Department of Computer Science
The Hong Kong University of Science and Technology

Student ID_____

# COMP 361 Computer Communications Networks

## *Fall Semester 2003*

## Final Examination: Solution key

Date: Dec 15, 2003, Time 8:30am - 11:30am, venue Rm 3007

Name:_____Student ID:_____Email:_____

**Instructions:**

1. This examination paper consists of 14 pages and 11 questions
2. Please write your name, student ID and Email on this page.
3. For each subsequent page, please write your student ID at the top of the page in the space provided.
4. Please answer all the questions within the space provided on the examination paper. You may use the back of the pages for your rough work.
5. Please read each question very carefully and answer the question clearly and to the point. Make sure that your answers are neatly written, readable and legible.
6. Show all the steps you use in deriving your answer, where ever appropriate.
7. For each of the questions assume that the concepts are known to the graders. Concentrate on answering to the point what is asked. Do not define or describe the concepts unless specifically asked to.

| Question | Points | Score |
|---|---|---|
| 1 | 8 | |
| 2 | 7 | |
| 3 | 10 | |
| 4 | 12 | |
| 5 | 15 | |
| 6 | 15 | |
| 7 | 10 | |
| 8 | 6 | |
| 9 | 5 | |
| 10 | 6 | |
| 11 | 6 | |
| **TOTAL** | 100 | |

Student ID_____

1) Answer the following true/false questions by circling either T or F. (8 points)

| | | |
|---|---|---|
| a) BGP is the unique Inter-AS routing protocol available on the Internet (an Inter-AS protocol is one that routes *between* Autonomous Systems). | **T** | F |
| b) Head of Line (HOL) blocking can result in output buffer overflow in routers | T | **F** |
| c) Slotted Aloha is more efficient than pure Aloha | **T** | F |
| d) An IP datagram that will be transported using the ATM AAL5 protocol will be padded so that its length will always be a multiple of 48 bytes | **T** | F |
| e) Host A is sending host B a large file over a TCP connection. Assume Host B has no data to send to A. Host B will not send acknowledgements to host A because host B can not piggyback the acknowledgements on data. | T | **F** |
| f) Consider Congestion Control in TCP. When a timer expires at the sender, the threshold is set to one half of its previous value. | T | **F** |
| g) The **Date**: header in an http response message indicates when the object in the response was last modified. | T | **F** |
| f) A two-dimensional parity check scheme can detect the occurrence of up to two bit errors in the original data. | **T** | F |

2) Consider a link of rate R Kbps carrying eight identical ongoing client /server applications, with each of the applications using one TCP connection.

a) If new application X comes along and opens one new TCP connection what transmission rate will it get? Explain your answer. (2 points)

b) If it wants to acquire a rate of R/2, how many TCP connections does it have to open? Explain your answer. (2 points)

c) Following up on (b); if the original 8 client/server applications with one TCP connection each all leave the link and 8 new UDP based applications then join the link, would application X be able to keep rate of R/2? Explain your answer. (3 points)

Answer:

a) Application will get R/9 Kbps.
This is because after X opens one connection there will be 9 connections and TCP tries to allocate the rate fairly among all the connections

b) It has to open 8 connections. At that point there will be 16 connections open. Since, as mentioned above, TCP tries to allocate the rate fairly among all the connections, X will receive 16/8=1/2 of the full rate.

c) In general it would not be able to maintain rate of R/2 because UDP flows do not have congestion control, and they will take as much of the bandwidth as they can.

