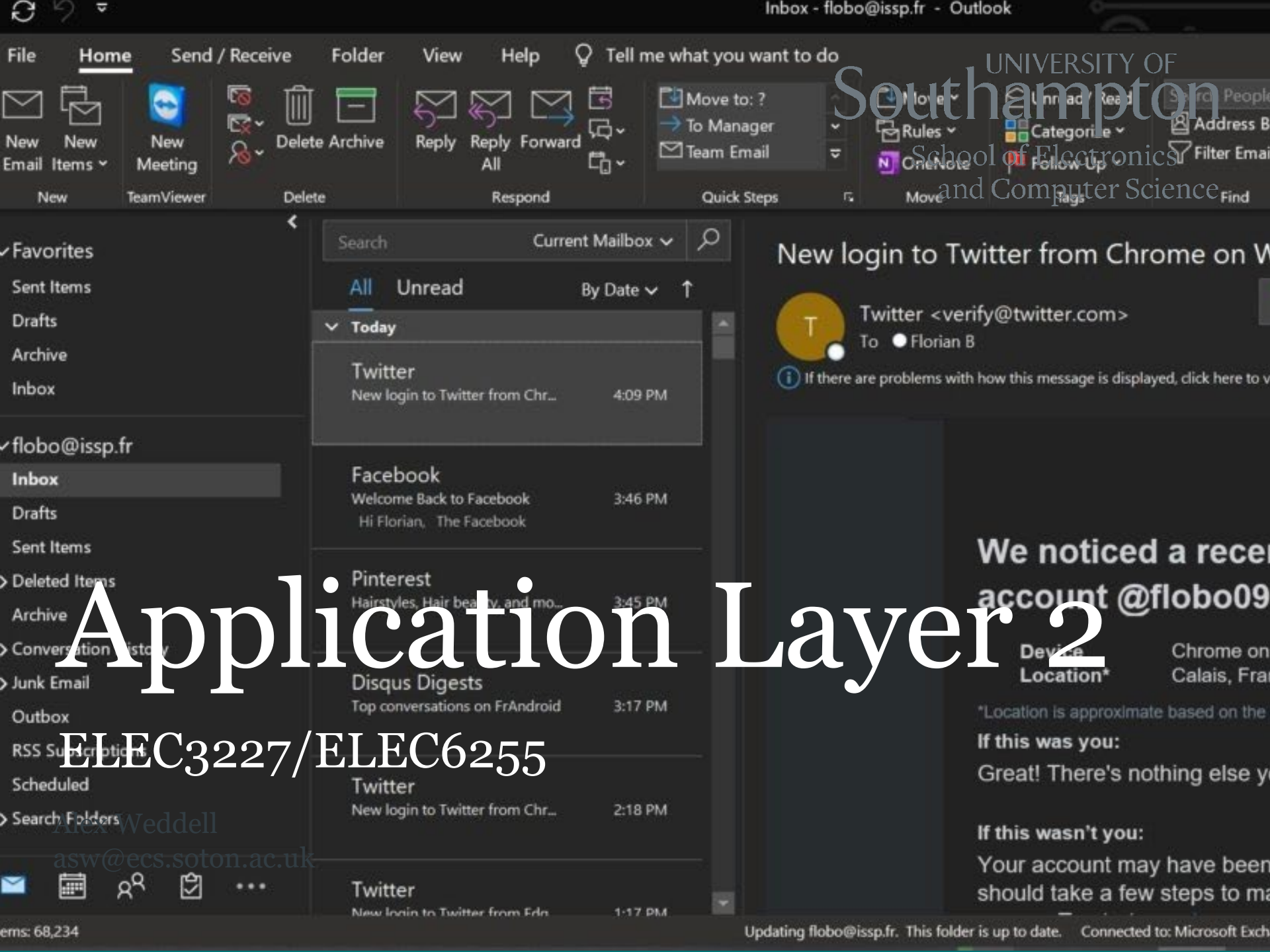

Application Layer 2

ELEC3227/ELEC6255

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Overview

- Email message transfer
- Uniform Resource Locators (URLs)
- Hypertext Transfer Protocol
- Static/Dynamic Webpages
- Caching
- Cookies

