Chapter 10: Application Layer

Introduction to Networks

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Chapter 10: Objectives

- 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 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.
- Explain how data is moved across the network, from opening an application to receiving data.

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Application Layer Protocols

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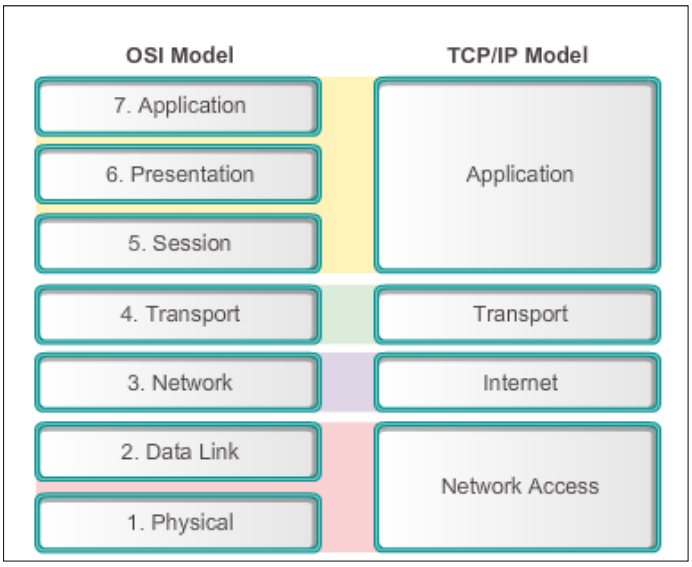
OSI and TCP/IP Models



The key parallels are in the transport and network layer.

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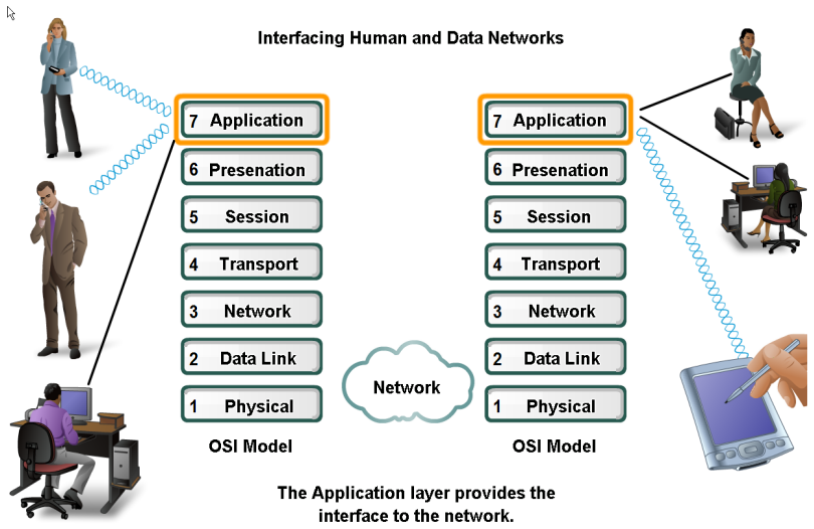
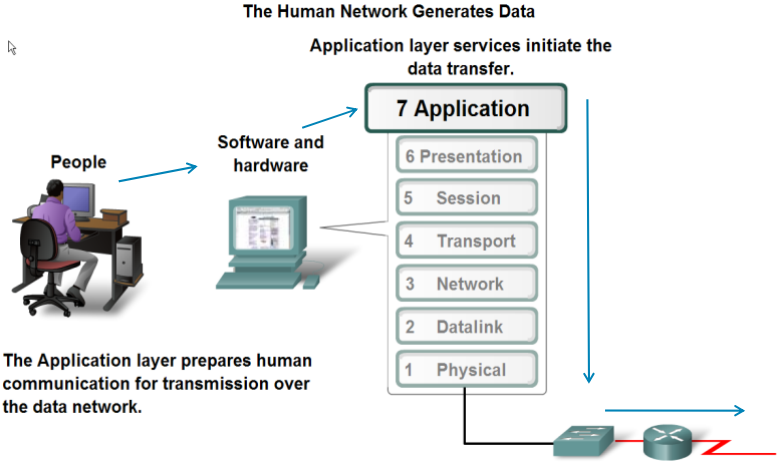
Applications – The Interface Between Human and Data Networks



OSI and TCP/IP Model

- The Open Systems Interconnection (OSI) model divides the networking process into 7 logical layers, each of which has unique functionality.

