Name______________ Student ID___________________ Department/Year__________

Midterm Examination

Introduction to Computer Networks
Class#: 901 E31110
Fall 2009

9:30-11:10 Tuesday
November 10, 2009

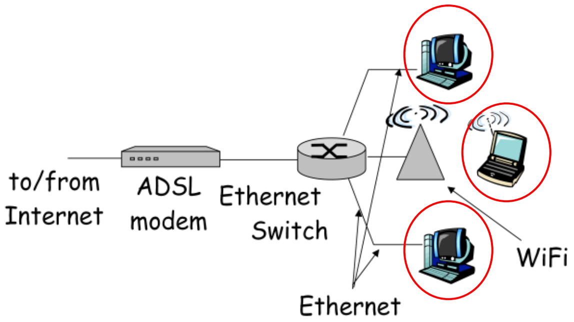
Prohibited

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 12 pages (including this title page), 19 questions.
2. Write your **name in Chinese**, student ID, and department/year down on top of the first page.
3. There are in total 200 points to earn. You have 100 minutes to answer the questions. Skim through all questions and start from the questions you are 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. Consider the home network above. Circle out (right on the figure) the devices that are end systems. (5%)



d 2. Consider the home network above. Which of the following is the access network used to access the Internet? (5%)
   (a) WiFi
   (b) Ethernet
   (c) Dial-up modem
   (d) ADSL
   (e) Cable Modem

a 3. Consider the home network above. Suppose the ADSL modem has an 8 Mbps downlink and 1Mbps uplink, the Ethernet switch is 10Gbps, and the WiFi base station is 54Mbps. What is the maximum bandwidth an end system in this home can download from the Internet? (5%)
   (a) 8Mbps
   (b) 1Mbps
   (c) 9Mbps
   (d) 10Gbps
   (e) 54Mbps

d 4. Follow from 3. What is the maximum bandwidth an end system in this home network can download from each other? (5%)
   (a) 8Mbps
   (b) 1Mbps
   (c) 9Mbps
   (d) 10Gbps
   (e) 54Mbps

a 5. Follow from 3. If all end systems are downloading data from the Internet simultaneously and each gets an equal share of the bandwidth, what is the maximum bandwidth an end system in this home can download from the Internet? (5%)
   (a) 2.67Mbps
   (b) 0.33Mbps

(c) 3Mbps

(d) 3.33Gbps

(e) 18Mbps

abcde 6. Which of the following functions are often provided as well in the Ethernet switch product today? (5%)

(a) DHCP

(b) NAT

(c) WiFi

(d) Firewall

(e) UPnP

abe 7. Which of the following access networks provide shared access? (5%)

(a) WiFi

(b) Ethernet

(c) Dial-up modem

(d) ADSL modem

(e) Cable Modem

abd 8. Which of the following phenomena occur in a packet-switched network? (5%)

(a) Packet reordering

(b) Congestion

(c) Connection setup

(d) Packet drop

a 9. Which of the following phenomena do not occur in a virtual-circuit packet-switched network? (5%)

(a) Packet reordering

(b) Congestion

(c) Connection setup

(d) Packet drop

ac 10. Which of the followings are not the reasons for structuring the Internet protocols in layers? (5%)

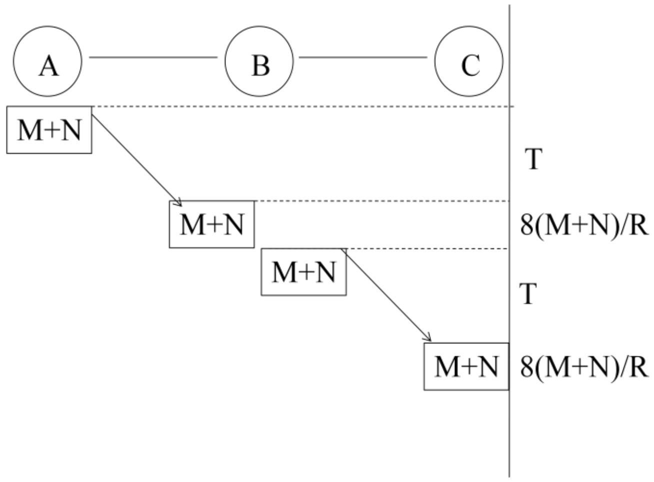
(a) To mimic lasagna and lasagna taste better than spaghetti

(b) To provide as a reference model to facilitate discussions

(c) To be similar to the process of taking the flights such that it is easy to explain

(d) To allow fast changes within a layer without needing to know the details of protocols in other layers

11. Suppose we have M bytes to send over a 3-node network as shown below.



Assume that there is no processing delay and no queuing delay at all. The propagation delay is T seconds for both link A-B and link B-C. The transmission rate is R bps for both link A-B and link B-C. Suppose the amount of data required to add to each packet in order to transmit the data over the network is N bytes.

