MODULE 10: Networking

Lecture 10.4
Application Layer Protocols

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Lecture 10.4 Objectives

- Describe the interaction between application- and transport-layer protocols
- Enumerate some widely used application-layer protocols
- Discuss the operation of file transfer, web browsing, email, and domain name systems as supported by FTP, HTTP, SMTP, POP3, and DNS

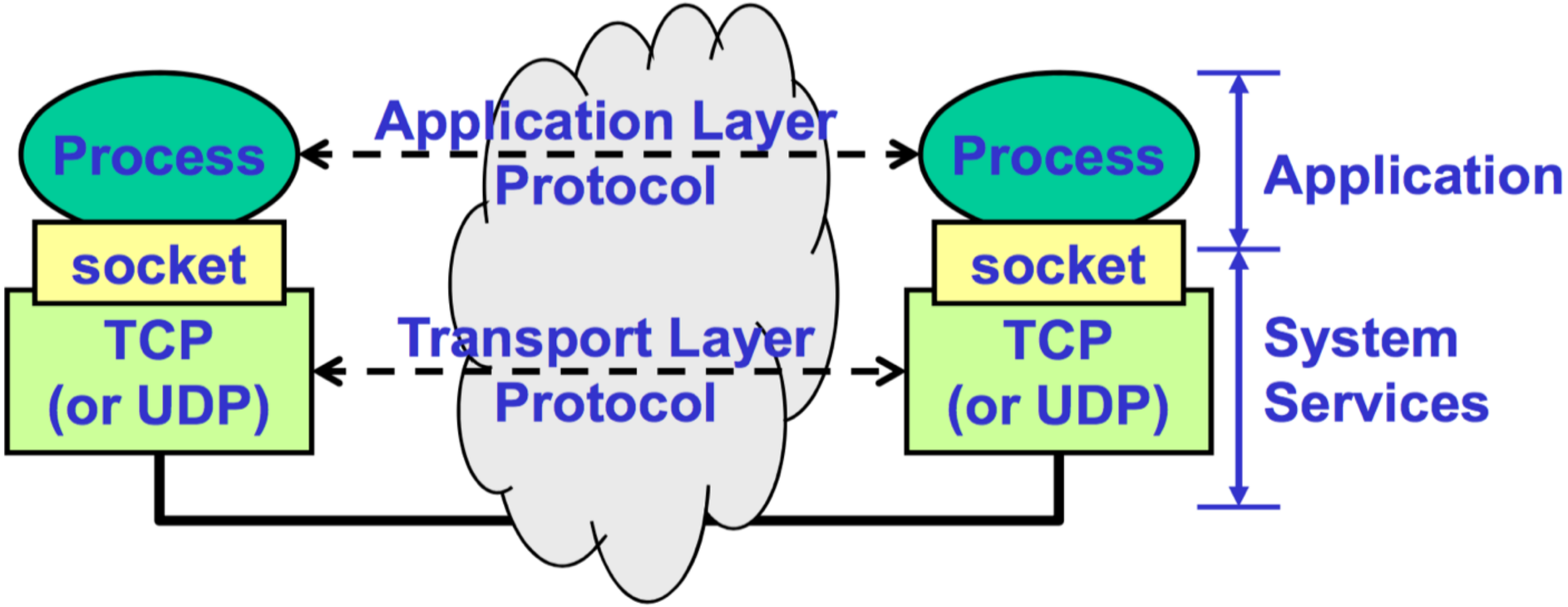
Network Applications

- Network applications are, of course, the motivation for networks
  - How do users communicate over the network?
  - How do programs communicate over the network?
- There are many commonly used network applications known to users (like the Web and Email), some that are part of the “plumbing” of the Internet (like DNS), and others that are for custom business applications

An Application Layer Protocol Defines:

- Messages and their processing (or remote procedure calls and their operation) define an application layer protocol
- Message types
  - Syntax: How are messages formatted?
  - Semantics: What do messages mean?
- Message processing
  - What actions are taken in response to messages?
  - What message sequences are valid?
  - What is the response in the event of errors?

