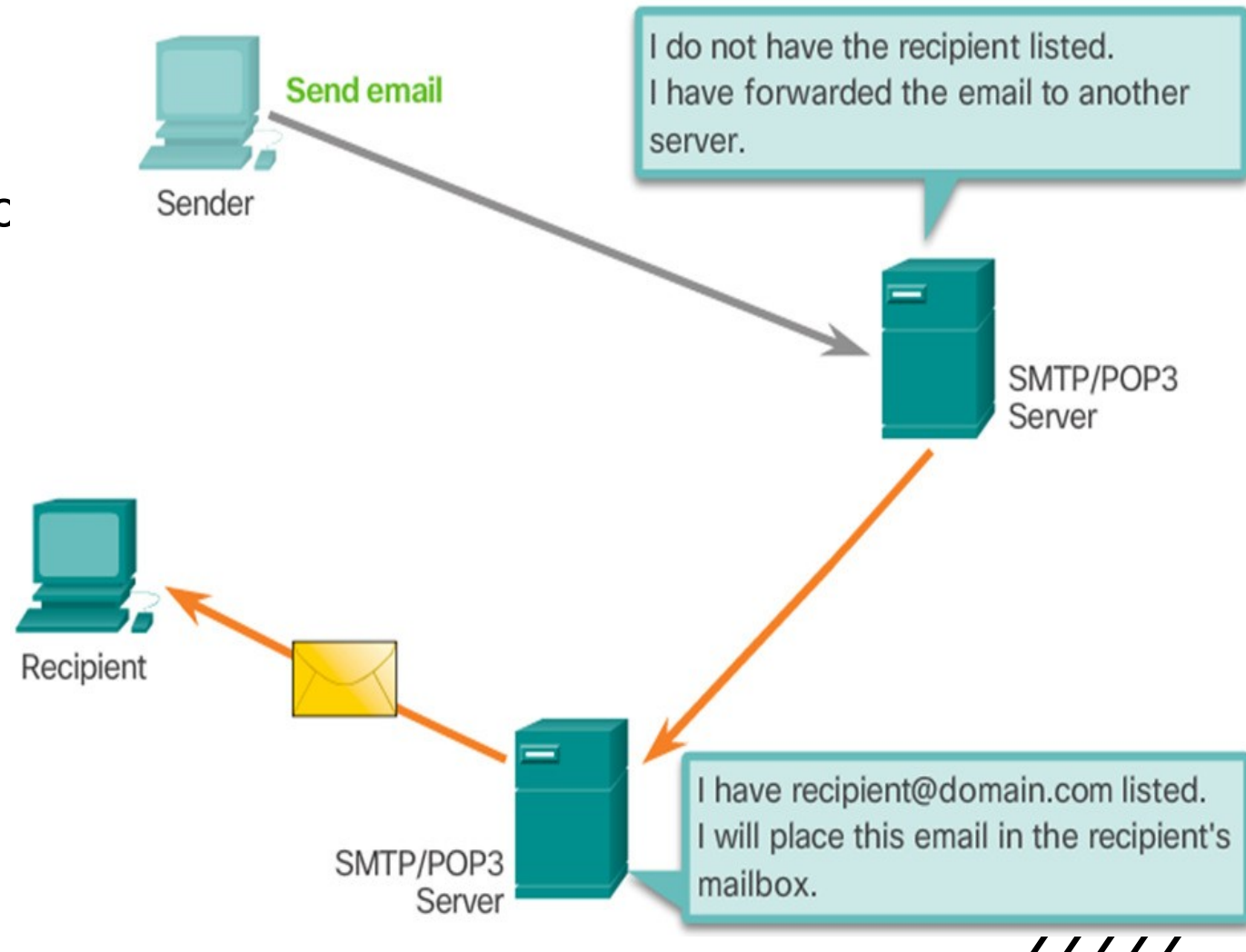
SMTP Operation

- SMTP message formats require a message header and body.
- The body can contain any amount of text.
- The header must have a properly formatted recipient email address and a sender address.
- An SMTP client sends an email by connecting to a SMTP server **on port 25**.
- The server receives the message and stores it message in a local mailbox or relays the message to another mail server.
- Users use email clients to retrieve messages stored on the server.
- IMAP and POP are two protocols commonly used by email clients to retrieve messages.