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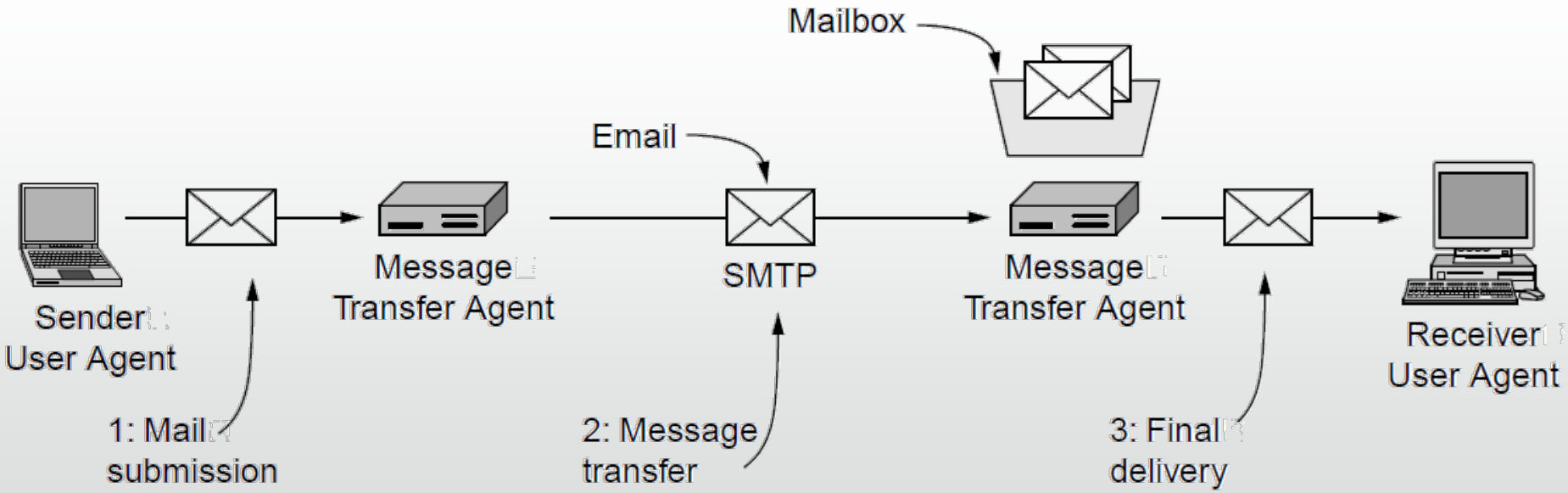
Email Message Transfer

- Messages are transferred with SMTP (Simple Mail Transfer Protocol)
  - Readable text commands
  - Submission from user agent to MTA on port 587
  - One MTA to the next MTA on port 25
  - Other protocols for final delivery (IMAP, POP3)



Email Message Transfer

- Header information for message transport; readable text

Header	Meaning
To:	Email address(es) of primary recipient(s)
Cc:	Email address(es) of secondary recipient(s)
Bcc:	Email address(es) for blind carbon copies
From:	Person or people who created the message
Sender:	Email address of the actual sender
Received:	Line added by each transfer agent along the route
Return-Path:	Can be used to identify a path back to the sender

- Other header fields useful for user agents

Header	Meaning
Date:	The date and time the message was sent
Reply-To:	Email address to which replies should be sent
Message-Id:	Unique number for referencing this message later
In-Reply-To:	Message-Id of the message to which this is a reply
References:	Other relevant Message-Ids
Keywords:	User-chosen keywords
Subject:	Short summary of the message for the one-line display

