Midterm Exam II
CMPSCI 453: Computer Networks
Fall 2010
Prof. Jim Kurose

Instructions:

- **Please use two exam blue books –** answer questions 1, 2 in one book, and the remaining two questions in the second blue book.
- Put your name and student number on the exam books NOW!
- The exam is closed book.
- **You have 80 minutes** to complete the exam. **Be a smart exam taker -** if you get stuck on one problem go on to another problem. Also, don't waste your time giving irrelevant (or not requested) details.
- The total number of points for each question is given in parenthesis. There are 100 points total. An approximate amount of time that would be reasonable to spend on each question is also given; if you follow the suggested time guidelines, you should finish with 5 minutes to spare. The exam is 80 minutes long.
- Show all your work. Partial credit is possible for an answer, but only if you show the intermediate steps in obtaining the answer.
- Good luck.

<u>Question 1: ``Quickies'' (24 points, 20 minutes)</u>

Answer each of the following questions *briefly*, i.e., <u>*in at most a few sentences.*</u> (Really – your answer should be very **brief** here)

a) (3 points) Recall the class (and/or textbook) discussion of "what's inside a router." Where and why does packet loss occur within a router? *Answer: packet loss occurs in buffer in either the input or output line cards, because the memory in the buffer is finite, and the input rate to the buffer exceed the output rate of the buffer over some period of time.*

b) (4 points) Suppose BGP router A sends a BGP path vector to BGP peer router B. BGP peer B is connected to BGP peer C. Must B advertise that path to C? *Answer: No. BGP allows a BGP router to employ policy to decide whether or not to advertise a route to a neighbor. For example, we say that a tier-1 network does not carry transit traffic (traffic that does not have a source or destination within a customer network of that tier-1 ISP.). So a tier1 BGP router would not advertise a path to another BGP router if that path would be for transit traffic.*

c) (4 points) How is a *generator* used in cyclic redundancy check? *Answer: A generator, G, is a pre-determined (standardized) bit pattern. The CRC value for data is chosen such that the original bit pattern, shifted r bits to the left and then XORed with the checksum is exactly divisible by G.*

d) (4 points) In a mobile GSM network, what is the function of the Home Location Register (HLR), and how are updates made to the HLR? *Answer: The home location register points to the network in which the remote node is located.*

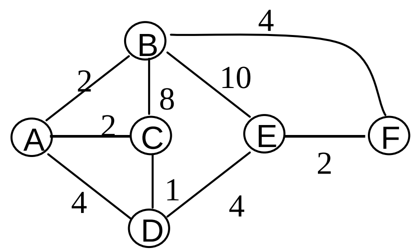
e) (4 points) In mobile IP, when a mobile node moves from one visited network to another, will the correspondent (the source node that is sending datagrams to the mobile) be aware of this move? *Answer: No, the datagrams from the correspondent will continue to be routed through (addressed to) the mobile node's home network.*

f) (5 points) Suppose that Bob and Alice have access to a public key system that makes their public keys available to each other. Each knows its own private key.

   1) Suppose Bob has a document, *m*, that he wants to digitally sign. How does he do so? Efficiency is not a concern here, any digital signature technique is fine. *Answer: Bob will encrypt the document, m, using his private key. This serves as Bob's digital signature on the document. If we want to be more efficient, Bob could compute a hash of m, and then encrypt hash(m).*

   2) What does Alice do to verify Bob's digital signature? *Answer: Alice applies Bob's public key to the signed version of m, i.e., computes $K_B^{+(}K_B^{-}(m))$. If that yields the message m, then Alice knows that Bob has signed the document.*

Question 2: Link State and Distance Vector Routing (26 points, 20 minutes)



Consider the network shown to the right.

a) (10 points) Show the operation of Dijkstra's (Link State) algorithm for computing the least cost path from **B** to all destinations.

b) (4 points) From these results, show the shortest path from B to D, and briefly describe (in a sentence) how you got that answer from your work in part a).

Answer:

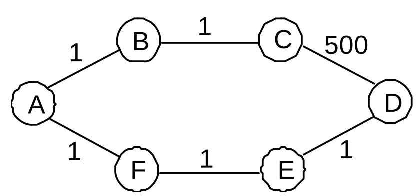
N	D(A),p(A)	D(c),p(c)	D(D),p(D)	D(E),p(E)	D(F),p(F)
B	2,B	8,B	infty	10,B	4,B
BA	---	4,A	6,A	10,B	4,B
BAC		---	5,C	10,B	4,B
BACF			5,C	6,F	--
BACFD				6,F	

The shortest from B to D can be found by BACD, this is found from the table as follows: last entry in D's column gives C as predecessor of D. Last entry in C column gives A is predecessor of C. Last entry in A's column isguve B (the source) as predecessor of A. So the reverse path is DCAB, and the forward path is BACD.

