Carnegie Mellon
Computer Science Department.
15-441 Spring 2010
Midterm

Name: _____

Andrew ID: _____

INSTRUCTIONS:

There are 11 pages (numbered at the bottom). Make sure you have all of them.

Please write your name on this cover and at the top of each page in this booklet **except the last.**

If you find a question ambiguous, be sure to write down any assumptions you make.

It is better to partially answer a question than to not attempt it at all.

Be clear and concise. Limit your answers to the space provided.

A	B	C	D	E	Total
/ 24	/ 23	/ 12	/ 18	/ 3	/ 80

A True and False

1. For the following statements, answer if they are true or false.

True OR False If we have bandwidth of t Hz, and the noise on the channel is about 1/8th the received signal strength, then it is very reasonable to expect transmission speed of $2t$ bits per second.

True OR False Both Manchester encoding and NRZI can handle long strings of 1's and long strings of 0's

True OR False UDP is a better choice than TCP for a real time voice application

True OR False Modern high speed routers use shared busses to gain benefits from statistical multiplexing.

True OR False Modern high speed routers use virtual output queues to avoid head-of-line blocking.

> **Solution:** T F T F T

2. A forwarding table for a router in a network using CIDR is given below.

Address prefix	Next hop
196.94.2.0/24	A
196.94.2.128/25	B
196.94.0.0/16	C
196.94.64.0/18	D
196.76.0.0/14	E
140.0.0.0/8	F
128.0.0.0/2	G
0.0.0.0/1	H

State the next hop for the following destination addresses.

(a) 139.1.1.1

> **Solution:** G – numerically closer to F, but need to look at bits

(b) 196.94.2.100

> **Solution:** A – doesn't match B...

(c) 196.94.2.200

> **Solution:** B – matches both A, B & C but must use longest prefix

(d) 196.94.3.100

> **Solution:** C

3. We discussed two different routing techniques: link state routing (LS), and distance vector routing (DV). Please answer the following questions by circling the protocol(s) for which the claim applies:

LS, DV - Requires each router to obtain a map of the complete topology

> **Solution: -2pts per error** LS

LS, DV - Sends its routing table to its neighbors

Solution: -2pts per error DV

LS, DV - Requires flooding

Solution: -2pts per error LS

LS, DV - Suffers the count to infinity problem

Solution: -2pts per error DV

4. One of the tasks in a router is determining which output port a packet should use. This is done by doing a longest prefix match (LPM) on the IP address of the incoming packet. Among the approaches to doing LPM are: binary trie (B), patricia trie (P), and direct high-radix trie (D). For each statement below circle the type of trie for which the claim applies:

   B, P, D - Requires the fewest number of lookups to perform LPM.

   Solution: D

   B, P, D - May require backtracking to find the LPM.

   Solution: P

   B, P, D - Uses the least amount of memory.

   Solution: P

5. Suppose you have a client C, a local name server L, and authoritative name servers A_root, A_com, and A_foo.com, where A_x is the name server that knows about the name zone x (and A_root is a root name server). C wants to lookup the address for www.foo.com. Assuming that all name servers initially have nothing in their cache, which of the following order of events is correct?

   A. C asks L, L asks A_root, A_root tells L to ask A_com, L asks A_com, A_com tells L to ask A_foo.com, L asks A_foo.com, A_foo.com answers to L, L answers to C.

   B. C asks A_root, A_root tells C to ask A_com, C asks A_com, A_com tells C to ask A_foo.com, C asks A_foo.com, A_foo.com answers to C, C tells L the address.

   C. C asks L, L asks A_root, A_root asks A_com, A_com asks A_foo.com, A_foo.com answers to C.

   D. C asks L, L asks A_foo.com, A_foo.com answers to L, L answers to C.

   E. C asks L, L asks A_root, A_root tells L to ask A_com, L asks A_com, A_com tells L to ask A_foo.com, L asks A_foo.com, A_foo.com answers to C.

Solution: A

6. Client C performs a lookup for `ftp.foo.com` immediately after the previous request. Assuming all records have long TTLs, which of the above order of events is correct?

Solution: D

B Link Layer: Yesterday and Today

7. Aloha was the first random medium access control protocol. It worked by having nodes transmit whenever they were ready and then wait for an acknowledgment packet from the destination to confirm successful reception. If no acknowledgment was heard within a certain period, the source assumed a collision happened and tried resending after a random delay.