Email Message Transfer

- Sending a message from Alice to Bob
- SMTP commands are marked [pink]
- Final message delivery uses IMAP, web interface, or proprietary protocol (e.g. MS Exchange)

```
                S: 220 ee.uwa.edu.au SMTP service ready
C: HELO abcd.com
                S: 250 cs.washington.edu says hello to ee.uwa.edu.au
C: MAIL FROM: <alice@cs.washington.edu>
                S: 250 sender ok
C: RCPT TO: <bob@ee.uwa.edu.au>
                S: 250 recipient ok
C: DATA
                S: 354 Send mail; end with "." on a line by itself
C: From: alice@cs.washington.edu
C: To: bob@ee.uwa.edu.au
C: MIME-Version: 1.0
C: Message-Id: <0704760941.AA00747@ee.uwa.edu.au>
C: Content-Type: multipart/alternative; boundary=qwertyuiopasdfghjklzxcvbnm
C: Subject: Earth orbits sun integral number of times
C:
C: This is the preamble. The user agent ignores it. Have a nice day.
C:
C: --qwertyuiopasdfghjklzxcvbnm
C: Content-Type: text/html
C:
C: <p>Happy birthday to you
C: Happy birthday to you

  . . . (rest of message) . . .

C: --qwertyuiopasdfghjklzxcvbnm
C: .
                S: 250 message accepted
C: QUIT
                S: 221 ee.uwa.edu.au closing connection
```

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Uniform Resource Locators

- Pages are named with URLs (Uniform Resource Locators)
  - Example: http://www.phdcomics.com/comics.php
  - Protocol: http; Server: www.phdcomics.com; Page on servers: comics.php

Our focus →

Name	Used for	Example
http	Hypertext (HTML)	http://www.ee.uwa.edu/~rob/
https	Hypertext with security	https://www.bank.com/accounts/
ftp	FTP	ftp://ftp.cs.vu.nl/pub/minix/README
file	Local file	file:///usr/suzanne/prog.c
mailto	Sending email	mailto:JohnUser@acm.org
rtsp	Streaming media	rtsp://youtube.com/montypython.mpg
sip	Multimedia calls	sip:eve@adversary.com
about	Browser information	about:plugins

Common URL Protocols

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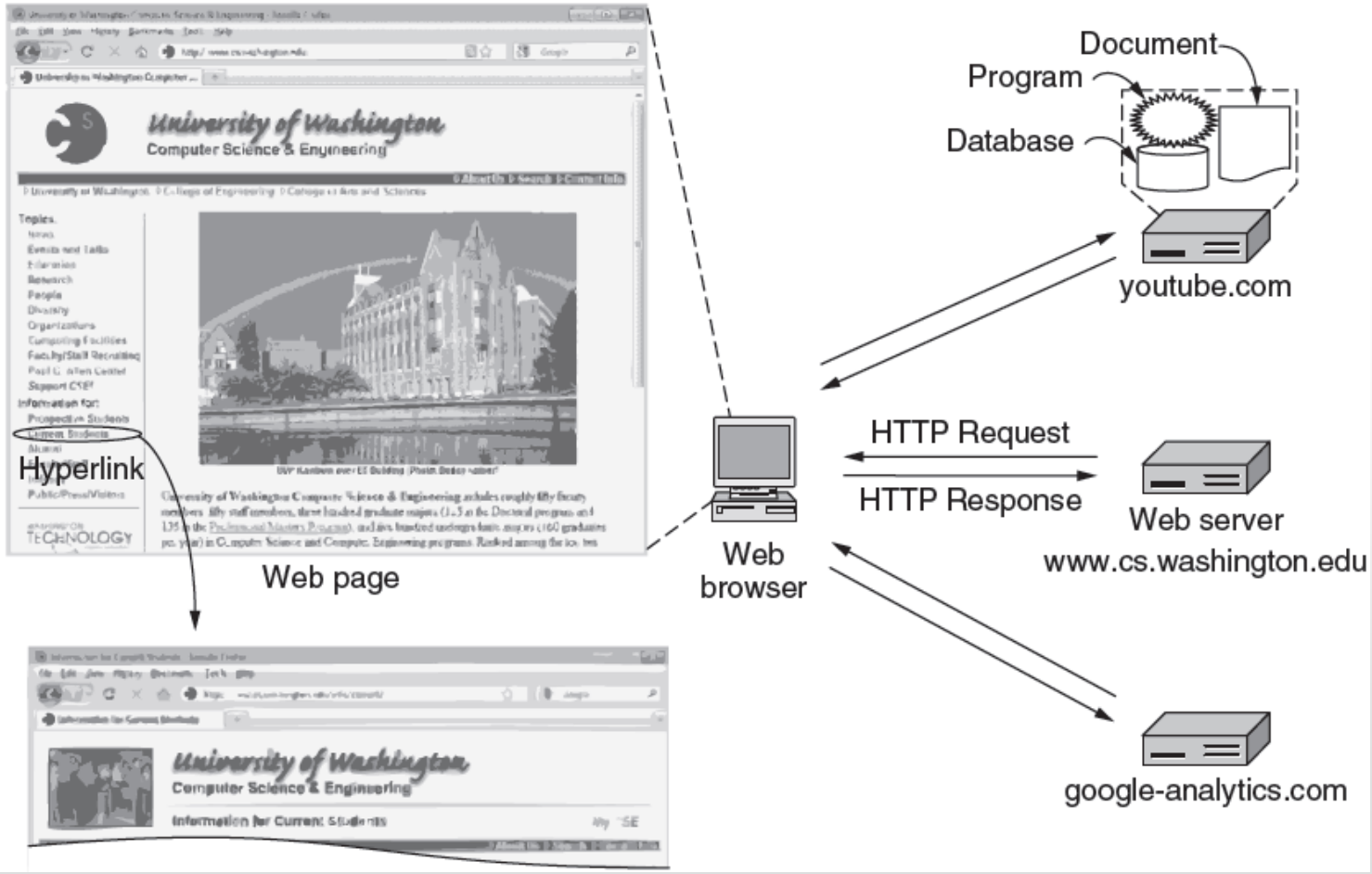
The World Wide Web

