Solution to CS118 Final Exam, Fall 2015

December 2015

Name:_____

Student ID:_____

Notes:

1. This is a 3-hour, closed-book, closed-notes examination. But you can use the information written in your two-page cheat-sheets. You have three hours to finish all questions.
2. You are allowed to use your calculator.
3. Be **brief** and **concise** in your answers. Answer only within the space provided. Use the back pages for scratch paper. Cross out your scratch work when you submit your exam paper.
4. If you wish to be considered for partial credit, show all your work.
5. You are expected to uphold the highest degree of academic honesty.
6. Make sure that you have 10 pages (including this page) before you begin.

PROBLEM	MAX SCORE	YOUR SCORE
1	24	
2	18	
3	10	
4	8	
5	8	
6	9	
7	16	
8	7	
TOTAL	100	

Problem 1: Multiple choices (24 points; 2 points each). Select *all* (i.e., possibly more than one) correct answers.

1. Which of the following statement regarding network address translation (NAT) is false?

   - Your answer D, E (A) All datagrams leaving local network use the same single source IP address of the NAT router. (B) Private addresses used inside the local network will not be carried to the global Internet. (C) The NAT translation table at the NAT router includes IP addresses and port numbers in the table entries. (D) Port numbers are used for addressing hosts. (E) The NAT router processes packets only up to the network layer.

2. DHCP can be used to obtain network configuration information. Which of the following information *cannot* be found using DHCP?

   - Your answer D, E (A) IP address of a new host; (B) the IP address of the DNS server; (C) the address of the default first-hop router; (D) MAC address of the first-hop router; (E) MAC address of the DNS server.

3. Which of the following statement on IEEE 802.11 Wireless MAC is false?

   - Your answer E (A) RTS/CTS is needed to mitigate the hidden station problem. (B) link-layer ACK is needed for fast loss recovery locally. (C) RTS/CTS is not required all the time. (D) Carrier sensing is available. (E) Upon hearing CTS, other stations will not defer their potential transmissions for the reserved duration.

4. Which of the following statement on datagram switching and virtual circuit switching is false?

   - Your answer A, D (A) Datagram switching needs a connection setup stage before data transfer. (B) Datagram is a packet switching technique. (C) Virtual circuit switching needs a virtual circuit ID at each switch. (D) Internet adopts both datagram switching and virtual circuit switching techniques. (E) Virtual circuit switching does not handle link or node failures as well as datagram switching.

5. Which field is available in the IPv6 header but not in the IPv4 header?

   - Your answer C (A) Source and destination IP addresses. (B) Internet checksum. (C) Flow label. (D) Options. (E) Version.

6. Which technique cannot be used to support Internet telephony on today's best-effort Internet?

   - Your answer E (A) adaptive playout delay. (B) FEC coded packets. (C) interleaving. (D) client side buffering. (E) make resource reservation for the audio stream at each intermediate router.

7. Which of the following statement on distance vector routing is true?

   - Your answer D (A) It is only used to compute the minimum-cost, Steiner tree for multicast. (B) Every node exchanges route information with all other nodes in the network. (C) Both good news and bad news would travel very fast. (D) It suffers from count-to-infinity problem when link cost increases. (E) It does not work at all when a node fails.

8. Which protocol is used to establish phone calls between a caller and a callee and enable the caller to find the callee's current IP address?

   - Your answer D (A) DHCP; (B) RTP; (C) RTCP; (D) SIP; (E) DNS.

9. Which protocol is used to carry multimedia data packets over the Internet?

   - Your answer A (A) RTP; (B) SIP; (C) RTSP; (D) TCP; (E) RTCP.

10. Which statement is false about virtual local area networks (VLANs)?

    - Your answer C (A) Port-based VLAN divides switch ports into multiple groups; (B) Ports in the same group form a broadcast domain; (C) All ports can still broadcast frames among one another; (D) A table of port-to-VLAN mapping is kept with the switch; (E) A switch can never know that a frame arriving on a trunk port belongs to a particular VLAN.

11. Consider sending a 3300-byte datagram into a link that has an MTU of 800 bytes. What is the size of the last fragment (including IP header)?

    - Your answer E (A) 100; (B) 120; (C) 140; (D) 160; (E) 180 Bytes.

12. Which protocols are using soft state (i.e., certain protocol states are deleted after timeout)?

    - Your answer A, B (A) ARP; (B) DHCP; (C) RIP; (D) RTP; (E) OSPF.

Problem 2 (18 points; 2 points each): Answer the following questions. Be brief and concise.

1. Why does the IP header include the TTL (time-to-live) field? How is the TTL field changed each time the datagram packet is processed by a router?

   (a) It is used to get rid of packets that suffer from routing loops.

   (b) TTL is decremented by 1 after each router.

