AMERICAN UNIVERSITY OF BEIRUT
MAROUN SEMAAN FACULTY OF ENGINEERING & ARCHITECTURE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
EECE 350/351 - Computer Networks

Problem Set 2
Application Layer

Question 1

For a communication session between a pair of processes, which process is the client and which is the server?

Answer: The process which initiates the communication is the client; the process that waits to be contacted is the server.

Question 2

For a P2P file-sharing application, do you agree with the statement, "There is no notion of client and server sides of a communication session"? Why or why not?

Answer: No. As stated in the text, all communication sessions have a client side and a server side. In a P2P file-sharing application, the peer that is receiving a file is typically the client and the peer that is sending the file is typically the server.

Question 3

What information is used by a process running on one host to identify a process running on another host?

Answer: The IP address of the destination host and the port number of the destination socket.

Question 4

Suppose you wanted to do a transaction from a remote client to a server as fast as possible. Would you use UDP or TCP? Why?

Answer: You would use UDP. With UDP, the transaction can be completed in one round-trip time (RTT) - the client sends the transaction request into a UDP socket, and the server sends the reply back to the client's UDP socket. With TCP, a minimum of two RTTs are needed - one to set up the TCP connection, and another for the client to send the request, and for the server to send back the reply.

Question 5

Why do HTTP, FTP, SMTP, and POP3 run on top of TCP rather than on UDP?

Answer: The applications associated with those protocols require that all application data be received in the correct order and without gaps. TCP provides this service whereas UDP does not.

Question 6

Describe how Web caching can reduce the delay in receiving a requested object. Will Web caching reduce the delay for all objects requested by a user or for only some of the objects? Why?

Answer: Web caching can bring the desired content "closer" to the user, perhaps to the same LAN to which the user's host is connected. Web caching can reduce the delay for all objects, even objects that are not cached, since caching reduces the traffic on links.

Question 7

Telnet into a Web server and send a multiline request message.

Answer: Issued the following command (in Windows command prompt) followed by the HTTP GET message to the "gaia.cs.umass.edu" web server:

```
> telnet gaia.cs.umass.edu 80
GET / HTTP/1.1
Host: gaia.cs.umass.edu
```

Question 8

Suppose Alice, with a Web-based e-mail account (such as Hotmail or Gmail), sends a message to Bob, who accesses his mail from his mail server using POP3. Discuss how the message gets from Alice's host to Bob's host. Be sure to list the series of application-layer protocols that are used to move the message between the two hosts.

Answer: Message is sent from Alice's host to her mail server over HTTP. Alice's mail server then sends the message to Bob's mail server over SMTP. Bob then transfers the message from his mail server to his host over POP3.

Problem 1

True or false?

(a) A user requests a Web page that consists of some text and two images. For this page, the client will send one request message and receive three response messages.

(b) Two distinct Web pages (e.g., www.mit.edu/research.html and www.mit.edu/students.html) can be sent over the same persistent connection.

(c) With non-persistent connections between browser and origin server, it is possible for a single TCP segment to carry two distinct HTTP request messages.

(d) The `Date:` header in the HTTP response message indicates when the object in the response was last modified.

Solution:

- (a) False
- (b) True
- (c) False
- (d) False

Problem 2

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?

Solution:

- Application layer protocols: DNS and HTTP
- Transport layer protocols: UDP for DNS; TCP for HTTP

Problem 3

Consider the following string of ASCII characters that were captured by Ethereal when the browser sent an HTTP GET message:

```
GET /cs453/index.html HTTP/1.1<cr></f>
Host: gaia.cs.umass.edu<cr></f>
User-Agent: Mozilla/5.0 (Windows ;U;
Windows NT 5.1; en-US; rv:1.7.2) Gecko/20040804 Netscape/7.2 (ax) <cr></f>
Accept: ext/xml, application
/xml, application/xhtml+xml, text/html;q=0.9text/plain;q=0.8,image/png,*/*q=
0.5<c r ><If>
Accept- Language: en-us,en;q=0.5<cr><If>
Accept-Encoding: zip, deflate<cr><If>
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7<cr><lf>
Keep-Alive: 300<cr><lf>
Connection: keep-alive<c r ><lf><c r ><lf>
```

Answer the following questions:

(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?

Solution:

- (a) The document request was `http://gaia.cs.umass.edu/cs453/index.html`. The `Host:` field indicates the server's name and `/cs453/index.html` indicates the file name.
- (b) The browser is running HTTP version 1.1, as indicated just before the first <cr><lf> pair.
- (c) The browser is requesting a persistent connection, as indicated by the `Connection: keep-alive`.

- (d) This is a trick question. This information is not contained in an HTTP message anywhere. So there is no way to tell this from looking at the exchange of HTTP messages alone. One would need information from the IP datagrams (that carried the TCP segment that carried the HTTP GET request) to answer this question.

Problem 4

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 2006 12:39:45 GMT<cr><lf>
Server: Apache/2.0.52 (FEDORA)<cr><lf>
Last-Modified: Sat, 10 Dec 2005 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 4.0 transitional//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-ST550A Spring 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?

Solution:

(a) The status code of 200 and the phrase ”OK” indicate that the server was able to locate the document successfully. The reply was provided on Tuesday, 07 Mar 2006 12:39:45 GMT.

(b) The document index.html was last modified on Saturday, 10 Dec 2005 18:27:46 GMT.

(c) There are 3874 bytes in the document being returned.

(d) The first five bytes of the returned document are: <!doc. The server agreed to a persistent connection, as indicated by the `Connection: Keep-Alive` field.

Problem 5

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?

Solution: The total amount of time to get the IP address is:

$$RTT_1 + RTT_2 + \cdots + RTT_n$$

Once the IP address is known, RTT_0 elapses to set up the TCP connection and another RTT_0 elapses to request and receive the small object. The total response time is:

$$RTT_1 + RTT_2 + \cdots + RTT_n + 2RTT_0$$

Problem 6

Referring to the previous problem, suppose the HTML file references three 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 parallel connections?

(c) Persistent HTTP?

Solution:

(a)

$$RTT_1 + \cdots + RTT_n + 2RTT_0 + 3 \cdot 2RTT_0$$
$$= 8RTT_0 + RTT_1 + \cdots + RTT_n.$$

(b)

$$RTT_1 + \cdots + RTT_n + 2RTT_0 + 2RTT_0$$
$$= 4RTT_0 + RTT_1 + \cdots + RTT_n.$$

(c)

$$RTT_1 + \cdots + RTT_n + 2RTT_0 + RTT_0.$$