- HTTP transfers pages from servers to browsers

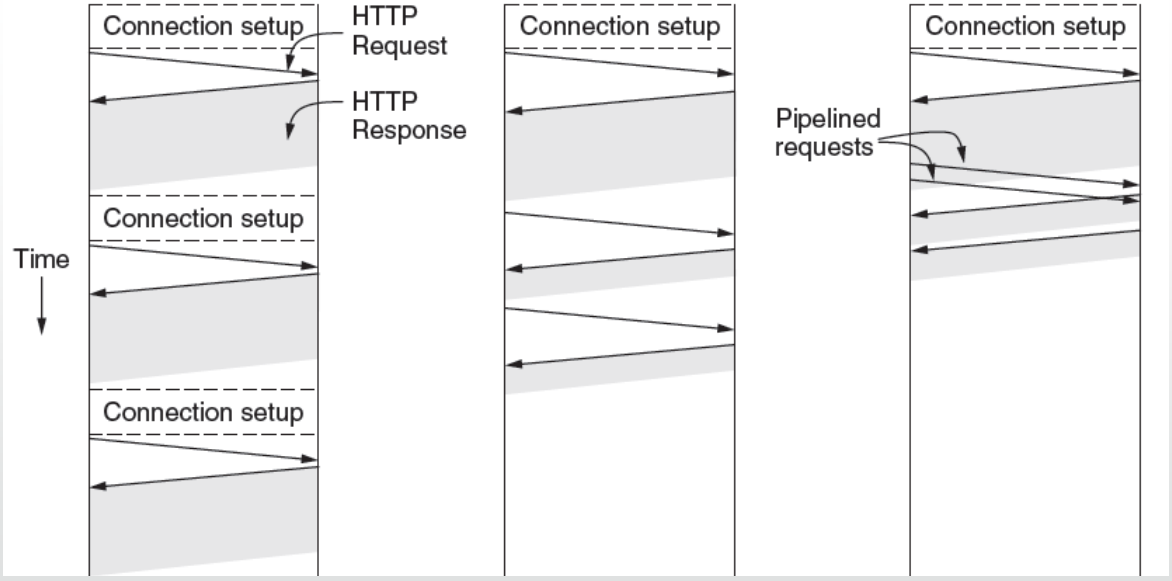


Following a Hyperlink...