2. Identify two cases when collisions may still occur, even when the CSMA/CD protocol is used for the wired channel access by every node.

   (1) when two nodes contend for the channel at exactly the same time (during initial access, or with the same random value for backoff);

   (2) two nodes contend sequentially but within certain propagation delay.

3. Does the path vector in BGP include any router's IP address? Briefly explain why.

   No. It is policy-based, inter-domain routing. So only AS domains (i.e., AS number) are carried in the path vector. (Note: IP address is used in the next-hop hop router field of the forwarding table)

4. Identify two techniques to handle packet losses for Internet VoIP applications.

   (1) FEC like error correction codes;

   (2) Alternative FEC codes (with low- priority copy carried in the followup packet);

   (3) Slicing each packet and interleaving slices together;

5. Suppose four active nodes - node A, B, C and D - are competing for access to a wired channel using slotted ALOHA. Assume each node has an infinite number of packets to send. Each node attempts to transmit in each slot with probability p. What is the best probability p that maximizes the overall channel access for these four nodes? Show your main steps.

   1. The success probability without collisions is $N \cdot p \cdot (1-p)^{N-1}$, where $N = 4$.
   2. To maximize the above probability, we take the derivative of the above with respect to p and set the derivative to 0.
   3. We arrive at $p = \frac{1}{N} = 0.25$

6. Will all available links and physical paths (connecting multiple nodes and links) over the Internet be *always* seen by a customer in the Internet routing? Hint: consider both inter-domain routing and intra-domain routing. Briefly justify why.

   No. As shown in the homework and the lecture slide, if certain AS decides to not advertise certain links and paths (among ASes), then customers will not see them even though they do exist physically.

7. The Session Initiation Protocol (SIP) can be used to call one's email address even though the user to be called (i.e., the callee) travels outside her/his home network. List the step-by-step operations for this case. Please be concise.

   1. contact the local SIP proxy server;
   2. contact the destination's (callee's email address) SIP proxy server;
   3. contact the visiting network's SIP server;
   4. caller and callee set up the call session (for voice data).

8. Traceroute allows us to trace route from a host to any other host on the Internet by displaying all the intermediate routes along the route. Can you identify how many protocols we have learned from the class will be used when we run the *traceroute* program? For each used protocol, explain why traceroute needs to use it.

   1. IP protocol: carry the ICMP packets
   2. ICMP protocol: to ping each intermediate router and gets its response;
   3. ARP protocol: forward IP/ICMP packets
   4. Routing protocols RIP/OSPF/BGP: route packets to the destination

9. In Project 2, how would you implement the retransmission timer? Can you propose an alternative way to implement it?

   One possible answer: per TCP segment based timer; or use a per window based timer.

Problem 3 (10 points): Layered protocols Alice uses her laptop to browse the web service at www.google.com. When walking into her office, she immediately boots up her laptop and connects it to the CS department's Ethernet, which is connected via an ISP to the Internet. The CS department has a local DNS server. Identify protocols used in each step during Alice's web browsing.

1. Identify at least three protocols used when Alice's laptop gets her IP address from the CS department Ethernet.

   1. DHCP; 2. CSMA/CD for Ethernet MAC; 3. ARP; UDP.

2. Alice's laptop needs to know the IP address for www.google.com. Identify two used protocols.

   1. DNS; 2. UDP; 3. IP; 4. routing RIP/OSPF/BGP

3. The name resolution query message is routed to the remote google server via intra- and inter-domain routing. Identify two protocols used here.

   1. inter-domain routing: BGP; 2. intra-domain routing: OSPF or RIP

4. Identify two protocols used when Alice's laptop is finally able to browse the website www.google.com.

   1. HTTP; 2. TCP.

5. Identify at least one *plug and play protocol* used in the above process.

   DHCP

Problem 4 (8 points): Routing Shown in the figure, a network has 9 routers connected as a grid: there are 3 routers in a row and 3 rows. Each router sends out routing updates every 30 seconds. Case-A: it uses distance-vector routing, and all routing update messages are 200 bytes long. Case-B: it uses link-state routing protocol, all routing update messages are 100 bytes long.

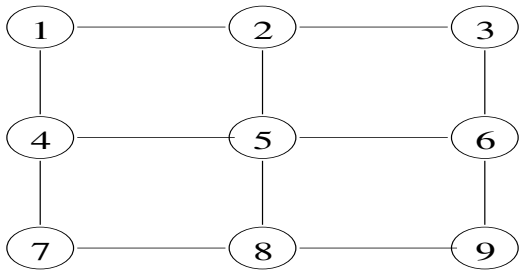

Figure 1: Network Topology

1. (4 points) for Case-A: on average how many bytes of routing update messages do Router-3 and Router-5 each receive per minute? Show your calculation steps.

