College of Computing

Georgia Institute of Technology

CS 6250: Computer Networking: Fall 2010

Quiz I

There are 14 questions and 10 pages in this quiz booklet (including this page). Answer each question according to the instructions given. You have **85 minutes** to answer the questions.

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! There are three pretty challenging questions (clearly marked); you may want to look through the whole quiz and save those for last.

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 "OPEN NOTES, OPEN PAPERS" QUIZ.
NO OTHER MATERIALS, NO PHONES, NO COMPUTERS, NO LAPTOPS, NO PDAS.
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 (feel free to fill it out after the quiz and give it to a TA, or take it with you). You won't get the five points if you don't tear off the page (this is to make certain you've read this far ;).

Do not write in the boxes below

1-5 (xx/20)	6-10 (xx/27)	11-13 (xx/9)	Bonus (xx+5/14)	Total (xx/70)

Name:

I Warmup

1. **[4 points]:** Which of the following is true about virtual LANs?
(Circle ALL that apply)

A. When a host sends an ARP query for some IP address, a host on a different virtual LAN with that IP address will not hear the ARP query.

B. Two hosts on different virtual LANs cannot communicate with one another without sending traffic through a layer 3 device (such as a router).

C. A switch port can only be trunked to a single VLAN.

D. If two wireless access points are trunked to the same VLAN, a host can move from one access point to another without breaking existing TCP connections.

E. All of the above.

Answer 1 The answer is: (A), (B), (D). ■

2. **[4 points]:** Which of the following are true about the BGP route selection process?
(Circle ALL that apply)

A. Local preference can be used to exercise control over inbound traffic.

B. AS path prepending can be used to exercise control over inbond traffic.

C. IP prefix deaggregation can be used to exercise control over inbound traffic.

D. When a BGP route is advertised from one AS to a neighboring AS, the local preference attribute is preserved.

E. None of the above.

Answer 2 The answer is : (B), (C). ■

3. **[4 points]:** Which of the following is true about IPv4 address space exhaustion?
(Circle ALL that apply)

A. The increase in IPv4 prefixes may slow the process of IP address lookup.

B. The increase in ASes that are multihomed has contributed to address space exhaustion.

C. Reassigning a contiguous block of IP addresses to each AS on the Internet could help reduce IPv4 address space exhaustion.

D. IPv4 address space exhaustion is primarily caused by the increase in the number of devices connected to the Internet.

E. All of the above.

Answer 3 The answer is: (A), (B), (C). ■

Initials:

4. [4 points]: Which of the following most accurately describes the differences between packet-level monitoring and flow-level monitoring?

(Circle ALL that apply)

A. A network operator can determine how much each application uses to total traffic volume from flow-level monitoring alone.

B. A network operator can determine statistics such as the average delay or jitter experienced by a flow from flow-level monitoring alone.

C. Trajectory sampling increases the likelihood that *some* router in the network samples traffic from a particular flow.

D. Flow statistics that are generated based on sampled packet traces may not have information about every flow.

E. All of the above.

Answer 4 The answer is (A), (D). ■

5. [4 points]: What are some of the motivations for using a layer two topology in a data center?

(Circle ALL that apply)

A. Layer two topologies are easier to configure than layer three topologies.

B. Layer two's "flat" addressing model makes it relatively easy to configure and perform various network operations tasks (e.g., perform migration).

C. It is easier to isolate different administrative groups from one another on a single, flat layer two topology than it is in a topology with routing.

D. Spanning trees provide better robustness and load-balancing capabilities than IP routing protocols.

E. None of the above

Answer 5 The answer is (A), (B). ■

II Potpourri

6. [5 points]: Define the *end-to-end argument*. Explain how TCP congestion control abides by the end-to-end argument; explain the potential drawbacks of individual routers enforcing congestion control at each hop.

(Answer legibly in the space below.)

Answer 6 The end-to-end argument says that the “intelligence” for network functions (e.g., failure recovery, in-order delivery, encryption) should be placed at network endpoints, not at nodes in the middle of the network. One rationale for this argument is that, if functions are implemented inside the network, then functions may be unnecessarily duplicated at each network hop.
For example, hop-by-hop congestion control may unnecessarily relieve congestion at a hop along the path that is not the path’s bottleneck. Additionally, if each hop performs congestion control, end hosts may not know to reduce their sending rates. ■

7. [4 points]: Network operators use virtual LANs (VLANs) to divide a single, flat layer two topology into many distinct domains, thus limiting the scope of broadcast traffic (e.g., ARP queries). Several data center topologies that we read about (e.g., SEATTLE, Portland) instead use lookup services to limit the scope of this type of traffic. Do layer two architectures like SEATTLE and Portland eliminate the need for VLANs in data centers? Why or why not?

(Answer legibly in the space below.)

Answer 7 These layer two architectures do not necessarily eliminate the need for VLANs in data centers. In addition to reducing the extent and size of each individual broadcast domain, VLANs can be used to separate administrative domains for reasons such as security (e.g., to force all traffic through a layer-3 firewall) or quality of service (e.g., to give higher priority to one administrative group over another). ■

Initials:

8. [6 points]: In Problem Set 1, you used the Click modular router to implement a learning switch. In this problem, you will use Click elements to rate-limit HTTP traffic. To do this problem, you will need two new elements, described below:

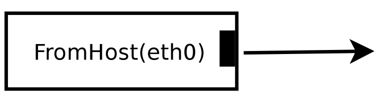
- `Classifier`: This element takes *one input* and can have *n outputs*. Processing is *push*. The input is *offset/pattern*, where the offset is in bytes. For example,

  Classifier(12/0800, -);

  sends IP packets to output 1, and all other packets to output 2. (You can add more patterns to this list, but you will only need two outputs for this question.)
- `Shaper`: This element "shapes" traffic to a maximum rate. It takes one parameter, *rate*, which is the number of packets per second to shape the traffic to. This element's processing is *pull*.