- Steps a client (browser) takes to follow a hyperlink:
  - Determine the protocol (HTTP)
  - Ask DNS for the IP address of server
  - Make a TCP connection to server
  - Send request for the page; server sends it back
  - Fetch other URLs as needed to display the page
  - Close idle TCP connections
- Steps a server takes to serve pages:
  - Accept a TCP connection from client
  - Get page request and map it to a resource (e.g., file name)
  - Get the resource (e.g., file from disk)
  - Send contents of the resource to the client.
  - Release idle TCP connections

HyperText Transfer Protocol

- HTTP is a request-response protocol that runs on top of TCP
  - Fetches pages from server to client, server usually runs on port 80
  - Headers are given in readable ASCII
  - Content is described with MIME types
  - Protocol has support for pipelining requests and caching
- HTTP uses persistent connections to improve performance



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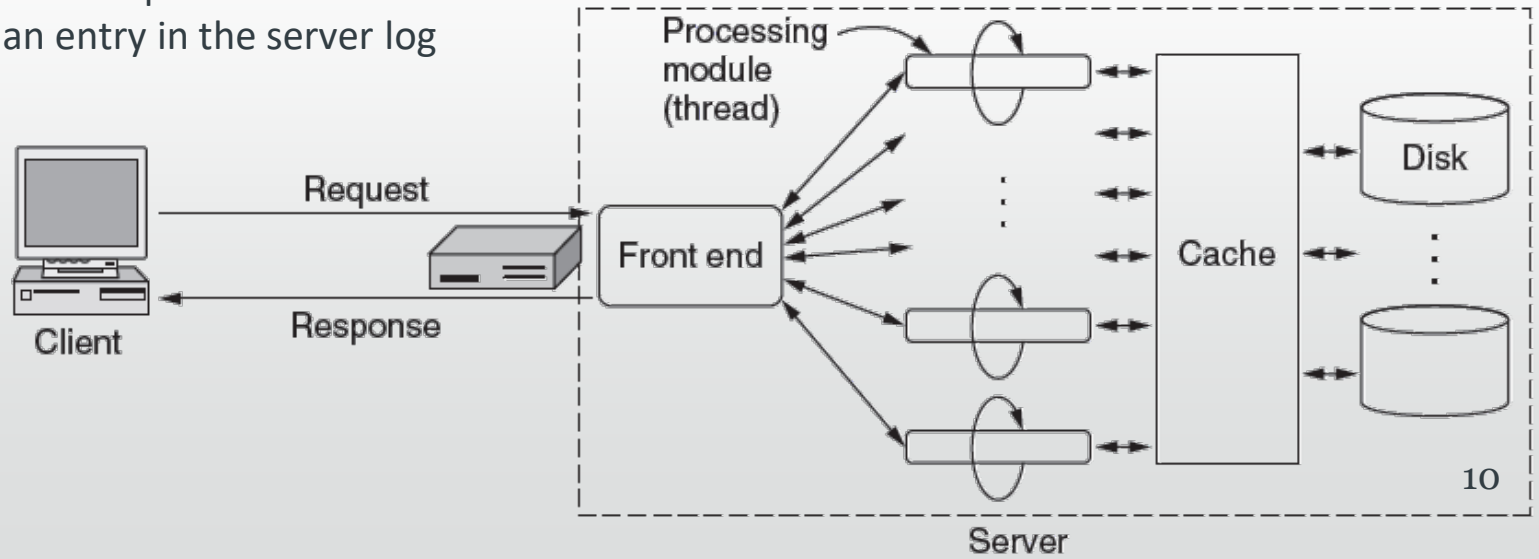
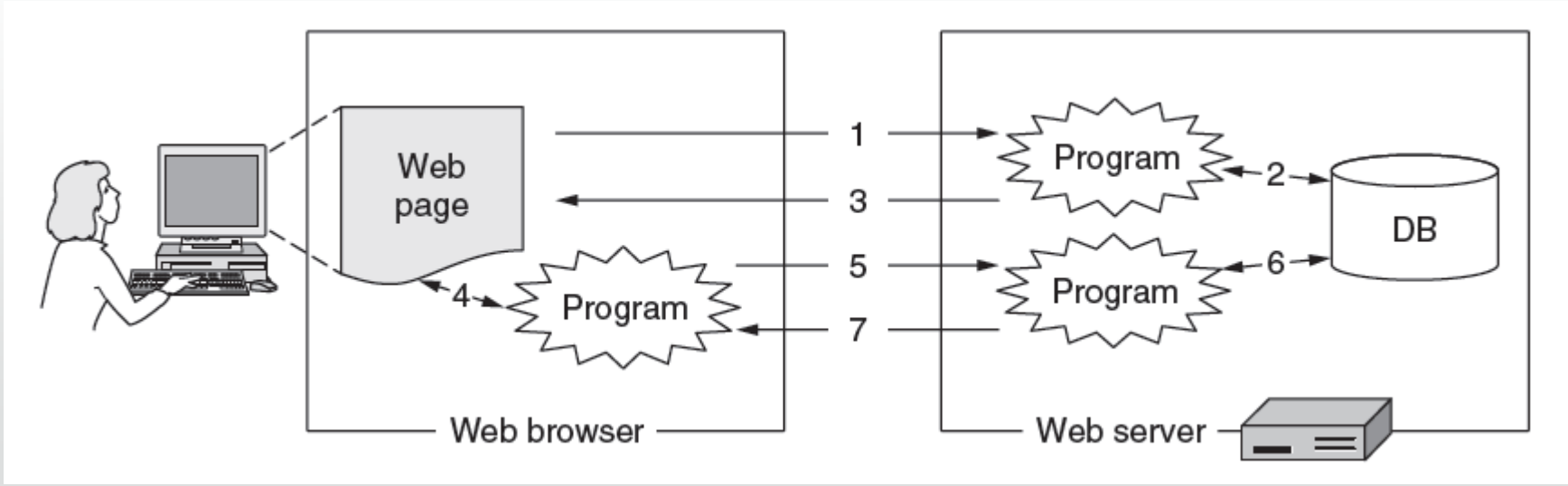
Steps Taken to Serve Pages

- To scale performance, Web servers can use caching, multiple threads, and a front end
- Server steps, revisited:
  - Resolve name of Web page requested
  - Perform access control on the Web page
  - Check the cache
  - Fetch requested page from disk or run program
  - Determine the rest of the response
  - Return the response to the client
  - Make an entry in the server log



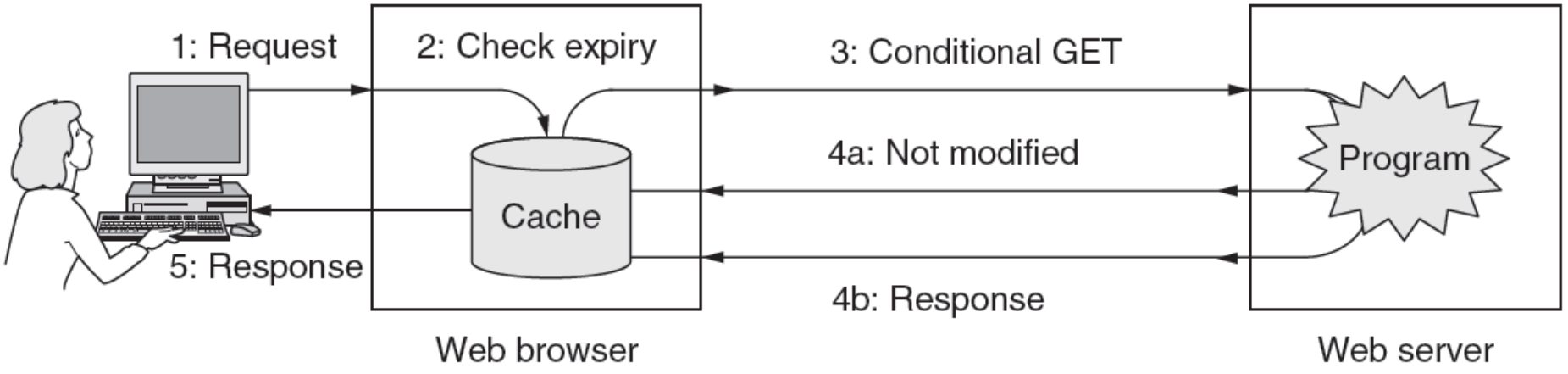
Static vs. Dynamic Web Pages

- **Static web pages** are simply files: have the same contents for each viewing. Can be visually rich and interactive nonetheless: HTML that mixes text and images, Forms that gather user input, style sheets that tailor presentation, vector graphics, videos, and more…
- **Dynamic web pages** are generated by programs running at the server (with a database) and the client: e.g., PHP at server, JavaScript at client pages vary each time, like using an application



HTTP Caching

- HTTP caching checks to see if the browser has a known fresh copy, and if not if the server has updated the page
  - Uses a collection of headers for the checks
  - Can include further levels of caching (e.g., proxy)



Cookies

- Cookies support **stateful** client/server interactions
  - Server sends cookies (state) with page response
  - Client stores cookies across page fetches
  - Client sends cookies back to server with requests

Domain	Path	Content	Expires	Secure
toms-casino.com	/	CustomerID=297793521	15-10-10 17:00	Yes
jills-store.com	/	Cart=1-00501;1-07031;2-13721	11-1-11 14:22	No
aportal.com	/	Prefs=Stk:CSCO+ORCL;Spt:Jets	31-12-20 23:59	No
sneaky.com	/	UserID=4627239101	31-12-19 23:59	No

Examples of cookies

Summary

- Email message transfer
- Uniform Resource Locators (URLs)
- Hypertext Transfer Protocol
- Static/Dynamic Webpages
- Caching
- Cookies

Application Layer

Question 1

Many business computers have three distinct and worldwide unique identifiers. What are they?

Question 2

Consider a situation in which a cyberterrorist makes all the DNS servers in the world crash simultaneously. How does this change your ability to use the Internet?

Question 3

DNS uses UDP instead of TCP. If a DNS packet is lost, there is no automatic recovery. Does this cause a problem, and if so, how is it solved?

Question 4

Can a machine with a single DNS name have multiple IP addresses? How could this occur?

Question 5

The number of companies with a Web site has grown explosively in recent years. As a result, thousands of companies are registered in the com domain, causing a heavy load on the top-level server for this domain.

Suggest a way to alleviate this problem without changing the naming scheme (i.e., without introducing new top-level domain names).

It is permitted that your solution requires changes to the client code.

Question 6

Some email systems support a Content Return: header field. It specifies whether the body of a message is to be returned in the event of non-delivery.

Does this field belong to the envelope or to the header?

Question 7

IMAP allows users to fetch and download email from a remote mailbox.

Does this mean that the internal format of mailboxes has to be standardized so any IMAP program on the client side can read the mailbox on any mail server?

Question 8

www.aportal.com keeps track of user preferences in a cookie. A disadvantage of this scheme is that cookies are limited to 4 KB, so if the preferences are extensive, for example, many stocks, sports teams, types of news stories, weather for multiple cities, specials in numerous product categories, and more, the 4-KB limit may be reached.

Suggest an alternative way to keep track of preferences that does not have this problem.

Domain	Path	Content	Expires	Secure
toms-casino.com	/	CustomerID=297793521	15-10-10 17:00	Yes
jills-store.com	/	Cart=1-00501;1-07031;2-13721	11-1-11 14:22	No
aportal.com	/	Prefs=Stk:CSCO+ORCL;Spt:Jets	31-12-20 23:59	No
sneaky.com	/	UserID=4627239101	31-12-19 23:59	No

Question 9

Sloth Bank wants to make online banking easy for its lazy customers, so after a customer signs up and is authenticated by a password, the bank returns a cookie containing a customer ID number. In this way, the customer does not have to identify himself or type a password on future visits to the online bank. What do you think of this idea?

- Will it work?
- Is it a good idea?

Question 10

The *If-Modified-Since* header can be used to check whether a cached page is still valid. Requests can be made for pages containing images, sound, video, and so on, as well as HTML.

Do you think the effectiveness of this technique is better or worse for JPEG images as compared to HTML?