CSE3300/CSE5299: Computer Networking
Homework 2

Due Date: **9/21/2025, Sunday**. Submission through HuskyCT.
Full score: 100 for CSE3300 students; 120 for CSE5299 students (will be normalized to 100 when entering the grade in HuskyCT).

1. **Packet-switched network: message segmentation (15 points).** Consider sending a large file of F bits from Host A to Host B. There are three links (and two routers) between A and B. Assume no queuing delay at the routers. Host A segments the file into packets of S bits each and adds 40 bits of header to each packet. Each link has a transmission rate of R Kbps. Suppose $F = 80,000$ bits, $R = 1$ Mbps. What is the delay of moving the file from A to B

   a. (5 points) when $S = F$?

$$\text{Per link transmission time: } \frac{80{,}040}{1{,}000{,}000} = 0.08004 \text{ s}$$

$$\text{Total delay: } 3 \times 0.08004 = \mathbf{0.24012} \text{ s.}$$

   b. (10 points) when $S = 8000$ bits?

$$\text{Per link transmission time: } \frac{8{,}040}{1{,}000{,}000} = 0.00804 \text{ s.}$$

$$\text{Total Delay: } 0.02412 + (10 - 1) \times 0.00804 = 0.09648 \text{ s.}$$

   We'll ignore nodal processing delay and propagation delay for this problem. Show intermediate steps.

2. **DNS (15 pts).**

   a. (5 points) Why might a local DNS server be able to skip sending a query to the Root DNS server? Already cached.

   b. (5 points) What type of response does the local DNS server receive from the TLD server, referral or final answer? referral

   c. (5 points) What TLD server is responsible for Amazon (amazon.com)? com

3. **DNS and HTTP (10 points).** Suppose within your web browser you click on a link to obtain a web page. The IP address of the associated URL **is not cached** in your local host, so a DNS look-up is necessary to obtain the IP address. Suppose that n DNS servers are visited before your host eventually receives the IP address from DNS; the successive visits incur an RTT of $T_1, T_2, \dots T_n$. Further suppose that the web page associated with the link contains exactly one object, consisting of a small amount of HTML text (i.e., the URL only has a base HTML file, with no embedded objects). Let T_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?

   Total time = DNS look up + TCP handshake + HTTP request = $\sum_{i=1}^{n} T_i \; + \; 2T_0$.

4. **HTTP (5 points).** Suppose within your web browser you click on a link to obtain a web page. The IP address of the associated URL is **already cached** in your local host, so no DNS look-up is necessary to obtain the IP address. Further suppose that the web page associated with the link contains exactly one object, consisting of a small amount of HTML text (i.e., the URL only has a base HTML file, with no referenced/embedded objects). Suppose TCP is the underlying transport protocol. Let T 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 you click on the link until the client receives the object?

   2T

5. **Persistent and non-persistent HTTP (20 points).** In the previous problem, suppose the base HTML references 9 very small objects on the same server. Neglect transmission times. Determine in each case below, (1) how much time elapses from when the client clicks on the link until the client receives the web page (i.e., all the objects, including the base and all referenced objects)? (2) how many TCP connections are opened?

   (a) non-persistent HTTP with no parallel TCP connections?
   20T

   (b) non-persistent HTTP with three parallel TCP connections?
   Connection 1: 2T 2T 2T 2T
   Connection 2: 2T 2T 2T
   Connection 3: 2T 2T 2T
   Total: 8T

   (c) persistent HTTP without pipelining?
   TCP(1T)+Base(1T)+9 obj(9T) = 11T

   (d) persistent HTTP with pipelining?
   TCP(1T) + Base(1T) + 9 very small obj(1T) = 3T

6. **Web proxy (15 points).** Fig. 1 shows an institutional network that is connected to the Internet. Specifically, there is a router (R_1) in the institution that is connected to an access link, which is connected to a router in the Internet (R_2). Suppose that the average object size is $900,000$ bits and that the average request rate from the institution's browsers to the original servers is 1.66×10^3 requests per second. The access link bandwidth is 1.5 Gbps. Also suppose that the amount of time it takes from when R_2 forwards an HTTP request until it receives the response is 100 ms on average (i.e., the average Internet delay, denoted as d,