Consider now the ring network shown to the right below.

c) (6 points) What are distance vectors in nodes B, and C? *Note: you do not have to run the distance vector algorithm; you should be able to compute distance vectors by inspection. Answer: Following notation from class, let $d_x(y)$ equal the min cost from x to y. $d_B(A)=1$, $d_B(C)=1$, $d_B(D)=4$, $d_B(E)=3$, $d_B(F)=2$. $d_C(A)=2$, $d_C(B)=1$, $d_C(D)=5$, $d_C(E)=4$, $d_C(F)=3.6$*

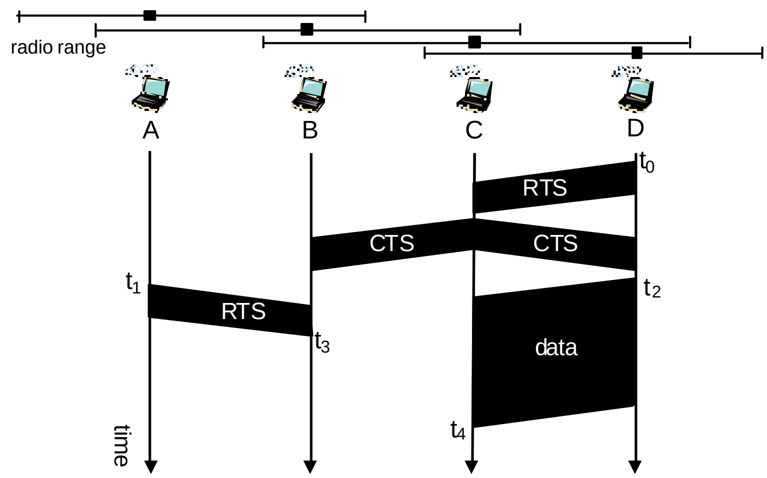
Now suppose that the only destination in the network to the right is A (i.e., we will *only* consider routing table entries here for A). Suppose that link from A to B fails (its cost goes to infinity)



d) (6 points) Once the failure is detected, approximately how many messages will be exchanged by all nodes by the distance vector algorithm until no more messages are exchanged? Justify your answer in one or two sentences. Note: you do not have to run the distance vector algorithm (it would take you hours); also, your answer need not be exactly correct, it can be off by a bit. This question is trying to get at the essence of the count-to-infinity problem). *Answer: F, E and D all route to A via the lower part of the loop before the failure and so their paths will be unchanged. B will initially say to C "my cost is now 3" – the cost from B to C plus C's cost to A (which is 2). C will then say to B, "my cost is now 4" – the cost from C to B plus B's just-advertised cost to A (which was 3). B will then say to C "my cost is now 5" … and so on. (This is the count to infinity problem). Thus, approximately 500 messages will be required until finally C will route through D. (any answer around 500 is fine).*

Question 3: 802.11 (25 points, 20 minutes)

Consider the scenario shown to the right, in which the lines at the top of the figure show the radio range (e.g., so A is heard by B only, and B is heard by A and C but not D). Node D sends an RTS to node C at t_0. Node C sends a CTS (which is heard by nodes B and D) in accordance with 802.11 protocol, and node D begins the transmission of its message at t_2. In the meantime, node A sends an RTS message to B at time t_1.



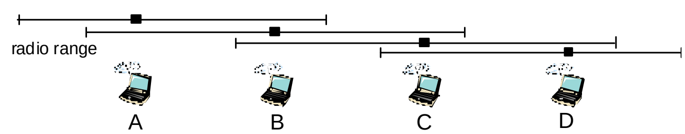
a) (2 points) If node A were to begin transmitting to node B at some point after t_3, would A's transmission interfere with the ongoing DATA transmission from D-to-C? *Answer: No, since A can not reach C.*

b) (3 points) At t_3, can B respond to A's RTS message with a CTS message? Why or why not? *Answer: No, since B has received a CTS and will have to defer all transmission until after data is sent and ACK is heard.*

c) (4 points) In the 801.11 protocol, what will node C do at t_4, at the end of the receipt of data from node D? *Answer: C will send an ACK (actually after deferring a bit, but that's not important).*

d) (4 points) If A were to begin transmitting to node B at some point after t_3, would A's transmission be successfully received at B? Justify/discuss your answer in a few sentences. *Answer: It could interfere with the later ACK transmission from C.*

Now suppose that the slotted Aloha protocol (rather than 802.11) is used.

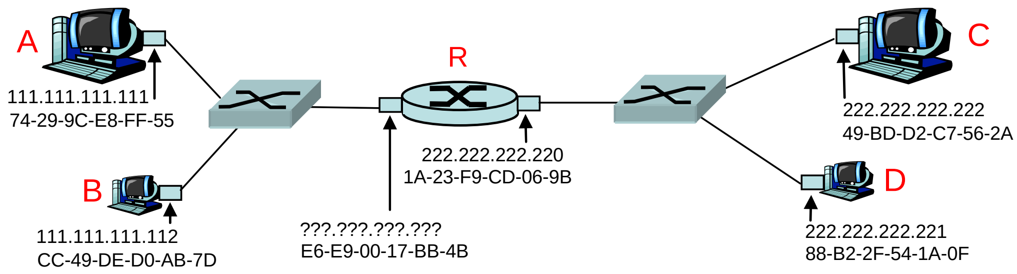


e) (4 points) Node A has an infinite supply of frames to send to node D (which will need to be relayed through nodes B and C); there is no other communication in the network. Will there be collisions in the slotted Aloha protocol? Explain in one or two sentences. *Answer. Yes there can be collisions since once node B has a frame to send, it will contend for the channel with A (and when C gets a frame it will content with B-to-C and A-to-B transmissions).*

f) (4 points) Suppose that nodes A, B, C, and D can somehow magically coordinate their transmissions, so that A will never send if B or C are sending, B will never send if A and C are transmitting and C will never send if A or B are transmitting). What is the maximum rate at which frames can be delivered to node D? (Note: make sure you take the limited transmission range into account, and the fact that no two nodes can transmit simultaneously). *Answer: no node can transmit at the same time, since a transmission from A to B would interfere (at B) with a transmission to D. Since a packet needs to cross three hops, it takes three time units to cross the hops and thus the end-end throughput is 1/3 packet per transmission slot.*

g) (4 points) Now suppose there is a 5th node E to the right of D (that is only in range of D) and suppose that A is sending to E. Nodes can magically coordinate as in f). What is the maximum rate at which frames can be delivered to node E? (same question as f), except there are 5 nodes and A is sending to E*). Answer: transmissions from D to E can occur simultaneously with transmission from A to B, so that as soon as a packet is delivered to E, the packet at B can then be delivered to C, D and then E in the next three time slots. Hence, the throughout is 1/3, as in f) above.*

Problem 4. LAN potpourri (25 points, 15 minutes)



Consider the LAN scenario above. Answer each question below _briefly_, e.g., _in a few words or a sentence or two at most._ (Really, please be **brief**)

a) (3 points) Assign an IP address to the leftmost interface of the router, given that the subnet part of IP addresses are 24 bits. *Answer: any address starting with 111.111.111.* is fine (except for * being 111 and 112).*

b) (3 points) Suppose A wants to send an IP datagram to B and knows B's IP address. Must A also know B's MAC address to send the datagram to B? If so, how does A get this info? If not, explain why not. *Answer: Yes, since B is on the same subnet, it will need to know B's MAC address. This will be done through the ARP protocol.*

c) (3 points) Suppose A wants to send an IP datagram to C and knows C's IP address. Must A also know C's MAC address to send the datagram to C? If so, how does A get this info? If not, explain why not. *Answer: No, A will forward the frame to the router, and the router will then de-capsulate the datagram and then re-encapsulate the datagram in a frame to be sent over the right subnet. R will need to run ARP in this case to get C's MAC address, but A will not).*

d) (4 points) Suppose that R has a datagram (that was originally sent by A) to send to C. What are the MAC addresses on the frame that is sent from R to C? What are the IP addresses in the IP datagram encapsulated within this frame? *Answer: source IP: 111.111.111.111, dest IP: 222.222.222.222. source MAC: 1A-23-F9-CD-06-9B (right interface of R), dest MAC: 49-BD-D2-C7-56-2A (node C).*

e) (4 points) Suppose the switches above are learning switches and suppose that the switch has just been turned on. Suppose now A send an Ethernet frame to B.
   a. On how many outgoing switch interfaces will this first frame be carried? *Answer: two interface (to B and to router)*
   b. Now suppose that B replies to A and A sends a second frame to B. On how many outgoing switch interfaces will this second frame be carried? *Answer: one interface (to B) since switch has learned where B is.*

Suppose now (for the two questions below) that the router is removed from the scenario above

f) (4 points) Can the nodes keep their IP addresses the same as shown in the picture above? Explain in one or two sentences. *Answer: If the subnet is /24 or actually anything except no network bits, then the answer is NO, since nodes on the same subnet need to have the same network part of their address.*

g) (4 points) Suppose that the network manager wants to assign A and C to the same VLAN and B and D to a different VLAN. When a frame is forwarded between

switches, how does the receiving switch know which VLAN the frame is destined to?
Answer: it’s contained in the VLAN tag in the Ethernet frame header