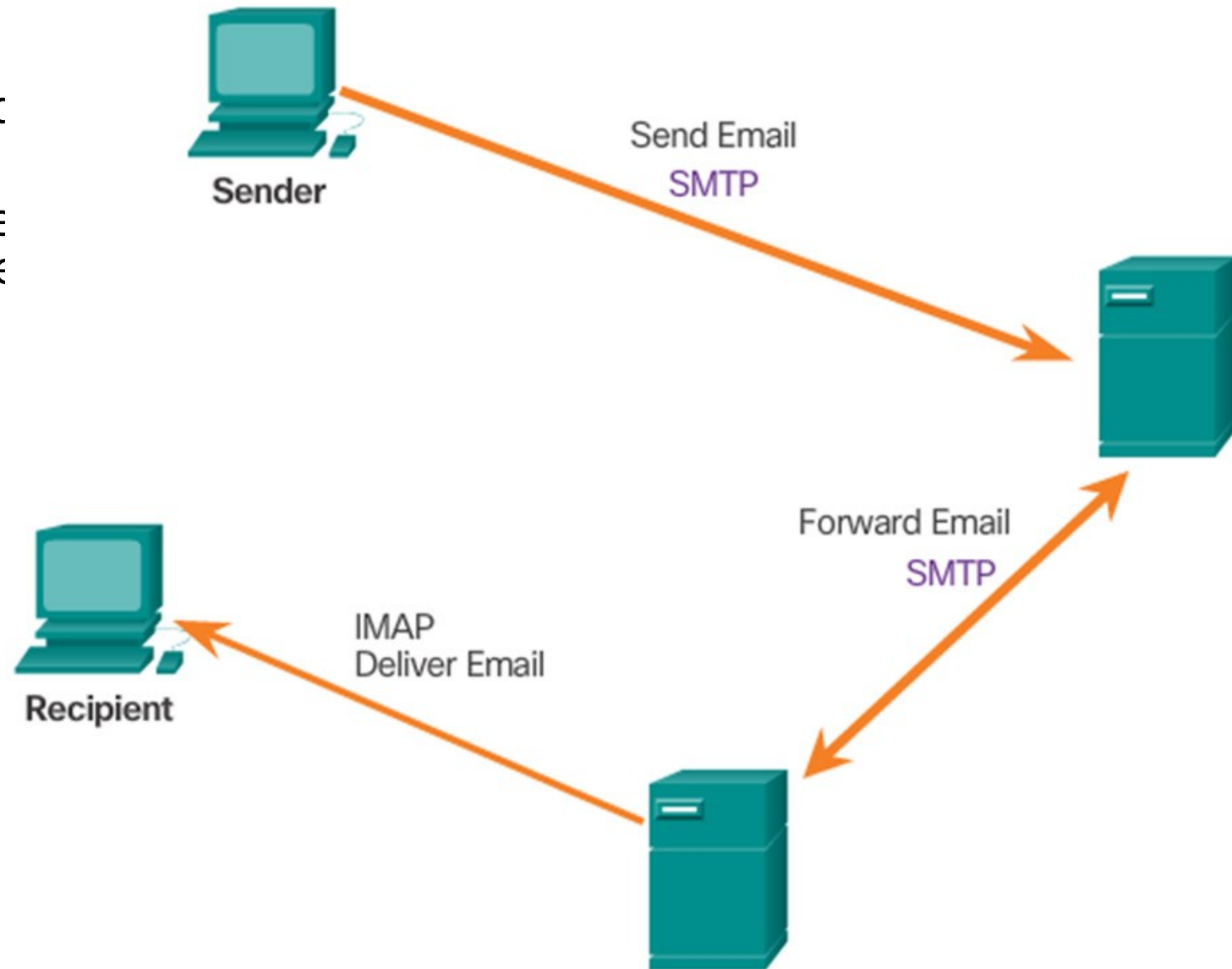
○ POP Operation

- Messages are downloaded from the server to the client.
- The server listens on **port 110 TCP** for client requests.
- Email clients direct their POP requests to mail servers on port TCP 110.
- The POP client and server exchange commands and responses until the connection is closed or aborted.
- POP allows for email messages to be downloaded to the client's device (computer or phone) and removed from the server.
- There is no centralized location where email messages are kept.
- A downloaded message resides on the device that triggered the download.



IMAP Operation

- IMAP is another protocol used to retrieve email messages.
- Allows for messages to be displayed to the user rather than downloaded
- The original messages reside on the server until manually deleted by the user.
- Users view copies of the messages in their email client software.
- Users can create a folder hierarchy on the server to organize and store mail.
- That file structure is displayed on the email client.
- When a user decides to delete a message, the server synchronizes that action and deletes the message from the server.



○ Next Class

- IP Addressing Protocols
 - DNS
- File Sharing Protocols
 - DHCP
 - FTP



○ References

- <https://www.siteground.com/tutorials/email/protocols-pop3-smtp-imap/#:~:text=By%20default%2C%20the%20IMAP%20protocol,to%20connect%20using%20IMAP%20securely>