(a) How much time does it take to send all M bytes of data as one packet from node A to node C? (5%)

(b) Divide the M bytes into two equal parts. How much time does it take to send all the data as two packets? (5%)

(c) Divide the M bytes into 3 equal parts. How much time does it take to send all the data as three packets? (5%)

(d) Divide the M bytes into K equal parts. How much time does it take to send all the data as K packets? (10%)

(e) Based on the result in (d), find K such that the data delivery delay is the minimum. (15%)

Sample Solution:

(a) 2*T + 2*8(M+N)/R

(b) 2*T + 3*8(M/2+N)/R

(c) 2*T + 4*8(M/3+N)/R

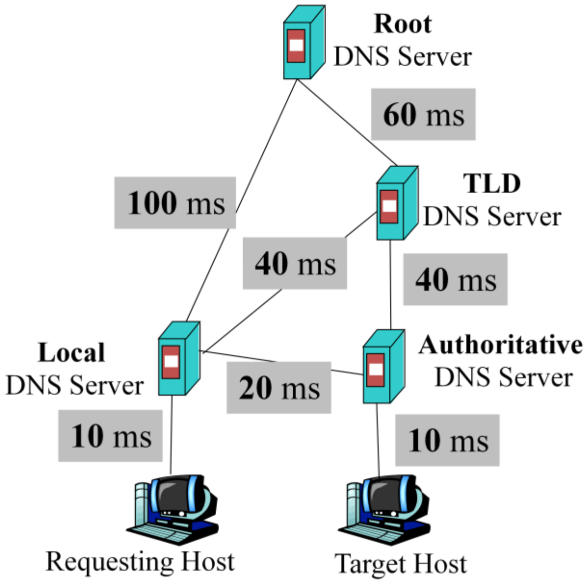
(d) 2*T + (1+K)*8(M/K+N)/R

(e) Formula in (d) can be extended to 2T + (8/R) (M/K+N) (1+K) =
2T + (8/R) (M/K + N + M + KN)

To find K that minimize the above form is equivalent to find K that minimize M/K + KN. All other terms are constant.

Take derivative of M/K + KN. We come to $N-M/K^2$.
Solve for $N-M/K^2$ equals 0. K = sqrt(M/N)

12. For each host we intend to connect to, a DNS query is often issued to find the corresponding IP address of the host. The figure below indicates the entities often involved when a DNS query is issued.



DNS queries and replies are small. Let's ignore the transmission delay of the DNS queries and replies. Given the propagation delay indicated in the figure between the entities, how long does it take to receive the DNS reply?

(a) In case that the DNS query is cached in the local DNS server (5%)

(b) In case that the DNS query is iterative (5%)

(c) In case that the DNS query is recursive (5%)

(d) Let L denote the propagation delay between the Requesting Host and the Local DNS server. Let R denote the delay between the Local to the Root DNS server. Let LT, LA, RT, and TA denote the delay between the Local-TLD, Local-Authoritative, Root-TLD, and TLD-Authoritative DNS servers respectively. Write out the formula of DNS response time for iterative query vs. recursive query. (10%)

(e) Comment and compare the delay of iterative and recursive queries depending on whether the TLD and authoritative DNS servers are closer to the local DNS vs. Root DNS server. (10%)

Sample Solution:

(a) 20ms
(b) 10+200+80+40+10 = 340ms
(c) 10+100+60+80+60+100+10 = 420ms
(d) Iterative: 2L+2R+2LT+2LA
    Recursive: 2L+2R+2RT+2TA
(e) When TLD and authoritative DNS servers are close to the local DNS server, LT and LA are small. Hence, the iterative queries will be faster. Otherwise, RT and TA are small and the recursive queries will be more beneficial.

13. Consider a very simple peer-to-peer file sharing system, e-Camel. In that there are 8 peers at maximum. The node ID are 0, 1, 2, … 7. The simple hash function to decide in which peer a file should reside is: key(File) mod 8. If a certain peer does not exist, the nearest peer with ID greater than the hash result will keep the file.

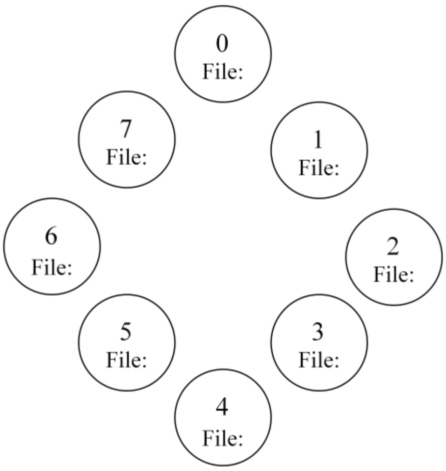
(a) If all 8 peers are alive, where will File with key 1, 2, 3, …, 8 go? Write the File key in the peer it belongs to. (5%)

(b) If peer #3 decides to leave e-Camel, as it logs out, the system can move the files on its storage to the rightful place. Write the File key in the peer it belongs to now. (5%)

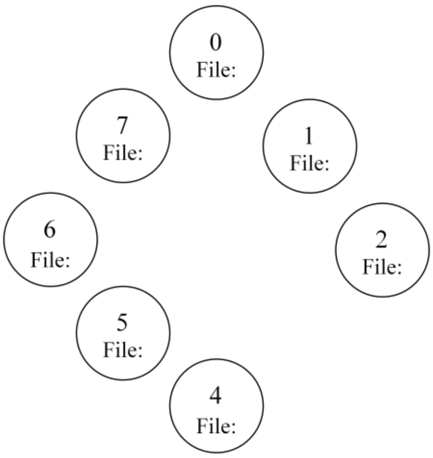
(c) If peer #3 suddenly drop out due to power failure, which peer will be hold which file as this event occurs? (5%)

(d) Devise a mechanism to improve e-Camel such that a file will not disappear from the system entirely in case of (c). Specify your design and explain why. (15%)

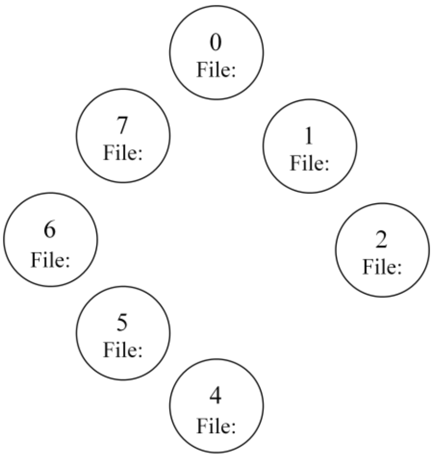
(a)



(b)

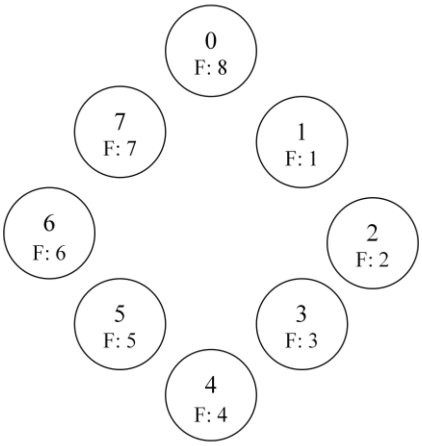


(c)

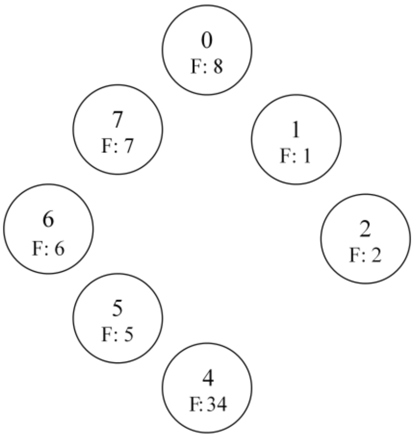


Sample solution:

