Name_____ Student ID_____ Department/Year_____

Final Examination

Introduction to Computer Networks
Class#: 901 31110
Fall 2004

9:20-11:00 Tuesday
January 11, 2004

Prohibited

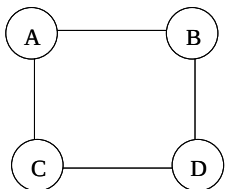
1. You are not allowed to write down the answers using pencils. Use only black- or blue-inked pens.
2. You are not allowed to read books or any references not on the question sheets.
3. You are not allowed to use calculators or electronic devices in any form.
4. You are not allowed to use extra sheets of papers.
5. You are not allowed to have any oral, visual, gesture exchange about the exam questions or answers during the exam.

Cautions

1. Check if you get 10 pages (including this title page), 7 questions.
2. Write your **name in Chinese**, student ID, and department/year down on top of the first page.
3. There are in total 150 points to earn. You have 100 minutes to answer the questions. Skim through all questions and start from the questions you feel more confident with.
4. Use only English to answer the questions. Misspelling and grammar errors will be tolerated, but you want to make sure with those errors your answers will still make sense.
5. If you have any extra-exam emergency or problem regarding the exam questions, raise your hand quietly. The exam administrator will approach you and deal with the problem.

1. (Routing) Consider the following simple network and the Reverse Path Forward (RPF)

algorithm below. Follow the questions one bye one to compare and contrast the source-based vs. group-shared trees used for multicast routing.



if (mcast datagram received on incoming link on the shortest path back to the sender)
then flood datagram onto all but the incoming link
else ignore datagram

(1) Computing the shortest paths from every node to every other node following the link state (LS) routing principle. Fill in the blanks in the tables provided below. (10%)

(2) Suppose A is the multicast source, and B, C, and D are the multicast receivers. For each data packet to be sent from the source to every receiver, how many copies of the data will be transmitted over link A-B, A-C, B-D, and C-D for source-based tree multicast using RPF? How many copies of the data will be transmitted over link A-B, A-C, B-D and C-D for group-shared tree multicast centered at D? (5%)

(3) Answer the questions in (2) when A, B, C, and D are all receivers. (5%)

(4) Based on the observation in (2) and (3), argue which of the source-based vs. group-shared trees is more bandwidth efficient for dense groups and which is more bandwidth efficient for sparse groups. (5%)

(1)

Step	Travel Set	D(B),p(B)	D(C),p(C)	D(D),p(D)
0	A	1,A	1,A	infinity
1	AB		1,A	2,B
2	ABC			2,B
3	ABCD			

Step	Travel Set	D(A),p(A)	D(C),p(C)	D(D),p(D)
0	B	1,B	infinity	1,B
1	BA		2,A	1,B
2	BAD		2,A	
3	BADC			

Step	Travel Set	D(A),p(A)	D(B),p(B)	D(D),p(D)
0	C	1,C	infinity	1,C
1	CA		2,A	1,C
2	CAD		2,A	
3	CADB			

Step	Travel Set	D(A),p(A)	D(B),p(B)	D(C),p(C)
0	D	infinity	1,D	1,D
1	DB	2,B		1,D
2	DBC	2,B		
3	DBCA			

(2)

	Source-based	Group-shared
A-B	1	1
A-C	1	0
B-D	1	2
C-D	2	1
Total	5	4

(3)

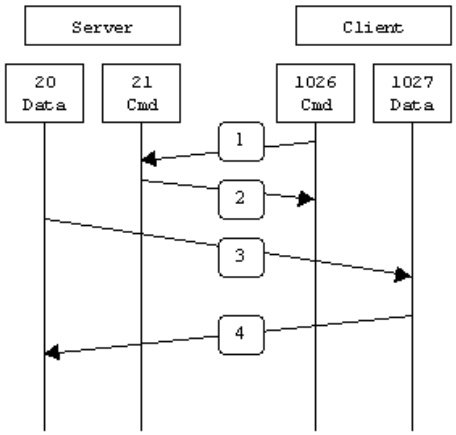
	Source-based	Group-shared
A-B	1	2
A-C	1	0
B-D	1	3
C-D	2	1
Total	5	6

(4)

source-based for dense groups: from (3) source-based tree is less bandwidth consuming than group-shared tree for the denser group (A,B,C,D)

group-shared for sparse groups: from (2) group-based tree is less bandwidth consuming than source-shared tree for the sparser group (B,C,D)

2. (NAT) Based on your understanding of Network Address Translation (NAT) service and the original (active) File Transfer Protocol (FTP) described below, try if you can address a problem earlier in the semester about submitting the homework assignments to the FTP server.



Active FTP:
In step 1, the client's command port contacts the server's command port and sends the data PORT 1027. The server then sends an ACK back to the client's command port in step 2. In step 3 the server initiates a connection on its local data port to the data port the client specified earlier. Finally, the client sends an ACK back as shown in step 4.

(1) Some of your classmates had trouble submitting homework assignments to the FTP server at the beginning of the semester. The FTP server, nslab.ee.ntu.edu.tw, might be a bit busy but it was running fine most of the time. Another possible reason is that these students might be trying to FTP from a host behind NAT. Could you explain why the host cannot upload/download files to the FTP server? (5%)

(2) When the instructor suggested that you connect to the FTP server using the 'passive' mode, the problem disappeared. What would you think the passive FTP and the active FTP work differently so the students behind NAT could submit homework assignments to the FTP server? (10%)

(3) The widespread use of NAT has forced a number of application-layer protocols to change. FTP is just one of the examples. What is your opinion about using NAT (give the advantages and disadvantages)? (10%)

Sample Solution:

(1) port 1027 on NAT is not mapped to port 1027 on the client

(2) Instead of the FTP server making data connection to the client, when the client receives the ack in Step 2, the client initiates the data connection to the FTP server.