   The Ethernet protocol, CSMA/CD can be seen as an evolution of the original Aloha design. For each of its two features below, give a very brief explanation of what it is and why it is an improvement over aloha.

   (a) Carrier sense

   Solution: Carrier sense is to listen for activity in the channel. In Aloha, nodes transmit immediately when they are ready to send. In CSMA/CD, carrier sense is used and only if the medium is idle do we transmit, therefore avoiding many unnecessary collisions.

   (b) Collision detection

   Solution: Collision detection is the method of detecting if two messages were sent at the same time, thus preventing proper communication. In CSMA/CD there are no timeouts or acknowledgments. Instead nodes constantly monitor the medium and send a jam sequence as soon as a collision is detected so that everyone learns about it as soon as possible.

8. The original Ethernet used 8 bit addresses and even today, LANs rarely have more than a few hundred nodes, so you might think something like 16 bits would be more than sufficient for a physical address. Give one significant reason that Ethernet uses 48 bit physical addresses despite the additional overhead?

   Solution: 48 bits allows the addresses to be unique, this means:

   - no configuration necessary for hooking up a new node;
   - separation of routing from addressing;
   - a basis for unique identification of files, programs and other objects on the networked hosts.

   Also, the leftovers are used for multicast, etc.

9. Oceanic Airlines has just built a new office on a desert island and you are hired to help design its local area network. The chosen technology is Ethernet, with copper wires for a propagation speed of $1.8 * 10^8$ m/s and a length of 600m.

   (a) Assuming the employes would be happy with 100 Mbps, how big must your packets be to ensure perfect collision detection? Justify by showing your calculations.

   Solution: 2 x propagation delay $= 2 \times 600m/1.8 \times 10^8 m/s = 6.667 \times 10^{-6} s$
   At 100 Mbps, how many bits do we send in $6.667 \times 10^{-6} s$? We send $6.667 \times 10^{-6} \times 1 \times 10^8 = 667 bits$

   (b) Somehow there aren't many clients on a desert island and employees are spending all of their time watching videos on You Tube, so you need to upgrade to 1 Gbps. What are the two ways you can change either the network topology, network protocol, or both to handle this new speed?

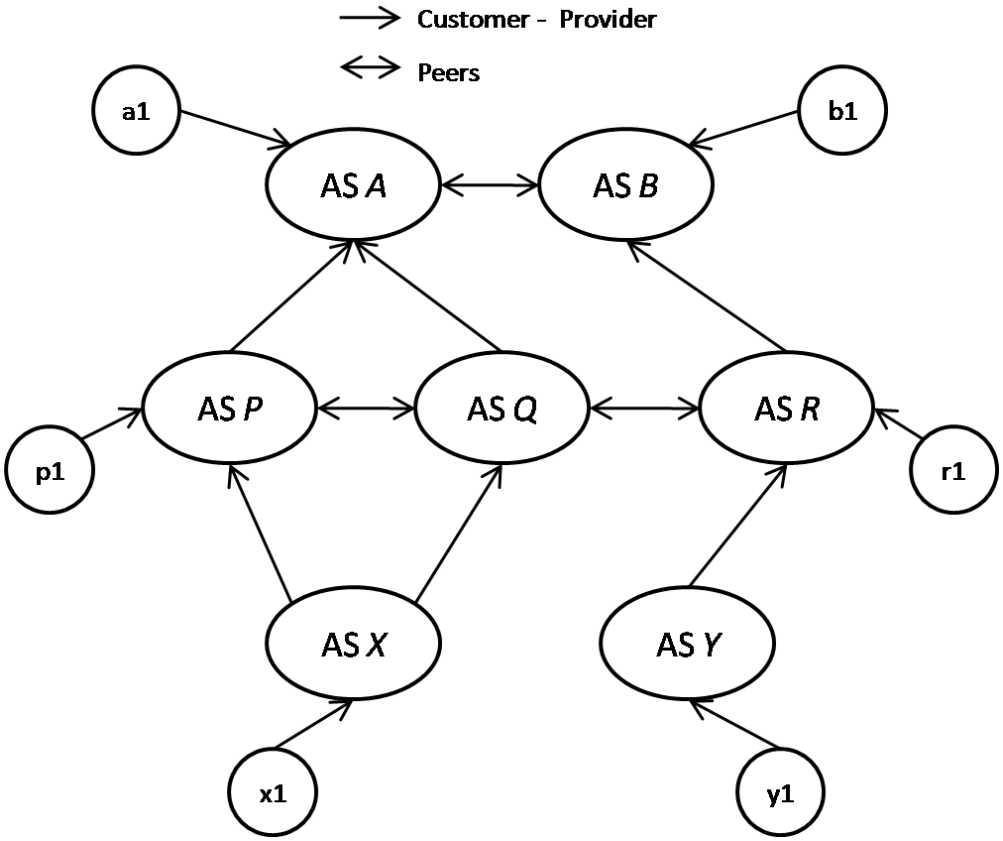
   Solution: Make packets ten times bigger (6670 bits), or the network ten times smaller (60 m).

