CSC 4501
Homework 1
Fall 2017
Duedate: Sept 25, Monday 10:30am in the classroom

1. Consider sending a packet from a source host to a destination host over a fixed route. List the delay components in the end-to-end delay. Which of these delays are constant and which are variable?

2. How long does it take a packet of length 5,250 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5 * 10^8 m/s, and transmission rate 2.5 Mbps? More generally, how long does it take a packet of length *L* to propagate over a link of distance *d*, propagation speed *s*, and transmission rate *R* bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

3. Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates *R1* = 400 kbps, *R2* = 3 Mbps, and *R3* = 2 Mbps.
   a. Assuming no other traffic in the network, what is the throughput for the file transfer?
   b. Suppose the file is 4.5 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?
   c. Repeat (a) and (b), but now with *R2* reduced to 150 kbps.

4. Consider two hosts, A and B, connected by a single link of rate *R* bps. Suppose that the two hosts are separated by *m* meters, and suppose the propagation speed along the link is *s* meters/sec. Host A is to send a packet of size *L* bits to Host B.
   a. Express the propagation delay, *d_prop*, in terms of *m* and *s*.
   b. Determine the transmission time of the packet, *d_trans*, in terms of *L* and *R*.
   c. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.
   d. Suppose Host A begins to transmit the packet at time *t* = 0. At time *t* = *d_trans*, where is the last bit of the packet?
   e. Suppose *d_prop* is greater than *d_trans*. At time *t* = *d_trans*, where is the first bit of the packet?
   f. Suppose *s* = 2.5 * 10^8, *L* = 375 bits, and *R* = 30 kbps. Find the distance *m* so that *d_prop* equals *d_trans*.

5. Consider a packet of length *L* which begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let *d_i*, *s_i*, and *R_i* denote the length, propagation speed, and the transmission rate of link *i*, for *i* = 1, 2, 3. The packet switch delays each packet by *d_proc*. Assuming no queuing delays, in terms of *d_i*, *s_i*,

R_i (for $i = 1, 2, 3$), and L, what is the total end-to-end delay for the packet? Suppose now the packet is 5,000 bytes, the propagation speed on all three links is $2.5 * 10^8$ m/s, the transmission rates of all three links are 3.5 Mbps, the packet switch processing delay is 2 msec, the length of the first link is 7,000 km, the length of the second link is 4,500 km, and the length of the last link is 3,500 km. For these values, what is the end-to-end delay?

6. In the previous problem, suppose $R1 = R2 = R3 = R$ and $d_{proc} = 0$. Further suppose the packet switch does not store-and-forward packets but instead immediately transmits each bit it receives before waiting for the entire packet to arrive. What is the end-to-end delay?

7. Perform a Traceroute between source and destination on the same continent at three different hours of the day.
    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.

8. Suppose two hosts, A and B, are separated by 23,000 kilometers and are connected by a direct link of $R = 2.5$ Mbps. Suppose the propagation speed over the link is $2.5 * 10^8$ meters/sec.
    a. Calculate the bandwidth-delay product, $R * d_{prop}$.
    b. Consider sending a file of 725,000 bits from Host A to Host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any given time?
    c. Provide an interpretation of the bandwidth-delay product.
    d. What is the width (in meters) of a bit in the link?
    e. Derive a general expression for the width of a bit in terms of the propagation speed s, the transmission rate R, and the length of the link m.

9. Why do HTTP, FTP, SMTP, and POP3 run on top of TCP rather than on UDP?

10. Is it possible for an organization's Web server and mail server to have exactly the same alias for a hostname (for example, foo.com)? What would be the type for the RR that contains the hostname of the mail server?

11. True or false? If it is false, explain why.

a. A user requests a Web page that consists of some text and four images. For this page, the client will send one request message and receive four response messages.
b. Two distinct Web pages (for example, www.lsu.edu/research.html and www.lsu.edu/students.html) can be sent over the same persistent connection.
c. With non-persistent connections between browser and origin server, it is possible for a single TCP segment to carry two distinct HTTP request messages.
d. The "Date:" header in the HTTP response message indicates when the object in the response was last modified.
e. HTTP response messages never have an empty message body.

12. Consider an HTTP client that wants to retrieve a Web document at a given URL. The IP address of the HTTP server is initially unknown. What transport and application-layer protocols besides HTTP are needed in this scenario?

13. 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 RTT_1, …, RTT_n. 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. 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?

14. Referring to the previous problem, suppose the HTML file references seven very small objects on the same server. Neglecting transmission times, how much time elapses with:
    a. Non-persistent HTTP with no parallel TCP connections?
    b. Non-persistent HTTP with the browser configured for 2 parallel connections?
    c. Persistent HTTP?

15. Suppose you compile and run the programs TCPClient and UDPClient on one host and TCPServer and UDPServer on another host.
    a. Suppose you run TCPClient before you run TCPServer. What happens? Why?
    b. Suppose you run UDPClient before you run UDPServer. What happens? Why?
    c. What happens if you use different port numbers for the client and server sides?

16. Suppose in UDPClient.py, after we create the socket, we add the line:

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clientSocket.bind((‘’, 5432)
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Will it become necessary to change UDPServer.py? What are the port numbers for the sockets in UDPClient and UDPServer? What were they before making this change?