COSC 4377 – Networking - Kevin B Long

# interlocking-uh-m-186.eps

DE VO (1080326) - Homework #1

Due 11:59am, Sunday, 9 June 2019

Multiple submissions accepted.

1. (10 pts) Do the Intro Wireshark lab found in the Wireshark folder on the class drive. Paste your answers either here or in a separate Wireshark document.

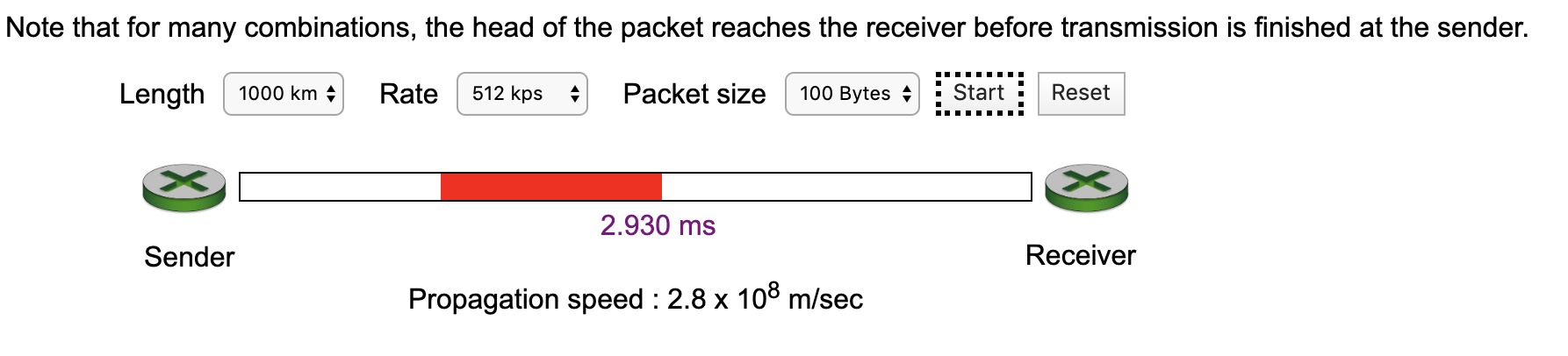
**PLEASE SEE LAB\_1 SUBMISSION FILE**

1. (15 pts) Complete the second Wireshark lab on HTTP. A note: if you have trouble seeing the packets you need on your network to complete your exercise (if Wireshark is working but they’re just not there), then you can revert back to a “pcap” file from the author that has all the packets you need that you can open with Wireshark. I’ve added a folder of those to the google drive.

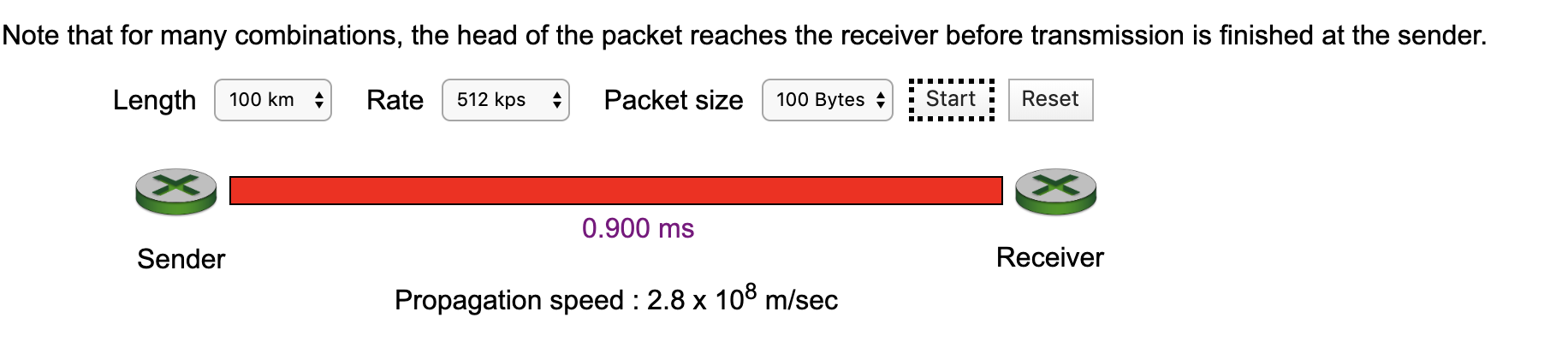
**PLEASE SEE LAB\_2 (HTTP File ) SUBMISSION FILE**

1. (4 pts) Visit the Transmission Versus Propagation Delay applet reachable from this page: <http://wps.pearsoned.com/ecs_kurose_compnetw_6/216/55463/14198700.cw/index.html>.
   1. Among the rates, propagation delay, and packet sizes available, find a combination for which the sender finishes transmitting before the first bit of the packet reaches the receiver. **Take a snapshot and paste it here**.

