CS168 Midterm

Thursday, 13 October 2016

Abandon all hope, ye who enter here

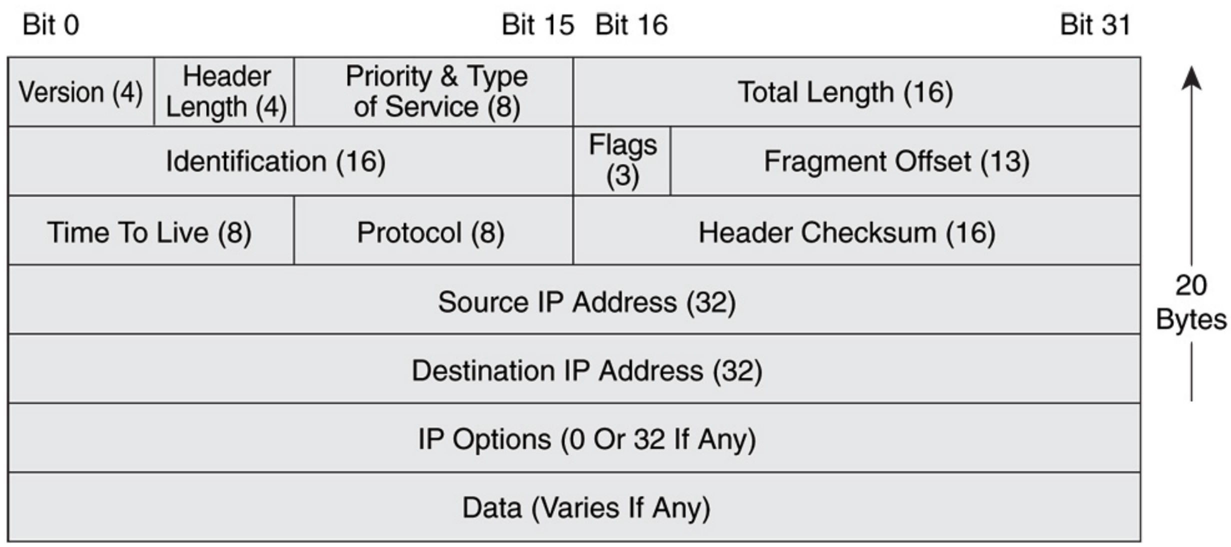
–Dante

Instructions: Read them NOW!

- **Please detach the last page of this test, and use it to enter all your answers.**
- **Write your name and SID on the answer sheet!**
- You may write on the test itself, but only the answer sheet will be graded. In addition, there are blank pages at the end for you to use as scratch paper.
- This examination is CLOSED BOOK/CLOSED NOTES.
- You will not require a calculator, iPhone, laptop computer, or other calculation aid. Please put them away right now! **Using electronics of any kind during the test will be considered cheating, and you will be excused from the room.**
- If you need to use a restroom, please give your test and your cell phone to a TA as you leave.
- You MAY use one 8.5”x11” double-sided crib sheet, packed with **handwritten** notes, formulas, and diagrams.

Fun Facts to Remember

- 1 TB = 10^{12} bytes; 1 GB is 10^9 bytes; 1 MB is 10^6 bytes
- 1Gbps is 10^9 bits/sec; 1Mbps is 10^6 bits/sec
- 1 msec is 10^{-3} seconds; 1 μsec is 10^{-6} seconds.
- The IPv4 header is depicted below.



(26) 1. **True/False**

(1) (a) In responding to a discovery message from a host, DHCP sends its response to IP address 255.255.255.255.

(1) (b) Learning switches must implement L3 as part of their total functionality.

(1) (c) When forwarding packets, L3 routers change the destination IP address.

(1) (d) When sending a DHCP packet (in typical usage), the resulting packet has four headers in this order (from outer to inner): Ethernet, IP, TCP, DHCP.

(1) (e) When using distance-vector, a router knows the path its packets will traverse to a given destination.

(1) (f) You poison a route when it changes its length.

(1) (g) Circuit switching uses statistical multiplexing to be more efficient than packet switching.

(1) (h) With valid destination-based routing, the set of network paths (from all sources) towards a particular destination forms a tree.

(1) (i) With valid destination-based routing the set of network paths from a particular source to all destinations forms a tree.

(1) (j) Split horizon is used when sending partial updates.

(1) (k) IPv6 has a checksum that detects header corruption.

(1) (l) Each interface has a permanent MAC address.

(1) (m) IP addresses may change for a given host.

(1) (n) TCP has a checksum that detects payload corruption.

(1) (o) The End-to-End Principle suggests that we should implement reliabilty in the network.

(1) (p) IPv4 has a checksum that detects payload corruption.

(1) (q) A router encapsulates the L3 header in an L2 header before forwarding a packet.

(1) (r) When a learning switch floods a packet because it has no entry in its forwarding table, it uses the `ff:ff:ff:ff:ff:ff` address.

(1) (s) When sending an HTTP message over an Ethernet, the resulting packet has four headers in this order (from outer to inner): HTTP, TCP, IP, Ethernet.

(1) (t) Fate-sharing argues that we should use LPM in routers.

(1) (u) L3 routers must implement L2 as part of their total functionality.

(1) (v) Layering results from the application of modularity to networks.

(1) (w) IPv6 eliminated all fields relating to fragmentation.

(1) (x) When forwarding packets, L3 routers change the destination port.

(1) (y) A reliable transport mechanism may give up and notify the invoking application of its failure.

(1) (z) When forwarding packets, L3 routers change the destination MAC address.

(32) 2. **A Few Short Questions**

(3) (a) **Learning switches**:

(1) i. Learning switches keep a table mapping MAC addresses to appropriate outgoing port. What happens when the switch receives a packet whose destination MAC is not in this table?

A. The packet is sent out all physical ports (regardless of whether they are on the spanning tree), other than the incoming port.

B. The switch picks a port at random on which to forward the packet.

C. The packet is sent out all ports on the spanning tree, other than the incoming port.

D. The packet is dropped.

(1) ii. What happens when the switch receives a packet whose destination MAC is in the table, but the entry points to the incoming port?

A. The packet is sent out all ports on the spanning tree, other than the incoming port.

B. The switch picks a port at random on which to forward the packet.

C. The packet is sent out all physical ports (regardless of whether they are on the spanning tree), other than the incoming port.

D. The packet is dropped.

(1) iii. Suppose there is a "mute" host that never sends a data packet. Which of the following is true?

A. Only the first packet sent to this mute host is flooded; all subsequent packets are delivered without flooding.

B. No packets can ever reach this mute host.

C. Such a host prevents the spanning tree protocol from converging.

D. All packets sent to this mute host are flooded by all switches.

(8) (b) **Addressing**:

(2) i. Does address `10.238.52.215` belong in the subnet `10.128.0.0/9` (Yes or No)

(2) ii. How many unique addresses are in the prefix `67.45.23.0/27`?

(2) iii. Does address `10.238.52.215` belong in the subnet `10.128.0.0/10` (Yes or No)

(2) iv. Which of the following correctly identify a network prefix? List all that apply.

A. `123.106.128/25`

B. `67.23.23/14/25`

C. `267.17.56/24`

(4) (c) **Layering**: What layers do these actions happen in? For each list one of L1, L2, L3, L4. A level can appear in more than one answer.

(1) i. Packet is broadcast

(1) ii. Packet is retransmitted after a timeout

(1) iii. Packet is fragmented

(1) iv. Packet bits are encoded onto an optical fiber

(3) (d) **Subnets**: Which of the following information does host A use to determine if it is on the same subnet as host B? List all that apply.

A. Host B's first hop router.
B. Host B's subnet mask.
C. Host B's IP address.
D. Host A's subnet mask.
E. Host A's first hop router.
F. Host A's IP address.

(4) (e) **LPM**: A router has the following four entries in its routing table:

`168.0.0.0/6` ⇒ port 1
`160.0.0.0/4` ⇒ port 2
`192.0.0.0/3` ⇒ port 3
default ⇒ port 4

For each of the destination addresses below, indicate to which port the packet would be forwarded.

(1) i. `10111000 10111101 00100000 100101111`

(1) ii. `10100100 00110001 10010010 000001000`

(1) iii. `10101010 00100110 11000111 111001000`

(1) iv. `11000100 00101111 01000010 111010011`

(4) (f) **Spanning Tree**: Consider a network running the spanning tree protocol and focus on the actions of node 5 in that network. We are not reminding you how that protocol works, but you have enough hints in this question to figure out what these messages mean.

(2) i. Which of the following messages can node 5 **never** send during the course of normal operation of the spanning tree protocol? List all that apply.

A. (3,15,5)
B. (5,0,5)
C. (6,1,5)
D. (3,5,4)

(2) ii. Assume Node 5 has just sent the message (5,0,5) to its neighboring nodes 6,7,9. It now receives messages (4,3,6), (3,2,7), (3,1,9) from them. What message does node 5 send next? Choose one of the following messages

A. (5,3,9)
B. (3,3,5)
C. (3,2,5)

D. (9,2,5))

(3) (g) **ACKstravaganza**: A source sends data packets D1, D2, D3, D4, D5, D6, D7, D8 (where Dx represents the xth data packet). It gets back the following cumulative ACKs: A1, A5, A8, A7 (where Ax acknowledges receipt of the first through the xth data packet, with the (x+1)th packet not yet arrived). Which two of the following, when combined, could have caused this?

A. Data packet reordering

B. Data packet drop

C. ACK reordering

D. ACK drop

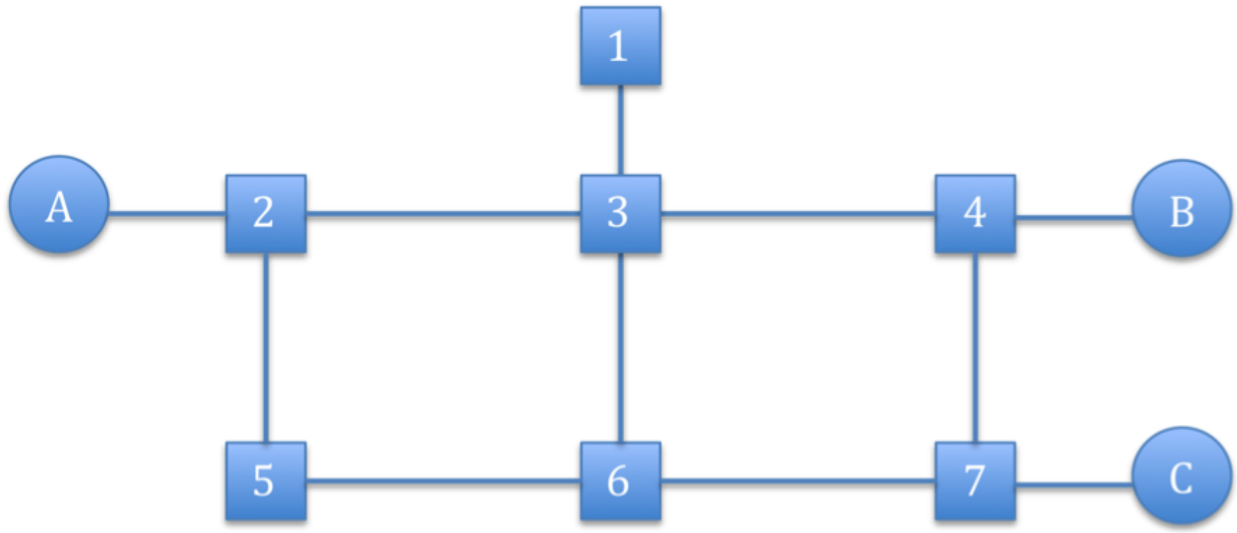
(3) (h) **When things go awry: transport protocol**: Consider a broken transport protocol comprised of the following sending and receiving algorithms.