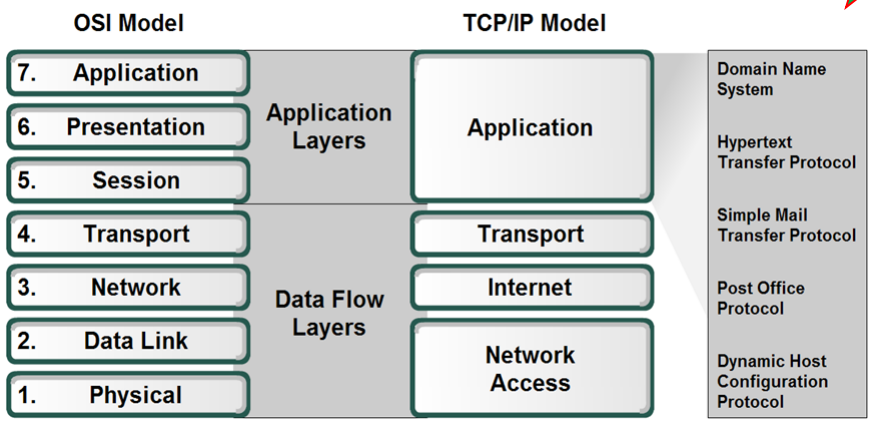


The Application Layer

- The top layer of both the OSI and TCP/IP models.
- It provides the interface between the applications we use to communicate and the underlying network over which our messages are transmitted.
- **Examples:**

  The World Wide Web and email, and their related services (HTTP, DNS, SMB, DHCP, SMTP/POP, and Telnet)

The Application Layer



- Functionality of the TCP/IP application layer protocols fit roughly into the top three layers of the OSI model: Application, Presentation and Session layers.

The Presentation Layer

- **The Presentation Layer** has three primary functions:
  - **Coding and conversion** of Application layer data to ensure that data from the source device can be interpreted by the destination device.
  - **Data Compression**.
  - **Data Encryption** for the transmission and the decryption of data upon receipt by the destination.

The Session Layer

- **The Session Layer** creates and maintains dialogs between source and destination applications.
  - It 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.

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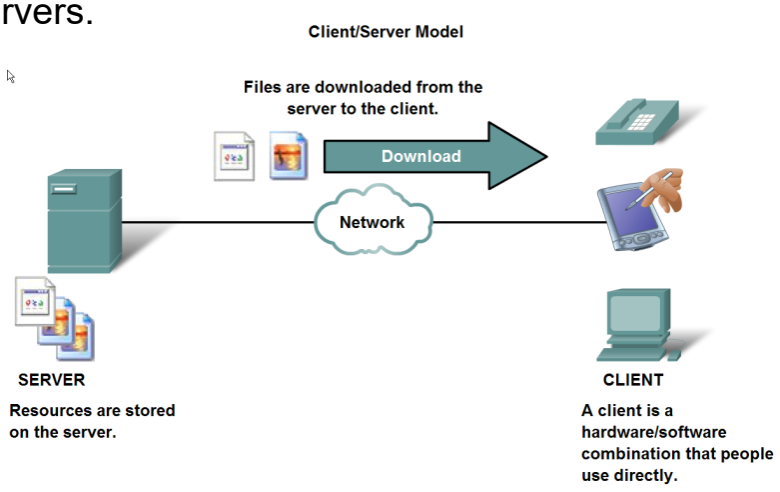
Application Layer Protocols

- Application layer protocols describe the format of the requests and responses between clients and servers.



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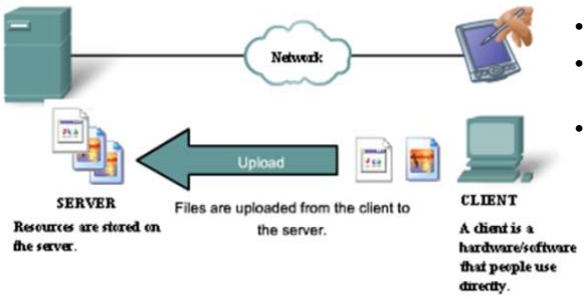
The Client-Server Model

