## Instructions

This assignment is due on **Thursday 20$^{\text{th}}$ February, 2020 by 1:00pm EST**
Please typewrite your answers and submit a pdf file to Canvas. You should complete this
assignment individually.
There are some **extra** credits for **EECS 325 and 325N** students. Credit points are shown
in front of each question. **Credits are marked as red for EECS 325/325N, and blue
for EECS 425, if they are different.**

Questions

1. (6pts) Consider a web page whose base file is of size $S_1 = 10$ KB. Assume that the
   web page consists of $N = 20$ inline objects each of size $S_2 = 100$ KB. Assume that the
   round-trip time to the web server is $T = 100$ ms and the bottleneck capacity is $C = 10$
   Mbps. Ignore any packetization delays and header overhead.

   a. (1pt) Assuming non-persistent HTTP is used with a single TCP connection, how
   long does it take to download the web page?

   b. (1pt) Assuming non-persistent HTTP is used with 4 parallel TCP connections,
   how long does it take to download the web page?

   c. (2pts) Assuming pipelined, persistent HTTP is used, how long does it take to
   download the web page? "Pipelined" means requests for multiple objects can be sent
   back-to-back on the same connection.

   d. (2pts) Assuming non-pipelined, persistent HTTP with 2 parallel TCP connections
   is used, how long does it take to download the web page? Assume that the 2 parallel
   connections equally share the total available bandwidth C.

2. (8pts) Consider the figure used to illustrate Web caching below. Suppose that the ac-
   cess link capacity is **C** bits/sec and the average object size is **S** bits and that the average
   request rate from the institution's browsers to the origin servers is **A** requests/sec. 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 **T** seconds
   on average. Model the total average response time perceived by the institutional users
   as the sum of the average access delay (that is, the delay from the Internet router to
   institution router) and the average Internet delay. For the average access delay, use
   $\dfrac{D}{1 - DB}$, where **D** is the average time required to transmit an object over the access
   lnik and **B** is the arrival rate of objects to the access link. Note that this access delay
   includes both the transmission and queuing delays. (Note also that B = A if there is
   no caching.) Ignore the details of persistent or non-persistent HTTP in this question
   as well as any LAN delays.
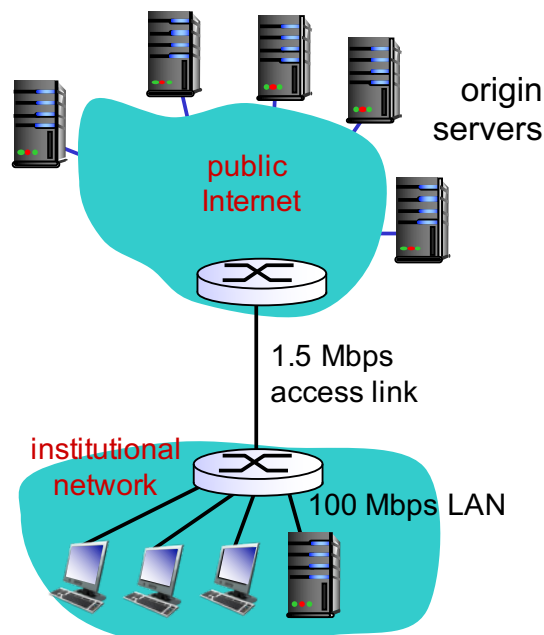
a. (2pts) What is the total average response time T_1?

b. (2pts) Now suppose a cache is installed in the institutional LAN and its hit rate is p. What is the total average response time T_2?

c. We didn't model DNS delays above. Suppose the root, TLD, and authoritative name servers are located at round-trip latencies of R_1, R_2, R_3 seconds respectively. What is the additional delay introduced by DNS if

   i) (2pts) the institution maintains a local name server internally in its LAN

   ii) (2pts) the local name server in maintained by the institution's ISP at a round-trip distance of R_0

3. a. (5pts) The DNS root hints file is a file that all DNS resolvers have to be able to bootstrap their resolution abilities. It is located at `http://www.internic.net/domain/named.root`, and it has entries for each root server as such:

```
.                         3600000       NS    A.ROOT-SERVERS.NET.
A.ROOT-SERVERS.NET.       3600000       A     198.41.0.4
A.ROOT-SERVERS.NET.       3600000       AAAA  2001:503:ba3e::2:30
;
.                         3600000       NS    B.ROOT-SERVERS.NET.
B.ROOT-SERVERS.NET.       3600000       A     199.9.14.201
B.ROOT-SERVERS.NET.       3600000       AAAA  2001:500:200::b
```

If you have only this file, how can you use the information in it, and `dig`, to look up

`www.facebook.com`? List the steps you need to take (along with the answer you might get), using the syntax `dig <name> @<server> <record type> +norecursive`.

b. Suppose you run a website at `www.foo.net`:

   i (2pts) Which name servers need to change their databases if you decide to change the name to `www.foo.com`?

   ii (1pt) To `web.foo.net`?

   iii (2pts) What needs to change if you decide to keep the name `www.foo.net`, but change the IP address?

c. (1pt) Explain why using a DNS resolver out on the Internet (i.e., open resolver) can result in poor choice of CDN servers.