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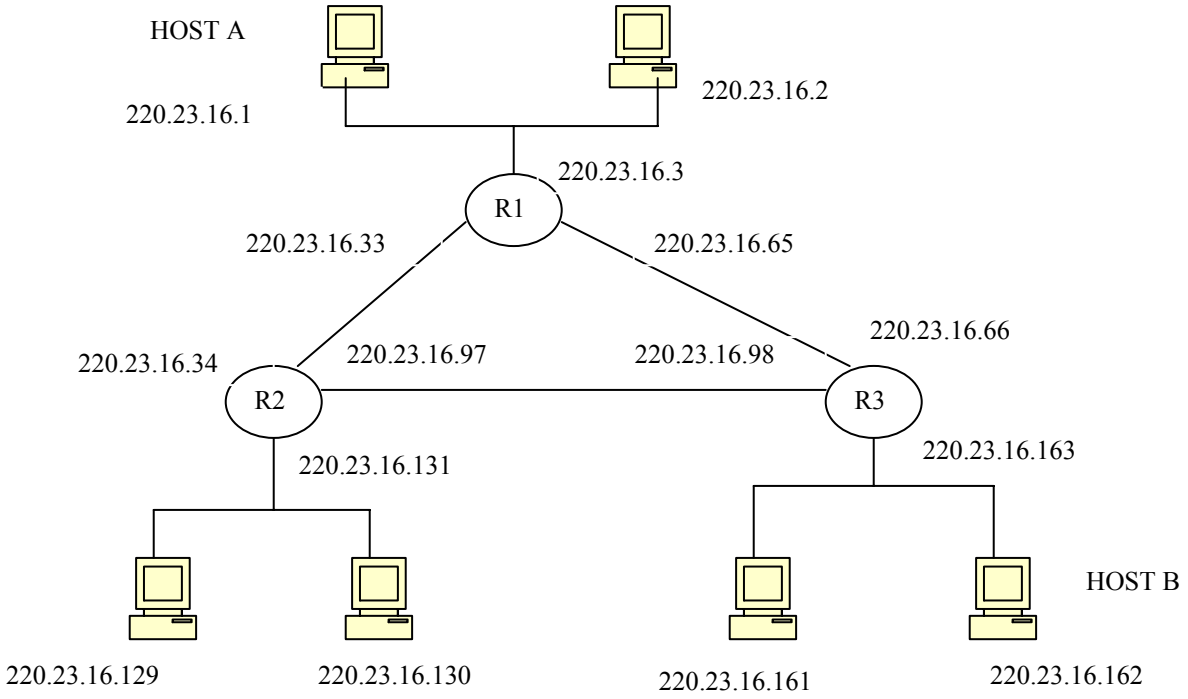
3) You are given a pool of **220.23.16.0/24** IP addresses to assign to hosts and routers in the system drawn below:

a. How many separate networks are in the system? (3 points)

b. Partition the given address space and assign addresses to the networks. To answer this question properly you should write down the addresses of all of the networks in the CIDR **A.B.C.D/x** format. (3 points)

c. Assign addresses to components of the network. To answer this question you should label all of the interfaces in the diagram below with their assigned addresses. (4 points.)




a) There are 6 networks.
b) Possible addresses are:
220.23.16.0/27
220.23.16.32/27
220.23.16.64/27
220.23.16.96/27
220.23.16.128/27
220.23.16.160/27

4) Suppose that HOST A from the previous picture (problem 3) wants to send an IP datagram to HOST B. Assume that A's ARP Cache is empty.

a) A starts the process by sending an ARP query. What will be the reply to its ARP query? (3 points)

b) What will be the content of the *destination-IP-address* field in the header of the IP-datagram sent by HOST A? (3 points)

c) Will routers R1 and R3 change any of the fields in the IP datagram's header? If yes, which field(s)? (3 points)

d) When router R3 receives the datagram, and if its ARP cache is empty, will it have to send an ARP query related to sending this datagram? If yes, what will be the reply to this query? (3 points).

Answer:

a) The data link address of the router's interface connected to network where host A is attached.
b) The IP address of host B.
c) Routers R1 and R3 will change the Time to Live field and header checksum fields.
d) Yes, an ARP query is needed. The answer will be issued by host B and it will be the data link address of host B's network interface.

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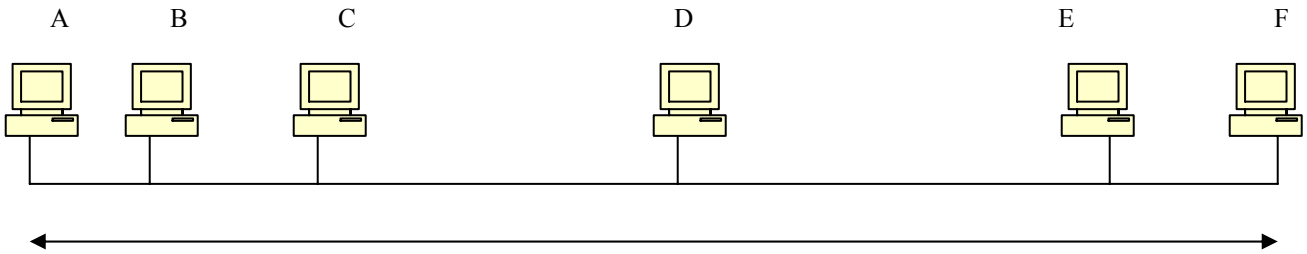
5) Consider the following linear network that is 2km long.




2km

Assume that propagation speed of electromagnetic waves sent over the medium is $2*10^8$ m/s and the transmission rate of the network is 10Mbps. What is the minimum frame size (in bits) necessary to ensure that CSMA/CD will work properly for this network? Explain your reasoning. (15 points)

In order for CSMA/CD to work a transmitting host must know about a collision (by hearing it on the link) BEFORE the transmitting host completes its transmission.