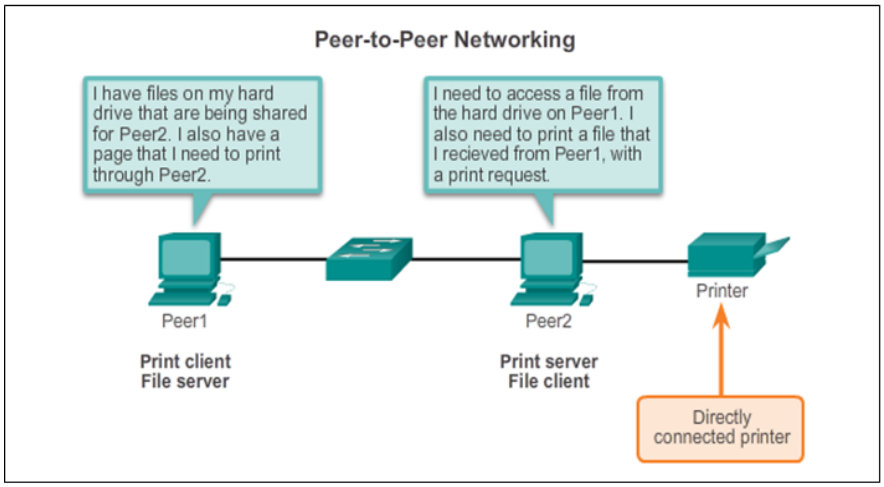
- One example of a client/server network - where employees use the company e-mail server to send and receive e-mails.
  - The e-mail client on an employee computer issues a request to the e-mail server for any unread mail.
  - The server responds by sending the requested e-mail to the client.



Advantages are:

- Centralized administration.
- Multiple clients/users can logon to a server.
- Security is easier to enforce.

Peer-to-Peer (P2P) 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 (P2P) Networks

In addition to the client/server model, there is also a peer-to-peer model:

- In a 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.
- P2P networks decentralize the resources on a network - data can be located anywhere and on any connected devices.
- Every connected end device (known as a peer) can function as either a server or a client.
- Peer-to-peer networks usually do not use centralized user accounts, permissions, or monitors, it is difficult to enforce security.

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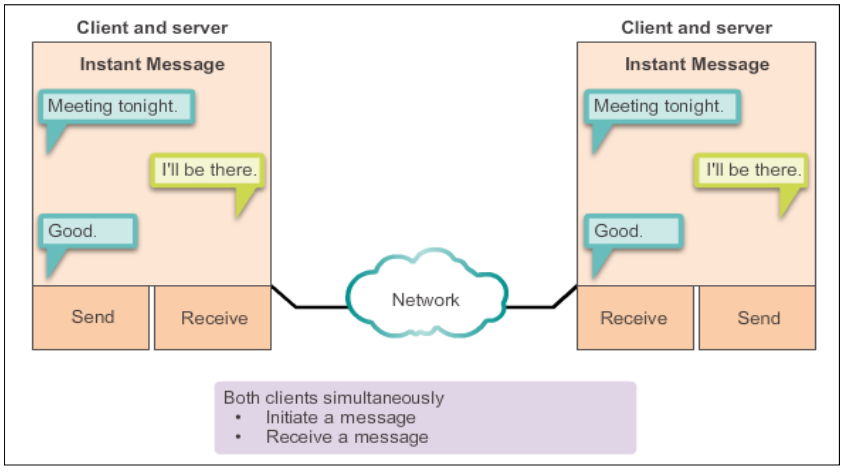
Peer-to-Peer Applications

Client and server in the same communication.



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

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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.

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Well-Known Application Layer Protocols and Services

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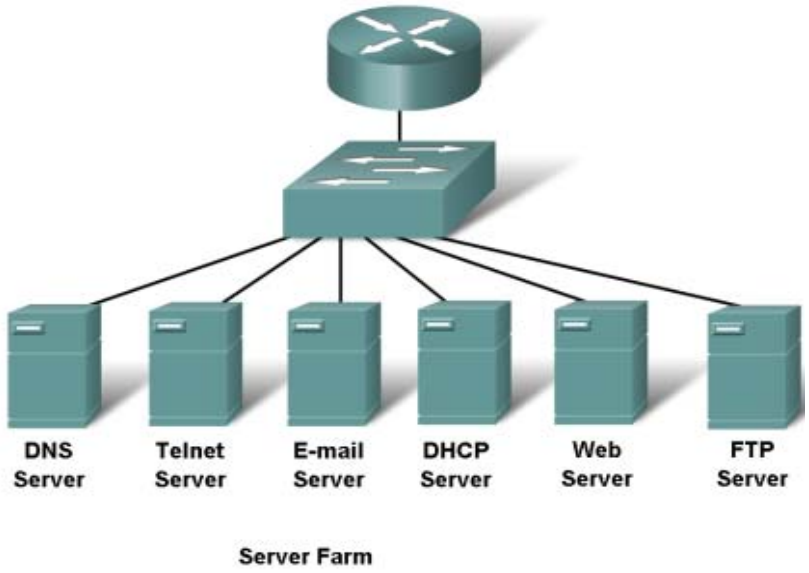
TCP/IP Application Layer Protocols:



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TCP/IP Application Layer Protocols:

- **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.
- **Dynamic Host Control Protocol (DHCP)** – used to assign an IP address, subnet mask, default gateway and DNS server to a host
- **File Transfer Protocol (FTP)** is used for interactive file transfer between systems

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Services and Protocol: Port Number

- The Transport layer uses an addressing scheme called a **port number**.
  - Port numbers identify applications and Application layer services.
  - Server programs generally use predefined port numbers that are commonly known by clients.
- **Some of these common services are:**
  - 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**) - UDP Port 110
  - **Telnet** - TCP Port 23
  - Dynamic Host Configuration Protocol (**DHCP**) - UDP Port 67
  - File Transfer Protocol (**FTP**) - TCP Ports 20 and 21

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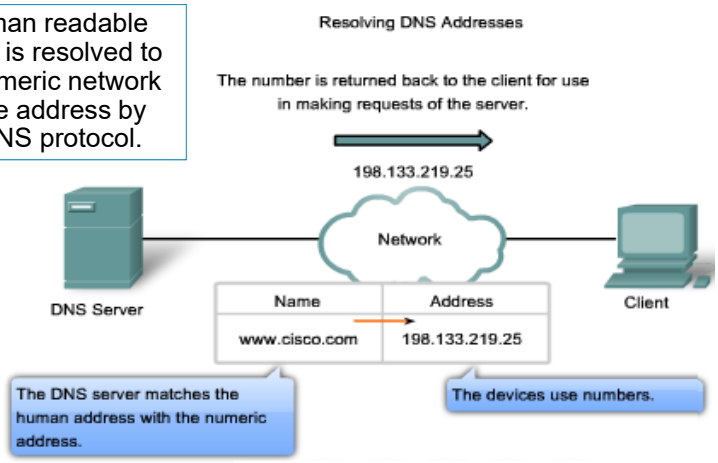
Domain Name System (DNS)

- A service that matches **names** with required **IP addresses**.
- Domain names, such as **www.cisco.com**, are much easier to remember than **198.133.219.25**.

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



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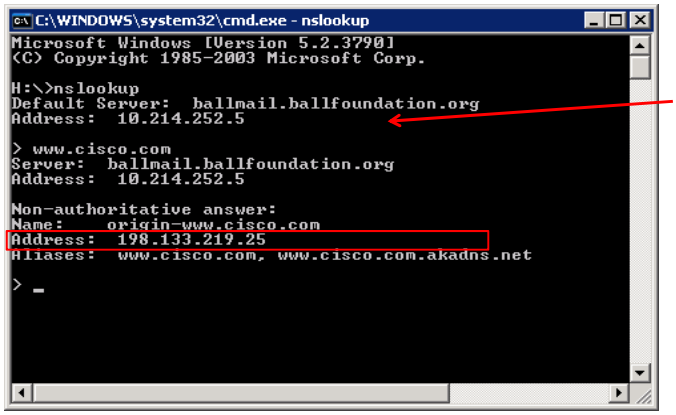
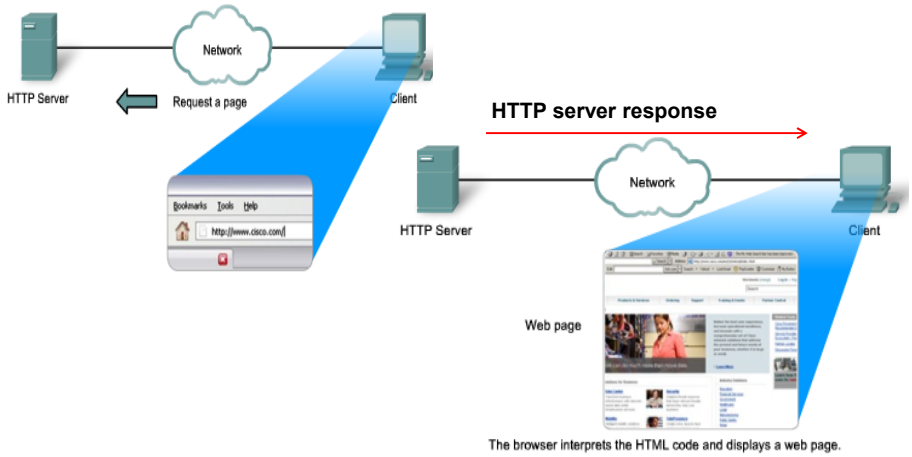
DNS Services and Protocol

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



WWW Service and HTTP

- 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.



WWW Service and HTTP

- **HTTP (TCP Port 80) is not a secure protocol.**
  - Information sent between server and client are in plain text, which can be intercepted and read by anyone.
- For secure communication across the Internet, the **HTTP Secure (HTTPS – Port 443)** 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.
  - HTTPS specifies additional rules for passing data between the Application layer and the Transport Layer.

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E-mail Service and SMTP/POP Protocols

- E-mail, the most popular network service, has revolutionized how people communicate through its simplicity and speed.
- **Post Office Protocol (POP - UDP Port 110)**
  - In order to receive e-mail from an e-mail server, the e-mail client can use POP.
- **Simple Mail Transfer Protocol (SMTP - TCP Port 25)**
  - Sending e-mail from either a client or a server uses formats and command defined by the SMTP protocol. SMTP is used for forwarding emails between mail servers.
- 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.

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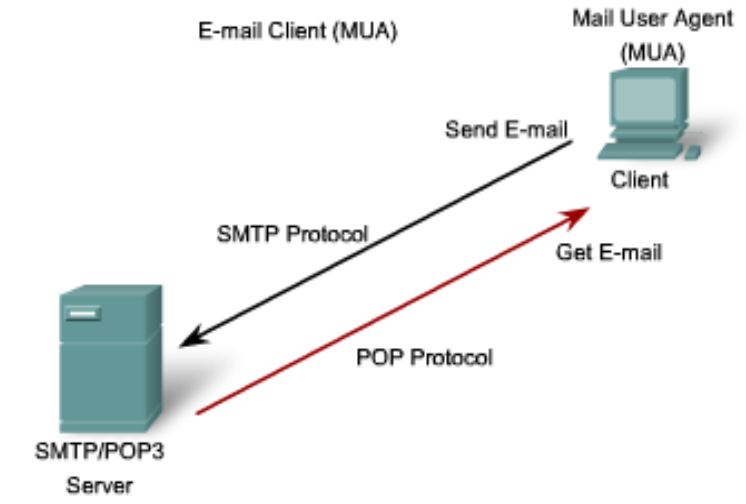
E-mail Service and SMTP/POP Protocols

Mail User Agent (MUA) or e-mail client



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

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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.

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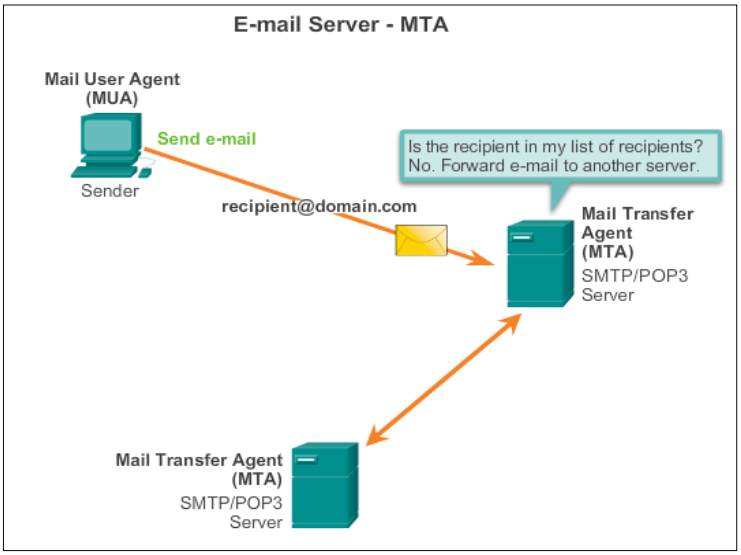
SMTP, POP, and IMAP (cont.)



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

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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

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Dynamic Host Configuration Protocol

- The DHCP service enables devices on a network to obtain IP addresses from a DHCP server dynamically.
  - This service automates the assignment of IP addresses, subnet masks, gateway and other IP networking parameters.
- 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.

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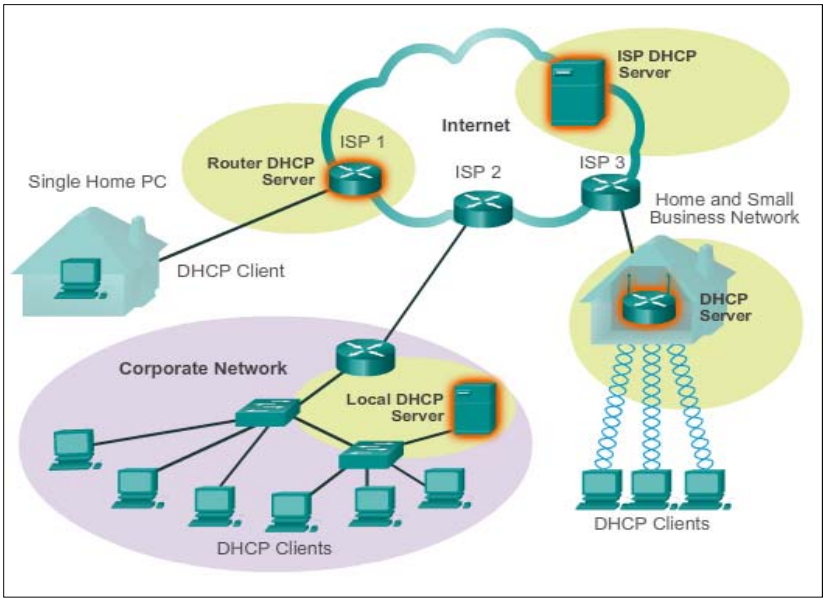
Dynamic Host Configuration Protocol



