Name_____ Student ID_____ Department/Year_____

Midterm Examination

Introduction to Computer Networks
Class#: 901 31110
Fall 2005

9:20-11:00 Tuesday
November 8, 2005

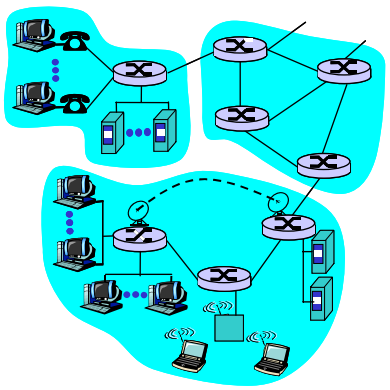
Prohibited

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), 6 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 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. (Overview) We have seen the figure on the right for many times in class. It illustrates a typical composition of a network on the Internet.



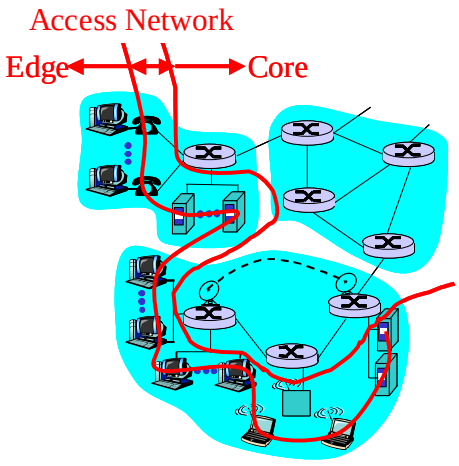
   (1) Based on how you understand what the Internet edge, core, and access network is, circle out the computers belonging to the edge of the network, the computers belonging to the core of the network, and the links belonging to the access network. (5%)

   (2) Consider two sets of terms, A={TCP, UDP} and B={circuit switching, packet switching}. Which set contains the terms to indicate different transport services use by the Internet edge computers? Which set to indicate different approaches to transmit data in the core of a network? (5%)

   (3) Consider two sets of terms, A={ADSL, cable modem, Ethernet, WiFi, FTTI} and B={HINET, TANET, sparq, APBT, wifly}. Which set contains the terms to indicate different kinds of access networks? Which set to indicate different ISPs in Taiwan? (5%)

Sample Solution:

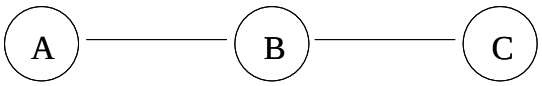
(1) As depicted



(2) A: edge, B: core

(3) A: access networks, B: ISPs

2. (Overview) Consider a simple network as follows. 12P bits of data need to be sent from node A, through node B, to node C. Link A-B and link B-C are identical. The link bandwidth is R bits per second. The link speed is S meter per second. The length of the link is D meters. Suppose the packet header containing necessary information to delivery any amount of data from A to C is P bits. And the queuing and processing delays are negligible.



   (1) If we send all the 12P bits data in one packet, the total numbers of bits in the packet to send is 13P bits (including the P bits necessary for the packet header). What is the total delay for all the data to arrive at C (in terms of R, P, S, or D)? (5%)
   (2) Let's send the 12P bits in 2 equal parts. 6P bits in each part. Each part is sent in a packet. The total number of bits in a packet to send is then 7P bits (including the P bits necessary for the packet header). The two packets are sent back to back (i.e., in the pipelined fashion). What is the total delay for all the data to arrive at C (in terms of R, P, S, or D)? (5%)
   (3) What are the total delays if the 12P bit data are sent in k equal parts? (10%)
   (4) What is the optimal k to minimize the delay for delivering all data? (10%)

Sample Solution:

   (1) 26P/R + 2D/S
   (2) 21P/R + 2D/S
   (3) $(k^2+13k+12)/k$
   (4) Let $f=(k^2+13k+12)/k$.
   Solve df/dk=0.
   (deduction omitted)
   k= sqrt(12)
   3 and 4 give the same result so either 3 or 4 will be correct

3. (Application) Compare and contrast the Web and Email systems. It is called a PULL service, if the data transfer goes from the server to the client and a PUSH service if the data transfer goes the other way.
   (1) What is the application-layer protocol to enable web object transfer between a web browser and a web server? (5%)
   (2) Which of the entities in the Web object transfer, web browser or web server, is the client? And which is the server? (5%)
   (3) Is the Web a PUSH or PULL service? (5%)
   (4) What is the application-layer protocol to enable email transfer between the mail servers? (5%)
   (5) Which of the entities in the Email transfer, sending mail server or receiving mail server, is the client? And which is the server? (5%)
   (6) Is Email transfer among the mail servers a PUSH or PULL service? (5%)

Sample Solution:

(1) HTTP.
(2) Web browser, Web server
(3) PULL
(4) SMTP
(5) Sending mail server, receiving mail server
(6) PUSH

4. (Application) Suppose you are designing the communication part of a massive multiplayer online role playing game. The game server is the database maintaining information about all the players and the artificial characters (monsters), for example the treasure being carried along, remaining life point, position in the game world, and etc. The game client displays the status of the player and the presence of other players or artificial character nearby. The game client also transmits user commands such as to trade treasures with other players, to move from places to places, and to engage in combats with other players or monsters. The table below shows the QoS (quality of service) the general players demand for the three types of game actions.

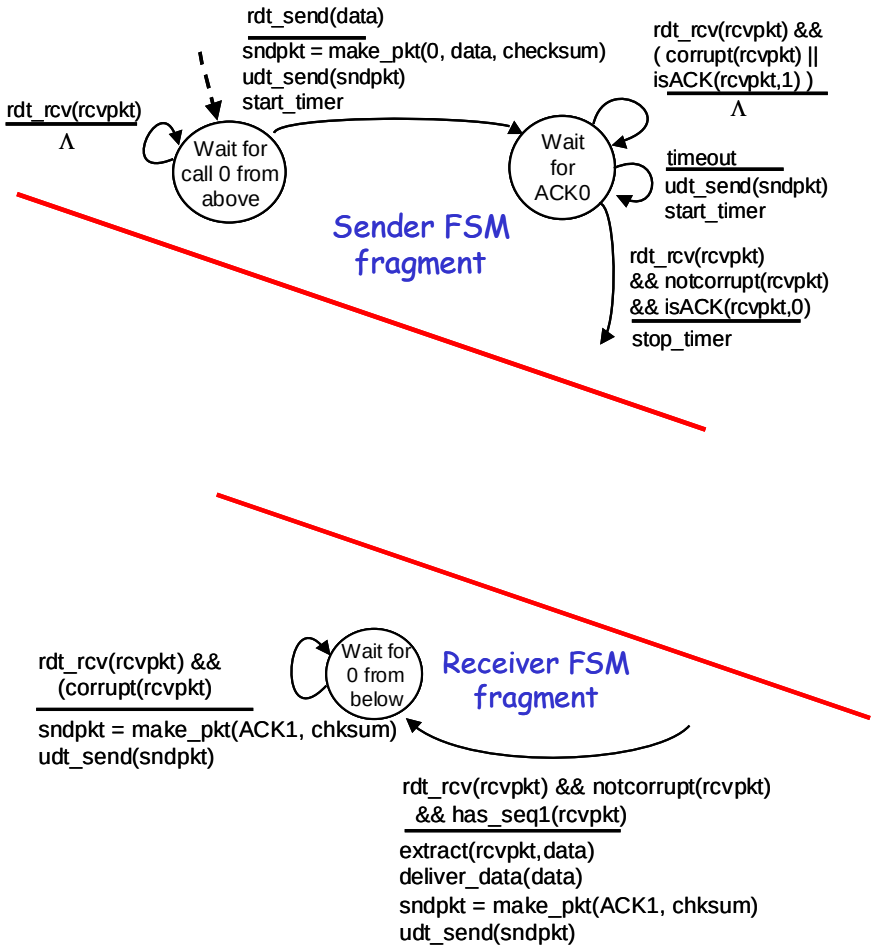
	Loss	Bandwidth	Time Sensitive
Treasure Trading	no loss	elastic	no
Moving	loss tolerant	elastic	yes
Combating	no loss	elastic	yes

   (1) Which transport layer services, TCP, UDP, or else, will you choose to transfer the user commands for exchanging treasure with another player and why? (10%)
   (2) Which transport layer services, TCP, UDP, or else, will you choose to transfer the user commands for moving to another position and why? (10%).
   (3) Which transport layer services, TCP, UDP, or else, will you choose to transfer the user commands for combating with an artificial character and why? (10%)

Sample Solution:

   (1) TCP. No-loss is the only requirement.
   (2) UDP. Delay is important. Reliability isn't. This way, there is no need to wait for the retransmission that might be too late already
   (3) Else. UDP doesn't provide reliable transfer. TCP might not meet the delay requirement when there are many packet losses either.
   (alternatively, TCP. UDP doesn't provide reliable transfer.)

5. (Transport) Below are the FSMs of the rdt 3.0 sender and receiver. Suggest two ways to further improve rdt 3.0 and explain why your rdt's are better than rdt 3.0. (30%).



Sample Solution:

(1) When the receiver a corrupted data packet, the receiver does not send a duplicate ACK. The sender times out anyway so the rdt will still work. And we save some bandwidth for not sending duplicate ACKs this way.

(2) When the sender receives a corrupted or duplicate ACK, retransmit the data packet immediately and restart the timer. The rdt will still work and we save some time recovering the error this way.

(3) Pipelined for better utilization

(Or whatever improvement that works)

6. (Transport) To find the proper Timeout interval for retransmission in TCP, we estimate the average round-trip time (RTT) and the average RTT 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).