   (c) There is a malfunctioning machine in your 1 Gbps network that thinks the maximum packet size is 100 bits and starts sending packets immediately after seeing the 100th bit of a packet, causing collisions. Your network interface card reports this collision after 700 bits have been sent. Can you identify the malfunctioning node by computing its relative distance to your own machine?

   Solution: $700 bits = 2x + 100 \equiv x = 300$
   $prop\_delay = 300 bits / 10^9 bits/s = 3 \times 10^{-}7s$
   $speed = 1.8 \times 10^8 m/s$
   $distance = prop\_delay \times speed = 3 \times 10^{-}7 \times 1.8 \times 10^8 = 54m$

C BGP relationships

Consider the network depicted and answer the questions below.



10. Which paths may packets take between a pair of end-hosts considering Internet economics? Circle valid and invalid for the paths and, if it is invalid, give a short statement why.

Valid OR Invalid x1 → AS X → AS Q → AS P → AS A → a1
why?

> **Solution:** F - goes over a peering link from AS Q to AS P before going to P's provider, which violates valley-free routing (AS P is losing in the process).

Valid OR Invalid r1 → AS R → AS Q → AS X → x1
why?

> **Solution:** T

Valid OR Invalid y1 → AS Y → AS R → AS B → AS A → a1
why?

Solution: T

Valid OR Invalid y1 $\rightarrow$ AS Y $\rightarrow$ AS R $\rightarrow$ AS Q $\rightarrow$ AS P $\rightarrow$ p1
why?

Solution: F - goes through 2 peering hops, which violates valley-free routing (AS Q is losing in the process).

Solution:

2 points for each correct answer with explanation. 1 point deducted if explanation is not clear or incorrect. Using (-1,0,+1) labeling for customer, peer and provider links was accepted if sufficient explanation was given.

11. Suppose AS's Q and R begin fighting
    (a) Using only BGP, is it possible for AS Q to implement a policy stating that traffic outbound from AS Q should not cross AS R? Why or why not?

    Solution: Yes, AS Q can only choose routes in which AS R does not appear in the AS PATH attribute.

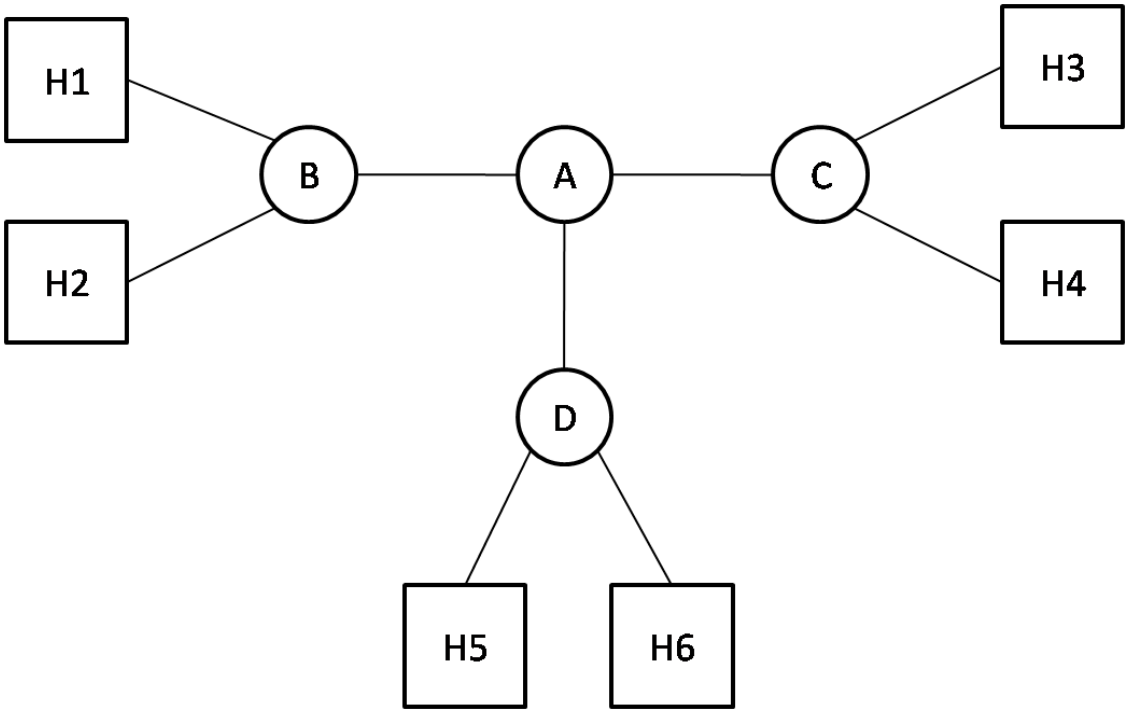
    (b) Using only BGP, is it possible for AS R to implement a policy stating that it doesn't want to carry traffic from Q to AS R's customers? Why or why not?