Transmission delay (t\_tran), time for the router to push out the packet (Packet size / Bit rate) Propagation delay (t\_prop), time it takes a bit to propagate from one router to the next (length/speed) => t\_tran < t\_prop => size/bit\_rate < length\_speed)



* 1. Find another combination for which the first bit of the packet reaches the receiver before the sender finishes transmitting. **Take a snapshot and paste it here**.



1. (6 pts) How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5⋅108 m/s, and transmission rate 2 Mbps?
   1. (2500\*10^3)/(2.5 \* 10^8) = 0.01 second

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?

* 1. time = d/s

Does this delay depend on packet length? Does this delay depend on transmission rate?

* 1. No, No

1. (6 pts) 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=500 kbps, R2=2 Mbps, and R3=1 Mbps.
   1. Assuming no other traffic in the network, what is the throughput for the file transfer?

Speed of slowest link => throughput R1 = 500 kbps

* 1. Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

(4\*10^6\*8bits/byte) / (500 \* 10^3) = 64 seconds

* 1. Repeat (a) and (b), but now with *R*2 reduced to 100 kbps.
     + - throughput R2 = 100 kbps
       - time = 64 \* (500/100) = 320 seconds

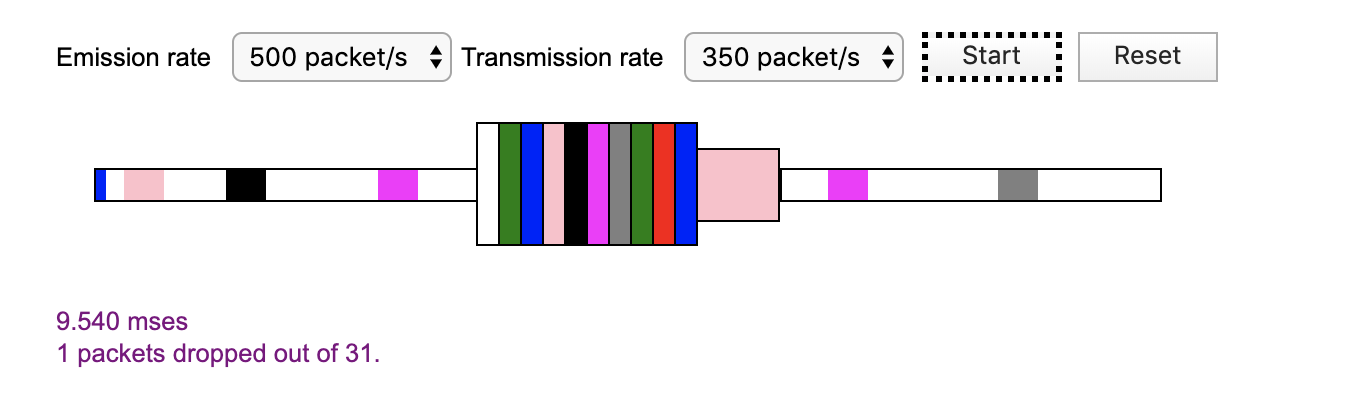
1. (8 pts 4x2) Visit the Queuing and Loss applet at the companion Web site.
   1. What is the maximum emission rate and the minimum transmission rate? With those rates, what is the traffic intensity?

Max emission: 500 packets/s ; Min transmission: 350 packets/s

Traffic Intensity: 500/350 = 1.42

Run the applet with these rates and determine how long it takes for packet loss to occur. Then repeat the experiment a second time and determine again how long it takes for packet loss to occur.

* 1. Are the values different? Why or why not?
     + - First run: packet loss occurs around: 9.2 mses
       - Second run:
* first loss occurs around: 8.8 mses
* Values are different because of randomness of packet emission



1. (3 pts) (P2) Equation 1.1 gives a formula for the end-to-end delay of sending one packet of length *L* over *N* links of transmission rate *R*.