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File Transfer Protocol (FTP)

- FTP was developed to allow for file transfers between a client and a server.
  - An FTP client is an application used to **push** and **pull** files from a FTP server.
    The client can download (pull) file from server
    or, the client can upload (push) file to server.
- To transfer files, FTP requires two connections between client and server:
  - The client establishes the first connection to the server on **TCP port 21** (The Command or Control port).
  - The server establishes the second connection to the client over **TCP port 20** (The Data port).
    - This connection is for the actual file transfer and is created every time there is a file transferred.

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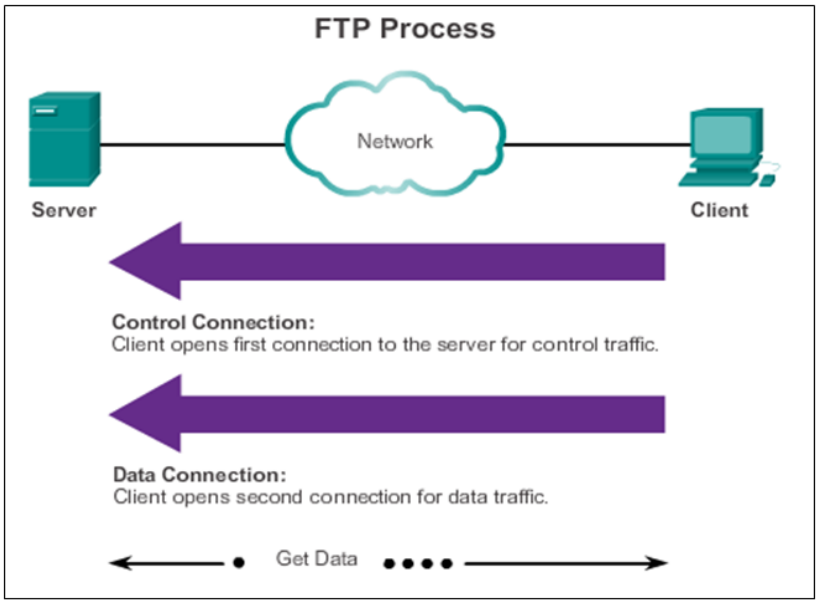
File Transfer Protocol (cont.)



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The Message Heard Around the World

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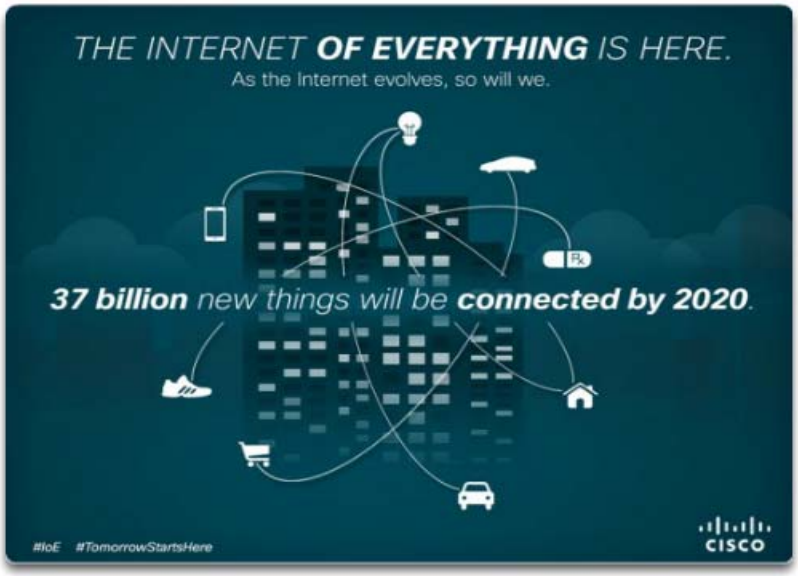
The Internet of Things