(3) Justify for your opinion. Here is just one reference answer. NAT might be OK as a temporary solution to the IP address space shortage problem, but it violates the principle of layer transparency. As a consequence, applications such as FTP will need to change to get around clients behind NAT.

3. (MAC) There are three big classes of MAC protocols, channel partitioning, random access, and taking turns. Could you name two examples, communication or real-life protocols, for each class and explain why?
   (1) Channel partitioning (5%)
   (2) Random access (5%)
   (3) Taking turns (5%)

Sample Solution:

You get credits for whatever that makes sense. Argue for your examples. Here are just some reference solutions.

(1) GSM using combination of TDMA and FDMA. Broadcast radio and TV are FDMA-based. One channel is allocated for one radio or TV station.
(2) LAN, WLAN, use of public printers on the hallway, taking rides in the theme park. There is not a particular order and the shared media/resources are randomly accessed.
(3) Bluetooth or students answering instructors' questions in lectures. A master invites the slaves to transmit or talk.

4. (ARP and Link-Layer Switch) Come to think of ARP and link-layer switching carefully. One could observe that they are simply mechanisms to provide mapping from one piece of information to another. The two mechanisms, however, work differently in terms of how they find out about the mappings.
   (1) What kind of mapping is kept in ARP table? (5%)
   (2) What kind of mapping is kept in the link-layer Switch? (5%)
   (3) How does ARP obtain the mappings in the table? (5%)
   (4) How does the link-layer switch obtain the mappings? (5%)

Sample Solution:

(1) IP to MAC address
(2) MAC address to interface
(3) Query and reply
(4) Self-learning from the source address of the data received from a particular interface

5. (WLAN) Revisit the evolution from CSMA/CD to CSMA/CA when we move from designing for the wired Ethernet LAN to the wireless LAN.
   (1) Describe the ‘hidden terminal’ problem. (5%)
   (2) Give 2 possible causes of wireless nodes experiencing the hidden terminal problem. (5%)
   (3) Would CSMA/CD designed for wired Ethernet LAN work for wireless LAN and why? (5%)
   (4) How does CSMA/CA work (state how RTS, CTS, DATA and ACK packets interact)? (5%)
   (5) Would CSMA/CA overcome the problem CSMA/CD has on wireless LANs and why? (5%)

Sample Solution:

(1) Two wireless nodes on the same subnet could have a common neighbor reachable by both, but the two wireless nodes could not reach each other.
(2) Obstacles, signal fading, or signal interference
(3) No. Because of the hidden terminal problem, the wireless nodes might not detect all collisions.
(4) The sender sends RTS to the receiver to reserve the channel. The receiver sends back CTS to acknowledge the reservation. While the sender sends the DATA, the other nodes will keep silent until the receiver sends back the ACK to acknowledge the successful transmission.
(5) Yes. Because when a collision indeed occurs, DATA will not be received. A retransmission of the DATA will be sent by the sender until the ACK is back from the receiver.

6. (Mobility) Compare and contrast indirect routing and direct routing for handling mobility based on the following criteria.
   (1) How is the route efficiency? (5%)
   (2) How is the transparency to the correspondent? (5%)
   (3) How is the continuity of the connection? (5%)
   (4) How is the burden of the home agent? (5%)
   (5) How is the packet encapsulation (a packet within a packet) overhead? (5%)

Sample Solution:

(1) Indirect routing results in triangle routing. It is not efficient in the route length. Using direct routing, the correspondent communicates directly to the destination. Therefore, it is more efficient.

(2) Indirect routing provides transparency to the correspondent. I.e., the correspondent does not need to know the current address of the destination. Direct routing does not provide transparency to the correspondent. The correspondent needs to learn a new address every time.

(3) Indirect routing could keep the connections ongoing to the destination's permanent address when the destination mobile node moves from one foreign network to another. Direct routing will receive a new address each time when the destination node moves to a new foreign network. It will not be able to keep the ongoing connections running continuously without re-establishing the connection to the new address.

(4) The home agent for indirect routing needs to track where the destination is currently and encapsulates the original packets to be sent to the care-of address of the mobile destination. The home agent of the direct routing only needs to track the designation's new address and let the correspondent node know when requested.

(5) In indirect routing, every original data packet is encapsulated within another packet. The extra header overhead (the size of IP header in TCP/IP) accumulates. As opposed to indirect routing, direct routing does not have the encapsulation overhead.

7. (EWMA) In the adaptive playout delay calculation for Internet phone multimedia applications, we estimate the average network delay and the average delay deviation using the following formula. The formula basically computes a new average (A_n) by taking the weighted (α) sum of current average (A_{n-1}) and new sample (S_n), where $0 < \alpha < 1$. When the value of α is close to 1, the new average adapts faster to the latest sample value. And vice versa, when the value is close to 0.

$$A_{n+1} = (1-\alpha)A_n+(\alpha)S_n$$

   (1) Let $A_0 = 0$. Expand A_{n+1} in terms of S_i, i=0…n. (10%)
   (2) Explain why A_{n+1} is called the 'exponentially weighted moving average'. (5%)

Sample Solution:

(1) $A_{n+1} = (1-\alpha)^n(\alpha)S_0 + (1-\alpha)^{n-1}(\alpha)S_1 + (1-\alpha)^{n-2}(\alpha)S_{2+}\ldots+ (1-\alpha)^2(\alpha)S_{n-2} + (1-\alpha)(\alpha)S_{n-1} + (\alpha)S_n$

(2) If the value of α is close to 1/0, the average is exponentially less/more relevant (i.e., $(1-\alpha)^n$) to earlier samples (some n time periods before).