Applications and Other Protocols

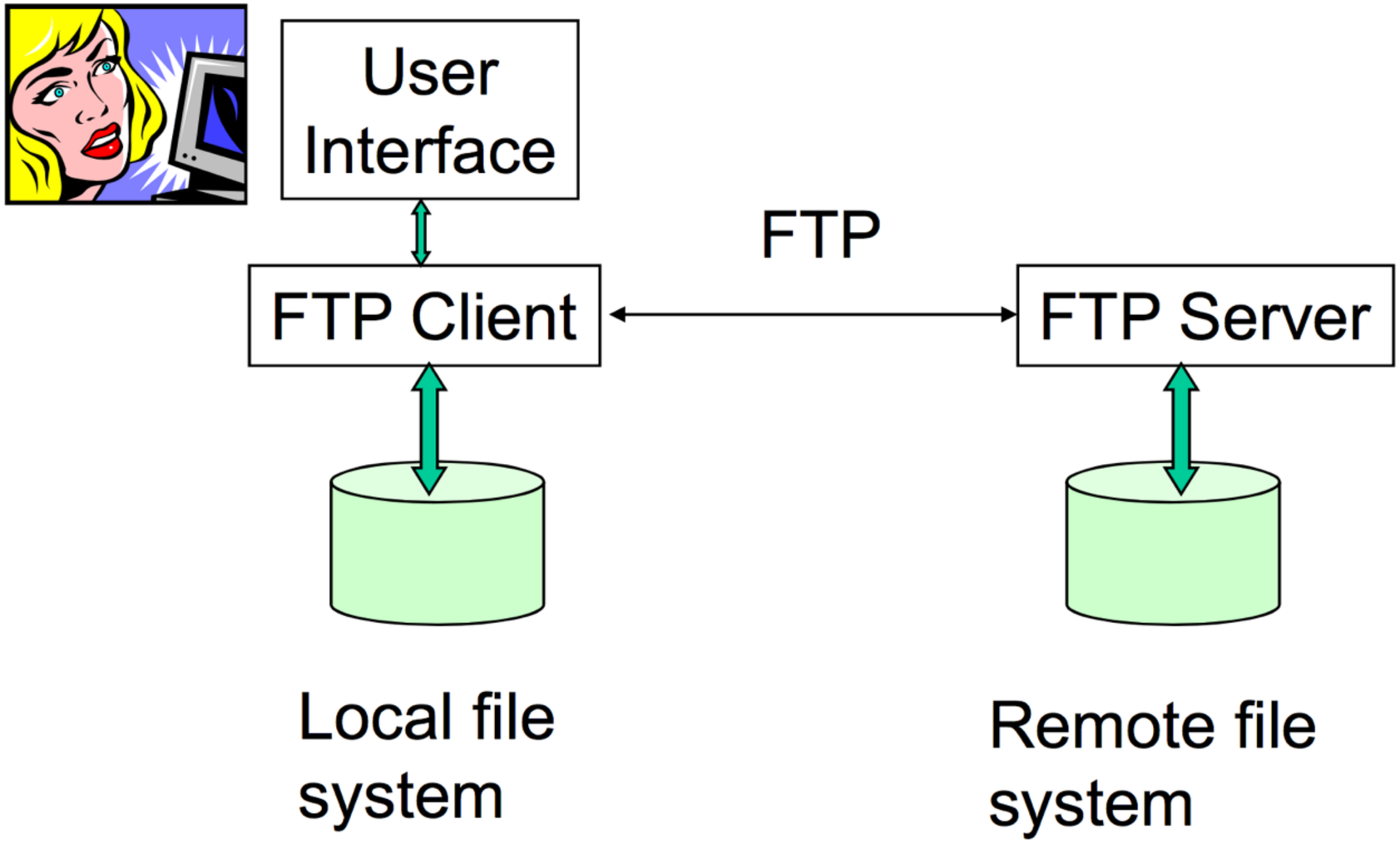


- Processes use an application program interface (API) to access operating system services for network communication

A Few Example Application Protocols

- World-Wide Web
  - HyperText Transfer Protocol (HTTP)
- Electronic mail
  - Simple Mail Transfer Protocol (SMTP)
  - Post Office Protocol (POP)
  - Internet Message Access Protocol (IMAP)
- Host name resolution
  - Domain Name Service (DNS)
- Host configuration
  - Dynamic Host Configuration Protocol (DHCP)

File Transfer Protocol



FTP Basics

- Runs over (uses the services of) TCP: connection-oriented
- Out-of band transmission of control information
  - Separate connections for control and data
- Control connection
  - Transmission of user ID, password, commands (change directory, put, get, etc.)
  - Persistent (open for the duration of the FTP session)
- Data connection
  - Transmission of files
  - Non-persistent (a new one is open for each command to transfer a file)

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Describe the interaction between application- and transport-layer protocols
- Enumerate some widely used application-layer protocols
- Discuss the operation of FTP

If you have any difficulties, please review the lecture video before continuing.

