Problem Set #1

Due Thursday, Sept 17th by 11:55 PM

Note: 1KB = 1024 bytes, 1MB = 1KB x 1KB, 1GB = 1MB x 1MB

Problem 1

Host A wants to send a 2,000 KB file to Host B. The Round Trip Time (RTT) of the Duplex Link between Host A and B is 160ms. Packet size is 1KB. One handshake between A and B is needed before data packets can start transferring which takes 2xRTT. Calculate the total required time of file transfer in the following cases. The transfer is considered complete when the final packet reaches B:

(a) The bandwidth of the link is 1.5Mbps. Data packets can be continuously transferred on the link.
(b) The bandwidth of the link is 1.5Mbps. After sending each packet, A need to wait one RTT before the next packet can be transferred.
(c) Assume we have "unlimited" bandwidth on the link, meaning that we assume transmit time to be zero. After sending 50 packets, A need to wait one RTT before sending next group of 50 packets.
(d) The bandwidth of the link is 1Mbps. During the first transmission A can send one(2^{1-1}) packets, during the 2nd transmission A can send 2^{2-1} packets, during the 3rd transmission A can send 2^{3-1} packets, and so on. Assume A still need to wait for 1 RTT between each transmission.

For the case of (b) in order to cut the transmission time in half. How much bandwidth will the link between A and B need to be?

Problem 2

Suppose a 50-Mbps point-to-point link is being setup between Earth and a new lunar base. The distance from the moon to Earth is approximately 385,000 km, and data travels over the link at the speed of light 3×10^8 m/s.

(a) Calculate the minimum RTT for the link.
(b) Using the RTT as the delay, calculate the delay bandwidth product for the link.
(c) A camera on the lunar base takes pictures of Earth and saves them to digital format on a disk. Suppose Mission Control (on Earth) wants to download the most current image, which is 25 MB. What is the minimum amount of time that will elapse between when the request for the data goes out, and the transfer is finished?

(d) For a 1Mbps link with 1000ms delay and 1Gbps link with 1ms delay. Their delay × Bandwidth product are the same. Does this mean this 2 links are similar? What are your comments?

Problem 3

(a) How long is a bit while being transmitted on 10Mbps copper wire using maximum bandwidth, where the speed of signal propagation in copper wire is 2.3×10^8 m/s

(b) How many bits can be "buffered" on a 10km 10-Gbps copper wire Simplex-Link (Simplex means communication can only happen in one direction at a given time)?

Problem 4

Consider a more realistic version of Problem 1. This is a simple protocol for file transfer between A and B. After some initial negotiation, A sends data packets of size 1 KB to B; B then replies with an acknowledgment. A always waits for each ACK before sending the next data packet; this is known as **stop-and-wait**. Packets that are overdue are presumed lost and are retransmitted.

(a) In the absence of any packet losses or duplications, explain why it is not necessary to include any "sequence number" data in the packet headers.

(b) Suppose that the link can lose occasional packets, but that packets that do arrive always arrive in the order sent. Is a 2-bit sequence number (that is, N mod 4) enough for A and B to detect and resend any lost packets? Is a 1-bit sequence number enough?

(c) Now suppose that the link can deliver out of order and that sometimes a packet can be delivered as much as 1 minute after subsequent packets. How does this change the sequence number requirements?

Problem 5

Consider a go-back-n sliding window algorithm running over a 40-km point-to-point fiber link.

(a) Compute the one-way propagation delay for this link, assuming that the speed of light is 2×10^8 m/s in the fiber.

(b) Suggest a suitable timeout value for the algorithm to use.

(c) Why might it still be possible for the algorithm to time out and retransmit a frame, given this timeout value?

Problem 6

Draw a time line diagram for the sliding window algorithm with SWS = RWS = 3 frames, for the following two situations. Use a timeout interval of about 2 × RTT. And assume 2 frames must be send ½ RTT apart.

(a) Frame4 is lost. Draw the algorithm till Frame7 is send.

