College of Computing

Georgia Institute of Technology

CS 6250: Computer Networking: Spring 2014

Quiz II

There are 14 questions and 9 pages in this quiz booklet (including this page). Answer each question according to the instructions given. You have **85 minutes**.

If you find a question ambiguous, write down any assumptions you make. **Be neat and legible.** If I can't understand your answer, I can't give you credit! You may want to look through the whole quiz to identify which questions you can complete most quickly for the most points.

Use the empty sides of this booklet if you need scratch space. You may also use them for answers, although you shouldn't need to. *If you do use the blank sides for answers, make sure to clearly say so!*

Note well: Write your name in the space below AND your initials at the bottom of each page of this booklet.

THIS IS AN "CLOSED BOOK" QUIZ.
YOU ARE PERMITTED ONE DOUBLE-SIDED SHEET OF PAPER FOR NOTES.
ABSOLUTELY NO EMAIL OR MESSAGING OF ANY KIND!
MAKE SURE YOU'VE READ ALL THE INSTRUCTIONS ABOVE!

Initial here to indicate that (1) you've read the instructions and (2) you agree to abide by the Georgia Tech Honor Code:

The last page has easy bonus questions, which you can answer outside of the allotted time. Rip the last page off of your quiz for five bonus points. Turn it in anonymously if you like.

Do not write in the boxes below

1-5 (xx/20)	6-9 (xx/20)	10-12 (xx/30)	13-14 (xx/30)	Total (xx/100)

Name:

I Warmup

1. [4 points]: What are some of the possible causes of congestion collapse?

(Circle ALL that apply)

A. Faulty router software

B. Spurious retransmissions in flight

C. Packets traveling distances that are too far in between routers

D. Undelivered packets

E. None of the above.

2. [4 points]: Which of the following are true about additive increase multiplicative decrease (AIMD) and fairness?

(Circle ALL that apply)

A. Additive increase improves efficiency.

B. Additive increase improves fairness.

C. Multiplicative decrease improves efficiency.

D. Multiplicative increase improves fairness.

E. All of the above.

3. [4 points]: Which of the following pathologies can streaming audio and video tolerate by adding more buffering at the receiver?

(Circle ALL that apply)

A. Packet loss

B. Delay variation or jitter

C. Low throughput

D. Out of order packets

E. All of the above

Name:

4. [4 points]: Which of the following statistics are possible to gather from information such as flow sampling (*e.g.*, NetFlow)?

(Circle ALL that apply)

A. The time in between each packet transmission

B. Packet headers

C. The number of bytes that each flow sends

D. The number of packets that each flow sends

E. None of the above

5. [4 points]: Which of the following are true about a leaky bucket traffic shaper?

(Circle the BEST answer)

A. A link that is shaped with a leaky bucket traffic shaper will never send traffic on the outgoing link at a rate that is higher than the average drain rate of the bucket.

B. On a link that is shaped by a leaky bucket, a sender can never send traffic faster than the average drain rate of the bucket; the link will simply drop any traffic that is sent at a higher rate.

C. Comcast's PowerBoost is likely implemented with a leaky bucket traffic shaper.

D. None of the above

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II Potpourri

6. [5 points]: Suppose the round trip time between the sender and receiver is 100 milliseconds and the window size is 20 packets, and each packet is 1500 bytes. What is the rate at which the sender is sending? Please put your answer here in terms of kilobits per second, keeping in mind that 1 byte is 8 bits. (You can use 1000 bytes for 1 KB, to keep your math simple.)

(Answer legibly in the space below.)

7. [5 points]: Suppose that the sustained rate that a subscriber subscribes to is 10 megabits per second, but they would like to "burst" at a rate of fifteen megabits per second. Suppose that the bucket size is one megabyte, or 8 megabits. How long can the sender send at the higher rate? Please give your answer in decimal form in seconds.

(Answer legibly in the space below.)

Name:

8. [5 points]: What are two reasons why measuring TCP throughput *from a home router* (as opposed to from a laptop on the same network connected via the home wireless network) may provide a more accurate reading of the TCP throughput of the access link?

(Answer legibly in the space below.)

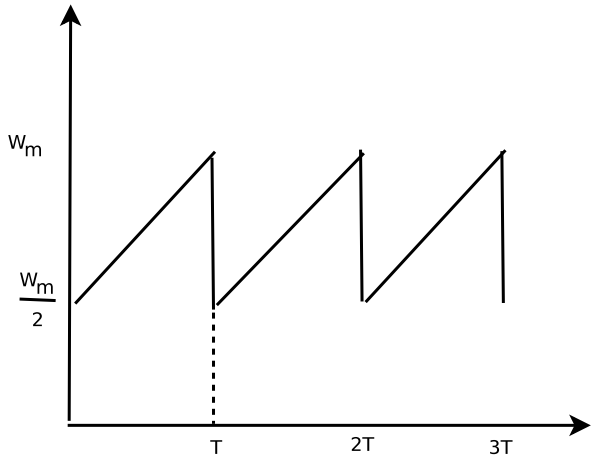
9. [5 points]: Given a link of a certain bandwidth and packet loss rate, explain why using multiple TCP connections in parallel can achieve higher throughput than a single TCP connection.

(Answer legibly in the space below.)

Name:

III Congestion Control and Streaming

10. [20 points]: In this problem, you will derive the relationship between TCP throughput, round-trip time, and packet loss. We'll do the derivation step-by-step. You won't need to know any calculus, but you'll need to use the formula for computing the area of a triangle: $\frac{1}{2} \cdot b \cdot h$. Consider the TCP window evolution shown in the diagram below for your answers.