The sending process starts by sending some number of packets. A timer is set every time a packet is sent (a separate timer for each packet), and upon timeout that packet is retransmitted. Whenever a packet is ACKed for the first time, a randomly chosen unACKed packet is sent.

The receiver only sends an individual ACK for every second packet it receives (i.e, it ACKs the 2nd, 4th, 6th, etc. packets that it receives, regardless if some of the packets have been received before).

Is this reliable? (Yes or No)

(6) 3. **L2 and ARP**

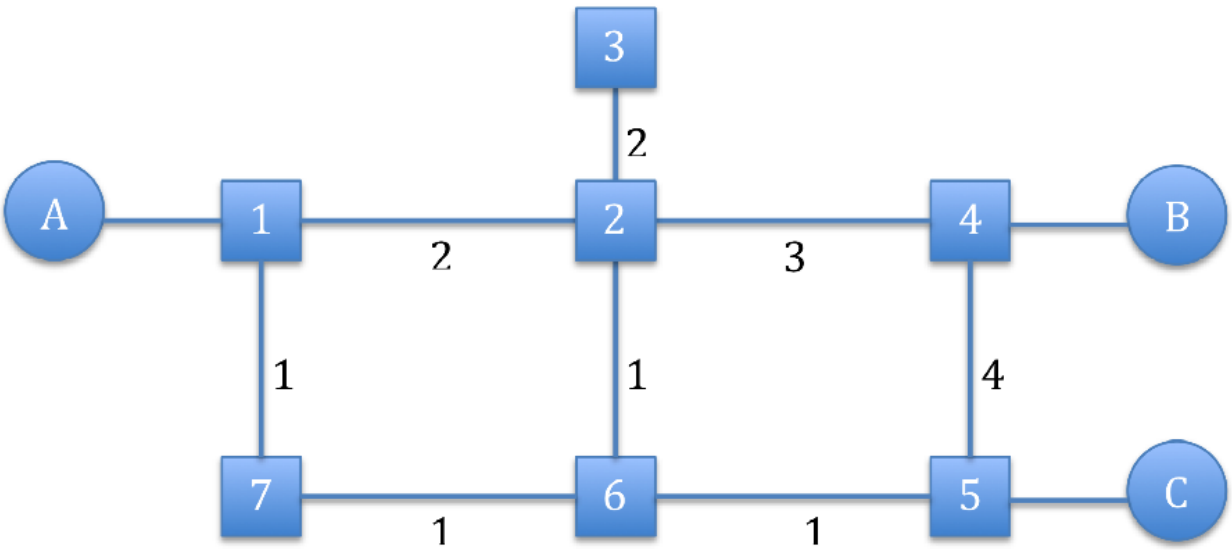


In this problem, A, B and C are hosts that connect to a local network where all internal nodes (the boxes) are learning switches. Assume that the spanning tree protocol has already run, but that the switches have no entries in their forwarding tables. Also assume that the hosts already know each other's IP addresses, but they have no entries cached in their ARP tables. Consider the following events, and list which of the nodes the packet traverses (and if it traverses all nodes, please just write ALL). There will be no partial credit for this problem, either your answer describes the path correctly, or it does not.

(3) (a) A sends an ARP request for C's MAC address. Which switches does it traverse? Please list in the numerical order (from smallest to largest, or say ALL).

(3) (b) C then sends an ARP response to A. Which switches does this response traverse? Please list in the numerical order (from smallest to largest, or say ALL).

(10) 4. **When Things Go Awry: L3 routing**



In this problem, A, B and C are hosts that connect to a network where all internal nodes (the boxes) are L3 routers, and the numbering on the links represents their link distances or costs (to be used in routing). The link distance/cost between a router and an attached host is assumed to be zero. We consider various packets sent by A, and ask about the path these packets traverse. Please list all (and only) the routers the packets traverse. There will be no partial credit for this problem, either your answer describes the path correctly, or it does not.