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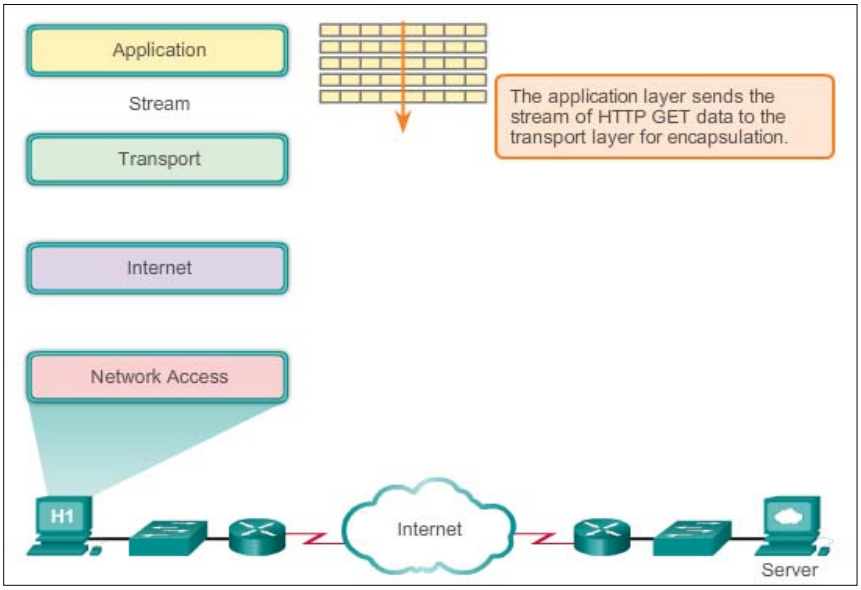
Message Travels Through a Network



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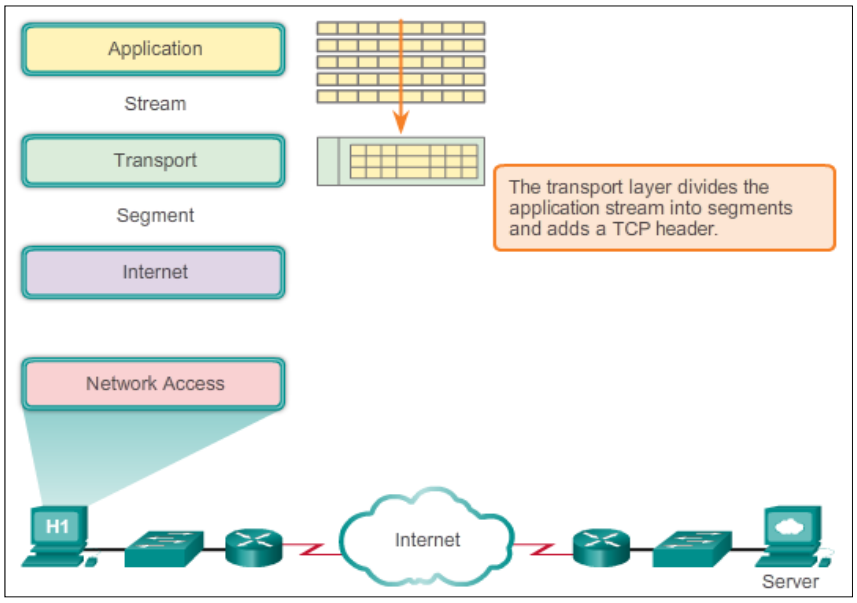
Message Travels Through a Network (cont.)