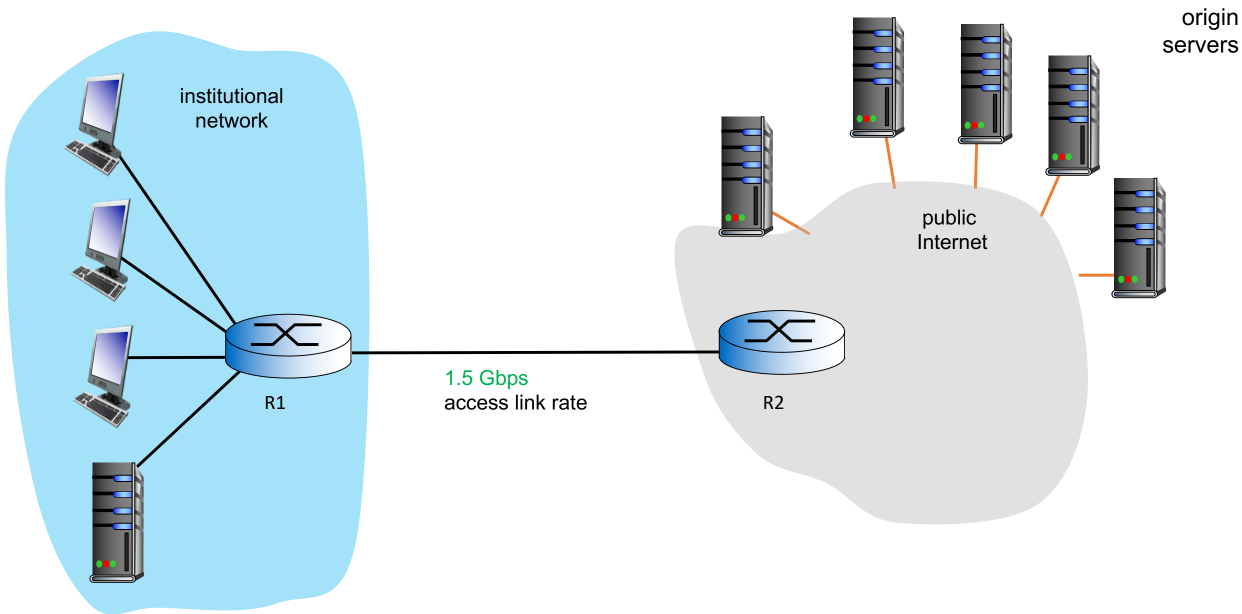

Figure 1: Illustration of an institutional network that is connected to the external Internet through an access link.

is 100 ms). We model the total average response time as the sum of the average access delay (that is, the delay from the Internet router R_2 to the institution router R_1) and the average Internet delay (i.e., $d = 100$ ms); all the other types of delays (e.g., the delays in the LAN) are ignored in this problem. For the average access delay, we model it as $\Delta/(1-\Delta\beta)$, 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) (5 points) Calculate the total average response time.

$$\Delta \;=\; \frac{900{,}000}{1.5\times 10^9} \;=\; 0.0006 \text{ s.}$$

$$\beta = 1.66\times 10^3 \text{ req/s}$$

$$\Delta\beta \;=\; 0.0006\times 1660 \;=\; 0.996$$

$$\text{Access delay} \;=\; \frac{\Delta}{1-\Delta\beta} \;=\; \frac{0.0006}{1-0.996} \;=\; 0.15 \text{ s.}$$

$$\text{Response time} = 0.15 + 0.1 = 0.25\text{s}$$

(b) (10 points) Now suppose a cache is installed in the institutional LAN. Suppose the hit rate is 0.4. Calculate the total response time.

$$\beta' = (1-p_h)\times 1.66\times 10^3 = 0.6\times 1660 = 996 \text{ req/s}$$

$$\Delta\beta' \;=\; 0.0006\times 996 \;=\; 0.5976$$

$$\text{New Access delay} = \frac{0.0006}{1-0.5976} \approx 0.0015 \text{ s.}$$

$$\text{New response time} = 0.0015{+}0.1 = 0.1015\text{s}$$

$$\text{Total time required} = 0.6 \cdot (0.1015) + 0.4 \cdot (\text{LAN delay} = 0) = 0.0609\text{s}$$

7. **Wireshark labs (20 points).** If you have not worked on Wireshark "Intro", please go over that first. For this homework, work on "HTTP" lab (posted in HuskyCT) and submit your answers to questions 1-7 (on "The Basic HTTP GET/response interaction").

8. **(For CSE5299 students only) (20 points)** Consider sending a large file of F bits from Host A to Host B. There are three links (and two routers) along the path. Host A segments the file into segments of S bits each and adds 160 bits of header to each segment, forming packets of $S+160$ bits. Each link has a transmission rate of R bps. Find the value of S that minimizes the delay of moving the file from Host A to Host B.

$$\text{Number of packets:}\frac{F}{S}$$

$$\text{Per Link transmission time:}\frac{S+160}{R}$$

$$\text{Wait time for the last packet till transmission:}[(\frac{F}{S})-1]\cdot\frac{S+160}{R}$$

$$\text{Last packet arrives at destination at:}3\cdot\frac{S+160}{R}+[(\frac{F}{S})-1]\cdot\frac{S+160}{R}$$

$$\text{Take partial derivative w.r.t S and set to 0:}\frac{d}{d_S}(\frac{S+160}{R}\cdot[(\frac{F}{S})+2])=0$$

$$\text{Product rule:}\frac{S+160}{R}\cdot(-\frac{F}{S^2})+[\frac{F}{S}+2]\frac{1}{R}=0$$

$$\text{Move 1st item to RHS and Simplify: }\frac{F}{S}+2=(S+160)\cdot(\frac{F}{S^2})$$

$$\text{Final result:}S=\sqrt{80F}$$