First consider the case where everything is functioning normally. A distance-vector routing algorithm is running on this network and has converged. Each router now has the appropriate routing state to reach hosts A, B, and C via a shortest path.

(2) (a) When A sends a packet with B's IP address as the destination, what routers does it traverse (listed in the order they are traversed)?

(2) (b) When A sends a packet with C's IP address as the destination, what routers does it traverse (listed in the order they are traversed)?

Now we consider the case where B and C were assigned the same IP address by accident, and then the distance-vector routing algorithm was run.

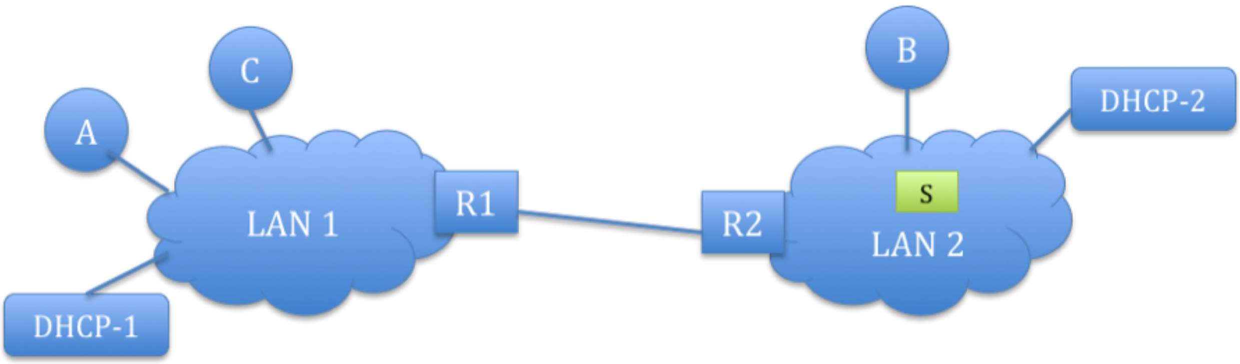
(2) (c) When A sends a packet with this IP address, what routers does it traverse (listed in the order they are traversed)?

Now we return to the case where B and C have separate IP addresses, and we rerun the distance-vector routing algorithm. However, during this process router 3 lies about its distances. In fact, in the distance-vector routing algorithm router 3 always advertises that it has paths with distance 0 (zero) to all IP addresses (and thus to hosts B and C). Furthermore, when data packets arrive at router 3, it drops them.

(2) (d) When A sends a packet with B's IP address as the destination, what routers does it traverse (listed in the order they are traversed)?

(2) (e) When A sends a packet with C's IP address as the destination, what routers does it traverse (listed in the order they are traversed)?

(18) 5. **Host-to-Host**



Consider two networks, LAN 1 and LAN 2, each with their own DHCP server (DHCP 1 and DHCP 2). Assume that host A just attached to the network LAN 1 and sends a packet to host B (which is on LAN 2). Host A knows nothing except for the IP address of B. For this question, assume that no other hosts try to exchange packets, no packets are lost, and no nodes have cached entries in their ARP tables.

The switch S is one of possibly many switches forwarding packets within the LAN 2 subnet, and assume that packets sent by A to B pass through this switch.

Let MAC(X) be the MAC address of node X, and IP(X) be the IP address of node X.

(2) (a) Which of the following fields does R1 modify before forwarding host A's packet to router R2? List all that apply.

A. Source IP address
B. Destination MAC address
C. Destination IP address
D. TTL
E. Source MAC address
F. IP Checksum
G. None of the these answers

(2) (b) Which of the following fields does switch S modify before forwarding host A's packet to host B? List all that apply.

A. Source IP address
B. None of these answers
C. Destination MAC address
D. Source MAC address
E. TTL
F. Destination IP address
G. IP Checksum

(2) (c) D. Which network nodes will **send** ARP **requests** during this process delivering a packet from A to B? List all that apply.

