Computer Networks 2018

Homework 3 solution

1. True of False (25%)

(a) 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.

False

There are four connections since each connection transports exactly one request message and one response message. So, each object will have its one request message instead of there being only one request message.

(b) 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.

True.

It is because both of these web pages are on the same physical server (www.mit.edu).

(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.

False.

In a non-persistent connection, the connection closes after each connection. In this case, the connection will close once the first message is received, and there will be a new connection opened to send the second message.

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

False.

The "Date:" is the time at which the request was created and not when the object was last modified.

(e) HTTP response messages never have an empty message body.

False.

Some HTTP response messages have an empty message body. For example, HTTP Status-Code of 204 and 304 MUST NOT include a message body. (RFC 2616)

2. (25%)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 $RTT_1, \ldots, RTT_n$. 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?

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

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

3. Referring to Problem 2, 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?

$$(2RTT_0 + RTT_1 + RTT_2 + \cdots + RTT_n) + 8 \times 2RTT_0$$
$$= 18RTT_0 + RTT_1 + RTT_2 + \cdots + RTT_n$$

b. Non-persistent HTTP with the browser configured for 5 parallel connections?

$$(2RTT_0 + RTT_1 + RTT_2 + \cdots + RTT_n) + 2 \times 2RTT_0$$
$$= 6RTT_0 + RTT_1 + RTT_2 + \cdots + RTT_n$$

c. Persistent HTTP?

$$(2RTT_0 + RTT_1 + RTT_2 + \cdots + RTT_n) + RTT_0$$
$$= 3RTT_0 + RTT_1 + RTT_2 + \cdots + RTT_n$$

4. 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.

   a. Suppose that $u_s \leq (u_s + u_1 + \cdots + u_N)/N$. Specify a distribution scheme that has a distribution time of F/u_s .

   Define $u = u_1 + \cdots + u_N$. By assumption

   $u_s \leq (u_s + u)/N$ (Equation 1

   Divide the file into N parts, with the i^{th} part having size $(u_i/u)F$. The server transmits the i^{th} part to peer i at rate $r_i = (u_i/u)u_s$. Note that $r_1 + r_2 + \cdots + r_N = u_s$, so that the aggregate server rate does not exceed the link rate of the server. Also have each peer i forward the bits it receives to each of the N-1 peers at rate r_i. The aggregate forwarding rate by peer i is $(N-1)r_i$. We have

$$(N-1)r_i = (N-1)(u_s u_i)/u \leq u_i,$$

where the last inequality follows from Equation 1. Thus the aggregate forwarding rate of peer i is less than its link rate $\mathrm{u_i}$.

In this distribution scheme, peer i receives bits at an aggregate rate of

$$r_i + \sum_{j<>i} r_j = u_s$$

Thus each peer receives the file in $\mathrm{F/u_s}$.

b. Suppose that $\mathrm{u_s \geq (u_s + u_1 + \cdots + u_N)/N}$. Specify a distribution scheme that has a distribution time of $\mathrm{NF/(u_s + u_1 + \cdots + u_N)}$.

Again define $\mathrm{u = u_1 + \cdots + u_N}$. By assumption

$u_s \geq (u_s + u)/N$ (Equation 2

Let $r_i = u_i/(\mathrm{N}-1)$ *and* $r_{N+1} = (u_s - u/(N-1))/N$

In this distribution scheme, the file is broken into N+1 parts. The server sends bits from the i^{th} part to the i^{th} peer (i = 1, …., N) at rate r_i. Each peer i forwards the bits arriving at rate r_i to each of the other N-1 peers. Additionally, the server sends bits from the $(\mathrm{N}+1)^{st}$ part at rate r_{N+1} to each of the N peers. The peers do not forward the bits from the $(\mathrm{N}+1)^{st}$ part.

The aggregate send rate of the server is

$$r_1 + \cdots r_N + N\ r_{N+!} = u/(N-1) + u_s - u/(N-1) = u_s$$

Thus, the server's send rate does not exceed its link rate. The aggregate send rate of peer i is

$$(\mathrm{N}-1)r_i = u_i$$

Thus, each peer's send rate does not exceed its link rate.

In this distribution scheme, peer i receives bits at an aggregate rate of

$$r_i + r_{N+1} + \sum_{j<>i} r_j = u/(N-1) + (u_s - u/(N-1))/N = (u_s + u)/N$$

Thus each peer receives the file in$\mathrm{NF}/(u_s + \mathrm{u})$.

(For simplicity, we neglected to specify the size of the file part for i = 1, …., N+1. We now provide that here. Let $\Delta = (u_s + \mathrm{u})/\mathrm{N}$ be the distribution time. For i = 1, …, N, the i^{th} file part is $F_i = r_i\ \Delta$ bits. The $(\mathrm{N}+1)^{st}$ file part is $F_{N+1} = r_{N+1}\ \Delta$ bits. It is straightforward to show that $F_1 + \cdots + F_{N+1} =$

F.)

c. Conclude that the minimum distribution time is in general given by $\max\{F/u_s,\ NF/(u_s + u_1 + \cdots + u_N)\}$.

We know from section 2.5 that

$$D_{p2p} \geq \max\{F/u_s\,, NF/(u_s + u)\}$$

Combining this with a) and b) gives the desired result.