Homework 2

Handed Out: October 25th, 2023 Due: November 4th, 2023

- Homework assignments must be submitted online through Blackboard. Hard copies are not accepted. Please submit a pdf file to Blackboard. You can either type your solution or scan a legible hand-written copy. We will not correct anything we do not understand. Contact the TAs via email if you face technical difficulties in submitting the assignment.
- While we encourage discussion within and outside of the class, cheating and copying is strictly prohibited. It is also your responsibility to ensure that your partner obeys the academic integrity rules as well.
- This assignment has a total of 100 points.
- **Please write your answer in the white space to the right of the corresponding problem**.

1 Choose all that Apply - 3 $\times$ 4 points

Each question may have more than one correct answer. You will only get points if you identify all the correct answers.

1. Two distinct Web pages (for example, *www.intl.zju.edu.cn/students.html* and *www.intl.zju.edu.cn/research.html*) can be sent over the same persistent connection.

   (a) True

   (b) False

   Answer: a

2. Is it possible for an organization's Web server and mail server to have exactly the same alias for the hostname(for example, foo.com?)

   (a) Yes

   (b) No

   Answer: a

3. Knowing the alias for the mail server, What type of RR should a DNS client to query to get the cannonical name for the mail server?

   (a) A

   (b) NS

   (c) CNAME

   (d) MX

   Answer: d

4. What protocol might be used if a user want to get email from user's mail server to his local PC?

   (a) SMTP

   (b) POP3

   (c) IMAP

   (d) HTTP

   Answer: bcd

2 Short Answer Questions - 5 $\times$ 2 points

1. Briefly explain the advantages and disadvantages of the use of cookie.

Answer: Advantage: track information, convenience...
Disadvantages: privacy problems...

2. 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? Explain why.

Answer: Web caching can bring the desired content "closer" to the user, possibly 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.

3 Web Caching - 7 x 3 points

Assume a group of students in an institution want to access a private server A outside of the institution. The bottleneck link from the institution to this server supports a bitrate of 2MB/S. Assume the average request rate from the institution is 80 times/s and each request is 0.02MB. Assuming there is no other traffic within or outside of the institution, answer the following questions. Assume that queueing delay dominates so you can neglect the much smaller propagation delays, transmit times, and processing delays

1. What is the average access time for a user in the institution to access this server? Assume the queuing delay is 1/(1-L) milliseconds, where L is the fraction of link usage. (Your answer should be in milliseconds).
Answer: 1/(1-0.02 * 80/2) = 5ms

2. To improve network performance, we now increase the bitrate of this bottleneck link to 6MB/s. Calculate the average access time again. Your unit should be milliseconds and must be computed up to 2 decimal places.
Answer: 1/(1-0.02 * 80/6) = 1.36ms

3. Another way to improve network performance is to add a cache server within the institution without increasing the bandwidth of bottleneck link. The bitrate to the cache server is 10MB/s. Assume there is a 60% cache hit rate. The queuing delay for both cache server and server A follows the formula in Q1. Calculate the average access time in this case. (Assume the network knows cache server so no additional delays are needed to find that cache server; also, your unit should be milliseconds, computed to 2 decimal places).

Answer: delay for cache: 1/(1-0.02*80* 0.6/10) = 1.10619 ms, delay for origin: 1/(1-0.02*80*0.4/2) = 1.47ms, total: 1.10619 * 0.6 + 1.4706 * 0.4 = 1.25 ms

4 Traceroute - 4 $\times$ 3 points

In the next 2 figures, you will see a series of results from running traceroute (with the -q 1 option to send one probe per hop). For each of the results, please answer the following questions:

