

- R27. For the client-server application over TCP described in Section 2.7, why must the server program be executed before the client program? For the client-server application over UDP, why may the client program be executed before the server program?

Problems

- P1. True or false?
- A user requests a Web page that consists of some text and three images. For this page, the client will send one request message and receive four response messages.
 - Two distinct Web pages (for example, `www.mit.edu/research.html` and `www.mit.edu/students.html`) can be sent over the same persistent connection.
 - With nonpersistent connections between browser and origin server, it is possible for a single TCP segment to carry two distinct HTTP request messages.
 - The `Date:` header in the HTTP response message indicates when the object in the response was last modified.
 - HTTP response messages never have an empty message body.
- P2. SMS, iMessage, Wechat, and WhatsApp are all smartphone real-time messaging systems. After doing some research on the Internet, for each of these systems write one paragraph about the protocols they use. Then write a paragraph explaining how they differ.
- P3. Consider an HTTP client that wants to retrieve a Web document at a given URL. The IP address of the HTTP server is initially unknown. What transport and application-layer protocols besides HTTP are needed in this scenario?
- P4. Consider the following string of ASCII characters that were captured by Wireshark when the browser sent an HTTP GET message (i.e., this is the actual content of an HTTP GET message). The characters `<cr>``<lf>` are carriage return and line-feed characters (that is, the italicized character string `<cr>` in the text below represents the single carriage-return character that was contained at that point in the HTTP header). Answer the following questions, indicating where in the HTTP GET message below you find the answer.

```
GET /cs453/index.html HTTP/1.1<cr><lf>Host: gai
a.cs.umass.edu<cr><lf>User-Agent: Mozilla/5.0 (
Windows;U; Windows NT 5.1; en-US; rv:1.7.2) Gec
ko/20040804 Netscape/7.2 (ax) <cr><lf>Accept:ex
t/xml, application/xml, application/xhtml+xml, text
/html;q=0.9, text/plain;q=0.8,image/png,*/*;q=0.5
```

```
<cr><lf>Accept-Language: en-us,en;q=0.5<cr><lf>Accept-
Encoding: zip,deflate<cr><lf>Accept-Charset: ISO
-8859-1,utf-8;q=0.7,*;q=0.7<cr><lf>Keep-Alive: 300<cr>
<lf>Connection:keep-alive<cr><lf><cr><lf>
```

- a. What is the URL of the document requested by the browser?
 - b. What version of HTTP is the browser running?
 - c. Does the browser request a non-persistent or a persistent connection?
 - d. What is the IP address of the host on which the browser is running?
 - e. What type of browser initiates this message? Why is the browser type needed in an HTTP request message?
- P5. The text below shows the reply sent from the server in response to the HTTP GET message in the question above. Answer the following questions, indicating where in the message below you find the answer.

```
HTTP/1.1 200 OK<cr><lf>Date: Tue, 07 Mar 2008
12:39:45GMT<cr><lf>Server: Apache/2.0.52 (Fedora)
<cr><lf>Last-Modified: Sat, 10 Dec2005 18:27:46
GMT<cr><lf>ETag: "526c3-f22-a88a4c80"<cr><lf>Accept-
Ranges: bytes<cr><lf>Content-Length: 3874<cr><lf>
Keep-Alive: timeout=max=100<cr><lf>Connection:
Keep-Alive<cr><lf>Content-Type: text/html; charset=
ISO-8859-1<cr><lf><cr><lf><!doctype html public "-
//w3c//dtd html 4.0transitional//en"><lf><html><lf>
<head><lf> <meta http-equiv="Content-Type"
content="text/html; charset=iso-8859-1"><lf> <meta
name="GENERATOR" content="Mozilla/4.79 [en] (Windows NT
5.0; U) Netscape]"><lf> <title>CMPSCI 453 / 591 /
NTU-ST550ASpring 2005 homepage</title><lf></head><lf>
<much more document text following here (not shown)>
```

- a. Was the server able to successfully find the document or not? What time was the document reply provided?
 - b. When was the document last modified?
 - c. How many bytes are there in the document being returned?
 - d. What are the first 5 bytes of the document being returned? Did the server agree to a persistent connection?
- P6. Obtain the HTTP/1.1 specification (RFC 2616). Answer the following questions:
- a. Explain the mechanism used for signaling between the client and server to indicate that a persistent connection is being closed. Can the client, the server, or both signal the close of a connection?