Generalize this formula for sending *P* such packets back-to-back over the *N* links.

* + - * At N\*(L/R) => the first packet reaches end.
      * Each packet after the first one only needs (L/R) to reach destination. (No transmisson time)

=> Time for P-1 packets to reach destination is : (P-1)\*(L/R)

* Total time : (P-1)(L/R) + N (L/R) = (L/R) \* (P-1+N)

1. (4 pts) (P5) Review the car-caravan analogy in section 1.4. Assume a propagation speed of 100 km/hour.
2. Suppose the caravan travels 150 km, beginning in front of one tollbooth, passing through a second tollbooth, and finishing just after a third tollbooth. What is the end-to-end delay?
   * + - Each tollbooth transmits time: 12 seconds:

10 cars and 3 tollbooths => total tollbooth delay = 12 \* 10 \* 3 = 360 s = 6 mins

Time to travel 150km @ 100kph = 150\*60/100 = 90 mins

* + - * End to end travel with delay = 90 + 6 = 96 minutes

1. Repeat (a), now assuming that there are eight cars in the caravan instead of ten.
   * + - 8 cars and 3 tollbooths => total tollbooth delay = 12 \* 8 \* 3 = 288 s = 4.8 mins
       - Time to travel 150km @ 100kph = 150\*60/100 = 90 mins
       - Total time: 90 + 4.8 = 94.8 minutes
2. (14 pts) P6. This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. 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.
3. Express the propagation delay, *d*prop, in terms of *m* and *s*.

*d*prop = m/s

1. Determine the transmission time of the packet, *d*trans, in terms of *L* and *R*.

*d*trans  = L/R

1. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.

End to end = m/s + L/R

1. 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?

Last bit is transmitted and is leaving Host A at t = *d*trans

1. Suppose *d*prop is greater than *d*trans. At time *t=dtrans*, where is the first bit of the packet?

First bit of packet is still being transported and has not yet reached B

1. Suppose *d*prop is less than *d*trans. At time *t=dtrans*, where is the first bit of the packet?

First bit of packet is at B

1. Suppose s=2.5⋅108, L=120 bits, and R=56kbps. Find the distance *m* so that *d*prop equals *d*trans.

L/R = m/s => m = (L\*s)/R = 120\*(2.5\*10^8)/(56\*10^3) = 535714 m

1. (4 pts) P10. Consider a packet of length *L* that 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 *di*, *si*, and *Ri* 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.
   1. Assuming no queuing delays, in terms of *di*, *si*, *Ri*, (i=1,2,3), and *L,* what is the total end-to-end delay for the packet?

End to end = L/R1 + d1/s1 + L/R2 + d2/s2 + L/R3 + d3/s3 + dproc + dproc

* 1. Suppose now the packet is 1,500 bytes, the propagation speed on all three links is 2.5⋅108m/s, the transmission rates of all three links are 2 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second link is 4,000 km, and the length of the last link is 1,000 km. For these values, what is the end-to-end delay?

Packet = 1500 bytes = 12000 bits

Rate = 2 \* 10^6 /s

L/R1 = L/R3 = L/R3 = (1500 \* 8) / 2 \* 10^6 /s = 0.006 sec = 6ms

d1/s1 = (5000 \* 10^3) m / 2.5 \* 108m/s = 0.020 sec = 20ms

d2/s2 = (4000 \* 10^3) m / 2.5 \* 108m/s = 0.016 sec = 16ms

d3/s3 = (1000 \* 10^3) m / 2.5 \* 108m/s = 0.004 sec = 4ms

end-to-end = 6+6+6+20+16+4+3+3 = 64 ms

1. (4 pts) P11. In the above problem, suppose *R1=R2=R3=R* and *dproc=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?

Only 1 transmit is needed from beginning to load into link

=> dend-to-end = L/R+ d1/s1 + d2/s2 + d3/s3 + dproc + dproc

L/R = (1500 \* 8) / 2 \* 10^6 /s = 0.006 sec = 6ms

d1/s1 = (5000 \* 10^3) m / 2.5 \* 10^8m/s = 0.020 sec = 20ms

d2/s2 = (4000 \* 10^3) m / 2.5 \* 10^8m/s = 0.016 sec = 16ms

d3/s3 = (1000 \* 10^3) m / 2.5 \* 10^8m/s = 0.004 sec = 4ms

dend-to-end = 6+20+16+4 = 46msec

1. (6 pts) P12. A packet switch receives a packet and determines the outbound link to which the packet should be forwarded. When the packet arrives, one other packet is halfway done being transmitted on this outbound link and four other packets are waiting to be transmitted. Packets are transmitted in order of arrival. Suppose all packets are 1,500 bytes and the link rate is 2 Mbps.
   1. What is the queuing delay for the packet?