A. What is the number of packets in the TCP window right after a packet loss occurs?

B. What is the number of packets in the TCP window right before a packet loss occurs?

C. What is the total number of packets transmitted in between packet losses, in terms of W_m. (*Hint:* Remember that, with additive increase, the TCP sender's window will increase by one packet per round trip. The formula for computing the area of a triangle may be useful in answering this question.). *Your answer here is equivalent to* $1/p$*, where* p *is the packet loss rate, and the number of bytes transmitted in between packet loss events is your answer here times the packet size* S.

D. How much time occurs between each packet loss, in terms of W_m and the round trip time R?

E. Express the TCP throughput, λ, in terms of your answers to the previous two questions. Your answer should be in terms of W_m, R, and S.

F. Use the relationship between p and W_m from part (C) to substitute into your equation for λ to obtain an equation for λ in terms of S, R, and p.

(Answer legibly in the space below.)
(You can use the back of the page as well.)

Name:

11. [5 points]: George Burdell notes that as the throughput of a link increases, the sender's TCP sending rate becomes more erratic, since the difference between W_m and $\frac{W_m}{2}$ becomes greater. (This problem of TCP on "large bandwidth-delay product links" is a well-known phenomenon.) For applications such as audio and video streaming, George notes that this behavior could result in poor performance.

Explain why a large "sawtooth" the results from a high bandwidth link could result in poor streaming performance.

(Answer legibly in the space below.)

12. [5 points]: George proposes two different ways of mitigating the effects of TCP senders with large bandwidth-delay products:

- Measuring the round-trip time and loss rate on a link from the sender and adjusting the throughput of the sender based on the TCP throughput equation (which you derived in the previous question).
- Increasing the buffer size on bottleneck links so that packets can be transmitted from the buffer while the sending rate is below the average rate of the link.

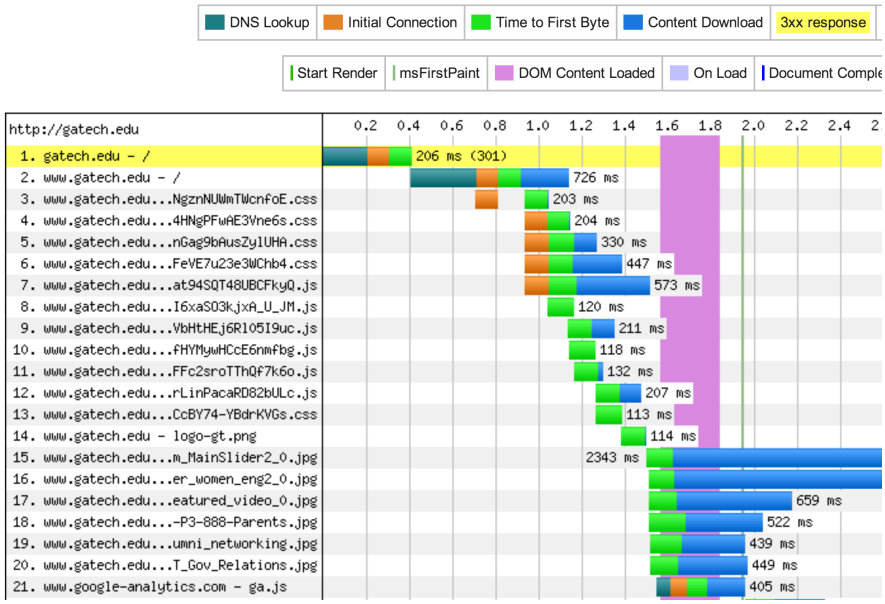
Describe one advantage and one disadvantage of each approach, in terms of either implementing the method described, or in terms of how well it is likely to help the performance of a streaming application.

(Answer legibly in the space below.)

Name:

IV Web Performance

13. [15 points]: Consider the *partial* "waterfall" diagram shown below, which shows a Firefox client's process of loading the home page at `http://gatech.com/`.



A. How many objects are being downloaded in parallel with the first object, the root document at `http://gatech.edu/` (the first row in the waterfall diagram?)

B. How many total DNS lookups are shown in the waterfall diagram?

C. Why is there not a DNS lookup for each object (*i.e.*, why does each row in the waterfall diagram not show a TCP lookup)?

D. How many TCP connections appear to be operating in parallel to any single domain? Justify your answer.

E. Why do rows 8–20 in the waterfall diagram not show TCP "initial connections"?

(Answer legibly in the space below.)

Name:

14. [15 points]: The paper *Measuring and Mitigating Web Performance Bottlenecks in Broadband Access Networks* demonstrates that Web page load times stop improving when the downstream throughput of the access link exceeds about 16 Mbits/sec. The paper claims that the latency of the connection to the server becomes the primary bottleneck.

A. Give two steps in the process of retrieving a Web page where higher round-trip latency to the server can ultimately slow the overall page load time.

B. In class, we discussed how *increasing TCP's initial congestion window* could reduce the overall page load time. Explain why.

C. We also discussed potential drawbacks of increasing TCP's initial congestion window. List one drawback.

D. In class, we discussed how *prefetching certain parts of a Web page load* could reduce the overall page load time. Explain which aspects of a Web page load can be prefetched and how doing so can reduce page load time.

E. We also discussed potential drawbacks of prefetching. List one drawback.

(Answer legibly in the space below.)

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