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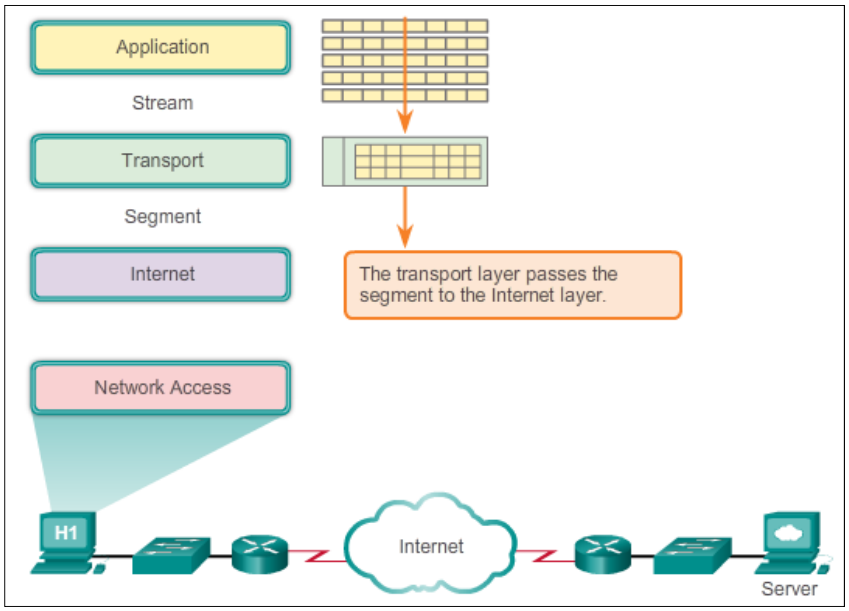
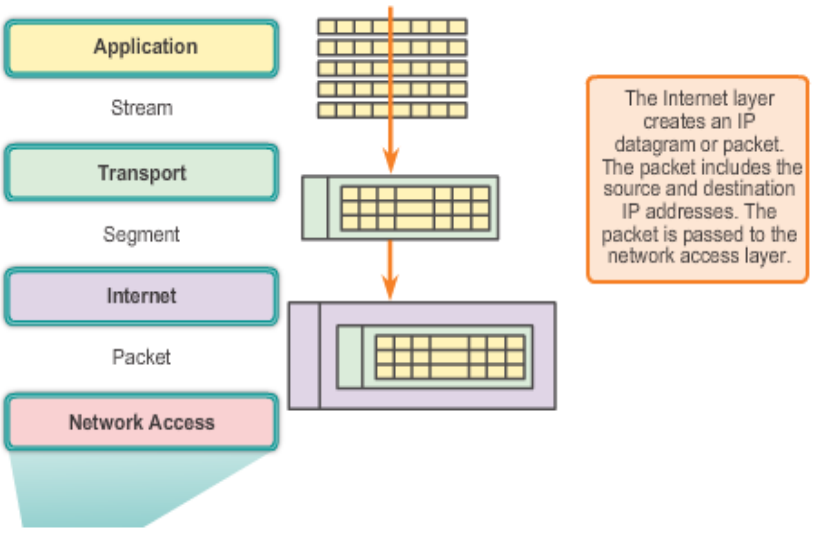
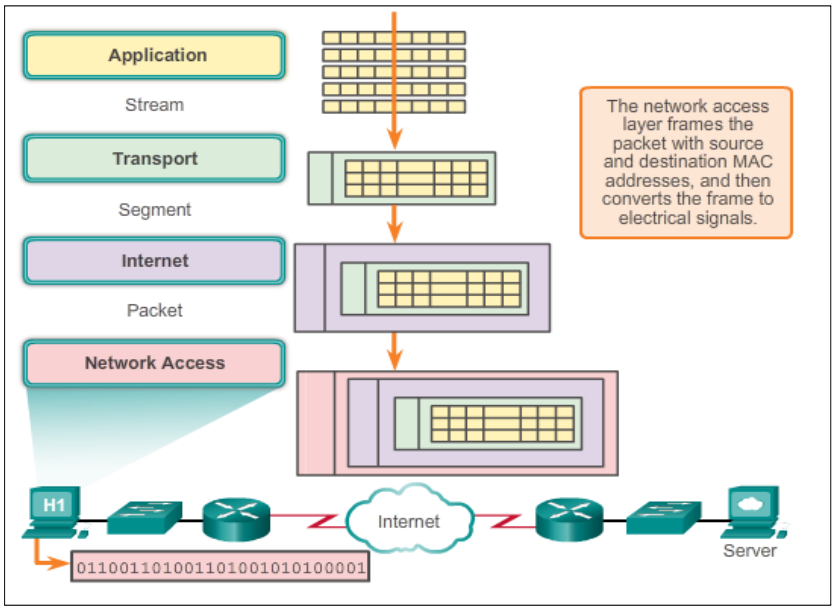
Message Travels Through a Network (cont.)



Getting the Data to the End Device



Getting the Data through the Internetwork



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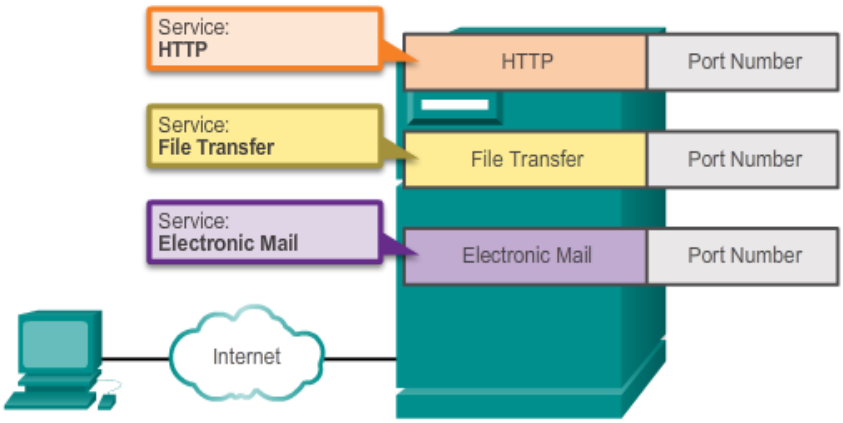
Getting the Data to the Right Application



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

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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.