Web Pages

- Web pages consist of collections of objects
  - Examples of objects: HTML file, GIF image, JPEG image, Java applet, audio clip, etc.
  - Usually a base HTML file and referenced objects
- A web page is referenced to by a Universal Resource Locator (URL)
- URL contains the name of the server that stores the object, plus the object's path name

Hyper Text Transfer Protocol

- Implemented in client and server programs
- Client and server talk to each other by exchanging HTTP messages
- HTTP defines the structure of the messages and how they should be generated by the client and server

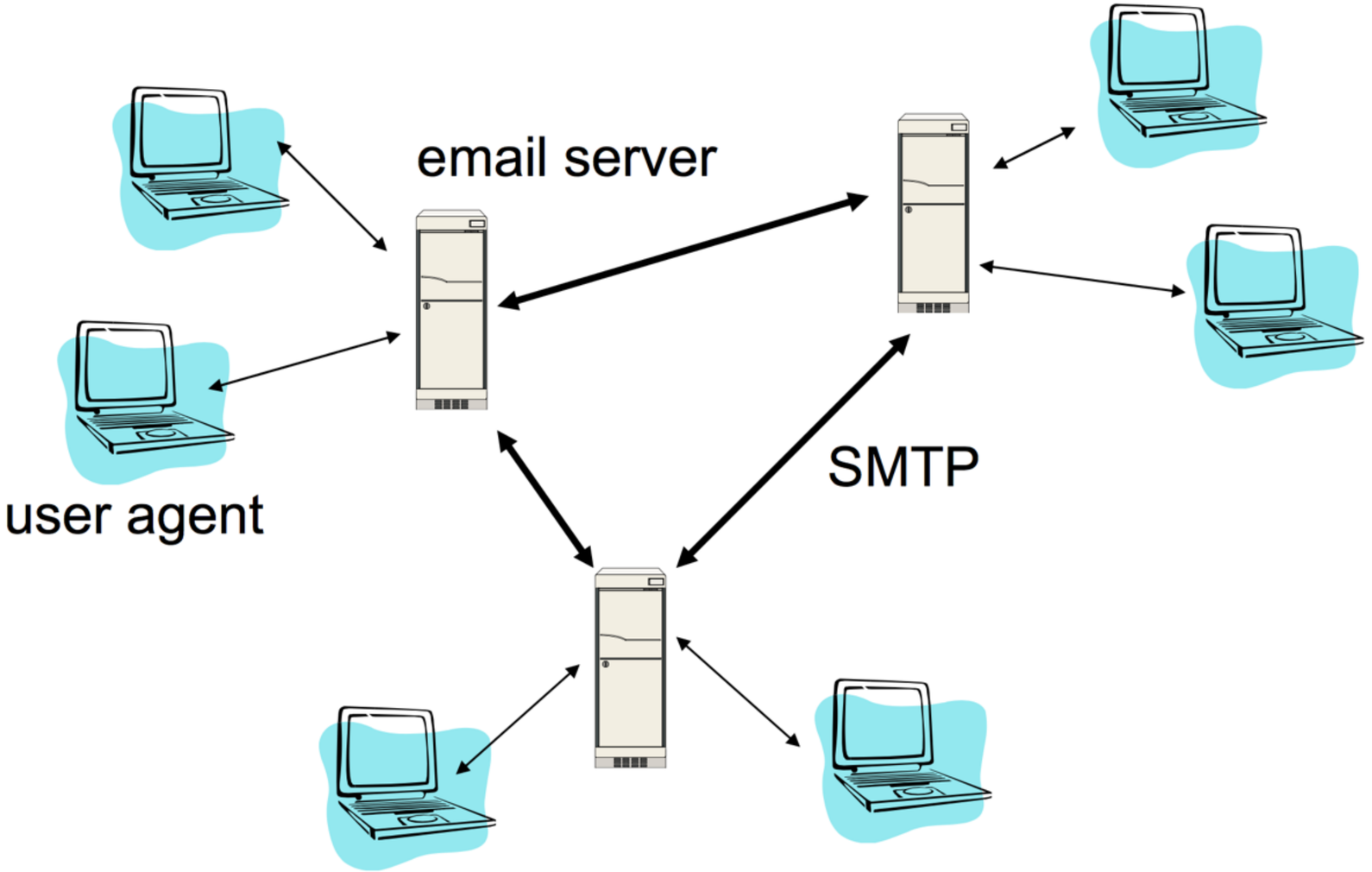
Browsers and Web Servers

- A browser displays to the user a requested web page
  - It also typically has additional capabilities such as interface to email, design tools for web pages, etc.
  - Implements the client side of HTTP
  - Examples: Safari, Chrome, Firefox, Internet Explorer
- A web server houses Web objects that are addressable by a URL
  - Implements the server side of HTTP
  - Examples: Apache, Microsoft Internet Information Server