- b. What encryption services are provided by HTTP?
 - c. Can a client open three or more simultaneous connections with a given server?
 - d. Either a server or a client may close a transport connection between them if either one detects the connection has been idle for some time. Is it possible that one side starts closing a connection while the other side is transmitting data via this connection? Explain.
- P7. Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that n DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT of RTT_1, \dots, RTT_n . Further suppose that the Web page associated with the link contains exactly one object, consisting of a small amount of HTML text. Let RTT_0 denote the RTT between the local host and the server containing the object. Assuming zero transmission time of the object, how much time elapses from when the client clicks on the link until the client receives the object?
- P8. Referring to Problem P7, suppose the HTML file references eight very small objects on the same server. Neglecting transmission times, how much time elapses with
- a. Non-persistent HTTP with no parallel TCP connections?
 - b. Non-persistent HTTP with the browser configured for 6 parallel connections?
 - c. Persistent HTTP?
- P9. Consider Figure 2.12, for which there is an institutional network connected to the Internet. Suppose that the average object size is 1,000,000 bits and that the average request rate from the institution's browsers to the origin servers is 16 requests per second. Also suppose that the amount of time it takes from when the router on the Internet side of the access link forwards an HTTP request until it receives the response is three seconds on average (see Section 2.2.5). Model the total average response time as the sum of the average access delay (that is, the delay from Internet router to institution router) and the average Internet delay. For the average access delay, use $\Delta/(1 - \Delta\beta)$, where Δ is the average time required to send an object over the access link and β is the arrival rate of objects to the access link.
- a. Find the total average response time.
 - b. Now suppose a cache is installed in the institutional LAN. Suppose the miss rate is 0.4. Find the total response time.
- P10. Consider a short, 10-meter link, over which a sender can transmit at a rate of 150 bits/sec in both directions. Suppose that packets containing data are 100,000 bits long, and packets containing only control (e.g., ACK or

- handshaking) are 200 bits long. Assume that N parallel connections each get $1/N$ of the link bandwidth. Now consider the HTTP protocol, and suppose that each downloaded object is 100 Kbits long, and that the initial downloaded object contains 10 referenced objects from the same sender. Would parallel downloads via parallel instances of non-persistent HTTP make sense in this case? Now consider persistent HTTP. Do you expect significant gains over the non-persistent case? Justify and explain your answer.
- P11. Consider the scenario introduced in the previous problem. Now suppose that the link is shared by Bob with four other users. Bob uses parallel instances of non-persistent HTTP, and the other four users use non-persistent HTTP without parallel downloads.
- Do Bob's parallel connections help him get Web pages more quickly? Why or why not?
 - If all five users open five parallel instances of non-persistent HTTP, then would Bob's parallel connections still be beneficial? Why or why not?
- P12. Write a simple TCP program for a server that accepts lines of input from a client and prints the lines onto the server's standard output. (You can do this by modifying the `TCPServer.py` program in the text.) Compile and execute your program. On any other machine that contains a Web browser, set the proxy server in the browser to the host that is running your server program; also configure the port number appropriately. Your browser should now send its GET request messages to your server, and your server should display the messages on its standard output. Use this platform to determine whether your browser generates conditional GET messages for objects that are locally cached.
- P13. Consider sending over HTTP/2 a Web page that consists of one video clip, and five images. Suppose that the video clip is transported as 2000 frames, and each image has three frames.
- If all the video frames are sent first without interleaving, how many "frame times" are needed until all five images are sent?
 - If frames are interleaved, how many frame times are needed until all five images are sent.
- P14. Consider the Web page in problem 13. Now HTTP/2 prioritization is employed. Suppose all the images are given priority over the video clip, and that the first image is given priority over the second image, the second image over the third image, and so on. How many frame times will be needed until the second image is sent?
- P15. What is the difference between `MAIL FROM:` in SMTP and `From:` in the mail message itself?
- P16. How does SMTP mark the end of a message body? How about HTTP? Can HTTP use the same method as SMTP to mark the end of a message body? Explain.

P17. Read RFC 5321 for SMTP. What does MTA stand for? Consider the following received spam e-mail (modified from a real spam e-mail). Assuming only the originator of this spam e-mail is malicious and all other hosts are honest, identify the malicious host that has generated this spam e-mail.

```

From - Fri Nov 07 13:41:30 2008
Return-Path: <tennis5@pp33head.com>
Received: from barmail.cs.umass.edu (barmail.cs.umass.edu
[128.119.240.3]) by cs.umass.edu (8.13.1/8.12.6) for
<hg@cs.umass.edu>; Fri, 7 Nov 2008 13:27:10 -0500
Received: from asusus-4b96 (localhost [127.0.0.1]) by
barmail.cs.umass.edu (Spam Firewall) for <hg@cs.umass.edu>; Fri, 7
Nov 2008 13:27:07 -0500 (EST)
Received: from asusus-4b96 ([58.88.21.177]) by barmail.
cs.umass.edu
for <hg@cs.umass.edu>; Fri, 07 Nov 2008 13:27:07 -0500
(EST)
Received: from [58.88.21.177] by inbnd55.exchangeddd.
com; Sat, 8
Nov 2008 01:27:07 +0700
From: "Jonny" <tennis5@pp33head.com>
To: <hg@cs.umass.edu>

Subject: How to secure your savings

```

- P18. a. What is a *whois* database?
- b. Use various whois databases on the Internet to obtain the names of two DNS servers. Indicate which whois databases you used.
 - c. Use nslookup on your local host to send DNS queries to three DNS servers: your local DNS server and the two DNS servers you found in part (b). Try querying for Type A, NS, and MX reports. Summarize your findings.
 - d. Use nslookup to find a Web server that has multiple IP addresses. Does the Web server of your institution (school or company) have multiple IP addresses?
 - e. Use the ARIN whois database to determine the IP address range used by your university.
 - f. Describe how an attacker can use whois databases and the nslookup tool to perform reconnaissance on an institution before launching an attack.
 - g. Discuss why whois databases should be publicly available.

- P19. In this problem, we use the useful *dig* tool available on Unix and Linux hosts to explore the hierarchy of DNS servers. Recall that in Figure 2.19, a DNS server in the DNS hierarchy delegates a DNS query to a DNS server lower in the hierarchy, by sending back to the DNS client the name of that lower-level DNS server. First read the man page for *dig*, and then answer the following questions.
- Starting with a root DNS server (from one of the root servers [a-m]. root-servers.net), initiate a sequence of queries for the IP address for your department's Web server by using *dig*. Show the list of the names of DNS servers in the delegation chain in answering your query.
 - Repeat part (a) for several popular Web sites, such as google.com, yahoo.com, or amazon.com.
- P20. Suppose you can access the caches in the local DNS servers of your department. Can you propose a way to roughly determine the Web servers (outside your department) that are most popular among the users in your department? Explain.
- P21. Suppose that your department has a local DNS server for all computers in the department. You are an ordinary user (i.e., not a network/system administrator). Can you determine if an external Web site was likely accessed from a computer in your department a couple of seconds ago? Explain.
- P22. Consider distributing a file of $F = 20$ Gbits to N peers. The server has an upload rate of $u_s = 30$ Mbps, and each peer has a download rate of $d_i = 2$ Mbps and an upload rate of u . For $N = 10, 100$, and $1,000$ and $u = 300$ Kbps, 700 Kbps, and 2 Mbps, prepare a chart giving the minimum distribution time for each of the combinations of N and u for both client-server distribution and P2P distribution.
- P23. Consider distributing a file of F bits to N peers using a client-server architecture. Assume a fluid model where the server can simultaneously transmit to multiple peers, transmitting to each peer at different rates, as long as the combined rate does not exceed u_s .
- Suppose that $u_s/N \leq d_{\min}$. Specify a distribution scheme that has a distribution time of NF/u_s .
 - Suppose that $u_s/N \geq d_{\min}$. Specify a distribution scheme that has a distribution time of F/d_{\min} .
 - Conclude that the minimum distribution time is in general given by $\max \{ NF/u_s, F/d_{\min} \}$.
- P24. Consider distributing a file of F bits to N peers using a P2P architecture. Assume a fluid model. For simplicity assume that d_{\min} is very large, so that peer download bandwidth is never a bottleneck.
- Suppose that $u_s \leq (u_s + u_1 + \dots + u_N)/N$. Specify a distribution scheme that has a distribution time of F/u_s .