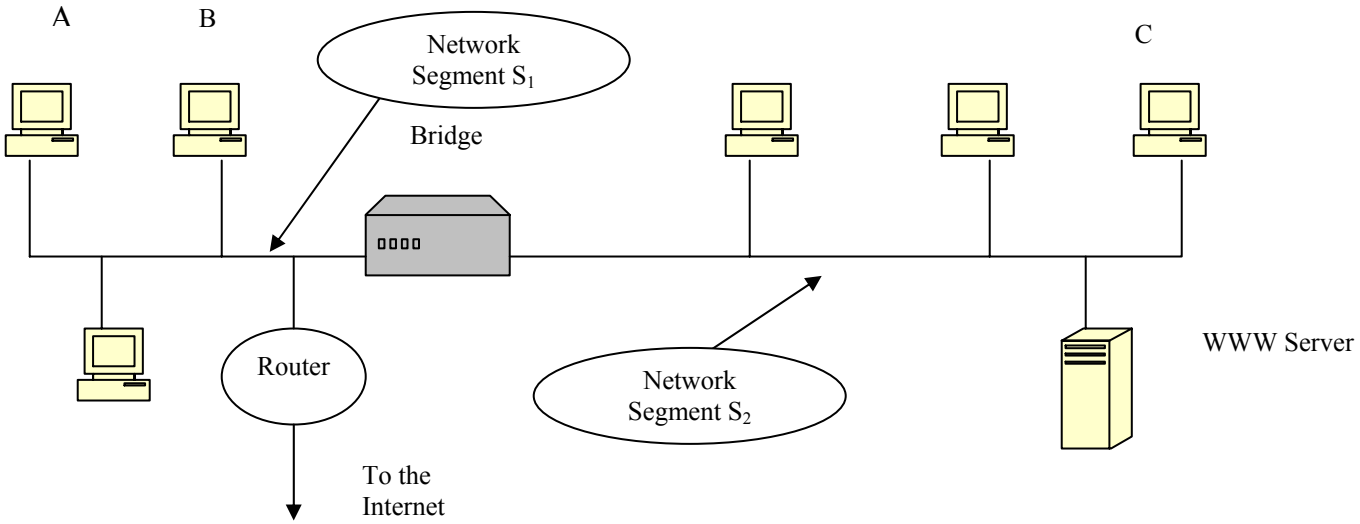
Let d = distance between hosts X and Y.
Let R = $2*10^8$ m/s be the propagation speed of the network
Suppose host X starts transmitting a frame of size F.
Then, before hearing the first bit of the frame, host Y starts transmitting a frame.
This can be at most d/R time after X starts transmitting and X hears the beginning of Y's transmission d/R time after that. Therefore, the MAXIMUM amount of time that can pass from the time that X starts transmitting until X hears the first bit from Y is 2d/R.

Therefore we must have F/10Mbps >= 2d/R.

d can be 2 X10^3 m (if X and Y are A and F) so F has to be at least

F = 2dR/10^3 = 200 bits.

6) Consider the following local area network:




a. Do the hosts A and C share the same network part of their IP addresses? Explain. (3 points)

b. Can host C access the WWW server at the same time as host B accesses the Internet through the router? Explain. (3 points)

c. Can host A access the WWW server at the same time as host B accesses the Internet through the router? Explain. (3 points)

d. What is the maximum size of the bridge's table (in the number of entries) in this configuration? (3 points)

e. When host A sends an ARP query to learn the data link address of the router, can host C hear it? Explain. (3 points)

Answer:

a) Yes. Host A can directly access host C access at the link layer, as the learning bridge is transparent to all the hosts.
b) Yes. The bridge will not forward the traffic form network segment $S_1$ to $S_2$ in this case, and the two network segments are partitioned into two independent collision domains.
c) No. Host A needs to use the same network segment ($S_1$) upon which Host B and the WWW server is communicating on.
d) 8 entries
e) Yes. Host A sends a BROADCST frame out and the bridge will forward all the broadcast frames that it receives to the other segment.

7)

a) List one advantage and one disadvantage of using channel-partitioning MAC protocols. (1 point)

b) List one advantage and one disadvantage of using random-access MAC protocols. (1 point)

c) The standard Ethernet CSMA/CD protocol uses *exponential backoff*.
First, describe the Ethernet *exponential backoff* algorithm (your explanation must include why it is called *exponential*).