HTTP and TCP

- TCP is the underlying transport protocol
  - Reliable communication
  - Connection-oriented
  - HTTP client first establishes a TCP connection with server
  - Then, browser and webserver processes accessTCP through their socket interfaces

Email



How does Email Work?

- User interface through user agents (Outlook, Mail, pine…)
- A mailbox is kept at the email server
  - Authentication occurs when a user wants to access his/her mailbox
- Server also maintains outgoing message queues
- Simple Mail Transfer Protocol (SMTP) is the primary application-layer protocol for communications between email servers
  - Uses the services of TCP
  - Client side executes on sender's email server
  - Server side executes on receiver's email server

Email Example

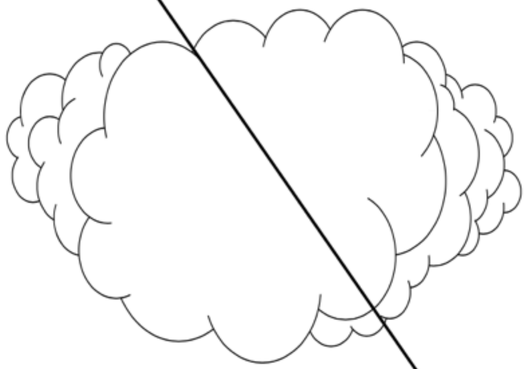
1. Bob opens MS Outlook (the user agent), writes an email message to Jane (including, of course, Jane's email address) and presses Send
2. Bob's user agent sends the message to Bob's email server, where it goes into a message queue
3. The client side of SMTP (running in Bob's email server) opens a TCP connection to the server side of SMTP (in Jane's email server) and sends the message
4. Jane's email server places the message in the mailbox reserved for Jane
5. Jane invokes Mozilla Thunderbird to read her email and downloads the message from Bob

Protocols Used in Email

SMTP

Bob's mail server

SMTP



POP3

Jane's mail server

Note: Mail access protocols include POP3, IMAP, HTTP

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Discuss the operation of HTTP
- Discuss the operation of Email from a protocol perspective

If you have any difficulties, please review the lecture video before continuing.

SMTP versus HTTP

- Both used to send files
- HTTP primarily a pull protocol
  - TCP connection initiated by the machine that receives the file
- SMTP primarily a push protocol
  - TCP connection initiated by the machine that sends the file
- HTTP encapsulates each object in its own HTTP response message
- In SMTP, all objects are placed in one message

POP 3

- Post Office Protocol – Version 3 [RFC 1939]
  - A mail access protocol – allows users to access/download emails from their mail servers
- User agent establishes a TCP connection to the mail server on port 110
- Once the TCP connection is established, 3 phases:
  - Authorization – authentication based on userid/password
  - Transaction – retrieval of messages, marking of messages for deletion, etc.
  - Update – mail server makes the updates defined by the user (deleting messages marked for deletion, etc.)

Other Email Access Protocols

- IMAP (Internet Mail Access Protocol)
  - Allows user to define folders to maintain messages in folders at the server
- HTTP
  - User agent is simply a web browser
  - Can also define folders, keep messages at the server (sometimes this is implemented using the functionalities of IMAP or SMTP)
  - Example: Gmail