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traceroute to www.google.com (216.58.192.132), 64 hops max, 52 byte packets
 1  0148-cslgeneral-net.gw.uiuc.edu (192.17.100.1)  0.958 ms
 2  t-core1-2.gw.uiuc.edu (172.20.101.29)  0.660 ms
 3  t-exiti1.gw.uiuc.edu (130.126.0.162)  0.321 ms
 4  t-fw1.gw.uiuc.edu (130.126.0.134)  0.716 ms
 5  t-exite1.gw.uiuc.edu (130.126.0.141)  1.067 ms
 6  t-dmzo.gw.uiuc.edu (130.126.0.202)  1.087 ms
 7  ur1rtr-uiuc.ex.ui-iccn.org (72.36.127.1)  1.100 ms
 8  t-ur2rtr.ix.ui-iccn.org (72.36.126.66)  1.413 ms
 9  r-equinix-isp-ae0-2244.wiscnet.net (216.56.50.49)  4.007 ms
10  74.125.49.37 (74.125.49.37)  4.113 ms
11  209.85.254.157 (209.85.254.157)  4.390 ms
12  216.239.42.149 (216.239.42.149)  4.459 ms
13  216.239.42.153 (216.239.42.153)  4.375 ms
14  ord36s01-in-f132.1e100.net (216.58.192.132)  4.414 ms
```

1. Which hop(s) (if any) is transoceanic

Answer:
(a) No transoceanic hop.
(b) 13-14

2. Based on the RTT to the last hop, what's the furthest away the corresponding server could possibly be located? (Note: use speed of packet propagation: (2×10^8) m/s.)

(a)RTT for last hop is 4.414 ms, and one side delay is 2.207 ms. If we take speed of packet propagation as (2×10^8), we have the maximum possible distance for the last hop router as $(2 \times 10^8) m/s \times (2.207 \times 10^{-3}) s = 441 km$. This is the maximum possible distance because the 2.207 ms also includes processing and queuing delays in addition to propagation delays.

(b) $206.567/2 \times 10^{-3} \times 2 \times 10^8 = 20657 km$

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traceroute to www.auckland.ac.nz (130.216.159.127), 64 hops max, 52 byte packets
 1  0148-cslgeneral-net.gw.uiuc.edu (192.17.100.1)  0.967 ms
 2  t-core1-1.gw.uiuc.edu (172.20.101.25)  0.536 ms
 3  t-exit1.gw.uiuc.edu (130.126.0.242)  0.407 ms
 4  t-fw1.gw.uiuc.edu (130.126.0.134)  0.666 ms
 5  t-exite1.gw.uiuc.edu (130.126.0.141)  0.937 ms
 6  t-dmzo.gw.uiuc.edu (130.126.0.202)  12.626 ms
 7  ur1rtr-uiuc.ex.ui-iccn.org (72.36.127.1)  1.051 ms
 8  t-ur2rtr.ix.ui-iccn.org (72.36.126.66)  1.576 ms
 9  internet2-710rtr.ex.ui-iccn.org (72.36.127.158)  4.107 ms
10  et-7-1-0.4070.rtsw.kans.net.internet2.edu (198.71.45.15)  21.305 ms
11  et-4-1-0.4070.rtsw.salt.net.internet2.edu (198.71.45.19)  41.337 ms
12  et-4-1-0.4070.rtsw.salt.net.internet2.edu (198.71.45.19)  41.280 ms
13  aarnet-1-is-jmb-776.lsanca.pacificwave.net (207.231.241.149)  81.268 ms
14  et-1-2-1.pe1.a.koa.aarnet.net.au (113.197.15.86)  205.814 ms
15  et-1-2-1.pe1.a.koa.aarnet.net.au (113.197.15.86)  205.753 ms
16  et-1-0-0-202.and12-nsh.reannz.co.nz (182.255.119.201)  205.921 ms
17  br-cpf1-north.net.auckland.ac.nz (130.216.95.106)  206.111 ms
18  cxj-alfa-430.net.auckland.ac.nz (130.216.95.122)  208.200 ms
19  cxj-alfa-430.net.auckland.ac.nz (130.216.95.122)  207.881 ms
20  *
21  www.auckland.ac.nz (130.216.159.127)  206.567 ms
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3. Sometimes the RTT of a subsequent hop is lower than the RTT of a previous one. Give one reason for this.

Answer: The RTT of a subsequent hop might be lower than the RTT of a previous one, because we are dealing with a real network which is very dynamic. Hence the various delays like queuing delays might vary over time, making it possible for subsequent RTTs to be smaller than the RTT of a previous hop.

5 HTTP - 7 × 3 points

Suppose a webpage has nothing but 10 large images each of size 10 MB. A client wants to access the webpage and load the images in his browser. The RTT between the client and the server is 40 ms and the transmission rate at the server is 500 MB/s. How long will it take to load the webpage in each of the following cases? (Note: the size of the object for indexing is negligible.) For all answers, please answer in milliseconds, and include the detail