   A router in DV exchanges info with its neighbors only.

   Router-3: $200B \cdot 2(neighbors) \cdot \frac{60sec}{30sec} = 800B$

   Router-5: $200B \cdot 4(neighbors) \cdot \frac{60sec}{30sec} = 1600B$

2. (4 points) for Case-B: on average how many bytes of routing update messages do Router-3 and Router-5 each receive per minute? Show your calculation steps.

   A router in LS exchanges LS info with all other routers.

   Router 3: $100B \cdot 8nodes \cdot \frac{60sec}{30sec} = 1600B$

   Router 5: $100B \cdot 8nodes \cdot \frac{60sec}{30sec} = 1600B$

Problem 5 (8 points): Multicast The network topology is shown below. All routers are capable of multicast routing. A host connected to router A sends out a multicast packet into the network. B, G, and E are routers with attached group member of the multicast packet. We use the RPF (Reverse Path Forwarding) algorithm; the link cost is marked in the figure. Show how the multicast packet is delivered through the network. You should use two different arrow signs (shown in the figure) to mark both cases in the figure: packet that will be forwarded; packet not forwarded beyond receiving router.

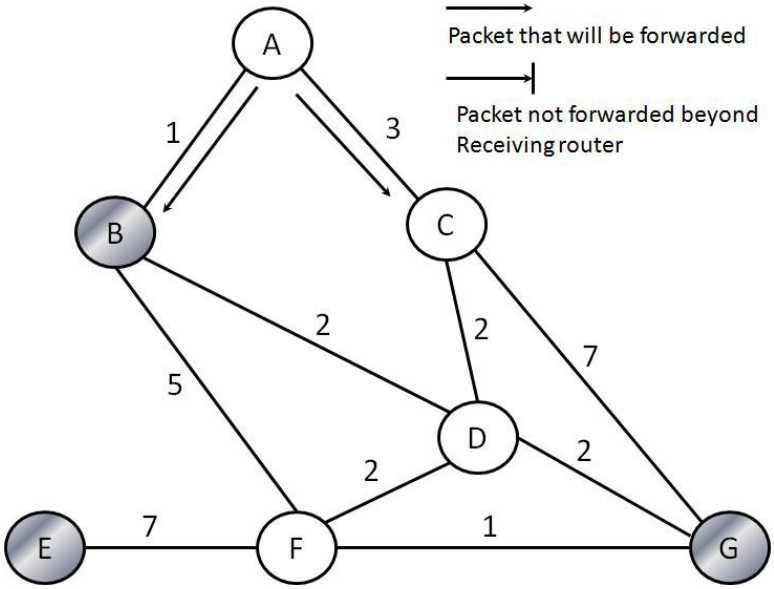

Figure 2: Multicast topology

Links where packets are forwarded: $B \to D$, $D \to G$, $D \to F$, $F \to E$.
Links where packets are NOT forwarded: $C \leftrightarrow D$, $C \leftrightarrow G$, $F \leftrightarrow G$,

Problem 6 (9 points): TCP Protocol

1. (6 points) You are asked to compute the retransmission timeout (RTO) for TCP. The initial estimated round-trip time (RTT) is set as 80ms, and initial RTT variation is 40ms. The RTT samples for 3 TCP segments are 160ms, 120ms, 200ms. In these 3 segments, the 2nd TCP segment has been retransmitted once. Compute *all* RTO values upon receiving *each* of three TCP segments. Show all the intermediate steps in your calculation. The following formula can be useful for your calculation:

$$EstimatedRTT = \frac{7}{8} \cdot EstimatedRTT + \frac{1}{8} \cdot SampleRTT$$

$$DevRTT = \frac{3}{4} \cdot DevRTT + \frac{1}{4} \cdot |SampleRTT - EstimatedRTT|$$

$$RTO = EstimatedRTT + 4 \times DevRTT$$

Note: if the expression is correct but the calculation is wrong, deduct 0.5 points only. Not sure my calculation is right.

For 1st Segment: $EstRTT = \frac{7}{8} \cdot 80 + \frac{1}{8} \cdot 160 = 90ms$;

$DevRTT = \frac{3}{4} \cdot 40 + \frac{1}{4} \cdot |160 - 90| = 47.5ms$

$RTO = 90 + 4 \cdot 47.5 = 260ms$

For 2nd Segment: It is not used for RTO calculation due to the retransmissions.

RTO is still the same as above, i.e., 260ms.

For 3rd Segment, repeat the above step for Segment 1.