(b) ACK 2 and 4 are lost. Draw the algorithm till Frame 6 is send.

Problem 7

Suppose that we attempt to run the sliding window algorithm with SWS = RWS = 3 and with MaxSeqNum = 5. The *N* th packet DATA[*N*] thus actually contains *N* mod 5 in its sequence number field. Assume no out-of-order arrivals. Give an example in which the algorithm becomes confused **PLEASE DRAW IT OUT**; that is, a scenario for example which the receiver expects DATA[5] and accepts DATA[0]—which has the same transmitted sequence number—in its stead. Note that this implies MaxSeqNum ≥ 6 is necessary and MaxSeqNum = 6 is sufficient.

Problem 8

Consider the following networked computers connected by Bridge X and Y. Bridge X has interface 1,2 and3. Bridge Y has interface 1 and 2. Assume at the beginning the address tables of Bridge X and Y are all empty. Write down the address tables of Bridge X and Y after the following communication finished.

1. A to B
2. B to E
3. A to C
4. C to A
5. D to A
6. D to E

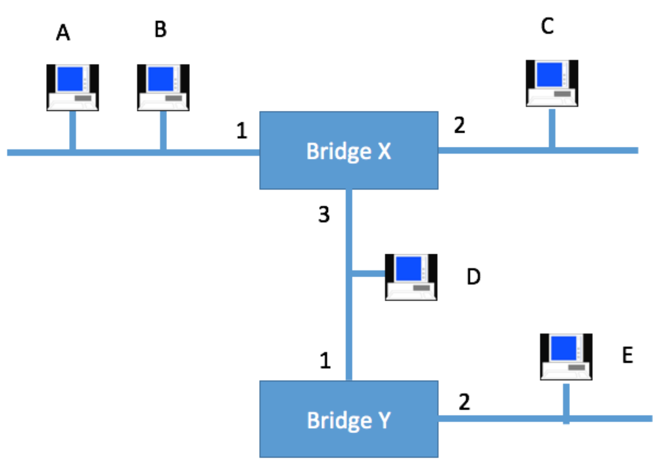

Figure 1

Bridge X

Address	Interface

Bridge Y

Address	Interface

Problem 9

Given the extended LAN shown in Figure 2, indicate which ports are not selected by the spanning tree algorithm. Note that the bridge with the smallest ID becomes a root.

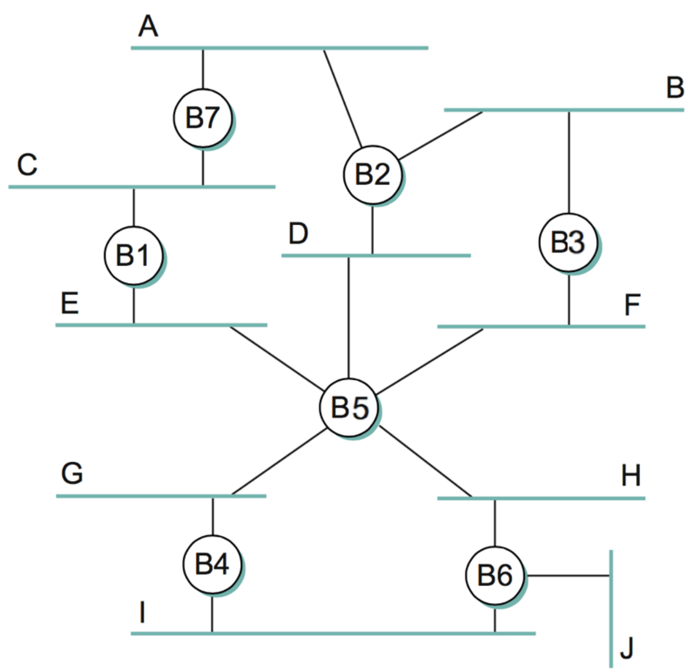

Figure 2

Problem 10

Still considering Figure 2. If Bridge B1 suffers catastrophic failure. Again indicate which ports are not selected by the spanning tree algorithm.