Packet just arrives needs to wait for : 1500 \* 4 + 1500/2 = 6750 bytes

Queuing delay = 6750 \* 8 / (2 \* 10^6) = 27 ms

* 1. More generally, what is the queuing delay when all packets have length *L*, the transmission rate is *R*, *x* bits of the currently-being-transmitted packet have been transmitted, and *n* packets are already in the queue?

queuing delay = [n\*L + (L -x)] / R

1. (4 pts) P13. Suppose *N* packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length *L* and the link has transmission rate *R*.
2. What is the average queuing delay for the *N* packets?

First packet waits 0 second

2nd packet waits : L/R

3rd waits: 2L/R

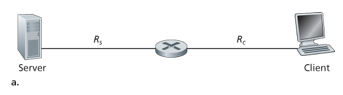
….

n packet waits: (n-1)\*L/R

Total wait for n packets: L/R + 2\*L/R + …. + (n-1)\*L/R = n\*(n-1)\*L/2\*R

Average wait = =

1. Now suppose that *N* such packets arrive to the link every *LN/R* second. What is the average queuing delay of a packet?
   * + - It takes L\*N/R seconds to transmit N packets. Thus, the buffer is empty when a each batch of N packets arrive. The average delay of a packet across all batches is same average delay within one batch (N-1)L/2R.
2. (4 pts) (P23) Consider Figure 1.19a:



Assume that we know the bottleneck link along the path from the server to the client is the first link with rate *Rs*bits/sec. Suppose we send a pair of packets back to back from the server to the client, and there is no other traffic on this path. Assume each packet of size *L* bits, and both links have the same propagation delay *d*prop.

1. What is the packet inter-arrival time at the destination? That is, how much time elapses from when the last bit of the first packet arrives until the last bit of the second packet arrives?
   * + - Assume the bottleneck link is first link, then the second packet is queued waiting for the transmission of first packet. Since both links have same propagation delays *d*prop => The inter-arrival time at destination is L/Rs
2. Now assume that the second link is the bottleneck link (i.e., Rc<Rs). Is it possible that the second packet queues at the input queue of the second link? Explain. Now suppose that the server sends the second packet *T* seconds after sending the first packet. How large must *T* be to ensure no queuing before the second link?
   * + - Since second link is bottleneck link (Rc < Rs) => L/Rs+ L/Rs+  dprop < L/Rs+ dprop + L/Rc. Time for 1st link to finish its transmission onto 2nd link is greater than the time it takes for second link to arrive at input queue of 2nd link, therefore it’s possible for the second packet to be queued at the input of 2nd link.
       - If server sends 2nd packet T seconds after the first packet, for no queuing before the second link. Then, time for 2nd packet to arrive at 2nd link input > time first packet finishes transmitted on 2nd link. This is equipvalent to:

L/Rs+ L/Rs+  dprop + T >= L/Rs+  dprop + L/Rc  
2L/Rs+ dprop+T >= L/Rs+  dprop + L/Rc  
2L/Rs+ dprop+T - L/Rs+  dprop >= L/Rc  
L/Rs+ T >= L/Rc

T >= L(1/Rc – 1/Rs)

1. (8 pts) P25. Suppose two hosts, A and B, are separated by 20,000 kilometers and are connected by a direct link of R=2 Mbps. Suppose the propagation speed over the link is 2.5⋅108 meters/sec.
2. Calculate the bandwidth-delay product, R⋅dprop.

dprop = 20\*10^6/2.5\*10^8 = 0.08 s

=>Bandwidth-delay = 0.08 \* 2 \* 10^6 = 160,000 bits

1. Consider sending a file of 800,000 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?

Maximum of bits in the link is bandwidth-delay which is 160,000 bits

1. What is the width (in meters) of a bit in the link? Is it longer than a ­football field?

20,000 \* 10^3 / 160,000 = 125 m

Assume its longer than a football field which is around 110m!

1. 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*.

Assume distance A to B is *d* speed over the link is *s*

Width = d/bandwidth =