A. Router R1
B. Host A
C. DHCP-1
D. Host B
E. Host C
F. DHCP-2
G. Router R2

(2) (d) What is the destination IP address of the datagram A sends to R1?

A. IP(R1)
B. IP(R2)
C. `255.255.255.255`
D. IP(B)

(2) (e) What is the destination MAC address of the datagram A sends to R1?

A. `ff:ff:ff:ff:ff:ff`
B. MAC(C)
C. MAC(R1)
D. MAC(R2)

(8) (f) Below are a number of different combinations of source and destination MAC and IP addresses. Choose the combinations that **do not** occur in any packets sent during this process of delivering a packet sent from A to B. List all that apply.

A. Source MAC = MAC(A), destination IP = IP(B)
B. Source IP = IP(A), destination MAC = MAC(B)
C. Source MAC = MAC(R1), destination MAC = MAC(B)
D. Source IP = IP(R1), destination IP = IP(R2)
E. Source IP = IP(R2), destination IP = IP(B)
F. Source MAC = MAC(R1), destination MAC = MAC(R2)
G. Source IP = IP(A), destination IP = IP(R1)
H. Source MAC = MAC(R2), destination MAC = MAC(B)

(6) 6. **Fragmentation**

Host A sends a 6000 byte packet (the 6000 bytes includes the IP header) to host B. Assume that IPv4 is used, that the IP header contains no options, and that a node always sends the maximal sized fragments, with only the last fragment non-maximal. For instance, if a node wants to forward 250 B onto a link with an MTU of 200 B, the first fragment will always be of size 200 B and the second fragment will be of size 50 B, even if there are other possible fragment sizes, (200 – X) bytes and 50 + X bytes for which the MTU wouldn't be exceeded.

(2) (a) How many fragments does R1 send to R2?

A. 7
B. 4
C. 5
D. 6

(2) (b) How many fragments does R2 send to B?

A. 9
B. 12
C. 14
D. 11
E. 8
F. 10
G. 13

(2) (c) Which of the following IP header fields are the same in all these fragments **and** in the original 6000 byte packet R1 received? List all that apply.

A. Fragmentation Identification
B. MF (the "more fragments coming" flag)
C. None of these answers
D. Datagram Length
E. Fragmentation Offset

1. **True/False**
   (a) ________________
   (b) ________________
   (c) ________________
   (d) ________________
   (e) ________________
   (f) ________________
   (g) ________________
   (h) ________________
   (i) ________________
   (j) ________________
   (k) ________________
   (l) ________________
   (m) ________________
   (n) ________________
   (o) ________________
   (p) ________________
   (q) ________________
   (r) ________________
   (s) ________________
   (t) ________________
   (u) ________________
   (v) ________________
   (w) ________________
   (x) ________________
   (y) ________________
   (z) ________________

2. **Short Questions**
   (a) Learning Switches
      i. ________________
      ii. ________________
      iii. ________________
   (b) Addressing
      i. ________________
      ii. ________________
      iii. ________________
      iv. ________________
   (c) Layering
      i. ________________
      ii. ________________
      iii. ________________
      iv. ________________
   (d) Subnets
      ____
   (e) LPM
      i. ________________
      ii. ________________
      iii. ________________
      iv. ________________
   (f) Spanning Tree
      i. ________________
      ii. ________________
   (g) ACKstravaganza
      ____
   (h) When things go awry: transport protocol
      ____

3. **L2 and ARP**
   (a) ________________
   (b) ________________

4. **When Things Go Awry: L3 Routing**
   (a) ________________
   (b) ________________
   (c) ________________
   (d) ________________
   (e) ________________

5. **Host-to-Host**
   (a) ________________
   (b) ________________
   (c) ________________
   (d) ________________
   (e) ________________
   (f) ________________

6. **Fragmentation**
   (a) ________________
   (b) ________________
   (c) ________________