Ping Assignment

Please remember to turn in traces (copies) of the output of your ping commands, for each ping the assignment asks you to do (in addition to answering the required questions)!

The primary aim of this component of the problem set is to collect and analyze ping traces from a set of wide-ranging locations. Ping is a program that allows a user to collect roundtrip time (RTT) samples from remote hosts. Ping can also be used to see if a remote host is up and running (i.e. if it responds to the ping, then it's alive).

On CS UNIX/Linux accounts, ping can be found in /bin/ping or /usr/sbin/ping. For more help, type "man ping" to your UNIX prompt to get the man page (also included below). On other UNIX platforms, it is also found in /usr/etc. Ping is also found on Windows machines within the Windows Command Prompt, by just typing 'ping'. The specifics of the 'ping' command line parameters varies according to the platform you use, so consult your local platform's man pages.

Here is an sample command that shows how to use ping

```
ping -c 10 -s 200 www.colorado.edu
```

This command will tell ping to send a ping packet of size 200 bytes once per second to remote host www.colorado.edu , and will stop after 10 pings. On some systems, the minimum data packet size may be 128 bytes. It will generate the following output:

```
PING www.colorado.edu (128.138.129.98): 200 data bytes
208 bytes from 128.138.129.98: icmp_seq=0 ttl=251 time=2.633 ms
208 bytes from 128.138.129.98: icmp_seq=1 ttl=251 time=3.748 ms
208 bytes from 128.138.129.98: icmp_seq=2 ttl=251 time=2.747 ms
208 bytes from 128.138.129.98: icmp_seq=3 ttl=251 time=3.172 ms
208 bytes from 128.138.129.98: icmp_seq=4 ttl=251 time=2.770 ms
208 bytes from 128.138.129.98: icmp_seq=5 ttl=251 time=3.443 ms
208 bytes from 128.138.129.98: icmp_seq=6 ttl=251 time=7.478 ms
208 bytes from 128.138.129.98: icmp_seq=7 ttl=251 time=3.004 ms

--- www.colorado.edu ping statistics ---
8 packets transmitted, 8 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 2.633/3.624/7.478/1.499 ms
```

The time quoted above is the roundtrip time, and is measured from the time the ping packet is sent to the time the ping echo reply arrives back at the sender.

(a) In this section you should generate the following table of averaged RTT's for three different destination servers at three different times of the day.

For each combination of destination server and time of day in the table, you should collect four ping traces and then compute an averaged RTT over the four ping traces. Each ping trace should consist of 20 samples. Choose a packet size anywhere from 200 bytes to 500 bytes. For your source, use any local host at CU. For your destinations, select one destination server from each of the three categories (Local, National, and International) listed at the end of this assignment.

For example, if you chose the server berkeley.edu as your national destination server and csel.cs.colorado.edu as your local source, then run ping four times in the morning from csel to berkeley, four times in the afternoon, and four times late at night from csel to berkeley.

What was the averaged roundtrip time to each server at each of the three different times of day? To answer, please fill in the below table for averaged RTT.

Average RTT	Local	National	International
Morning			
Afternoon			
Late Night			

Server of choice:

Local:

National:

International:

(b) Was there significant variation of the average RTT over the course of the day? How would you explain the variation, if any?

(c) What was the average packet loss to each server at each of the three different times of day? Please hand in your averaged values in a table form for packet loss. Was there significant variation of packet loss over the course of the day? Please explain.

Average Packet Loss	Local	National	International
Morning			
Afternoon			
Late Night			

(d) Was there significant variation of average RTT with respect to geographic location, and how would you explain the variation, if any?

(e) What is your estimate of the propagation delay to each server? Explain your methodology for inferring the propagation delay from the RTT estimates.

What are the predicted propagation delays if you were to draw a shortest-distance line between Boulder and the location of each server? Explain the difference between your predicted propagation delays and the propagation delays inferred from your RTT's, if any.