$EstRTT = \frac{7}{8} \cdot 90 + \frac{1}{8} \cdot 200 = 103.75ms$;

$DevRTT = \frac{3}{4} \cdot 47.5 + \frac{1}{4} \cdot |200 - 103.75| = 35.625 + 24.0625 = 59.7ms$

$RTO = 103.75 + 4 \cdot 59.7 = 342.5ms$

2. (3 points) Now assume that the RTO timer (based on the above calculation) for the 4th segment expires three times. TCP retransmits the 4th segment whenever the timer expires during the process. What is the final RTO value afterwards? Show your reasoning.

It doubles after each timeout.

So the RTO value will be $2^3 = 8$ of the above value.

Problem 7 (16 points): Ethernet and MAC

Part 1 (8 points): A company named SmartMaster has all its workstations connected to one Ethernet. A year ago, the total number of workstations was 20, the performance of data communication among the 20 stations was very good. However the company has now grown to 120 workstations, still connected to the same single Ethernet and the performance was poor due to frequent collisions. To improve the situation SmartMaster decided to install three additional Ethernets and spread the workstations evenly among all the four networks. However SmartMaster cannot figure out whether to use switches or routers to interconnect the four Ethernets.

1. (4 points) If SmartMaster decides to use switches,

   - (2 points) Will the collision problem as observed within each Ethernet segment be reduced? Explain why in your answer. Yes, to some extent. This is mainly due to the self-learning

     algorithm at each switch, which will not always broadcast every Ethernet frame across all 120 nodes.

   - (2 points) What algorithms are needed for interconnecting the four Ethernets? Will any changes be made to the workstations?

     self-learning at each switch.

     No changes are needed at each workstation.

2. (4 points) If SmartMaster decides to use routers,

   - Will the collision problem as observed with the current single Ethernet case be reduced? Explain your answer.

     Yes. Routers will isolate packet forwarding by not broadcasting packets across different subnets.

   - Will there be any changes needed to some of, or all, the workstations? If so, what kind of changes are needed? Explain your answer. (*Hint*: consider routing table at each host)

   Yes. Each workstation needs to reconfigure its forwarding/routing table. This requires the change of the next-hop router plus running the routing protocol (say, OSPF).

Part 2 (8 points): For the following scenario, please design a medium access control (MAC) protocol that provides the best performance. You need to: (1) identify your selected MAC; and (2) briefly justify your answer. (Hint: You can consider TDMA, CDMA, CSMA/CD, CSMA/CA, Slotted Aloha, Token-passing, and polling MAC protocols.)

1. (2 points) 5 periodic, uncompressed audio traffic sources, each of which comes from a laptop. All 5 laptops are sharing a wireless channel via the base station. The audio packets produced by each source are of identical size and they arrive at regular intervals.

   TDMA. The sources have regular periodic traffic and audio also requires timely delivery. TDMA is the best fit.

2. (2 points) 10 hosts are connected via a single cable to form a local area network. Each of them generates bursty, Internet data traffic. CSMA/CD. This is the typical scenario for random

   access. Ethernet MAC is the best fit.

3. (2 points) 40 laptops and PDAs share the wireless radio channel. Each is used to occasionally check for emails and browse the web but remain silent for other times.

   CSMA/CA. It is for random access over wireless channels. WiFi MAC is the best fit.

4. (2 points) Now you can use a node to serve as the master node. You are required to design a MAC to support 20 (compressed) variable-data-rate video traffic sources. Each source produces approximately constant-bit-rate traffic within a 400-ms interval, but the traffic rate changes every 400-ms interval.

You can use polling, since the master node can regularly poll each station on a regular basis.

Problem 8 (7 points) Mobility Support: Assume that IPv4 is used for current Internet access. Each of the three UCLA departments (e.g., EE, CS, and MATH) uses its own IP subnet. Each department has also deployed WiFi in its own subnet, thus enabling its faculty, staff and students to access the department subnet from the mobile devices (e.g., smartphones and tablets). You are asked to design a mobility support as the user roams.

1. (2 points) If you are asked to support mobility within each department's WiFi subnet, what is your proposed solution? Briefly justify your answer.

   WiFi already provides inter-AP roaming, so no extra mobility solution is needed.

2. (3 points) Now if these three departments decide to deploy new mobility support solutions so that members in all three departments can freely roam across different subnets, what is your proposed solution? Your solution needs to enable roaming devices across these three subnets to keep the ongoing TCP connection without disruption.

   You can use Mobile IP for this case, since it has to work across different subnets. WiFi roaming only works within a single subnet.

3. (2 points) If we further ask your solution that is also incrementally deployable (i.e., each department is allowed to gradually upgrade its network infrastructure for mobility support), what is your technique to handle this issue?

   The issue is that each host may not have upgrade immediately. So you may use indirect routing in Mobile Ip for this purpose. Moreover, home agents and foreign agents are needed in each department, you may use special servers for this purpose. Tunneling can also be used.