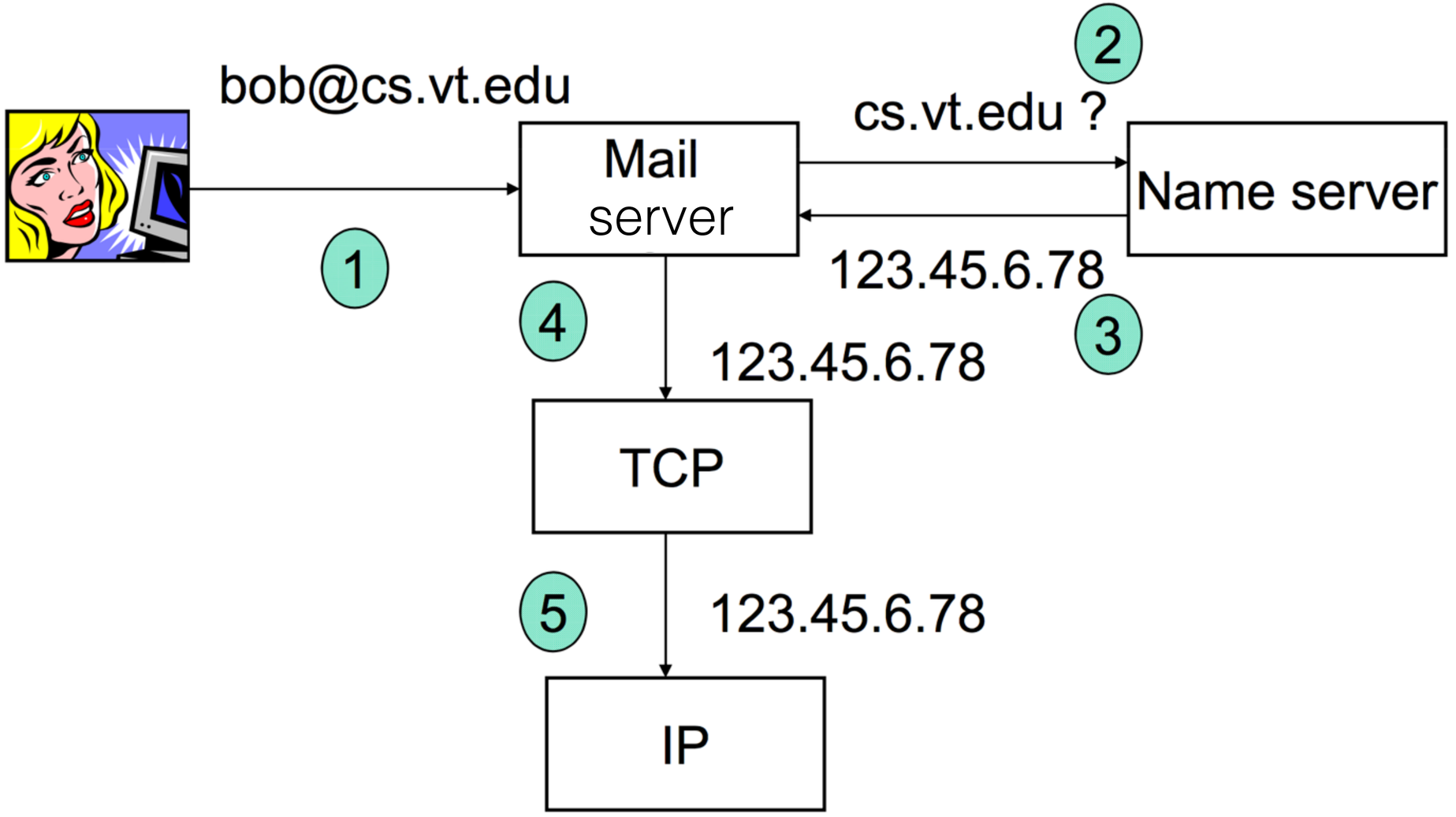
Motivation for DNS

- Hosts on the Internet are identified by an IP address
  - IP addresses are unique and in corporate location information
- Hosts are also known by more mnemonic names
  - Example: ece.vt.edu
  - These generally tell us little or nothing about host location
- Need a way to translate between the two: Domain Name System (DNS)

DNS

- A distributed database holding alpha-numeric names and IP addresses of every registered system in the Internet
- Databases are held by systems running name servers
- DNS is also a protocol that allows hosts and name servers to communicate for translation services
- Runs over UDP, using port 53
- Services include address translation, host aliasing, mail server aliasing and load distribution

DNS Example



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- Discuss the operation of DNS

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Summary

- Application-layer protocols define the syntax and semantics of messages exchanged by applications over the network
- FTP runs over TCP and supports file transfer
- HTTP defines the structure of the messages exchanged between browsers and web servers
- Email exchange is supported by SMTP and several email access protocols like POP3, IMAP and HTTP
- DNS provides translation between mnemonic names used in the Internet and their unique IP addresses

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