(1) Draw a Click element pipeline that takes traffic from an interface, `eth0`, shapes traffic *destined for the HTTP port* to a maximum of 1000 packets per second, and sends the rest of traffic unshaped; send your output to an interface `eth1`; we have started the pipeline for you in a diagram below; (2) Write the Click configuration corresponding to this pipeline. *Hint:* The destination port offset is 42 bytes from the beginning of the Ethernet frame, and port 80 is HTTP traffic.

(Answer legibly in the space below.)



Answer 8
in :: FromHost(eth0)
classifier :: Classifier(42/80, -)
in → classifier
classifier[0] → Queue → Shaper(1000) → ToHost(eth0)
classifier[1] → ToHost(eth1)

[2 points for correctly drawing the diagram; 4 points for Click configuration. Partial credit for connecting elements in the right order. One point for recognizing that a Queue element is needed to connect a push element to a pull element.] ■

Initials:

9. [4 points]: Explain the roles of the four "D"s of the 4D network architecture: What is the function of each of the the (a) decision; (b) dissemination; (c) discovery; (d) data planes? Explain how the IRSCP implements each of these four "planes". (Your answer should be roughly of the form: "The data plane [insert function here]; the IRSCP's data plane is implemented [roughly explain how]."

Answer 9 The decision plane is the "brains" of the network. It effectively takes information such as the network topology and other parameters and sets forwarding table entries in the routers to control the forwarding behavior of the network devices. In the IRSCP, the decision plane is instantiated by a route control server that collects routing information and makes routing decisions to achieve some high-level policy. The dissemination plane transfers information from the routers to the decision plane—in the case of the IRSCP, iBGP serves as the dissemination plane. The discovery plane allows the decision plane to learn about information such as the network topology—in the IRSCP, the IGP is the decision plane. The data plane forwards traffic; the IRSCP's data plane is implemented with routers that forward IP traffic according to the BGP routes that the decision plane installs. ■

10. [8 points]: Given the lookup table below *for four-bit addresses*:

0*
01*
10*
101*
1011

produce the following:

A. A two-level trie that resolves two bits at each level.

B. A four-level trie that resolves one bits at each level.

C. Suppose that SRAM lookup speeds are 10 nanoseconds per lookup (i.e., one lookup takes 1 $\times 10^{-8}$ seconds). How many packets per second can this router forward, for each type of trie?

D. Assuming 1500-byte packets and 10-nanosecond lookup speeds, at what rate can the router forward traffic, for each type of trie.

(Answer legibly in the space below.)

Initials:

Answer 10

Initials:

III Design Question: Interdomain Routing

Consider the BGP routing table below:

```
*  12.148.128.0/23  154.11.11.113          0      0      0 852 174 7018 2386 i
*  12.148.128.0/23  154.11.98.225          0      0      0 852 174 7018 2386 i
*  12.148.128.0/23  147.28.7.2             0      0      0 3130 1239 7018 2386 i
*  12.148.128.0/23  12.0.1.63              0      0      0 7018 2386 i
```

11. [3 points]: Circle which route this router would select for `143.215.129.92`; which route selection criterion would this router use to "break ties" between the multiple routing choices in the table above.

(Answer legibly in the space below.)

Answer 11 The router would select the last route in the routing table, because the AS path is the shortest (assume that local preference values are the same for each of these routes). The selection criterion that the router would use to break ties is "shortest AS path" (the second stage of the route selection process). [1 point for circling the best route; 2 points for identifying the correct step in the route selection process.] ■

12. [3 points]: What is the next-hop IP address for the route that you have selected above? How would this router determine the outgoing interface corresponding to that IP address?

(Answer legibly in the space below.)

Answer 12 The next-hop IP address is `12.0.1.63`. The router might learn this IP address in a number of ways, including a static route or dynamic routing (e.g., an IGP such as OSPF).

[1 point for identifying the next-hop IP address; 2 points for explaining how that IP address is reachable.]

■

Initials:

13. [3 points]: Notice that the routing table has two different BGP routes with the same next-hop AS. What is the next-hop AS? Why might that AS have advertise two routes with the same AS path to this router?

(Answer legibly in the space below.)

Answer 13 The next-hop AS is 852. That AS might advertise two routes to this router for any of the reasons related to the benefits of multihoming (e.g., availability, reliability, performance, load balance).

[1 point for identifying the next-hop AS; 2 points for explaining multihoming as the reason why you might see two routes appear from the same next-hope AS.] ■

14. [9 points]: *Bonus.* George Burdell observes that IP routing tables have grown excessively over the last several years, and that one of the causes is that prefixes must fall on power of two boundaries: "If each IP address range could be an *arbitrary* range, instead of falling on power-of-two boundaries, much less IP address space would be wasted."

A. How would you test George's hypothesis? (Hint: think about how you might scalably "probe" to determine whether addresses in the Internet's routing table were actually being used)

B. Sketch a rough design/approach for how you might execute a "smallest range" match for IP address ranges that are not a power of two. (Your solution need not be efficient, but it should be correct! *Hint:* Also remember that you might have overlapping prefixes that are not strict subsets of one another.)

(Answer legibly in the space below.)

Answer 14 ■

Initials:

IV Bonus: Anonymous Course Feedback

This page is anonymous. Rip this off from your exam, and turn it in separately if you like. You'll get five points for simply ripping off the last page of the exam, but I'd prefer if you fill it out and hand it in in a separate stack.

What are the things you like most about the course so far? Anything is fair game here (topics, course structure, board technique, etc.).

What are the things you like least about the course so far? Again, anything is fair game.

What topics would you like to see covered?

Initials: