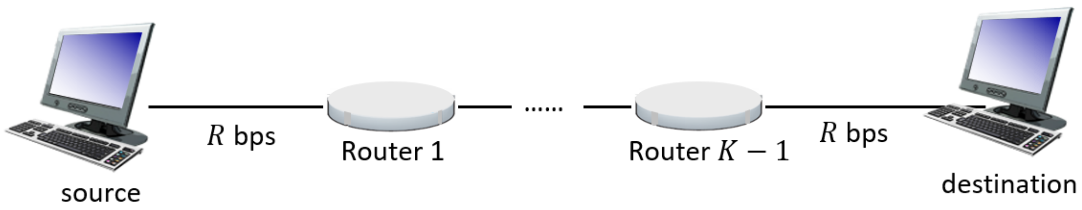
CS305: Computer Networking
2022 Fall Semester Written Assignment # 1

Due: Oct. 25th, 2022, please submit through Sakai

Please answer questions in English. Using any other language will lead to a zero point.

Q 1. Consider a packet of L bits sending from the source to destination through a K-hop path. That is, there are $K-1$ routers between the source and destination. Suppose each link has a transmission rate of R bits per



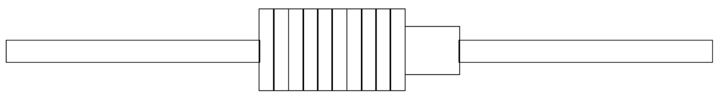
second (bps), and the propagation delay is d for each hop.

(a) Consider a packet switching network. Suppose there is no nodal processing delay and queuing delay. What is the end-to-end delay?

(b) Consider a circuit switching network. Suppose the circuit setup time is τ seconds, and links in the network use time division multiplexing (TDM) with M slots. What is the end-to-end delay?

(c) Consider a packet switching network with $L = 1000$ bits, $K = 2$, $R = 10$ Mbps, $d = 40\mu s$. There are two packets sent one after the other, and there are no other packet in the system. Let the nodal processing delay at the router be $25\mu s$. Compute the time required to send both packets from the source and destination.

Q 2. Consider a queue with a transmission rate of R bps. There are a set of packets with length L bits. Consider a time-slotted system with $\mathcal{T} = \{0, 1, \cdots\}$. Each time slot corresponds to a duration of L/R seconds.



(a) Suppose there is one packet arrival at the beginning of each time slot. What is the average queuing delay of these packets?

(b) Suppose N packets arrive simultaneously at the beginning of each of the time slots $t = kNL/R$, where k is a nonnegative integer. What is the average queuing delay of these packets? What is the average queuing delay when N approaches infinity?

(c) Derive the traffic intensity of the setting in (a) and (b) respectively. Any insights from the results?

Q 3. Explain the five-layer Internet protocol stack. Please include the following details:

- What are the five layers?
- What is the functionality or description of each layer?
- What are the typical protocols of each layer (if any)?

Q 4. Consider the following message and answer questions.

(a) Does HTTP message run on top of TCP or UDP? Why is TCP or UDP a better choice? Please explain the reason by considering the features of TCP or UDP.

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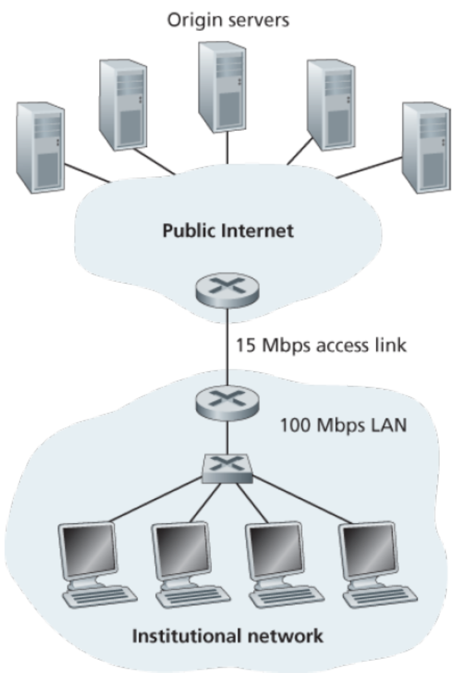
(b) Is this message an HTTP request message or an HTTP response message?

(c) Does this message corresponds to a non-persistent or a persistent connection?

(d) Suppose the browser who sent this message was assigned an identification number 1150 by the associated host. What is the corresponding entry in the cookie file of the browser? To specific its cookie, which header line (including header field name and value) should be included in the message?

(e) If the server receives this message successfully and is going to return the requested object in a message, what would be the status line? What would be included in the entity body?

Q 5. Consider the following figure with an institutional network connected to the Internet. Consider an object



size of 650, 000 bits. Suppose the institution's browsers has an average request rate of 20 requests per second, and all those requests are sent to the origin servers. Suppose the average Internet delay, i.e., the average round trip time that the router on the Internet side of the access link sends a requests to the origin servers, is three seconds. Let

$$TotalAverageResponseTime = AverageAccessDelay + AverageInternetDelay. \tag{1}$$

The average access delay is the delay from Internet router to institution router. The average access delay is equal to $\Delta/(1-\Delta)$, where Δ is the average time required to send an object over the access link, and is the arrival rate at the access link.

(a) Derive the total average response time of the system.

(b) Suppose there is a cache installed in the institutional LAN, and the hit rate is 0.4. Derive the total response time.

Q 6. Suppose you click a web page within your Web browser, and your local DNS server does not have any related resource records. Assume that before your host receives the IP address from DNS, the successive visits incur RTT of $\text{RTT}_1, \ldots, \text{RTT}_n$. On the web page you visit, there are an HTTP basic file and ten referenced objects. Let RTT_0 denote the RTT between the local host and the Web server. We ignore the transmission time of the objects. Compute how much time elapses from when you click the link until your web browser receives the objects.

(a) Non-persistent HTTP with no parallel TCP connections?

(b) Non-persistent HTTP with the browser configured for 4 parallel connections?

(c) Persistent HTTP? In this case, the client can send requests of referenced object back-to-back without waiting for the responses.

Q 7. Answer the following questions:

(a) Explain the differences between HTTP and SMTP

(b) Can SMTP be used as a mail access protocol? Why?

(c) Can we place the receiver's mail server at the receiver's PC? How about placing the sender's mail server at the sender's PC?

(d) Does DNS run on top of TCP or UDP? Why?

Q 8. Consider a server distributes a file of $F = 15$ Gbits to N peers. The server has a upload rate of $u_s = 30$ Mbps. Each peer has a upload rate of u Mbps and a download rate of $d = 2$ Mbps. Please plot or draw the following curves with x-axis corresponding to N (ranging from 1 to 1000) and y-axis corresponding to the minimum distribution time.

(a) Client-server distribution

(b) P2P distribution with $u = 100$ Kbps, 600 Kbps, 4 Mbps, respectively.

Q 9. Consider distributing a file of F bits to N peers using a client-server architecture. Assume a fluid model where the server can simultaneously transmit to multiple peers, transmitting to each peer at different rates, as long as the combined rate does not exceed u_s.

(a) Suppose that $u_s/N \leq d_{min}$. Specify a distribution scheme that has a distribution time of NF/u_s.

(b) Suppose that $u_s/N \geq d_{min}$. Specify a distribution scheme that has a distribution time of F/d_{min}.

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