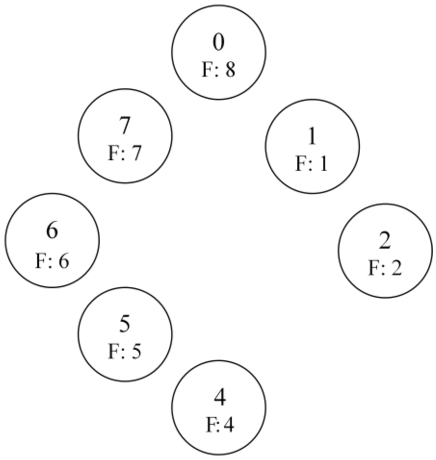
(a)



(b)



(c)



(d) Many solutions will work here. Justify for your own solution.

cd 14. What functionalities do TCP and UDP have in common? (5%)

(a) In-order delivery
(b) Reliable transfer
(c) Checksum
(d) Multiplexing
(e) Connection establishment

cd 15. What type of applications would prefer UDP transport service? (5%)

(a) WWW
(b) Online chess game
(c) Video conferencing
(d) Interactive voice
(e) Email

ce 16. Which of the following is true about Go-Back-N? (5%)

(a) Sequence number in GBN needs to be at least twice as large as the window size.
(b) GBN uses multiple timers.
(c) GBN discards packets received out of order.
(d) GBN retransmits packets upon receiving duplicate acknowledgements.
(e) GBN requires less memory space to implement.

d 17. Which of the following is true about Selective Repeat? (5%)

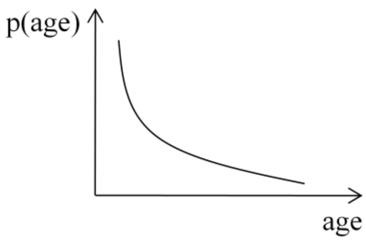
(a) SR receiver sends duplicate acknowledgement for all packets that are not expected.
(b) SR uses cumulative acknowledgement.
(c) SR retransmits packets upon receiving duplicate acknowledgements.
(d) SR uses multiple timers.
(e) SR requires less memory space to implement.

bce 18. Which of the following is true about TCP's reliable data transfer? (5%)

(a) TCP uses multiple timers.
(b) TCP may retransmit packets upon receiving duplicate acknowledgements.
(c) TCP may retransmit packets upon timer timeout events.
(d) TCP receiver always transmits acknowledgement immediately upon receiving a data packet.
(e) TCP uses cumulative acknowledgement.

19. TCP's sequence number is 32 bits long. When the sequence number goes beyond the limit, it wraps around and starts from the beginning again. When the network stays congested for a long time, it is possible that certain packets sent a wrap ago finally get through. An acknowledgement of a-wrap-ago packet may arrive and acknowledges for new packets that are just sent and not yet acknowledged. If the newly-sent data packet is unfortunately lost, the source will not resend because of receiving the acknowledgement for the wrap-age-old packet. This creates a hole in TCP's data transfer reliability mechanism.

    Let's try to think through the problem and see if you can provide a proper solution to avoid the wrap-old acknowledge packet clearing for the newly sent data. The probability of a wrap-old packet's acknowledgement coming back to acknowledge a new packet depends on the age of the old packet. The distribution is typical as follows.



    Let S denote the time to transmit 2^{32} bytes of data and W the time to transmit a window full of data. Consider a case that the application keeps calling from above and passes data to the TCP sender for transmission continuously. The age of an old packet whose sequence number equals the 'sent-base' of the in-flight batch can be denoted as S+W. The age of the old packet whose sequence number is identical to the latest packet sent is S. The probability of an old acknowledgement appears for the sent-base of the batch is p(S+W) and for the latest packet p(S). Given the fixed window size, i.e., W is fixed, what can one do to reduce the probability of TCP failing to guarantee reliability? (20%)

Sample Solution:

There are any possible solutions. Justify for your solution.

E.g., make the sequence space larger. Hence S is larger. p(S) and p(S+W) become lower.

E.g., make host wait before allowing the next TCP connect to start on the same port. That adds a more time, C, to the age. p(C+S) and p(C+S+W) are slower.