    Solution: No, it needs to provide service to customers and, therefore, announce reachability to its customers to its BGP neighbors. At that point, AS Q may receive an announcement from one its neighbors of reachability through AS R.

Solution:

2 points for each correct answer with explanation. 1 point deducted if explanation is not clear or incorrect.

D Repeaters, Bridges, Routers and Tunneling



12. In the above topology, Hn represents a host machine and A, B, C, D are repeaters/bridges/routers. The edges represent Ethernet cabling between the devices.

    (a) Suppose A, B, C and D are repeaters (hubs). Assuming that the sender does not hear the packet it sends, list the hosts that can overhear a packet sent from H1 destined to H4.

    Solution: H2, H3, H4, H5, H6

    (b) If A is a switch (learning bridge) which knows where the hosts are (i.e. has a filled in bridging table), and B, C and D are repeaters (hubs), list the hosts that can overhear a packet sent from H1 destined to H4.

    Solution: H2, H3, H4

    (c) If A, B, C and D are learning bridges which know about the hosts' locations, which hosts can hear the packet from H1 to H4?

    Solution: H4

    Solution: 2 pts each. partially correct solutions got 1 point

13. For this question, we use the following notation. The IP address and link-layer address of a node is IP-<name> and MAC-<name> (e.g. IP-H1 is the IP address of H1 and MAC-A is the link-layer address of A).

In a setting where A, B, C and D are all hubs, the table below shows the headers for a packet sent from H1 to H4 as it traverses the link B-A. Answer the remaining questions using the same notation.

Header Type	**Src Addr**	**Dest Addr**
link-layer	MAC-H1	MAC-H4
IP	IP-H1	IP-H4

(a) In a setting where A is a switch and B, C and D are repeaters (hubs), show the network and link-layer headers for the packet sent from H1 to H4 (outermost header first) as it traverses link B-A.

Header Type	Src Addr	Dest Addr
link-layer	MAC-H1	MAC-H4
IP	IP-H1	IP-H4

(b) Suppose A, B, C and D are routers. show the network and link-layer headers for a packet sent from H1 to H4 (outermost header first) as it traverses link B-A.

Header Type	Src Addr	Dest Addr
link-layer	MAC-B	MAC-A
IP	IP-H1	IP-H4

(c) Suppose A, B, C and D are routers, and there is an IP-in-IP tunnel from B to C. Show all network and link-layer header(s) for a packet sent from H1 to H4 (outermost header first) as it traverses link B-A. (hint: remember to show any encapsulated headers)

Header Type	Src Addr	Dest Addr
link-layer	MAC-B	MAC-A
IP	IP-B	IP-C
IP	IP-H1	IP-H4

Solution: 4 points each -0.5 for each incorrect cell (.5's are floored down) -2 for missing row -1 for additional row

The End – Phew!

E 3 Free Points for Tearing Off Page: Anonymous Feeback

List one thing you liked about the *class* and would like to see more of or see continued (any topic - lectures, homework, projects, bboards, topics covered or not covered, etc., etc.):

List one thing you would like to have changed or have improved about the class: