COSC 4P14
Assignment 1

Due date: October 8th, 2020 at 23:55 (11:55pm)
Delivery method: the student needs to delivery the assignment only through Sakai.
Delivery contents: document with answers and [Java, C, C++] codes if applicable (see Submission instructions).

Attention: check the Late Assignment Policy.

Introduction [30]

1.1. Suppose users share a 2 Mbps link. Also suppose each user transmits continuously at 1 Mbps when transmitting, but each user transmits only 20 percent of the time. (Refer the discussion of statistical multiplexing). **[15]**

- **a.** When circuit switching is used, how many users can be supported?
- **b.** For the remainder of this problem, suppose packet switching is used. Why will there be essentially no queuing delay before the link if two or fewer users transmit at the same time? Why will there be a queuing delay if three users transmit at the same time?
- **c.** Find the probability that a given user is transmitting.
- **d.** Suppose now there are three users. Find the probability that at any given time, all three users are transmitting simultaneously. Find the fraction of time during which the queue grows.

1.2. Perform a Traceroute between source and destination on the same continent at three different hours of the day. **[15]**

- **a.** Find the average and standard deviation of the round-trip delays at each of the three hours.
- **b.** Find the number of routers in the path at each of the three hours. Did the paths change during any of the hours?
- **c.** Try to identify the number of ISP networks that the Traceroute packets pass through from source to destination. Routers with similar names and/or similar IP addresses should be considered as part of the same ISP. In your experiments, do the largest delays occur at the peering interfaces between adjacent ISPs?
- **d.** Repeat the above for a source and destination on different continents. Compare the intra-continent and inter-continent results.

Application Layer [30]

2.1. Consider the following string of ASCII characters that were captured by Wireshark when the browser sent an HTTP GET message (i.e., this is the actual content of an HTTP GET message). The characters <cr><lf> are carriage return and line-feed characters (that is, the italized character string <cr> in the text below represents the single carriage-return character that was contained at that point in the HTTP header). Answer the following questions, indicating where in the HTTP GET message below you find the answer. **[10]**

```
GET /~rdegrande/index.html HTTP/1.1<cr><lf>Host: cosc.brocku.ca
<cr><lf>User-Agent: Mozilla/5.0 (
Windows;U; Windows NT 5.1; en-US; rv:1.7.2) Gec
ko/20040804 Netscape/7.2 (ax) <cr><lf>Accept:ex
t/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>
```

a. What is the URL of the document requested by the browser?

b. What version of HTTP is the browser running?

c. Does the browser request a non-persistent or a persistent connection?

d. What is the IP address of the host on which the browser is running?

e. What type of browser initiates this message? Why is the browser type needed in an

f. HTTP request message?

2.2. 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 RTT1,. . .,RTTn. 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. **[10]**

a. 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?

b. Suppose the HTML file references eight very small objects on the same server. Neglecting transmission times, how much time elapses with Non-persistent HTTP with no parallel TCP connections?

c. Suppose the HTML file references eight very small objects on the same server. Neglecting transmission times, how much time elapses with Non-persistent HTTP with the browser configured for 5 parallel connections?

d. Suppose the HTML file references eight very small objects on the same server. Neglecting transmission times, how much time elapses with Persistent HTTP?

2.3. Consider distributing a file of F=15 Gbits to N peers. The server has an upload rate of us=30 Mbps, and each peer has a download rate of di=2 Mbps and an upload rate of u. For N=10, 100, and 1,000 and u=300 Kbps, 700 Kbps, and 2 Mbps, prepare a chart giving the minimum distribution time for each of the combinations of N and u for both client-server distribution and P2P distribution. **[10]**

Transport Layer [40]

3.1. UDP and TCP use 1s complement for their checksums **[10]**.

- **a.** Suppose you have the following 2 bytes: 01011100 and 01100101. What is the 1s complement of the sum of these 2 bytes?
- **b.** Suppose you have the following 2 bytes: 11011010 and 01100101. What is the 1s complement of the sum of these 2 bytes?
- **c.** For the bytes in part (a), give an example where one bit is flipped in each of the 2 bytes and yet the 1s complement doesn't change.

3.2. Compare GBN, SR, and TCP (no delayed ACK). Assume that the timeout values for all three protocols are sufficiently long such that 5 consecutive data segments and their corresponding ACKs can be received (if not lost in the channel) by the receiving host (Host B) and the sending host (Host A) respectively. Suppose Host A sends 5 data segments to Host B, and the 2nd segment (sent from A) is lost. In the end, all 5 data segments have been correctly received by Host B **[15]**.

- **a.** How many segments has Host A sent in total and how many ACKs has Host B sent in total? What are their sequence numbers? Answer this question for all three protocols.
- **b.** If the timeout values for all three protocol are much longer than 5 RTT, then which protocol successfully delivers all five data segments in shortest time interval?

3.3. Consider that only a single TCP (Reno) connection uses one 10Mbps link which does not buffer any data. Suppose that this link is the only congested link between the sending and receiving hosts. Assume that the TCP sender has a huge file to send to the receiver, and the receiver's receive buffer is much larger than the congestion window. We also make the following assumptions: each TCP segment size is 1,500 bytes; the two-way propagation delay of this connection is 150 msec; and this TCP connection is always in congestion avoidance phase, that is, ignore slow start **[15]**.

- **a.** What is the maximum window size (in segments) that this TCP connection can achieve?
- **b.** What is the average window size (in segments) and average throughput (in bps) of this TCP connection?
- **c.** How long would it take for this TCP connection to reach its maximum window again after recovering from a packet loss?

Marking Scheme

Marks will be awarded for completeness and demonstration of understanding of the material. It is important that you fully show your knowledge when providing solutions in a concise manner. Quality and conciseness of solutions are considered when awarding marks. Every code added to the originals should be well commented and explicitly indicated in the Java files; lack of clarity may lead you to loose marks, so keep it simple and clear.

Submission
The submission is expected to contain one part: a word processed document. The document can only be in DOC, DOCX, ODT, or PDF format; it should be single column, at least single spaced, and at least in font size 11. All the submission should be performed electronically through Sakai.

Late Assignment Policy
A penalty of 25% will be applied on late assignments. Late assignments are accepted until the Late Assignment Date, three days after the Assignment Due Date. No excuses are accepted for missing deadlines. However, deadline extensions may be granted under extenuating circumstances, such as medical or physical conditions; please note that granting the extension is under the instructor's discretion. However, deadline extensions may be granted under extenuating circumstances, such as medical or physical conditions; please note that granting the extension is under the instructor's discretion.

Plagiarism
Students are expected respect academic integrity and deliver evaluation materials that are only produced by themselves. Any copy of content, text or code, from other students, books, web, or any other source is not tolerated. The similarity check tool, Turnitin, will be employed to identify plagiarism in the submitted document. If there is any indication that an activity contains any part copied from any source, a case will be open and brought to a plagiarism committee's attention. In case plagiarism is determined, the activity will be cancelled, and the author(s) will be subject to the university regulations. For further information on this sensitive subject, please refer to the document below:

`https://brocku.ca/academic-integrity/`