Note: if you assume there should be a delay for closing the HTTP connection, or if you assume that it takes no time (RTT) to fetch the webpage itself, the answers are also accepted1. Using Non-Persistent HTTP?

Answer: It will take 2 × RTT + (2 × RTT + 10MB/ 500MB/s) × 10 = 200 + 400 × 50 = 1080ms
2. Using Persistent HTTP?

Answer: It will take 2 × RTT + (RTT + 10MB/ 500MB/s) × 10 = 680ms

3. Using Pipelined Persistent HTTP?
Answer: It will take 2 × RTT + RTT + 10MB/ 500MB/s × 10 = 320ms

6 Client-Server - 7 × 2 points

Think about spreading an F-bit file among N peers using a client-server structure. Let the server have a maximum upload capacity μ_s, and each client c has a download capacity d_c. Assume that the server can serve multiple clients simultaneously and fluidly set the rate for each client r_c.

1. Suppose that $\mu_s/N \leq d_{min}$, where $d_min = min_c d_c$ be the minimum download rate. How would you set the rates r_c for each client so that the file is fully distributed to all clients in a minimum time? (i.e., you are minimizing the time that the slowest client receives the file.) What would the distribution time be?
Answer: The time required to distribute a file of F bits to N peers is given by max Since here we have $\mu_s/N \leq d_{min}$, this implies $NF/s \geq F/d_{min}$. Hence the distribution time will be NF/μ_s, with each client being set a rate of µs/N, i.e. $r_c = \mu_s/N$ for all c

2. Suppose now that $\mu_s/N > d_{min}$. How would you set the rates r_c now to fully distribute the file to the clients in a minimum time? And what would this time be?
Answer: In this case we have $\mu_s/N > d_{min}$. Hence $NF/\mu_s < F/d_{min}$, and the minimum time required to distribute the file will be F/d_{min}. Hence the distribution time here is being defined by the bottleneck client and we need to ensure that the bottleneck client is set to maximum capacity, i.e. d_{min}. All other clients, as long as they are faster than d_{min}, will not affect the distribution time. Hence the valid client rate setting would be: $\forall_c r_c \geq r_{min} = d_{min}(where \forall_c r_c \leq d_c and \sum_c r_c \leq \mu_s)$.

7 DNS - 7 + 3 points

The task requires using the **dig** command to provide answers. To ensure accurate results, it is recommended to perform these steps from a computer located on a campus network. The user can refer to the dig documentation to understand how to utilize it.

1. Starting from one of the root servers a–m.root-servers.net, perform an **iterative** lookup for the host www.eecs.mit.edu to get the ip address. For instance, you can initiate the search by using the following command:
dig @h.root-servers.net www.eecs.mit.edu
(You may first use **dig www.eecs.mit.edu** to get the canonical name and use the canonical name for the following query.)
show the process of your query and point out:
(1) the domain name of the name server being visited
(2) the IP address of the name server that is currently being used
(3) For how long can you store the results in cache.
Answer: (1) is the domain name after "@" in the command, (2) is provided in the "SERVER:" line in the end of the response, (3) is provided in the second column of both "ANSWER" and "AUTHORITY" section.

2. Can you explain why the DNS protocol tends to utilize UDP rather than TCP?
Answer: TCP would require a connection establishment part for each query, so you would have to add an RTT to each of the steps in the lookup. OR There are too much overhead and delay of establishing TCP connection (3-wary handshake, which will be covered in later lectures) for small packets of DNS. Also, UDP does not have to keep connection states, which allows the server to support many more active clients than using TCP.