Next, explain the reason(s) for using exponential backoff.
(4 points)

d) The 802.11 wireless LAN protocols use CSMA/CA instead of CSMA/CD. Explain why 802.11 **does not** use CSMA/CD. (4 points)

Answers:

a) advantage: shares channel efficiently at high loads
disadvantage: inefficient at low loads

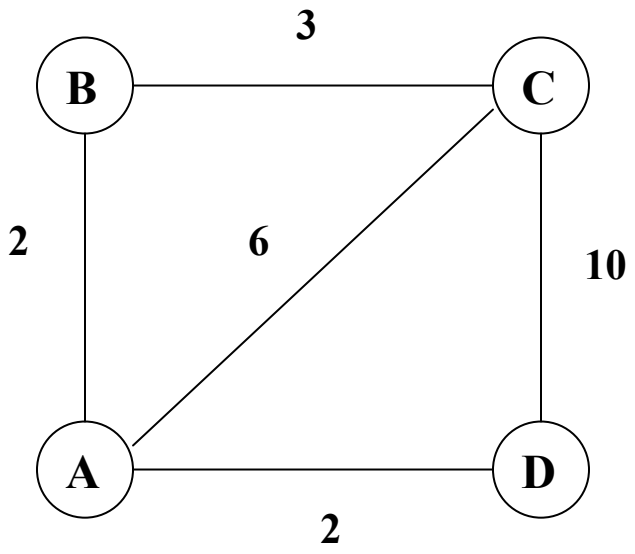
b) advantage: efficient usage of channel at low loads
disadvantage: inefficient at high loads (due to collision overheard)

c) After a collision choose K at random from {0,1,2,…,2^min(m,10) -1} and wait KX512 bit times before sensing channel again.
m is the number of collisions encountered while trying to broadcast this particular frame.
It is called exponential backoff due to the 2^m-1 term.

The reason for using exponential backoff is that if there have been a lot of collisions so far this implies that there are many nodes trying to access the link at the same time. Increasing the possible range of waiting times from which the link(s) choose makes it more likely that no two nodes will choose the same waiting time.

d) Due to the hidden terminal problem when using wireless LAN it is not always possible to do **collision detection.**

8) Consider the network below with the given link costs.




Fill in the final values in B's distance table that will result after running the *distance vector routing algorithm* with *Poisoned Reverse*. (6 points)

$D^B()$

| dest | cost to dest via A | cost to dest via C |
|---|---|---|
| A | 2 | infty |
| C | infty | 3 |
| D | 4 | infty |

9) Consider NAT (Network Address Translation).

a) Briefly describe how NAT works. (3 points)

b) What problem was NAT introduced to solve? (1 point)

c) Give one reason why NAT is controversial. (In class, we discussed a few. Just give one of them). (1 point)

Answers:

a) Every (IP address, port #) of a message leaving the internal network is mapped by the NAT gateway to a (NAT IP address, new port #) pair which is stored by the NAT gateway node. When a message from outside arrives at the NAT gateway node for that port # the NAT gateway node checks its table and sends the message on to the proper (IP address, port 3) in the internal network.

b) Local networks running out of IP addresses

c) routers should only process up to level 3 but NAT routers process higher up (they need to be aware of pplications). Also, NAT violates the end-to-end argument. Finally, NAT translation can cause problems when designing applications.

10) Describe two changes that were made when designing IPv6 that speed up packet processing and forwarding compared to IPv4.

Briefly explain HOW these changes speed up packet processing and forwarding.
(6 points)

IPv6 does not allow datagram fragmentation as allowed by IPv4.
Fragmentation was done by routers and was time consuming. Getting rid of it speeds up IP-forwarding within the network

IPv6 also does not have a header checksum for the datagram while IPv4 does..
Checksums need to be recalculated every hop (due to the change in the TTL field).
Removing them reduced the work needed to be done by the router, speeding up processing.

11) In this question you must calculate CRC bits.

The input data is the string of 4 bits **D = 1 1 0 0.**

Set r=3. The r+1 generator bit pattern used by the algorithm will be **G = 1 0 1 1.**

Given **D** and **G** as above, find the r CRC bits generated by the CRC algorithm and explain how you calculated those bits. (6 points)

D(x) x^3 = x^6 + x^5
G(x) = x^3 + x +1

Doing the division we find that, modulo base 2 coefficients,

D(x) x^3 = x^6 + x^5 = G(x) (x^3 + x^2 + 1) + x

So the remainder polynomial is R(x) = x = 0 x^2 + 1 x + 0

Since we need r =3 bits for the CRC this means that the three bits generated are

**0 1 0.**